FreeNAS® 11.2-BETA2 User Guide

August 2018 Edition

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Written by users of the FreeNAS® network-attached storage operating system.
Version 11.2
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Welcome . . . 1
Typographic Conventions . . . 2

1 Introduction **3**
1.1 New Features in 11.2 . . . 3
1.2 Path and Name Lengths . . . 5
1.3 Hardware Recommendations . . . 6
1.3.1 RAM . . . 6
1.3.2 The Operating System Device . . . 7
1.3.3 Storage Disks and Controllers . . . 7
1.3.4 Network Interfaces . . . 8
1.4 Getting Started with ZFS . . . 9

2 Installing and Upgrading **10**
2.1 Getting FreeNAS® . . . 10
2.2 Preparing the Media . . . 10
2.2.1 On FreeBSD or Linux . . . 11
2.2.2 On Windows . . . 11
2.2.3 macOS . . . 12
2.3 Performing the Installation . . . 12
2.4 Installation Troubleshooting . . . 20
2.5 Upgrading . . . 21
2.5.1 Caveats . . . 21
2.5.2 Initial Preparation . . . 21
2.5.3 Upgrading Using the ISO . . . 22
2.5.4 Upgrading From the GUI . . . 25
2.5.5 If Something Goes Wrong . . . 25
2.5.6 Upgrading a ZFS Pool . . . 27
2.6 Virtualization . . . 28
2.6.1 VirtualBox . . . 29
2.6.2 VMware ESXi . . . 37

3 Booting **44**
3.1 Obtaining an IP Address . . . 45
3.2 Logging In . . . 46
3.3 Initial Configuration . . . 48

4 Account **49**
4.1 Groups . . . 49
4.2 Users . . . 52

5 System **56**
5.1 Information . . . 56
5.2 General . . . 57
5.3 Boot . . . 60

5.3.1 Mirroring the Boot Device . . . 62
5.4 Advanced . . . 63
5.4.1 Autotune . . . 65
5.4.2 Self-Encrypting Drives . . . 66
5.5 Email . . . 67
5.6 System Dataset . . . 68
5.7 Tunables . . . 69
5.8 Update . . . 71
5.8.1 Preparing for Updates . . . 72
5.8.2 Updates and Trains . . . 72
5.8.3 Checking for Updates . . . 73
5.8.4 Applying Updates . . . 74
5.8.5 Manual Updates . . . 74
5.9 Cloud Credentials . . . 75
5.10 Alerts . . . 76
5.11 Alert Services . . . 77
5.11.1 How it Works . . . 78
5.12 CAs . . . 79
5.13 Certificates . . . 81
5.14 Support . . . 84

6 Tasks **87**
6.1 Cloud Sync . . . 87
6.1.1 Cloud Sync Example . . . 90
6.2 Cron Jobs . . . 91
6.3 Init/Shutdown Scripts . . . 94
6.4 Rsync Tasks . . . 95
6.4.1 Rsync Module Mode . . . 99
6.4.2 Rsync over SSH Mode . . . 99
6.5 S.M.A.R.T. Tests . . . 102

7 Network **105**
7.1 Global Configuration . . . 105
7.2 Interfaces . . . 107
7.3 IPMI . . . 109
7.4 Link Aggregations . . . 111
7.4.1 LACP, MPIO, NFS, and ESXi . . . 111
7.4.2 Creating a Link Aggregation . . . 112
7.5 Network Summary . . . 115
7.6 Static Routes . . . 115
7.7 VLANs . . . 116

8 Storage **118**
8.1 Volumes . . . 118
8.1.1 Volume Manager . . . 118
Encryption . . . 120
Encryption Performance . . . 121
Manual Setup . . . 121
Extending a ZFS Volume . . . 122
8.1.2 Change Permissions . . . 123
8.1.3 Create Dataset . . . 125
Deduplication . . . 127
Compression . . . 128
8.1.4 Create zvol . . . 128
8.1.5 Import Disk . . . 130
8.1.6 Import Volume . . . 131
Importing an Encrypted Pool . . . 131
8.1.7 View Disks . . . 132

8.1.8 Volumes . . . 134
Managing Encrypted Volumes . . . 136
Additional Controls for Encrypted Volumes . . . 137
8.1.9 View Multipaths . . . 140
8.1.10 Replacing a Failed Drive . . . 140
Replacing an Encrypted Drive . . . 142
Removing a Log or Cache Device . . . 142
8.1.11 Replacing Drives to Grow a ZFS Pool . . . 142
8.1.12 Hot Spares . . . 143
8.2 Periodic Snapshot Tasks . . . 143
8.3 Replication Tasks . . . 145
8.3.1 Examples: Common Configuration . . . 145
Alpha (Source) . . . 145
Beta (Destination) . . . 146
8.3.2 Example: FreeNAS® to FreeNAS® Semi-Automatic Setup . . . 146
8.3.3 Example: FreeNAS® to FreeNAS® Dedicated User Replication . . . 148
8.3.4 Example: FreeNAS® to FreeNAS® or Other Systems, Manual Setup . . . 149
Encryption Keys . . . 149
8.3.5 Replication Options . . . 152
8.3.6 Replication Encryption . . . 153
8.3.7 Limiting Replication Times . . . 153
8.3.8 Troubleshooting Replication . . . 153
SSH . . . 153
Compression . . . 154
Manual Testing . . . 154
8.4 Resilver Priority . . . 154
8.5 Scrubs . . . 155
8.6 Snapshots . . . 158
8.6.1 Browsing a snapshot collection . . . 160
8.7 VMware-Snapshot . . . 160

9 Directory Services **162**
9.1 Active Directory . . . 162
9.1.1 Troubleshooting Tips . . . 166
9.1.2 If the System Will not Join the Domain . . . 166
9.2 LDAP . . . 167
9.3 NIS . . . 169
9.4 Kerberos Realms . . . 170
9.5 Kerberos Keytabs . . . 171
9.6 Kerberos Settings . . . 172

10 Sharing **173**
10.1 Apple (AFP) Shares . . . 174
10.1.1 Creating AFP Guest Shares . . . 176
10.1.2 Creating Authenticated and Time Machine Shares . . . 177
10.2 Unix (NFS) Shares . . . 181
10.2.1 Example Configuration . . . 185
10.2.2 Connecting to the Share . . . 185
From BSD or Linux . . . 185
From Microsoft . . . 186
From macOS . . . 186
10.2.3 Troubleshooting NFS . . . 187
10.3 WebDAV Shares . . . 188
10.4 Windows (SMB) Shares . . . 189
10.4.1 Configuring Unauthenticated Access . . . 194
10.4.2 Configuring Authenticated Access Without a Domain Controller . . . 195
10.4.3 Configuring Shadow Copies . . . 197

10.5 Block (iSCSI) . . . 199
10.5.1 Target Global Configuration . . . 200
10.5.2 Portals . . . 201
10.5.3 Initiators . . . 203
10.5.4 Authorized Accesses . . . 204
10.5.5 Targets . . . 206
10.5.6 Extents . . . 207
10.5.7 Target/Extents . . . 210
10.5.8 Connecting to iSCSI . . . 211
10.5.9 Growing LUNs . . . 211
Zvol Based LUN . . . 212
File Extent Based LUN . . . 212

11 Services **214**
11.1 Control Services . . . 214
11.2 AFP . . . 216
11.2.1 Troubleshooting AFP . . . 217
11.3 Domain Controller . . . 217
11.3.1 Samba Domain Controller Backup . . . 219
11.4 Dynamic DNS . . . 219
11.5 FTP . . . 220
11.5.1 Anonymous FTP . . . 223
11.5.2 FTP in chroot . . . 224
11.5.3 Encrypting FTP . . . 225
11.5.4 Troubleshooting FTP . . . 225
11.6 iSCSI . . . 225
11.7 LLDP . . . 225
11.8 Netdata . . . 226
11.9 NFS . . . 227
11.10 Rsync . . . 229
11.10.1 Configure Rsyncd . . . 229
11.10.2 Rsync Modules . . . 230
11.11 S3 . . . 231
11.12 S.M.A.R.T. . . . 233
11.13 SMB . . . 234
11.13.1 Troubleshooting SMB . . . 237
11.14 SNMP . . . 238
11.15 SSH . . . 240
11.15.1 SCP Only . . . 241
11.15.2 Troubleshooting SSH . . . 242
11.16 TFTP . . . 242
11.17 UPS . . . 243
11.17.1 Multiple Computers with One UPS . . . 247
11.18 WebDAV . . . 247

12 Plugins **249**
12.1 Installed Plugins . . . 249
12.2 Deleting Plugins . . . 249

13 Jails **251**
13.1 Jails Configuration . . . 251
13.2 Managing Jails . . . 254
13.2.1 Accessing a Jail Using SSH . . . 256
13.2.2 Add Storage . . . 256
13.3 Starting Installed Software . . . 259

14 Virtual Machines **261**
14.1 Creating VMs . . . 261

14.2 Adding Devices to a VM . . . 262
14.2.1 Network Interfaces . . . 263
14.2.2 Disk Devices . . . 264
14.2.3 Raw Files . . . 264
14.2.4 CD-ROM Devices . . . 265
14.2.5 VNC Interface . . . 265
14.2.6 Virtual Serial Ports . . . 266
14.3 Running VMs . . . 267
14.4 Deleting VMs . . . 267
14.5 Docker/Rancher VM . . . 268
14.5.1 Rancher VM Requirements . . . 268
14.5.2 Create the Rancher VM . . . 268
14.5.3 Start the Rancher VM . . . 270
14.5.4 Installing the Rancher Server . . . 271

15 Reporting **272**

16 Wizard **274**

17 Display System Processes **281**

18 Shell **282**

19 Log Out **284**

20 Reboot **285**

21 Shutdown **286**

22 Support Icon **287**

23 Guide **288**

24 Alert **289**

25 Support Resources **291**
25.1 Website and Social Media . . . 291
25.2 Forums . . . 291
25.3 IRC . . . 292
25.4 Videos . . . 292
25.5 Professional Support . . . 293

26 Command Line Utilities **294**
26.1 Iperf . . . 294
26.2 Netperf . . . 297
26.3 IOzone . . . 298
26.4 arcstat . . . 300
26.5 tw_cli . . . 305
26.6 MegaCli . . . 307
26.7 freenas-debug . . . 307
26.8 tmux . . . 308
26.9 Dmidecode . . . 308

27 Contributing to FreeNAS® **310**
27.1 Translation . . . 310

28 ZFS Primer **314**

29 VAAI **318**
29.1 VAAI for iSCSI . . . 318

30 Using the API **319**
30.1 A Simple API Example 320
30.2 A More Complex Example 321

Index **323**

Welcome

This Guide covers the installation and use of FreeNAS® 11.2.

The FreeNAS® User Guide is a work in progress and relies on the contributions of many individuals. If you are interested in helping us to improve the Guide, read the instructions in the README (https://github.com/freenas/freenas-docs/blob/master/README.md). IRC Freenode users are welcome to join the *#freenas* channel where you will find other FreeNAS® users.

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Typographic Conventions

Typographic Conventions

The FreeNAS® 11.2 User Guide uses these typographic conventions:

Table 1: Text Format Examples

Item	Visual Example
Graphical elements: buttons, icons, fields, columns, and boxes	Click the *Import CA* button.
Menu selections	Select `System` → `Information`.
Commands	Use the `scp` command.
File names and volume and dataset names	Locate the `/etc/rc.conf` file.
Keyboard keys	Press the `Enter` key.
Important points	**This is important.**
Values entered into fields, or device names	Enter *127.0.0.1* in the address field.

CHAPTER

ONE

INTRODUCTION

FreeNAS® is an embedded open source network-attached storage (NAS) operating system based on FreeBSD and released under a 2-clause BSD license (https://opensource.org/licenses/BSD-2-Clause). A NAS has an operating system optimized for file storage and sharing.

FreeNAS® provides a browser-based, graphical configuration interface. The built-in networking protocols provide storage access to multiple operating systems. A plugin system is provided for extending the built-in features by installing additional software.

1.1 New Features in 11.2

FreeNAS® 11.2 is a feature release, which includes several new significant features, many improvements and bug fixes to existing features, and version updates to the operating system, base applications, and drivers. Users are encouraged to *Update* (page 71) to this release in order to take advantage of these improvements and bug fixes.

These major features are new in this version:

- The login screen defaults to the new, Angular-based UI. Users who wish to continue to use the classic UI can select "Legacy UI" in the login screen.
- Beginning with this release, the screenshots that appear in the published version of the Guide (http://doc.freenas.org/11.2/freenas.html) and in the *Guide* icon within the new UI are for the new UI. However, users who click on the *Guide* icon while logged into the classic UI will continue to see screenshots for the old UI. The availability of both versions of the Guide is to assist users as they become familiar with the new UI during the transition period before the classic UI is deprecated in a future release.
- The rewrite from the old API to the new middlewared continues. Once the rewrite is complete, api.freenas.org (http://api.freenas.org/) will be deprecated and replaced by the new API documentation. In the mean time, to see the API documentation for the new middleware, log into the new UI, click on the URL for the FreeNAS system in your browser's location bar, and add /guilabel::*api/docs* to the end of that URL.
- The boot loader has changed from GRUB to the native FreeBSD boot loader. This should resolve several issues that some users experienced with GRUB. GRUB was introduced as a temporary solution until the FreeBSD boot loader had full support for boot environments, which it now has.
- The *Plugins* (page 249) and *Jails* (page 251) backend has switched from `warden` to `iocage` and `warden` will no longer receive bug fixes. The new UI will automatically use `iocage` to create and manage *Plugins* (page 249) and *Jails* (page 251). Users are encouraged to recreate any existing *Plugins* (page 249) and *Jails* (page 251) using the new UI to ensure that they are running the latest supported application versions.
- *Plugins* (page 249) have switched to FreeBSD 11.2-RELEASE and all Plugins have been rebuilt for this version.
- *Virtual Machines* (page 261) are more crash-resistant. When a guest is started, the amount of available memory is checked and an initialization error will occur if there is insufficient system resources. When a guest is stopped, its resources are returned to the system. In addition, the UEFI boot menu fix allows Linux kernels 4.15 and higher to boot properly.

- *Cloud Sync* (page 87) provides configuration options to encrypt data before it is transmitted and to keep it in the encrypted format while stored on the cloud. The filenames can also be encrypted.
- Preliminary support has been added for *Self-Encrypting Drives* (page 66) (SEDs).

This software has been added or updated:

- The base operating system has been updated to FreeBSD 11.2 (https://www.freebsd.org/releases/11.2R/announce.html), which brings in many updated drivers and bug fixes.
- OpenZFS is up-to-date with Illumos and slightly ahead due to support for sorted scrubs which were ported from ZFS on Linux. Notable improvements include channel programs, data disk removal, more resilient volume import, the ability to import a pool with missing vdevs, pool checkpoints, improved compressed ARC performance, and ZIL batching. Note that many of these improvements need further testing so have not yet been integrated into the UI.
- The IPsec kernel module has been added. It can be manually loaded with `kldload ipsec`.
- The vt terminal (https://www.freebsd.org/cgi/man.cgi?query=vt&sektion=4&manpath=FreeBSD+11.2-RELEASE+and+Ports) is now used by default and the syscons terminal is removed from the kernel.
- ncdu (https://dev.yorhel.nl/ncdu) has been added to the base system. This CLI utility can be used to analyze disk usage from the console or an SSH session.
- Netatalk has been updated to the 3.1.12 development version which addresses known issues with Time Machine timeouts.
- rsync has been updated to version 3.1.3 (https://download.samba.org/pub/rsync/src/rsync-3.1.3-NEWS).
- Minio has been updated to version 2018-04-04T05 (https://github.com/minio/minio/releases/tag/RELEASE.2018-04-04T05-20-54Z).
- Netdata as been updated to version 1.10.1 (https://github.com/firehol/netdata/releases/tag/v1.10.0).
- iocage has been synced with upstream as of July 10, providing many bug fixes and improved IPv6 support.
- zsh (http://www.zsh.org/) is the root shell for new installations. Upgrades will continue to use the `csh` shell as the default root shell.
- xattr (https://github.com/xattr/xattr) has been added to the base system and can be used to modify file extended attributes from the command line. Type `xattr -h` to view the available options.
- convmv (https://www.j3e.de/linux/convmv/man/) has been added to the base system and can be used to convert the encoding of filenames from the command line. Type `convmv` to view the available options.
- These switches have been added to *freenas-debug* (page 307): `-M` for dumping SATADOM info and `-Z` to delete old debug information. The `-G` switch has been removed as the system no longer uses GRUB.

These screen options have changed:

- The *ATA Security User*, *SED Password*, and *Reset SED Password* fields have been added to `System → Advanced`.
- The *Enable screen saver* field has been removed from `System → Advanced`.
- *Alerts* has been added to *System* and can be used to list the available alert conditions and to configure the notification frequency on a per-alert basis.
- These *Cloud Credentials* (page 75) have been added to `System → Cloud Credentials`: Amazon Cloud Drive, Box, Dropbox, FTP, Google Drive, HTTP, Hubic, Mega, Microsoft OneDrive, pCloud, SFTP, WebDAV, and Yandex.
- The *Remote encryption*, *Filename encryption*, *Encryption password*, and *Encryption salt* fields have been added to `Tasks → Cloud Sync Tasks → Add Cloud Sync`.
- The *Exec* field has been added to `Storage → Volumes → Create Dataset → Advanced Mode`.
- The *Password for SED* column has been added to `Storage → Volumes → View Disks`.
- The *MSDOSFS locale* drop-down menu has been added to `Storage → Import Disk`.

- The *Enable home directories*, *Home directories*, *Home share name*, and *Home Share Time Machine* fields have been removed from `Services → AFP` and the *Time Machine Quota* field has been removed from `Sharing → Apple (AFP) Shares`. These fields have been replaced by `Sharing → Apple (AFP) Shares → Use as home share`.
- The *Umask* field in `Services → TFTP` has changed to a *File Permissions* selector.
- Disk temperature graphs have been added to `Reporting → Disk`.

1.2 Path and Name Lengths

Names of files, directories, and devices are subject to some limits imposed by the FreeBSD operating system. The limits shown here are for names using plain-text characters that each occupy one byte of space. Some UTF-8 characters take more than a single byte of space, and using those characters reduces these limits proportionally. System overhead can also reduce the length of these limits by one or more bytes.

Table 1.1: Path and Name Lengths

Type	Maximum Length	Description
File Paths	1024 bytes	Total file path length (*PATH_MAX*). The full path includes directory separator slash characters, subdirectory names, and the name of the file itself. For example, the path `/mnt/tank/mydataset/mydirectory/myfile.txt` is 42 bytes long. Using very long file or directory names can be problematic. A complete path with long directory and file names can exceed the 1024-byte limit, preventing direct access to that file until the directory names or filename are shortened or the file is moved into a directory with a shorter total path length.
File and Directory Names	255 bytes	Individual directory or file name length (*NAME_MAX*).
Mounted Filesystem Paths	88 bytes	Mounted filesystem path length (*MNAMELEN*). Longer paths can prevent a device from being mounted or data from being accessible.
Device Filesystem Paths	63 bytes	devfs(8) (https://www.freebsd.org/cgi/man.cgi?query=devfs&sektion=8) device path lengths (*SPECNAMELEN*). Longer paths can prevent a device from being created.

Note: 88 bytes is equal to 88 ASCII characters. The number of characters will vary when using Unicode.

Warning: If the mounted path length for a snapshot exceeds 88 bytes the data in the snapshot will be safe but inaccessible. When the mounted path length of the snapshot is less than the 88 byte limit, the data will be accessible again.

The 88 byte limit affects automatic and manual snapshot mounts in slightly different ways:

- **Automatic mount:** ZFS temporarily mounts a snapshot whenever a user attempts to view or search the files within the snapshot. The mountpoint used will be in the hidden directory `.zfs/snapshot/name` within the same ZFS dataset. For example, the snapshot `mypool/dataset/snap1@snap2` is mounted at `/mnt/mypool/dataset/.zfs/snapshot/snap2/`. If the length of this path exceeds 88 bytes the snapshot will not be automatically mounted by ZFS and the snapshot contents will not be visible or searchable. This can be resolved by renaming the ZFS pool or dataset containing the snapshot to shorter names (`mypool` or `dataset`), or by shortening the second part of the snapshot name (`snap2`), so that the total mounted path length does not exceed 88 bytes. ZFS will automatically perform any necessary unmount or remount of the file system as part of the rename operation. After renaming, the snapshot data will be visible and searchable again.

- **Manual mount:** If the same example snapshot is mounted manually from the `CLI`, using `mount -t zfs mypool/dataset/snap1@snap2 /mnt/mymountpoint` the path `/mnt/mountpoint/` must not exceed 88 bytes, but the length of the snapshot name will be *irrelevant*. When renaming a manual mountpoint, any object mounted on the mountpoint must be manually unmounted (using the `umount` command in the `CLI`) before renaming the mountpoint and can be remounted afterwards.

Note: A snapshot that cannot be mounted automatically by ZFS, can still be mounted manually from the `CLI` using a shorter mountpoint path. This makes it possible to mount and access snapshots that cannot be accessed automatically in other ways, such as from the GUI or from features such as "File History" or "Versions".

1.3 Hardware Recommendations

FreeNAS® 11.2 is based on FreeBSD 11.2 and supports the same hardware found in the FreeBSD Hardware Compatibility List (https://www.freebsd.org/releases/11.2R/hardware.html). Supported processors are listed in section 2.1 amd64 (https://www.freebsd.org/releases/11.2R/hardware.html#proc). FreeNAS® is only available for 64-bit processors. This architecture is called *amd64* by AMD and *Intel 64* by Intel.

Note: FreeNAS® boots from a GPT partition. This means that the system BIOS must be able to boot using either the legacy BIOS firmware interface or EFI.

Actual hardware requirements vary depending on the usage of the FreeNAS® system. This section provides some starter guidelines. The FreeNAS® Hardware Forum (https://forums.freenas.org/index.php?forums/hardware.18/) has performance tips from FreeNAS® users and is a place to post questions regarding the hardware best suited to meet specific requirements. Hardware Recommendations (https://forums.freenas.org/index.php?resources/hardware-recommendations-guide.12/) gives detailed recommendations for system components, with the FreeNAS® Quick Hardware Guide (https://forums.freenas.org/index.php?resources/freenas%C2%AE-quick-hardware-guide.7/) providing short lists of components for various configurations. Building, Burn-In, and Testing your FreeNAS® system (https://forums.freenas.org/index.php?threads/building-burn-in-and-testing-your-freenas-system.17750/) has detailed instructions on testing new hardware.

1.3.1 RAM

The best way to get the most out of a FreeNAS® system is to install as much RAM as possible. More RAM allows ZFS to provide better performance. The FreeNAS® Forums (https://forums.freenas.org/index.php) provide anecdotal evidence from users on how much performance can be gained by adding more RAM.

General guidelines for RAM:

- **A minimum of 8 GB of RAM is required.**

  Additional features require additional RAM, and large amounts of storage require more RAM for cache. An old, somewhat overstated guideline is 1 GB of RAM per terabyte of disk capacity.

- To use Active Directory with many users, add an additional 2 GB of RAM for the winbind internal cache.
- For iSCSI, install at least 16 GB of RAM if performance is not critical, or at least 32 GB of RAM if good performance is a requirement.
- *Jails* (page 251) are very memory-efficient, but can still use memory that would otherwise be available for ZFS. If the system will be running many jails, or a few resource-intensive jails, adding 1 to 4 additional gigabytes of RAM can be helpful. This memory is shared by the host and will be used for ZFS when not being used by jails.
- *Virtual Machines* (page 261) require additional RAM beyond any amounts listed here. Memory used by virtual machines is not available to the host while the VM is running, and is not included in the amounts described above. For example, a system that will be running two VMs that each need 1 GB of RAM requires an additional 2 GB of RAM.

- When installing FreeNAS® on a headless system, disable the shared memory settings for the video card in the BIOS.
- For ZFS deduplication, ensure the system has at least 5 GB of RAM per terabyte of storage to be deduplicated.

If the hardware supports it, install ECC RAM. While more expensive, ECC RAM is highly recommended as it prevents in-flight corruption of data before the error-correcting properties of ZFS come into play, thus providing consistency for the checksumming and parity calculations performed by ZFS. If your data is important, use ECC RAM. This Case Study (http://research.cs.wisc.edu/adsl/Publications/zfs-corruption-fast10.pdf) describes the risks associated with memory corruption.

Do not use FreeNAS® to store data without at least 8 GB of RAM. Many users expect FreeNAS® to function with less memory, just at reduced performance. The bottom line is that these minimums are based on feedback from many users. Requests for help in the forums or IRC are sometimes ignored when the installed system does not have at least 8 GB of RAM because of the abundance of information that FreeNAS® may not behave properly with less memory.

1.3.2 The Operating System Device

The FreeNAS® operating system is installed to at least one device that is separate from the storage disks. The device can be a SSD, USB memory stick, or DOM (Disk on Module). Installation to a hard drive is discouraged as that drive is then not available for data storage.

Note: To write the installation file to a USB stick, **two** USB ports are needed, each with an inserted USB device. One USB stick contains the installer, while the other USB stick is the destination for the FreeNAS® installation. Be careful to select the correct USB device for the FreeNAS® installation. FreeNAS® cannot be installed onto the same device that contains the installer. After installation, remove the installer USB stick. It might also be necessary to adjust the BIOS configuration to boot from the new FreeNAS® boot device.

When determining the type and size of the target device where FreeNAS® is to be installed, keep these points in mind:

- The absolute *bare minimum* size is 8 GB. That does not provide much room. The *recommended* minimum is 16 GB. This provides room for the operating system and several boot environments created by updates. More space provides room for more boot environments and 32 GB or more is preferred.
- SSDs (Solid State Disks) are fast and reliable, and make very good FreeNAS® operating system devices. Their one disadvantage is that they require a disk connection which might be needed for storage disks.

  Even a relatively large SSD (120 or 128 GB) is useful as a boot device. While it might appear that the unused space is wasted, that space is instead used internally by the SSD for wear leveling. This makes the SSD last longer and provides greater reliability.
- When planning to add your own boot environments, budget about 1 GB of storage per boot environment. Consider deleting older boot environments after making sure they are no longer needed. Boot environments can be created and deleted using `System → Boot`.
- Use quality, name-brand USB sticks, as ZFS will quickly reveal errors on cheap, poorly-made sticks.
- For a more reliable boot disk, use two identical devices and select them both during the installation. This will create a mirrored boot device.

Note: Current versions of FreeNAS® run directly from the operating system device. Early versions of FreeNAS® ran from RAM, but that has not been the case for years.

1.3.3 Storage Disks and Controllers

The Disk section (https://www.freebsd.org/releases/11.2R/hardware.html#disk) of the FreeBSD Hardware List lists the supported disk controllers. In addition, support for 3ware 6 Gbps RAID controllers has been added along with the CLI utility `tw_cli` for managing 3ware RAID controllers.

FreeNAS® supports hot pluggable drives. Using this feature requires enabling AHCI in the BIOS.

Reliable disk alerting and immediate reporting of a failed drive can be obtained by using an HBA such as an Broadcom MegaRAID controller or a 3Ware twa-compatible controller.

Note: Upgrading the firmware of Broadcom SAS HBAs to the latest version is recommended.

Some Highpoint RAID controllers do not support pass-through of S.M.A.R.T. data or other disk information, potentially including disk serial numbers. It is best to use a different disk controller with FreeNAS®.

Note: The system is configured to prefer the mrsas(4) (https://www.freebsd.org/cgi/man.cgi?query=mrsas) driver for controller cards like the Dell PERC H330 and H730 which are supported by several drivers. Although not recommended, the mfi(4) (https://www.freebsd.org/cgi/man.cgi?query=mfi) driver can be used instead by removing the loader *Tunable* (page 69): `hw.mfi.mrsas_enable` or setting the *Value* to *0*.

Suggestions for testing disks before adding them to a RAID array can be found in this forum post (https://forums.freenas.org/index.php?threads/checking-new-hdds-in-raid.12082/#post-55936). Additionally, badblocks (https://linux.die.net/man/8/badblocks) is installed with FreeNAS® for testing disks.

If the budget allows optimization of the disk subsystem, consider the read/write needs and RAID requirements:

- For steady, non-contiguous writes, use disks with low seek times. Examples are 10K or 15K SAS drives which cost about $1/GB. An example configuration would be six 600 GB 15K SAS drives in a RAID 10 which would yield 1.8 TB of usable space, or eight 600 GB 15K SAS drives in a RAID 10 which would yield 2.4 TB of usable space.

For ZFS, Disk Space Requirements for ZFS Storage Pools (https://docs.oracle.com/cd/E19253-01/819-5461/6n7ht6r12/index.html) recommends a minimum of 16 GB of disk space. Due to the way that ZFS creates swap, **it is not possible to format less than 3 GB of space with ZFS**. However, on a drive that is below the minimum recommended size, a fair amount of storage space is lost to swap: for example, on a 4 GB drive, 2 GB will be reserved for swap.

Users new to ZFS who are purchasing hardware should read through ZFS Storage Pools Recommendations (https://web.archive.org/web/20161028084224/http://www.solarisinternals.com/wiki/index.php/ZFS_Best_Practices_Guide#ZFS_Sto first.

ZFS *vdevs*, groups of disks that act like a single device, can be created using disks of different sizes. However, the capacity available on each disk is limited to the same capacity as the smallest disk in the group. For example, a vdev with one 2 TB and two 4 TB disks will only be able to use 2 TB of space on each disk. In general, use disks that are the same size for the best space usage and performance.

The ZFS Drive Size and Cost Comparison spreadsheet (https://forums.freenas.org/index.php?threads/zfs-drive-size-and-cost-comparison-spreadsheet.38092/) is available to compare usable space provided by different quantities and sizes of disks.

1.3.4 Network Interfaces

The Ethernet section (https://www.freebsd.org/releases/11.2R/hardware.html#ethernet) of the FreeBSD Hardware Notes indicates which interfaces are supported by each driver. While many interfaces are supported, FreeNAS® users have seen the best performance from Intel and Chelsio interfaces, so consider these brands when purchasing a new NIC. Realtek cards often perform poorly under CPU load as interfaces with these chipsets do not provide their own processors.

At a minimum, a GigE interface is recommended. While GigE interfaces and switches are affordable for home use, modern disks can easily saturate their 110 MB/s throughput. For higher network throughput, multiple GigE cards can be bonded together using the LACP type of *Link Aggregations* (page 111). The Ethernet switch must support LACP, which means a more expensive managed switch is required.

When network performance is a requirement and there is some money to spend, use 10 GigE interfaces and a managed switch. Managed switches with support for LACP and jumbo frames are preferred, as both can be used to increase net-

work throughput. Refer to the 10 Gig Networking Primer (https://forums.freenas.org/index.php?threads/10-gig-networking-primer.25749/) for more information.

Note: At present, these are not supported: InfiniBand, FibreChannel over Ethernet, or wireless interfaces.

Both hardware and the type of shares can affect network performance. On the same hardware, SMB is slower than FTP or NFS because Samba is single-threaded (https://www.samba.org/samba/docs/old/Samba3-Developers-Guide/architecture.html). So a fast CPU can help with SMB performance.

Wake on LAN (WOL) support depends on the FreeBSD driver for the interface. If the driver supports WOL, it can be enabled using ifconfig(8) (https://www.freebsd.org/cgi/man.cgi?query=ifconfig). To determine if WOL is supported on a particular interface, use the interface name with the following command. In this example, the capabilities line indicates that WOL is supported for the *re0* interface:

```
ifconfig -m re0
re0: flags=8943<UP,BROADCAST,RUNNING,PROMISC,SIMPLEX,MULTICAST> metric 0 mtu 1500
        options=42098<VLAN_MTU,VLAN_HWTAGGING,VLAN_HWCSUM,WOL_MAGIC,VLAN_HWTSO>
        capabilities=5399b<RXCSUM,TXCSUM,VLAN_MTU,VLAN_HWTAGGING,VLAN_HWCSUM,TSO4,WOL_UCAST,WOL_MCAST,␣
↪WOL_MAGIC,VLAN_HWFILTER,VLAN_H WTSO>
```

If WOL support is shown but not working for a particular interface, create a bug report using the instructions in *Support* (page 84).

1.4 Getting Started with ZFS

Readers new to ZFS should take a moment to read the *ZFS Primer* (page 314).

CHAPTER

TWO

INSTALLING AND UPGRADING

The FreeNAS® operating system must be installed on a separate device from the drives which hold the storage data. In other words, with only one disk drive, the FreeNAS® graphical interface is available, but there is no place to store any data. And storing data is, after all, the whole point of a NAS system. Home users experimenting with FreeNAS® can install FreeNAS® on an inexpensive USB thumb drive and use the computer disks for storage.

This section describes:

- *Getting FreeNAS®* (page 10)
- *Preparing the Media* (page 10)
- *Performing the Installation* (page 12)
- *Installation Troubleshooting* (page 20)
- *Upgrading* (page 21)
- *Virtualization* (page 28)

2.1 Getting FreeNAS®

The latest STABLE version of FreeNAS® 11.2 can be downloaded from https://download.freenas.org/latest/.

Note: FreeNAS® requires 64-bit hardware.

The download page contains an *.iso* file. This is a bootable installer that can be written to either a CD or USB flash as described in *Preparing the Media* (page 10).

The *.iso* file has an associated `sha256.txt` file which is used to verify the integrity of the downloaded file. The command to verify the checksum varies by operating system:

- on a BSD system use the command `sha256 name_of_file`
- on a Linux system use the command `sha256sum name_of_file`
- on a Mac system use the command `shasum -a 256 name_of_file`
- Windows or Mac users can install additional utilities like HashCalc (http://www.slavasoft.com/hashcalc/) or HashTab (http://implbits.com/products/hashtab/)

The value produced by running the command must match the value shown in the `sha256.txt` file. Checksum values that do not match indicate a corrupted installer file that should not be used.

2.2 Preparing the Media

The FreeNAS® installer can run from either a CD or a USB memory stick.

A CD burning utility is needed to write the `.iso` file to a CD.

The `.iso` file can also be written to a USB memory stick. The method used to write the file depends on the operating system. Examples for several common operating systems are shown below.

Note: To install from a USB stick to another USB stick, **two** USB ports are needed, each with an inserted USB device. One USB stick contains the installer. The other USB stick is the destination for the FreeNAS® installation. Take care to select the correct USB device for the FreeNAS® installation. It is **not** possible to install FreeNAS® onto the same USB stick containing the installer. After installation, remove the installer USB stick. It might also be necessary to adjust the BIOS configuration to boot from the new FreeNAS® USB stick.

Ensure the boot device order in the BIOS is set to boot from the device containing the FreeNAS® installer media, then boot the system to start the installation.

2.2.1 On FreeBSD or Linux

On a FreeBSD or Linux system, the `dd` command is used to write the `.iso` file to an inserted USB thumb drive.

Warning: The `dd` command is very powerful and can destroy any existing data on the specified device. Make **absolutely sure** of the device name to write to and do not mistype the device name when using `dd`! The use of this command can be avoided by writing the `.iso` file to a CD instead.

This example demonstrates writing the image to the first USB device connected to a FreeBSD system. This first device usually reports as */dev/da0*. Replace `FreeNAS-RELEASE.iso` with the filename of the downloaded FreeNAS® ISO file. Replace `/dev/da0` with the device name of the device to write.

```
dd if=FreeNAS-RELEASE.iso of=/dev/da0 bs=64k
6117+0 records in
6117+0 records out
400883712 bytes transferred in 88.706398 secs (4519220 bytes/sec)
```

When using the `dd` command:

- **if=** refers to the input file, or the name of the file to write to the device.
- **of=** refers to the output file; in this case, the device name of the flash card or removable USB drive. Note that USB device numbers are dynamic, and the target device might be *da1* or *da2* or another name depending on which devices are attached. Before attaching the target USB drive, use `ls /dev/da*`. Then attach the target USB drive, wait ten seconds, and run `ls /dev/da*` again to see the new device name and number of the target USB drive. On Linux, use `/dev/sdX`, where *X* refers to the letter of the USB device.
- **bs=** refers to the block size, the amount of data to write at a time. The larger 64K block size shown here helps speed up writes to the USB drive.

2.2.2 On Windows

Microsoft provides the USB/DVD Download Tool to create a USB bootable image from an `.iso` file. Follow these instructions (https://www.microsoft.com/en-us/download/windows-usb-dvd-download-tool), but enter the name of the downloaded `.iso` into the *SOURCE FILE* box.

Image Writer (https://launchpad.net/win32-image-writer/) and Rufus (http://rufus.akeo.ie/) are alternate programs for writing images to USB sticks on a computer running Windows. When using Rufus, check *Create a bootable disk using* and select *DD Image* from the drop-down menu.

2.2.3 macOS

Insert the USB thumb drive. In the Finder, go to `Applications` → `Utilities` → `Disk Utility`. Unmount any mounted partitions on the USB thumb drive. Check that the USB thumb drive has only one partition, or partition table errors will be shown on boot. If needed, use Disk Utility to set up one partition on the USB drive. Selecting *Free space* when creating the partition works fine.

Determine the device name of the inserted USB thumb drive. From TERMINAL, navigate to the Desktop, then type this command:

```
diskutil list
/dev/disk0

#:     TYPE NAME               SIZE            IDENTIFIER
0:     GUID_partition_scheme   *500.1 GB       disk0
1:     EFI                     209.7 MB        disk0s1
2:     Apple_HFS Macintosh HD  499.2 GB        disk0s2
3:     Apple_Boot Recovery HD  650.0 MB        disk0s3

/dev/disk1
#:     TYPE NAME               SIZE            IDENTIFIER
0:     FDisk_partition_scheme  *8.0 GB         disk1
1:     DOS_FAT_32 UNTITLED     8.0 GB          disk1s1
```

This shows which devices are available to the system. Locate the target USB stick and record the path. To determine the correct path for the USB stick, remove the device, run the command again, and compare the difference. Once sure of the device name, navigate to the Desktop from TERMINAL, unmount the USB stick, and use the `dd` command to write the image to the USB stick. In this example, the USB thumb drive is `/dev/disk1`. It is first unmounted. The `dd` command is used to write the image to the faster "raw" version of the device (note the extra `r` in `/dev/rdisk1`).

When running these commands, replace `FreeNAS-RELEASE.iso` with the name of the FreeNAS® ISO. Replace `/dev/rdisk1` with the correct path to the USB thumb drive:

```
diskutil unmountDisk /dev/disk1
Unmount of all volumes on disk1 was successful

dd if=FreeNAS-RELEASE.iso of=/dev/rdisk1 bs=64k
```

Note: If the error "Resource busy" is shown when the `dd` command is run, go to `Applications` → `Utilities` → `Disk Utility`, find the USB thumb drive, and click on its partitions to make sure all of them are unmounted. If a "Permission denied" is shown, use `sudo` for elevated rights: `sudo dd if=FreeNAS-RELEASE.iso of=/dev/rdisk1 bs=64k`. This will prompt for the password.

The `dd` command can take some minutes to complete. Wait until the prompt returns and a message is displayed with information about how long it took to write the image to the USB drive.

2.3 Performing the Installation

With the installation media inserted, boot the system from that media.

The FreeNAS® installer boot menu is displayed as is shown in Figure 2.1.

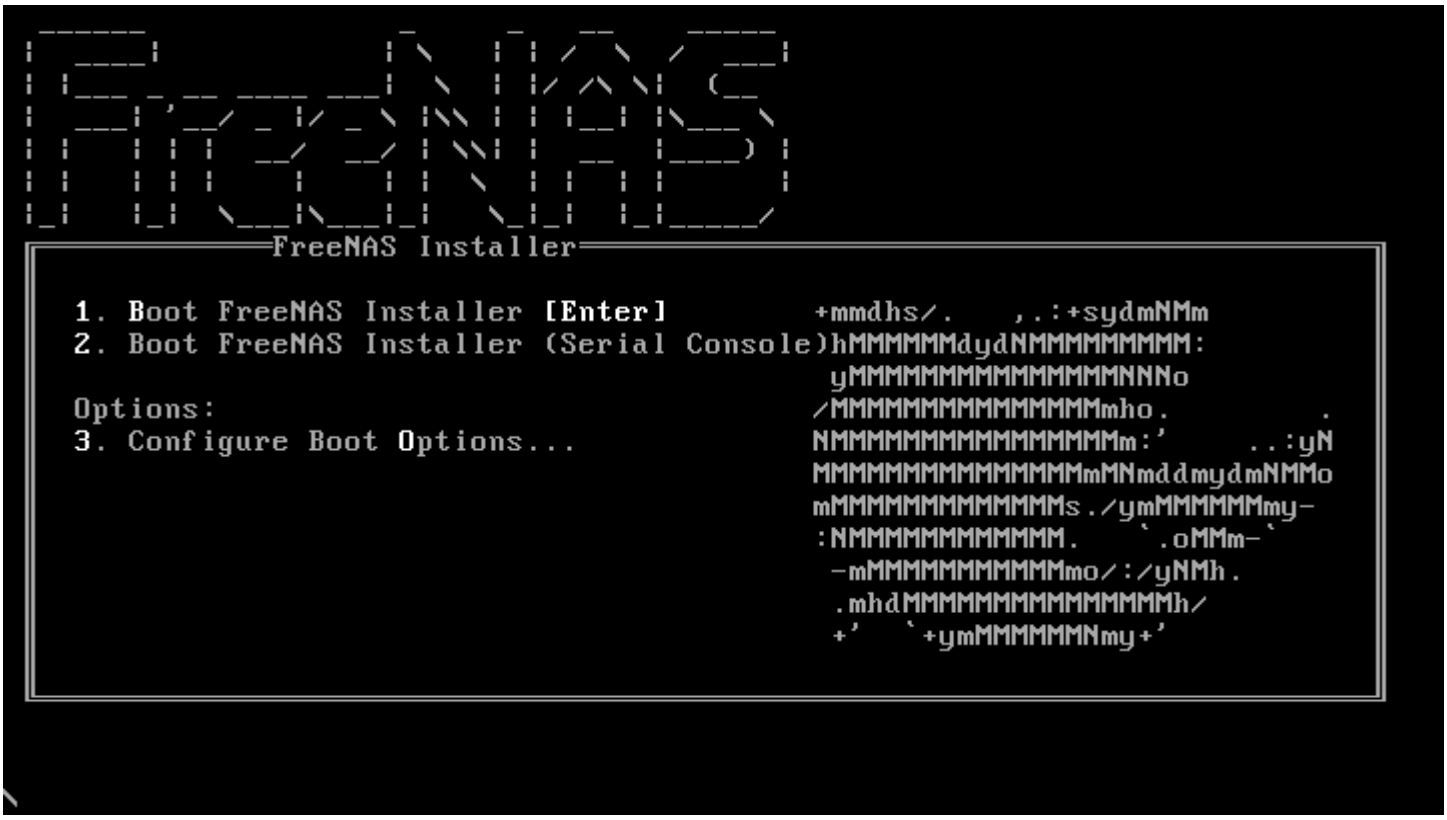


Fig. 2.1: Installer Boot Menu

The FreeNAS® installer automatically boots into the default option after ten seconds. If needed, choose another boot option by pressing the `Spacebar` to stop the timer and then enter the number of the desired option.

Tip: The *Serial Console* option is useful on systems which do not have a keyboard or monitor, but are accessed through a serial port, *Serial over LAN*, or *IPMI* (page 109).

Note: If the installer does not boot, verify that the installation device is listed first in the boot order in the BIOS. When booting from a CD, some motherboards may require connecting the CD device to SATA0 (the first connector) to boot from CD. If the installer stalls during bootup, double-check the SHA256 hash of the `.iso` file. If the hash does not match, re-download the file. If the hash is correct, burn the CD again at a lower speed or write the file to a different USB stick.

Once the installer has finished booting, the installer menu is displayed as shown in Figure 2.2.

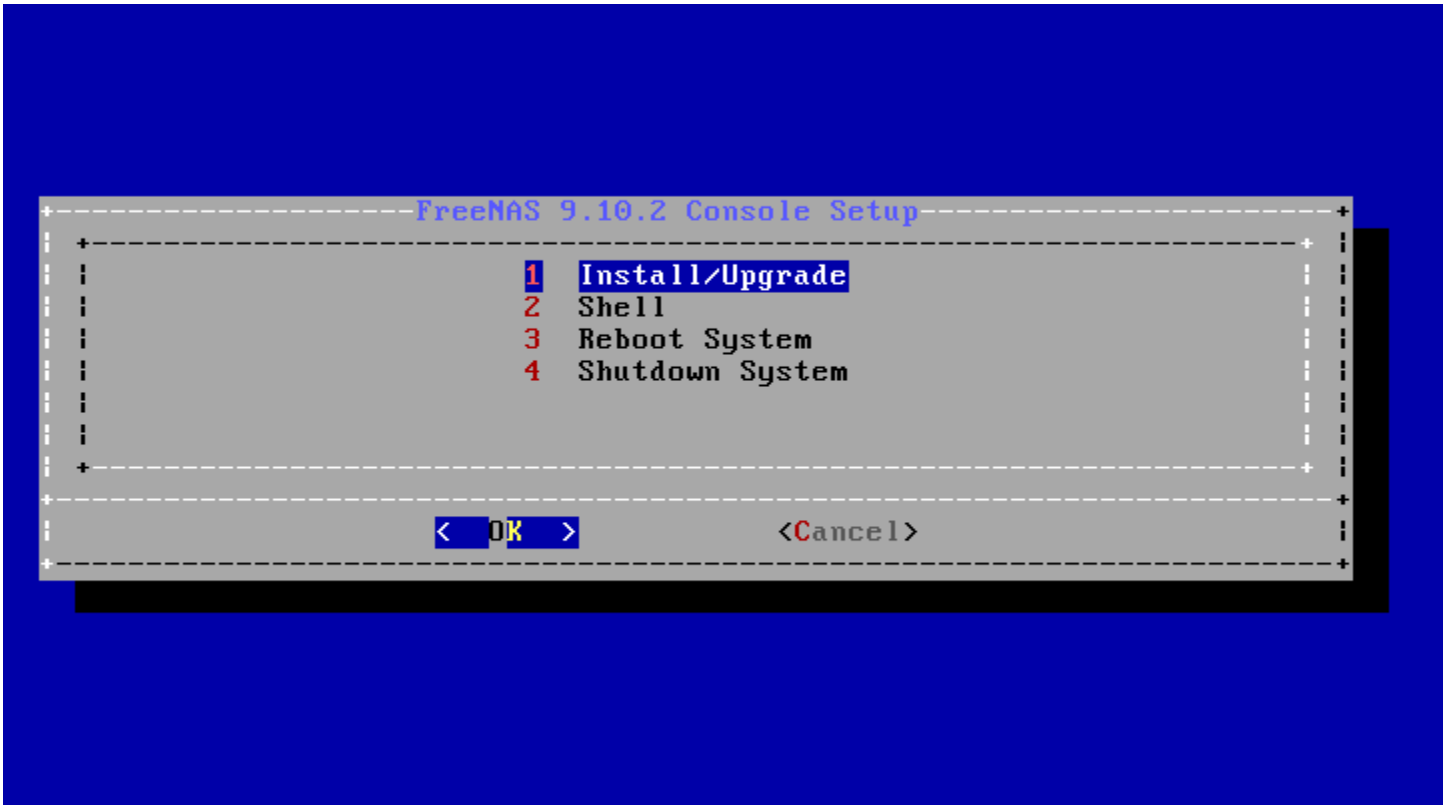


Fig. 2.2: Installer Menu

Press `Enter` to select the default option, *1 Install/Upgrade*. The next menu, shown in Figure 2.3, lists all available drives. This includes any inserted USB thumb drives, which have names beginning with *da*.

Note: A minimum of 8 GB of RAM is required and the installer will present a warning message if less than 8 GB is detected.

In this example, the user is performing a test installation using VirtualBox and has created a 16 GB virtual disk to hold the operating system.

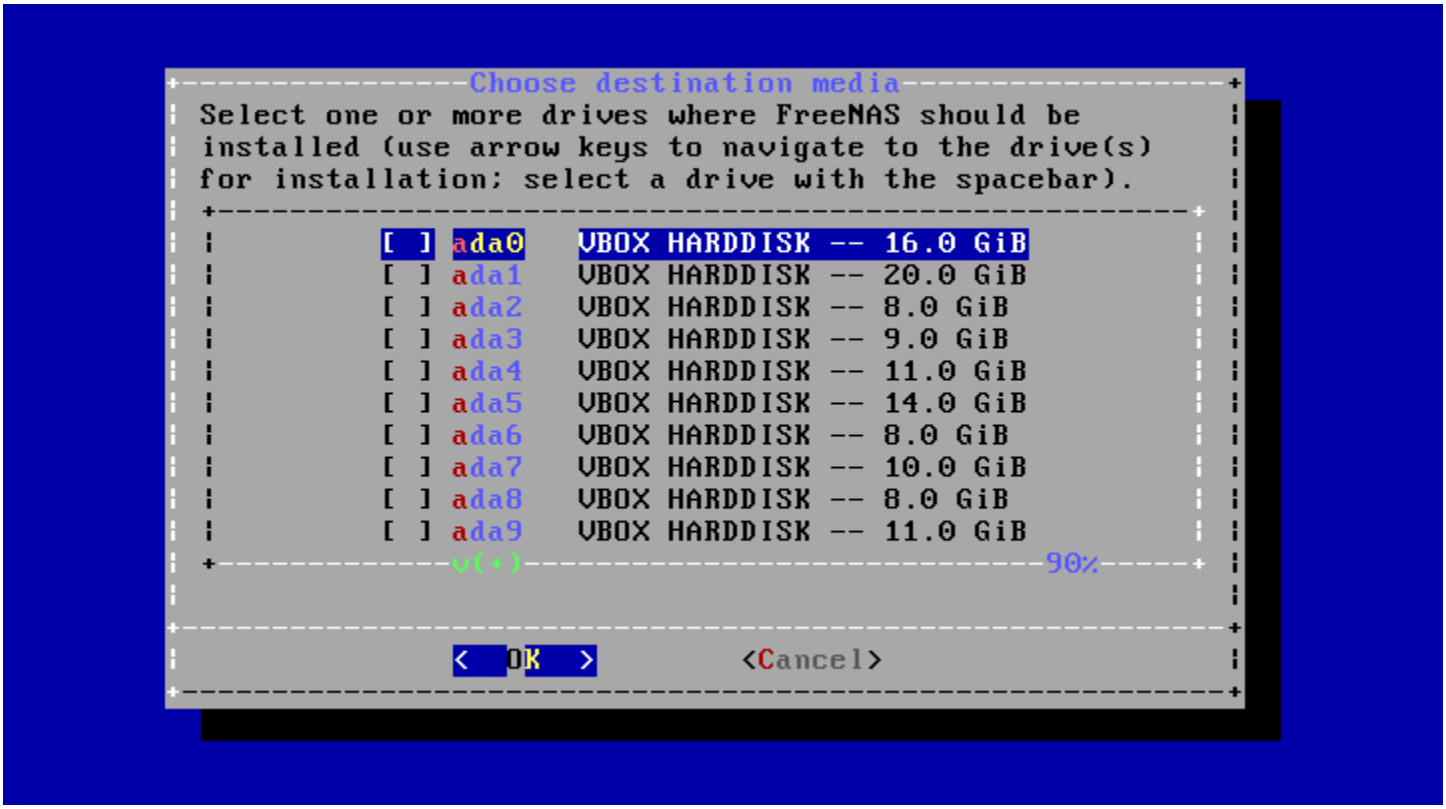


Fig. 2.3: Selecting the Install Drive

Use the arrow keys to highlight the destination USB drive, SSD, DOM (Disk on Module), or virtual disk. Press the `spacebar` to select it. To mirror the boot device, move to the second device and press `spacebar` to select it also. After making these selections, press `Enter`. The warning shown in Figure 2.4 is displayed, a reminder not to install the operating system on a drive that is meant for storage. Press `Enter` to continue on to the screen shown in Figure 2.6.

Fig. 2.4: Installation Warning

Note: A minimum of 8 GB of space on the boot device is required. However, 32 GB is recommended to provide room for future additions and boot environments. When using mirrored boot devices, it is best to use devices of the same size. If the device sizes are different, the mirror is limited to the size of the smaller device.

The installer recognizes existing installations of previous versions of FreeNAS®. When an existing installation is present, the menu shown in Figure 2.5 is displayed. To overwrite an existing installation, use the arrows to move to *Fresh Install* and press `Enter` twice to continue to the screen shown in Figure 2.6.

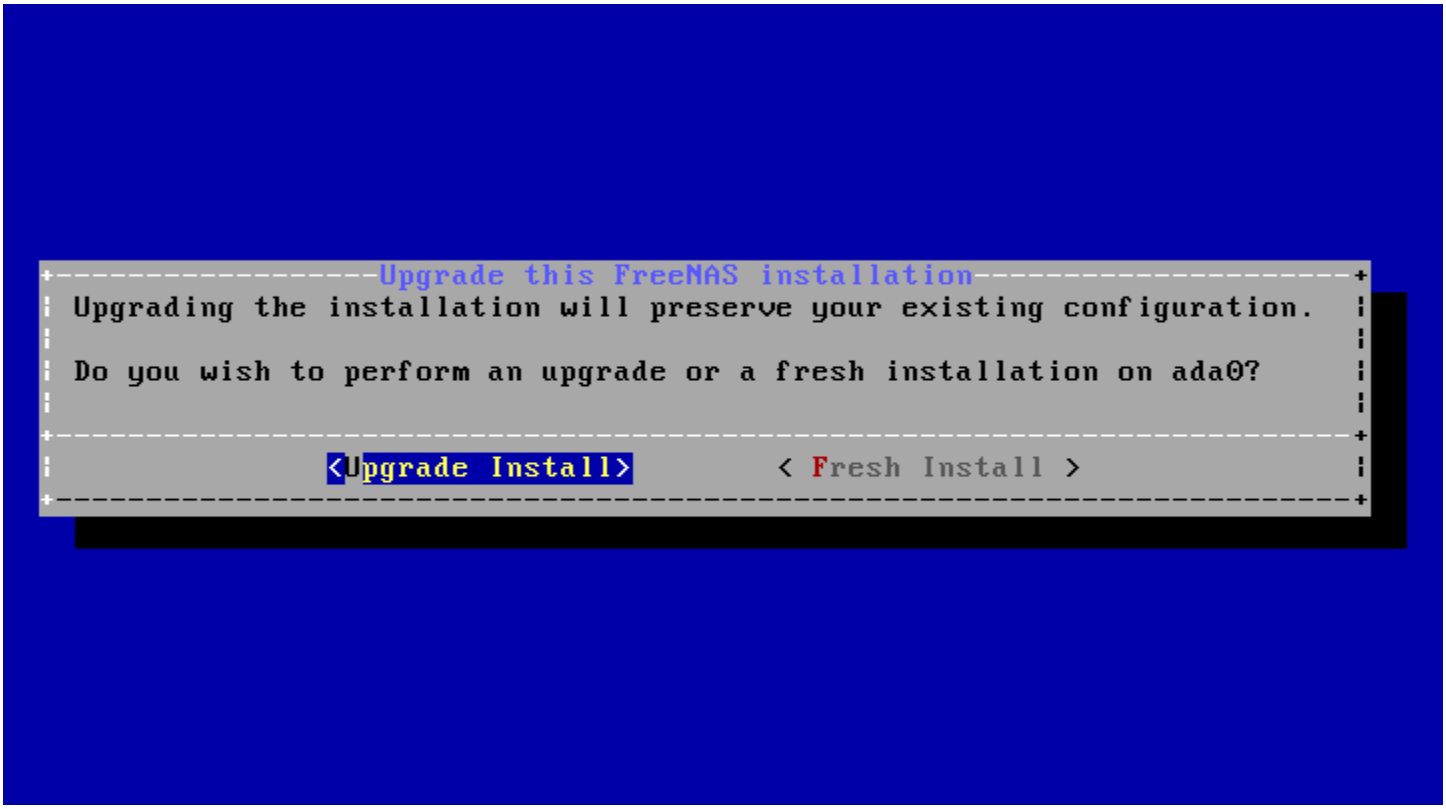


Fig. 2.5: Performing a Fresh Install

The screen shown in Figure 2.6 prompts for the *root* password which is used to log in to the administrative graphical interface.

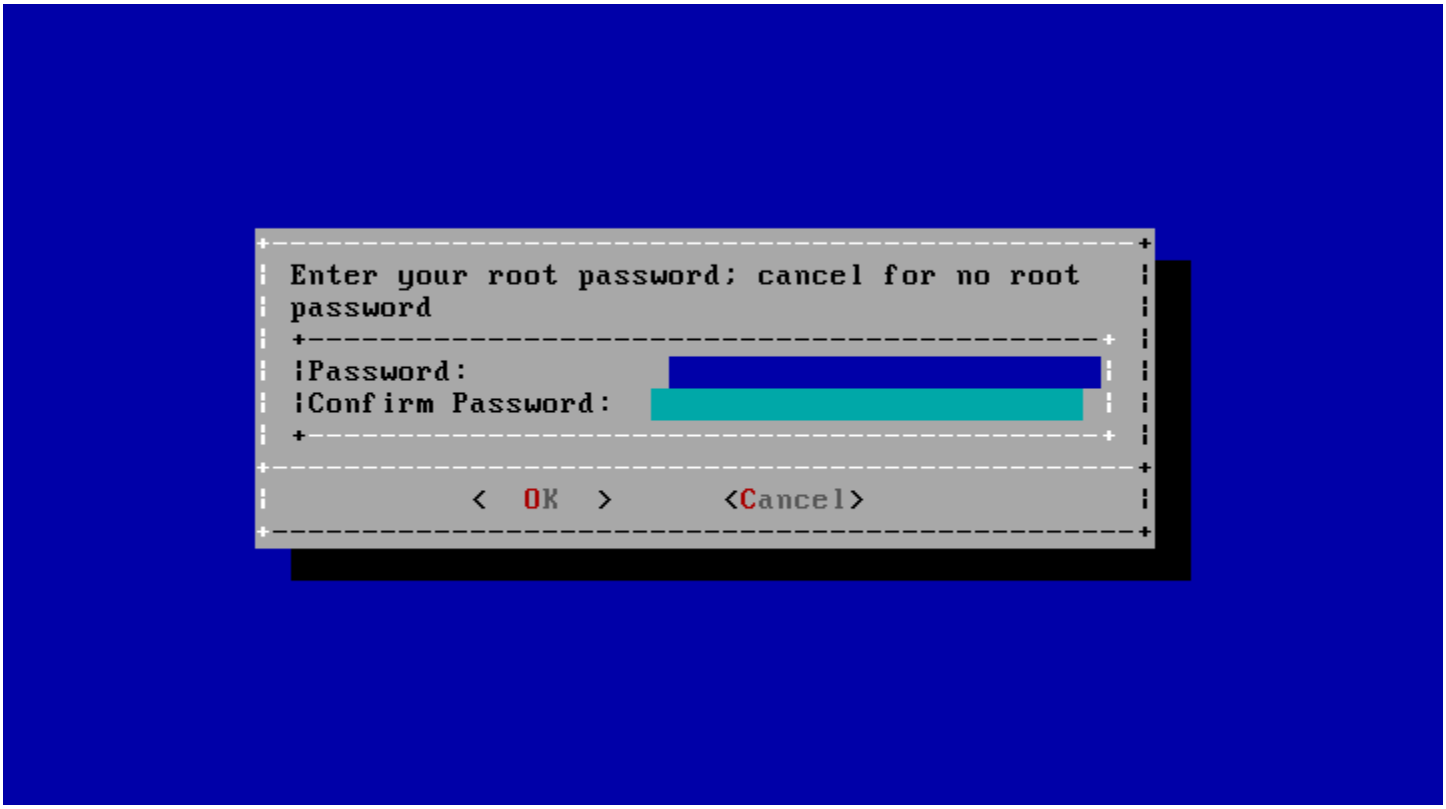


Fig. 2.6: Set the Root Password

Setting a password is mandatory and the password cannot be blank. Since this password provides access to the administrative GUI, it should be hard to guess. Enter the password, press the down arrow key, and confirm the password. Then press `Enter` to continue with the installation.

Note: For security reasons, the SSH service and *root* SSH logins are disabled by default. Unless these are set, the only way to access a shell as *root* is to gain physical access to the console menu or to access the web shell within the administrative GUI. This means that the FreeNAS® system should be kept physically secure and that the administrative GUI should be behind a properly configured firewall and protected by a secure password.

FreeNAS® can be configured to boot with the standard BIOS boot mechanism or UEFI booting as shown Figure 2.7. BIOS booting is recommended for legacy and enterprise hardware. UEFI is used on newer consumer motherboards.

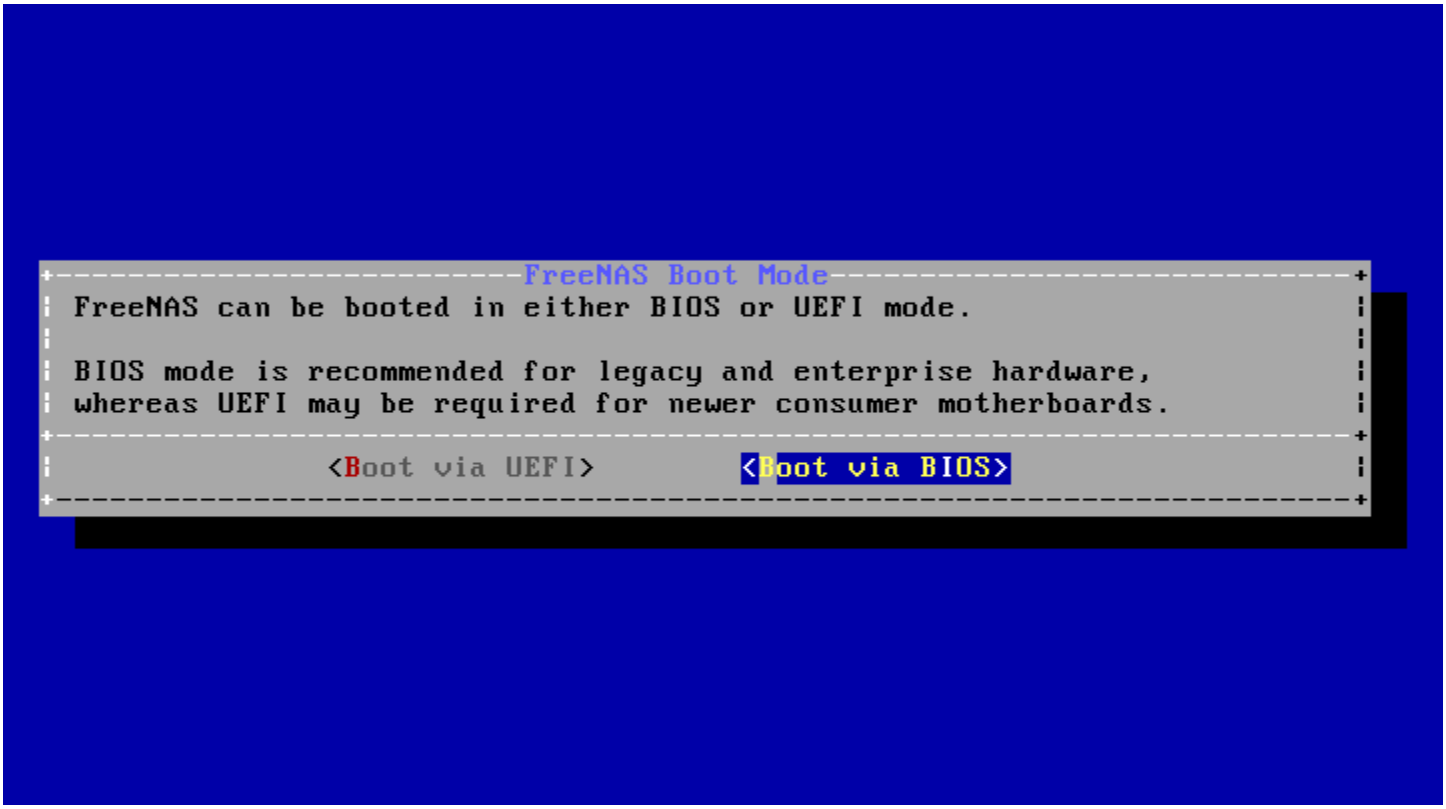


Fig. 2.7: Choose UEFI or BIOS Booting

Note: Most UEFI systems can also boot in BIOS mode if CSM (Compatibility Support Module) is enabled in the UEFI setup screens.

The message in Figure 2.8 is shown after the installation is complete.

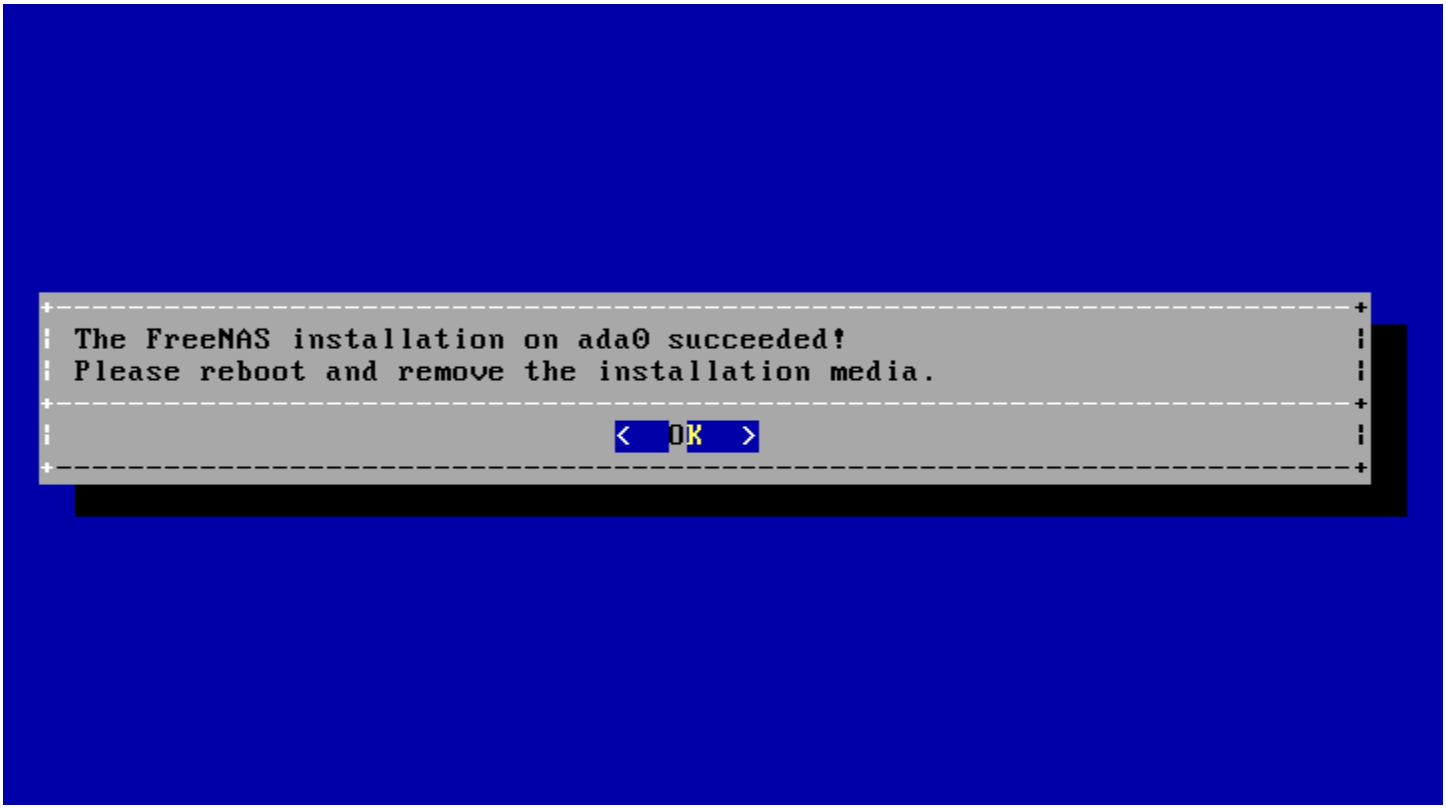


Fig. 2.8: Installation Complete

Press `Enter` to return to *Installer Menu* (page 14). Highlight *3 Reboot System* and press `Enter`. If booting from CD, remove the CDROM. As the system reboots, make sure that the device where FreeNAS® was installed is listed as the first boot entry in the BIOS so the system will boot from it.

FreeNAS® boots into the *Console Setup* menu described in *Booting* (page 44) after waiting five seconds in the *boot menu* (page 26). Press the `Spacebar` to stop the timer and use the boot menu.

2.4 Installation Troubleshooting

If the system does not boot into FreeNAS®, there are several things that can be checked to resolve the situation.

Check the system BIOS and see if there is an option to change the USB emulation from CD/DVD/floppy to hard drive. If it still will not boot, check to see if the card/drive is UDMA compliant.

If the system BIOS does not support EFI with BIOS emulation, see if it has an option to boot using legacy BIOS mode.

When the system starts to boot but hangs with this repeated error message:

```
run_interrupt_driven_hooks: still waiting after 60 seconds for xpt_config
```

Go into the system BIOS and look for an onboard device configuration for a 1394 Controller. If present, disable that device and try booting again.

If the system starts to boot but hangs at a *mountroot*> prompt, follow the instructions in Workaround/Semi-Fix for Mountroot Issues with 9.3 (https://forums.freenas.org/index.php?threads/workaround-semi-fix-for-mountroot-issues-with-9-3.26071/).

If the burned image fails to boot and the image was burned using a Windows system, wipe the USB stick before trying a second burn using a utility such as Active@ KillDisk (http://how-to-erase-hard-drive.com/). Otherwise, the second burn attempt will fail as Windows does not understand the partition which was written from the image file. Be very careful to specify the correct USB stick when using a wipe utility!

2.5 Upgrading

FreeNAS® provides flexibility for keeping the operating system up-to-date:

1. Upgrades to major releases, for example from version 9.3 to 9.10, can still be performed using either an ISO or the graphical administrative interface. Unless the Release Notes for the new major release indicate that the current version requires an ISO upgrade, either upgrade method can be used.
2. Minor releases have been replaced with signed updates. This means that it is not necessary to wait for a minor release to update the system with a system update or newer versions of drivers and features. It is also no longer necessary to manually download an upgrade file and its associated checksum to update the system.
3. The updater automatically creates a boot environment, making updates a low-risk operation. Boot environments provide the option to return to the previous version of the operating system by rebooting the system and selecting the previous boot environment from the boot menu.

This section describes how to perform an upgrade from an earlier version of FreeNAS® to 11.2. After 11.2 has been installed, use the instructions in *Update* (page 71) to keep the system updated.

2.5.1 Caveats

Be aware of these caveats **before** attempting an upgrade to 11.2:

- **Warning: upgrading the ZFS pool can make it impossible to go back to a previous version.** For this reason, the update process does not automatically upgrade the ZFS pool, though the *Alert* (page 289) system shows when newer feature flags are available for a pool. Unless a new feature flag is needed, it is safe to leave the pool at the current version and uncheck the alert. If the pool is upgraded, it will not be possible to boot into a previous version that does not support the newer feature flags.
- The *Wizard* (page 274) does not recognize an encrypted ZFS pool. If the ZFS pool is GELI-encrypted and the *Wizard* (page 274) starts after the upgrade, cancel the *Wizard* (page 274) and use the instructions in *Importing an Encrypted Pool* (page 131) to import the encrypted volume. The *Wizard* (page 274) can be run afterward for post-configuration. It will then recognize that the volume has been imported and not prompt to reformat the disks.
- Upgrading the firmware of Broadcom SAS HBAs to the latest version is recommended.
- If upgrading from 9.3.x, please read the FAQ: Updating from 9.3 to 9.10 (https://forums.freenas.org/index.php?threads/faq-updating-from-9-3-to-9-10.54260/) first.
- **Upgrades from** FreeNAS® **0.7x are not supported.** The system has no way to import configuration settings from 0.7x versions of FreeNAS®. The configuration must be manually recreated. If supported, the FreeNAS® 0.7x volumes or disks must be manually imported.
- **Upgrades on 32-bit hardware are not supported.** However, if the system is currently running a 32-bit version of FreeNAS® **and** the hardware supports 64-bit, the system can be upgraded. Any archived reporting graphs will be lost during the upgrade.
- **UFS is not supported.** If the data currently resides on **one** UFS-formatted disk, create a ZFS volume using **other** disks after the upgrade, then use the instructions in *Import Disk* (page 130) to mount the UFS-formatted disk and copy the data to the ZFS volume. With only one disk, back up its data to another system or media before the upgrade, format the disk as ZFS after the upgrade, then restore the backup. If the data currently resides on a UFS RAID of disks, it is not possible to directly import that data to the ZFS volume. Instead, back up the data before the upgrade, create a ZFS volume after the upgrade, then restore the data from the backup.
- **The VMware Tools VMXNET3 drivers are no longer supported**. Configure and use the vmx(4) (https://www.freebsd.org/cgi/man.cgi?query=vmx) driver instead.

2.5.2 Initial Preparation

Before upgrading the operating system, perform the following steps:

1. **Back up the** FreeNAS® **configuration** in `System → General → Save Config`.
2. If any volumes are encrypted, **remember** to set the passphrase and download a copy of the encryption key and the latest recovery key. After the upgrade is complete, use the instructions in *Importing an Encrypted Pool* (page 131) to import the encrypted volume.
3. Warn users that the FreeNAS® shares will be unavailable during the upgrade; scheduling the upgrade for a time that will least impact users is recommended.
4. Stop all services in `Services → Control Services`.

2.5.3 Upgrading Using the ISO

To perform an upgrade using this method, download (http://download.freenas.org/latest/) the `.iso` to the computer that will be used to prepare the installation media. Burn the downloaded `.iso` file to a CD or USB thumb drive using the instructions in *Preparing the Media* (page 10).

Insert the prepared media into the system and boot from it. The installer waits ten seconds in the *installer boot menu* (page 13) before booting the default option. If needed, press the `Spacebar` to stop the timer and choose another boot option. After the media finishes booting into the installation menu, press `Enter` to select the default option of *1 Install/Upgrade.* The installer presents a screen showing all available drives.

Warning: *All* drives are shown, including boot drives and storage drives. Only choose boot drives when upgrading. Choosing the wrong drives to upgrade or install will cause loss of data. If unsure about which drives contain the FreeNAS® operating system, reboot and remove the install media. In the FreeNAS® GUI, use `System → Boot` to identify the boot drives. More than one drive is shown when a mirror has been used.

Move to the drive where FreeNAS® is installed and press the `Spacebar` to mark it with a star. If a mirror has been used for the operating system, mark all of the drives where the FreeNAS® operating system is installed. Press `Enter` when done.

The installer recognizes earlier versions of FreeNAS® installed on the boot drive or drives and presents the message shown in Figure 2.9.

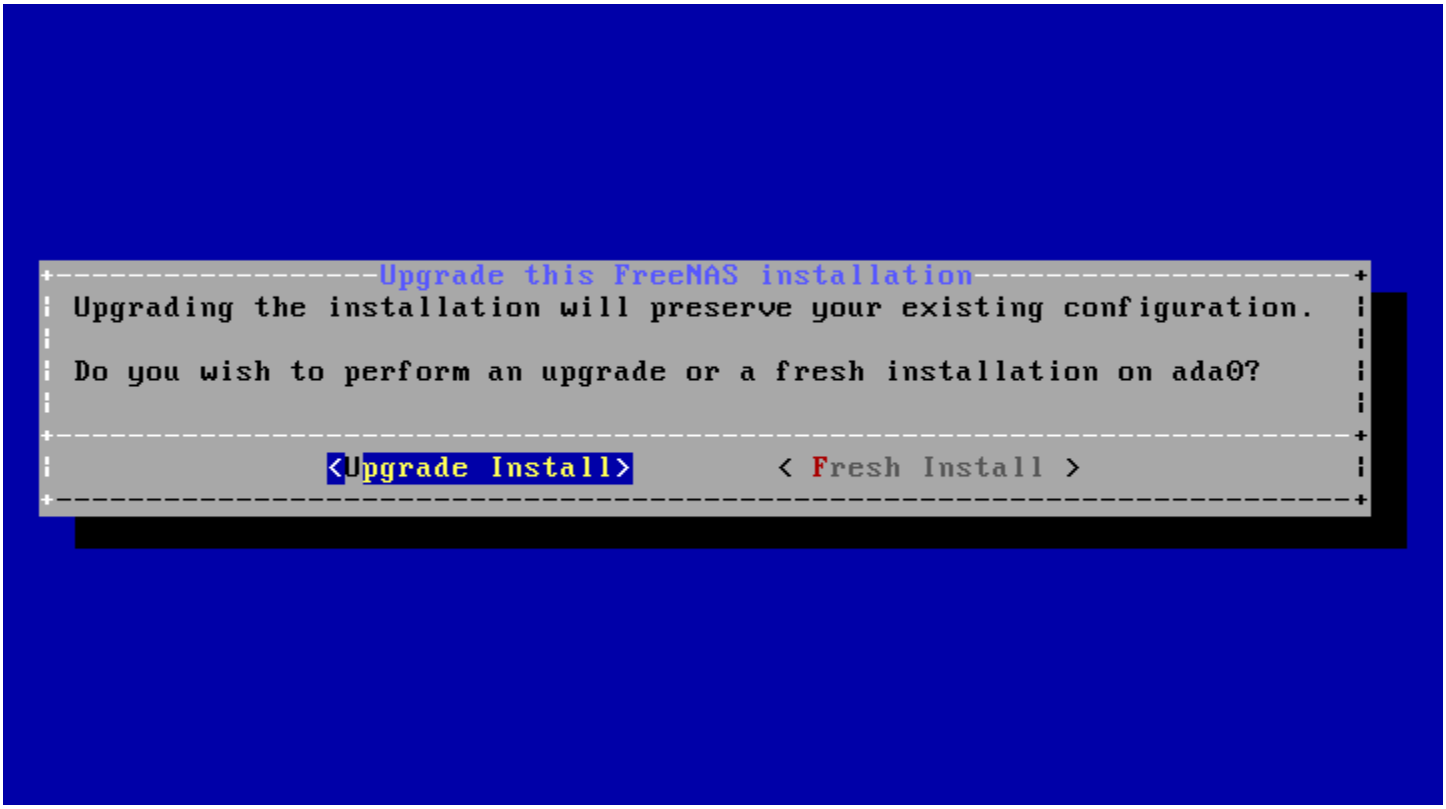


Fig. 2.9: Upgrading a FreeNAS® Installation

Note: If *Fresh Install* is chosen, the backup of the configuration data must be restored using `System` → `General` → `Upload Config` after booting into the new operating system.

To perform an upgrade, press `Enter` to accept the default of *Upgrade Install*. The installer recommends installing the operating system on a disk not used for storage.

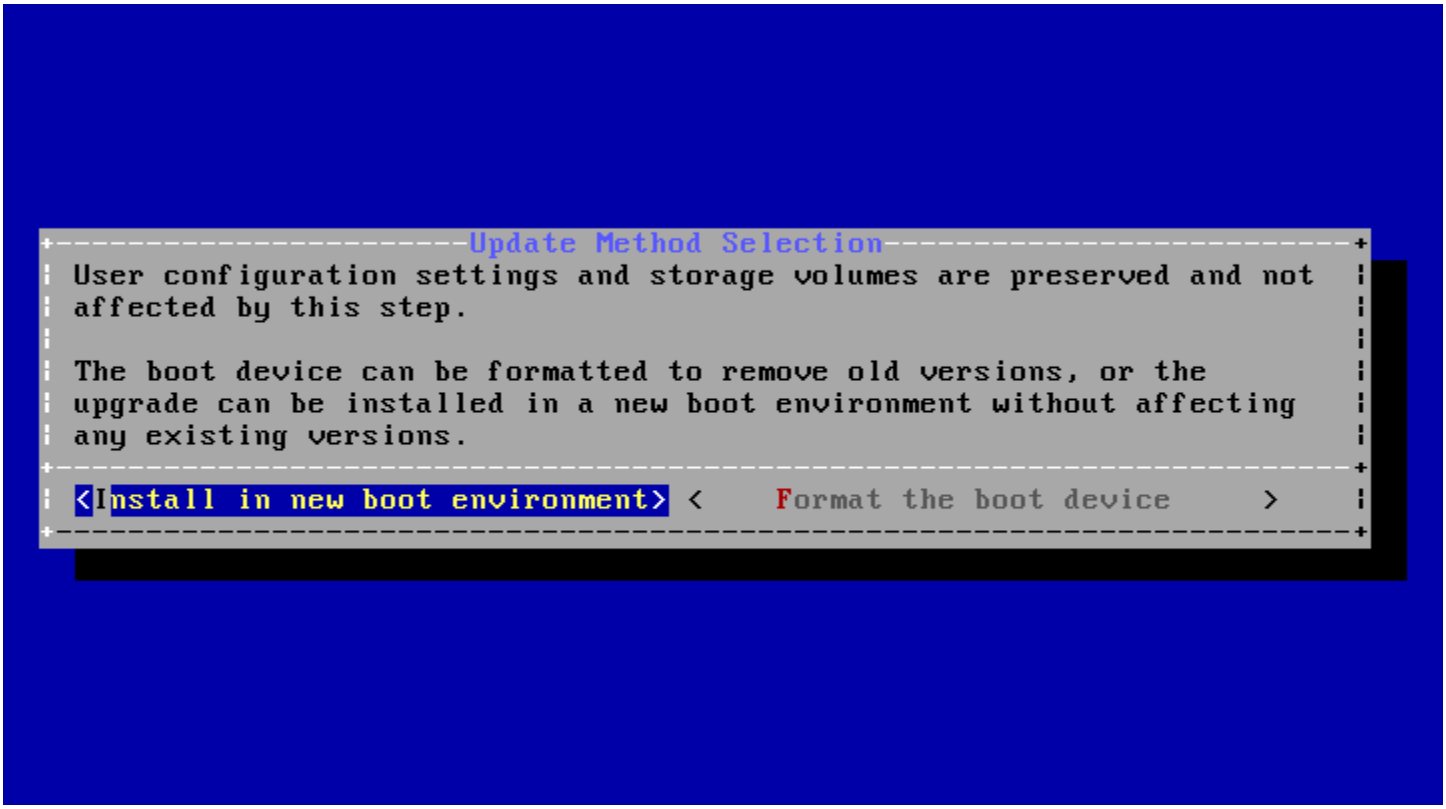


Fig. 2.10: Install in New Boot Environment or Format

The updated system can be installed in a new boot environment, or the entire boot device can be formatted to start fresh. Installing into a new boot environment preserves the old code, allowing a roll-back to previous versions if necessary. Formatting the boot device is usually not necessary but can reclaim space. User data and settings are preserved when installing to a new boot environment and also when formatting the boot device. Move the highlight to one of the options and press `Enter` to start the upgrade.

The installer unpacks the new image and displays the menu shown in Figure 2.11. The database file that is preserved and migrated contains the FreeNAS® configuration settings.

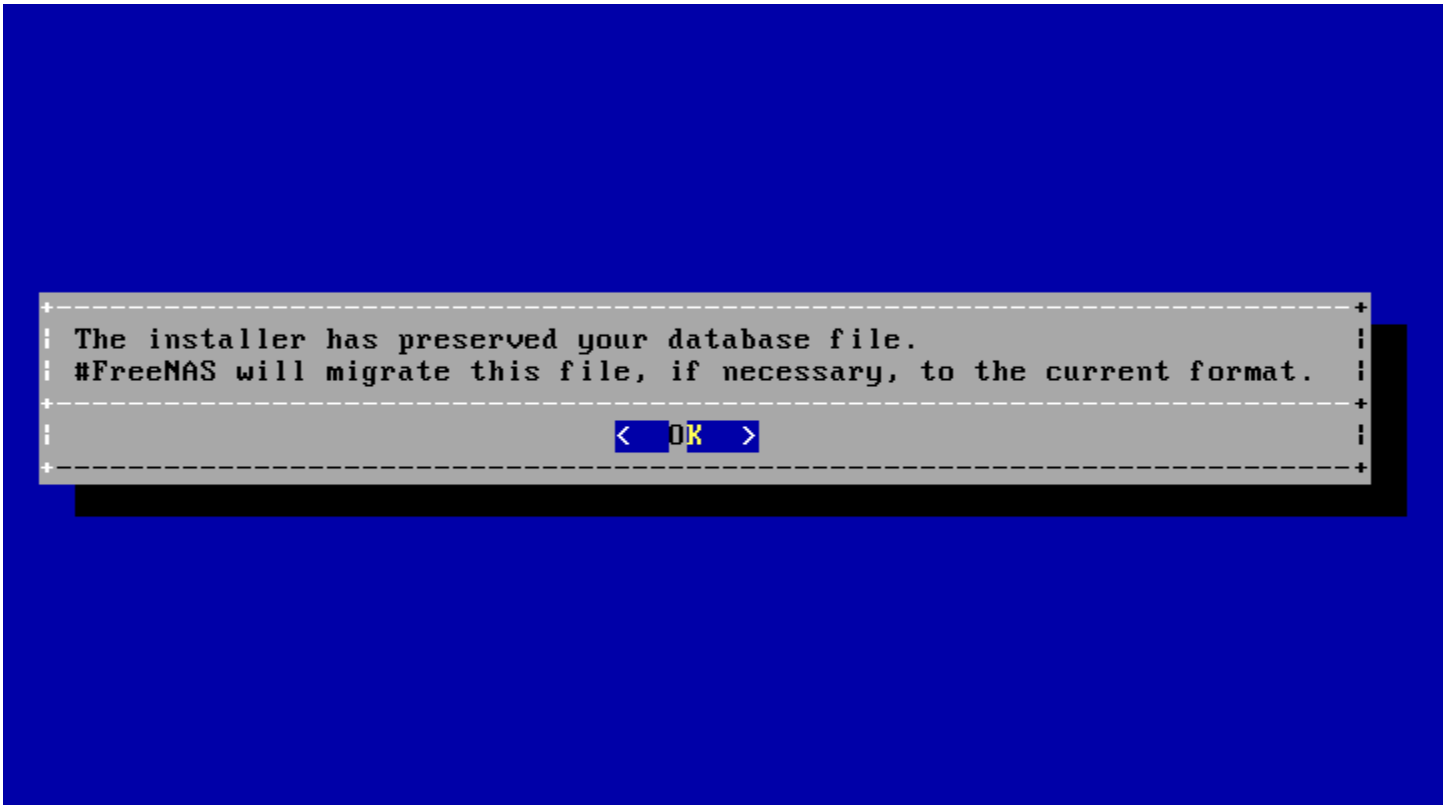


Fig. 2.11: Preserve and Migrate Settings

Press `Enter`. FreeNAS® indicates that the upgrade is complete and a reboot is required. Press *OK*, highlight *3 Reboot System*, then press `Enter` to reboot the system. If the upgrade installer was booted from CD, remove the CD.

During the reboot there can be a conversion of the previous configuration database to the new version of the database. This happens during the "Applying database schema changes" line in the reboot cycle. This conversion can take a long time to finish, sometimes fifteen minutes or more, and can cause the system to reboot again. The system will start normally afterwards. If database errors are shown but the graphical administrative interface is accessible, go to `Settings` → `General` and use the *Upload Config* button to upload the configuration that was saved before starting the upgrade.

2.5.4 Upgrading From the GUI

To perform an upgrade using this method, go to `System` → `Update`.

After the update is complete, the connection will be lost temporarily as the FreeNAS® system reboots into the new version of the operating system. The FreeNAS® system will normally receive the same IP address from the DHCP server. Refresh the browser after a moment to see if the system is accessible.

2.5.5 If Something Goes Wrong

If an update fails, an alert is issued and the details are written to `/data/update.failed`.

To return to a previous version of the operating system, physical or IPMI access to the FreeNAS® console is needed. Reboot the system and watch for the boot menu:

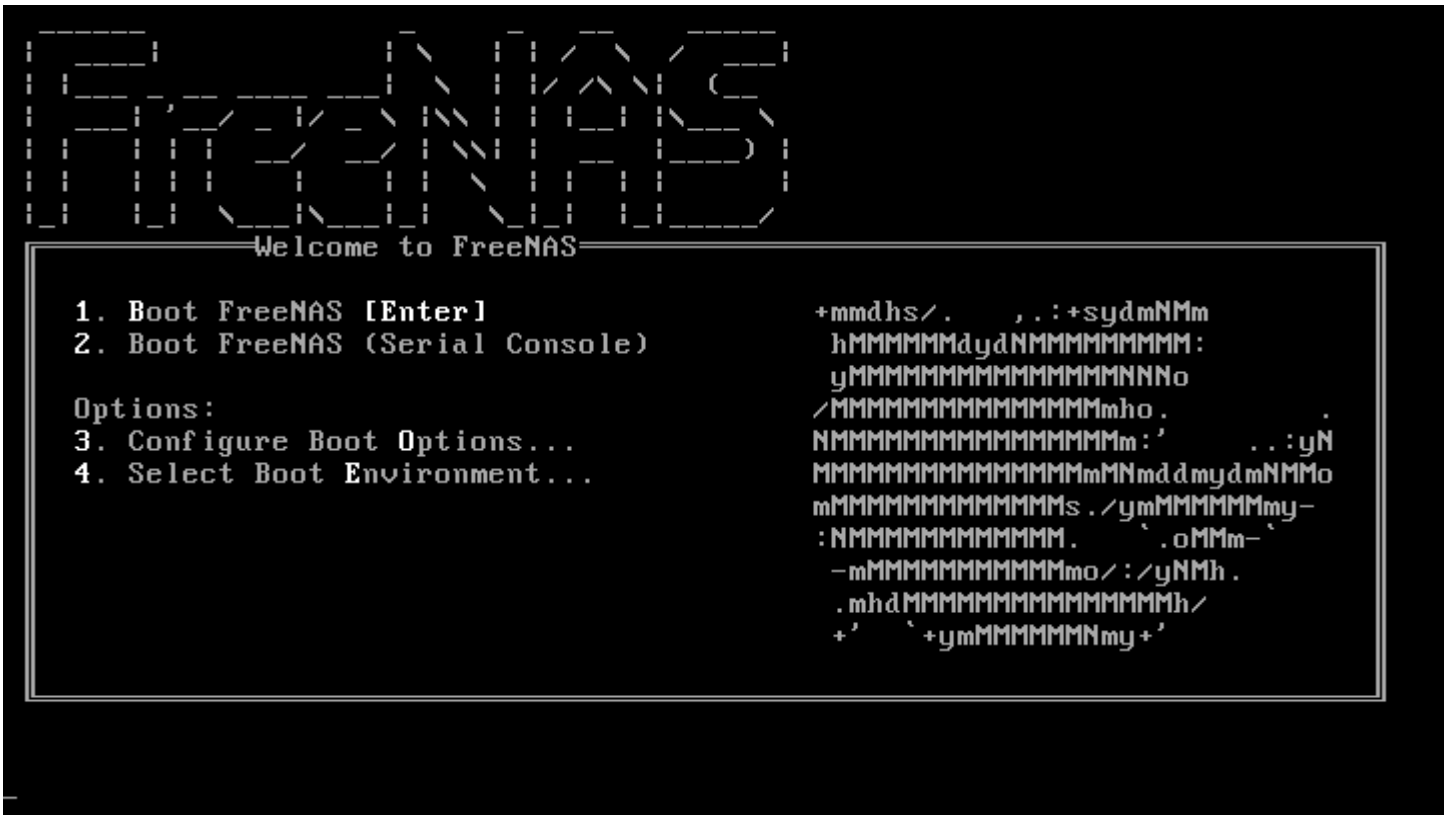


Fig. 2.12: Boot Menu

FreeNAS® waits five seconds before booting into the default boot environment. Press the `Spacebar` to stop the automatic boot timer. Press `4` to display the available boot environments and press `3` as needed to scroll through multiple pages.

Fig. 2.13: Boot Environments

In the example shown in Figure 2.13, the first entry in *Boot Environments* is `11.2-MASTER-201807250900`. This is the current version of the operating system, after the update was applied. Since it is the first entry, it is the default selection.

The next entry is `Initial-Install`. This is the original boot environment created when FreeNAS® was first installed. Since there are no other entries between the initial installation and the first entry, only one update has been applied to this system since its initial installation.

To boot into another version of the operating system, enter the number of the boot environment to set it as *Active*. Press `Backspace` to return to the *Boot Menu* (page 26) and press `Enter` to boot into the chosen *Active* boot environment.

If a boot device fails and the system no longer boots, don't panic. The data is still on the disks and there is still a copy of the saved configuration. The system can be recovered with a few steps:

1. Perform a fresh installation on a new boot device.
2. Import the volumes in `Storage → Auto Import Volume`.
3. Restore the configuration in `System → General → Upload Config`.

Note: It is not possible to restore a saved configuration that is newer than the installed version. For example, if a reboot into an older version of the operating system is performed, a configuration that was created in a later version cannot be restored.

2.5.6 Upgrading a ZFS Pool

In FreeNAS®, ZFS pools can be upgraded from the graphical administrative interface.

Before upgrading an existing ZFS pool, be aware of these caveats first:

- the pool upgrade is a one-way street, meaning that **if you change your mind you cannot go back to an earlier ZFS version or downgrade to an earlier version of the software that does not support those feature flags.**
- before performing any operation that may affect the data on a storage disk, **always back up all data first and verify the integrity of the backup.** While it is unlikely that the pool upgrade will affect the data, it is always better to be safe than sorry.
- upgrading a ZFS pool is **optional**. Do not upgrade the pool if the the possibility of reverting to an earlier version of FreeNAS® or repurposing the disks in another operating system that supports ZFS is desired. It is not necessary to upgrade the pool unless the end user has a specific need for the newer ZFS feature flags. If a pool is upgraded to the latest feature flags, it will not be possible to import that pool into another operating system that does not yet support those feature flags.

To perform the ZFS pool upgrade, go to `Storage → Volumes → View Volumes` and highlight the volume (ZFS pool) to upgrade. Click the *Upgrade* button as shown in Figure 2.14.

Note: If the *Upgrade* button does not appear, the pool is already at the latest feature flags and does not need to be upgraded.

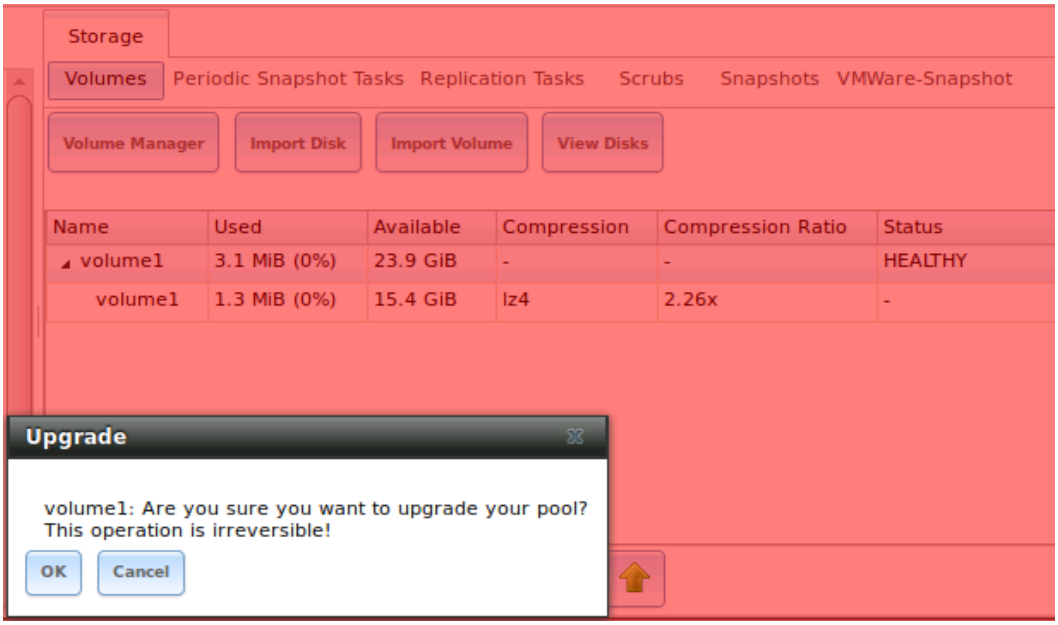


Fig. 2.14: Upgrading a ZFS Pool

The warning serves as a reminder that a pool upgrade is not reversible. Click *OK* to proceed with the upgrade.

The upgrade itself only takes a few seconds and is non-disruptive. It is not necessary to stop any sharing services to upgrade the pool. However, it is best to upgrade when the pool is not being heavily used. The upgrade process will suspend I/O for a short period, but is nearly instantaneous on a quiet pool.

2.6 Virtualization

FreeNAS® can be run inside a virtual environment for development, experimentation, and educational purposes. Note that running FreeNAS® in production as a virtual machine is not recommended (https://forums.freenas.org/index.php?threads/please-do-not-run-freenas-in-production-as-a-virtual-machine.12484/). Before using FreeNAS within a virtual environment for the first time, read this post (https://forums.freenas.org/index.php?threads/absolutely-must-virtualize-freenas-a-guide-to-not-completely-losing-your-data.12714/) as it contains useful guidelines for minimizing the risk of losing data.

To install or run FreeNAS® within a virtual environment, create a virtual machine that meets these minimum requirements:

- **at least** 8192 MB (8 GB) base memory size
- a virtual disk **at least 8 GB in size** to hold the operating system and boot environments
- at least one additional virtual disk **at least 4 GB in size** to be used as data storage
- a bridged network adapter

This section demonstrates how to create and access a virtual machine within VirtualBox and VMware ESXi environments.

2.6.1 VirtualBox

VirtualBox <https://www.virtualbox.org/>'__ is an open source virtualization program originally created by Sun Microsystems. VirtualBox runs on Windows, BSD, Linux, Macintosh, and OpenSolaris. It can be configured to use a downloaded FreeNAS:sup:'® `.iso` file, and makes a good testing environment for practicing configurations or learning how to use the features provided by FreeNAS®.

To create the virtual machine, start VirtualBox and click the *New* button, shown in Figure 2.15, to start the new virtual machine wizard.

Fig. 2.15: Initial VirtualBox Screen

Click the *Next* button to see the screen in Figure 2.16. Enter a name for the virtual machine, click the *Operating System* drop-down menu and select BSD, and select *FreeBSD (64-bit)* from the *Version* dropdown.

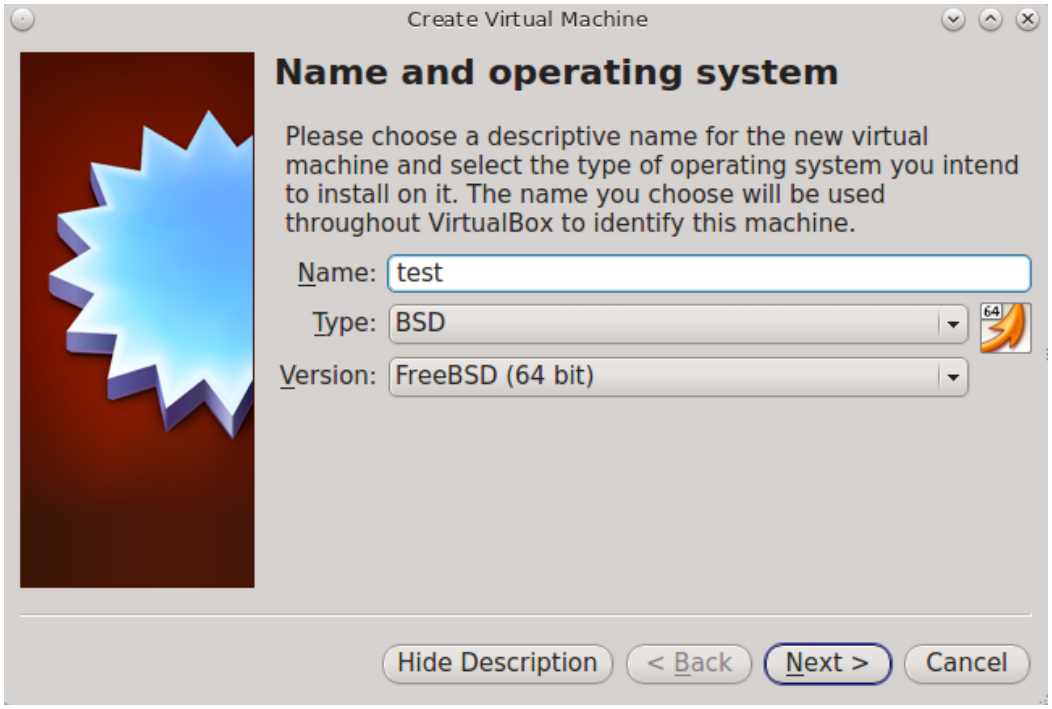


Fig. 2.16: Type in a Name and Select the Operating System for the New Virtual Machine

Click *Next* to see the screen in Figure 2.17. The base memory size must be changed to **at least 8192 MB**. When finished, click *Next* to see the screen in Figure 2.18.

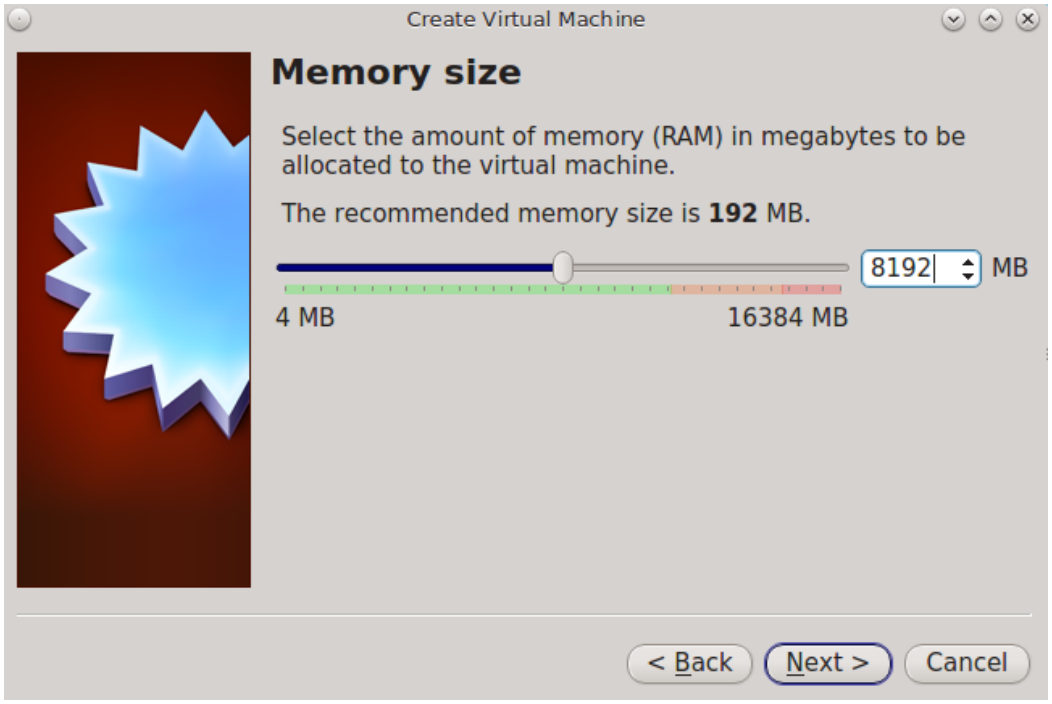


Fig. 2.17: Select the Amount of Memory Reserved for the Virtual Machine

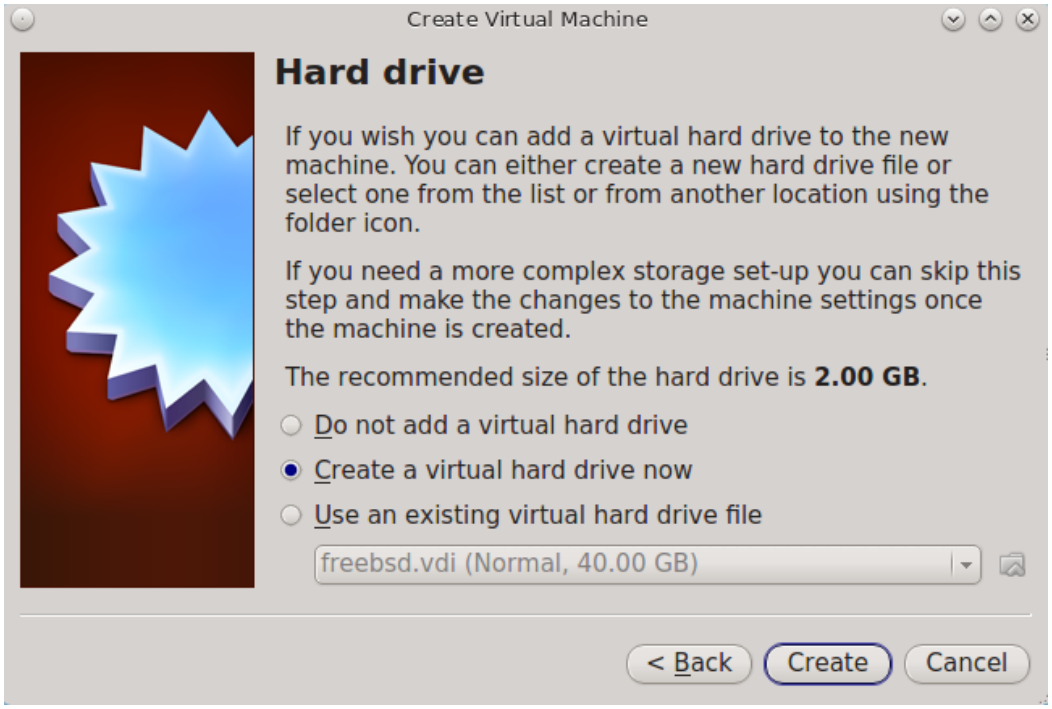


Fig. 2.18: Select Existing or Create a New Virtual Hard Drive

Click *Create* to launch the *Create Virtual Hard Drive Wizard* shown in Figure 2.19.

Fig. 2.19: Create New Virtual Hard Drive Wizard

Select *VDI* and click the *Next* button to see the screen in Figure 2.20.

Fig. 2.20: Select Storage Type for Virtual Disk

Choose either *Dynamically allocated* or *Fixed-size* storage. The first option uses disk space as needed until it reaches the maximum size that is set in the next screen. The second option creates a disk the full amount of disk space, whether it is used or not. Choose the first option to conserve disk space; otherwise, choose the second option, as it allows VirtualBox to run slightly faster. After selecting *Next*, the screen in Figure 2.21 is shown.

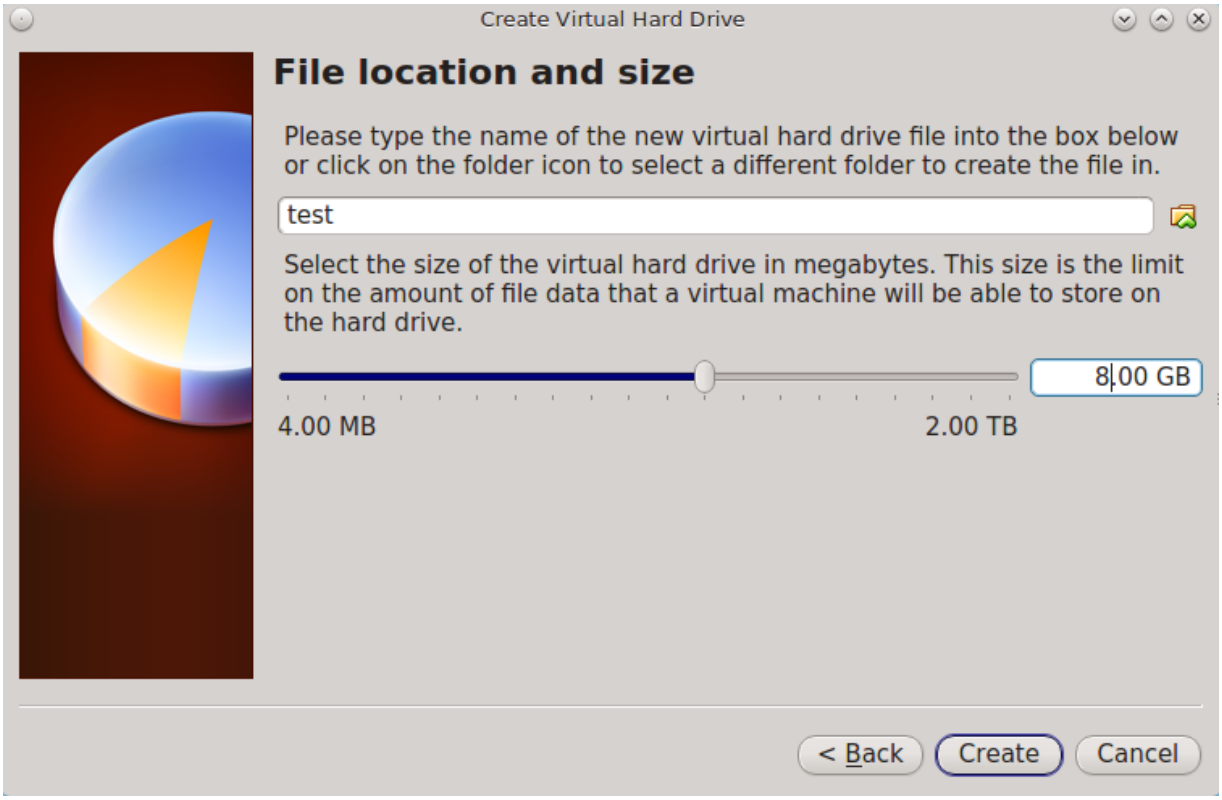


Fig. 2.21: Select File Name and Size of Virtual Disk

This screen is used to set the size (or upper limit) of the virtual disk. **Increase the default size to 8 GB**. Use the folder icon to browse to a directory on disk with sufficient space to hold the virtual disk files. Remember that there will be a system disk of at least 8 GB and at least one data storage disk of at least 4 GB.

After making a selection and pressing *Next*, a summary of the configuration options chosen is shown. Use the *Back* button to return to a previous screen if any values need to be modified. Otherwise, click *Finish* to complete the wizard. The new virtual machine is listed in the left frame, as shown in the example in Figure 2.22.

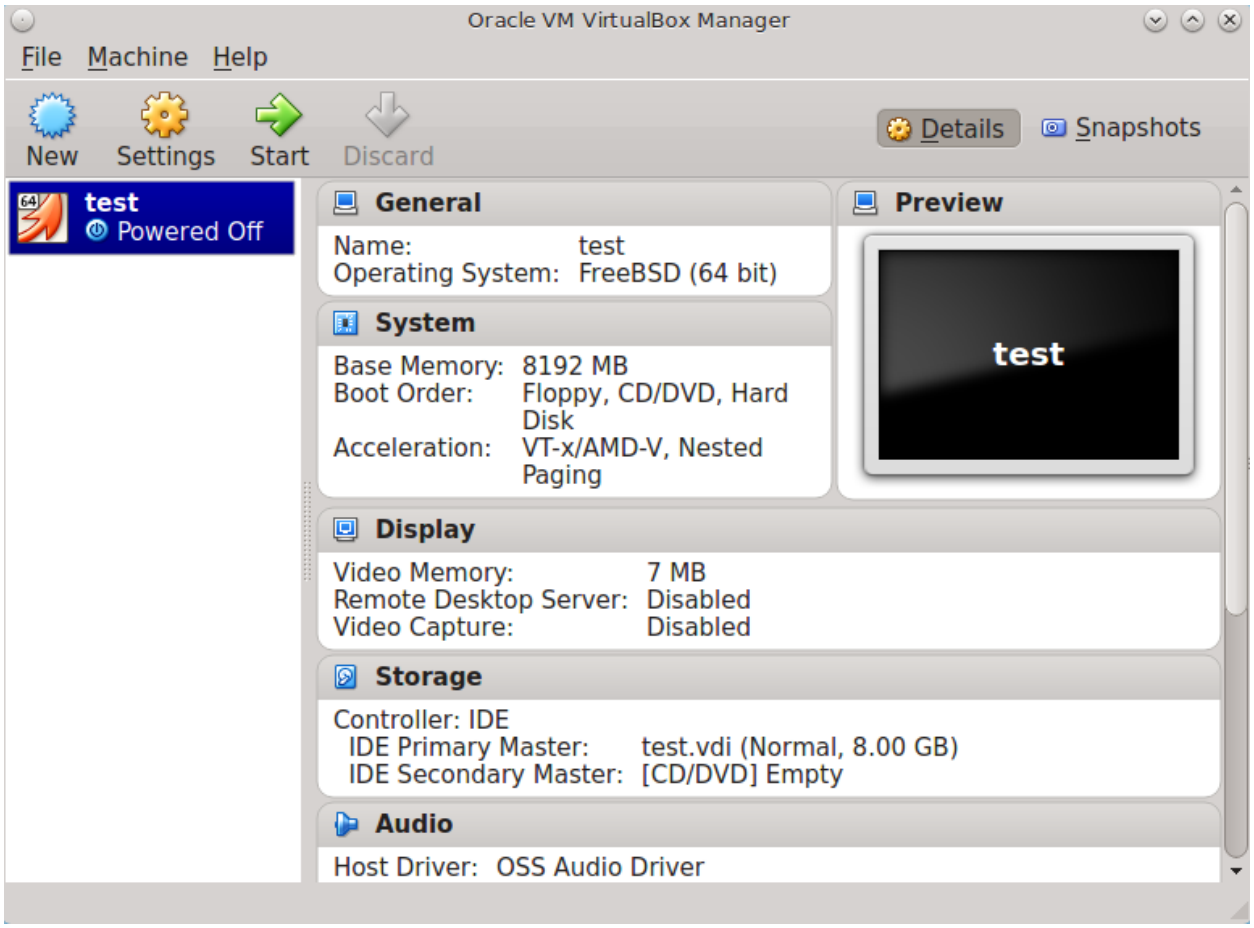


Fig. 2.22: The New Virtual Machine

Create the virtual disks to be used for storage. Click the *Storage* hyperlink in the right frame to access the storage screen seen in Figure 2.23.

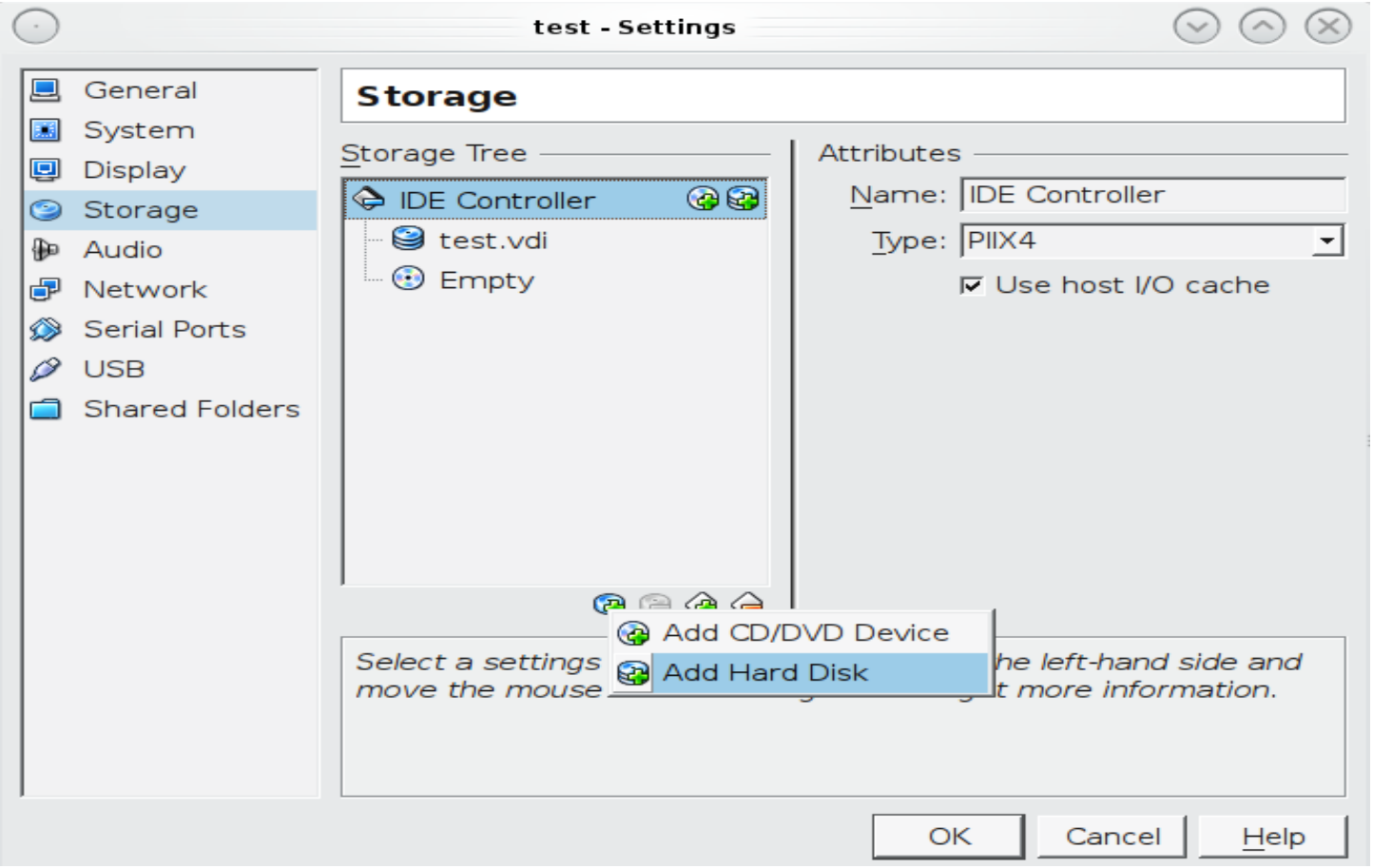


Fig. 2.23: Storage Settings of the Virtual Machine

Click the *Add Attachment* button, select *Add Hard Disk* from the pop-up menu, then click the *Create New Disk* button. This launches the Create New Virtual Hard Drive Wizard (seen in Figure 2.19 and 2.20). This disk will be used for storage, so create a size appropriate to your needs, making sure that it is **at least 4 GB**. To practice with RAID configurations, create as many virtual disks as needed. Two disks can be created on each IDE controller. For additional disks, click the *Add Controller* button to create another controller for attaching additional disks.

Create a device for the installation media. Highlight the word "Empty", then click the *CD* icon as shown in Figure 2.24.

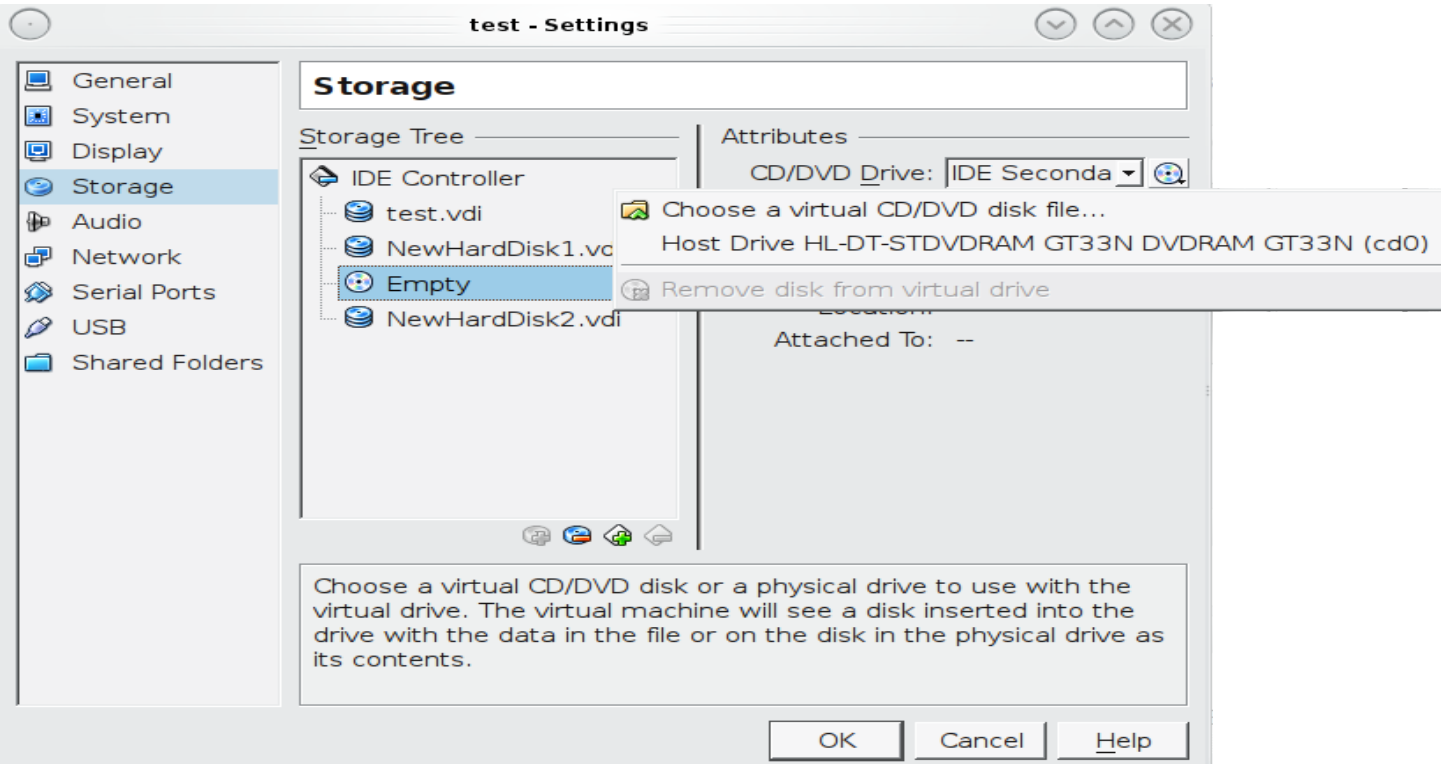


Fig. 2.24: Configuring ISO Installation Media

Click *Choose a virtual CD/DVD disk file...* to browse to the location of the `.iso` file. If the `.iso` was burned to CD, select the detected *Host Drive*.

Depending on the extensions available in the host CPU, it might not be possible to boot the VM from an `.iso`. If "your CPU does not support long mode" is shown when trying to boot the `.iso`, the host CPU either does not have the required extension or AMD-V/VT-x is disabled in the system BIOS.

Note: If there is a kernel panic when booting into the ISO, stop the virtual machine. Then, go to *System* and check the box *Enable IO APIC*.

To configure the network adapter, go to `Settings` → `Network`. In the *Attached to* drop-down menu select *Bridged Adapter*, then choose the name of the physical interface from the *Name* drop-down menu. In the example shown in Figure 2.25, the Intel Pro/1000 Ethernet card is attached to the network and has a device name of *em0*.

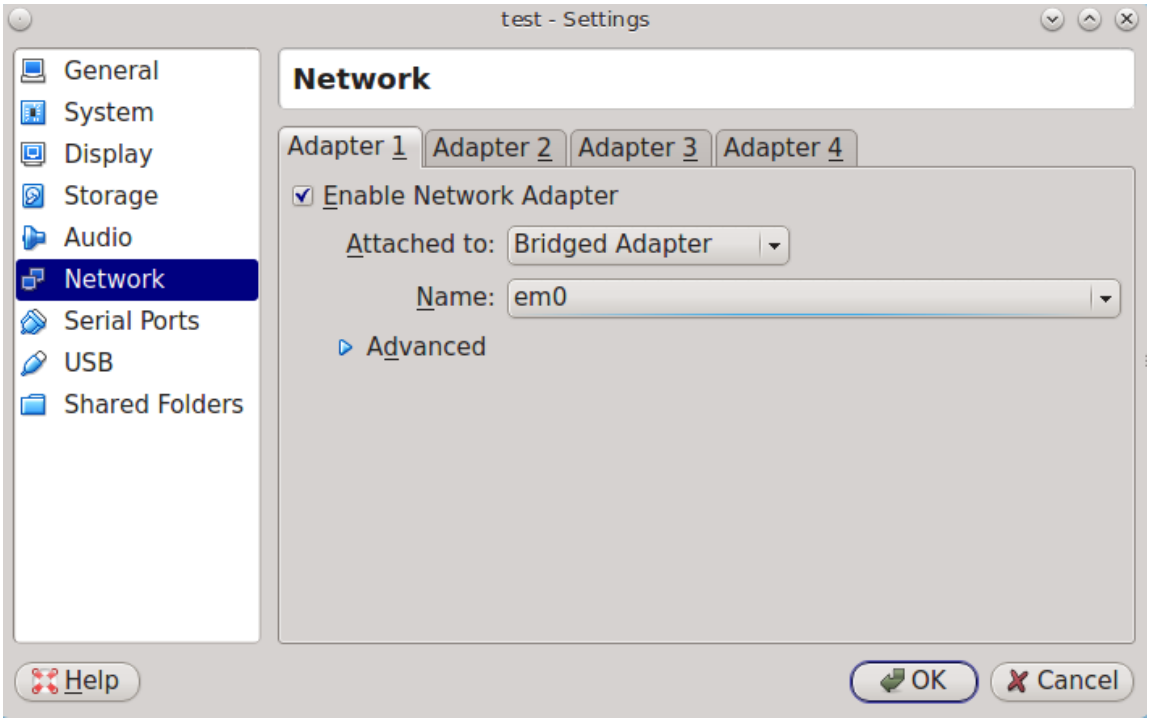


Fig. 2.25: Configuring a Bridged Adapter in VirtualBox

After configuration is complete, click the *Start* arrow and install FreeNAS® as described in *Performing the Installation* (page 12). Once FreeNAS® is installed, press `F12` when the VM starts to boot to access the boot menu. Select the primary hard disk as the boot option. To permanently boot from disk, remove the *CD/DVD* device in *Storage* or uncheck *CD/DVD-ROM* in the *Boot Order* section of *System*.

2.6.2 VMware ESXi

Before using ESXi, read this post (https://forums.freenas.org/index.php?threads/sync-writes-or-why-is-my-esxi-nfs-so-slow-and-why-is-iscsi-faster.12506/) for an explanation of why iSCSI will be faster than NFS.

ESXi is a bare-metal hypervisor architecture created by VMware Inc. Commercial and free versions of the VMware vSphere Hypervisor operating system (ESXi) are available from the VMware website (https://www.vmware.com/products/esxi-and-esx.html). After the operating system is installed on supported hardware, use a web browser to connect to its IP address. The welcome screen provides a link to download the VMware vSphere client which is used to create and manage virtual machines.

Once the VMware vSphere client is installed, use it to connect to the ESXi server. To create a new virtual machine, click `File` → `New` → `Virtual Machine`. The New Virtual Machine Wizard will launch as shown in Figure 2.26.

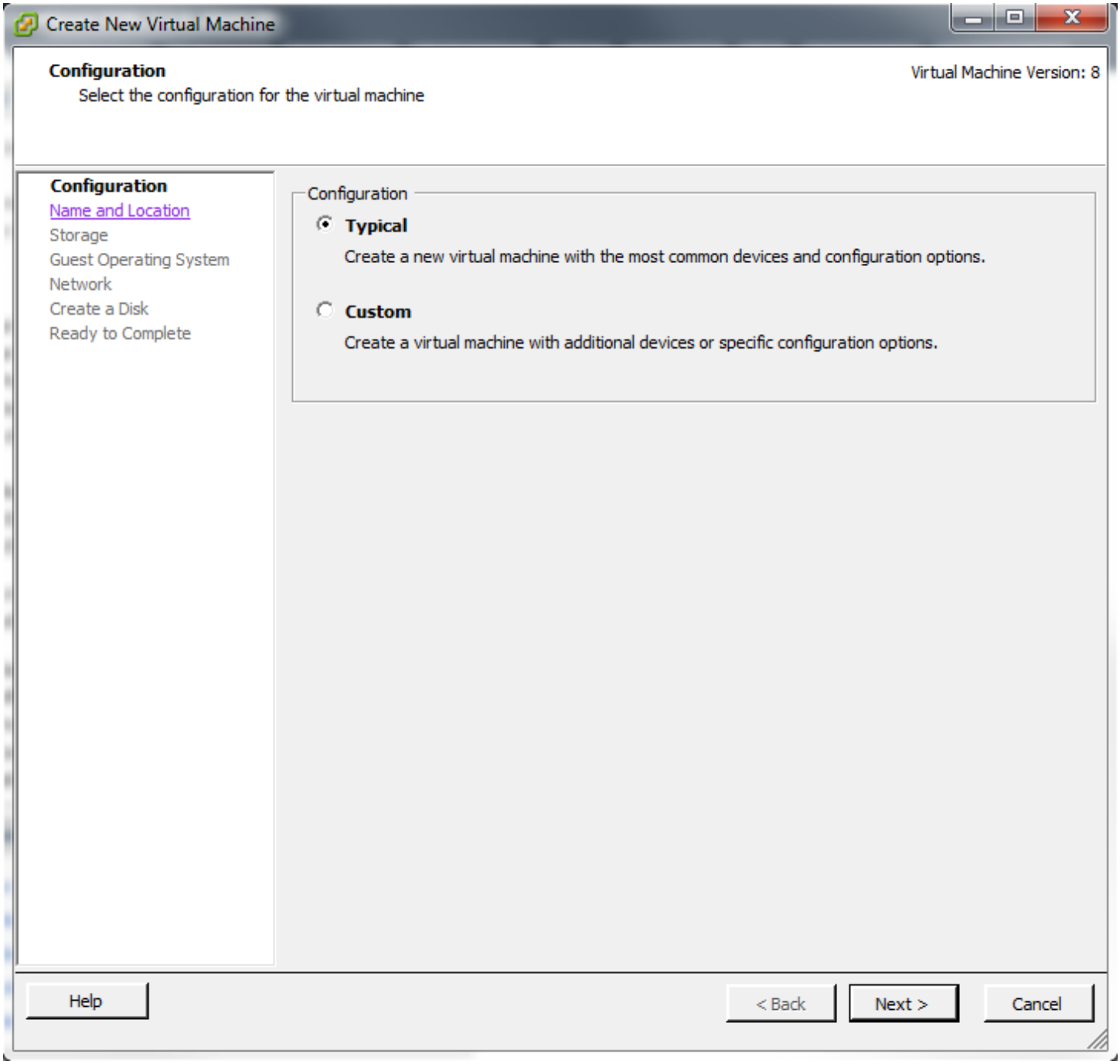


Fig. 2.26: New Virtual Machine Wizard

Click *Next* and enter a name for the virtual machine. Click *Next* and highlight a datastore. An example is shown in Figure 2.27. Click *Next*. In the screen shown in Figure 2.28, click *Other*, then select a FreeBSD 64-bit architecture.

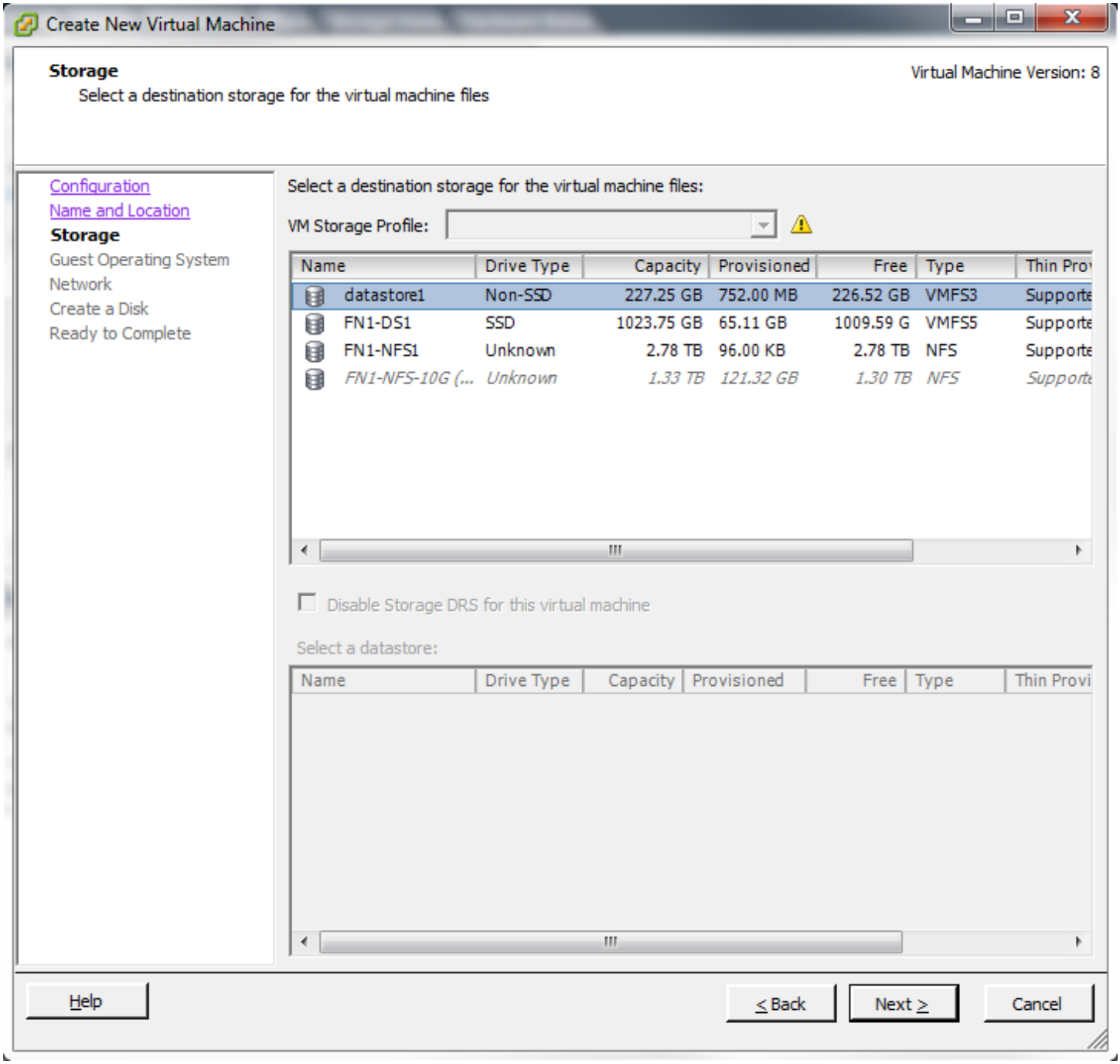


Fig. 2.27: Select Datastore

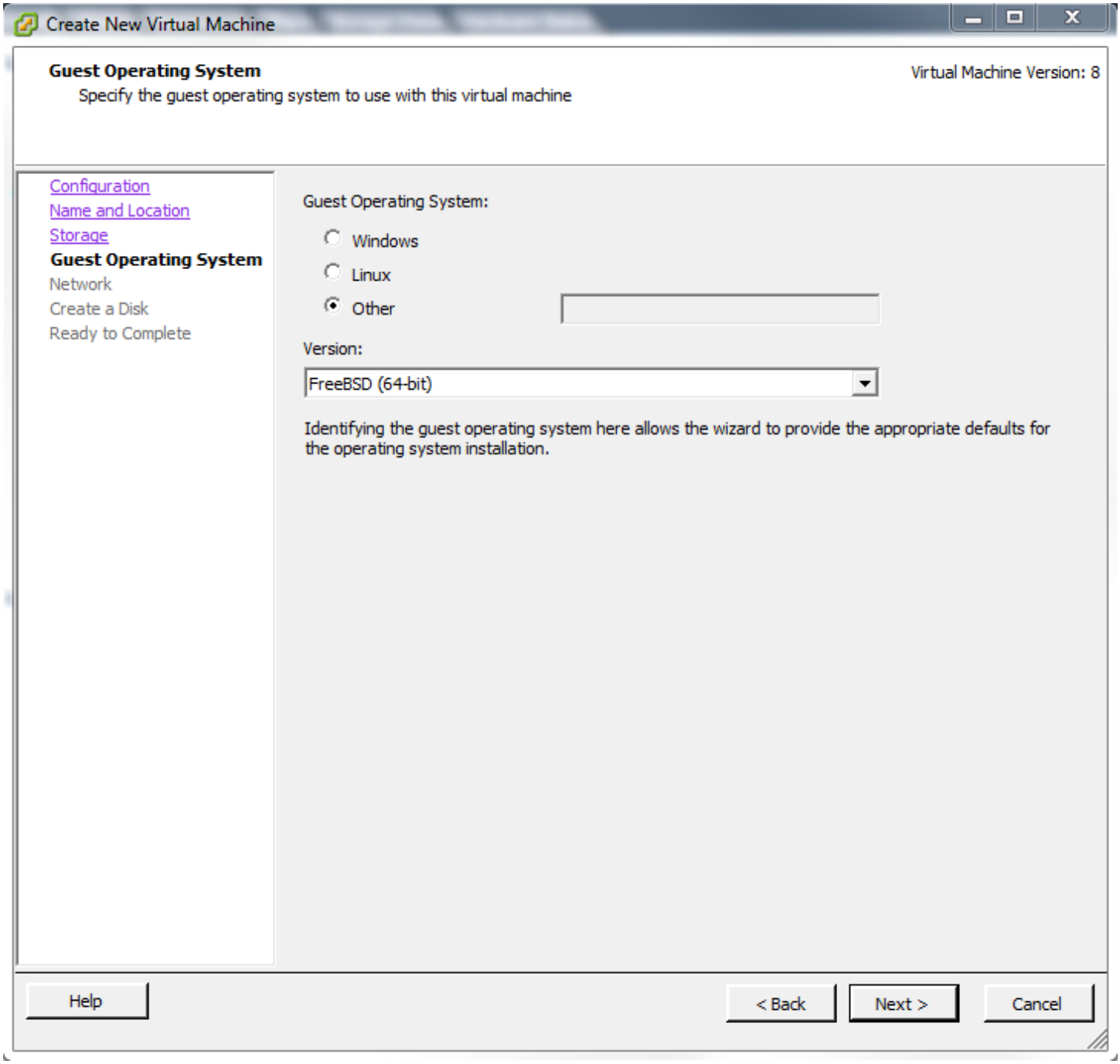


Fig. 2.28: Select Operating System

Click *Next* and create a virtual disk file of **8 GB** to hold the FreeNAS® operating system, as shown in Figure 2.29.

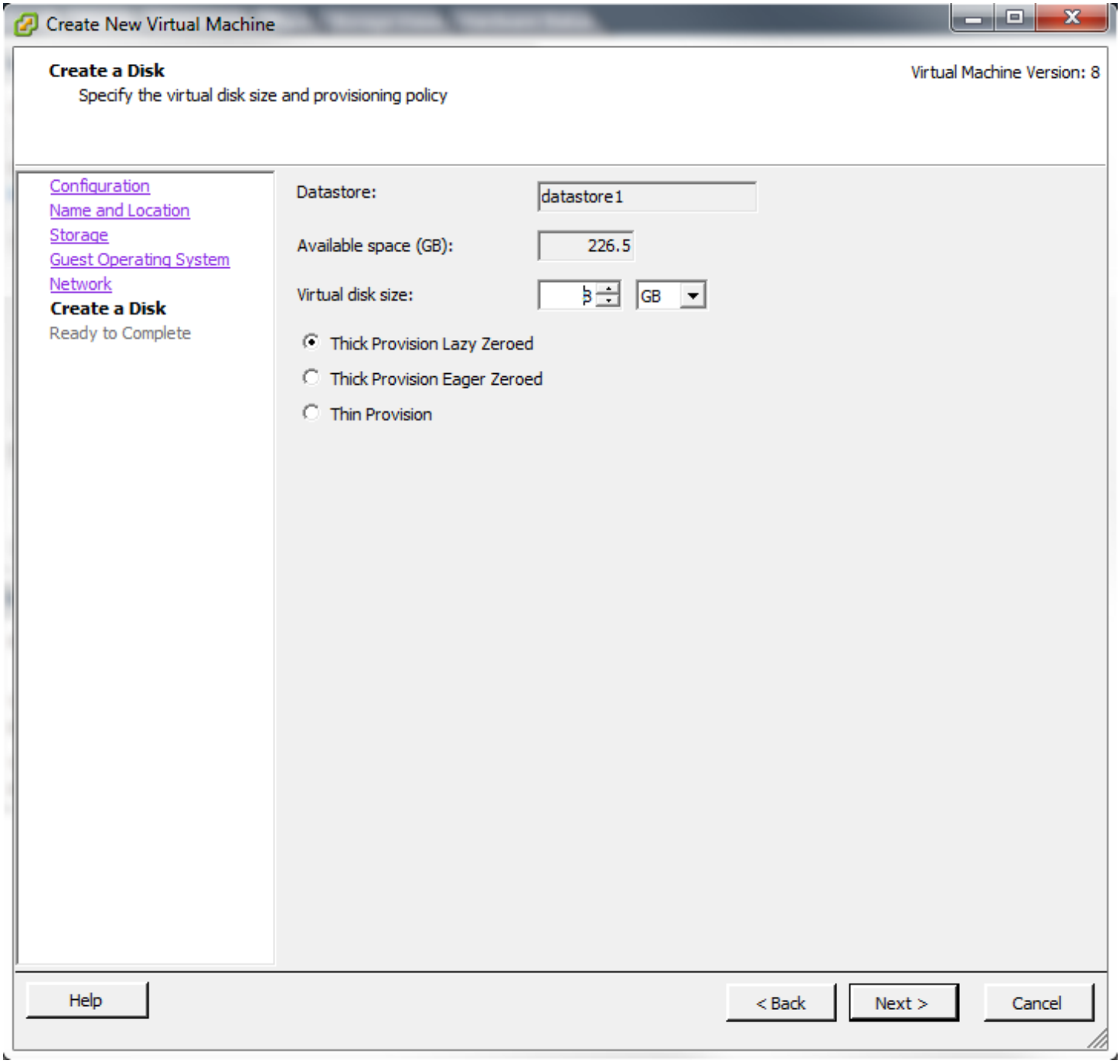


Fig. 2.29: Create Disk for the Operating System

Click *Next* and *Finish*. The new virtual machine is listed in the left frame. Right-click the virtual machine and select *Edit Settings* to access the screen shown in Figure 2.30.

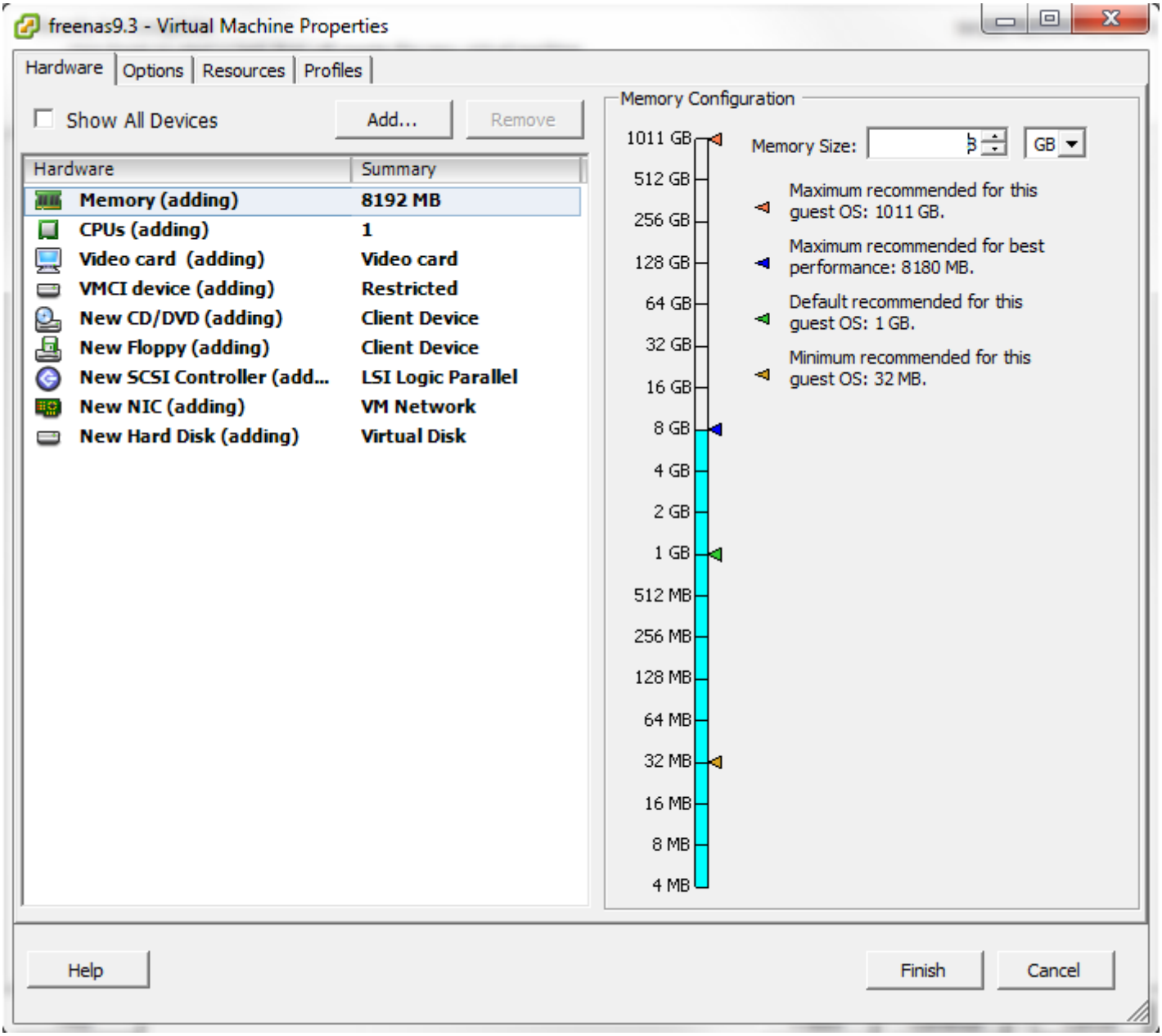


Fig. 2.30: Virtual Machine Settings

Increase the *Memory Configuration* to **at least 8192 MB**.

To create a storage disk, click `Hard disk 1 → Add`. In the *Device Type* menu, highlight *Hard Disk* and click *Next*. Select *Create a new virtual disk* and click *Next*. In the screen shown in Figure 2.31, select the size of the disk. To dynamically allocate space as needed, check the box *Allocate and commit space on demand (Thin Provisioning)*. Click *Next*, then *Next*, then *Finish* to create the disk. Repeat to create the amount of storage disks needed to meet your requirements.

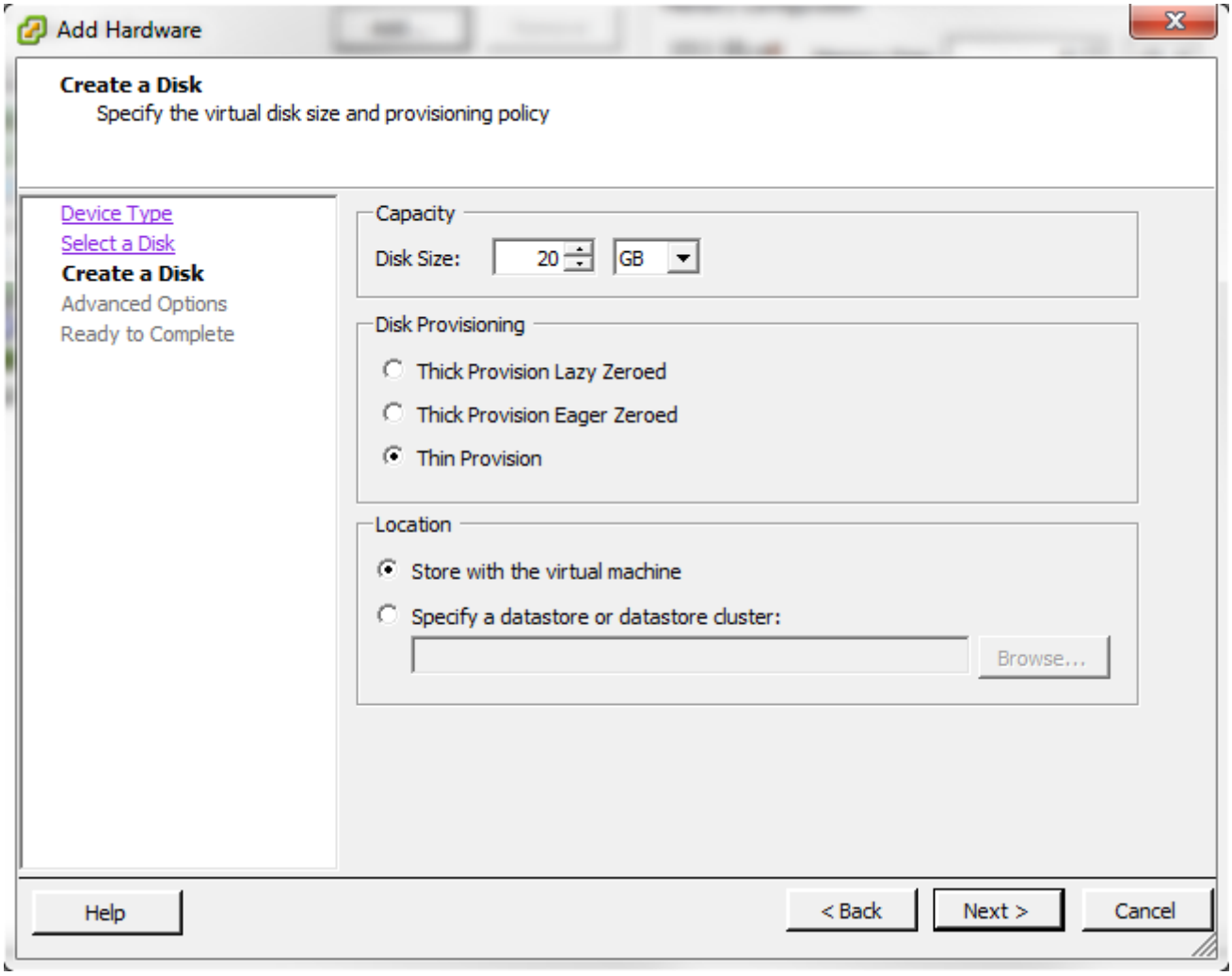


Fig. 2.31: Creating a Storage Disk

For ESX 5.0, Workstation 8.0, or Fusion 4.0 or higher, additional configuration is needed so that the virtual HPET setting does not prevent the virtual machine from booting.

If ESX is running, while in *Edit Settings*, click `Options → Advanced → General → Configuration Parameters`. Change *hpet0.present* from *true* to *false*, then click *OK* twice to save the setting.

For Workstation or Player, while in *Edit Settings*, click `Options → Advanced → File Locations`. Locate the path for the Configuration file named `filename.vmx`. Open that file in a text editor, change *hpet0.present* from *true* to *false*, and save the change.

CHAPTER

THREE

BOOTING

The Console Setup menu, shown in Figure 3.1, appears at the end of the boot process. If the FreeNAS® system has a keyboard and monitor, this Console Setup menu can be used to administer the system.

Note: When connecting to the FreeNAS® system with SSH or the web *Shell* (page 282), the Console Setup menu is not shown by default. It can be started by the *root* user or another user with root permissions by typing `/etc/netcli`.

The Console Setup menu can be disabled by unchecking *Enable Console Menu* in `System → Advanced`.

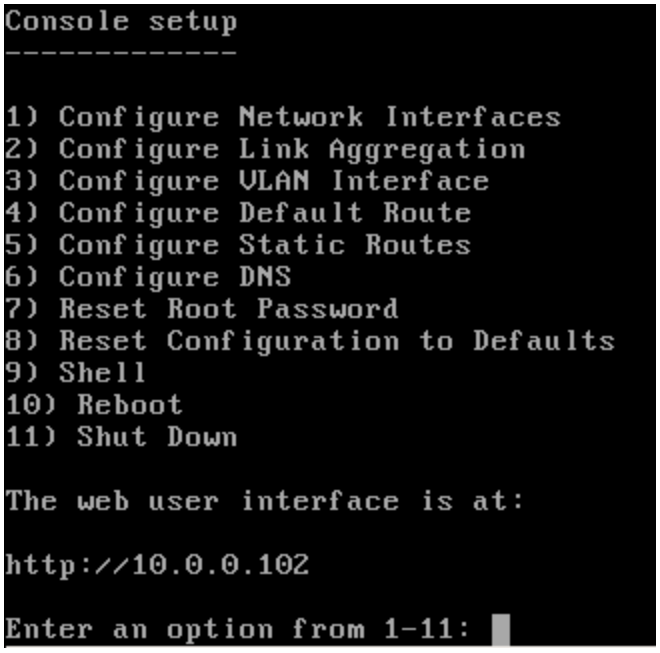


Fig. 3.1: Console Setup Menu

The menu provides these options:

1) Configure Network Interfaces provides a configuration wizard to set up the system's network interfaces.

2) Configure Link Aggregation is for creating or deleting link aggregations.

3) Configure VLAN Interface is used to create or delete VLAN interfaces.

4) Configure Default Route is used to set the IPv4 or IPv6 default gateway. When prompted, enter the IP address of the default gateway.

5) Configure Static Routes prompts for the destination network and gateway IP address. Re-enter this option for each static route needed.

6) Configure DNS prompts for the name of the DNS domain and the IP address of the first DNS server. When adding multiple DNS servers, press `Enter` to enter the next one. Press `Enter` twice to leave this option.

7) Reset Root Password is used to reset a lost or forgotten `root` password. Select this option and follow the prompts to set the password.

8) Reset Configuration to Defaults **Caution**! This option deletes *all* of the configuration settings made in the administrative GUI and is used to reset a FreeNAS® system back to defaults. **Before selecting this option, make a full backup of all data and make sure all encryption keys and passphrases are known!** After this option is selected, the configuration is reset to defaults and the system reboots. `Storage → Pools → Import Pool` can be used to re-import pools.

9) Shell starts a shell for running FreeBSD commands. To leave the shell, type `exit`.

10) Reboot reboots the system.

11) Shut Down shuts down the system.

Note: The numbering and quantity of options on this menu can change due to software updates, service agreements, or other factors. Please carefully check the menu before selecting an option, and keep this in mind when writing local procedures.

3.1 Obtaining an IP Address

During boot, FreeNAS® automatically attempts to connect to a DHCP server from all live network interfaces. If it successfully receives an IP address, the address is displayed so it can be used to access the graphical user interface. The example in Figure 3.1 shows a FreeNAS® system that is accessible at *http://192.168.1.119*.

Some FreeNAS® systems are set up without a monitor, making it challenging to determine which IP address has been assigned. On networks that support Multicast DNS (mDNS), the hostname and domain can be entered into the address bar of a browser. By default, this value is *freenas.local*.

If the FreeNAS® server is not connected to a network with a DHCP server, use the console network configuration menu to manually configure the interface as shown here. In this example, the FreeNAS® system has one network interface, *em0*.

```
Enter an option from 1-12: 1
1) em0
Select an interface (q to quit): 1
Reset network configuration (y/n) n
Configure interface for DHCP? (y/n) n
Configure IPv4? (y/n) y
Interface name:     (press enter, the name can be blank)
Several input formats are supported
Example 1 CIDR Notation:
    192.168.1.1/24
Example 2 IP and Netmask separate:
    IP: 192.168.1.1
    Netmask: 255.255.255.0, or /24 or 24
IPv4 Address: 192.168.1.108/24
Saving interface configuration: Ok
Configure IPv6? (y/n) n
Restarting network: ok

...

The web user interface is at
http://192.168.1.108
```

After the system has an IP address, enter that address into a graphical web browser from a computer connected to the same network as the FreeNAS® system.

3.2 Logging In

By default, the login screen shown in Figure 3.2 prompts to log into the new UI.

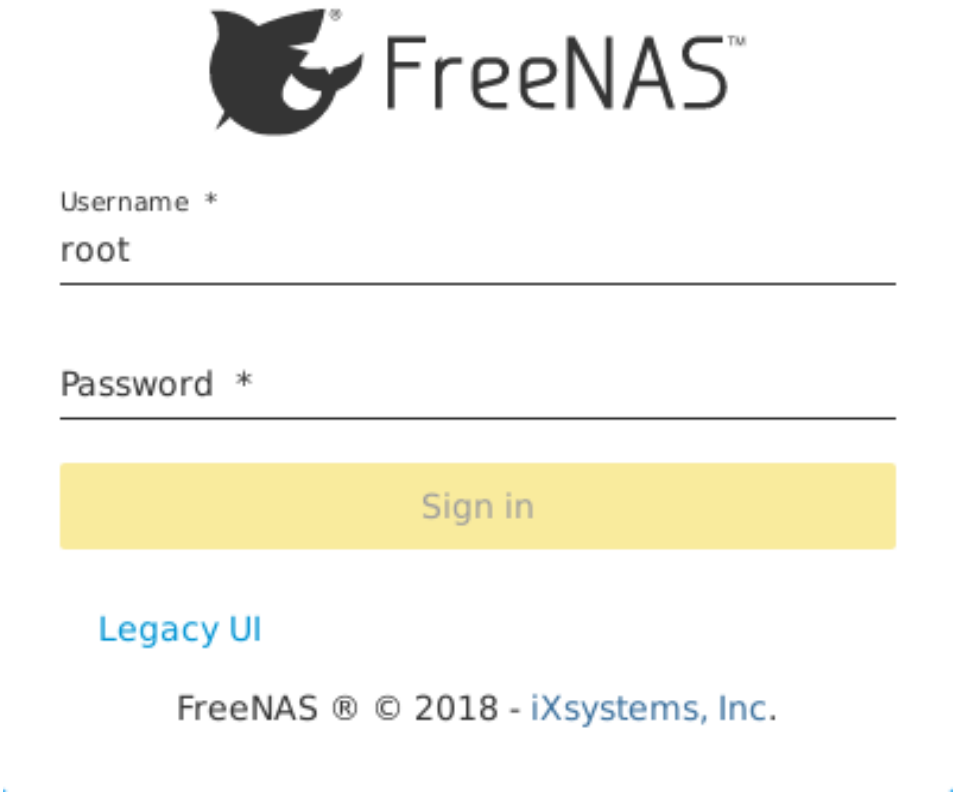


Fig. 3.2: Enter the Root Password

To instead log into the legacy UI, click the *Legacy UI* link.

Enter the password for the root user that was chosen during the installation. The administrative GUI for the legacy UI is displayed as shown in Figure 3.3.

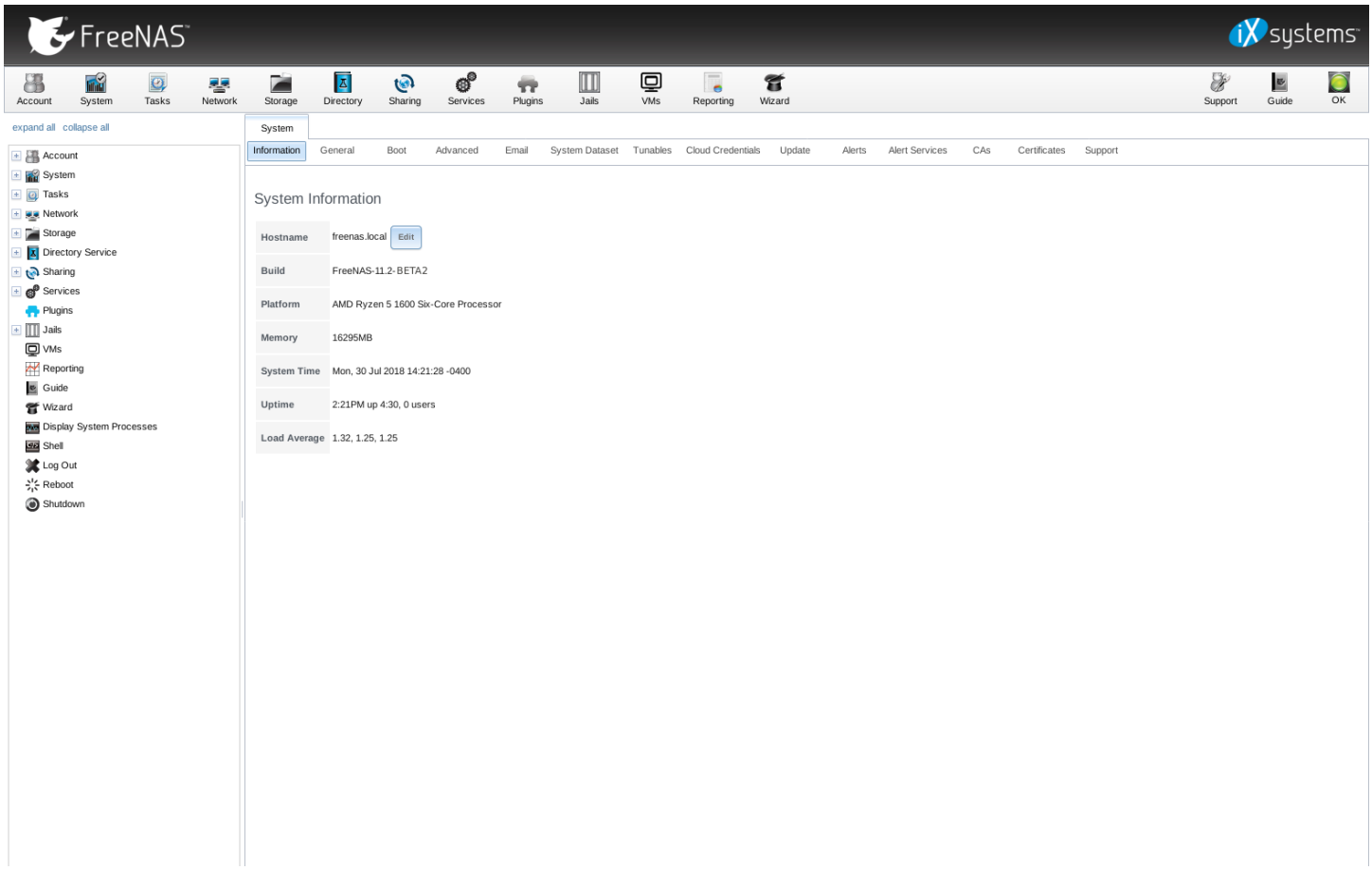


Fig. 3.3: FreeNAS® Graphical Configuration Menu

Note: The rest of this Guide describes the legacy UI. To access the Guide for the new UI, log into the new UI and click *Guide* or access it online at doc.freenas.org/11.2/freenas.html.

If the FreeNAS® system does not respond to the IP address or mDNS name entered in a browser:

- If proxy settings are enabled in the browser configuration, disable them and try connecting again.
- If the page does not load, check whether the FreeNAS® system's IP address responds to a `ping` from another computer on the same network. If the FreeNAS® IP address is in a private IP address range, it can only be accessed from within that private network.
- If the user interface loads but is unresponsive or seems to be missing menu items, try a different web browser. IE9 has known issues and does not display the graphical administrative interface correctly if compatibility mode is turned on. Firefox (https://www.mozilla.org/en-US/firefox/all/) is recommended.
- If *An error occurred!* messages are shown when attempting to configure an item in the GUI, make sure that the browser is set to allow cookies from the FreeNAS® system.

This blog post (http://fortysomethinggeek.blogspot.com/2012/10/ipad-iphone-connect-with-freenas-or-any.html) describes some applications which can be used to access the FreeNAS® system from an iPad or iPhone.

3.3 Initial Configuration

The first time the FreeNAS® GUI is accessed, the *Wizard* (page 274) starts automatically to help configure the FreeNAS® device quickly and easily.

CHAPTER

FOUR

ACCOUNT

The Account Configuration section of the administrative GUI describes how to manually create and manage users and groups. This section contains these entries:

- *Groups* (page 49): used to manage UNIX-style groups on the FreeNAS® system.
- *Users* (page 52): used to manage UNIX-style accounts on the FreeNAS® system.

Each entry is described in more detail in this section.

4.1 Groups

The Groups interface provides management of UNIX-style groups on the FreeNAS® system.

Note: It is unnecessary to recreate the network users or groups when a directory service is running on the same network. Instead, import the existing account information into FreeNAS®. Refer to *Directory Services* (page 162) for details.

This section describes how to create a group and assign user accounts to it. The next section, *Users* (page 52), describes creating user accounts.

Click `Groups` → `View Groups` to see a screen like Figure 4.1.

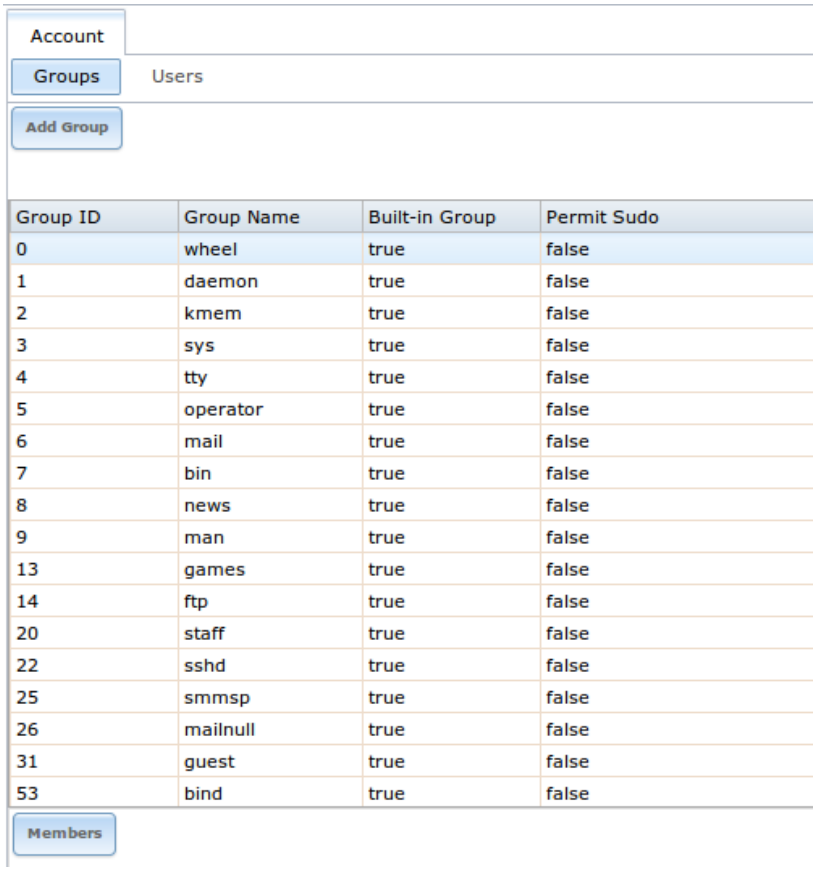


Fig. 4.1: Group Management

The *Groups* page lists all groups, including those built-in and used by the operating system. The table displays group names, group IDs (GID), built-in groups, and if `sudo` is permitted. Clicking a group entry causes a *Members* button to appear. Click the button to view and modify the group membership

The *Add Group* button opens the screen shown in Figure 4.2. Table 4.1 summarizes the available options when creating a group.

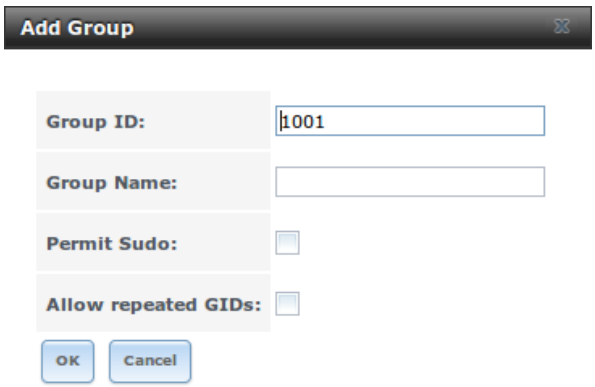


Fig. 4.2: Creating a New Group

Table 4.1: Group Creation Options

Setting	Value	Description
Group ID	string	The next available group ID is suggested. UNIX groups containing user accounts typically have an ID greater than 1000 and groups required by a service have an ID equal to the default port number used by the service. Example: the sshd group has an ID of 22.
Group Name	string	Required. Enter a descriptive name for the new group.
Permit Sudo	checkbox	Set to allow group members to use sudo (https://www.sudo.ws/). When using `sudo`, a user is prompted for their own password.
Allow repeated GIDs	checkbox	Set to allow multiple groups to share the same group id (GID). This is useful when a GID is already associated with the UNIX permissions for existing data, but is generally not recommended.

After a group and users are created, users can be added to a group. Highlight the group where users will be assigned, then click the *Members* button. Highlight the user in the *Member users* list. This shows all user accounts on the system. Click >> to move that user to the right frame. The user accounts which appear in the right frame are added as members of the group.

Figure 4.3, shows user1 added as a member of group data1.

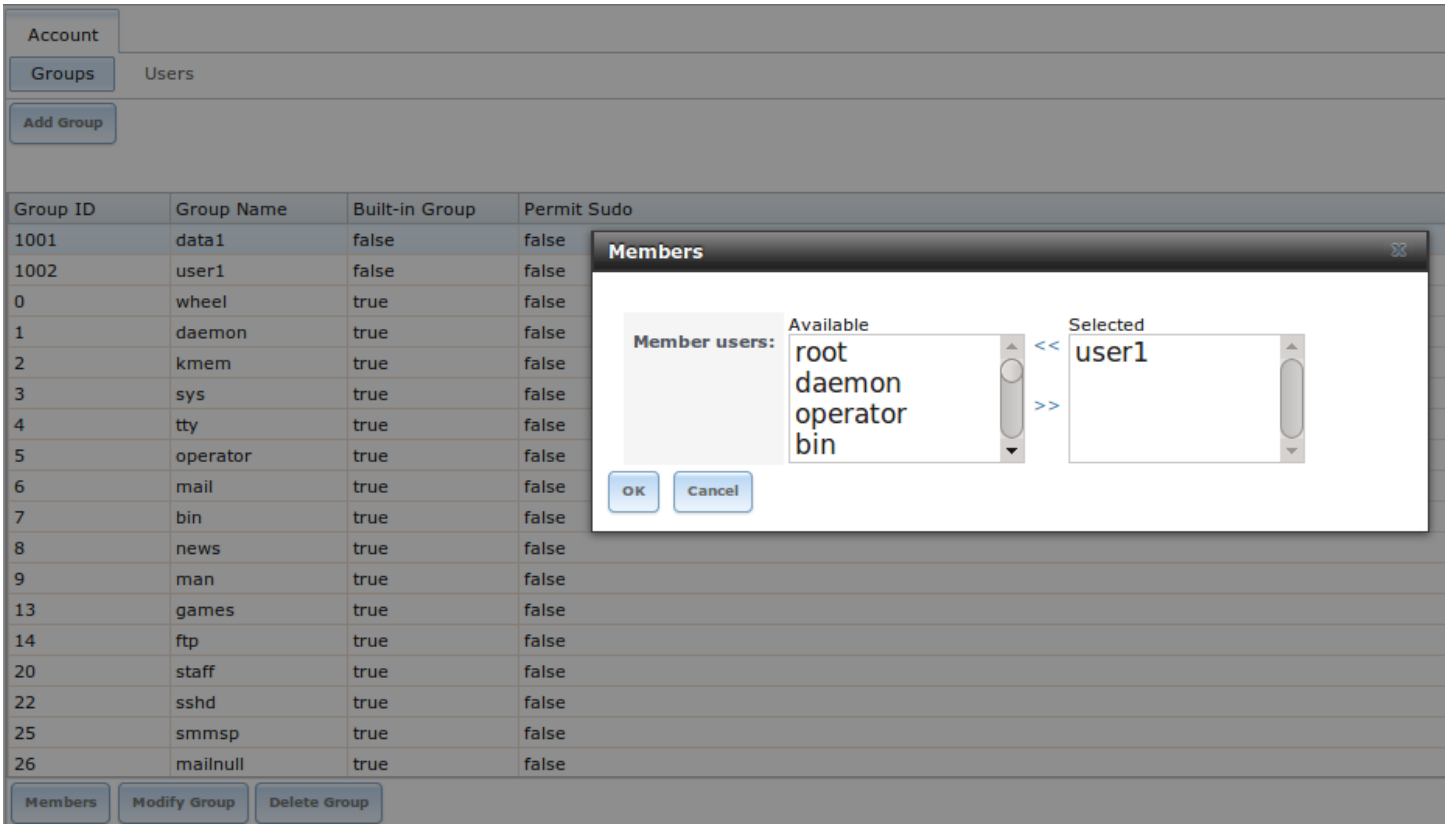


Fig. 4.3: Assigning a User to a Group

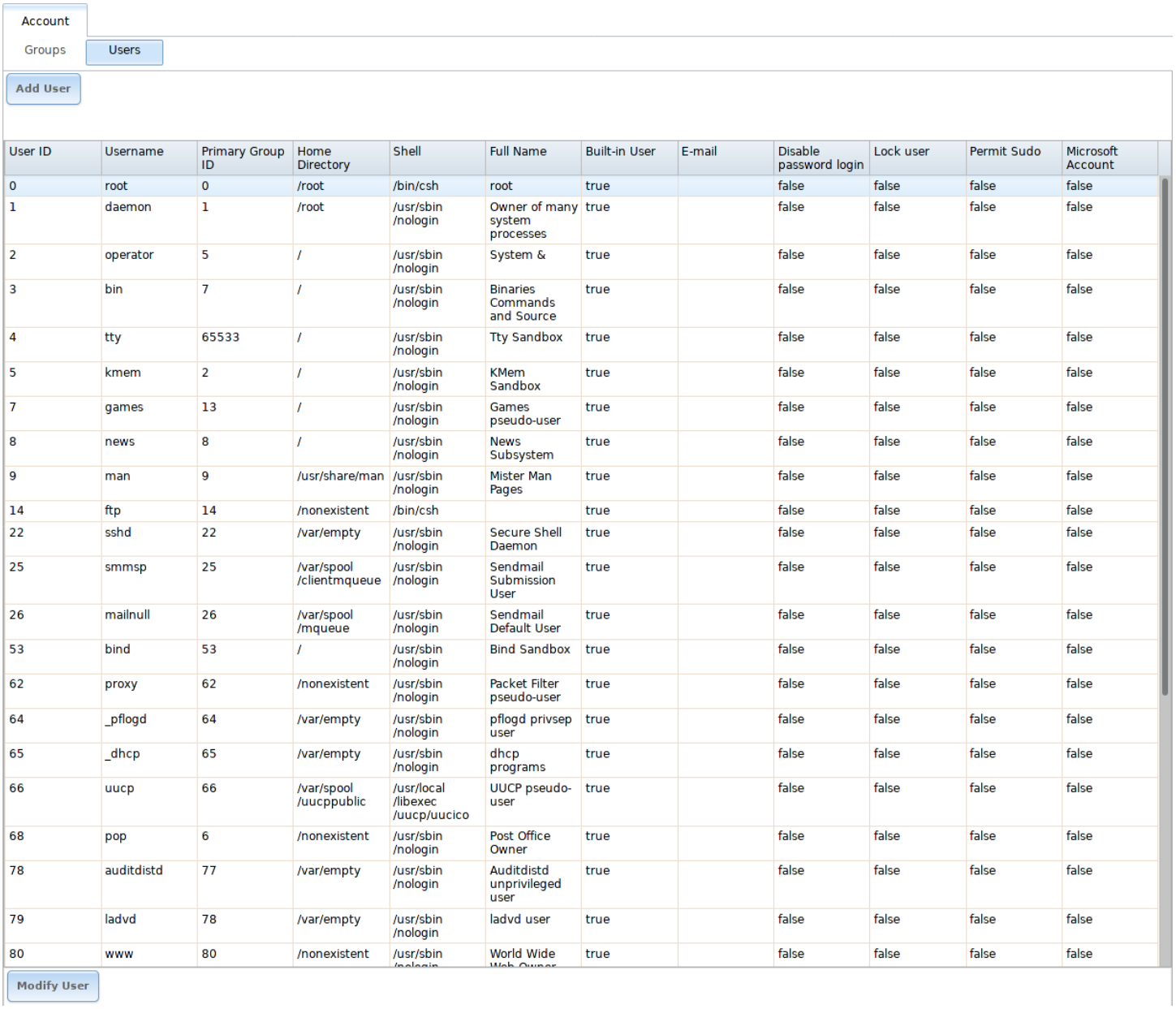
The *Delete Group* button deletes a group. The pop-up message asks whether all members of that group should also be deleted. Note that the built-in groups do not provide a *Delete Group* button.

4.2 Users

FreeNAS® supports users, groups, and permissions, allowing flexibility in configuring which users have access to the data stored on FreeNAS®. To assign permissions to shares, **one of these options** must be done:

1. Create a guest account for all users, or create a user account for every user in the network where the name of each account is the same as a login name used on a computer. For example, if a Windows system has a login name of *bobsmith*, create a user account with the name *bobsmith* on FreeNAS®. A common strategy is to create groups with different sets of permissions on shares, then assign users to those groups.
2. If the network uses a directory service, import the existing account information using the instructions in *Directory Services* (page 162).

`Account → Users → View Users` lists all system accounts installed with the FreeNAS® operating system, as shown in Figure 4.4.



User ID	Username	Primary Group ID	Home Directory	Shell	Full Name	Built-in User	E-mail	Disable password login	Lock user	Permit Sudo	Microsoft Account
0	root	0	/root	/bin/csh	root	true		false	false	false	false
1	daemon	1	/root	/usr/sbin /nologin	Owner of many system processes	true		false	false	false	false
2	operator	5	/	/usr/sbin /nologin	System &	true		false	false	false	false
3	bin	7	/	/usr/sbin /nologin	Binaries Commands and Source	true		false	false	false	false
4	tty	65533	/	/usr/sbin /nologin	Tty Sandbox	true		false	false	false	false
5	kmem	2	/	/usr/sbin /nologin	KMem Sandbox	true		false	false	false	false
7	games	13	/	/usr/sbin /nologin	Games pseudo-user	true		false	false	false	false
8	news	8	/	/usr/sbin /nologin	News Subsystem	true		false	false	false	false
9	man	9	/usr/share/man	/usr/sbin /nologin	Mister Man Pages	true		false	false	false	false
14	ftp	14	/nonexistent	/bin/csh		true		false	false	false	false
22	sshd	22	/var/empty	/usr/sbin /nologin	Secure Shell Daemon	true		false	false	false	false
25	smmsp	25	/var/spool /clientmqueue	/usr/sbin /nologin	Sendmail Submission User	true		false	false	false	false
26	mailnull	26	/var/spool /mqueue	/usr/sbin /nologin	Sendmail Default User	true		false	false	false	false
53	bind	53	/	/usr/sbin /nologin	Bind Sandbox	true		false	false	false	false
62	proxy	62	/nonexistent	/usr/sbin /nologin	Packet Filter pseudo-user	true		false	false	false	false
64	_pflogd	64	/var/empty	/usr/sbin /nologin	pflogd privsep user	true		false	false	false	false
65	_dhcp	65	/var/empty	/usr/sbin /nologin	dhcp programs	true		false	false	false	false
66	uucp	66	/var/spool /uucppublic	/usr/local /libexec /uucp/uucico	UUCP pseudo-user	true		false	false	false	false
68	pop	6	/nonexistent	/usr/sbin /nologin	Post Office Owner	true		false	false	false	false
78	auditdistd	77	/var/empty	/usr/sbin /nologin	Auditdistd unprivileged user	true		false	false	false	false
79	ladvd	78	/var/empty	/usr/sbin /nologin	ladvd user	true		false	false	false	false
80	www	80	/nonexistent	/usr/sbin /nologin	World Wide Web Owner	true		false	false	false	false

Fig. 4.4: Managing User Accounts

Each account entry indicates the user ID, username, primary group ID, home directory, default shell, full name, whether it is a built-in user that came with the FreeNAS® installation, the email address, if logins are disabled, if the user account is locked, whether the user is allowed to use `sudo`, and if the user connects from a Windows 8 or newer system. To reorder the list, click the desired column name. An arrow indicates which column controls the view sort order. Click the arrow to reverse the sort order.

Click a user account to cause these buttons to appear:

- **Modify User:** used to modify the account's settings, as listed in Table 4.2.
- **Change E-mail:** used to change the email address associated with the account.

Note: Setting the the email address for the built-in *root* user account is recommended as important system messages are sent to the *root* user. For security reasons, password logins are disabled for the *root* account and changing this setting is discouraged.

Except for the *root* user, the accounts that come with FreeNAS® are system accounts. Each system account is used by a service and should not be used as a login account. For this reason, the default shell on system accounts is nologin(8) (https://www.freebsd.org/cgi/man.cgi?query=nologin). For security reasons and to prevent breakage of system services, do not modify the system accounts.

The *Add User* button opens the screen shown in Figure 4.5. Some settings are only available in *Advanced Mode*. To see these settings, either click *Advanced Mode* or configure the system to always display these settings by setting *Show advanced fields by default* in `System` → `Advanced`. Table 4.2 summarizes the options which are available when user accounts are created or modified.

Warning: When using *Active Directory* (page 162), Windows user passwords must be set from within Windows.

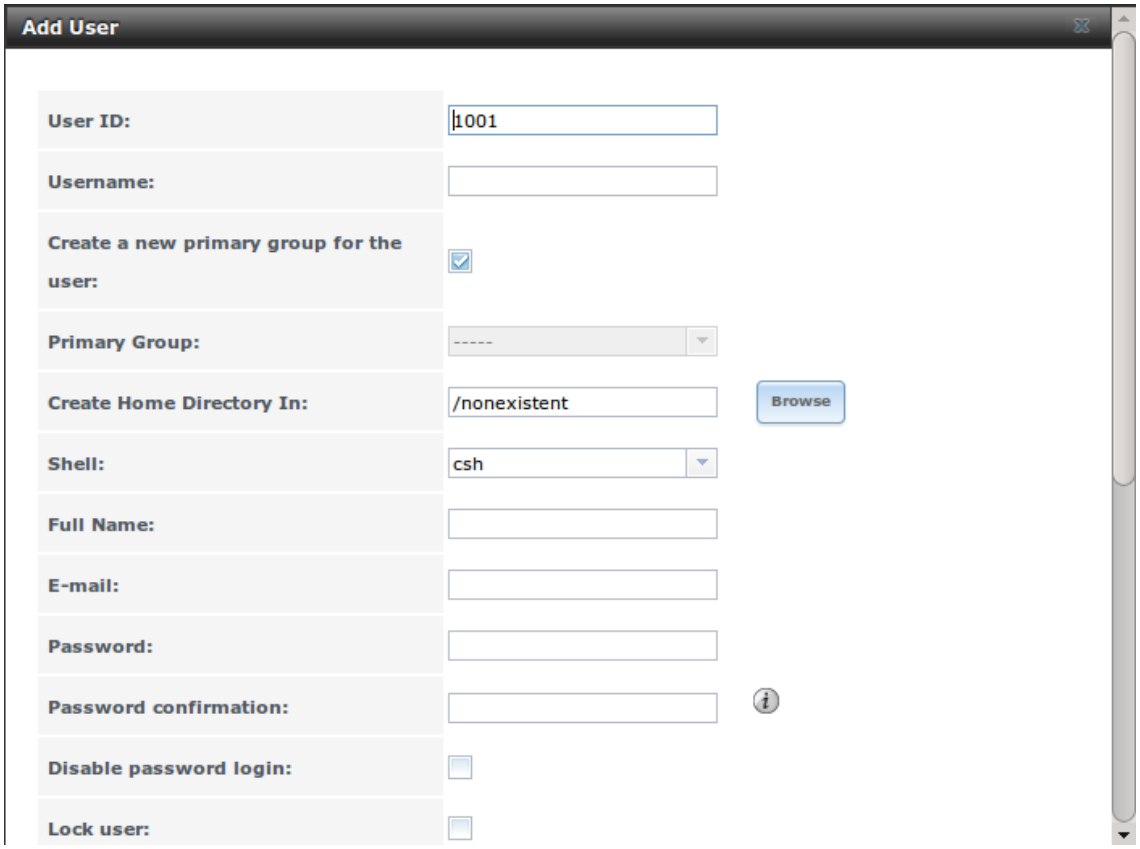


Fig. 4.5: Adding or Editing a User Account

Table 4.2: User Account Configuration

Setting	Value	Advanced Mode	Description
User ID	integer		Grayed out if the user already exists. When creating an account, the next numeric ID is suggested. User accounts typically have an ID greater than 1000 and system accounts have an ID equal to the default port number used by the service.
Username	string		Grayed out if the user already exists. Maximum 16 characters, though a maximum of 8 is recommended for interoperability. Cannot begin with a hyphen –, if a `$` is used it can only be the last character, and it cannot contain a space, tab, or the characters `, : + & # % ^ & ( ) ! @ ~ * ? < > =`.
Create a new primary group	checkbox		A primary group with the same name as the user is created automatically. Unset to select a different primary group name.
Primary Group	drop-down menu		Unset *Create a new primary group* to access this menu. For security reasons, FreeBSD does not give a user `su` permissions if *wheel* is their primary group. To give a user `su` access, add them to the *wheel* group in *Auxiliary groups*.
Create Home Directory In	browse button		Browse to the name of an **existing** volume or dataset that the user will be assigned permission to access.
Home Directory Mode	checkboxes	✓	Sets default Unix permissions of the user's home directory. This is read-only for built-in users.
Shell	drop-down menu		Select the shell to use for local and SSH logins. See Table 4.3 for an overview of available shells.
Full Name	string		Required. This field may contain spaces.
E-mail	string		The email address associated with the account.
Password	string		Required unless *Disable password login* is set. Cannot contain a `?`.
Password confirmation	string		This must match the value of *Password*.
Disable password login	checkbox		Set to disable password logins and authentication to SMB shares. To undo this setting, create a password for the user by clicking *Modify User* for the user in the *View Users* screen. Setting this grays out *Lock user* and *Permit Sudo*.
Lock user	checkbox		Set to prevent the user from logging in until this box is unset. Setting this grays out *Disable password login*.
Permit Sudo	checkbox		Set to give group members permission to use sudo (https://www.sudo.ws/). When using `sudo`, a user is prompted for their own password.
Microsoft Account	checkbox		Set this when the user is connecting from a Windows 8 or newer system.
SSH Public Key	string		Enter or paste the user's **public** SSH key to be used for key-based authentication. **Do not paste the private key!**
Auxiliary groups	mouse selection		Highlight groups to add the user. Click the >> to add the user to the highlighted groups.

Note: Some fields cannot be changed for built-in users and will be grayed out.

Table 4.3: Available Shells

Shell	Description
netcli.sh	User is shown the Console Setup menu (Figure 3.1) on connection, even if it is disabled in `System → Advanced → Enable Console Menu`. The user must be *root* or have root permissions (effective user ID 0, like *toor*).
csh	C shell (https://en.wikipedia.org/wiki/C_shell)
sh	Bourne shell (https://en.wikipedia.org/wiki/Bourne_shell)
tcsh	Enhanced C shell (https://en.wikipedia.org/wiki/Tcsh)
nologin	Use when creating a system account or to create a user account that can authenticate with shares but which cannot login to the FreeNAS system using `ssh`.
bash	Bourne Again shell (https://en.wikipedia.org/wiki/Bash_%28Unix_shell%29)
ksh93	Korn shell (http://www.kornshell.com/)
mksh	mirBSD Korn shell (https://www.mirbsd.org/mksh.htm)
rbash	Restricted bash (http://www.gnu.org/software/bash/manual/html_node/The-Restricted-Shell.html)
rzsh	Restricted zsh (http://www.csse.uwa.edu.au/programming/linux/zsh-doc/zsh_14.html)
scponly	Select scponly (https://github.com/scponly/scponly/wiki) to restrict the user's SSH usage to only the `scp` and `sftp` commands.
zsh	Z shell (http://www.zsh.org/)
git-shell	restricted git shell (https://git-scm.com/docs/git-shell)

Built-in user accounts needed by the system cannot be removed. A *Remove User* button appears for custom users that were added by the system administrator. If the user to be removed is the last user in a custom group, an option is presented to delete the group as well.

CHAPTER

FIVE

SYSTEM

The System section of the administrative GUI contains these entries:

- *Information* (page 56) provides general FreeNAS® system information such as hostname, operating system version, platform, and uptime
- *General* (page 57) configures general settings such as HTTPS access, the language, and the timezone
- *Boot* (page 60) creates, renames, and deletes boot environments. It also shows the condition of the Boot Volume.
- *Advanced* (page 63) configures advanced settings such as the serial console, swap space, and console messages
- *Email* (page 67) configures the email address to receive notifications
- *System Dataset* (page 68) configures the location where logs and reporting graphs are stored
- *Tunables* (page 69) provides a front-end for tuning in real-time and to load additional kernel modules at boot time
- *Update* (page 71) performs upgrades and checks for system updates
- *Cloud Credentials* (page 75) is used to enter connection credentials for remote cloud service providers
- *Alerts* (page 76) lists the available *Alert* (page 289) conditions and provides configuration of the notification frequency for each alert.
- *Alert Services* (page 77) configures services used to notify the administrator about system events.
- *CAs* (page 79): import or create internal or intermediate CAs (Certificate Authorities)
- *Certificates* (page 81): import existing certificates or create self-signed certificates
- *Support* (page 84): report a bug or request a new feature.

Each of these is described in more detail in this section.

5.1 Information

`System` → `Information` displays general information about the FreeNAS® system. An example is seen in Figure 5.1.

The information includes hostname, build version, type of CPU (platform), amount of memory, current system time, system uptime, number of users connected at the console or by serial, telnet, or SSH connections, and current load average. On systems supplied or certified by iXsystems, an additional *Serial Number* field showing the hardware serial number is displayed.

To change the system hostname, click the *Edit* button, type in the new hostname, and click *OK*. The hostname must include the domain name. If the network does not use a domain name, add *.local* after the hostname.

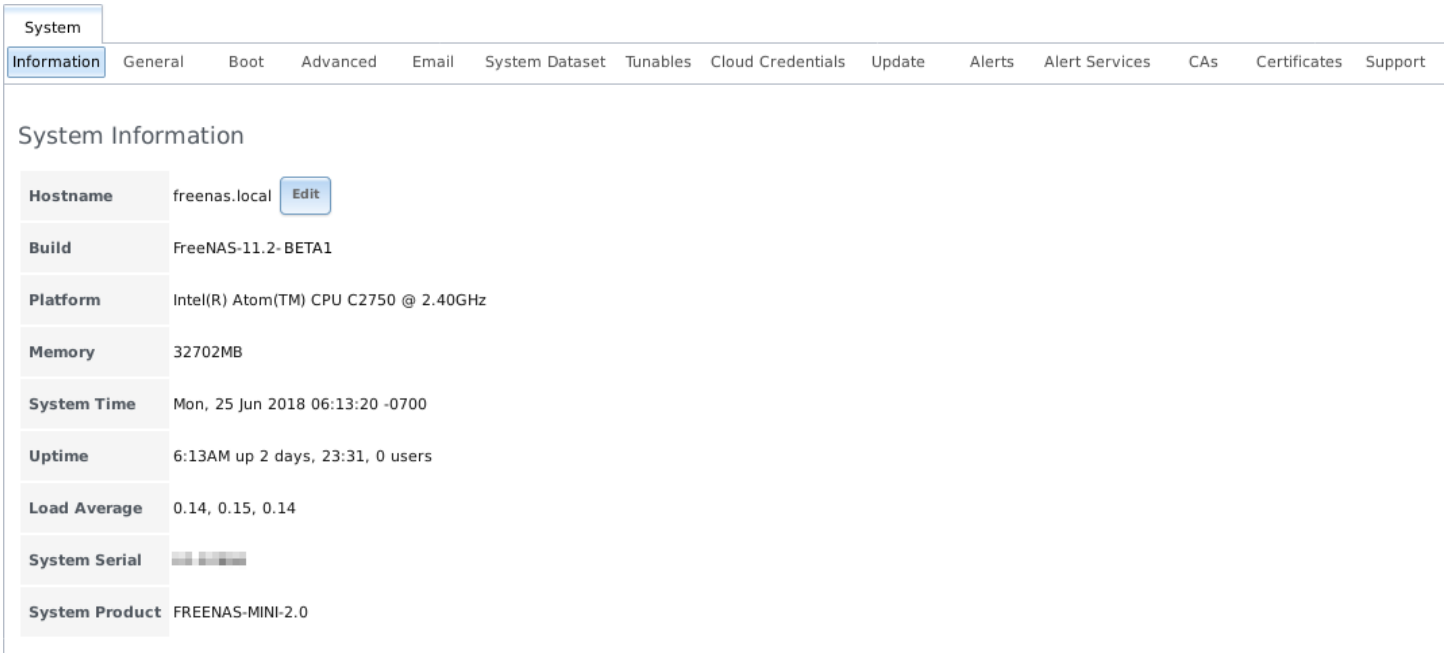


Fig. 5.1: System Information Tab

5.2 General

`System → General` is shown in Figure 5.2.

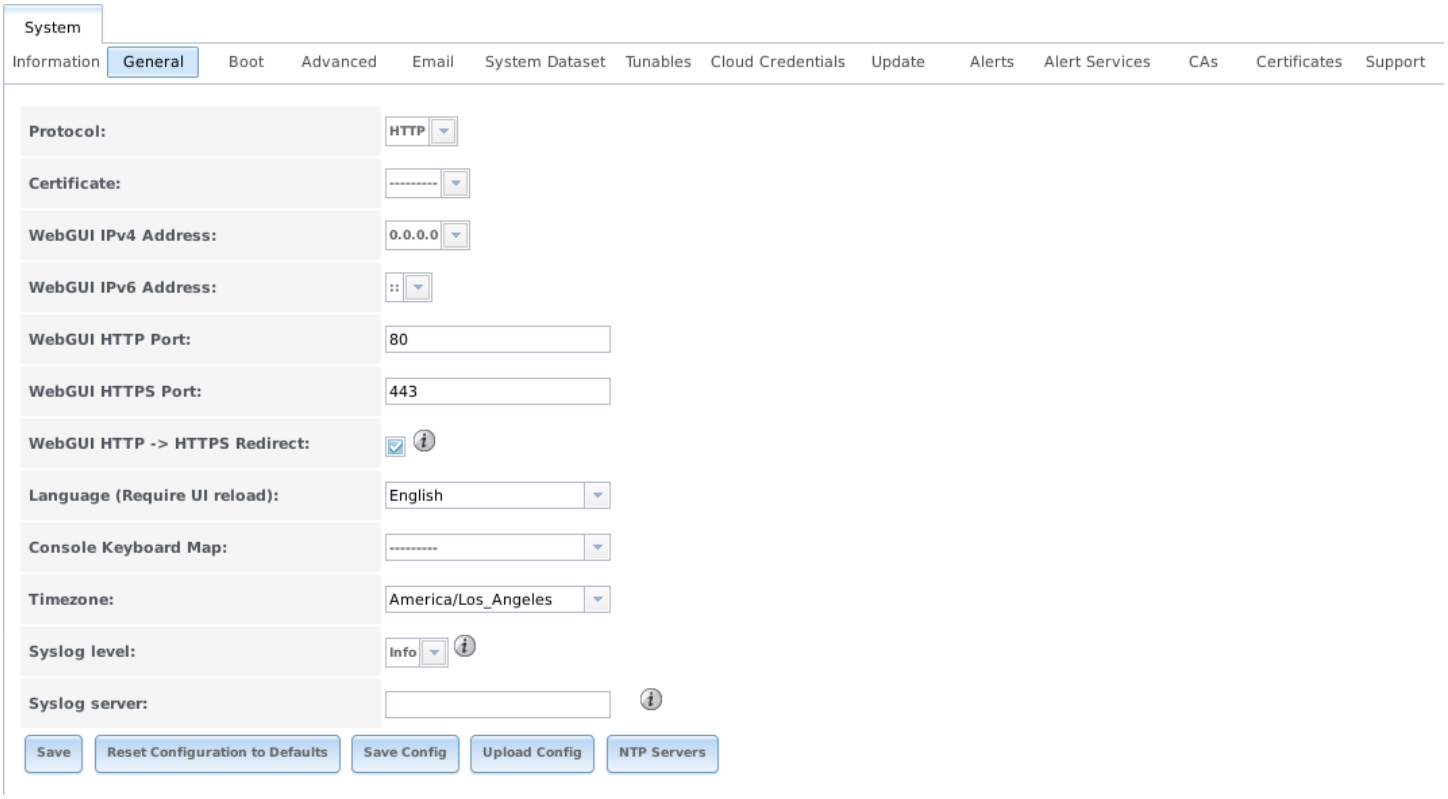


Fig. 5.2: General Screen

Table 5.1 summarizes the configurable settings in the General tab:

Table 5.1: General Configuration Settings

Setting	Value	Description
Protocol	drop-down menu	Set the web protocol to use when connecting to the administrative GUI from a browser. To change the default *HTTP* to *HTTPS* or to *HTTP+HTTPS*, select a certificate to use in *Certificate*. If there are no certificates, first create a *CA* (page 79) then a *certificate* (page 81).
Certificate	drop-down menu	Required for *HTTPS*. *Browse* to the location of the certificate to use for encrypted connections.
WebGUI IPv4 Address	drop-down menu	Choose a recent IP address to limit the usage when accessing the administrative GUI. The built-in HTTP server binds to the wildcard address of *0.0.0.0* (any address) and issues an alert if the specified address becomes unavailable.
WebGUI IPv6 Address	drop-down menu	Choose a recent IPv6 address to limit the usage when accessing the administrative GUI. The built-in HTTP server binds to any address issues an alert if the specified address becomes unavailable.
WebGUI HTTP Port	integer	Allow configuring a non-standard port for accessing the administrative GUI over HTTP. Changing this setting can also require changing a Firefox configuration setting (https://www.redbrick.dcu.ie/~d_fens/articles/Firefox:_This_Address_is_Restricted).
WebGUI HTTPS Port	integer	Allow configuring a non-standard port for accessing the administrative GUI over HTTPS.
WebGUI HTTP –> HTTPS Redirect	checkbox	Set to redirect *HTTP* connections to *HTTPS*. *HTTPS* must be selected in *Protocol*.
Language	drop-down menu	Select a localization. View the status of the localization at weblate.trueos.org (https://weblate.trueos.org/projects/freenas/).
Console Keyboard Map	drop-down menu	Select a keyboard layout.
Timezone	drop-down menu	Select a timezone.
Syslog level	drop-down menu	When *Syslog server* is defined, only logs matching this level are sent.
Syslog server	string	Select an *IP address_or_hostname:optional_port_number* to send logs to. Set to write log entries to both the console and the remote server.

After making any changes, click the *Save* button.

This screen also contains these buttons:

Reset Configuration to Defaults: reset the configuration database to the default base version. This does not delete user SSH keys or any other data stored in a user home directory. Since configuration changes stored in the configuration database are erased, this option is useful when a mistake has been made or to return a test system to the original configuration.

Save Config: save a backup copy of the current configuration database in the format *hostname-version-architecture* to the computer accessing the administrative interface. Saving the configuration after making any configuration changes is highly recommended. FreeNAS® automatically backs up the configuration database to the system dataset every morning at 3:45. However, this backup does not occur if the system is shut down at that time. If the system dataset is stored on the boot pool and the boot pool becomes unavailable, the backup will also not be available. The location of the system dataset is viewed or set using `System → System Dataset`.

Note: *SSH* (page 240) keys are not stored in the configuration database and must be backed up separately.

There are two types of passwords. User account passwords for the base operating system are stored as hashed values, do not need to be encrypted to be secure, and are saved in the system configuration backup. Other passwords, like iSCSI

CHAP passwords, Active Directory bind credentials, and cloud credentials are stored in an encrypted form to prevent them from being visible as plain text in the saved system configuration. The key or *seed* for this encryption is normally stored only on the boot device. When *Save Config* is chosen, a dialog gives the option to *Export Password Secret Seed* with the saved configuration, allowing the configuration file to be restored to a different boot device where the decryption seed is not already present. Configuration backups containing the seed must be physically secured to prevent decryption of passwords and unauthorized access.

Warning: The *Export Password Secret Seed* option is off by default and should only be used when making a configuration backup that will be stored securely. After moving a configuration to new hardware, media containing a configuration backup with a decryption seed should be securely erased before reuse.

Upload Config: allows browsing to the location of a previously saved configuration file to restore that configuration. The screen turns red as an indication that the system will need to reboot to load the restored configuration.

NTP Servers: The network time protocol (NTP) is used to synchronize the time on the computers in a network. Accurate time is necessary for the successful operation of time sensitive applications such as Active Directory or other directory services. By default, FreeNAS® is pre-configured to use three public NTP servers. If the network is using a directory service, ensure that the FreeNAS® system and the server running the directory service have been configured to use the same NTP servers.

Available NTP servers can be found at https://support.ntp.org/bin/view/Servers/NTPPoolServers. For time accuracy, choose NTP servers that are geographically close to the physical location of the FreeNAS® system.

Click `NTP Servers → Add NTP Server` to add an NTP server. Figure 5.3 shows the screen that appears. Table 5.2 summarizes the options available when adding an NTP server. ntp.conf(5) (https://www.freebsd.org/cgi/man.cgi?query=ntp.conf) explains these options in more detail.

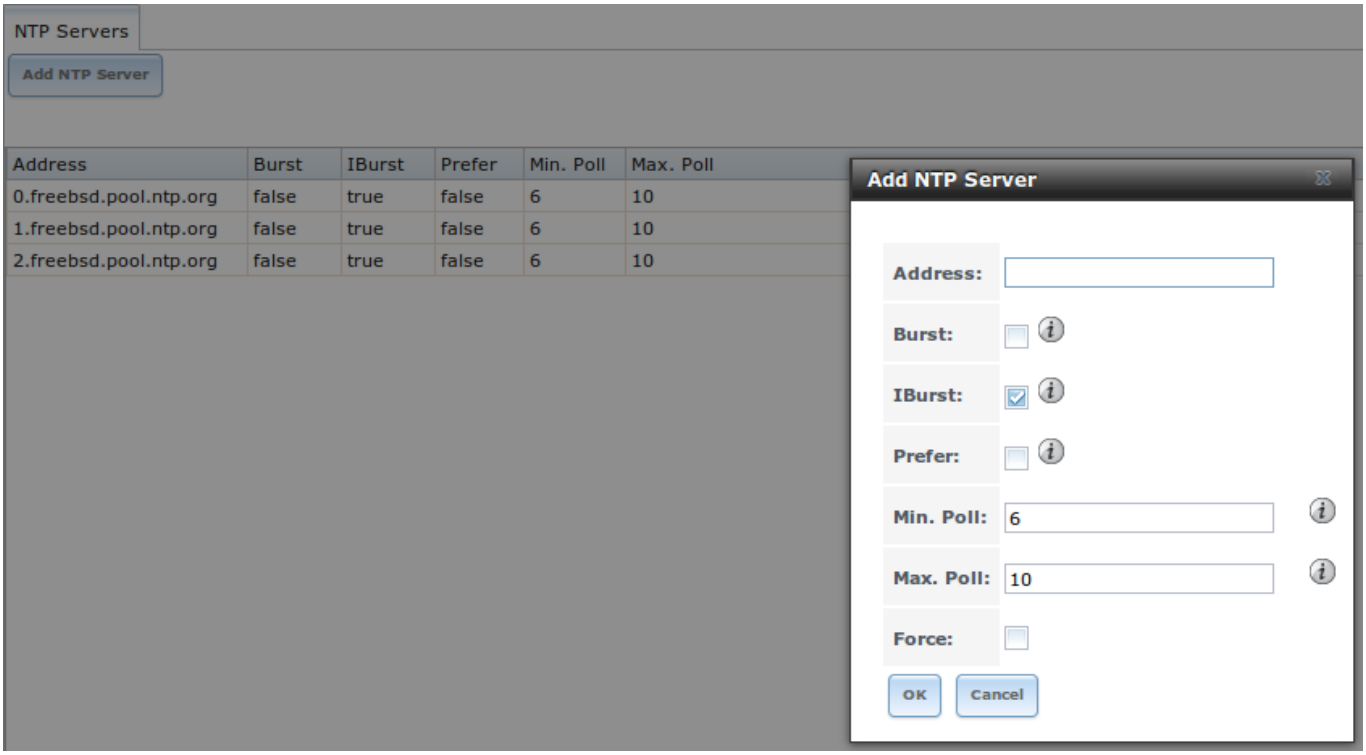


Fig. 5.3: Add an NTP Server

Table 5.2: NTP Servers Configuration Options

Setting	Value	Description
Address	string	Enter the hostname or IP address of the NTP server.
Burst	checkbox	Recommended when *Max. Poll* is greater than *10*. Only use on private servers. **Do not** use with a public NTP server.
IBurst	checkbox	Speed up the initial synchronization, taking seconds rather than minutes.
Prefer	checkbox	This option is only recommended for highly accurate NTP servers, such as those with time monitoring hardware.
Min. Poll	integer	Minimum polling time in seconds. Must be a power of 2, and cannot be lower than *4* or higher than *Max. Poll*.
Max. Poll	integer	Maximum polling time in seconds. Must be a power of 2, and cannot be higher than *17* or lower than *Min. Poll*.
Force	checkbox	Force the addition of the NTP server, even if it is currently unreachable.

5.3 Boot

FreeNAS® supports a ZFS feature known as multiple boot environments. With multiple boot environments, the process of updating the operating system becomes a low-risk operation. The updater automatically creates a snapshot of the current boot environment and adds it to the boot menu before applying the update.

If an update fails, reboot the system and select the previous boot environment, using the instructions in *If Something Goes Wrong* (page 25), to instruct the system to go back to that system state.

Note: Boot environments are separate from the configuration database. Boot environments are a snapshot of the *operating system* at a specified time. When a FreeNAS® system boots, it loads the specified boot environment, or operating system, then reads the configuration database to load the current configuration values. If the intent is to make configuration changes rather than operating system changes, make a backup of the configuration database first using `System → General → Save Config`.

As seen in Figure 5.4, FreeNAS® displays the condition and statistics of the *Boot Volume*. It also shows the two boot environments that are created when FreeNAS® is installed. The system will boot into the *default* boot environment and users can make their changes and update from this version. The *Initial-Install* boot environment can be booted into if the system needs to be returned to a non-configured version of the installation.

If the *Wizard* (page 274) was used, a third boot environment called `Wizard-date` is also created, indicating the date and time the *Wizard* (page 274) was run.

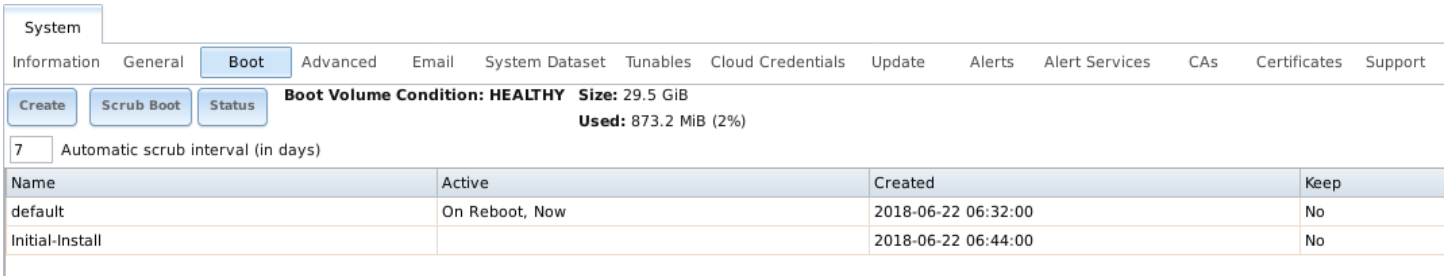


Fig. 5.4: Viewing Boot Environments

Each boot environment entry contains this information:

- **Name:** the name of the boot entry as it will appear in the boot menu.
- **Active:** indicates which entry will boot by default if the user does not select another entry in the boot menu.

- **Created:** indicates the date and time the boot entry was created.
- **Keep:** indicates whether or not this boot environment can be pruned if an update does not have enough space to proceed. Click *Keep* for an entry if that boot environment should not be automatically pruned.

Highlight an entry to view the configuration buttons for it. These configuration buttons are shown:

- **Rename:** used to change the name of the boot environment.
- **Keep/Unkeep:** used to toggle whether or not the updater can prune (automatically delete) this boot environment if there is not enough space to proceed with the update.
- **Clone:** used to create a copy of the highlighted boot environment.
- **Delete:** used to delete the highlighted entry, which also removes that entry from the boot menu. Since an activated entry cannot be deleted, this button does not appear for the active boot environment. To delete an entry that is currently activated, first activate another entry, which will clear the *On reboot* field of the currently activated entry. Note that this button does not appear for the *default* boot environment as this entry is needed to return the system to the original installation state.
- **Activate:** only appears on entries which are not currently set to *Active*. Changes the selected entry to the default boot entry on next boot. Its status changes to *On Reboot* and the current *Active* entry changes from *On Reboot, Now* to *Now*, indicating that it was used on the last boot but will not be used on the next boot.

The buttons above the boot entries can be used to:

- **Create:** a manual boot environment. A pop-up menu prompts for entry of a *Name* for the boot environment. Only alphanumeric characters, underscores, and dashes are allowed.
- **Scrub Boot:** can be used to perform a manual scrub of the boot devices. By default, the boot device is scrubbed every 7 days. To change the default interval, change the number in the *Automatic scrub interval (in days)* field. The date and results of the last scrub are also listed in this screen. The condition of the boot device should be listed as *HEALTHY*.
- **Status:** click this button to see the status of the boot devices. Figure 5.5, shows only one boot device, which is *ONLINE*.

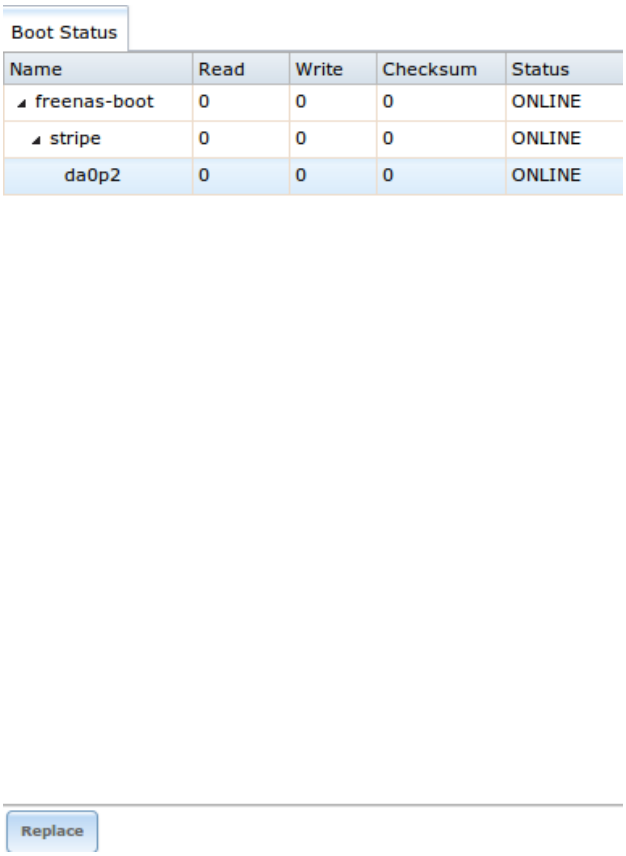


Fig. 5.5: Viewing the Status of the Boot Device

If the system has a mirrored boot pool, there will be a *Detach* button in addition to the *Replace* button. To remove a device from the boot pool, highlight the device and click its *Detach* button. Alternately, if one of the boot devices has an *OFFLINE Status*, click the device to replace, then click *Replace* to rebuild the boot mirror.

Note that **you cannot replace the boot device if it is the only boot device** as it contains the operating system itself.

5.3.1 Mirroring the Boot Device

If the system is currently booting from a device, another device can be added to create a mirrored boot device. If one device in a mirror fails, the remaining device can still be used to boot the system.

Note: When adding another boot device for a mirror, the new device must have at least the same capacity as the existing boot device. Larger capacity devices can be added, but the mirror will only have the capacity of the smallest device. Different models of devices which advertise the same nominal size are not necessarily the same actual size. For this reason, adding another of the same model of boot device is recommended.

In the example shown in Figure 5.6, the user has clicked `System → Boot → Status` to display the current status of the boot device. The example indicates that there is currently one device, *ada0p2*, its status is *ONLINE*, and it is currently the only boot device as indicated by the word *stripe*. To create a mirrored boot device, click either the entry called *freenas-boot* or *stripe*, then click the *Attach* button. If another device is available, it appears in the *Member disk* drop-down menu. Select the desired device.

The *Use all disk space* option gives control of how much of the new device is made available to ZFS. The new device is partitioned to the same size as the existing device by default. Select *Use all disk space* to use all available space on the new device. If either device in the mirror fails, it can be replaced with another of the same size as the original boot device.

When *Use all disk space* is enabled, the entire capacity of the new device is used. If the original boot device fails and is removed, the boot mirror will consist of just the newer drive, and will grow to whatever capacity it provides. However, new devices added to this mirror must now be as large as the new capacity.

Click *Attach Disk* to attach the new disk to the mirror.

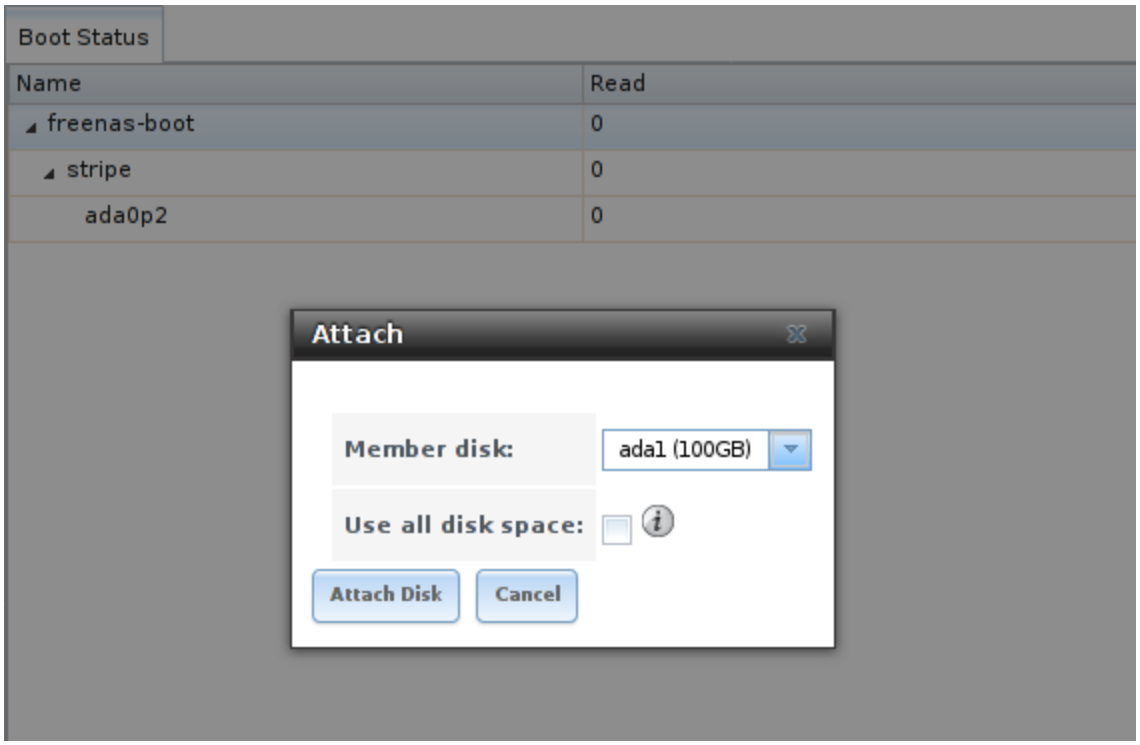


Fig. 5.6: Mirroring a Boot Device

After the mirror is created, the *Status* screen indicates that it is now a *mirror*. The number of devices in the mirror are shown as in Figure 5.7.

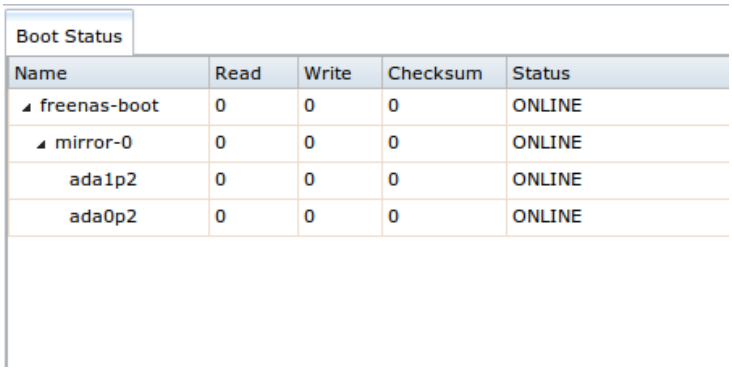


Fig. 5.7: Viewing the Status of a Mirrored Boot Device

5.4 Advanced

`System → Advanced` is shown in Figure 5.8. The configurable settings are summarized in Table 5.3.

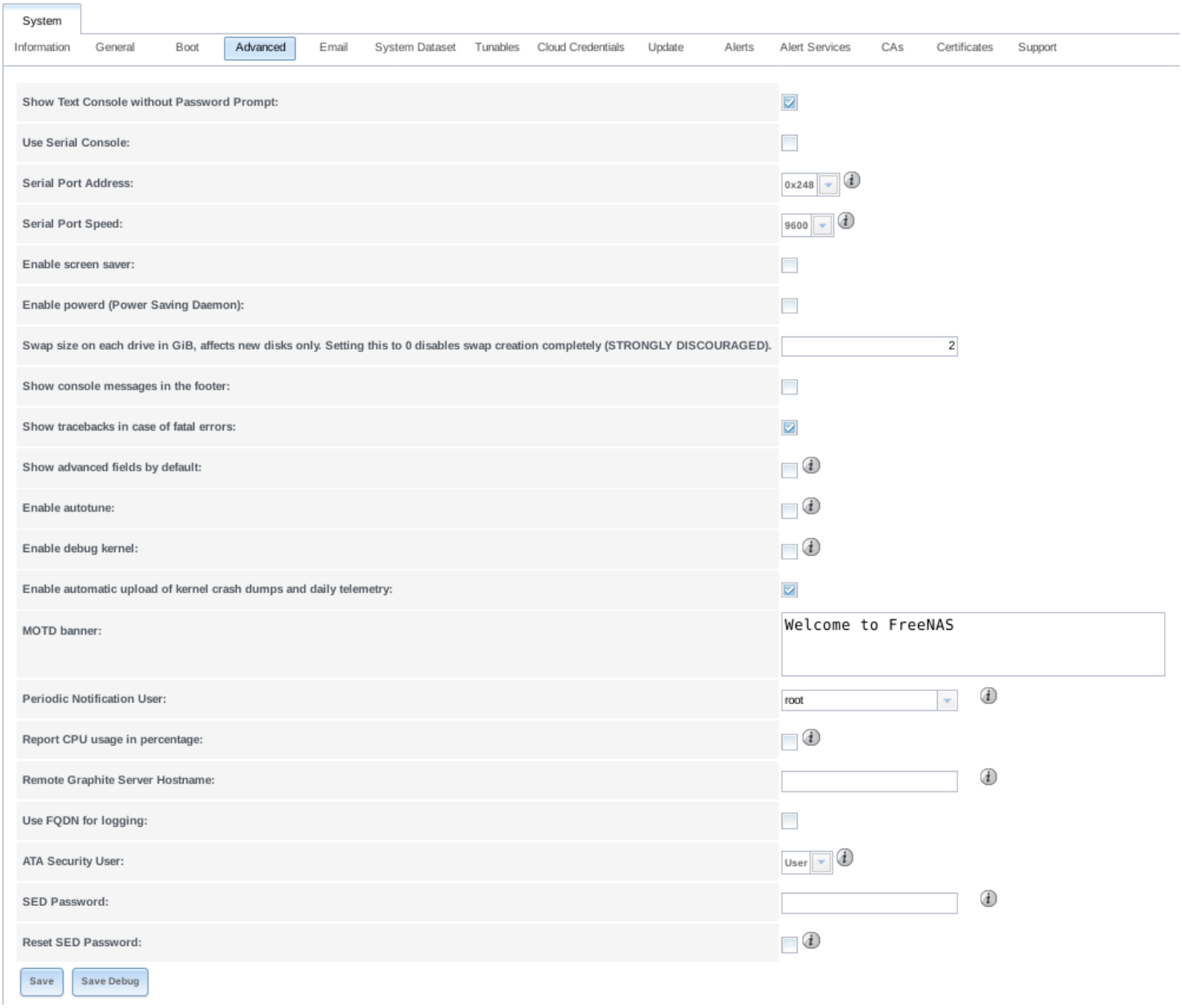


Fig. 5.8: Advanced Screen

Table 5.3: Advanced Configuration Settings

Setting	Value	Description
Show Text Console without Password Prompt	checkbox	Set for the system to immediately display the text console after booting. Unset to require logging into the system before the console menu is shown.
Use Serial Console	checkbox	**Do not** enable this option if the serial port is disabled.
Serial Port Address	string	Select the serial port address in hex.
Serial Port Speed	drop-down menu	Select the speed used by the serial port.
Enable powerd (Power Saving Daemon)	checkbox	powerd(8) (https://www.freebsd.org/cgi/man.cgi?query=powerd) monitors the system state and sets the CPU frequency accordingly.

Continued on next page

Table 5.3 – continued from previous page

Setting	Value	Description
Swap size	non-zero integer representing GB	By default, all data disks are created with this amount of swap. This setting does not affect log or cache devices as they are created without swap.
Show console messages in the footer	checkbox	Set to display console messages in real time at the bottom of the browser. Click the console to bring up a scrollable screen. Enable the *Stop refresh* option in the scrollable screen to pause updating, and deselect the option to continue to watch the messages as they occur.
Show tracebacks in case of fatal errors	checkbox	Open a pop-up of diagnostic information when a fatal error occurs.
Show advanced fields by default	checkbox	Show *Advanced Mode* fields by default.
Enable autotune	checkbox	Enable *Autotune* (page 65) script which attempts to optimize the system based on the installed hardware. *Warning*: Autotuning is only used as a temporary measure and is not a permanent fix for system hardware issues.
Enable debug kernel	checkbox	Use a debug version of the kernel on the next boot.
Enable automatic upload of kernel crash dumps and daily telemetry	checkbox	Set to report kernel crash dumps and daily performance measurements to iXsystems.
MOTD banner	string	This message is shown when a user logs in with SSH.
Periodic Notification User	drop-down menu	Choose a user to receive security output emails. This output runs nightly but only sends email when the system reboots or encounters an error.
Report CPU usage in percentage	checkbox	Display CPU usage as percentages in *Reporting* (page 272).
Remote Graphite Server hostname	string	IP address or hostname of a remote server running Graphite (http://graphiteapp.org/).
Use FQDN for logging	checkbox	Include the Fully-Qualified Domain Name in logs to precisely identify systems with similar hostnames.
ATA Security User	drop-down menu	User passed to `camcontrol security -u` for unlocking *Self-Encrypting Drives* (page 66). Values are *User* or *Master*.
SED Password	string	Global password used to unlock *Self-Encrypting Drives* (page 66).
Reset SED Password	checkbox	Select to clear the *Password for SED* column of `Storage → View Disks`.

Click the *Save* button after making any changes.

This tab also contains this button:

Save Debug: used to generate a text file of diagnostic information. After the debug data is collected, the system prompts for a location to save the generated ASCII text file.

5.4.1 Autotune

FreeNAS® provides an autotune script which optimizes the system depending on the installed hardware. For example, if a ZFS volume exists on a system with limited RAM, the autotune script automatically adjusts some ZFS sysctl values in an attempt to minimize ZFS memory starvation issues. It should only be used as a temporary measure on a system that hangs until the underlying hardware issue is addressed by adding more RAM. Autotune will always slow such a system, as it caps the ARC.

The *Enable autotune* option in `System → Advanced` is off by default. Enable this option to run the autotuner at boot time. To run the script immediately, reboot the system.

If the autotune script adjusts any settings, the changed values appear in `System → Tunables`. These values can be modified and overridden. Note that deleting tunables that were created by autotune only affects the current session, as autotune-set tunables are recreated at boot.

When attempting to increase the performance of the FreeNAS® system, and particularly when the current hardware may be limiting performance, try enabling autotune.

For those who wish to see which checks are performed, the autotune script is located in `/usr/local/bin/autotune`.

5.4.2 Self-Encrypting Drives

FreeNAS® version 11.1-U5 introduced Self-Encrypting Drive (SED) support.

Three types of SED devices are supported:

- Legacy interface for older ATA devices. **Not recommended for security-critical environments**
- TCG OPAL 2 standard for newer consumer-grade devices (HDD or SSD over PCIe or SATA)
- TCG Enterprise standard for newer enterprise-grade SAS devices

The FreeNAS® middleware implements the security capabilities of camcontrol (https://www.freebsd.org/cgi/man.cgi?query=camcontr (for legacy devices) and sedutil-cli (https://www.mankier.com/8/sedutil-cli) (for TCG devices). When managing SED devices from the command line, it is important to use `sedutil-cli` rather than camcontrol to access the full capabilities of the device. FreeNAS® provides the `sedhelper` wrapper script to ease SED device administration from the command line.

By default, SED devices are not locked until the administrator explicitly configures a global or per-device password and initializes the devices.

Once configured, the system automatically unlocks all SEDs during the boot process, without requiring manual intervention. This allows a pool to contain a mix of SED and non-SED devices.

A password-protected SED device protects the data stored on the device when the device is physically removed from the FreeNAS® system. This allows secure disposal of the device without having to first wipe its contents. If the device is instead removed to be repurposed on another system, it can only be unlocked if the password is known.

Warning: It is important to remember the password! Without it, the device is unlockable and its data remains unavailable. While it is possible to specify the PSID number on the label of the device with the `sedutil-cli` command, doing so will erase the contents of the device rather than unlock it. Always record SED passwords whenever they are configured or modified and store them in a safe place!

When SED devices are detected during system boot, the middleware checks for global and device-specific passwords. Devices with their own password are unlocked with their password and any remaining devices, without a device-specific password, are unlocked using the global password.

To configure a global password, go to `System → Advanced → SED Password` and enter the password. Recording the password and storing it in a safe place is recommended.

To determine which devices support SED and their device names:

```
sedutil-cli --scan
```

In the results:

- **no** indicates a non-SED device
- **1** indicates a legacy TCG OPAL 1 device
- **2** indicates a modern TCG OPAL 2 device
- **E** indicates a TCG Enterprise device

To specify a password for a device, go to `Storage → View Disks`. Highlight the device name for the confirmed SED device and click *Edit*. Enter and confirm the password in the *Password for SED* and *Confirm SED Password* fields. Disks that have a configured password will show bullets in their row of the *Password for SED* column of `Storage → View Disks`. Conversely, the rows in that column will be empty for disks that do not support SED or which are unlocked using the global password.

Next, remember to initialize the devices:

```
sedhelper setup password
```

This command ensures that all detected SED disks are properly setup using the specified password.

This command is used to unlock all available SED disks:

```
sedhelper unlock
```

5.5 Email

An automatic script sends a nightly email to the *root* user account containing important information such as the health of the disks. *Alert* (page 289) events are also emailed to the *root* user account. Problems with *Scrubs* (page 155) are reported separately in an email sent at 03:00AM.

Note: *S.M.A.R.T.* (page 233) reports are mailed separately to the address configured in that service.

The administrator typically does not read email directly on the FreeNAS® system. Instead, these emails are usually sent to an external email address where they can be read more conveniently. It is important to configure the system so it can send these emails to the administrator's remote email account so they are aware of problems or status changes.

The first step is to set the remote address where email will be sent. Select `Account → Users`, click on *root* to highlight that user, then click *Modify User*. In the *E-mail* field, enter the email address on the remote system where email is to be sent, like *admin@example.com*. Click *OK* to save the settings.

Additional configuration is performed with `System → Email`, shown in Figure 5.9.

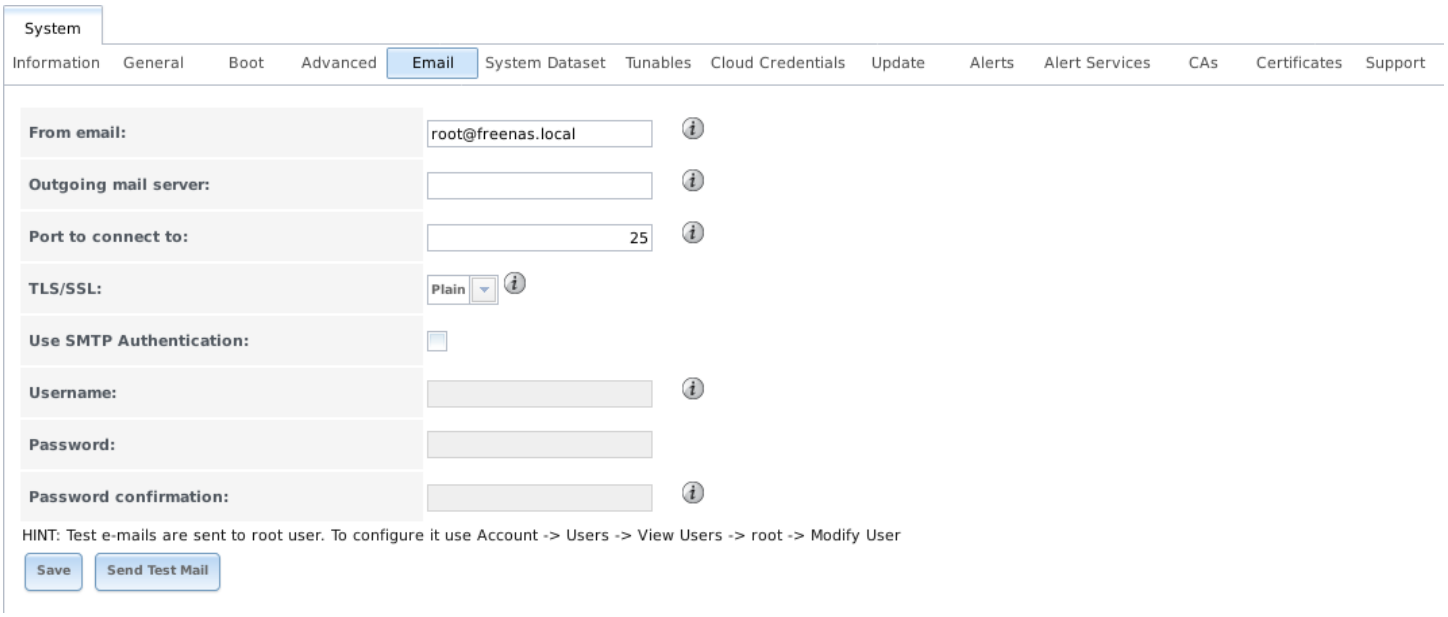


Fig. 5.9: Email Screen

Table 5.4: Email Configuration Settings

Setting	Value	Description
From email	string	Setting a known **From** address can be helpful in filtering mail on the receiving system.
Outgoing mail server	string or IP address	Hostname or IP address of SMTP server used for sending this email.
Port to connect to	integer	SMTP port number. Typically *25*, *465* (secure SMTP), or *587* (submission).
TLS/SSL	drop-down menu	Choose an encryption type. Choices are *Plain*, *SSL*, or *TLS*
Use SMTP Authentication	checkbox	Enable or disable SMTP AUTH (https://en.wikipedia.org/wiki/SMTP_Authentication) using PLAIN SASL. If enabled, enter the required *Username* and *Password*.
Username	string	Enter the SMTP username if the SMTP server requires authentication.
Password	string	Enter the SMTP password if the SMTP server requires authentication.
Password Confirmation	string	Confirm the SMTP password.

Click the *Send Test Mail* button to verify that the configured email settings are working. If the test email fails, double-check that the *E-mail* field of the *root* user is correctly configured by clicking the *Modify User* button for the *root* account in `Account → Users → View Users`.

Configuring email for TLS/SSL email providers is described in Are you having trouble getting FreeNAS to email you in Gmail? (https://forums.freenas.org/index.php?threads/are-you-having-trouble-getting-freenas-to-email-you-in-gmail.22517/).

Note: The FreeNAS® user who receives periodic email is set in the *Periodic Notification User* field in `System → Advanced`.

5.6 System Dataset

`System → System Dataset`, shown in Figure 5.10, is used to select the pool which contains the persistent system dataset. The system dataset stores debugging core files and Samba4 metadata such as the user or group cache and share level permissions. If the FreeNAS® system is configured to be a Domain Controller, all of the domain controller state is stored there as well, including domain controller users and groups.

Note: When the system dataset is moved, a new dataset is created and set active. The old dataset is intentionally not deleted by the system because the move might be transient or the information in the old dataset might be useful for later recovery.

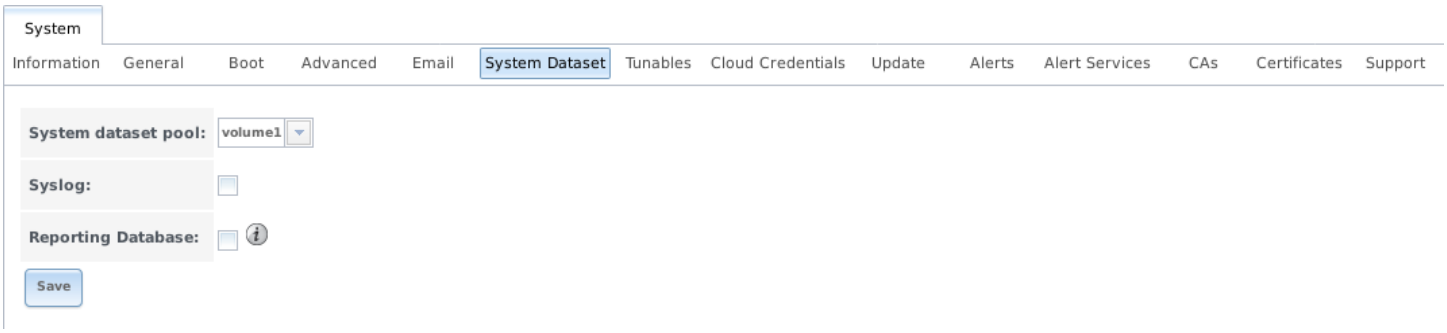


Fig. 5.10: System Dataset Screen

Note: Encrypted volumes are not displayed in the *System dataset pool* drop-down menu.

The system dataset can optionally be configured to also store the system log and *Reporting* (page 272) information. If there are lots of log entries or reporting information, moving these to the system dataset will prevent `/var/` on the device holding the operating system from filling up as `/var/` has limited space.

Use the drop-down menu to select the ZFS volume (pool) to contain the system dataset. Whenever the location of the system dataset is changed, a pop-up warning indicates that the SMB service must be restarted, causing a temporary outage of any active SMB connections.

To store the system log on the system dataset, enable the *Syslog* option.

To store the reporting information on the system dataset, enable the *Reporting Database* option. When this option is not enabled, a RAM disk is created to prevent reporting information from filling up `/var`.

Click the *Save* button to save changes.

If the pool storing the system dataset is changed at a later time, FreeNAS® migrates the existing data in the system dataset to the new location.

Note: Depending on configuration, the system dataset can occupy a large amount of space and receive frequent writes. Do not put the system dataset on a flash drive or other media with limited space or write life.

5.7 Tunables

`System` → `Tunables` can be used to manage the following:

1. **FreeBSD sysctls:** a sysctl(8) (https://www.freebsd.org/cgi/man.cgi?query=sysctl) makes changes to the FreeBSD kernel running on a FreeNAS® system and can be used to tune the system.
2. **FreeBSD loaders:** a loader is only loaded when a FreeBSD-based system boots and can be used to pass a parameter to the kernel or to load an additional kernel module such as a FreeBSD hardware driver.
3. **FreeBSD rc.conf options:** rc.conf(5) (https://www.freebsd.org/cgi/man.cgi?query=rc.conf&manpath=FreeBSD+11.0-RELEASE) is used to pass system configuration options to the system startup scripts as the system boots. Since FreeNAS® has been optimized for storage, not all of the services mentioned in rc.conf(5) are available for configuration. Note that in FreeNAS®, customized rc.conf options are stored in `/tmp/rc.conf.freenas`.

Warning: Adding a sysctl, loader, or `rc.conf` option is an advanced feature. A sysctl immediately affects the kernel running the FreeNAS® system and a loader could adversely affect the ability of the FreeNAS® system to successfully boot. **Do not create a tunable on a production system unless you understand and have tested the ramifications of that change.**

Since sysctl, loader, and rc.conf values are specific to the kernel parameter to be tuned, the driver to be loaded, or the service to configure, descriptions and suggested values can be found in the man page for the specific driver and in many sections of the FreeBSD Handbook (https://www.freebsd.org/doc/en_US.ISO8859-1/books/handbook/).

To add a loader, sysctl, or `rc.conf` option, go to `System` → `Tunables` → `Add Tunable`, to access the screen shown in Figure 5.11.

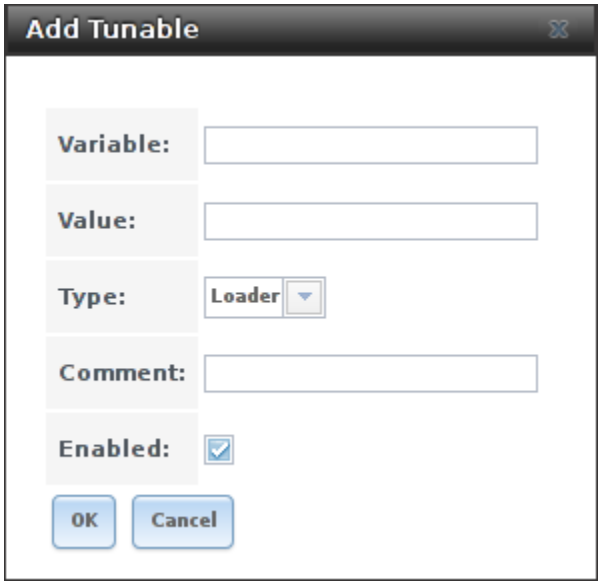


Fig. 5.11: Adding a Tunable

Table 5.5 summarizes the options when adding a tunable.

Table 5.5: Adding a Tunable

Setting	Value	Description
Variable	string	The name of the sysctl or driver to load.
Value	integer or string	Set a value for the *Variable*. Refer to the man page for the specific driver or the FreeBSD Handbook (https://www.freebsd.org/doc/en_US.ISO8859-1/books/handbook/) for suggested values.
Type	drop-down menu	Choices are *Loader*, *rc.conf*, or *Sysctl*.
Comment	string	Enter a userful description of this tunable.
Enabled	checkbox	Deselect this option to disable the tunable without deleting it.

Note: As soon as a *Sysctl* is added or edited, the running kernel changes that variable to the value specified. However, when a *Loader* or *rc.conf* value is changed, it does not take effect until the system is rebooted. Regardless of the type of tunable, changes persist at each boot and across upgrades unless the tunable is deleted or the *Enabled* option is deselected.

Any added tunables are listed in `System → Tunables`. To change the value of an existing tunable, click its *Edit* button. To remove a tunable, click its *Delete* button.

Restarting the FreeNAS® system after making sysctl changes is recommended. Some sysctls only take effect at system startup, and restarting the system guarantees that the setting values correspond with what is being used by the running system.

The GUI does not display the sysctls that are pre-set when FreeNAS® is installed. FreeNAS® 11.2 ships with the following sysctls set:

```
kern.metadelay=3
kern.dirdelay=4
kern.filedelay=5
kern.coredump=1
kern.sugid_coredump=1
vfs.timestamp_precision=3
net.link.lagg.lacp.default_strict_mode=0
vfs.zfs.min_auto_ashift=12
```

Do not add or edit these default sysctls as doing so may render the system unusable.

The GUI does not display the loaders that are pre-set when FreeNAS® is installed. FreeNAS® 11.2 ships with these loaders set:

```
autoboot_delay="2"
loader_logo="freenas"
loader_menu_title="Welcome to FreeNAS"
loader_brand="freenas-brand"
loader_version=" "
kern.cam.boot_delay="30000"
debug.debugger_on_panic=1
debug.ddb.textdump.pending=1
hw.hptrr.attach_generic=0
vfs.mountroot.timeout="30"
ispfw_load="YES"
freenas_sysctl_load="YES"
hint.isp.0.role=2
hint.isp.1.role=2
hint.isp.2.role=2
hint.isp.3.role=2
hint.isp.0.topology="nport-only"
hint.isp.1.topology="nport-only"
hint.isp.2.topology="nport-only"
hint.isp.3.topology="nport-only"
module_path="/boot/kernel;/boot/modules;/usr/local/modules"
net.inet6.ip6.auto_linklocal="0"
vfs.zfs.vol.mode=2
kern.geom.label.disk_ident.enable="0"
hint.ahciem.0.disabled="1"
hint.ahciem.1.disabled="1"
kern.msgbufsize="524288"
hw.mfi.mrsas_enable="1"
hw.usb.no_shutdown_wait=1
hw.cxgbe.toecaps_allowed=0
hw.cxgbe.rdmacaps_allowed=0
hw.cxgbe.iscsicaps_allowed=0
vfs.nfsd.fha.write=0
vfs.nfsd.fha.max_nfsds_per_fh=32
```

Do not add or edit the default tunables. Changing the default tunables can make the system unusable.

The ZFS version used in 11.2 deprecates these tunables:

```
vfs.zfs.write_limit_override
vfs.zfs.write_limit_inflated
vfs.zfs.write_limit_max
vfs.zfs.write_limit_min
vfs.zfs.write_limit_shift
vfs.zfs.no_write_throttle
```

After upgrading from an earlier version of FreeNAS®, these tunables are automatically deleted. Please do not manually add them back.

5.8 Update

FreeNAS® has an integrated update system to make it easy to keep up to date.

5.8.1 Preparing for Updates

It is best to perform updates at times the FreeNAS® system is idle, with no clients connected and no scrubs or other disk activity going on. A reboot is required after most updates, so they are often planned for scheduled maintenance times to avoid disrupting user activities.

The update process will not proceed unless there is enough free space in the boot pool for the new update files. If a space warning is shown, use *Boot* (page 60) to remove unneeded boot environments.

5.8.2 Updates and Trains

FreeNAS® uses signed update files. This provides flexibility in deciding when to upgrade the system with patches, new drivers, or new features. It also allows "test driving" an upcoming release. Combined with boot environments, new features or system patches can be tested while still being able to revert to a previous version of the operating system (see *If Something Goes Wrong* (page 25)). Digitally signing update files eliminates the need to manually download both an upgrade file and the associated checksum to verify file integrity.

Figure 5.12 shows an example of the `System → Update` screen.

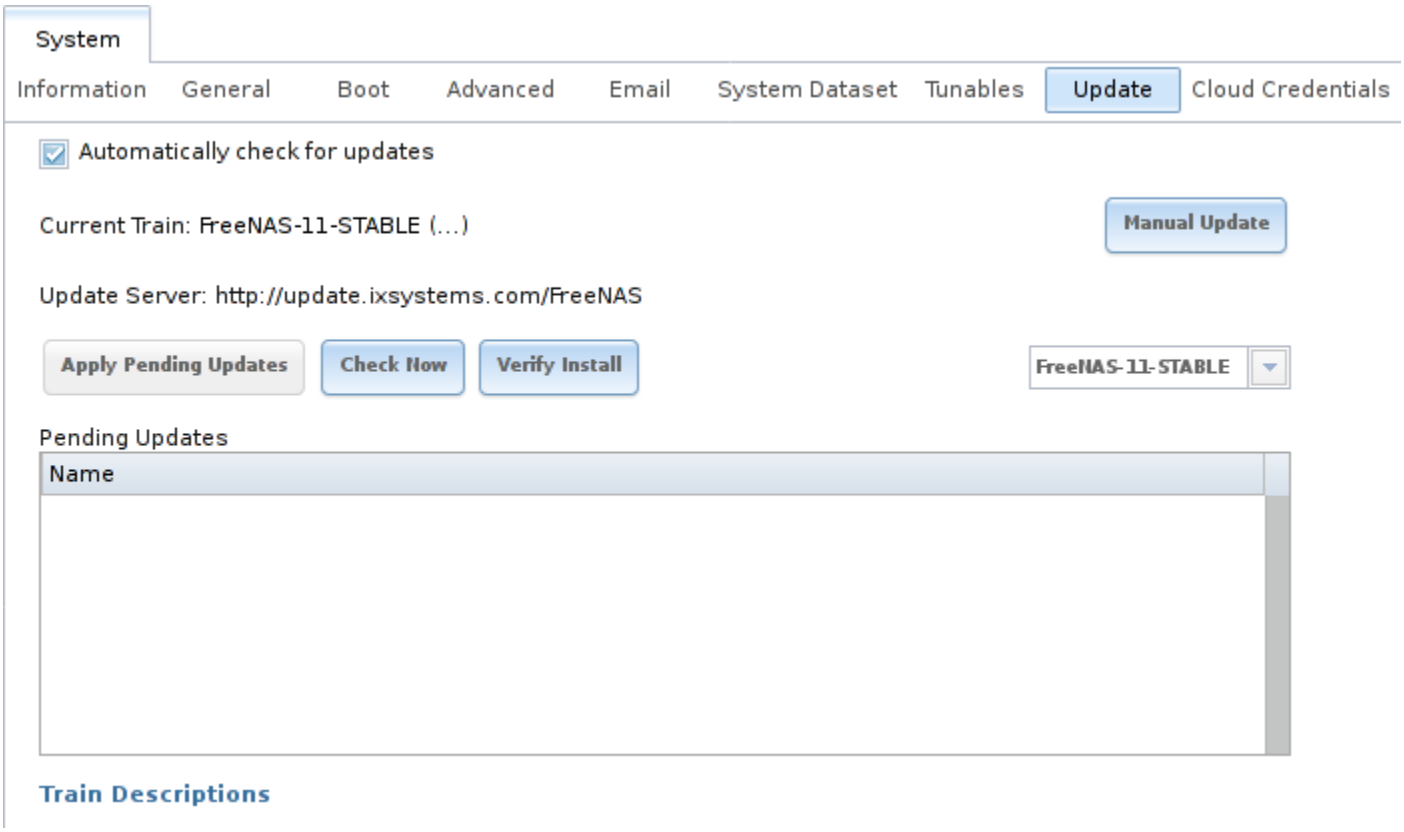


Fig. 5.12: Update Options

By default, the system automatically checks for updates and issues an alert when a new update becomes available. The automatic check can be disabled by deselecting *Automatically check for updates*.

This screen lists the URL of the official update server in case that information is needed in a network with outbound firewall restrictions. It also shows which software branch, or *train*, is being tracked for updates.

Several trains are available for updates.

Caution: Only Production trains are recommended for regular usage. Other trains are made available for pre-production testing and updates to legacy versions. Pre-production testing trains are provided only to permit testing of new versions before switching to a new branch. Before using a non-production train, be prepared to experience bugs or problems. Testers are encouraged to submit bug reports at https://redmine.ixsystems.com/projects/freenas/issues.

These trains are available:

For Production Use

- **FreeNAS-11-STABLE: Recommended.** After testing, new fixes and features are added to this train. Selecting this train and applying any pending updates is recommended.
- **FreeNAS-11.2-STABLE: Recommended for Jails/Plugins/VM users.** This train provides the latest updates to the new UI, the new iocage backend for Jails and Plugins, and the latest fixes for VMs. Users who rely on these features are encouraged to upgrade to this train and to use the *Support Icon* (page 287) to report any issues.

For Pre-Production Testing

- **FreeNAS-11-Nightlies: Do not use this train in production**. It is the experimental branch for future versions and is meant only for testers and developers.
- **FreeNAS-11-Nightlies-SDK: Do not use this train in production**. This train is meant only for developers. It is similar to *FreeNAS-11-Nightlies* but with extra development and debugging utilities added.
- **FreeNAS-HEAD-Nightlies: Do not use this train in production**. This train is meant only for developers and contains the source that will eventually become FreeNAS® version 12.

Legacy Versions

- **FreeNAS-9.10-STABLE**

  Maintenance-only updates to the older version of FreeNAS®. Upgrading to FreeNAS-11-STABLE is recommended to ensure that the system receives bug fixes and new features.

To change the train, use the drop-down menu to make a different selection.

Note: The train selector does not allow downgrades. For example, the STABLE train cannot be selected while booted into a Nightly boot environment, or a 9.10 train cannot be selected while booted into a 11 boot environment. To go back to an earlier version after testing or running a more recent version, reboot and select a boot environment for that earlier version. This screen can then be used to check for updates that train.

This screen also shows the URL of the official update server. That information can be required when using a network with outbound firewall restrictions.

The *Verify Install* button verifies that the operating system files in the current installation do not have any inconsistencies. If any problems are found, a pop-up menu lists the files with checksum mismatches or permission errors.

5.8.3 Checking for Updates

Check for updates by making sure the desired train is selected and clicking the *Check Now* button. Any available updates are listed. In the example shown in Figure 5.13, the numbers which begin with a # represent the issue number from the issue tracker (https://redmine.ixsystems.com/projects/freenas/issues). Numbers which do not begin with a # represent a git commit. Click the *ChangeLog* link to open the log of changes in a web browser. Click the *ReleaseNotes* link to open the Release Notes in the browser.

Fig. 5.13: Reviewing Updates

5.8.4 Applying Updates

Make sure the system is in a low-usage state as described above in *Preparing for Updates* (page 72).

Click the *OK* button to download and apply the updates. Be aware that some updates automatically reboot the system after they are applied.

Warning: Each update creates a boot environment. If the update process needs more space, it attempts to remove old boot environments. Boot environments marked with the *Keep* attribute as shown in *Boot* (page 60) will not be removed. If space for a new boot environment is not available, the upgrade fails. Space on the boot device can be manually freed using `System → Boot`. Review the boot environments and remove the *Keep* attribute or delete any boot environments that are no longer needed.

Updates can also be downloaded and applied later. To do so, deselect the *Apply updates after downloading* option before pressing *OK*. In this case, this screen closes after updates are downloaded. Downloaded updates are listed in the *Pending Updates* section of the screen shown in Figure 5.12. When ready to apply the previously downloaded updates, click the *Apply Pending Updates* button. Remember that the system may reboot after the updates are applied.

Warning: After updates have completed, reboot the system. Configuration changes made after an update but before that final reboot will not be saved.

5.8.5 Manual Updates

Updates can be manually downloaded as a file. These updates are then applied with the *Manual Update* button. After obtaining the update file, click *Manual Update* and choose a location to temporarily store the file on the FreeNAS® system. Use the file browser to locate the update file, then click *Apply Update* to apply it.

Manual update files can be identified by their filenames, which end in `-manual-update-unsigned.tar`.

Manual updates cannot be used to upgrade from older major versions.

There is also an option to back up the system configuration before updating. Click *Click here* and select any options to export in the configuration file. Click *OK* to open a popup window to save the system configuration.

5.9 Cloud Credentials

FreeNAS® can use cloud services for features like *Cloud Sync* (page 87). The credentials to provide secure connections with cloud services are entered here. Amazon Cloud Drive, Amazon S3, Backblaze B2, Box, Dropbox, FTP, Google Cloud Storage, Google Drive, HTTP, Hubic, Mega, Microsoft Azure Blob Storage, Microsoft OneDrive, pCloud, SFTP, WebDAV, and Yandex are supported. Select `System → Cloud Credentials → Add Cloud Credential` to display the dialog shown in Figure 5.14.

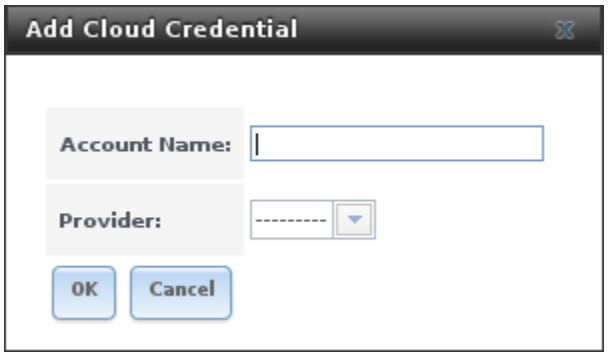


Fig. 5.14: Adding Cloud Credentials

Enter a descriptive name for the cloud credential in the *Account Name* field, then select a provider. The remaining options vary by provider, and are shown in Table 5.6.

Table 5.6: Cloud Credential Options

Provider	Setting	Description
Amazon Cloud Drive	Application Client ID, Application Key	Enter the Amazon application client ID and application key.
Amazon S3	Access Key, Secret Key	Enter the Amazon account access key and secret key.
Amazon S3	Endpoint URL	Enter the Endpoint URL for the web service.
Backblaze B2	Account ID, Application Key	Enter the Backblaze account ID and paste the application.
Box	Access Token	Enter the Box access token.
Dropbox	Access Token	Enter the Dropbox access token. The token is located on the App Console (https://www.dropbox.com/developers/apps) After creating an app, go to *Settings* and click the *Generate* button under the Generated access token field.
FTP	Host, Port	Enter the FTP host and port.
FTP	Username, Password	Enter the FTP username and password.
Google Cloud Storage	JSON Service Account Key	*Browse* to the location of the saved Google Cloud Storage key and select it.
Google Drive	Access Token	Enter the Google Drive Access Token.
HTTP	URL	Enter the URL.
Hubic	Access Token	Enter the access token.
Mega	Username, Password	Enter the Mega (https://mega.nz) username and password.
Microsoft Azure Blob Storage	Account Name, Account Key	Enter the Azure Blob Storage account name and key.
Microsoft OneDrive	Access Token	Enter the access token.
pCloud	Access Token	Enter the access token.
SFTP	Host, Port	Enter the SFTP host and port.

Continued on next page

Table 5.6 – continued from previous page

Provider	Setting	Description
SFTP	Username, Password, key file path	Enter the SFTP username, password, and PEM-encoded private key file path.
WebDAV	URL, WebDAV Service	Enter URL and use the dropdown to select the WebDAV service.
WebDAV	Username, Password	Enter the username and password.
Yandex	Access Token	Enter the access token.

Additional fields are displayed after *Provider* is selected. For Amazon S3, *Access Key* and *Secret Key* are shown. These values are found on the Amazon AWS website by clicking on the account name, then *My Security Credentials* and *Access Keys (Access Key ID and Secret Access Key)*. Copy the Access Key value to the FreeNAS® Cloud Credential *Access Key* field, then enter the *Secret Key* value saved when the key pair was created. If the Secret Key value is unknown, a new key pair can be created on the same Amazon screen. The Google Cloud Storage *JSON Service Account Key* is found on the Google Cloud Platform Console (https://console.cloud.google.com/apis/credentials).

5.10 Alerts

`System` → `Alerts` displays the default notification frequency for each type of *Alert* (page 289). An example is seen in Figure 5.15.

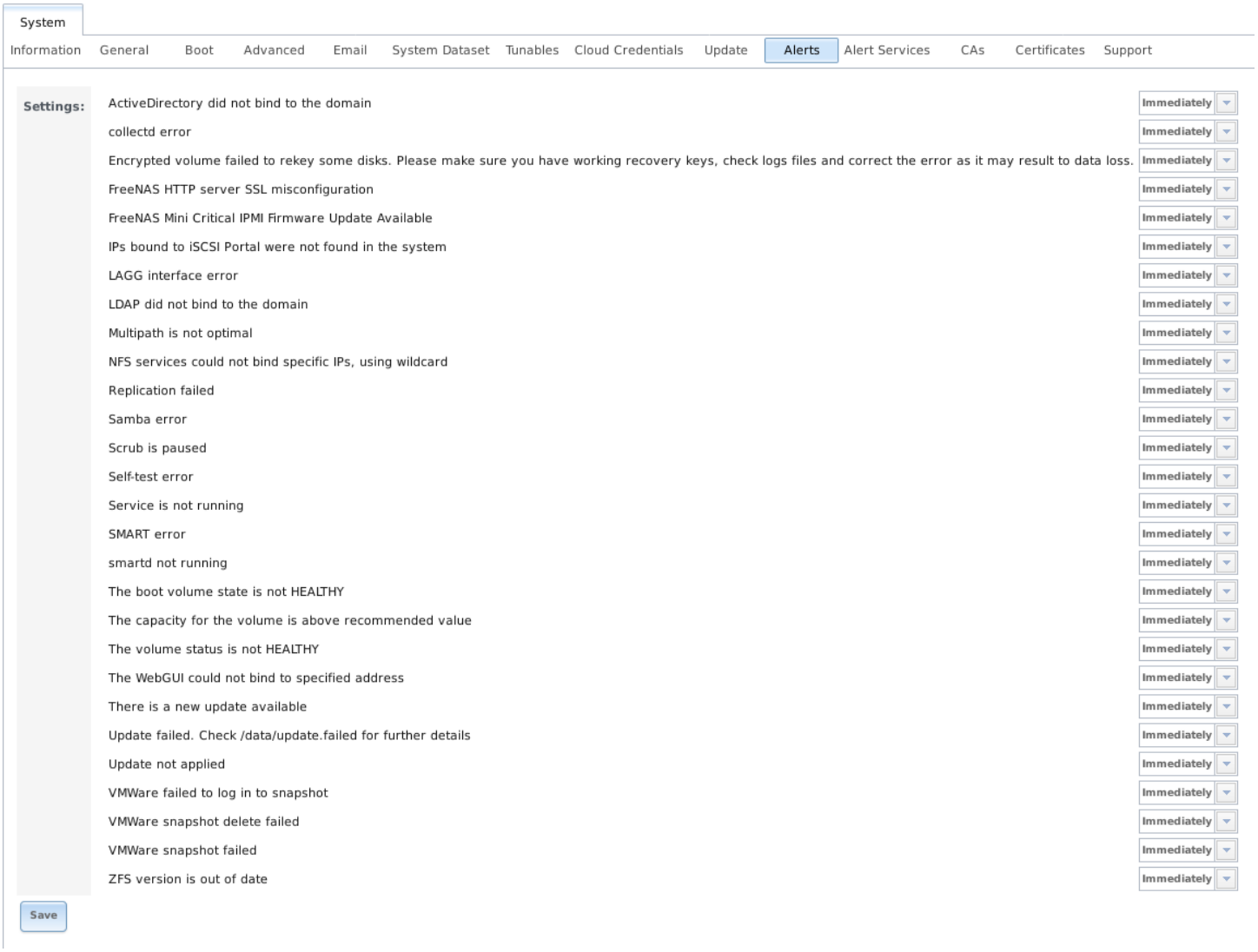


Fig. 5.15: Configure Alert Notification Frequency

To change the notification frequency of an alert, click its drop-down menu and select *IMMEDIATELY*, *HOURLY*, *DAILY*, or *NEVER*.

Note: To configure where to send alerts, use *Alert Services* (page 77).

5.11 Alert Services

FreeNAS® can use a number of methods to notify the administrator of system events that require attention. These events are system *Alerts* (page 289) marked *WARN* or *CRITICAL*.

Currently available alert services:

- AWS-SNS (https://aws.amazon.com/sns/)
- Hipchat (https://www.atlassian.com/software/hipchat)
- InfluxDB (https://www.influxdata.com/)
- Slack (https://slack.com/)

- Mattermost (https://about.mattermost.com/)
- OpsGenie (https://www.opsgenie.com/)
- PagerDuty (https://www.pagerduty.com/)
- VictorOps (https://victorops.com/)

Warning: These alert services might use a third party commercial vendor not directly affiliated with iXsystems. Please investigate and fully understand that vendor's pricing policies and services before using their alert service. iXsystems is not responsible for any charges incurred from the use of third party vendors with the Alert Services feature.

Select `System → Alert Services` to show the Alert Services screen. Click *Add Service* to display the dialog shown in Figure 5.16.

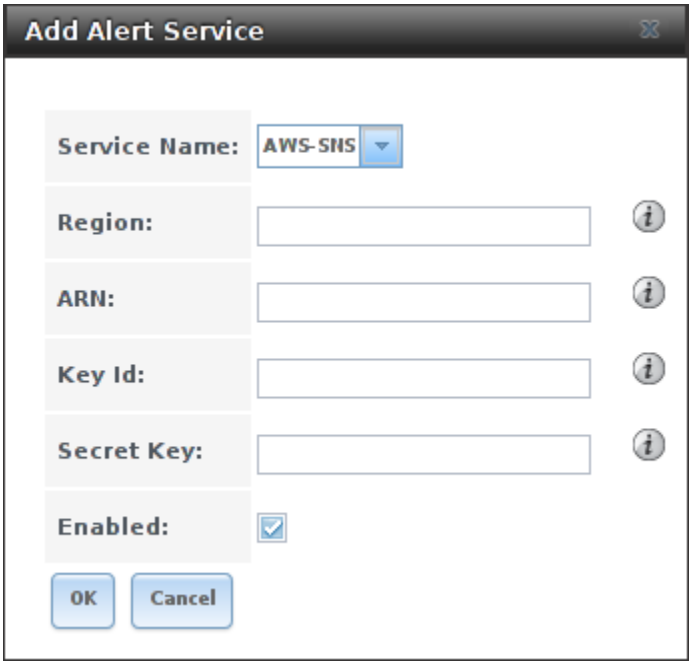


Fig. 5.16: Add Alert Service

The *Service Name* drop-down menu is used to pick a specific alert service. The fields shown in the rest of the dialog change to those required by that service. Enter the required information, set the *Enabled* option, then click *OK* to save the settings.

System alerts marked *WARN* or *CRITICAL* are sent to each alert service that has been configured and enabled.

Alert services are deleted from this list by clicking them and then clicking the *Delete* button at the bottom of the window. To disable an alert service temporarily, click *Edit* and remove the checkmark from the *Enabled* option.

Note: To send a test alert, highlight an alert entry, click *Edit*, and click the *Send Test Alert* button.

5.11.1 How it Works

A *nas-health* service is registered with Consul. This service runs `/usr/local/etc/consul-checks/freenas_health.sh` periodically, currently every two minutes. If an alert marked *WARNING* or *CRITICAL* is found, the *nas-health* service is marked as "unhealthy", triggering `consul-alerts` to notify configured alert services.

5.12 CAs

FreeNAS® can act as a Certificate Authority (CA). When encrypting SSL or TLS connections to the FreeNAS® system, either import an existing certificate, or create a CA on the FreeNAS® system, then create a certificate. This certificate will appear in the drop-down menus for services that support SSL or TLS.

For secure LDAP, the public key of an existing CA is imported with *Import CA*, or a new CA created on the FreeNAS® system and used on the LDAP server also.

Figure 5.17 shows the screen after clicking `System → CAs`.

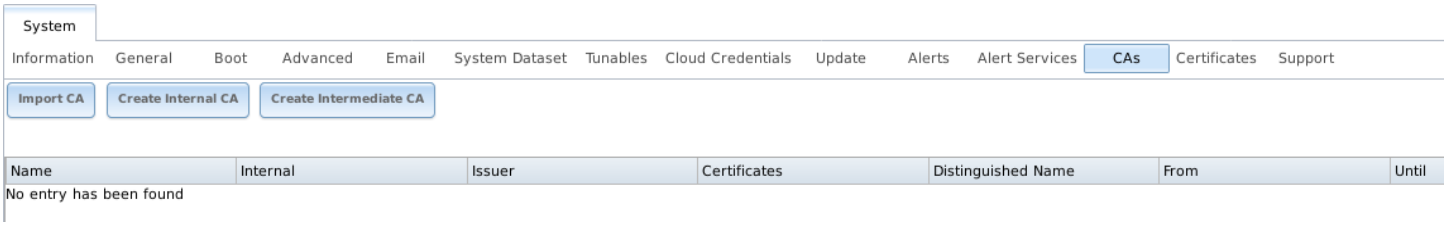


Fig. 5.17: Initial CA Screen

If the organization already has a CA, the CA certificate and key can be imported. Click the *Import CA* button to open the configuration screen shown in Figure 5.18. The configurable options are summarized in Table 5.7.

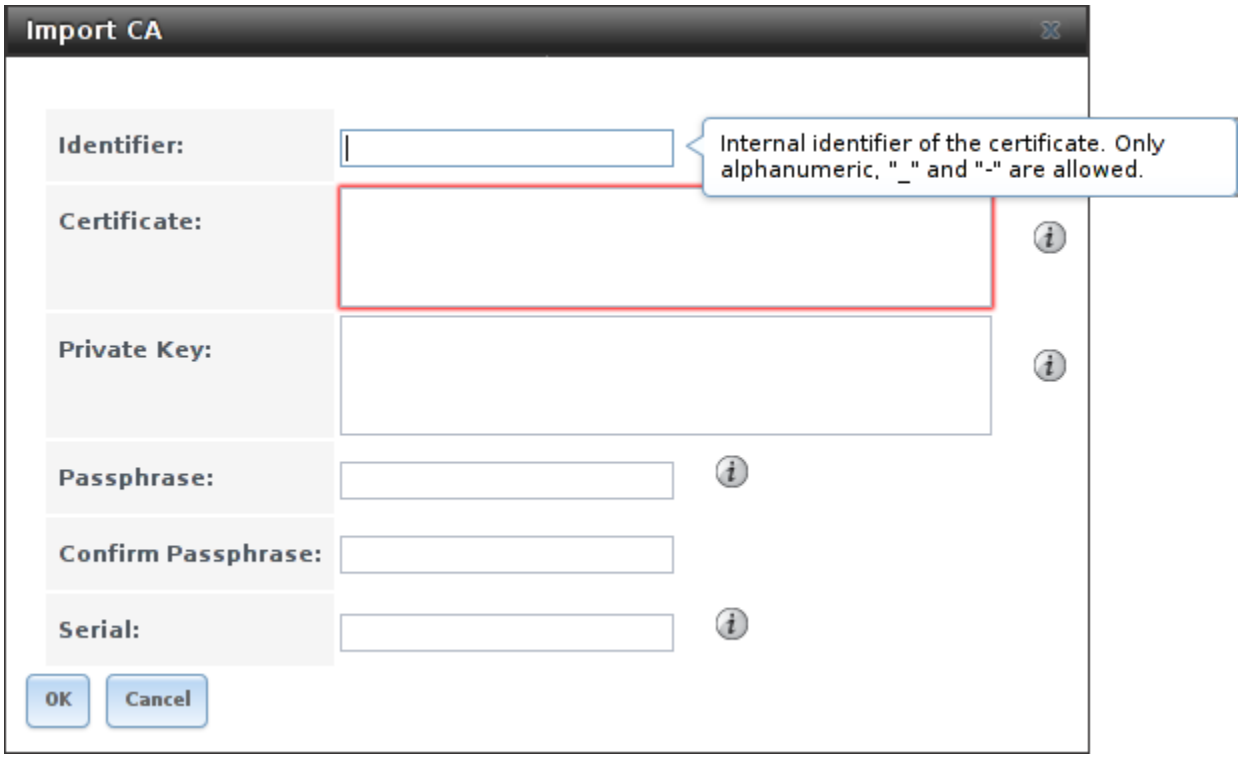


Fig. 5.18: Importing a CA

Table 5.7: Importing a CA Options

Setting	Value	Description
Identifier	string	Enter a descriptive name for the CA using only alphanumeric, underscore (_), and dash (-) characters.
Certificate	string	Paste in the certificate for the CA.
Private Key	string	If there is a private key associated with the *Certificate*, paste it here.
Passphrase	string	If the *Private Key* is protected by a passphrase, enter it here and repeat it in the "Confirm Passphrase" field.
Serial	string	Enter the serial number for the certificate.

To create a new CA, first decide if it will be the only CA which will sign certificates for internal use or if the CA will be part of a certificate chain (https://en.wikipedia.org/wiki/Root_certificate).

To create a CA for internal use only, click the *Create Internal CA* button which will open the screen shown in Figure 5.19.

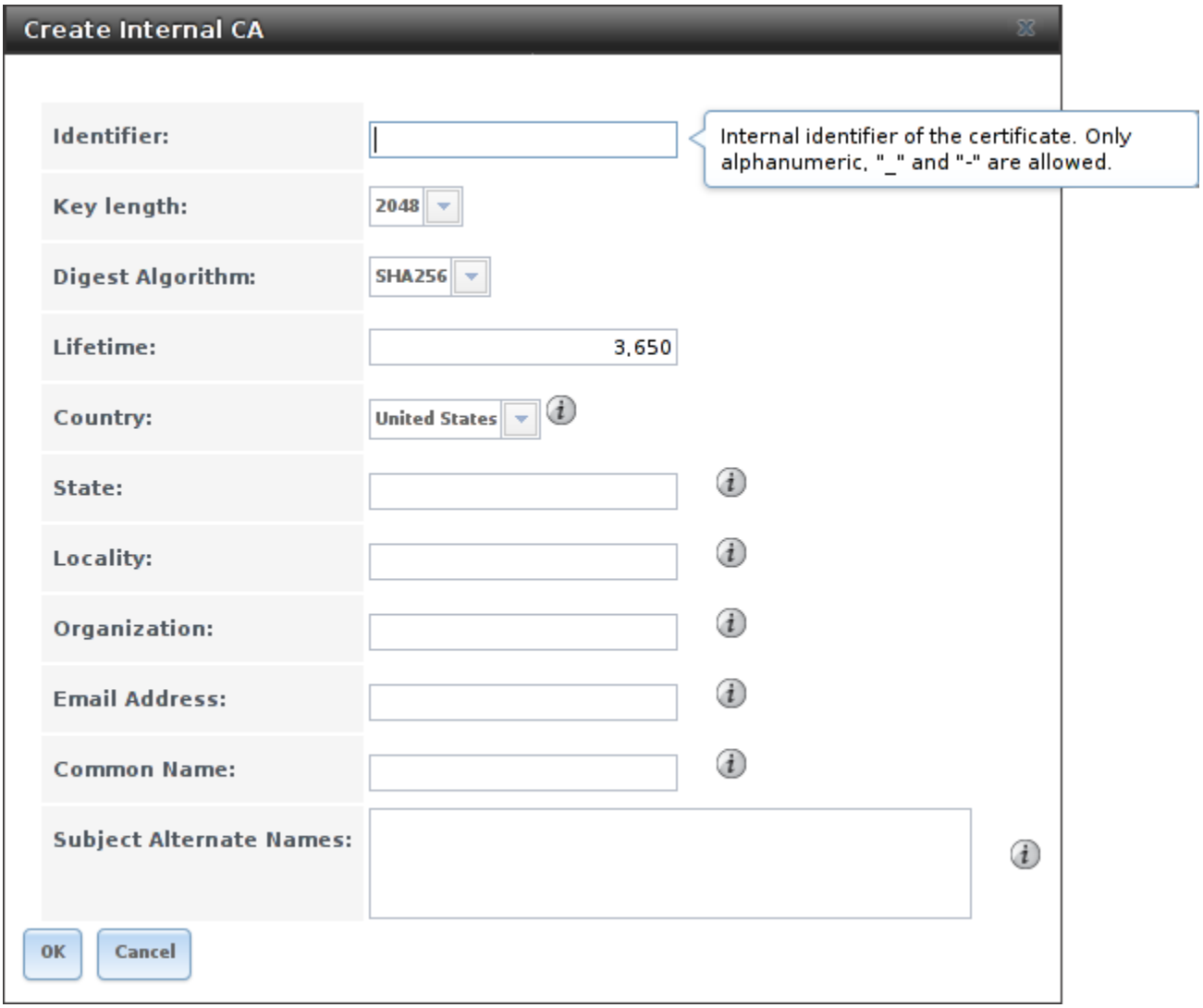


Fig. 5.19: Creating an Internal CA

The configurable options are described in Table 5.8. When completing the fields for the certificate authority, supply the information for the organization.

Table 5.8: Internal CA Options

Setting	Value	Description
Identifier	string	Enter a descriptive name for the CA using only alphanumeric, underscore (_), and dash (-) characters.
Key Length	drop-down menu	For security reasons, a minimum of *2048* is recommended.
Digest Algorithm	drop-down menu	The default is acceptable unless the organization requires a different algorithm.
Lifetime	integer	The lifetime of the CA is specified in days.
Country	drop-down menu	Select the country for the organization.
State	string	Enter the state or province of the organization.
Locality	string	Enter the location of the organization.
Organization	string	Enter the name of the company or organization.
Email Address	string	Enter the email address for the person responsible for the CA.
Common Name	string	Enter the fully-qualified hostname (FQDN) of the system. The *Common Name* **must** be unique within a certificate chain.
Subject Alternate Names	string	Multi-domain support. Enter additional domain names and separate them with a space.

To create an intermediate CA which is part of a certificate chain, click *Create Intermediate CA*. This screen adds one more option to the screen shown in Figure 5.19:

- **Signing Certificate Authority:** this drop-down menu is used to specify the root CA in the certificate chain. This CA must first be imported or created.

Imported or created CAs are added as entries in `System → CAs`. The columns in this screen indicate the name of the CA, whether it is an internal CA, whether the issuer is self-signed, the number of certificates that have been issued by the CA, the distinguished name of the CA, the date and time the CA was created, and the date and time the CA expires.

Clicking the entry for a CA causes these buttons to become available:

- **Sign CSR:** used to sign internal Certificate Signing Requests created using `System → Certificates → Create Certificate Signing Request`.
- **Export Certificate:** prompts to browse to the location to save a copy of the CA X.509 certificate on the computer being used to access the FreeNAS® system.
- **Export Private Key:** prompts to browse to the location to save a copy of the CA private key on the computer being used to access the FreeNAS® system. This option only appears if the CA has a private key.
- **Delete:** prompts for confirmation before deleting the CA.

5.13 Certificates

FreeNAS® can import existing certificates, create new certificates, and issue certificate signing requests so that created certificates can be signed by the CA which was previously imported or created in *CAs* (page 79).

Figure 5.20 shows the initial screen after clicking `System → Certificates`.

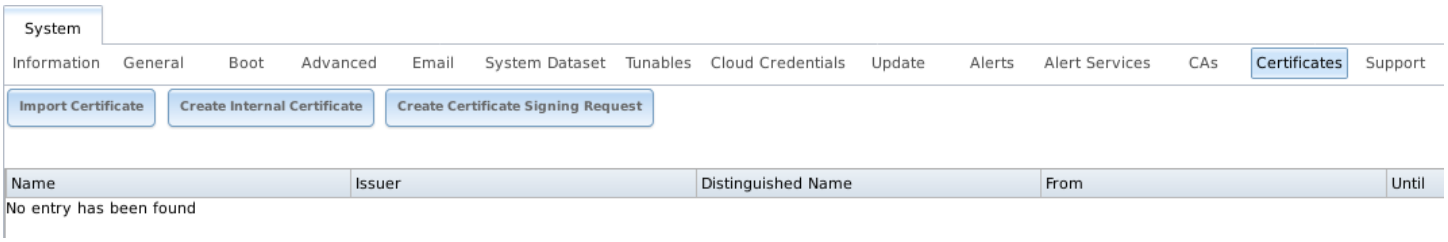


Fig. 5.20: Initial Certificates Screen

To import an existing certificate, click *Import Certificate* to open the configuration screen shown in Figure 5.21. When importing a certificate chain, paste the primary certificate, followed by any intermediate certificates, followed by the root CA certificate.

The configurable options are summarized in Table 5.9.

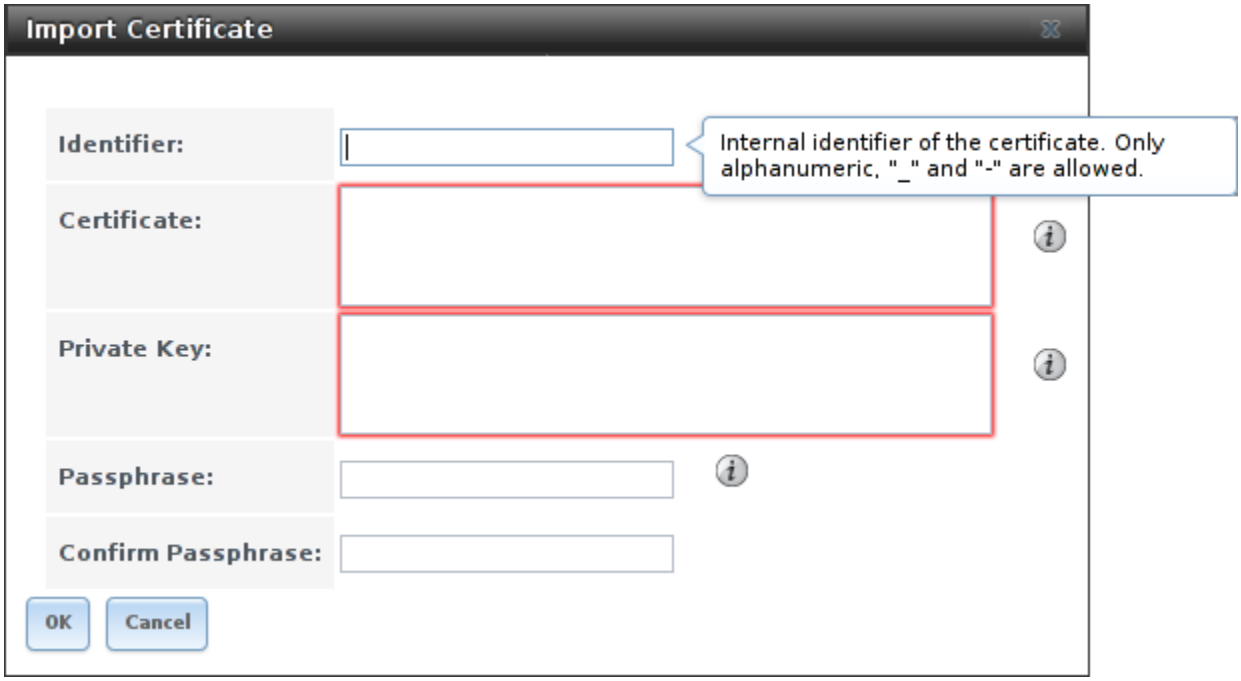


Fig. 5.21: Importing a Certificate

Table 5.9: Certificate Import Options

Setting	Value	Description
Identifier	string	Enter a descriptive name for the certificate using only alphanumeric, underscore (_), and dash (–) characters.
Certificate	string	Paste the contents of the certificate.
Private Key	string	Paste the private key associated with the certificate.
Passphrase	string	If the private key is protected by a passphrase, enter it here and repeat it in the *Confirm Passphrase* field.

To create a new self-signed certificate, click the *Create Internal Certificate* button to see the screen shown in Figure 5.22. The configurable options are summarized in Table 5.10. When completing the fields for the certificate authority, use the information for the organization. Since this is a self-signed certificate, use the CA that was imported or created with *CAs* (page 79) as the signing authority.

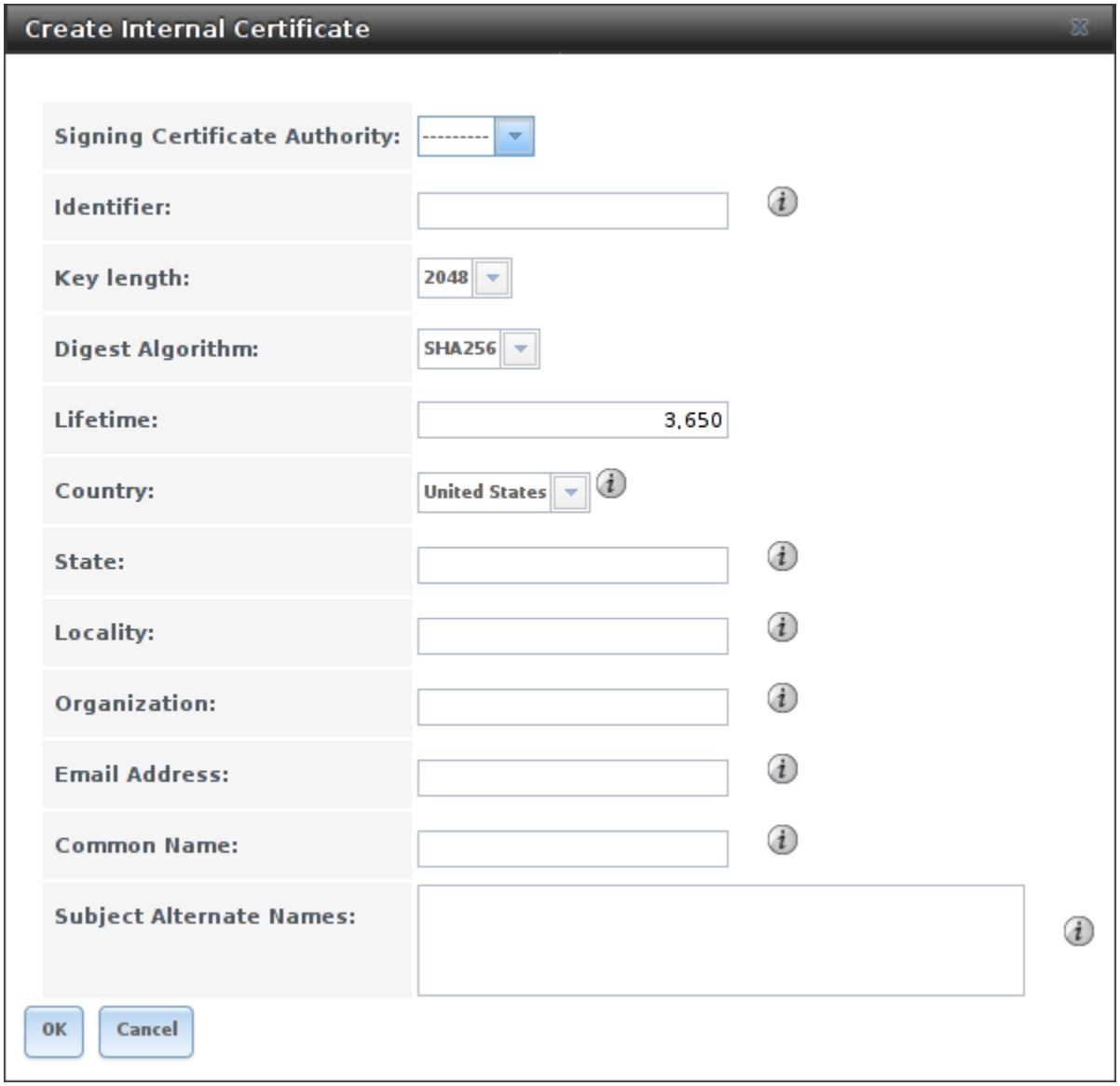


Fig. 5.22: Creating a New Certificate

Table 5.10: Certificate Creation Options

Setting	Value	Description
Signing Certificate Authority	drop-down menu	Select the CA which was previously imported or created using *CAs* (page 79).
Identifier	string	Enter a descriptive name for the certificate using only alphanumeric, underscore (_), and dash (-) characters.
Key Length	drop-down menu	For security reasons, a minimum of *2048* is recommended.
Digest Algorithm	drop-down menu	The default is acceptable unless the organization requires a different algorithm.
Lifetime	integer	The lifetime of the certificate is specified in days.
Country	drop-down menu	Select the country for the organization.
State	string	State or province for the organization.
Locality	string	Location of the organization.
Organization	string	Name of the company or organization.
Email Address	string	Email address for the person responsible for the CA.

Continued on next page

Table 5.10 – continued from previous page

Setting	Value	Description
Common Name	string	Enter the fully-qualified hostname (FQDN) of the system. The *Common Name* **must** be unique within a certificate chain.
Subject Alternate Names	string	Multi-domain support. Enter additional domain names and separate them with a space.

If the certificate is signed by an external CA, such as Verisign, instead create a certificate signing request. To do so, click *Create Certificate Signing Request*. A screen like the one in Figure 5.22 opens, but without the *Signing Certificate Authority* field.

Certificates that are imported, self-signed, or for which a certificate signing request is created are added as entries to `System → Certificates`. In the example shown in Figure 5.23, a self-signed certificate and a certificate signing request have been created for the fictional organization *My Company*. The self-signed certificate was issued by the internal CA named *My Company* and the administrator has not yet sent the certificate signing request to Verisign so that it can be signed. Once that certificate is signed and returned by the external CA, it should be imported using *Import Certificate* so it is available as a configurable option for encrypting connections.

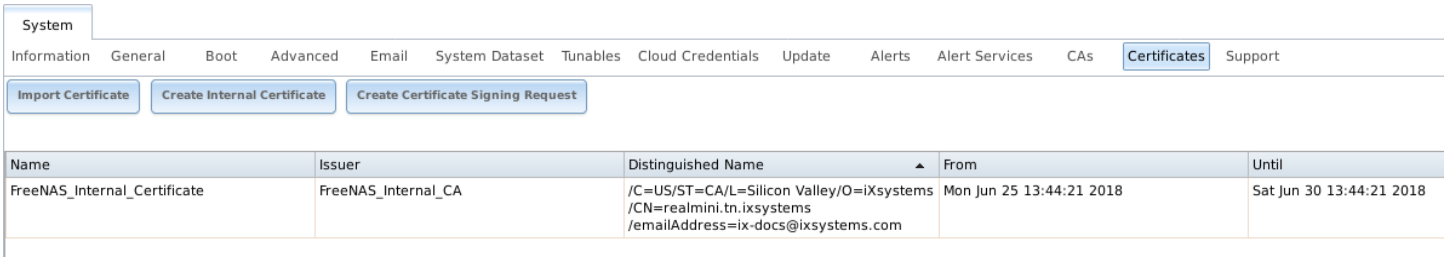


Fig. 5.23: Managing Certificates

Clicking an entry activates these configuration buttons:

- **View:** use this option to view the contents of an existing certificate or to edit the *Identifier*.
- **Export Certificate** saves a copy of the certificate or certificate signing request to the system being used to access the FreeNAS® system. For a certificate signing request, send the exported certificate to the external signing authority so that it can be signed.
- **Export Private Key** saves a copy of the private key associated with the certificate or certificate signing request to the system being used to access the FreeNAS® system.
- **Delete** is used to delete a certificate or certificate signing request.

5.14 Support

The FreeNAS® *Support* tab, shown in Figure 5.24, provides a built-in ticketing system for generating bug reports and feature requests.

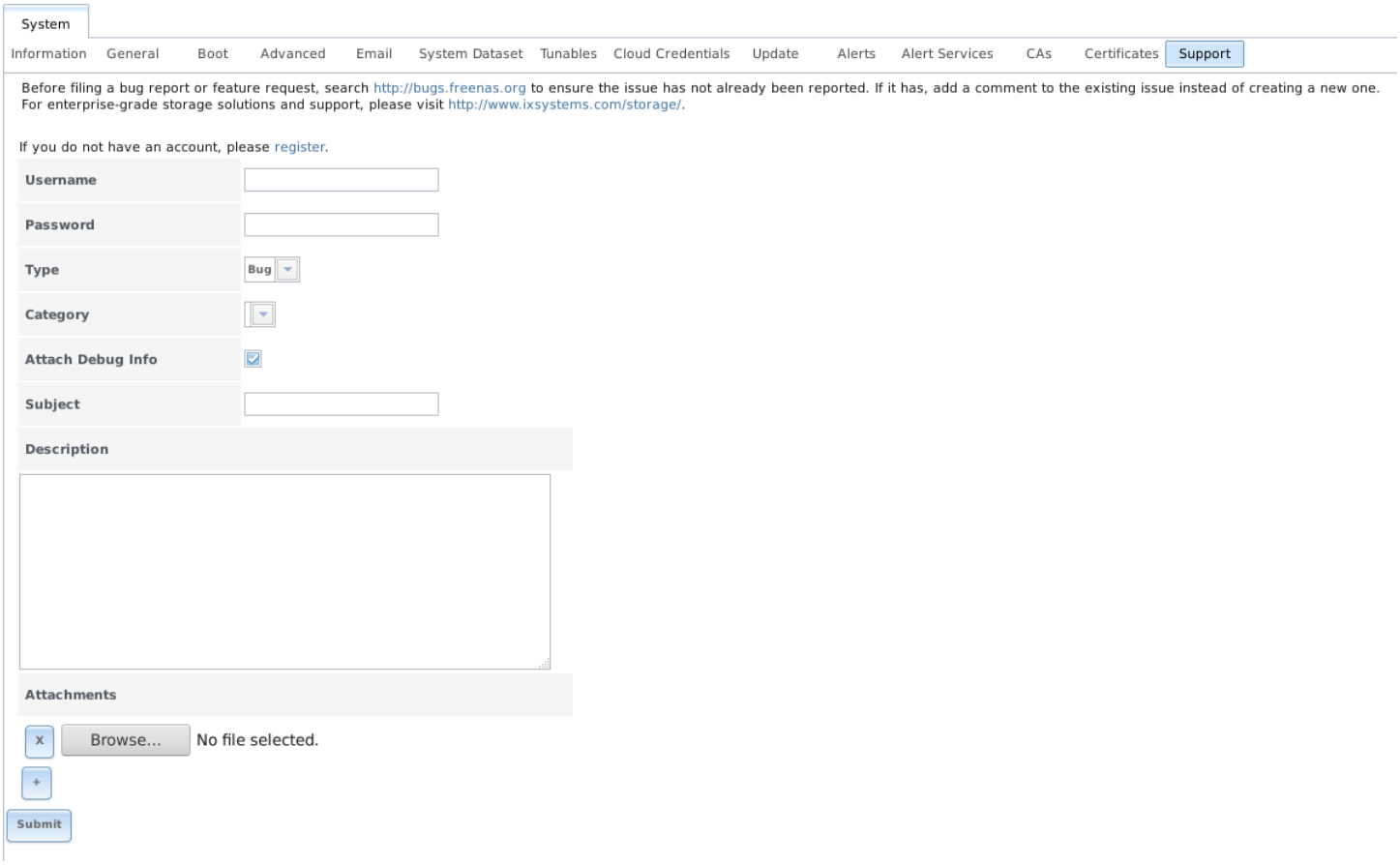


Fig. 5.24: Support Tab

This screen provides a built-in interface to the FreeNAS® issue tracker located at https://redmine.ixsystems.com/projects/freenas/issues. When using the FreeNAS® bug tracker for the first time, go to the website, click the *Register* link, fill out the form, and reply to the registration email. This will create a username and password which can be used to create bug reports and receive notifications as the reports are actioned.

Before creating a bug report or feature request, ensure that an existing report does not already exist at https://redmine.ixsystems.com/projects/freenas/issues. If a similar issue is already present and has not been marked as *Closed* or *Resolved*, comment on that issue, adding new information to help solve it. If similar issues have already been *Closed* or *Resolved*, create a new issue and refer to the previous issue.

Note: Update the system to the latest version of STABLE and retest before reporting an issue. Newer versions of the software might have already fixed the problem.

To generate a report using the built-in *Support* screen, complete the following fields:

- **Username:** enter the login name created when registering at https://redmine.ixsystems.com/projects/freenas/issues.
- **Password:** enter the password associated with the registered login name.
- **Type:** select *Bug* when reporting an issue or *Feature* when requesting a new feature.
- **Category:** this drop-down menu is empty until a registered *Username* and *Password* are entered. An error message is displayed if either value is incorrect. After the *Username* and *Password* are validated, possible categories are populated to the drop-down menu. Select the one that best describes the bug or feature being reported.
- **Attach Debug Info:** enabling this option is recommended so an overview of the system hardware, build string, and configuration is automatically generated and included with the ticket. Generating and attaching a debug to the ticket can take some time. An error will occur if the debug is more than the file size limit of 20M.

- **Subject:** enter a descriptive title for the ticket. A good *Subject* makes it easy for you and other users to find similar reports.
- **Description:** enter a one- to three-paragraph summary of the issue that describes the problem, and if applicable, what steps can be taken to reproduce it.
- **Attachments:** this is the only optional field. It is useful for including configuration files or screenshots of any errors or tracebacks.

After completing the fields, click the *Submit* button to automatically generate and upload the report to https://redmine.ixsystems.com/projects/freenas/issues. A pop-up menu provides a clickable URL so to view status or add additional information to the report.

CHAPTER

SIX

TASKS

The Tasks section of the administrative GUI is used to configure repetitive tasks:

- *Cloud Sync* (page 87) schedules data synchronization to cloud providers
- *Cron Jobs* (page 91) schedules a command or script to automatically execute at a specified time
- *Init/Shutdown Scripts* (page 94) configures a command or script to automatically execute during system startup or shutdown
- *Rsync Tasks* (page 95) schedules data synchronization to another system
- *S.M.A.R.T. Tests* (page 102) schedules disk tests

Each of these tasks is described in more detail in this section.

Note: By default, *Scrubs* (page 155) are run once a month by an automatically-created task. *S.M.A.R.T. Tests* (page 102) and *Periodic Snapshot Tasks* (page 143) must be set up manually.

6.1 Cloud Sync

Files or directories can be synchronized to remote cloud storage providers with the *Cloud Sync* feature.

Warning: This Cloud Sync task might go to a third party commercial vendor not directly affiliated with iXsystems. Please investigate and fully understand that vendor's pricing policies and services before creating any Cloud Sync task. iXsystems is not responsible for any charges incurred from the use of third party vendors with the Cloud Sync feature.

Cloud Credentials (page 75) must be pre-defined before a cloud sync is created. One set of credentials can be used for more than one cloud sync. For example, a single set of credentials for Amazon S3 can be used for separate cloud syncs that push different sets of files or directories.

A cloud storage area must also exist. With Amazon S3, these are called *buckets*. The bucket must be created before a sync task can be created.

After the credentials and receiving bucket have been configured, `Tasks → Cloud Syncs → Add Cloud Sync` is used to define the schedule for running a cloud sync task. An example is shown in Figure 6.1.

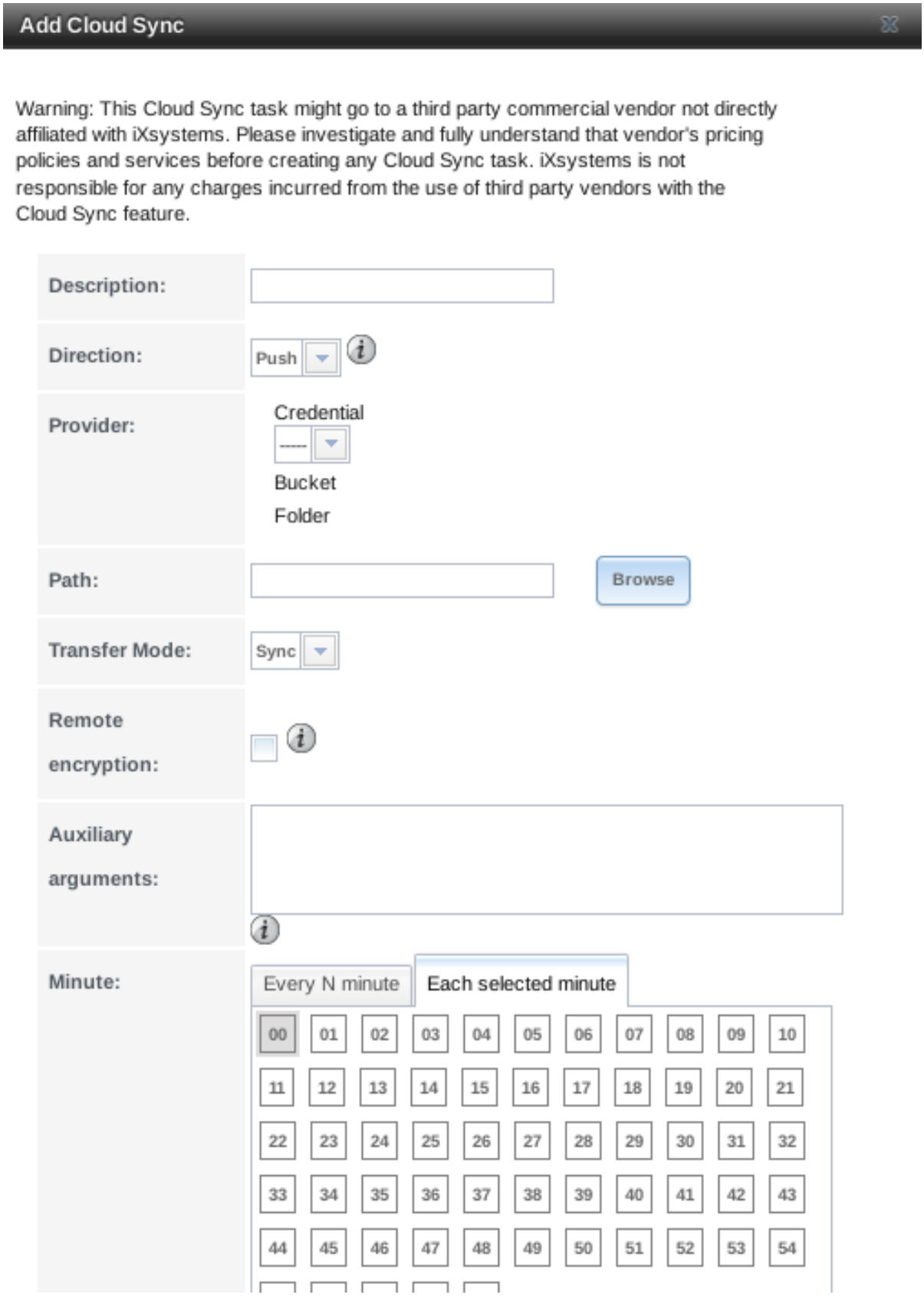


Fig. 6.1: Adding a Cloud Sync

Table 6.1 shows the configuration options for Cloud Syncs.

Table 6.1: Cloud Sync Options

Setting	Value Type	Description
Description	string	Enter a descriptive name for this Cloud Sync.
Direction	string	*Push* sends data to cloud storage. *Pull* receives data from cloud storage.
Provider	drop-down menu	Choose the cloud storage provider credentials from the list of entered *Cloud Credentials* (page 75). The UI automatically tests the credential and displays an error if a connection cannot be made.
Amazon S3 Buckets	drop-down menu	Only appears when an S3 credential is the *Provider*. Select the pre-defined S3 bucket to use.
Folder	string	Only appears when an S3 credential is the *Provider*. Optionally enter the name of the folder within the selected bucket.
Server Side Encryption	drop-down menu	Only appears when an S3 credential is the *Provider*. Choices are *None* (no encryption) or *AES-256* (encrypted).
Path	browse button	Select the directories or files to be sent to the cloud for *Push* syncs, or the destination to be written as the destinations for *Pull* syncs. Be cautious about the destination of *Pull* jobs to avoid overwriting existing files.
Transfer Mode	drop-down menu	*Sync* (default) makes files on destination system identical to those on the source. Files removed from the source are also removed from the destination, similar to `rsync --delete`. *Copy* copies files from the source to the destination, skipping files that are identical, similar to `rsync`. *Move* copies files from the source to the destination, deleting files from the source after the copy, similar to `mv`.
Remote encryption	checkbox	Set to encrypt files before transfer and store the encrypted files on the remote system. rclone Crypt (https://rclone.org/crypt/) is used.
Filename encryption	checkbox	Only appears when *Remote encryption* is enabled. Set to encrypt the shared file names.
Encryption password	string	Only appears when *Remote encryption* is enabled. Enter the password for encrypting and decrypting remote data. *Warning*: Always save and back up this password. Losing the encryption password can result in data loss.
Encryption salt	string	Only appears when *Remote encryption* is enabled. Enter a long string of random characters for use as salt (https://searchsecurity.techtarget.com/definition/salt) for the encryption password. *Warning*: Save and back up the encryption salt value. Losing the salt value can result in data loss.
Minute	slider or minute selections	Select *Every N minutes* and use the slider to choose a value, or select *Each selected minute* and choose specific minutes to run the task.
Hour	slider or hour selections	Select *Every N hours* and use the slider to choose a value, or select *Each selected hour* and choose specific hours to run the task.
Day of month	slider or day of month selections	Select *Every N days of month* and use the slider to choose a value, or select *Each selected day of month* and choose specific days to run the task.
Month	checkboxes	Months when the task runs.
Day of week	checkboxes	Days of the week to run the task.
Enabled	checkbox	Unset to temporarily disable this Cloud Sync.

Figure 6.2 shows a cloud sync called *backup-acctg* that "pushes" a file to cloud storage. The last run finished with a status of *SUCCESS*.

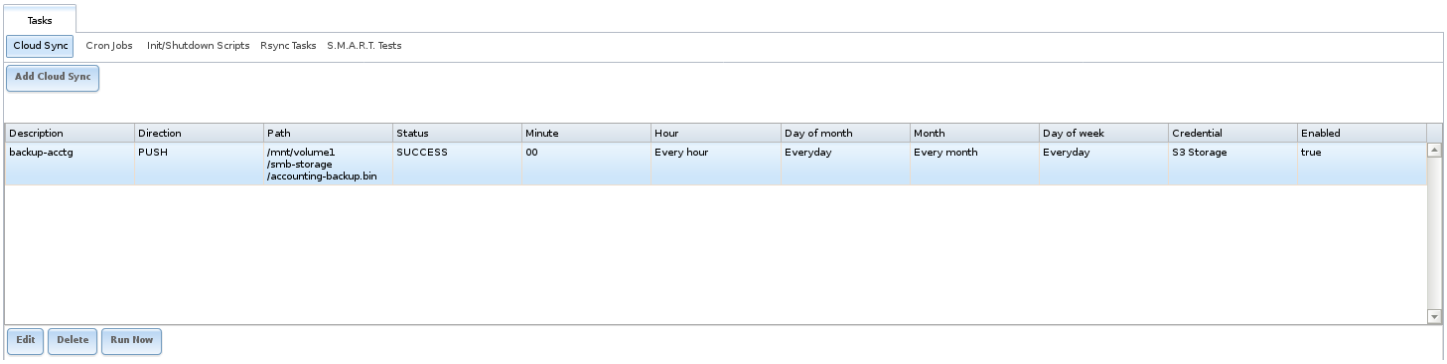


Fig. 6.2: Cloud Sync Status

To modify an existing cloud sync, click its entry to access its *Edit*, and *Delete*, and *Run Now* buttons.

If a cloud sync fails, click the *Status* column. This will open the log in a pop-up window so that the error message can be read.

6.1.1 Cloud Sync Example

This example shows a *Push* cloud sync which writes an accounting department backup file from the FreeNAS® system to Amazon S3 storage.

Before the new cloud sync was added, a bucket called *cloudsync-bucket* was created with the Amazon S3 web console for storing data from the FreeNAS® system.

`System → Cloud Credentials → Add Cloud Credential` is used to enter the credentials for storage on an Amazon AWS account. The credential is given the name *S3 Storage*, as shown in Figure 6.3:

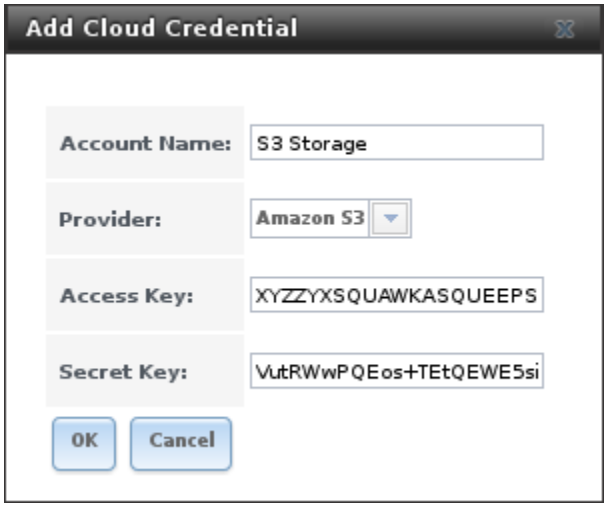


Fig. 6.3: Example: Adding Cloud Credentials

The local data to be sent to the cloud is a single file called `accounting-backup.bin` on the `smb-storage` dataset. A cloud sync job is created with `Tasks → Cloud Sync → Add Cloud Sync`. The *Description* is set to *backup-acctg* to describe the job. This data is being sent to cloud storage, so this is a *Push*. The provider comes from the cloud credentials defined in the previous step, and the destination bucket *cloudsync-bucket* is selected.

The *Path* to the data file is selected.

The remaining fields are for setting a schedule. The default is to send the data to cloud storage once an hour, every day. The options provide great versatility in configuring when a cloud sync runs, anywhere from once a minute to once a year.

The *Enabled* option is set by default, so this cloud sync will run at the next scheduled time.

The completed dialog is shown in Figure 6.4:

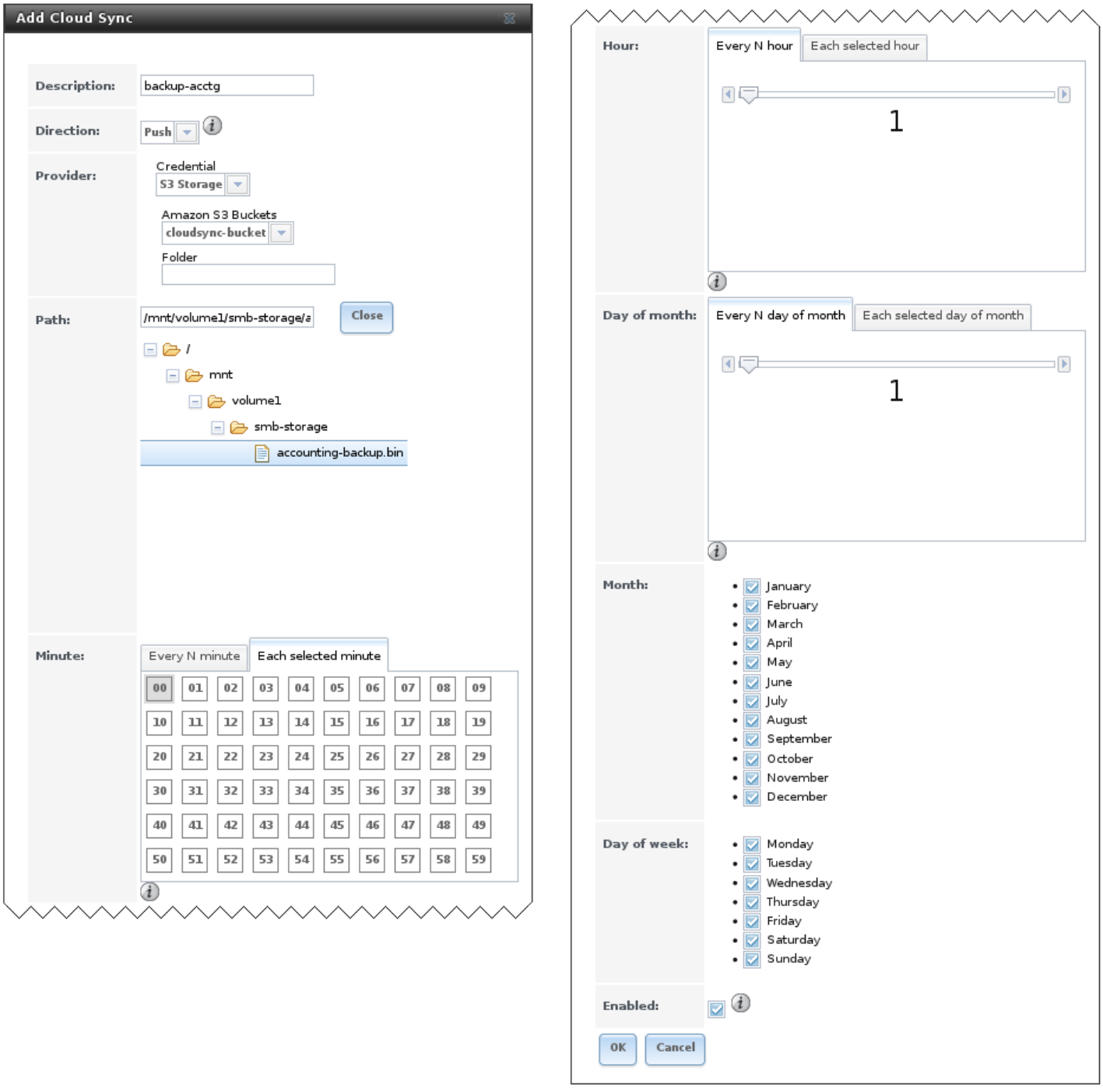


Fig. 6.4: Example: Adding a Cloud Sync

6.2 Cron Jobs

cron(8) (https://www.freebsd.org/cgi/man.cgi?query=cron) is a daemon that runs a command or script on a regular schedule

as a specified user.

Figure 6.5 shows the screen that opens after clicking `Tasks → Cron Jobs → Add Cron Job`.

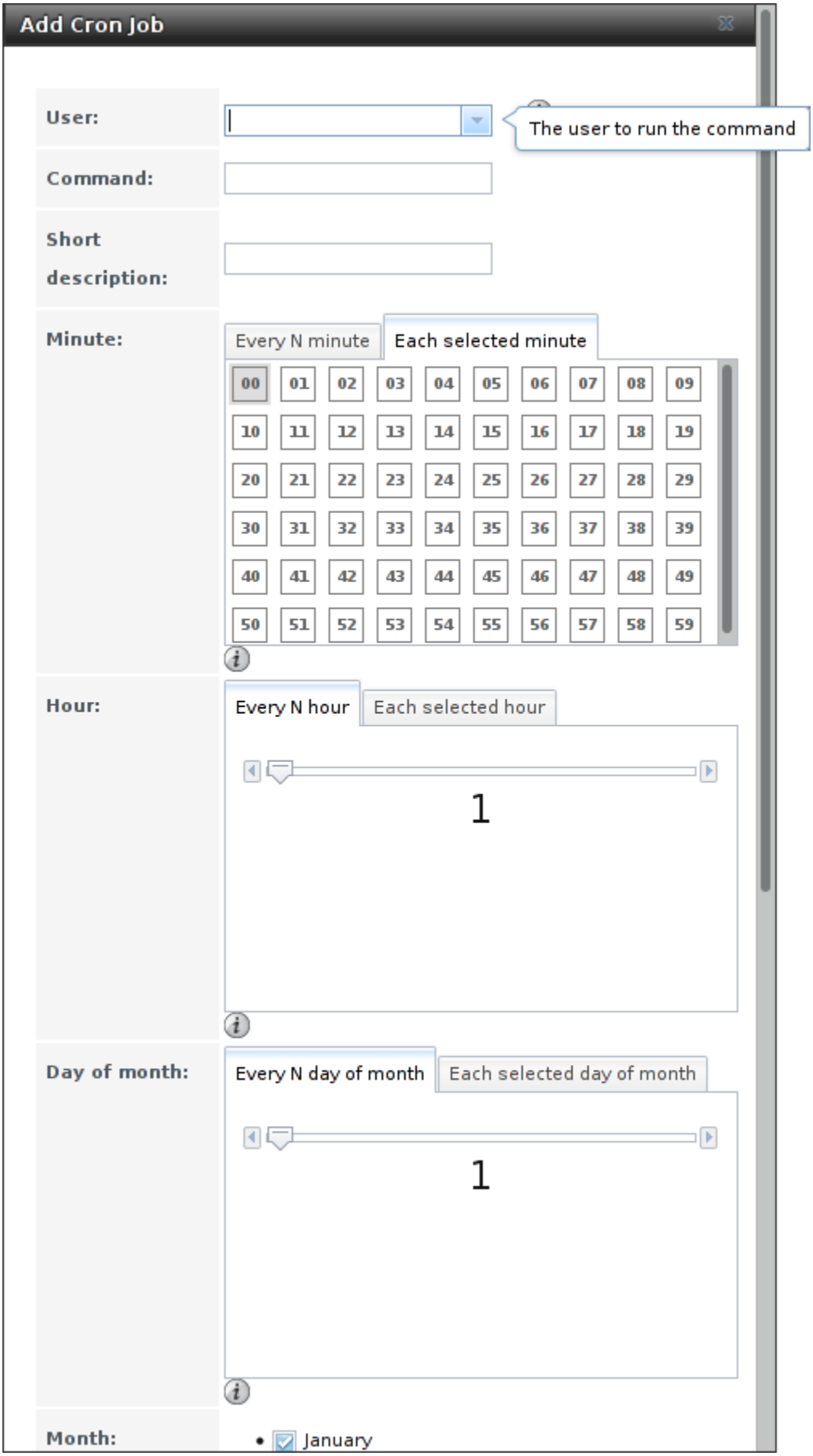


Fig. 6.5: Creating a Cron Job

Table 6.2 lists the configurable options for a cron job.

Table 6.2: Cron Job Options

Setting	Value	Description
User	drop-down menu	Choose a user account to run the command or script. The user must have permissions to run the command.
Command	string	Enter the **full path** to the command or script to be run. If it is a script, test it at the command line first to make sure that it works as expected.
Short description	string	Optional. Describe the new cron job.
Minute	slider or minute selections	With the slider, the cron job occurs every N minutes. With minute selections, the cron job occurs at the highlighted minutes
Hour	slider or hour selections	With the slider, the cron job occurs every N hours. With hour selections, the cron job occurs at the highlighted hours.
Day of month	slider or month selections	With the slider, the cron job occurs every N days. With day selections, the cron job occurs on the highlighted days each month.
Month	checkboxes	Cron job occurs on the selected months.
Day of week	checkboxes	Cron job occurs on the selected days.
Redirect Stdout	checkbox	Disables emailing standard output to the *root* user account.
Redirect Stderr	checkbox	Disables emailing errors to the *root* user account.
Enabled	checkbox	Deselect disable the cron job without deleting it.

Cron jobs are shown in *View Cron Jobs*. Highlight a cron job entry to display buttons to *Edit*, *Delete*, or *Run Now*.

Note: `%` symbols are automatically escaped and should not be prefixed with backslashes. For example, use `date '+%Y-%m-%d'` in a cron job to generate a filename based on the date.

6.3 Init/Shutdown Scripts

FreeNAS® provides the ability to schedule commands or scripts to run at system startup or shutdown.

Figure 6.6 shows the screen that opens after clicking `Tasks → Init/Shutdown Scripts → Add Init/Shutdown Script`. Table 6.3 summarizes the options.

Scheduled commands must be in the default path. The full path to the command can also be included in the entry. The path can be tested by typing `which commandname`. If the command is not found, it is not in the path.

When scheduling a script, make sure that the script is executable and has been fully tested to ensure it achieves the desired results.

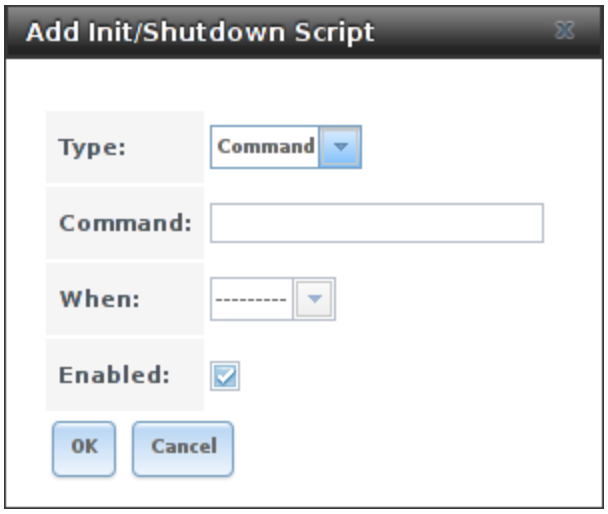


Fig. 6.6: Add an Init/Shutdown Script

Table 6.3: Options When Adding an Init/Shutdown Script

Setting	Value	Description
Type	drop-down menu	Select *Command* for an executable or *Script* for an executable script.
Command	string	If *Command* is selected, enter the command plus any desired options. If *Script* is selected, *Browse* to the location of the script.
When	drop-down menu	Select when the command or script runs. *Pre Init* is very early in boot process before mounting filesystems, *Post Init* is towards end of boot process before FreeNAS services start, or at *Shutdown*.
Enabled	checkbox	Unset to disable the task.

6.4 Rsync Tasks

Rsync (https://www.samba.org/ftp/rsync/rsync.html) is a utility that copies specified data from one system to another over a network. Once the initial data is copied, rsync reduces the amount of data sent over the network by sending only the differences between the source and destination files. Rsync is used for backups, mirroring data on multiple systems, or for copying files between systems.

Rsync is most effective when only a relatively small amount of the data has changed. There are also some limitations when using Rsync with Windows files (https://forums.freenas.org/index.php?threads/impaired-rsync-permissions-support-for-windows-datasets.43973/). For large amounts of data, data that has many changes from the previous copy, or Windows files, *Replication Tasks* (page 145) are often the faster and better solution.

Rsync is single-threaded and gains little from multiple processor cores. To see whether rsync is currently running, use `pgrep rsync` from the *Shell* (page 282).

Both ends of an rsync connection must be configured:

- **the rsync server:** this system pulls (receives) the data. This system is referred to as *PULL* in the configuration examples.
- **the rsync client:** this system pushes (sends) the data. This system is referred to as *PUSH* in the configuration examples.

FreeNAS® can be configured as either an *rsync client* or an *rsync server*. The opposite end of the connection can be another FreeNAS® system or any other system running rsync. In FreeNAS® terminology, an *rsync task* defines which data is synchronized between the two systems. To synchronize data between two FreeNAS® systems, create the *rsync task* on the *rsync client*.

FreeNAS® supports two modes of rsync operation:

- **rsync module mode:** exports a directory tree, and its configured settings, as a symbolic name over an unencrypted connection. This mode requires that at least one module be defined on the rsync server. It can be defined in the FreeNAS® GUI under `Services → Rsync → Rsync Modules`. In other operating systems, the module is defined in rsyncd.conf(5) (https://www.samba.org/ftp/rsync/rsyncd.conf.html).
- **rsync over SSH:** synchronizes over an encrypted connection. Requires the configuration of SSH user and host public keys.

This section summarizes the options when creating an rsync task. It then provides a configuration example between two FreeNAS® systems for each mode of rsync operation.

Note: If there is a firewall between the two systems or if the other system has a built-in firewall, make sure that TCP port 873 is allowed.

Figure 6.7 shows the screen that appears after selecting `Tasks → Rsync Tasks → Add Rsync Task`. Table 6.4 summarizes the options that can be configured when creating an rsync task.

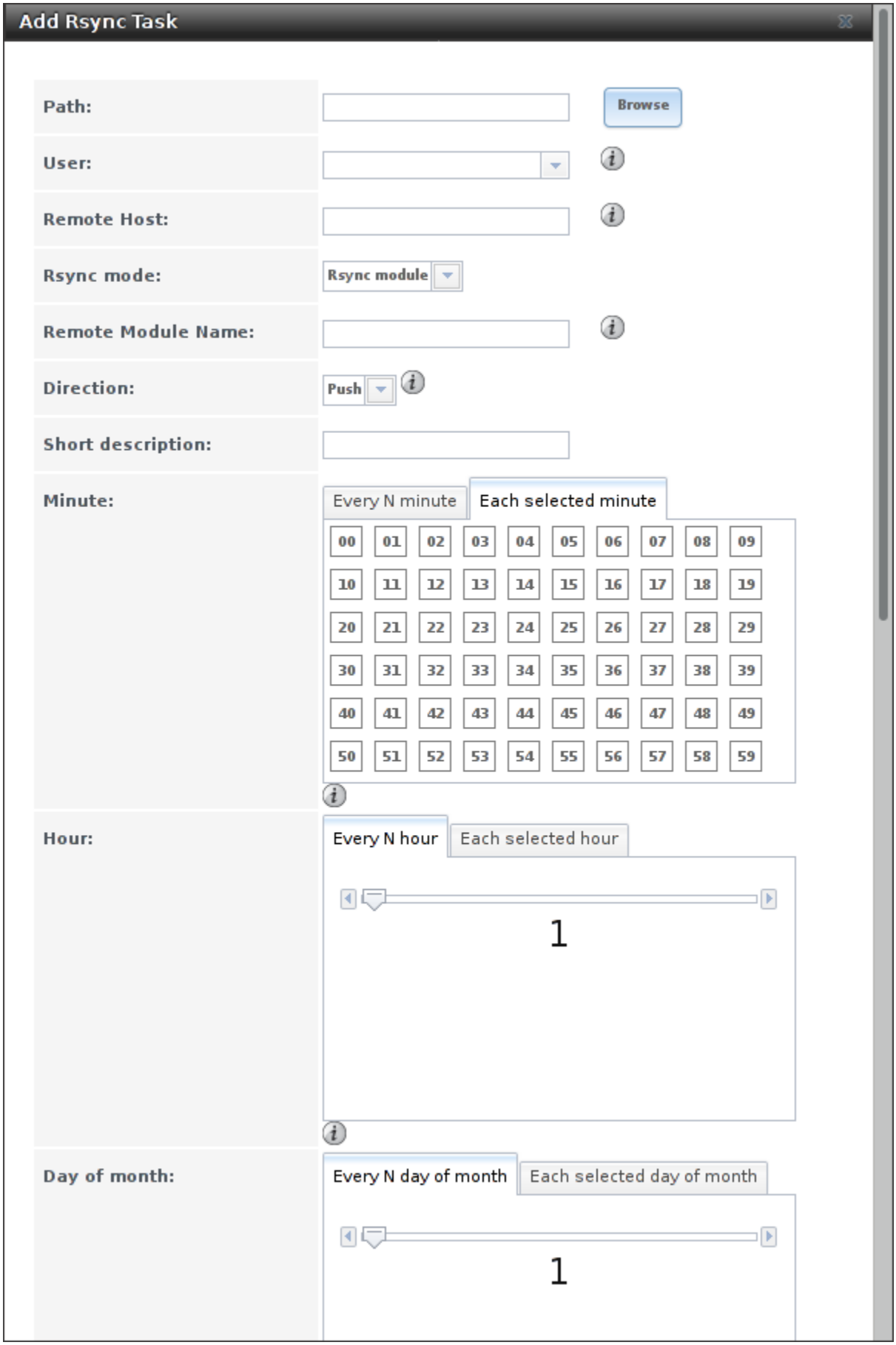


Fig. 6.7: Adding an Rsync Task

Table 6.4: Rsync Configuration Options

Setting	Value	Description
Path	browse button	*Browse* to the path to be copied. Path lengths cannot be greater than 255 characters.
User	drop-down menu	The chosen user must have permissions to write to the specified directory on the remote system. The user name cannot contain spaces or exceed 17 characters.
Remote Host	string	Enter the IP address or hostname of the remote system that will store the copy. Use the format *username@remote_host* if the username differs on the remote host.
Remote SSH Port	integer	Only available in *Rsync over SSH* mode. Allows specifying an SSH port other than the default of *22*.
Rsync mode	drop-down menu	Choices are *Rsync module* or *Rsync over SSH*.
Remote Module Name	string	At least one module must be defined in rsyncd.conf(5) (https://www.samba.org/ftp/rsync/rsyncd.conf.html) of the rsync server or in the *Rsync Modules* of another system.
Remote Path	string	Only appears when using *Rsync over SSH* mode, enter the **existing** path on the remote host to sync with, example: */mnt/volume*. Note that maximum path length is 255 characters.
Validate Remote Path	checkbox	Verifies the existence of the *Remote Path*.
Direction	drop-down menu	Direct the flow of the data to the remote host. Choices are *Push* or *Pull*. Default is to push to a remote host.
Short Description	string	Enter an optional description of the new rsync task.
Minute	slider or minute selections	When the slider is used the sync occurs every N minutes. When *Each selected minute* is used, the sync occurs at the highlighted minutes.
Hour	slider or hour selections	When the slider is used the sync occurs every N hours. When *Each selected hour* is used, the sync occurs at the highlighted hours.
Day of month	slider or day selections	When the slider is used the sync occurs every N days. When *Each selected day of the month* is used, the sync occurs on the highlighted days.
Month	checkboxes	Define which months to run the task.
Day of week	checkboxes	Define which days of the week to run the task.
Recursive	checkbox	Set to include all subdirectories of the specified volume during the rsync task.
Times	checkbox	Set to preserve the modification times of the files.
Compress	checkbox	Set to reduce the size of data to transmit. Recommended for slower connections.
Archive	checkbox	Equivalent to `-rlptgoD`. This will run the task as recursive, copy symlinks as symlinks, preserve permissions, preserve modification times, preserve group, preserve owner (root only), and preserve device files, and special files.
Delete	checkbox	Set to delete files in the destination directory that do not exist in the sending directory.
Quiet	checkbox	Set to suppresses informational messages from the remote server.
Preserve permissions	checkbox	Set to preserve original file permissions. Useful if User is set to *root*.
Preserve extended attributes	checkbox	Both systems must support extended attributes. (https://en.wikipedia.org/wiki/Xattr)
Delay Updates	checkbox	Set to save the temporary file from each updated file to a holding directory until the end of the transfer, when all transferred files are renamed into place.

Continued on next page

Table 6.4 – continued from previous page

Setting	Value	Description
Extra options	string	Add any other rsync(1) (http://rsync.samba.org/ftp/rsync/rsync.html) options. The `*` character must be escaped with a backslash (`\*.txt`) or used inside single quotes (`'*.txt'`).
Enabled	checkbox	Unset to disable the rsync task without deleting it. When the *Rsync* (page 229) service is OFF, the rsync task will continue to look for the server unless this option is unset.

If the rysnc server requires password authentication, enter `--password-file=/PATHTO/FILENAME` in the *Extra options* option, replacing `/PATHTO/FILENAME` with the appropriate path to the file containing the password.

Created rsync tasks will be listed in *View Rsync Tasks*. Highlight the entry for an rsync task to display buttons for *Edit*, *Delete*, or *Run Now*.

6.4.1 Rsync Module Mode

This configuration example configures rsync module mode between these two FreeNAS® systems:

- *192.168.2.2* has existing data in `/mnt/local/images`. It will be the rsync client, meaning that an rsync task needs to be defined. It will be referred to as *PUSH.*
- *192.168.2.6* has an existing volume named `/mnt/remote`. It will be the rsync server, meaning that it will receive the contents of `/mnt/local/images`. An rsync module needs to be defined on this system and the rsyncd service needs to be started. It will be referred to as *PULL.*

On *PUSH*, an rsync task is defined in `Tasks → Rsync Tasks → Add Rsync Task`. In this example:

- the *Path* points to `/usr/local/images`, the directory to be copied
- the *Remote Host* points to *192.168.2.6*, the IP address of the rsync server
- the *Rsync Mode* is *Rsync module*
- the *Remote Module Name* is *backups*; this will need to be defined on the rsync server
- the *Direction* is *Push*
- the rsync is scheduled to occur every 15 minutes
- the *User* is set to *root* so it has permission to write anywhere
- the *Preserve Permissions* option is enabled so that the original permissions are not overwritten by the *root* user

On *PULL*, an rsync module is defined in `Services → Rsync Modules → Add Rsync Module`. In this example:

- the *Module Name* is *backups*; this needs to match the setting on the rsync client
- the *Path* is `/mnt/remote`; a directory called `images` will be created to hold the contents of `/usr/local/images`
- the *User* is set to *root* so it has permission to write anywhere
- *Hosts allow* is set to *192.168.2.2*, the IP address of the rsync client

Descriptions of the configurable options can be found in *Rsync Modules*.

To finish the configuration, start the rsync service on *PULL* in `Services → Control Services`. If the rsync is successful, the contents of `/mnt/local/images/` will be mirrored to `/mnt/remote/images/`.

6.4.2 Rsync over SSH Mode

SSH replication mode does not require the creation of an rsync module or for the rsync service to be running on the rsync server. It does require SSH to be configured before creating the rsync task:

- a public/private key pair for the rsync user account (typically *root*) must be generated on *PUSH* and the public key copied to the same user account on *PULL*
- to mitigate the risk of man-in-the-middle attacks, the public host key of *PULL* must be copied to *PUSH*
- the SSH service must be running on *PULL*

To create the public/private key pair for the rsync user account, open *Shell* (page 282) on *PUSH* and run `ssh-keygen`. This example generates an RSA type public/private key pair for the *root* user. When creating the key pair, do not enter the passphrase as the key is meant to be used for an automated task.

```
ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Created directory '/root/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
f5:b0:06:d1:33:e4:95:cf:04:aa:bb:6e:a4:b7:2b:df root@freenas.local
The key's randomart image is:
+--[ RSA 2048]----+
|         .o. oo   |
|          o+o. .  |
|        . =o +    |
|         + +   o  |
|       S o .      |
|       .o         |
|      o.          |
|    o oo          |
|     **oE         |
|------------------|
|                  |
|------------------|
```

FreeNAS® supports RSA keys for SSH. When creating the key, use `-t rsa` to specify this type of key.

Note: If a different user account is used for the rsync task, use the `su -` command after mounting the filesystem but before generating the key. For example, if the rsync task is configured to use the *user1* user account, use this command to become that user:

```
su - user1
```

Next, view and copy the contents of the generated public key:

```
more .ssh/id_rsa.pub
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQC1lBEXRgw1W8y8k+lXPlVR3xsmVSjtsoyIzV/PlQPo
SrWotUQzqILq0SmUpViAAv4Ik3T8NtxXyohKmFNbBczU6tEsVGHo/2BLjvKiSHRPHc/1DX9hofcFti4h
dcD7Y5mvU3MAEeDClt02/xoi5xS/RLxgP0R5dNrakw958Yn001sJS9VMf528fknUmasti00qmDDcp/kO
xT+S6DFNDBy6IYQN4heqmhTPRXqPhXqcD1G+rWr/nZK4H8Ckzy+l9RaEXMRuTyQgqJB/rsRcmJX5fApd
DmNfwrRSxLjDvUzfywnjFHlKk/+TQIT1gg1QQaj21PJD9pnDVF0AiJrWyWnR root@freenas.local
```

Go to *PULL* and paste (or append) the copied key into the *SSH Public Key* field of `Account` → `Users` → `View Users` → `root` → `Modify User`, or the username of the specified rsync user account. The paste for the above example is shown in Figure 6.8. When pasting the key, ensure that it is pasted as one long line and, if necessary, remove any extra spaces representing line breaks.

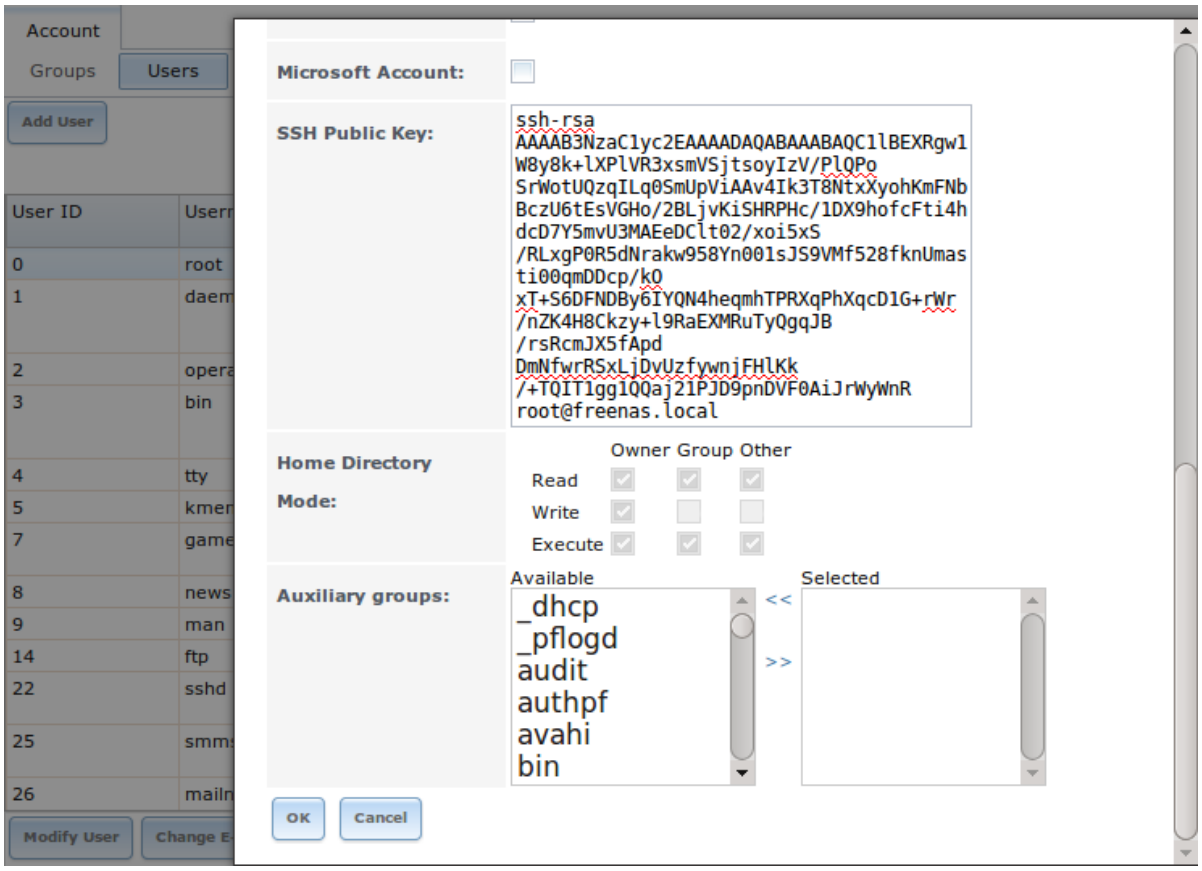


Fig. 6.8: Pasting the User SSH Public Key

While on *PULL*, verify that the SSH service is running in `Services → Control Services` and start it if it is not.

Next, copy the host key of *PULL* using Shell on *PUSH*. The command below copies the RSA host key of the *PULL* server used in our previous example. Be sure to include the double bracket >> to prevent overwriting any existing entries in the `known_hosts` file:

```
ssh-keyscan -t rsa 192.168.2.6 >> /root/.ssh/known_hosts
```

Note: If *PUSH* is a Linux system, use this command to copy the RSA key to the Linux system:

```
cat ~/.ssh/id_rsa.pub | ssh user@192.168.2.6 'cat >> .ssh/authorized_keys'
```

The rsync task can now be created on *PUSH*. To configure rsync SSH mode using the systems in the previous example, use this configuration:

- the *Path* points to `/mnt/local/images`, the directory to be copied
- the *Remote Host* points to *192.168.2.6*, the IP address of the rsync server
- the *Rsync Mode* is *Rsync over SSH*
- the rsync is scheduled to occur every 15 minutes
- the *User* is set to *root* so it has permission to write anywhere; the public key for this user must be generated on *PUSH* and copied to *PULL*
- the *Preserve Permissions* option is enabled so that the original permissions are not overwritten by the *root* user

Save the rsync task and the rsync will automatically occur according to the schedule. In this example, the contents of `/mnt/local/images/` will automatically appear in `/mnt/remote/images/` after 15 minutes. If the content does not appear, use Shell on *PULL* to read `/var/log/messages`. If the message indicates a *n* (newline character) in the key, remove the space in the pasted key–it will be after the character that appears just before the *n* in the error message.

6.5 S.M.A.R.T. Tests

S.M.A.R.T. (https://en.wikipedia.org/wiki/S.M.A.R.T.) (Self-Monitoring, Analysis and Reporting Technology) is a monitoring system for computer hard disk drives to detect and report on various indicators of reliability. When a failure is anticipated by S.M.A.R.T., the drive should be replaced. Most modern ATA, IDE, and SCSI-3 hard drives support S.M.A.R.T. – refer to the drive documentation for confirmation.

Figure 6.9 shows the configuration screen that appears after selecting `Tasks → S.M.A.R.T. Tests → Add S.M.A.R.T. Test`. Tests are listed under *View S.M.A.R.T. Tests*. After creating tests, check the configuration in `Services → S.M.A.R.T.`, then click the slider to *ON* for the S.M.A.R.T. service in `Services → Control Services`. The S.M.A.R.T. service will not start if there are no volumes.

Note: To prevent problems, do not enable the S.M.A.R.T. service if the disks are controlled by a RAID controller. It is the job of the controller to monitor S.M.A.R.T. and mark drives as Predictive Failure when they trip.

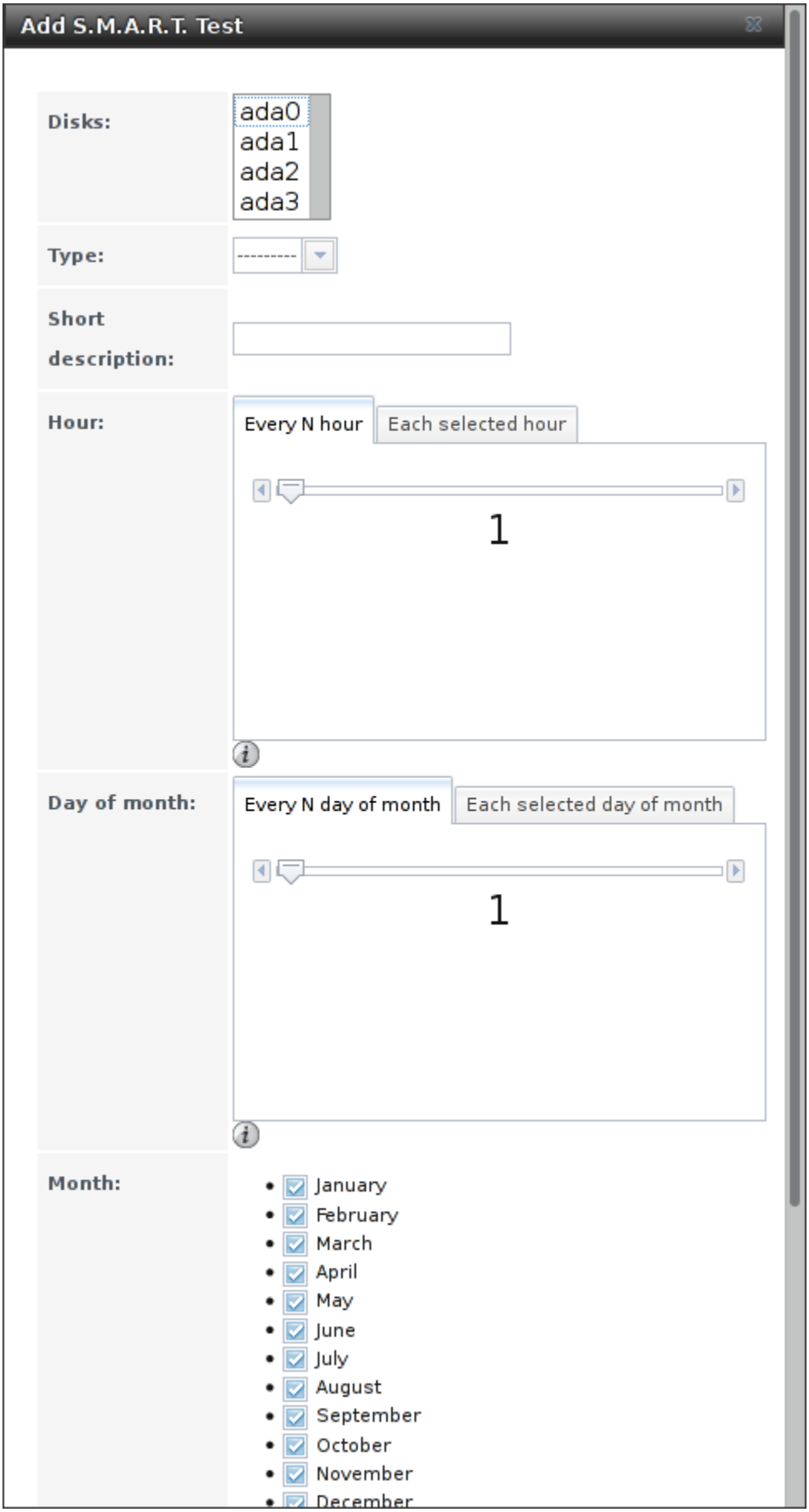


Fig. 6.9: Adding a S.M.A.R.T. Test

Table 6.5 summarizes the configurable options when creating a S.M.A.R.T. test.

Table 6.5: S.M.A.R.T. Test Options

Setting	Value	Description
Disks	list	Select the disks to monitor.
Type	drop-down menu	Choose the test type. See smartctl(8) (https://www.smartmontools.org/browser/trunk/smartmontools/smartctl.8.in) for descriptions of each type of test. Some test types will degrade performance or take disks offline. Avoid scheduling S.M.A.R.T. tests simultaneously with scrub or resilver operations.
Short description	string	Optional. Enter a short description of this test.
Hour	slider or hour selections	When the slider is used the sync occurs every N hours. When *Each selected hour* is used, the test occurs at the highlighted hours.
Day of month	slider or day selections	When the slider is used the sync occurs every N days. When *Each selected day of the month* is used, the sync occurs on the highlighted days.
Month	checkboxes	Select which months to run the test.
Day of week	checkboxes	Select which days of the week to run the test.

An example configuration is to schedule a *Short Self-Test* once a week and a *Long Self-Test* once a month. These tests should not have a performance impact, as the disks prioritize normal I/O over the tests. If a disk fails a test, even if the overall status is *Passed*, start to think about replacing that disk.

Warning: Some S.M.A.R.T. tests cause heavy disk activity and can drastically reduce disk performance. Do not schedule S.M.A.R.T. tests to run at the same time as scrub or resilver operations or during other periods of intense disk activity.

Which tests will run and when can be verified by typing `smartd -q showtests` within *Shell* (page 282).

The results of a test can be checked from *Shell* (page 282) by specifying the name of the drive. For example, to see the results for disk *ada0*, type:

```
smartctl -l selftest /dev/ada0
```

If an email address is entered in the *Email to report* field of `Services → S.M.A.R.T.`, the system will send an email to that address when a test fails. Logging information for S.M.A.R.T. tests can be found in `/var/log/daemon.log`.

CHAPTER

SEVEN

NETWORK

The Network section of the administrative GUI contains these components for viewing and configuring network settings on the FreeNAS® system:

- *Global Configuration* (page 105): general network settings.
- *Interfaces* (page 107): settings for each network interface.
- *IPMI* (page 109): settings controlling connection to the appliance through the hardware side-band management interface if the graphical user interface becomes unavailable.
- *Link Aggregations* (page 111): settings for network link aggregation and link failover.
- *Network Summary* (page 115): display an overview of the current network settings.
- *Static Routes* (page 115): add static routes.
- *VLANs* (page 116): configure IEEE 802.1q tagging for virtual LANs.

Each of these is described in more detail in this section.

7.1 Global Configuration

`Network → Global Configuration`, shown in Figure 7.1, is for general network settings that are not unique to any particular network interface.

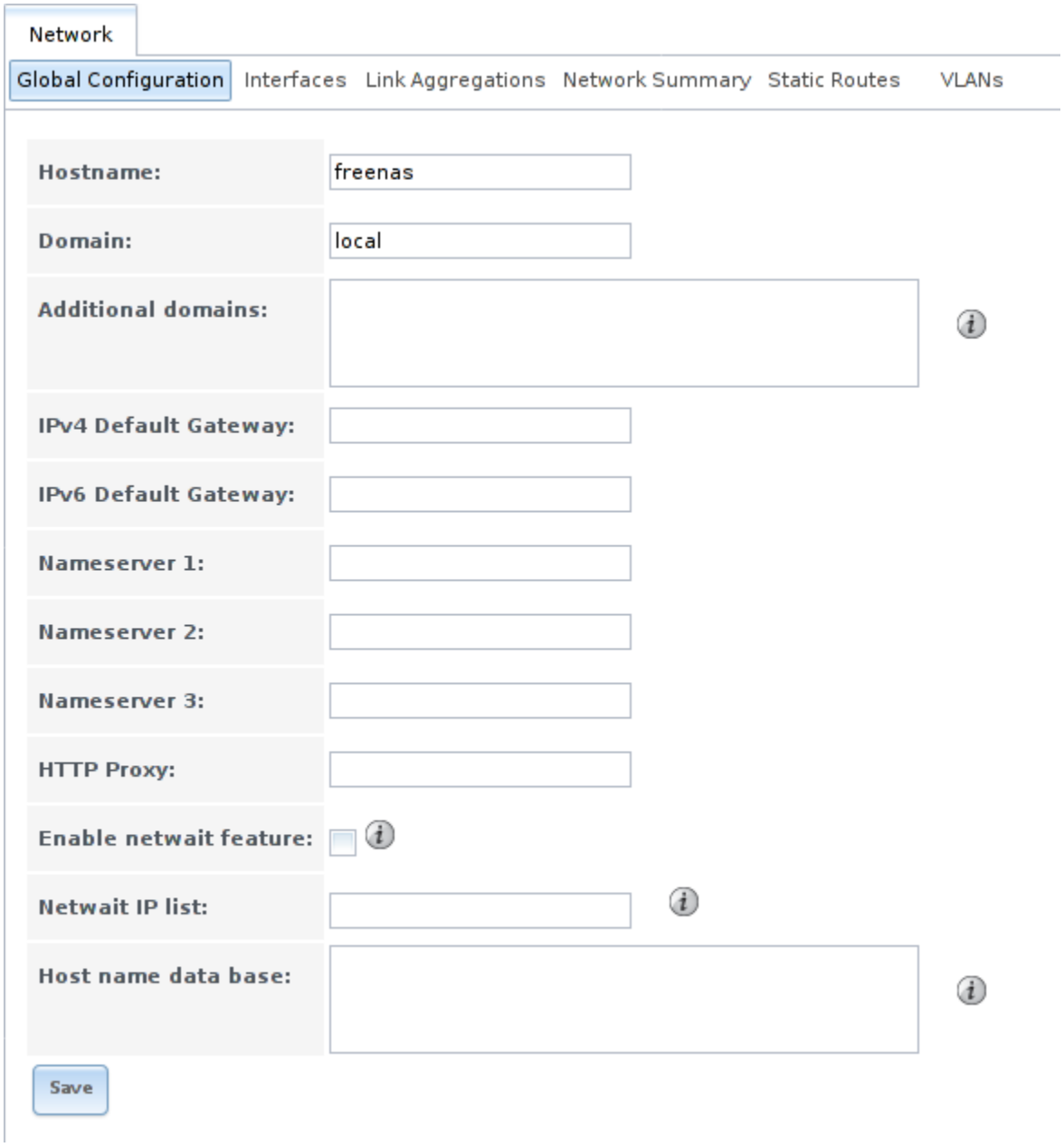


Fig. 7.1: Global Network Configuration

Table 7.1 summarizes the settings on the Global Configuration tab. *Hostname* and *Domain* fields are pre-filled as shown in Figure 7.1, but can be changed to meet requirements of the local network.

Table 7.1: Global Configuration Settings

Setting	Value	Description
Hostname	string	System host name. Cannot contain the underscore character.
Domain	string	System domain name.
Additional domains	string	Can enter up to 6 space delimited search domains. Adding multiple domains may result in slower DNS lookups.
IPv4 Default Gateway	IP address	Typically not set. See *this note about Gateways* (page 107). If set, used instead of default gateway provided by DHCP.

Continued on next page

Table 7.1 – continued from previous page

Setting	Value	Description
IPv6 Default Gateway	IP address	Typically not set. See *this note about Gateways* (page 107).
Nameserver 1	IP address	Primary DNS server (typically in Windows domain).
Nameserver 2	IP address	Secondary DNS server.
Nameserver 3	IP address	Tertiary DNS server.
HTTP Proxy	string	Enter the proxy information for the network in the format *http://my.proxy.server:3128* or *http://user:password@my.proxy.server:3128*.
Enable netwait feature	checkbox	If enabled, network services do not start at boot until the interface is able to ping the addresses listed in the *Netwait IP list*.
Netwait IP list	string	If *Enable netwait feature* is unset, list of IP addresses to ping. Otherwise, ping the default gateway.
Host name database	string	Used to add one entry per line which will be appended to `/etc/hosts`. Use the format *IP_address space hostname* where multiple hostnames can be used if separated by a space.

When using Active Directory, set the IP address of the realm's DNS server in the *Nameserver 1* field.

If the network does not have a DNS server, or NFS, SSH, or FTP users are receiving "reverse DNS" or timeout errors, add an entry for the IP address of the FreeNAS® system in the *Host name database* field.

Note: In many cases, a FreeNAS® configuration does not include default gateway information as a way to make it more difficult for a remote attacker to communicate with the server. While this is a reasonable precaution, such a configuration does **not** restrict inbound traffic from sources within the local network. However, omitting a default gateway will prevent the FreeNAS® system from communicating with DNS servers, time servers, and mail servers that are located outside of the local network. In this case, it is recommended to add *Static Routes* (page 115) to be able to reach external DNS, NTP, and mail servers which are configured with static IP addresses. When a gateway to the Internet is added, make sure the FreeNAS® system is protected by a properly configured firewall.

7.2 Interfaces

`Network → Interfaces` shows which interfaces have been manually configured and allows adding or editing a manually configured interface.

Note: Typically, the interface used to access the FreeNAS® administrative GUI is configured by DHCP. This interface does not appear in this screen, even though it is already dynamically configured and in use.

Creating a Link Aggregation (page 112) that does **not** include the NIC used to access the FreeNAS® administrative GUI may require adding an *Interfaces* entry for this interface with DHCP enabled.

Figure 7.2 shows the screen that opens on clicking `Interfaces → Add Interface`. Table 7.2 summarizes the configuration options shown when adding an interface or editing an already configured interface. Note that if any changes to this screen require a network restart, the screen will turn red when the *OK* button is clicked and a pop-up message will point out that network connectivity to the FreeNAS® system will be interrupted while the changes are applied.

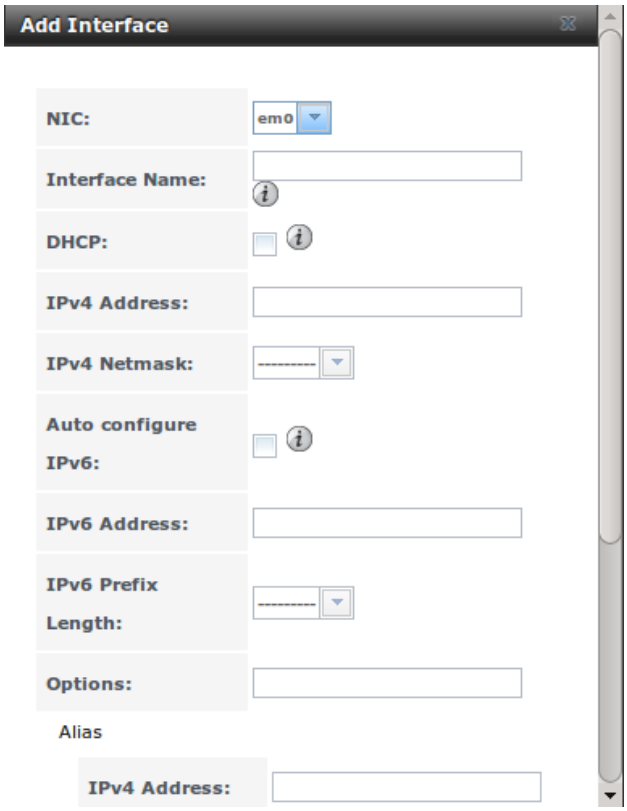


Fig. 7.2: Adding or Editing an Interface

Table 7.2: Interface Configuration Settings

Setting	Value	Description
NIC	drop-down menu	The FreeBSD device name of the interface. This is a read-only field when editing an interface.
Interface Name	string	Description of interface.
DHCP	checkbox	Requires static IPv4 or IPv6 configuration if unselected. Only one interface can be configured for DHCP.
IPv4 Address	IP address	Enter a static IP address if *DHCP* is unset.
IPv4 Netmask	drop-down menu	Enter a netmask if *DHCP* is unset.
Auto configure IPv6	checkbox	Only one interface can be configured for this option. If unset, manual configuration is required to use IPv6.
IPv6 Address	IPv6 address	Must be unique on the network.
IPv6 Prefix Length	drop-down menu	Match the prefix used on the network.
Options	string	Additional parameters from ifconfig(8) (https://www.freebsd.org/cgi/man.cgi?query=ifconfig). Separate multiple parameters with a space. For example: *mtu 9000* increases the MTU for interfaces which support jumbo frames (but see *this note* (page 115) about MTU and lagg interfaces).

This screen also provides for the configuration of IP aliases, making it possible for a single interface to have multiple IP addresses. To set multiple aliases, click the *Add extra alias* link for each alias. Aliases are deleted by clicking the interface in the tree, clicking the *Edit* button, checking the *Delete* checkbox below the alias, then clicking the *OK* button.

Warning: Aliases are deleted by checking the *Delete* checkbox in the alias area, then clicking *OK* for the interface. **Do not** click the *Delete* button at the bottom of this screen, which deletes the entire interface.

Multiple interfaces **cannot** be members of the same subnet. See Multiple network interfaces on a single subnet (https://forums.freenas.org/index.php?threads/multiple-network-interfaces-on-a-single-subnet.20204/) for more information. Check the subnet mask if an error is shown when setting the IP addresses on multiple interfaces.

This screen will not allow an interface's IPv4 and IPv6 addresses to both be set as primary addresses. An error is shown if both the *IPv4 address* and *IPv6 address* fields are filled in. Instead, set only one of these address fields and create an alias for the other address.

7.3 IPMI

Beginning with version 9.2.1, FreeNAS® provides a graphical screen for configuring an IPMI interface. This screen will only appear if the system hardware includes a Baseboard Management Controller (BMC).

IPMI provides side-band management if the graphical administrative interface becomes unresponsive. This allows for a few vital functions, such as checking the log, accessing the BIOS setup, and powering on the system without requiring physical access to the system. IPMI is also used to give another person remote access to the system to assist with a configuration or troubleshooting issue. Before configuring IPMI, ensure that the management interface is physically connected to the network. The IPMI device may share the primary Ethernet interface, or it may be a dedicated separate IPMI interface.

Warning: It is recommended to first ensure that the IPMI has been patched against the Remote Management Vulnerability before enabling IPMI. This article (https://www.ixsystems.com/blog/how-to-fix-the-ipmi-remote-management-vulnerability/) provides more information about the vulnerability and how to fix it.

Note: Some IPMI implementations require updates to work with newer versions of Java. See PSA: Java 8 Update 131 breaks ASRock's IPMI Virtual console (https://forums.freenas.org/index.php?threads/psa-java-8-update-131-breaks-asrocks-ipmi-virtual-console.53911/) for more information.

IPMI is configured from `Network → IPMI`. The IPMI configuration screen, shown in Figure 7.3, provides a shortcut to the most basic IPMI configuration. Those already familiar with IPMI management tools can use them instead. Table 7.3 summarizes the options available when configuring IPMI with the FreeNAS® GUI.

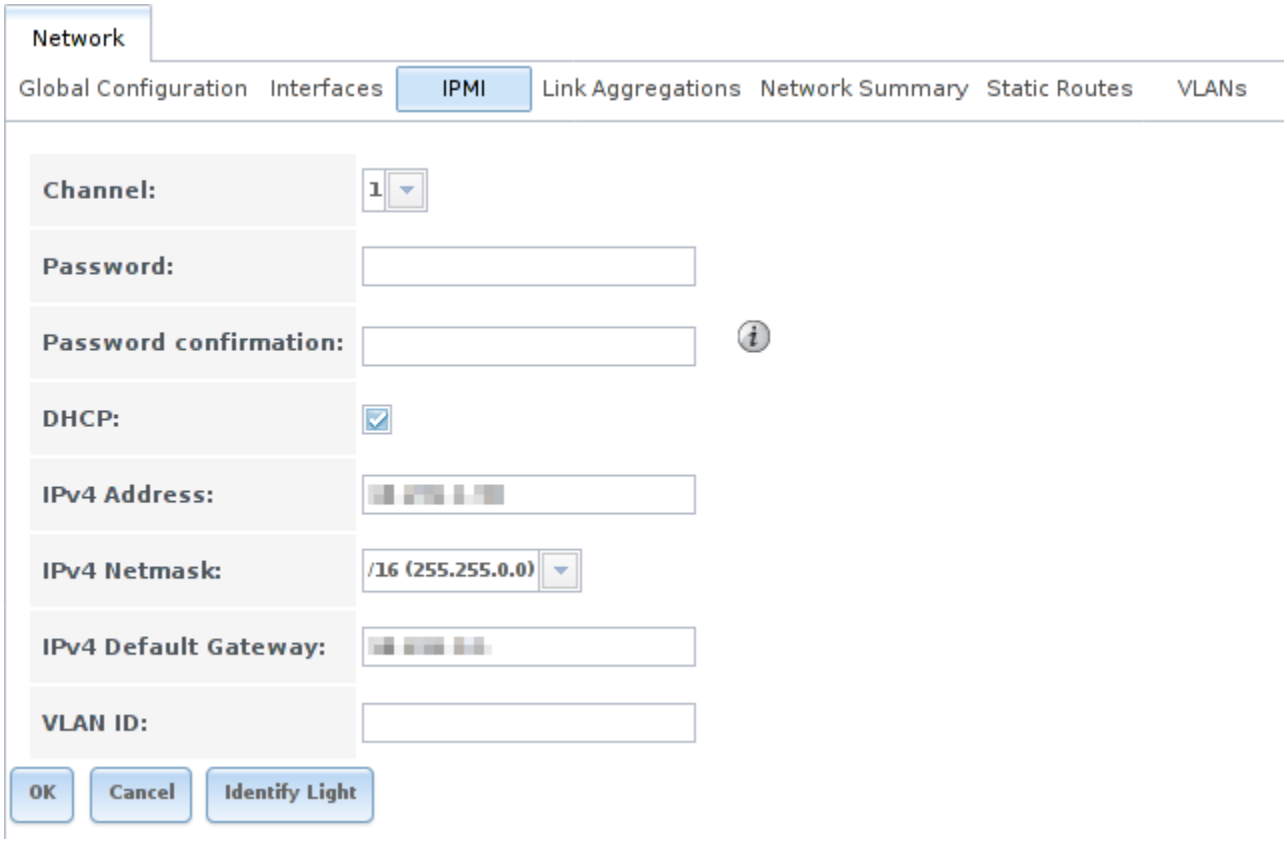


Fig. 7.3: IPMI Configuration

Table 7.3: IPMI Options

Setting	Value	Description
Channel	drop-down menu	Select the channel to use.
Password	string	Enter the password used to connect to the IPMI interface from a web browser.
DHCP	checkbox	If left unset, the next three fields must be set.
IPv4 Address	string	IP address used to connect to the IPMI web GUI.
IPv4 Netmask	drop-down menu	Subnet mask associated with the IP address.
IPv4 Default Gateway	string	Default gateway associated with the IP address.
VLAN ID	string	Enter the VLAN identifier if the IPMI out-of-band management interface is not on the same VLAN as management networking.

The *Identify Light* button can be used to identify a system in a multi-system rack by flashing its IPMI LED light. Clicking this button will present a pop-up with a menu of times, ranging from 15 seconds to 4 minutes, to flash the LED light.

After configuration, the IPMI interface is accessed using a web browser and the IP address specified in the configuration. The management interface prompts for a username and the configured password. Refer to the IPMI device's documentation to determine the default administrative username.

After logging in to the management interface, the default administrative username can be changed, and additional users created. The appearance of the IPMI utility and the functions that are available vary depending on the hardware.

A command-line utility called `ipmitool` is available to control many features of the IPMI interface. See How To: Change IPMI Sensor Thresholds using ipmitool (https://forums.freenas.org/index.php?resources/how-to-change-ipmi-sensor-thresholds-using-ipmitool.35/) for some examples.

7.4 Link Aggregations

FreeNAS® uses FreeBSD's lagg(4) (https://www.freebsd.org/cgi/man.cgi?query=lagg) interface to provide link aggregation and link failover. The lagg interface allows aggregation of multiple network interfaces into a single virtual lagg interface, providing fault-tolerance and high-speed multi-link throughput. The aggregation protocols supported by lagg determine which ports are used for outgoing traffic and whether a specific port accepts incoming traffic. The link state of the lagg interface is used to validate whether the port is active.

Aggregation works best on switches supporting LACP, which distributes traffic bi-directionally while responding to failure of individual links. FreeNAS® also supports active/passive failover between pairs of links. The LACP and load-balance modes select the output interface using a hash that includes the Ethernet source and destination address, VLAN tag (if available), IP source and destination address, and flow label (IPv6 only). The benefit can only be observed when multiple clients are transferring files *from* the NAS. The flow entering *into* the NAS depends on the Ethernet switch load-balance algorithm.

The lagg driver currently supports several aggregation protocols, although only *Failover* is recommended on network switches that do not support LACP:

Failover: the default protocol. Sends traffic only through the active port. If the master port becomes unavailable, the next active port is used. The first interface added is the master port; any interfaces added after that are used as failover devices. By default, received traffic is only accepted when received through the active port. This constraint can be relaxed, which is useful for certain bridged network setups, by creating a tunable with a *Variable* of *net.link.lagg.failover_rx_all*, a *Value* of a non-zero integer, and a *Type* of *Sysctl* in `System → Tunables → Add Tunable`.

LACP: supports the IEEE 802.3ad Link Aggregation Control Protocol (LACP) and the Marker Protocol. LACP negotiates a set of aggregable links with the peer into one or more link aggregated groups (LAGs). Each LAG is composed of ports of the same speed, set to full-duplex operation. Traffic is balanced across the ports in the LAG with the greatest total speed; in most cases there will only be one LAG which contains all ports. In the event of changes in physical connectivity, link aggregation will quickly converge to a new configuration. LACP must be configured on the switch, and LACP does not support mixing interfaces of different speeds. Only interfaces that use the same driver, like two *igb* ports, are recommended for LACP. Using LACP for iSCSI is not recommended, as iSCSI has built-in multipath features which are more efficient.

Load Balance: balances outgoing traffic across the active ports based on hashed protocol header information and accepts incoming traffic from any active port. This is a static setup and does not negotiate aggregation with the peer or exchange frames to monitor the link. The hash includes the Ethernet source and destination address, VLAN tag (if available), and IP source and destination address. Requires a switch which supports IEEE 802.3ad static link aggregation.

Round Robin: distributes outgoing traffic using a round-robin scheduler through all active ports and accepts incoming traffic from any active port. This mode can cause unordered packet arrival at the client. This has a side effect of limiting throughput as reordering packets can be CPU intensive on the client. Requires a switch which supports IEEE 802.3ad static link aggregation.

None: this protocol disables any traffic without disabling the lagg interface itself.

Note: When using LACP, verify that the switch is configured for active LACP. Passive LACP is not supported.

7.4.1 LACP, MPIO, NFS, and ESXi

LACP bonds Ethernet connections to improve bandwidth. For example, four physical interfaces can be used to create one mega interface. However, it cannot increase the bandwidth for a single conversation. It is designed to increase bandwidth when multiple clients are simultaneously accessing the same system. It also assumes that quality Ethernet hardware is used and it will not make much difference when using inferior Ethernet chipsets such as a Realtek.

LACP reads the sender and receiver IP addresses and, if they are deemed to belong to the same TCP connection, always sends the packet over the same interface to ensure that TCP does not need to reorder packets. This makes LACP ideal for load balancing many simultaneous TCP connections, but does nothing for increasing the speed over one TCP connection.

MPIO operates at the iSCSI protocol level. For example, if four IP addresses are created and there are four simultaneous TCP connections, MPIO will send the data over all available links. When configuring MPIO, make sure that the IP addresses

on the interfaces are configured to be on separate subnets with non-overlapping netmasks, or configure static routes to do point-to-point communication. Otherwise, all packets will pass through one interface.

LACP and other forms of link aggregation generally do not work well with virtualization solutions. In a virtualized environment, consider the use of iSCSI MPIO through the creation of an iSCSI Portal with at least two network cards on different networks. This allows an iSCSI initiator to recognize multiple links to a target, using them for increased bandwidth or redundancy. This how-to (https://fojta.wordpress.com/2010/04/13/iscsi-and-esxi-multipathing-and-jumbo-frames/) contains instructions for configuring MPIO on ESXi.

NFS does not understand MPIO. Therefore, one fast interface is needed, since creating an iSCSI portal will not improve bandwidth when using NFS. LACP does not work well to increase the bandwidth for point-to-point NFS (one server and one client). LACP is a good solution for link redundancy or for one server and many clients.

7.4.2 Creating a Link Aggregation

Before creating a link aggregation, make sure that all interfaces to be used in the lagg have not been manually configured in `Network → Interfaces → View Interfaces`.

If any manually-configured interfaces to be included in the lagg exist, delete them. **Lagg creation fails if any of the included interfaces are manually configured**.

Warning: Creating or editing link aggregations can disconnect clients using the FreeNAS® computer. Please verify that clients have saved their work and are not connected through the affected networks before making changes.

Figure 7.4 shows the configuration options when adding a lagg interface using `Network → Link Aggregations → Create Link Aggregation`.

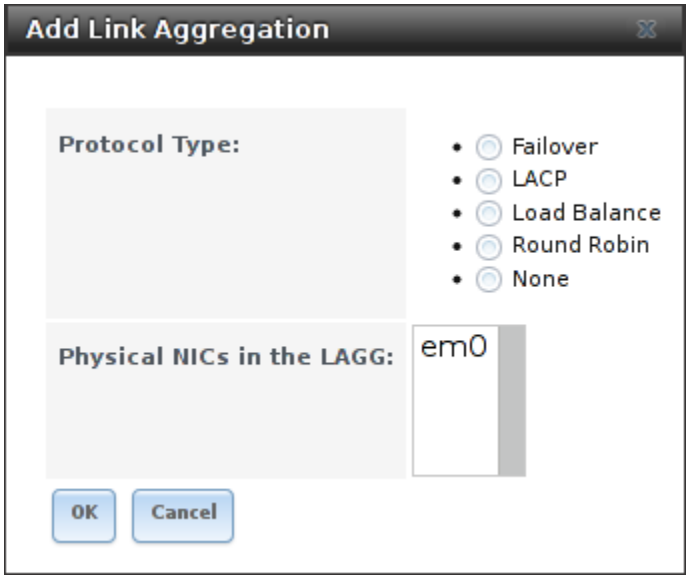


Fig. 7.4: Creating a lagg Interface

Note: If interfaces are installed but do not appear in the *Physical NICs* list, check that a FreeBSD driver for the interface exists here (https://www.freebsd.org/releases/11.1R/hardware.html#ethernet).

To create a link aggregation, select the desired *Protocol Type*. *LACP* is preferred. If the network switch does not support LACP, choose *Failover*. Highlight the interfaces to associate with the lagg device, and click the *OK* button.

Once the lagg device has been created, click its entry to enable its *Edit*, *Delete*, and *Edit Members* buttons.

Clicking the *Edit* button for a lagg opens the configuration screen shown in Figure 7.5. Table 7.4 describes the options in this screen.

If the network interface used to connect to the FreeNAS® web GUI is a member of the lagg, the network connection will be lost when the new lagg is created. The switch settings might also require changes to communicate through the new lagg interface.

The IP address of the new lagg can be set with DHCP or manually from the console setup menu. If the IP address is set manually, it might also be necessary to enter a default gateway to allow access to the GUI from the new lagg interface.

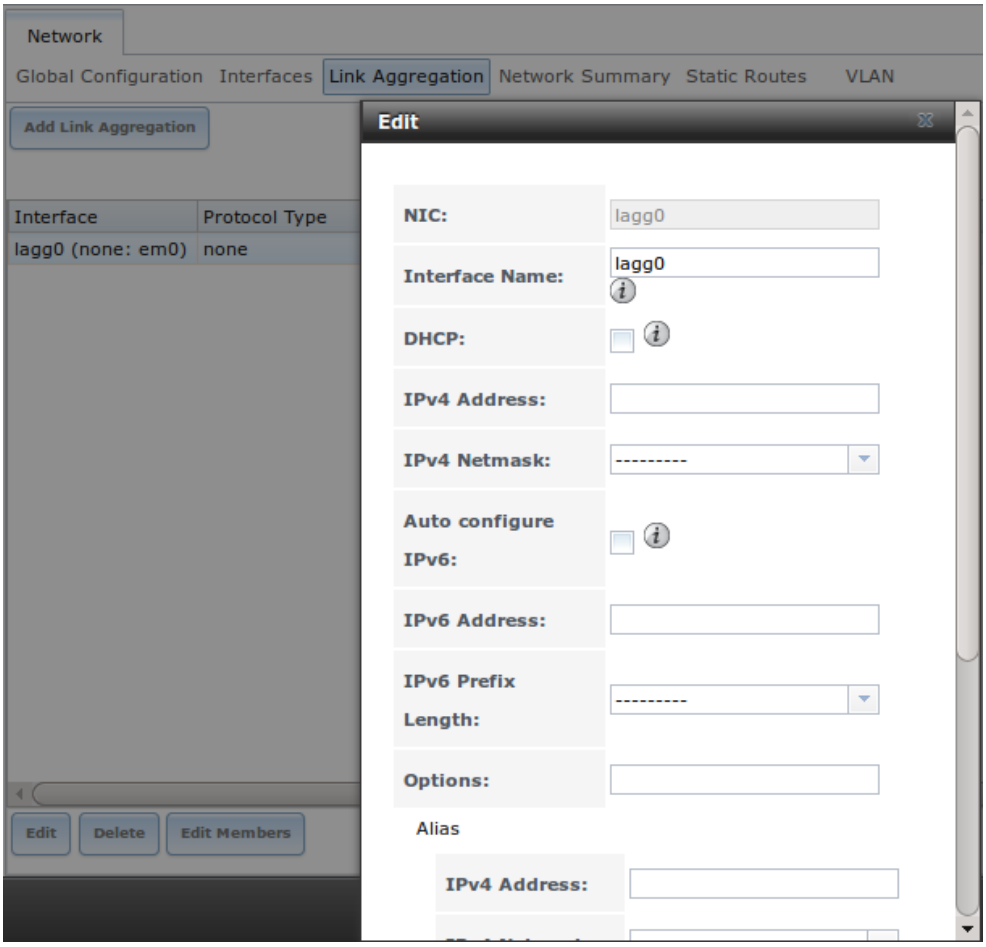


Fig. 7.5: Editing a lagg

Table 7.4: Configurable Options for a lagg

Setting	Value	Description
NIC	string	Read-only. Automatically assigned the next available numeric ID.
Interface Name	string	By default, this is the same as device (NIC) name. This can be changed to a more descriptive value.
DHCP	checkbox	Enable if the lagg device will get IP address info from DHCP server.
IPv4 Address	string	Enter a static IP address if *DHCP* is unset.
IPv4 Netmask	drop-down menu	Enter a netmask if *DHCP* is unset.
Auto configure IPv6	checkbox	Set only if DHCP server available to provide IPv6 address info
IPv6 Address	string	This is optional.
IPv6 Prefix Length	drop-down menu	Required if an *IPv6 address* is entered.

Continued on next page

Table 7.4 – continued from previous page

Setting	Value	Description
Options	string	Additional ifconfig(8) (https://www.freebsd.org/cgi/man.cgi?query=ifconfig) options.

This screen also allows the configuration of an alias for the lagg interface. Multiple aliases can be added with the *Add extra Alias* link.

Click the *Edit Members* button, click the entry for a member, then click its *Edit* button to see the configuration screen shown in Figure 7.6. The configurable options are summarized in Table 7.5.

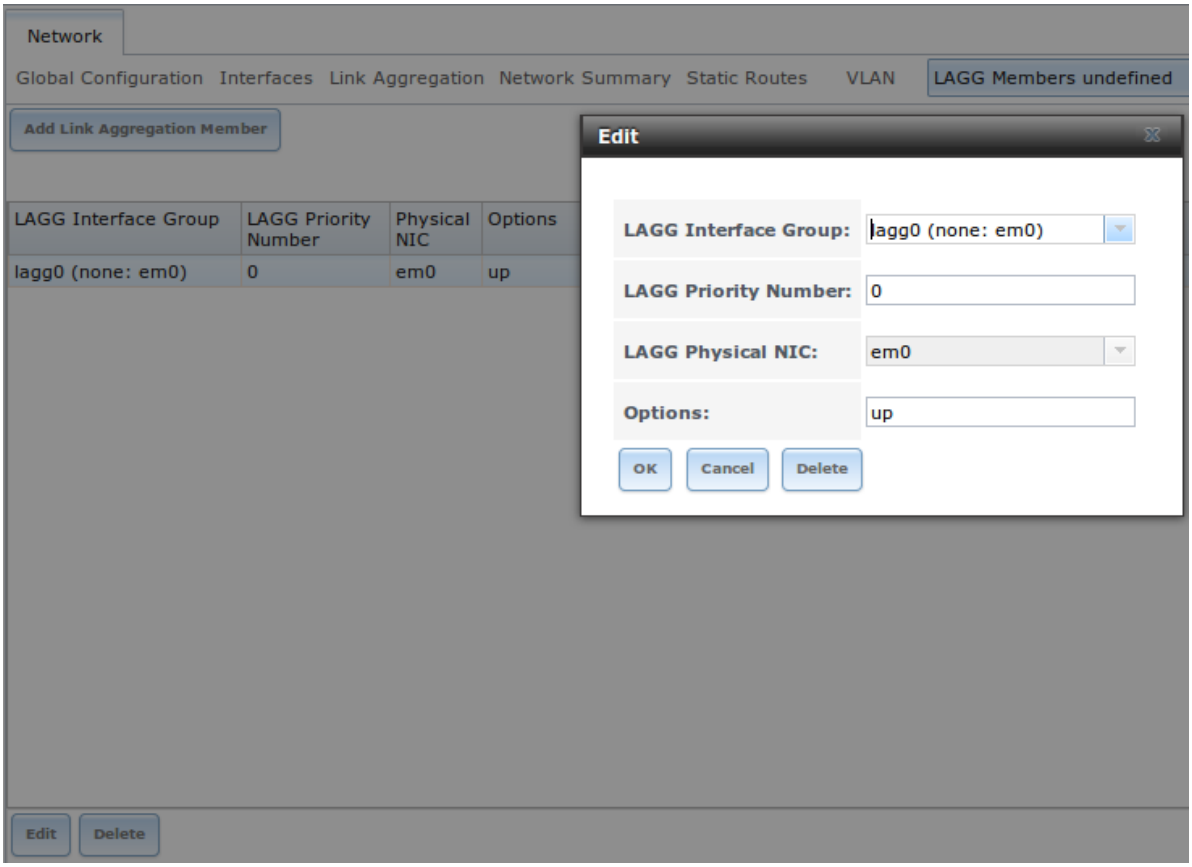


Fig. 7.6: Editing a Member Interface

Table 7.5: Configuring a Member Interface

Setting	Value	Description
LAGG Interface group	drop-down menu	Select the member interface to configure.
LAGG Priority Number	integer	Order of selected interface within the lagg. Configure a failover to set the master interface to *0* and the other interfaces to *1*, *2*, etc.
LAGG Physical NIC	drop-down menu	Physical interface of the selected member.
Options	string	Additional parameters from ifconfig(8) (https://www.freebsd.org/cgi/man.cgi?query=ifconfig).

Options can be set at the lagg level using the *Edit* button, or at the individual parent interface level using the *Edit Members* button. Changes are typically made at the lagg level (Figure 7.5) as each interface member will inherit from the lagg. To

configure at the interface level (Figure 7.6) instead, repeat the configuration for each interface within the lagg. Some options can only be set on the parent interfaces and are inherited by the lagg interface. For example, to set the MTU on a lagg, use *Edit Members* to set the MTU for each parent interface.

If the MTU settings on the lagg member interfaces are not identical, the smallest value is used for the MTU of the entire lagg.

Note: A reboot is required after changing the MTU to create a jumbo frame lagg.

Link aggregation load balancing can be tested with:

```
systat -ifstat
```

More information about this command can be found at systat(1) (https://www.freebsd.org/cgi/man.cgi?query=systat).

7.5 Network Summary

`Network → Network Summary` shows a quick summary of the addressing information of every configured interface. For each interface name, the configured IPv4 and IPv6 addresses, DNS servers, and default gateway are displayed.

7.6 Static Routes

No static routes are defined on a default FreeNAS® system. If a static route is required to reach portions of the network, add the route with `Network → Static Routes → Add Static Route`, shown in Figure 7.7.

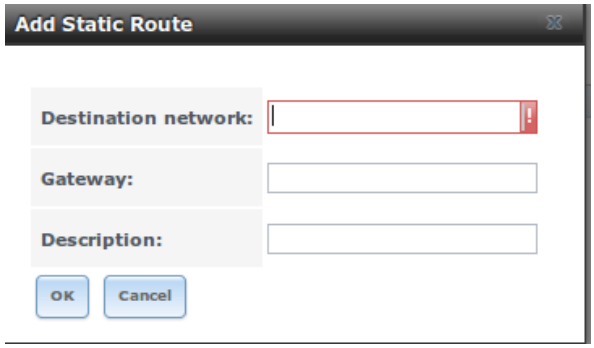


Fig. 7.7: Adding a Static Route

The available options are summarized in Table 7.6.

Table 7.6: Static Route Options

Setting	Value	Description
Destination network	integer	Use the format *A.B.C.D/E* where *E* is the CIDR mask.
Gateway	integer	Enter the IP address of the gateway.
Description	string	Optional. Add any notes about the route.

Added static routes are shown in *View Static Routes*. Click a route's entry to access the *Edit* and *Delete* buttons.

7.7 VLANs

FreeNAS® uses FreeBSD's vlan(4) (https://www.freebsd.org/cgi/man.cgi?query=vlan) interface to demultiplex frames with IEEE 802.1q tags. This allows nodes on different VLANs to communicate through a layer 3 switch or router. A vlan interface must be assigned a parent interface and a numeric VLAN tag. A single parent can be assigned to multiple vlan interfaces provided they have different tags.

Note: VLAN tagging is the only 802.1q feature that is implemented. Additionally, not all Ethernet interfaces support full VLAN processing. See the HARDWARE section of vlan(4) (https://www.freebsd.org/cgi/man.cgi?query=vlan) for details.

Click `Network → VLANs → Add VLAN`, to see the screen shown in Figure 7.8.

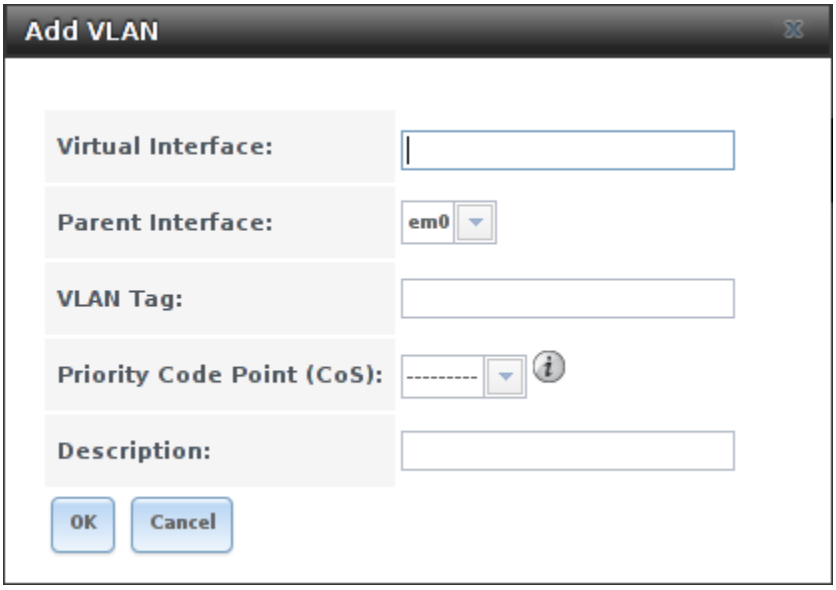


Fig. 7.8: Adding a VLAN

Table 7.7 summarizes the configurable fields.

Table 7.7: Adding a VLAN

Setting	Value	Description
Virtual Interface	string	Use the format *vlanX* where *X* is a number representing a vlan interface not currently being used as a parent.
Parent Interface	drop-down menu	Usually an Ethernet card connected to a properly configured switch port. Newly created *Link Aggregations* (page 111) do not appear in the drop-down until the system is rebooted.
VLAN Tag	integer	Enter a number between *1* and *4095* which matches a numeric tag set up in the switched network.
Priority Code Point	drop-down menu	Available 802.1p Class of Service ranges from *Best Effort (default)* to *Network Control (highest)*.
Description	string	Optional. Enter any notes about this VLAN.

The parent interface of a VLAN must be up, but it can either have an IP address or be unconfigured, depending upon the requirements of the VLAN configuration. This makes it difficult for the GUI to do the right thing without trampling the configuration. To remedy this, add the VLAN, then select `Network → Interfaces → Add Interface`. Choose the parent interface from the *NIC* drop-down menu and in the *Options* field, type `up`. This will bring up the parent interface. If an IP

address is required, it can be configured using the rest of the options in the *Add Interface* screen.

Warning: Creating a VLAN causes an interruption to network connectivity. The GUI provides a warning and an opportunity to cancel the VLAN creation.

CHAPTER

EIGHT

STORAGE

The Storage section of the graphical interface allows configuration of these options:

- *Volumes* (page 118) create and manage storage volumes.
- *Periodic Snapshot Tasks* (page 143) schedule automatic creation of filesystem snapshots.
- *Replication Tasks* (page 145) automate the replication of snapshots to a remote system.
- *Resilver Priority* (page 154) control the priority of resilvers.
- *Scrubs* (page 155) schedule scrubs as part of ongoing disk maintenance.
- *Snapshots* (page 158) manage local snapshots.
- *VMware-Snapshot* (page 160) coordinate OpenZFS snapshots with a VMware datastore.

8.1 Volumes

The *Volumes* section of the FreeNAS® graphical interface is used to format volumes, attach a disk to copy data onto an existing volume, or import a ZFS volume. It is also used to create ZFS datasets and zvols and to manage their permissions.

Note: In ZFS terminology, groups of storage devices managed by ZFS are referred to as a *pool*. The FreeNAS® graphical interface uses the term *volume* to refer to a ZFS pool.

Proper storage design is important for any NAS. **Please read through this entire chapter before configuring storage disks. Features are described to help make it clear which are beneficial for particular uses, and caveats or hardware restrictions which limit usefulness.**

8.1.1 Volume Manager

Before creating a volume, determine the level of required redundancy, how many disks will be added, and if any data exists on those disks. Creating a volume overwrites disk data, so save any required data to different media before adding disks to a pool. Refer to the *ZFS Primer* (page 314) for information on ZFS redundancy with multiple disks before using *Volume Manager*. It is important to realize that different layouts of virtual devices (*vdevs*) affect which operations can be performed on that volume later. For example, drives can be added to a mirror to increase redundancy, but that is not possible with RAIDZ arrays.

To create a volume, click `Storage → Volumes → Volume Manager`. This opens a screen like the example shown in Figure 8.1.

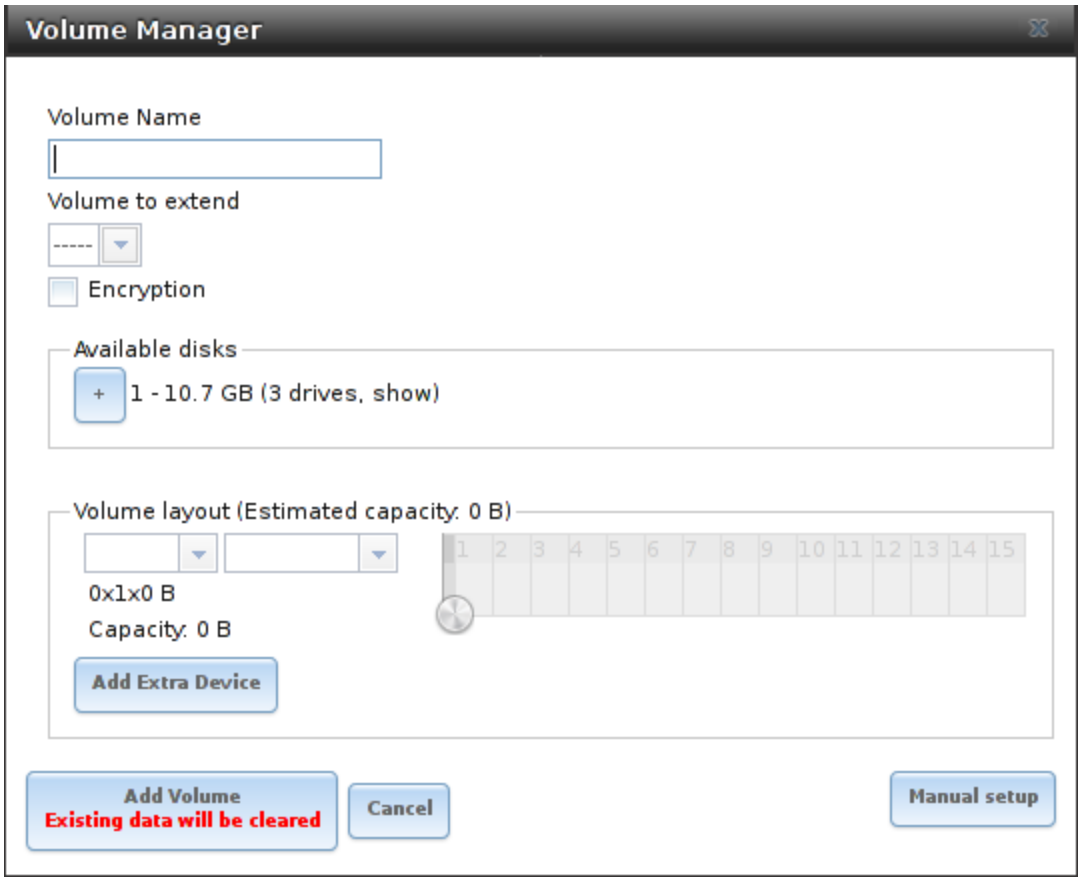


Fig. 8.1: Creating a ZFS Pool Using Volume Manager

Table 8.1 summarizes the configuration options of this screen.

Table 8.1: ZFS Volume Creation Options

Setting	Value	Description
Volume name	string	ZFS volumes must conform to these naming conventions (https://docs.oracle.com/cd/E23824_01/html/821-1448/gbcpt.html) Choosing a memorable name that sticks out in the logs and avoiding generic names, like `data` or `freenas`, is recommended.
Volume to extend	drop-down menu	Extend an existing ZFS pool. See *Extending a ZFS Volume* (page 122) for more details.
Encryption	checkbox	See the warnings in *Encryption* (page 120) before enabling encryption.
Available disks	display	Display the number and size of available disks. Hover over *show* to list the available device names, and click the + to add all of the disks to the pool.
Volume layout	drag and drop	Click and drag the icon to select the desired number of disks for a vdev. When at least one disk is selected, the layouts supported by the selected number of disks are added to the drop-down menu.
Add Extra Device	button	Configure multiple vdevs or add log or cache devices during pool creation.
Manual setup	button	Create a pool manually, which is not recommended. See *Manual Setup* (page 121) for more details.

Click the *Volume name* field and enter a name for the pool. Ensure that the chosen name conforms to these naming conventions (http://docs.oracle.com/cd/E23824_01/html/821-1448/gbcpt.html).

If the underlying disks need to be encrypted as a protection against physical theft, enable the *Encryption* option.

Warning: Refer to the warnings in *Encryption* (page 120) before enabling encryption! Be aware that this form of encryption will be replaced by OpenZFS native encryption in a future version. Pools created with the current encryption mechanism will need to be backed up and destroyed in order to be recreated with native encryption when it becomes available.

Drag the slider to select the desired number of disks. *Volume Manager* displays the resulting storage capacity, taking reserved swap space into account. To change the layout or the number of disks, drag the slider to the desired volume layout. The *Volume layout* drop-down menu can also be clicked if a different level of redundancy is required.

Note: For performance and capacity reasons, this screen does not allow creating a volume from disks of differing sizes. While it is not recommended, it is possible to create a volume of differently-sized disks with the *Manual setup* button. Follow the instructions in *Manual Setup* (page 121).

Volume Manager only allows choosing a configuration if enough disks have been selected to create that configuration. These layouts are supported:

- **Stripe:** requires at least one disk
- **Mirror:** requires at least two disks
- **RAIDZ1:** requires at least three disks
- **RAIDZ2:** requires at least four disks
- **RAIDZ3:** requires at least five disks
- **log device:** requires at least one dedicated device, a fast, low-latency, power-protected SSD is recommended
- **cache device:** requires at least one dedicated device, SSD is recommended

When more than five disks are used, consideration must be given to the optimal layout for the best performance and scalability. An overview of the recommended disk group sizes as well as more information about log and cache devices can be found in the *ZFS Primer* (page 314).

The *Add Volume* button warns that **existing data will be cleared**. In other words, creating a new volume **reformats the selected disks**. To preserve existing data, click the *Cancel* button and refer to *Import Disk* (page 130) and *Import Volume* (page 131) to see if the existing format is supported. If so, perform that action instead. If the current storage format is not supported, it is necessary to back up the data to external media, format the disks, then restore the data to the new volume.

Depending on the size and number of disks, the type of controller, and whether encryption is selected, creating the volume may take some time. After the volume is created, the screen refreshes and the new volume is listed in the tree under `Storage → Volumes`. Click the + next to the volume name to access *Change Permissions* (page 123), *Create Dataset* (page 125), and *Create zvol* (page 128) options for that volume.

Encryption

Note: The encryption facility used by FreeNAS® is designed to protect against physical theft of the disks. It is not designed to protect against unauthorized software access. Ensure that only authorized users have access to the administrative GUI and that proper permissions are set on shares if sensitive data is stored on the system.

FreeNAS® supports GELI (https://www.freebsd.org/cgi/man.cgi?query=geli) full disk encryption for ZFS volumes. It is important to understand the details when considering whether encryption is right for your FreeNAS® system:

- FreeNAS® encryption is different from the encryption used in Oracle's proprietary, non-open source version of ZFS.
- In FreeNAS®, entire disks are encrypted, not individual filesystems. Encrypted devices are created from the underlying drives, then the volume (pool) is created on top of the encrypted devices. Data is encrypted as it is written and decrypted as it is read.

- This type of encryption is primarily useful for users storing sensitive data but wanting the ability to remove disks from the pool without having to first wipe the disk contents.
- The FreeNAS® encryption design is only suitable for safe disposal of disks independent of the encryption key. As long as the key and the disks are intact, the system is vulnerable to being decrypted. The key should be protected by a strong passphrase and any backups of the key should be securely stored.
- If the encryption key is lost, the data on the disks is inaccessible. Always back up the key!
- Encryption keys are per ZFS volume (pool). Each pool has a separate encryption key. Technical details about how encryption keys are used, stored, and managed within FreeNAS® are described in this forum post (https://forums.freenas.org/index.php?threads/recover-encryption-key.16593/#post-85497).
- Data in memory, including ARC, is not encrypted. ZFS data on disk, including ZIL and SLOG, are encrypted if the underlying disks are encrypted. Swap data on disk is always encrypted.

> **Warning:** Data stored in Cache (L2ARC) drives is not encrypted. Do not use Cache (L2ARC) with encrypted volumes.

- At present, there is no one-step way to encrypt an existing, unencrypted volume. Instead, the data must be backed up, the existing pool destroyed, a new encrypted volume created, and the backup restored to the new volume.
- Hybrid pools are not supported. Added vdevs must match the existing encryption scheme. *Volume Manager* (page 118) automatically encrypts a new vdev being added to an existing encrypted pool.

To create an encrypted volume, enable the *Encryption* option shown in Figure 8.1. A pop-up message shows a reminder that **it is extremely important to make a backup of the key**. Without the key, the data on the disks is inaccessible. See *Managing Encrypted Volumes* (page 136) for instructions.

Encryption Performance

Encryption performance depends upon the number of disks encrypted. The more drives in an encrypted volume, the more encryption and decryption overhead, and the greater the impact on performance. **Encrypted volumes composed of more than eight drives can suffer severe performance penalties**. If encryption is desired, please benchmark such volumes before using them in production.

Note: Processors with support for the AES-NI (https://en.wikipedia.org/wiki/AES_instruction_set#Supporting_x86_CPUs) instruction set are strongly recommended. These processors can handle encryption of a small number of disks with negligible performance impact. They also retain performance better as the number of disks increases. Older processors without the AES-NI instructions see significant performance impact with even a single encrypted disk. This forum post (https://forums.freenas.org/index.php?threads/encryption-performance-benchmarks.12157/) compares the performance of various processors.

Manual Setup

The *Manual Setup* button shown in Figure 8.1 can be used to create a ZFS volume manually. While this is **not** recommended, it can, for example, be used to create a non-optimal volume containing disks of different sizes.

Note: The usable space of each disk in a volume is limited to the size of the smallest disk in the volume. Because of this, creating volumes with disks of the same size through the *Volume Manager* is recommended.

Figure 8.2 shows the *Manual Setup* screen. Table 8.2 shows the available options.

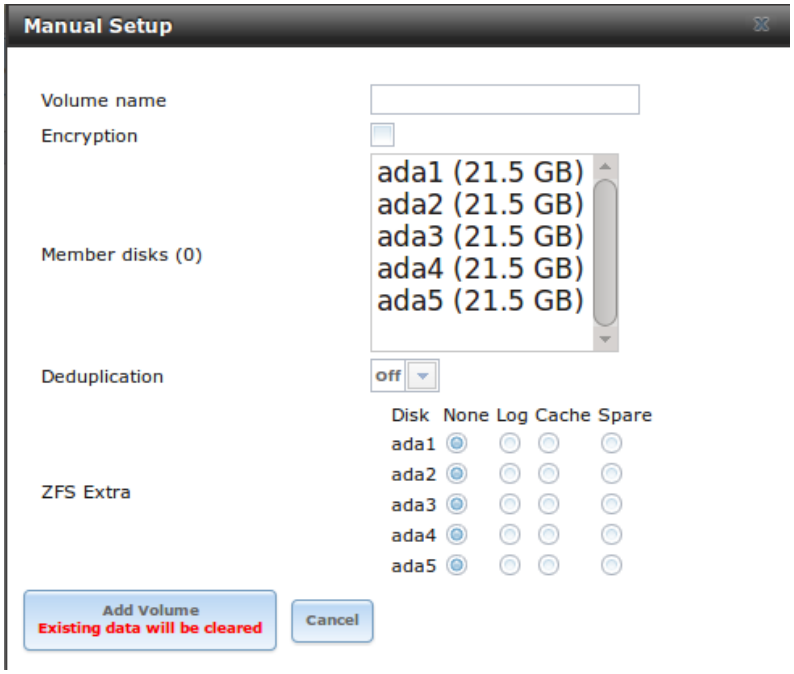


Fig. 8.2: Manually Creating a ZFS Volume

Note: Because of the disadvantages of creating volumes with disks of different sizes, the displayed list of disks is sorted by size.

Table 8.2: Manual Setup Options

Setting	Value	Description
Volume name	string	ZFS volumes must conform to these naming conventions (https://docs.oracle.com/cd/E53394_01/index.html). Choosing a memorable name is recommended.
Encryption	checkbox	See the warnings in *Encryption* (page 120) before using encryption.
Member disks	list	Highlight desired number of disks from list of available disks.
Deduplication	drop-down menu	Choices are *Off*, *Verify*, and *On*. Carefully consider the section on *Deduplication* (page 127) before changing this setting.
ZFS Extra	bullet selection	Specify disk usage: storage (*None*), a log device, a cache device, or a spare.

Extending a ZFS Volume

The *Volume to extend* drop-down menu in `Storage → Volumes → Volume Manager`, shown in Figure 8.1, is used to add disks to an existing ZFS volume to increase capacity. This menu is empty if there are no ZFS volumes yet.

If more than one disk is added, the arrangement of the new disks into stripes, mirrors, or RAIDZ vdevs can be specified. Mirrors and RAIDZ arrays provide redundancy for data protection if an individual drive fails.

Note: If the existing volume is encrypted, a warning message shows a reminder that **extending a volume resets the passphrase and recovery key**. After extending the volume, immediately recreate both using the instructions in *Managing Encrypted Volumes* (page 136).

After an existing volume has been selected from the drop-down menu, drag and drop the desired disks and select the desired

volume layout. For example, disks can be added to increase the capacity of the volume.

When adding disks to increase the capacity of a volume, ZFS supports the addition of virtual devices, or *vdevs*, to an existing ZFS pool. A vdev can be a single disk, a stripe, a mirror, a RAIDZ1, RAIDZ2, or a RAIDZ3. **After a vdev is created, more drives cannot be added to that vdev**. However, a new vdev can be striped with another of the **same type of existing vdev** to increase the overall size of the volume. Extending a volume often involves striping similar vdevs. Here are some examples:

- to extend a ZFS stripe, add one or more disks. Since there is no redundancy, disks do not have to be added in the same quantity as the existing stripe.
- to extend a ZFS mirror, add the same number of drives. The resulting striped mirror is a RAID 10. For example, if ten new drives are available, a mirror of two drives could be created initially, then extended by creating another mirror of two drives, and repeating three more times until all ten drives have been added.
- to extend a three drive RAIDZ1, add three additional drives. The result is a RAIDZ+0, similar to RAID 50 on a hardware controller.
- to extend a RAIDZ2 requires a minimum of four additional drives. The result is a RAIDZ2+0, similar to RAID 60 on a hardware controller.

If an attempt is made to add a non-matching number of disks to the existing vdev, an error message appears, indicating the number of disks that are required. Select the correct number of disks to continue.

Adding L2ARC or SLOG Devices

`Storage → Volumes → Volume Manager` (see Figure 8.1) is also used to add L2ARC or SLOG SSDs to improve volume performance for specific use cases. Refer to the *ZFS Primer* (page 314) to determine if the system will benefit or suffer from the addition of the device.

Once the SSD has been physically installed, click the *Volume Manager* button and choose the volume from the *Volume to extend* drop-down menu. Click the + next to the SSD in the *Available disks* list. In the *Volume layout* drop-down menu, select *Cache (L2ARC)* to add a cache device, or *Log (ZIL)* to add a log device. Finally, click *Extend Volume* to add the SSD.

8.1.2 Change Permissions

Setting permissions is an important aspect of managing data access. The graphical administrative interface is meant to set the **initial** permissions for a volume or dataset in order to make it available as a share. Once a share is available, the client operating system should be used to fine-tune the permissions of the files and directories that are created by the client.

Sharing (page 173) contains configuration examples for several types of permission scenarios. This section provides an overview of the options available for configuring the initial set of permissions.

Note: For users and groups to be available, they must either be first created using the instructions in *Account* (page 49) or imported from a directory service using the instructions in *Directory Services* (page 162). If more than 50 users or groups are available, the drop-down menus described in this section will automatically truncate their display to 50 for performance reasons. In this case, start to type in the desired user or group name so that the display narrows its search to matching results.

After a volume or dataset is created, it is listed by its mount point name in `Storage → Volumes`. Clicking the *Change Permissions* icon for a specific volume or dataset displays the screen shown in Figure 8.3. Table 8.3 summarizes the options in this screen.

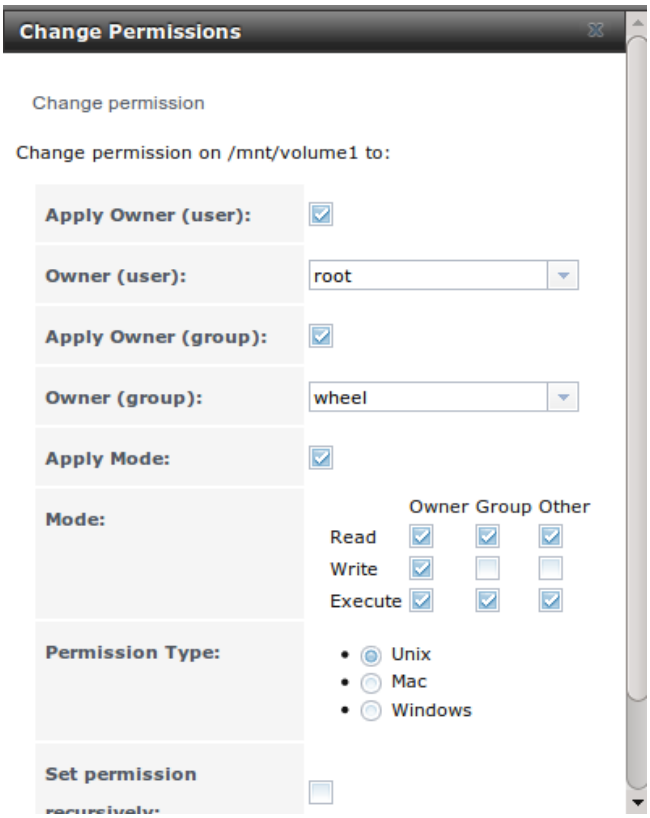


Fig. 8.3: Changing Permissions on a Volume or Dataset

Table 8.3: Options When Changing Permissions

Setting	Value	Description
Apply Owner (user)	checkbox	Deselect to prevent new permission change from being applied to *Owner (user)*, see Note below.
Owner (user)	drop-down menu	Select the user to control the volume or dataset. Users manually created or imported from a directory service will appear in the drop-down menu.
Apply Owner (group)	checkbox	Deselect to prevent new permission change from being applied to *Owner (group)*, see Note below for more information.
Owner (group)	drop-down menu	Select the group to control the volume or dataset. Groups manually created or imported from a directory service will appear in the drop-down menu.
Apply Mode	checkbox	Deselect to prevent new permission change from being applied to *Mode*, see Note below
Mode	checkboxes	Only applies to the *Unix* or *Mac* "Permission Type" so will be grayed out if *Windows* is selected.
Permission Type	bullet selection	Select the type which matches the type of client accessing the volume or dataset Choices are *Unix*, *Mac* or *Windows*.
Set permission recursively	checkbox	If enabled, permissions will also apply to subdirectories of the volume or dataset. If data already exists on the volume or dataset, change the permissions on the **client side** to prevent a performance lag.

Note: The *Apply Owner (user)*, *Apply Owner (group)*, and *Apply Mode* options allow fine-tuning of the change permissions behavior. By default, all options are enabled and FreeNAS® resets the owner, group, and mode when the *Change* button is clicked. These optionss allow choosing which settings to change. For example, to change just the *Owner (group)* setting,

deselect the *Apply Owner (user)* and *Apply Mode* options.

The *Windows Permission Type* is used for *Windows (SMB) Shares* (page 189) or when the FreeNAS® system is a member of an Active Directory domain. This type adds ACLs to traditional *Unix* permissions. When the *Windows Permission Type* is set, ACLs are set to the Windows defaults for new files and directories. A Windows client can be used to further fine-tune permissions as needed. After a volume or dataset has been set to *Windows*, it cannot be changed to *Unix* permissions because that would clobber the extended permissions provided by *Windows* ACLs.

The *Unix Permission Type* is usually used with *Unix (NFS) Shares* (page 181). Unix permissions are compatible with most network clients and generally work well with a mix of operating systems or clients. However, *Unix* permissions do not support Windows ACLs and should not be used with *Windows (SMB) Shares* (page 189).

The *Mac Permission Type* can be used with *Apple (AFP) Shares* (page 174).

8.1.3 Create Dataset

An existing ZFS volume can be divided into datasets. Permissions, compression, deduplication, and quotas can be set on a per-dataset basis, allowing more granular control over access to storage data. Like a folder or directory, permissions can be set on dataset. Datasets are also similar to filesystems in that properties such as quotas and compression can be set, and snapshots created.

Note: ZFS provides thick provisioning using quotas and thin provisioning using reserved space.

Selecting an existing ZFS volume in the tree and clicking *Create Dataset* shows the screen in Figure 8.4.

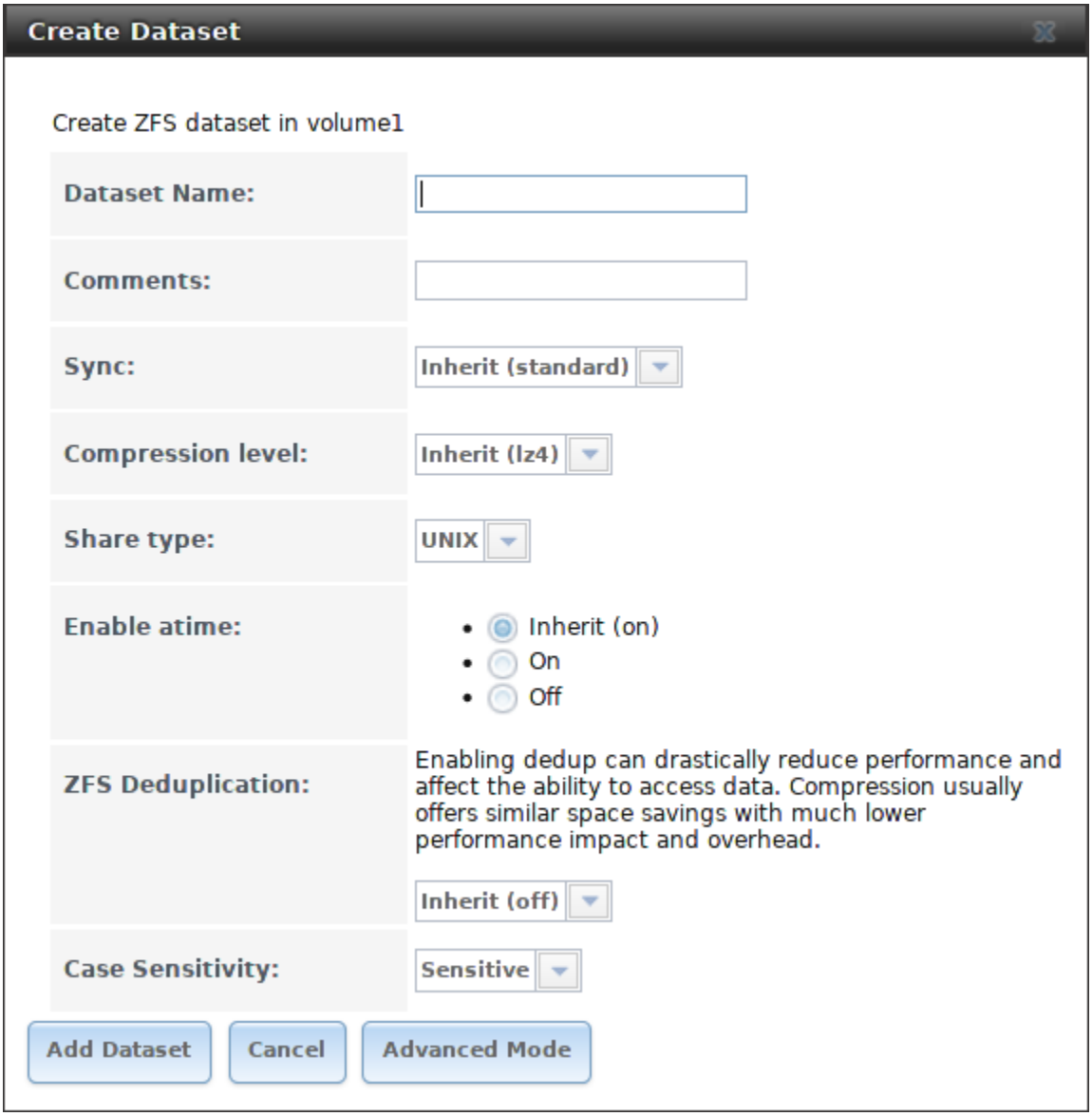


Fig. 8.4: Creating a ZFS Dataset

Table 8.4 shows the options available when creating a dataset. Some settings are only available in *Advanced Mode*. To see these settings, either click the *Advanced Mode* button, or configure the system to always display advanced settings by enabling the *Show advanced fields by default* option in `System → Advanced`. Most attributes, except for the *Dataset Name*, *Case Sensitivity*, and *Record Size*, can be changed after dataset creation by highlighting the dataset name and clicking the *Edit Options* button in `Storage → Volumes`.

Table 8.4: ZFS Dataset Options

Setting	Value	Description
Dataset Name	string	Enter a mandatory unique name for the dataset.
Comments	string	Enter optional comments or notes about this dataset.
Sync	drop-down menu	Sets the data write synchronization. *Inherit* inherits the sync settings from the parent dataset. *Standard* uses the sync settings that have been requested by the client software. *Always* always waits for data writes to complete. *Disabled* never waits for writes to complete.

Continued on next page

Table 8.4 – continued from previous page

Setting	Value	Description
Compression Level	drop-down menu	Refer to the section on *Compression* (page 128) for a description of the available algorithms.
Share type	drop-down menu	Select the type of share that will be used on the dataset. Choices are *UNIX* for an NFS share, *Windows* for a SMB share, or *Mac* for an AFP share.
Enable atime	Inherit, On, or Off	Choose *On* to update the access time for files when they are read. Choose *Off* to prevent producing log traffic when reading files. This can result in significant performance gains.
Quota for this dataset	integer	Only available in *Advanced Mode*. Default of *0* disables quotas. Specifying a value means to use no more than the specified size and is suitable for user datasets to prevent users from hogging available space.
Quota for this dataset and all children	integer	Only available in *Advanced Mode*. A specified value applies to both this dataset and any child datasets.
Reserved space for this dataset	integer	Only available in *Advanced Mode*. Default of *0* is unlimited. Specifying a value means to keep at least this much space free and is suitable for datasets containing logs which could take up all available free space.
Reserved space for this dataset and all children	integer	Only available in *Advanced Mode*. A specified value applies to both this dataset and any child datasets.
ZFS Deduplication	drop-down menu	Read the section on *Deduplication* (page 127) before making a change to this setting.
Read-Only	drop-down menu	Only available in *Advanced Mode*. Choices are *Inherit (off)*, *On*, or *Off*.
Exec	drop-down menu	Only available in *Advanced Mode*. Choices are *Inherit (on)*, *On*, or *Off*. Setting to *Off* prevents the installation of *Plugins* (page 249) or *Jails* (page 251).
Record Size	drop-down menu	Only available in *Advanced Mode*. While ZFS automatically adapts the record size dynamically to adapt to data, if the data has a fixed size, matching that size can result in better performance.
Case Sensitivity	drop-down menu	*Sensitive* is the default and assumes filenames are case sensitive. *Insensitive* assumes filenames are not case sensitive. *Mixed* understands both types of filenames.

After a dataset is created, click on that dataset and select *Create Dataset*, to create a nested dataset, or a dataset within a dataset. A zvol can also be created within a dataset. When creating datasets, double-check that you are using the *Create Dataset* option for the intended volume or dataset. If you get confused when creating a dataset on a volume, click all existing datasets to close them–the remaining *Create Dataset* will be for the volume.

Deduplication

Deduplication is the process of ZFS transparently reusing a single copy of duplicated data to save space. Depending on the amount of duplicate data, deduplicaton can improve storage capacity, as less data is written and stored. However, deduplication is RAM intensive. A general rule of thumb is 5 GB of RAM per terabyte of deduplicated storage. **In most cases, compression provides storage gains comparable to deduplication with less impact on performance.**

In FreeNAS®, deduplication can be enabled during dataset creation. Be forewarned that **there is no way to undedup the data within a dataset once deduplication is enabled**, as disabling deduplication has **NO EFFECT** on existing data. The more data written to a deduplicated dataset, the more RAM it requires. When the system starts storing the DDTs (dedup tables) on disk because they no longer fit into RAM, performance craters. Further, importing an unclean pool can require between 3-5 GB of RAM per terabyte of deduped data, and if the system does not have the needed RAM, it will panic. The only solution is to add more RAM or recreate the pool. **Think carefully before enabling dedup!** This article (https://constantin.glez.de/2011/07/27/zfs-to-dedupe-or-not-dedupe/) provides a good description of the value versus cost considerations for deduplication.

Unless a lot of RAM and a lot of duplicate data is available, do not change the default deduplication setting of "Off". For performance reasons, consider using compression rather than turning this option on.

If deduplication is changed to *On*, duplicate data blocks are removed synchronously. The result is that only unique data is stored and common components are shared among files. If deduplication is changed to *Verify*, ZFS will do a byte-to-byte comparison when two blocks have the same signature to make sure that the block contents are identical. Since hash collisions are extremely rare, *Verify* is usually not worth the performance hit.

Note: After deduplication is enabled, the only way to disable it is to use the `zfs set dedup=off dataset_name` command from *Shell* (page 282). However, any data that has already been deduplicated will not be un-deduplicated. Only newly stored data after the property change will not be deduplicated. The only way to remove existing deduplicated data is to copy all of the data off of the dataset, set the property to off, then copy the data back in again. Alternately, create a new dataset with *ZFS Deduplication* left disabled, copy the data to the new dataset, and destroy the original dataset.

Tip: Deduplication is often considered when using a group of very similar virtual machine images. However, other features of ZFS can provide dedup-like functionality more efficiently. For example, create a dataset for a standard VM, then clone a snapshot of that dataset for other VMs. Only the difference between each created VM and the main dataset are saved, giving the effect of deduplication without the overhead.

Compression

When selecting a compression type, you need to balance performance with the amount of disk space saved by compression. Compression is transparent to the client and applications as ZFS automatically compresses data as it is written to a compressed dataset or zvol and automatically decompresses that data as it is read. These compression algorithms are supported:

- **lz4:** default and recommended compression method as it allows compressed datasets to operate at near real-time speed. This algorithm only compresses the files that will benefit from compression.
- **gzip:** varies from levels 1 to 9 where *gzip fastest* (level 1) gives the least compression and *gzip maximum* (level 9) provides the best compression but is discouraged due to its performance impact.
- **zle:** fast but simple algorithm which eliminates runs of zeroes.
- **lzjb:** provides decent data compression, but is considered deprecated as *lz4* provides much better performance.

If you select *Off* as the *Compression level* when creating a dataset or zvol, compression will not be used on that dataset/zvol. This is not recommended as using *lz4* has a negligible performance impact and allows for more storage capacity.

8.1.4 Create zvol

A zvol is a feature of ZFS that creates a raw block device over ZFS. The zvol can be used as an *iSCSI* (page 225) device extent.

To create a zvol, select an existing ZFS volume or dataset from the tree then click *Create zvol* to open the screen shown in Figure 8.5.

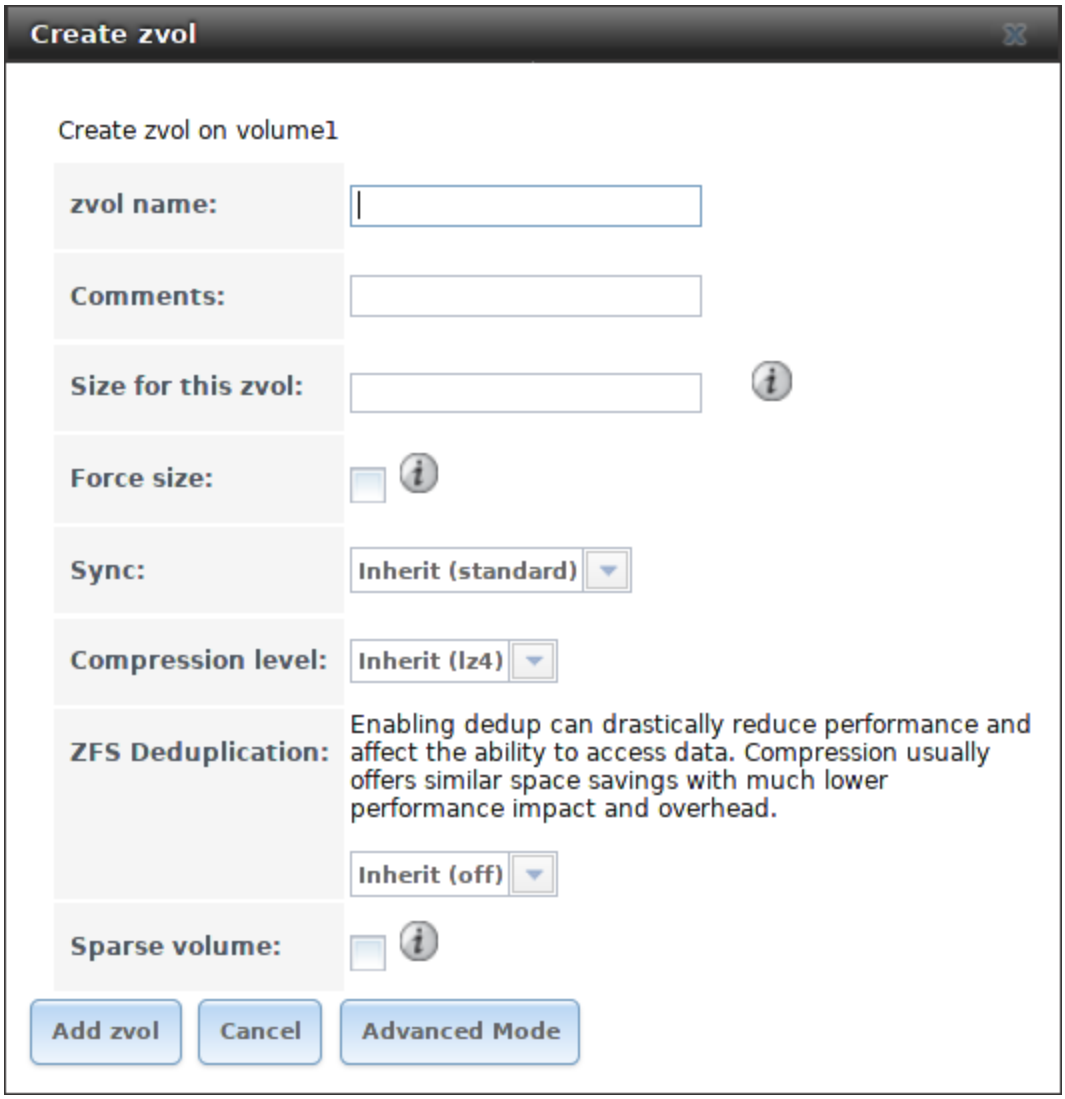


Fig. 8.5: Creating a Zvol

The configuration options are described in Table 8.5. Some settings are only available in *Advanced Mode*. To see these settings, either click the *Advanced Mode* button or configure the system to always display these settings by enabling *Show advanced fields by default* in `System → Advanced`.

Table 8.5: zvol Configuration Options

Setting	Value	Description
zvol Name	string	Enter a short name for the zvol. Using a zvol name longer than 63-characters can prevent accessing zvols as devices. For example, a zvol with a 70-character filename or path cannot be used as an iSCSI extent. This setting is mandatory.
Comments	string	Enter any notes about this zvol.
Size for this zvol	integer	Specify size and value such as *10Gib*. If the size is more than 80% of the available capacity, the creation will fail with an "out of space" error unless *Force size* is also enabled.
Force size	checkbox	By default, the system will not create a zvol if that operation will bring the pool to over 80% capacity. **While NOT recommended**, enabling this option will force the creation of the zvol.

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Table 8.5 – continued from previous page

Setting	Value	Description
Compression level	drop-down menu	Refer to the section on *Compression* (page 128) for a description of the available algorithms.
Sparse volume	checkbox	Used to provide thin provisioning. Use with caution for when this option is selected, writes will fail when the pool is low on space.
Block size	drop-down menu	Only available in *Advanced Mode* and by default is based on the number of disks in pool. Can be set to match the block size of the filesystem which will be formatted onto the iSCSI target.

8.1.5 Import Disk

The `Volume → Import Disk` screen, shown in Figure 8.6, is used to import a **single** disk that has been formatted with the UFS, NTFS, MSDOS, or EXT2 filesystem. The import is meant to be a temporary measure to copy the data from a disk to an existing ZFS dataset. Only one disk can be imported at a time.

Note: Imports of EXT3 or EXT4 filesystems are possible in some cases, although neither is fully supported. EXT3 journaling is not supported, so those filesystems must have an external *fsck* utility, like the one provided by E2fsprogs utilities (http://e2fsprogs.sourceforge.net/), run on them before import. EXT4 filesystems with extended attributes or inodes greater than 128 bytes are not supported. EXT4 filesystems with EXT3 journaling must have an *fsck* run on them before import, as described above.

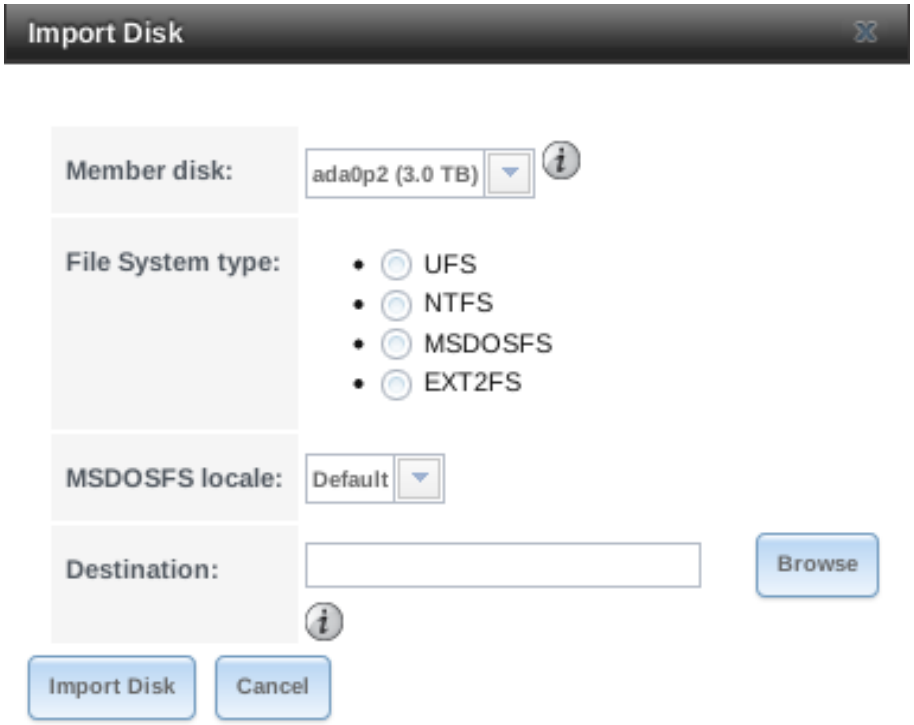


Fig. 8.6: Importing a Disk

Use the drop-down menu to select the disk to import, select the type of filesystem on the disk, and browse to the ZFS dataset that will hold the copied data. If the *MSDOSFS* filesystem is selected, the *MSDOSFS locale* drop-down menu can be used to select the locale when non-ascii characters are present on the disk.

Once *Import Disk* is clicked, the disk is mounted, its contents are copied to the specified ZFS dataset, and the disk is unmounted after the copy operation completes.

8.1.6 Import Volume

Click `Storage → Volumes → Import Volume`, to configure FreeNAS® to use an **existing** ZFS pool. This action is typically performed when an existing FreeNAS® system is re-installed. Since the operating system is separate from the storage disks, a new installation does not affect the data on the disks. However, the new operating system needs to be configured to use the existing volume.

Figure 8.7 shows the initial pop-up window that appears when a volume is imported.

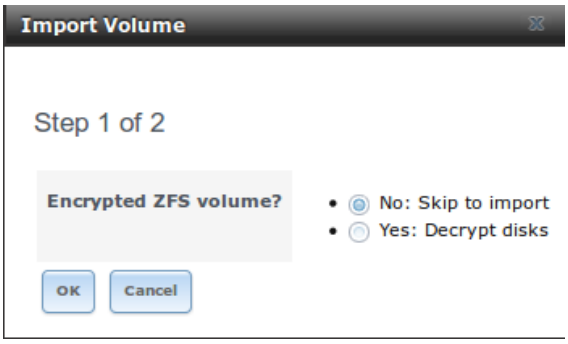


Fig. 8.7: Initial Import Volume Screen

If importing an unencrypted ZFS pool, select *No: Skip to import* to open the screen shown in Figure 8.8.

Fig. 8.8: Importing a Non-Encrypted Volume

Existing volumes should be available for selection from the drop-down menu. In the example shown in Figure 8.8, the FreeNAS® system has an existing, unencrypted ZFS pool. Once the volume is selected, click the *OK* button to import the volume.

If an existing ZFS pool does not show in the drop-down menu, run `zpool import` from *Shell* (page 282) to import the pool.

If physically installing ZFS formatted disks from another system, ensure to export the drives on that system to prevent an "in use by another machine" error during the import.

If the hardware is not being detected, run `camcontrol devlist` from *Shell* (page 282). If the disk does not appear in the output, check to see if the controller driver is supported or if it needs to be loaded using *Tunables* (page 69).

Importing an Encrypted Pool

Disks in existing GELI-encrypted ZFS pools must be decrypted before importing the pool. In the Import Volume dialog shown in Figure 8.7, select *Yes: Decrypt disks*. The screen shown in Figure 8.9 is then displayed.

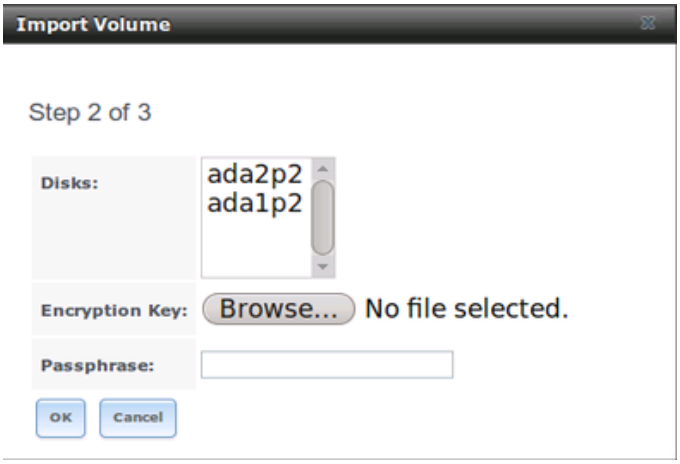


Fig. 8.9: Decrypting Disks Before Importing a ZFS Pool

Select the disks in the encrypted pool, browse to the location of the saved encryption key, enter the passphrase associated with the key, then click *OK* to decrypt the disks.

Note: The encryption key is required to decrypt the pool. If the pool cannot be decrypted, it cannot be re-imported after a failed upgrade or lost configuration. This means that it is **very important** to save a copy of the key and to remember the passphrase that was configured for the key. Refer to *Managing Encrypted Volumes* (page 136) for instructions on how to manage the keys for encrypted volumes.

After the pool is decrypted, it appears in the drop-down menu of Figure 8.8. Click the *OK* button to finish the volume import.

Note: For security reasons, GELI keys for encrypted volumes are not saved in a configuration backup file. When FreeNAS® has been installed to a new device and a saved configuration file restored to it, the GELI keys for encrypted disks will not be present, and the system will not request them. To correct this, export the encrypted volume with Detach Volume, making sure that the options *Mark the disks as new (destroy data)* or *Also delete the share's configuration* are **not** selected. Then import the volume again. During the import, the GELI keys can be entered as described above.

8.1.7 View Disks

`Storage` → `Volumes` → `View Disks` shows all of the disks recognized by the FreeNAS® system. An example is shown in Figure 8.10.

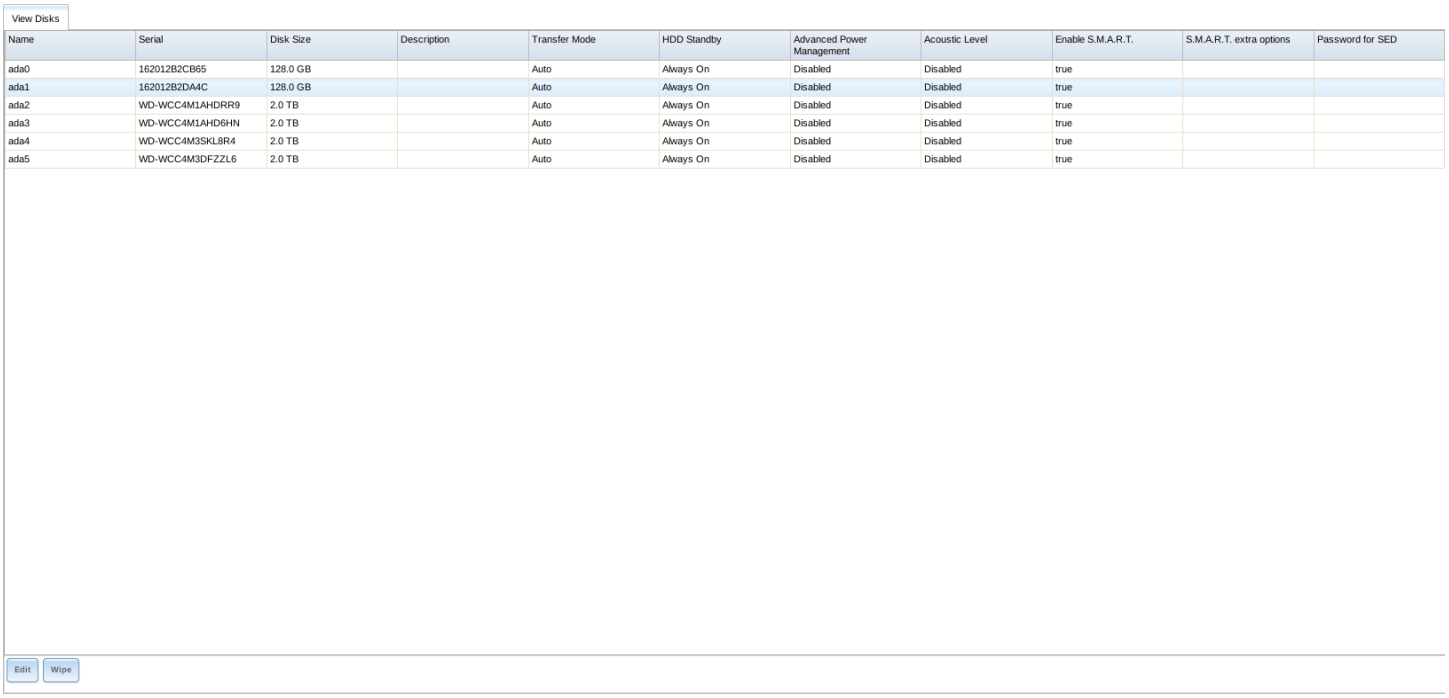


Fig. 8.10: Viewing Disks

The current configuration of each device is displayed. Click a disk entry and the *Edit* button to change its configuration. The configurable options are described in Table 8.6.

Table 8.6: Disk Options

Setting	Value	Description
Name	string	This is the FreeBSD device name of the disk.
Serial	string	This is the serial number of the disk.
Description	string	Enter any notes about this disk.
HDD Standby	drop-down menu	Indicates the time of inactivity (in minutes) before the drive enters standby mode in order to conserve energy. This forum post (https://forums.freenas.org/index.php?threads/how-to-find-out-if-a-drive-is-spinning-down-properly.2068/) demonstrates how to determine if a drive has spun down.
Advanced Power Management	drop-down menu	Select a power management profile from the menu. Default is *Disabled*.
Acoustic Level	drop-down menu	Modify for disks that understand AAM (https://en.wikipedia.org/wiki/Automatic_acoustic_management). Default is *Disabled*.
Enable S.M.A.R.T.	checkbox	Enabled by default if the disk supports S.M.A.R.T. Deselect to disable any configured *S.M.A.R.T. Tests* (page 102) for the disk.
S.M.A.R.T. extra options	string	Enter additional smartctl(8) (https://www.smartmontools.org/browser/trunk/smartm options.
Password for SED	string	Enter and confirm the password that will be used for this device instead of the global SED password. Refer to *Self-Encrypting Drives* (page 66) for more information.

Note: If the serial number of a disk is not displayed in this screen, use the `smartctl` command from *Shell* (page 282). For example, to determine the serial number of disk *ada0*, type `smartctl -a /dev/ada0 | grep Serial`.

The *Wipe* function is provided for when an unused disk is to be discarded.

Warning: Make certain that all data has been backed up and that the disk is no longer in use. Triple-check that the correct disk is being selected to be wiped, as recovering data from a wiped disk is usually impossible. If there is any doubt, physically remove the disk, verify that all data is still present on the FreeNAS® system, and wipe the disk in a separate computer.

Clicking *Wipe* offers several choices. *Quick* erases only the partitioning information on a disk, making it easy to reuse but without clearing other old data. For more security, *Full with zeros* overwrites the entire disk with zeros, while *Full with random data* overwrites the entire disk with random binary data.

Quick wipes take only a few seconds. A *Full with zeros* wipe of a large disk can take several hours, and a *Full with random data* takes longer. A progress bar is displayed during the wipe to track status.

8.1.8 Volumes

`Storage` → `Volumes` is used to view and further configure existing ZFS pools, datasets, and zvols. The example shown in Figure 8.11 shows one ZFS pool (*volume1*) with two datasets (the one automatically created with the pool, *volume1*, and *dataset1*) and one zvol (*zvol1*).

Note that in this example, there are two datasets named *volume1*. The first represents the ZFS pool and its *Used* and *Available* entries reflect the total size of the pool, including disk parity. The second represents the implicit or root dataset and its *Used* and *Available* entries indicate the amount of disk space available for storage.

Buttons are provided for quick access to *Volume Manager*, *Import Disk*, *Import Volume*, and *View Disks*. If the system has multipath-capable hardware, an extra button will be added, *View Multipaths*. For each entry, the columns indicate the *Name*, how much disk space is *Used*, how much disk space is *Available*, the type of *Compression*, the *Compression Ratio*, the *Status*, whether it is mounted as read-only, and any *Comments* entered for the volume.

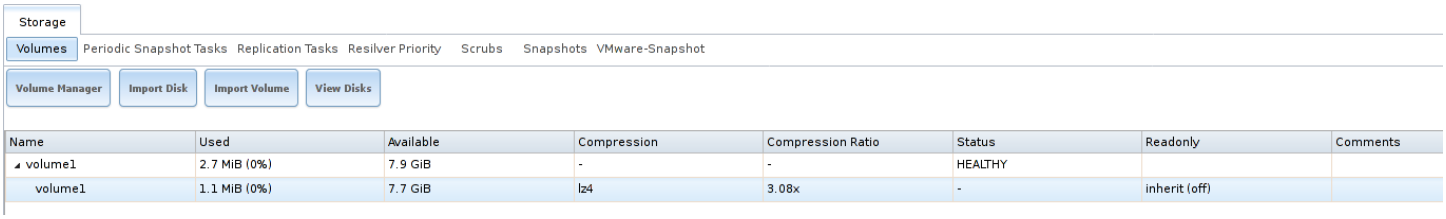


Fig. 8.11: Viewing Volumes

Clicking the entry for a pool causes several buttons to appear at the bottom of the screen.

Detach Volume: allows exporting the pool or deleting the contents of the pool, depending upon the choice made in the screen shown in Figure 8.12. The *Detach Volume* screen displays the current used space and indicates whether there are any shares, provides options to *Mark the disks as new (destroy data)* and to *Also delete the share's configuration*, and asks if you are sure about doing this. The browser window turns red to indicate that some choices will make the data inaccessible. **When the option to select the disks as new is left deselected, the volume is exported.** The data is not destroyed and the volume can be re-imported at a later time. When moving a ZFS pool from one system to another, perform this export action first as it flushes any unwritten data to disk, writes data to the disk indicating that the export was done, and removes all knowledge of the pool from the system.

When the option to mark the disks as new is selected, the pool and all the data in its datasets, zvols, and shares is destroyed and the individual disks are returned to their raw state. Desired data must be backed up to another disk or device before using this option.

Fig. 8.12: Detach or Delete a Volume

Scrub Volume: scrubs and scheduling them are described in more detail in *Scrubs* (page 155). This button allows manually initiating a scrub. Scrubs are I/O intensive and can negatively impact performance. Avoid initiating a scrub when the system is busy.

A *Cancel* button is provided to cancel a scrub. When a scrub is cancelled, it is abandoned. The next scrub to run starts from the beginning, not where the cancelled scrub left off.

The status of a running scrub or the statistics from the last completed scrub can be seen by clicking the *Volume Status* button.

Volume Status: as shown in the example in Figure 8.13, this screen shows the device name and status of each disk in the ZFS pool as well as any read, write, or checksum errors. It also indicates the status of the latest ZFS scrub. Clicking the entry for a device causes buttons to appear to edit the device options (shown in Figure 8.14), offline or online the device, or replace the device (as described in *Replacing a Failed Drive* (page 140)).

Upgrade: used to upgrade the pool to the latest ZFS features, as described in *Upgrading a ZFS Pool* (page 27). This button does not appear if the pool is running the latest version of feature flags.

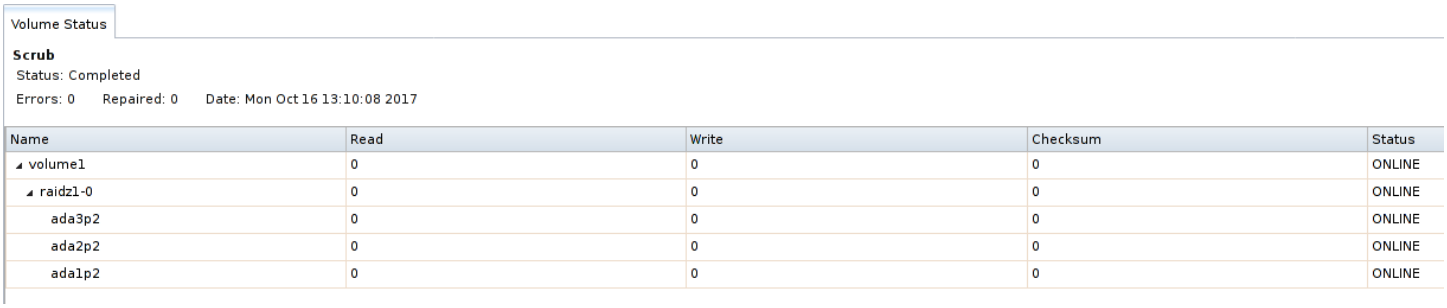


Fig. 8.13: Volume Status

Selecting a disk in *Volume Status* and clicking its *Edit Disk* button shows the screen in Figure 8.14. Table 8.6 summarizes the configurable options.

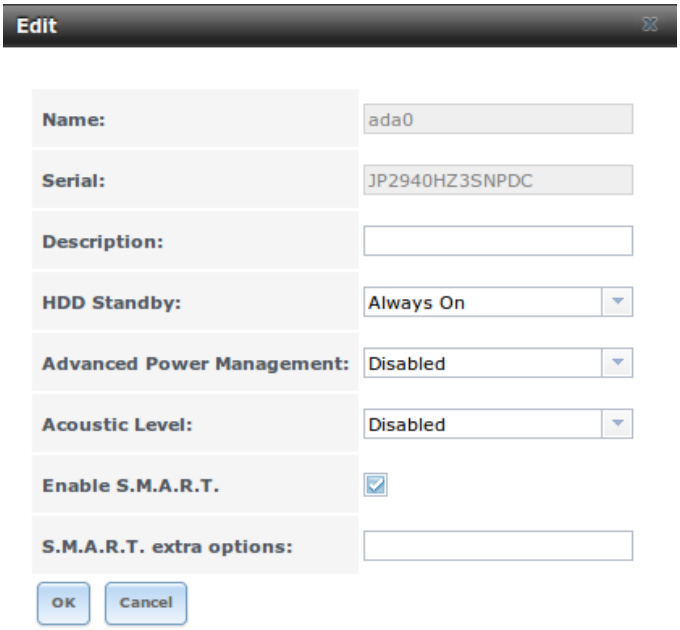


Fig. 8.14: Editing a Disk

Note: Versions of FreeNAS® prior to 8.3.1 required a reboot to apply changes to the *HDD Standby*, *Advanced Power Management*, and *Acoustic Level* settings. As of 8.3.1, changes to these settings are applied immediately.

Clicking a dataset in `Storage → Volumes` causes buttons to appear at the bottom of the screen, providing these options:

Change Permissions: edit the dataset permissions as described in *Change Permissions* (page 123).

Create Snapshot: create a one-time snapshot. To schedule the regular creation of snapshots, instead use *Periodic Snapshot Tasks* (page 143).

Promote Dataset: only applies to clones. When a clone is promoted, the origin filesystem becomes a clone of the clone making it possible to destroy the filesystem that the clone was created from. Otherwise, a clone cannot be destroyed while the origin filesystem exists.

Destroy Dataset: clicking the *Destroy Dataset* button causes the browser window to turn red to indicate that this is a destructive action. The *Destroy Dataset* screen forces you to enable the option *I'm aware this will destroy all child datasets and snapshots within this dataset* before it will perform this action.

Edit Options: edit the volume properties described in Table 8.4. Note that it will not allow changing the dataset name.

Create Dataset: used to create a child dataset within this dataset.

Create zvol: create a child zvol within this dataset.

Clicking a zvol in `Storage → Volumes` causes icons to appear at the bottom of the screen: *Create Snapshot*, *Edit zvol*, and *Destroy zvol*. Similar to datasets, a zvol name cannot be changed, and destroying a zvol requires confirmation.

Managing Encrypted Volumes

FreeNAS® generates and stores a randomized *encryption key* whenever a new encrypted volume is created. This key is required to read and decrypt any data on the volume.

Encryption keys can also be downloaded as a safety measure, to allow decryption on a different system in the event of failure, or to allow the locally stored key to be deleted for extra security. Encryption keys can also be optionally protected with a *passphrase* for additional security. The combination of encryption key location and whether a passphrase is used provide several different security scenarios:

- *Key stored locally, no passphrase*: the encrypted volume is decrypted and accessible when the system running. Protects "data at rest" only.
- *Key stored locally, with passphrase*: the encrypted volume is not accessible until the passphrase is entered by the FreeNAS® administrator.
- *Key not stored locally*: the encrypted volume is not accessible until the FreeNAS® administrator provides the key. If a passphrase is set on the key, it must also be entered before the encrypted volume can be accessed (two factor authentication (https://en.wikipedia.org/wiki/Multi-factor_authentication)).

Encrypted data cannot be accessed when the disks are removed or the system has been shut down. On a running system, encrypted data cannot be accessed when the volume is locked (see below) and the key is not available. If the key is protected with a passphrase, both the key and passphrase are required for decryption.

Encryption applies to a volume, not individual users. When a volume is unlocked, data is accessible to all users with permissions to access it.

Note: GELI (https://www.freebsd.org/cgi/man.cgi?query=geli) uses *two* randomized encryption keys for each disk. The first has been discussed here. The second, the disk's "master key", is encrypted and stored in the on-disk GELI metadata. Loss of a disk master key due to disk corruption is equivalent to any other disk failure, and in a redundant pool, other disks will contain accessible copies of the uncorrupted data. While it is *possible* to separately back up disk master keys, it is usually not necessary or useful.

Additional Controls for Encrypted Volumes

If the *Encryption* option is enabled during the creation of a pool, additional buttons appear in the entry for the volume in `Storage → Volumes`. An example is shown in Figure 8.15.

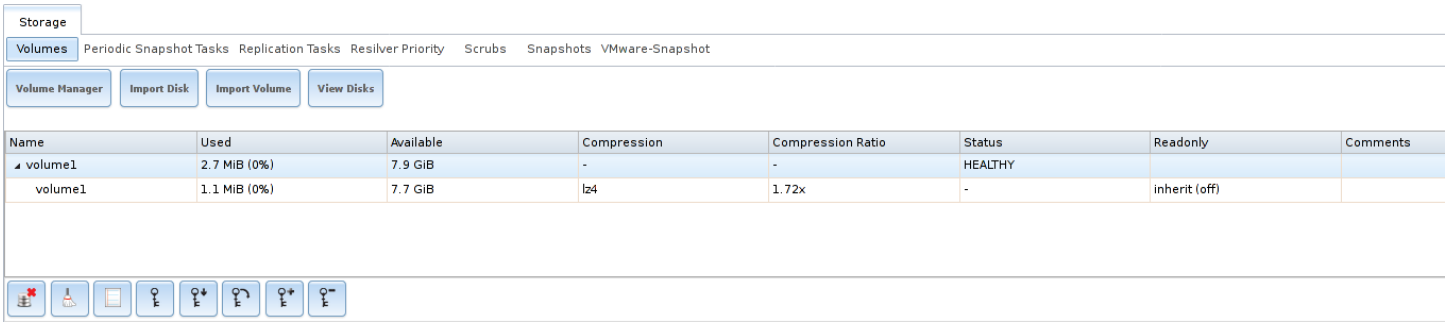


Fig. 8.15: Encryption Icons Associated with an Encrypted Volume

These additional encryption buttons are used to:

Create/Change Passphrase: set and confirm a passphrase associated with the GELI encryption key. The desired passphrase is entered and repeated for verification. A red warning is a reminder to *Remember to add a new recovery key as this action invalidates the previous recovery key*. Unlike a password, a passphrase can contain spaces and is typically a series of words. A good passphrase is easy to remember (like the line to a song or piece of literature) but hard to guess (people who know you should not be able to guess the passphrase). **Remember this passphrase. An encrypted volume cannot be reimported without it.** In other words, if the passphrase is forgotten, the data on the volume can become inaccessible if it becomes necessary to reimport the pool. Protect this passphrase, as anyone who knows it could reimport the encrypted volume, thwarting the reason for encrypting the disks in the first place.

Fig. 8.16: Add or Change a Passphrase to an Encrypted Volume

After the passphrase is set, the name of this button changes to *Change Passphrase*. After setting or changing the passphrase, it is important to *immediately* create a new recovery key by clicking the *Add recovery key* button. This way, if the passphrase is forgotten, the associated recovery key can be used instead.

Encrypted volumes with a passphrase display an additional lock button:

Fig. 8.17: Lock Button

These encrypted volumes can be *locked*. The data is not accessible until the volume is unlocked by suppying the passphrase or encryption key, and the button changes to an unlock button:

Fig. 8.18: Unlock Button

To unlock the volume, click the unlock button to display the Unlock dialog:

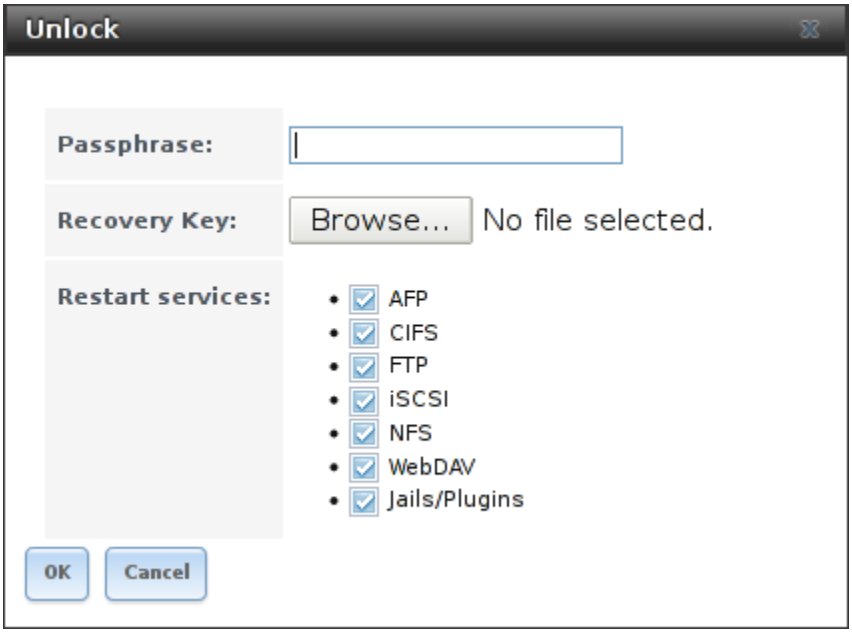


Fig. 8.19: Unlock Locked Volume

Unlock the volume by entering a passphrase *or* using the *Browse* button to load the recovery key. If both a passphrase and a recovery key are entered, only the passphrase is used. By default, the services listed will restart when the volume is unlocked. This allows them to see the new volume and share or access data on it. Individual services can be prevented from restarting by deselecting them. However, a service that is not restarted might not be able to access the unlocked volume.

Download Key: download a backup copy of the GELI encryption key. The encryption key is saved to the client system, not on the FreeNAS® system. The FreeNAS® administrative password must be entered, then the directory in which to store the key is chosen. Since the GELI encryption key is separate from the FreeNAS® configuration database, **it is highly recommended to make a backup of the key. If the key is ever lost or destroyed and there is no backup key, the data on the disks is inaccessible.**

Encryption Re-key: generate a new GELI encryption key. Typically this is only performed when the administrator suspects that the current key may be compromised. This action also removes the current passphrase.

Add recovery key: generate a new recovery key. This screen prompts for the FreeNAS® administrative password and then the directory in which to save the key. Note that the recovery key is saved to the client system, not on the FreeNAS® system. This recovery key can be used if the passphrase is forgotten. **Always immediately add a recovery key whenever the passphrase is changed.**

Remove recovery key: Typically this is only performed when the administrator suspects that the current recovery key may be compromised. **Immediately** create a new passphrase and recovery key.

Note: The passphrase, recovery key, and encryption key must be protected. Do not reveal the passphrase to others. On the system containing the downloaded keys, take care that the system and its backups are protected. Anyone who has the keys has the ability to re-import the disks if they are discarded or stolen.

Warning: If a re-key fails on a multi-disk system, an alert is generated. **Do not ignore this alert** as doing so may result in the loss of data.

8.1.9 View Multipaths

FreeNAS® uses gmultipath(8) (https://www.freebsd.org/cgi/man.cgi?query=gmultipath) to provide multipath I/O (https://en.wikipedia.org/wiki/Multipath_I/O) support on systems containing hardware that is capable of multipath. An example would be a dual SAS expander backplane in the chassis or an external JBOD.

Multipath hardware adds fault tolerance to a NAS as the data is still available even if one disk I/O path has a failure.

FreeNAS® automatically detects active/active and active/passive multipath-capable hardware. Any multipath-capable devices that are detected will be placed in multipath units with the parent devices hidden. The configuration will be displayed in `Storage → Volumes → View Multipaths`. Note that this option is not be displayed in the `Storage → Volumes` tree on systems that do not contain multipath-capable hardware.

8.1.10 Replacing a Failed Drive

With any form of redundant RAID, failed drives must be replaced as soon as possible to repair the degraded state of the RAID. Depending on the hardware capabilities, it might be necessary to reboot to replace the failed drive. Hardware that supports AHCI does not require a reboot.

Note: Striping (RAID0) does not provide redundancy. If a disk in a stripe fails, the volume will be destroyed and must be recreated and the data restored from backup.

Note: If the volume is encrypted with GELI, refer to *Replacing an Encrypted Drive* (page 142) before proceeding.

Before physically removing the failed device, go to `Storage → Volumes`. Select the volume name. At the bottom of the interface are several icons, one of which is *Volume Status*. Click the *Volume Status* icon and locate the failed disk. Then perform these steps:

1. Click the disk entry, then its *Offline* button to change the disk status to OFFLINE. This step removes the device from the ZFS pool and prevents swap issues. If the hardware supports hot-pluggable disks, click the disk *Offline* button and pull the disk, then skip to step 3. If there is no *Offline* button but only a *Replace* button, the disk is already offlined and this step can be skipped.

   Note: If the process of changing the disk status to OFFLINE fails with a "disk offline failed - no valid replicas" message, the ZFS volume must be scrubbed first with the *Scrub Volume* button in `Storage → Volumes`. After the scrub completes, try to *Offline* the disk again before proceeding.

2. If the hardware is not AHCI capable, shut down the system to physically replace the disk. When finished, return to the GUI and locate the OFFLINE disk.
3. After the disk has been replaced and is showing as OFFLINE, click the disk again and then click its *Replace* button. Select the replacement disk from the drop-down menu and click the *Replace Disk* button. After clicking the *Replace Disk* button, the ZFS pool begins resilvering.
4. After the drive replacement process is complete, re-add the replaced disk in the *S.M.A.R.T. Tests* (page 102) screen.

In the example shown in Figure 8.20, a failed disk is being replaced by disk *ada5* in the volume named `volume1`.

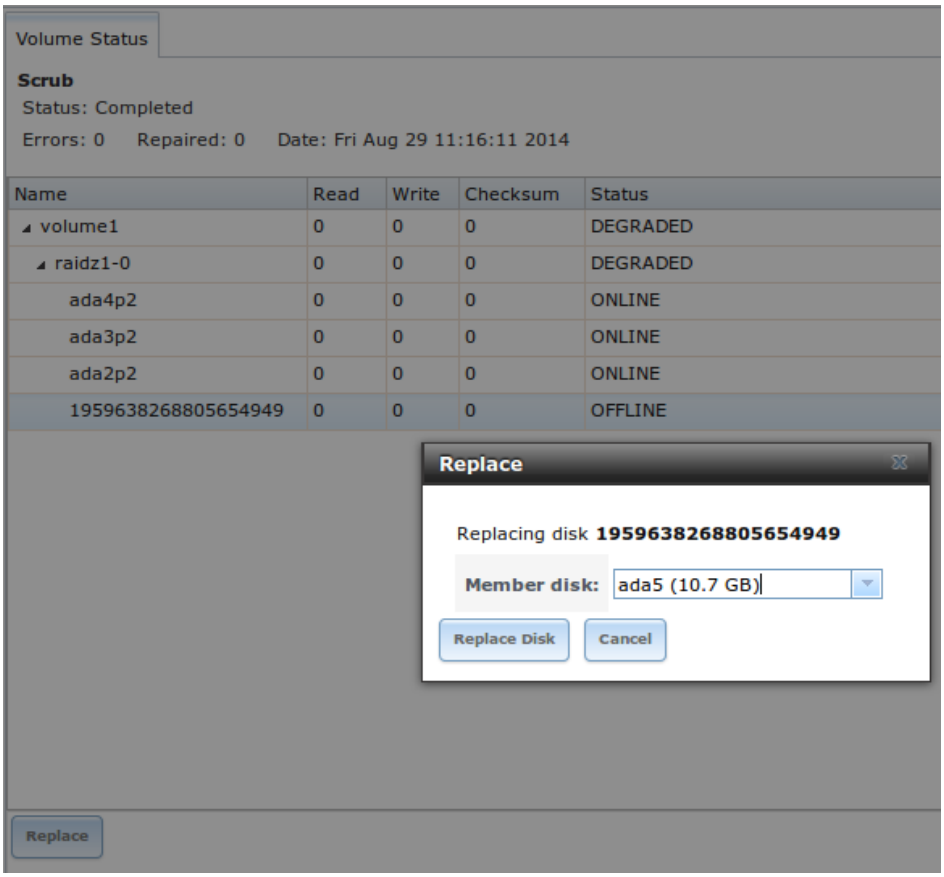


Fig. 8.20: Replacing a Failed Disk

After the resilver is complete, *Volume Status* shows a *Completed* resilver status and indicates any errors. Figure 8.21 indicates that the disk replacement was successful in this example.

Note: A disk that is failing but has not completely failed can be replaced in place, without first removing it. Whether this is a good idea depends on the overall condition of the failing disk. A disk with a few newly-bad blocks that is otherwise functional can be left in place during the replacement to provide data redundancy. A drive that is experiencing continuous errors can actually slow down the replacement. In extreme cases, a disk with serious problems might spend so much time retrying failures that it could prevent the replacement resilvering from completing before another drive fails.

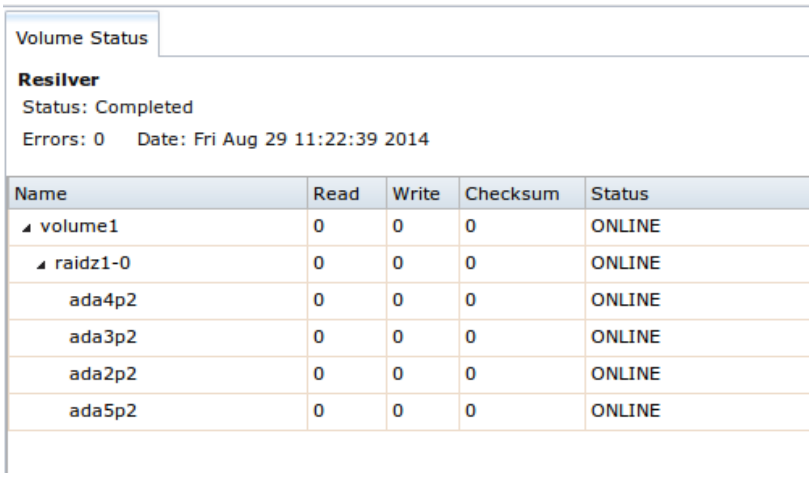


Fig. 8.21: Disk Replacement is Complete

Replacing an Encrypted Drive

If the ZFS pool is encrypted, additional steps are needed when replacing a failed drive.

First, make sure that a passphrase has been set using the instructions in *Encryption* (page 120) **before** attempting to replace the failed drive. Then, follow the steps 1 and 2 as described above. During step 3, a prompt will appear to input and confirm the passphrase for the pool. Enter this information then click the *Replace Disk* button. Wait until the resilvering is complete.

Next, restore the encryption keys to the pool. **If the following additional steps are not performed before the next reboot, access to the pool might be permanently lost.**

1. Highlight the pool that contains the disk that was just replaced and click the *Encryption Re-key* button in the GUI. Entry of the *root* password will be required.
2. Highlight the pool that contains the recently replaced disk and click *Create Passphrase* and enter the new passphrase. The old passphrase can be reused if desired.
3. Highlight the pool that contains the recently replaced disk and click the *Download Key* button to save the new encryption key. Since the old key will no longer function, any old keys can be safely discarded.
4. Highlight the pool that contains the disk that was just replaced and click the *Add Recovery Key* button to save the new recovery key. The old recovery key will no longer function, so it can be safely discarded.

Removing a Log or Cache Device

Added log or cache devices appear in `Storage → Volumes → Volume Status`. Clicking the device enables its *Replace* and *Remove* buttons.

Log and cache devices can be safely removed or replaced with these buttons. Both types of devices improve performance, and throughput can be impacted by their removal.

8.1.11 Replacing Drives to Grow a ZFS Pool

The recommended method for expanding the size of a ZFS pool is to pre-plan the number of disks in a vdev and to stripe additional vdevs using *Volume Manager* (page 118) as additional capacity is needed.

However, this is not an option if there are no open drive ports and a SAS/SATA HBA card cannot be added. In this case, one disk at a time can be replaced with a larger disk, waiting for the resilvering process to incorporate the new disk into the pool, then repeating with another disk until all of the original disks have been replaced.

The safest way to perform this is to use a spare drive port or an eSATA port and a hard drive dock. The process follows these steps:

1. Shut down the system.
2. Install one new disk.
3. Start up the system.
4. Go to `Storage → Volumes`, select the pool to expand and click the *Volume Status* button. Select a disk and click the *Replace* button. Choose the new disk as the replacement.
5. The status of the resilver process can be viewed by running `zpool status`. When the new disk has resilvered, the old one will be automatically offlined. The system is then shut down to physically remove the replaced disk. One advantage of this approach is that there is no loss of redundancy during the resilver.

If a spare drive port is not available, a drive can be replaced with a larger one using the instructions in *Replacing a Failed Drive* (page 140). This process is slow and places the system in a degraded state. Since a failure at this point could be disastrous, **do not attempt this method unless the system has a reliable backup.** Replace one drive at a time and wait for the resilver process to complete on the replaced drive before replacing the next drive. After all the drives are replaced and the final resilver completes, the added space will appear in the pool.

8.1.12 Hot Spares

ZFS provides the ability to have "hot" *spares*. These are drives that are connected to a volume, but not in use. If the volume experiences the failure of a data drive, the system uses the hot spare as a temporary replacement. If the failed drive is replaced with a new drive, the hot spare drive is no longer needed and reverts to being a hot spare. If the failed drive is instead removed from the volume, the spare is promoted to a full member of the volume.

Hot spares can be added to a volume during or after creation. On FreeNAS®, hot spare actions are implemented by zfsd(8) (https://www.freebsd.org/cgi/man.cgi?query=zfsd).

8.2 Periodic Snapshot Tasks

A periodic snapshot task allows scheduling the creation of read-only versions of ZFS volumes and datasets at a given point in time. Snapshots can be created quickly and, if little data changes, new snapshots take up very little space. For example, a snapshot where no files have changed takes 0 MB of storage, but as changes are made to files, the snapshot size changes to reflect the size of the changes.

Snapshots provide a clever way of keeping a history of files, providing a way to recover an older copy or even a deleted file. For this reason, many administrators take snapshots often (perhaps every fifteen minutes), store them for a period of time (possibly a month), and store them on another system (typically using *Replication Tasks* (page 145)). Such a strategy allows the administrator to roll the system back to a specific point in time. If there is a catastrophic loss, an off-site snapshot can be used to restore the system up to the time of the last snapshot.

An existing ZFS volume is required before creating a snapshot. Creating a volume is described in *Volume Manager* (page 118).

To create a periodic snapshot task, click `Storage → Periodic Snapshot Tasks → Add Periodic Snapshot` which opens the screen shown in Figure 8.22. Table 8.7 summarizes the fields in this screen.

Note: If only a one-time snapshot is needed, instead use `Storage → Volumes` and click the *Create Snapshot* button for the volume or dataset to snapshot.

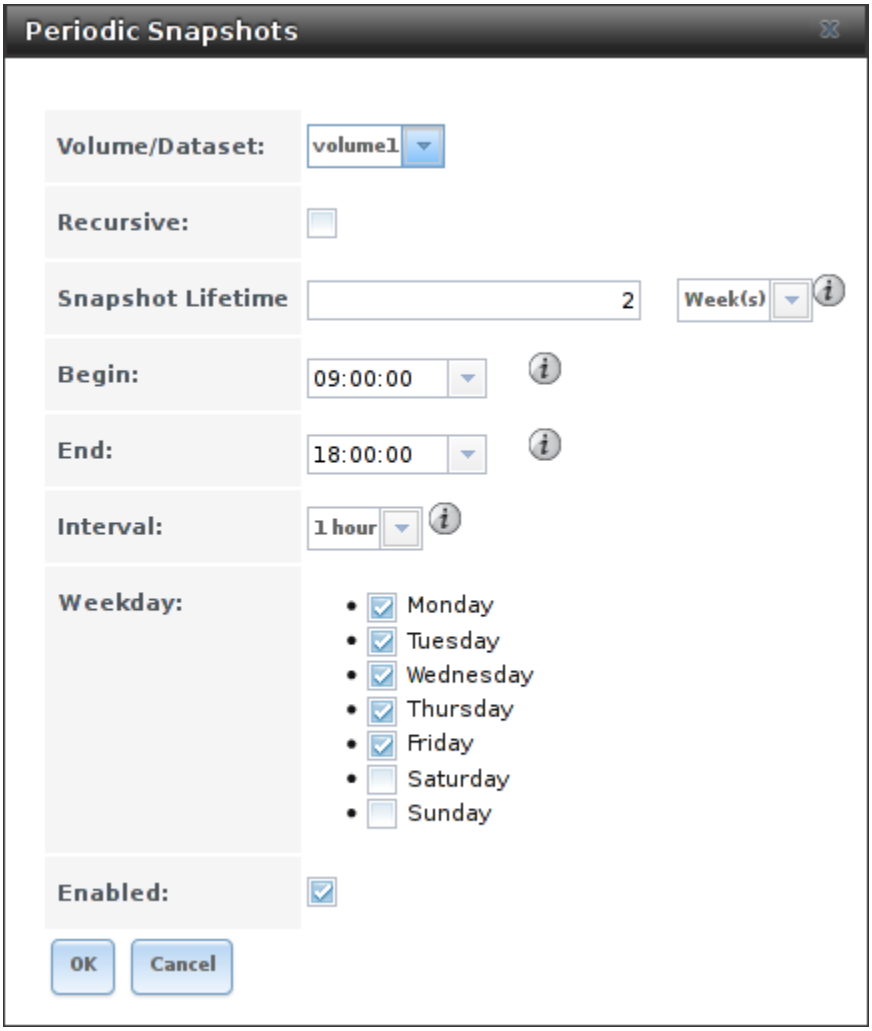


Fig. 8.22: Creating a Periodic Snapshot

Table 8.7: Options When Creating a Periodic Snapshot

Setting	Value	Description
Volume/Dataset	drop-down menu	Select an existing ZFS volume, dataset, or zvol.
Recursive	checkbox	Enable this option to take separate snapshots of the volume or dataset and each of its child datasets. If deselected, a single snapshot is taken of only the specified volume or dataset, but not any child datasets.
Snapshot Lifetime	integer and drop-down menu	Define a length of time to retain the snapshot on this system. After the time expires, the snapshot is removed. Snapshots replicated to other systems are not affected.
Begin	drop-down menu	Choose the hour and minute when the system can begin taking snapshots.
End	drop-down menu	Choose the hour and minute when the system should will stop taking snapshots.
Interval	drop-down menu	Define how often the system takes snapshots between *Begin* and *End* times.
Weekday	checkboxes	Choose the days of the week to take snapshots.
Enabled	checkbox	Unset to disable this task without deleting it.

If the *Recursive* option is enabled, child datasets of this dataset are included in the snapshot and there is no need to create

snapshots for each child dataset. The downside is that there is no way to exclude particular child datasets from a recursive snapshot.

Click the *OK* button to save the task. Entries for each task are shown in *View Periodic Snapshot Tasks*. Click an entry to display *Edit* and *Delete* buttons for it.

8.3 Replication Tasks

Replication is the duplication of snapshots from one FreeNAS® system to another computer. When a new snapshot is created on the source computer, it is automatically replicated to the destination computer. Replication is typically used to keep a copy of files on a separate system, with that system sometimes being at a different physical location.

The basic configuration requires a source system with the original data and a destination system where the data will be replicated. The destination system is prepared to receive replicated data, a *periodic snapshot* (page 143) of the data on the source system is created, and then a replication task is created. As snapshots are automatically created on the source computer, they are automatically replicated to the destination computer.

Note: Replicated data is not visible on the receiving system until the replication task completes.

Note: The target dataset on the receiving system is automatically created in read-only mode to protect the data. To mount or browse the data on the receiving system, create a clone of the snapshot and use the clone. Clones are created in read/write mode, making it possible to browse or mount them. See *Snapshots* (page 158) for more information on creating clones.

8.3.1 Examples: Common Configuration

The examples shown here use the same setup of source and destination computers.

Alpha (Source)

Alpha is the source computer with the data to be replicated. It is at IP address *10.0.0.102*. A *volume* (page 118) named *alphavol* has already been created, and a *dataset* (page 125) named *alphadata* has been created on that volume. This dataset contains the files which will be snapshotted and replicated onto *Beta*.

This new dataset has been created for this example, but a new dataset is not required. Most users will already have datasets containing the data they wish to replicate.

Create a periodic snapshot of the source dataset by selecting `Storage → Periodic Snapshot Tasks`. Click the *alphavol/alphadata* dataset to highlight it. Create a *periodic snapshot* (page 143) of it by clicking *Periodic Snapshot Tasks*, then *Add Periodic Snapshot* as shown in Figure 8.23.

This example creates a snapshot of the *alphavol/alphadata* dataset every two hours from Monday through Friday between the hours of 9:00 and 18:00 (6:00 PM). Snapshots are automatically deleted after their chosen lifetime of two weeks expires.

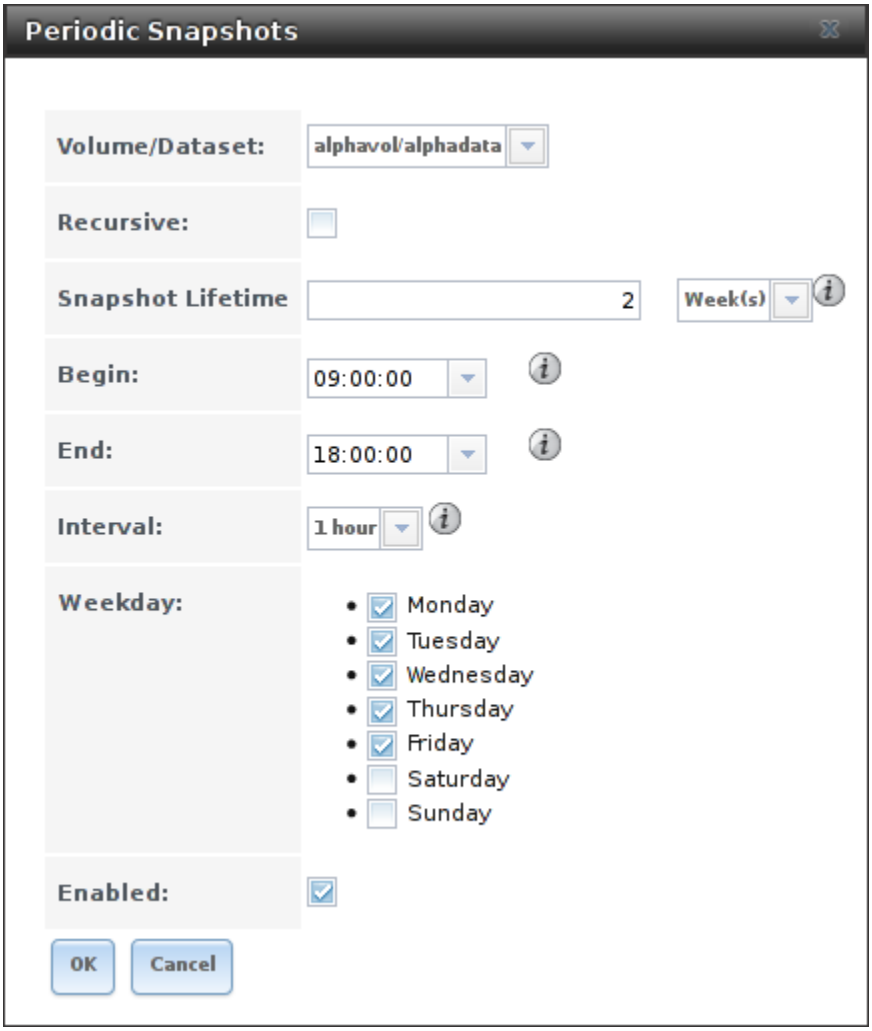


Fig. 8.23: Create a Periodic Snapshot for Replication

Beta (Destination)

Beta is the destination computer where the replicated data will be copied. It is at IP address *10.0.0.118*. A *volume* (page 118) named *betavol* has already been created.

Snapshots are transferred with *SSH* (page 240). To allow incoming connections, this service is enabled on *Beta*. The service is not required for outgoing connections, and so does not need to be enabled on *Alpha*.

8.3.2 Example: FreeNAS® to FreeNAS® Semi-Automatic Setup

FreeNAS® offers a special semi-automatic setup mode that simplifies setting up replication. Create the replication task on *Alpha* by clicking *Replication Tasks* and *Add Replication*. *alphavol/alphadata* is selected as the dataset to replicate. *betavol* is the destination volume where *alphadata* snapshots are replicated. The *Setup mode* dropdown is set to *Semi-automatic* as shown in Figure 8.24. The IP address of *Beta* is entered in the *Remote hostname* field. A hostname can be entered here if local DNS resolves for that hostname.

Note: If *WebGUI HTTP -> HTTPS Redirect* has been enabled in `System → General` on the destination computer, *Remote HTTP/HTTPS Port* must be set to the HTTPS port (usually *443*) and *Remote HTTPS* must be enabled when creating the replication on the source computer.

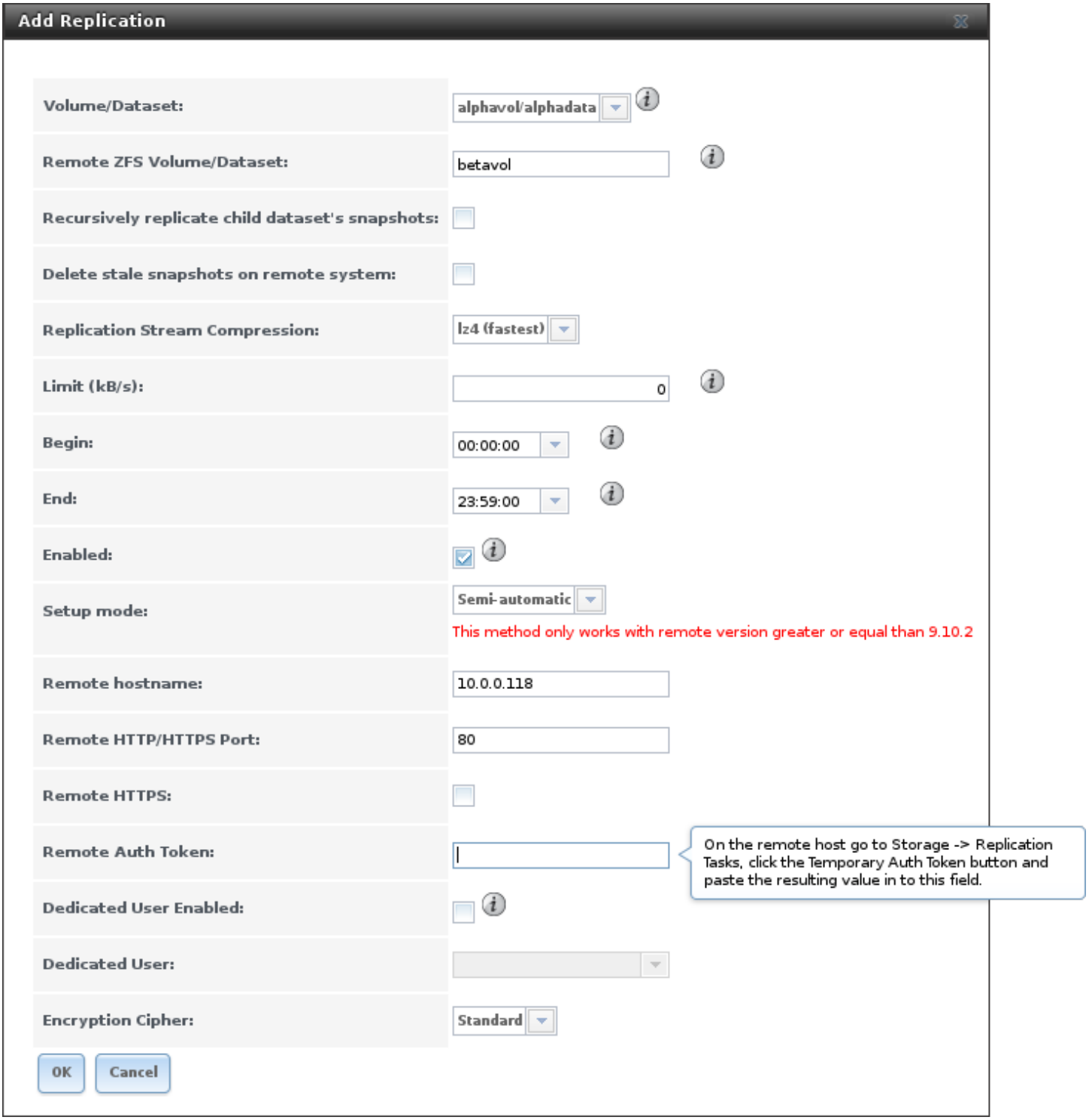


Fig. 8.24: Add Replication Dialog, Semi-Automatic

The *Remote Auth Token* field expects a special token from the *Beta* computer. On *Beta*, choose `Storage → Replication Tasks`, then click *Temporary Auth Token*. A dialog showing the temporary authorization token is shown as in Figure 8.25.

Highlight the temporary authorization token string with the mouse and copy it.

Fig. 8.25: Temporary Authentication Token on Destination

On the *Alpha* system, paste the copied temporary authorization token string into the *Remote Auth Token* field as shown in Figure 8.26.

Fig. 8.26: Temporary Authentication Token Pasted to Source

Finally, click the *OK* button to create the replication task. After each periodic snapshot is created, a replication task will copy it to the destination system. See *Limiting Replication Times* (page 153) for information about restricting when replication is allowed to run.

Note: The temporary authorization token is only valid for a few minutes. If a *Token is invalid* message is shown, get a new temporary authorization token from the destination system, clear the *Remote Auth Token* field, and paste in the new one.

8.3.3 Example: FreeNAS® to FreeNAS® Dedicated User Replication

A *dedicated user* can be used for replications rather than the root user. This example shows the process using the semi-automatic replication setup between two FreeNAS® systems with a dedicated user named *repluser*. SSH key authentication is used to allow the user to log in remotely without a password.

In this example, the periodic snapshot task has not been created yet. If the periodic snapshot shown in the *example configuration* (page 145) has already been created, go to `Storage → Periodic Snapshot Tasks`, click on the task to select it, and click *Delete* to remove it before continuing.

On *Alpha*, select `Account → Users`. Click the *Add User*. Enter *repluser* for *Username*, enter */mnt/alphavol/repluser* in the *Create Home Directory In* field, enter *Replication Dedicated User* for the *Full Name*, and set the *Disable password login* option. Leave the other fields at their default values, but note the *User ID* number. Click *OK* to create the user.

On *Beta*, the same dedicated user must be created as was created on the sending computer. Select `Account → Users`. Click the *Add User*. Enter the *User ID* number from *Alpha*, *repluser* for *Username*, enter */mnt/betavol/repluser* in the *Create Home Directory In* field, enter *Replication Dedicated User* for the *Full Name*, and set the *Disable password login* option. Leave the other fields at their default values. Click *OK* to create the user.

A dataset with the same name as the original must be created on the destination computer, *Beta*. Select `Storage → Volumes`, click on *betavol*, then click the *Create Dataset* icon at the bottom. Enter *alphadata* as the *Dataset Name*, then click *Add Dataset*.

The replication user must be given permissions to the destination dataset. Still on *Beta*, open a *Shell* (page 282) and enter this command:

```
zfs allow -ldu repluser create,destroy,diff,mount,readonly,receive,release,send,userprop betavol/
↪alphadata
```

The destination dataset must also be set to read-only. Enter this command in the *Shell* (page 282):

```
zfs set readonly=on betavol/alphadata
```

Close the *Shell* (page 282) by typing `exit` and pressing `Enter`.

The replication user must also be able to mount datasets. Still on *Beta*, go to `System → Tunables`. Click *Add Tunable*. Enter *vfs.usermount* for the *Variable*, *1* for the *Value*, and choose *Sysctl* from the *Type* drop-down. Click *OK* to save the tunable settings.

Back on *Alpha*, create a periodic snapshot of the source dataset by selecting `Storage → Periodic Snapshot Tasks`. Click the *alphavol/alphadata* dataset to highlight it. Create a *periodic snapshot* (page 143) of it by clicking *Periodic Snapshot Tasks*, then *Add Periodic Snapshot* as shown in Figure 8.23.

Still on *Alpha*, create the replication task by clicking *Replication Tasks* and *Add Replication*. *alphavol/alphadata* is selected as the dataset to replicate. *betavol/alphadata* is the destination volume and dataset where *alphadata* snapshots are replicated.

The *Setup mode* dropdown is set to *Semi-automatic* as shown in Figure 8.24. The IP address of *Beta* is entered in the *Remote hostname* field. A hostname can be entered here if local DNS resolves for that hostname.

Note: If *WebGUI HTTP -> HTTPS Redirect* has been enabled in `System → General` on the destination computer, *Remote HTTP/HTTPS Port* must be set to the HTTPS port (usually *443*) and *Remote HTTPS* must be enabled when creating the replication on the source computer.

The *Remote Auth Token* field expects a special token from the *Beta* computer. On *Beta*, choose `Storage → Replication Tasks`, then click *Temporary Auth Token*. A dialog showing the temporary authorization token is shown as in Figure 8.25.

Highlight the temporary authorization token string with the mouse and copy it.

On the *Alpha* system, paste the copied temporary authorization token string into the *Remote Auth Token* field as shown in Figure 8.26.

Set the *Dedicated User* option. Choose *repluser* in the *Dedicated User* drop-down.

Click the *OK* button to create the replication task.

Note: The temporary authorization token is only valid for a few minutes. If a *Token is invalid* message is shown, get a new temporary authorization token from the destination system, clear the *Remote Auth Token* field, and paste in the new one.

Replication will begin when the periodic snapshot task runs.

Additional replications can use the same dedicated user that has already been set up. The permissions and read only settings made through the *Shell* (page 282) must be set on each new destination dataset.

8.3.4 Example: FreeNAS® to FreeNAS® or Other Systems, Manual Setup

This example uses the same basic configuration of source and destination computers shown above, but the destination computer is not required to be a FreeNAS® system. Other operating systems can receive the replication if they support SSH, ZFS, and the same features that are in use on the source system. The details of creating volumes and datasets, enabling SSH, and copying encryption keys will vary when the destination computer is not a FreeNAS® system.

Encryption Keys

A public encryption key must be copied from *Alpha* to *Beta* to allow a secure connection without a password prompt. On *Alpha*, select `Storage → Replication Tasks → View Public Key`, producing the window shown in Figure 8.27. Use the mouse to highlight the key data shown in the window, then copy it.

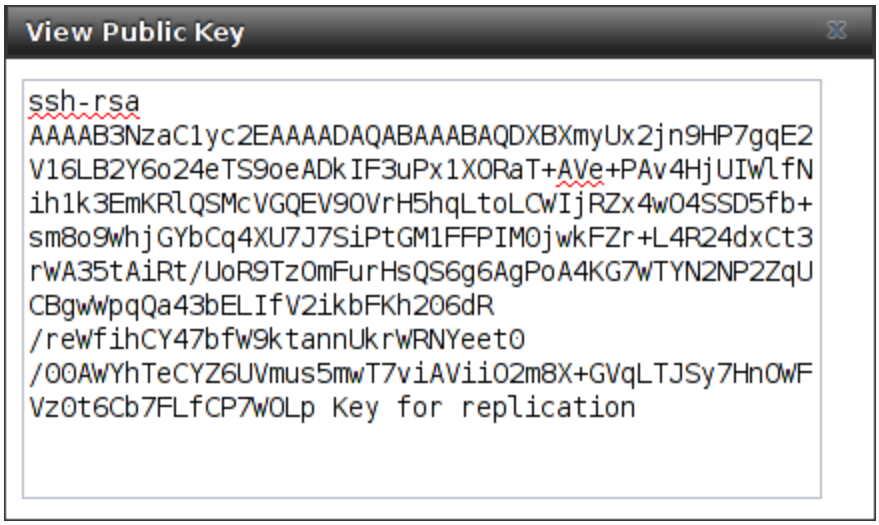


Fig. 8.27: Copy the Replication Key

On *Beta*, select `Account` → `Users` → `View Users`. Click the *root* account to select it, then click *Modify User*. Paste the copied key into the *SSH Public Key* field and click *OK* as shown in Figure 8.28.

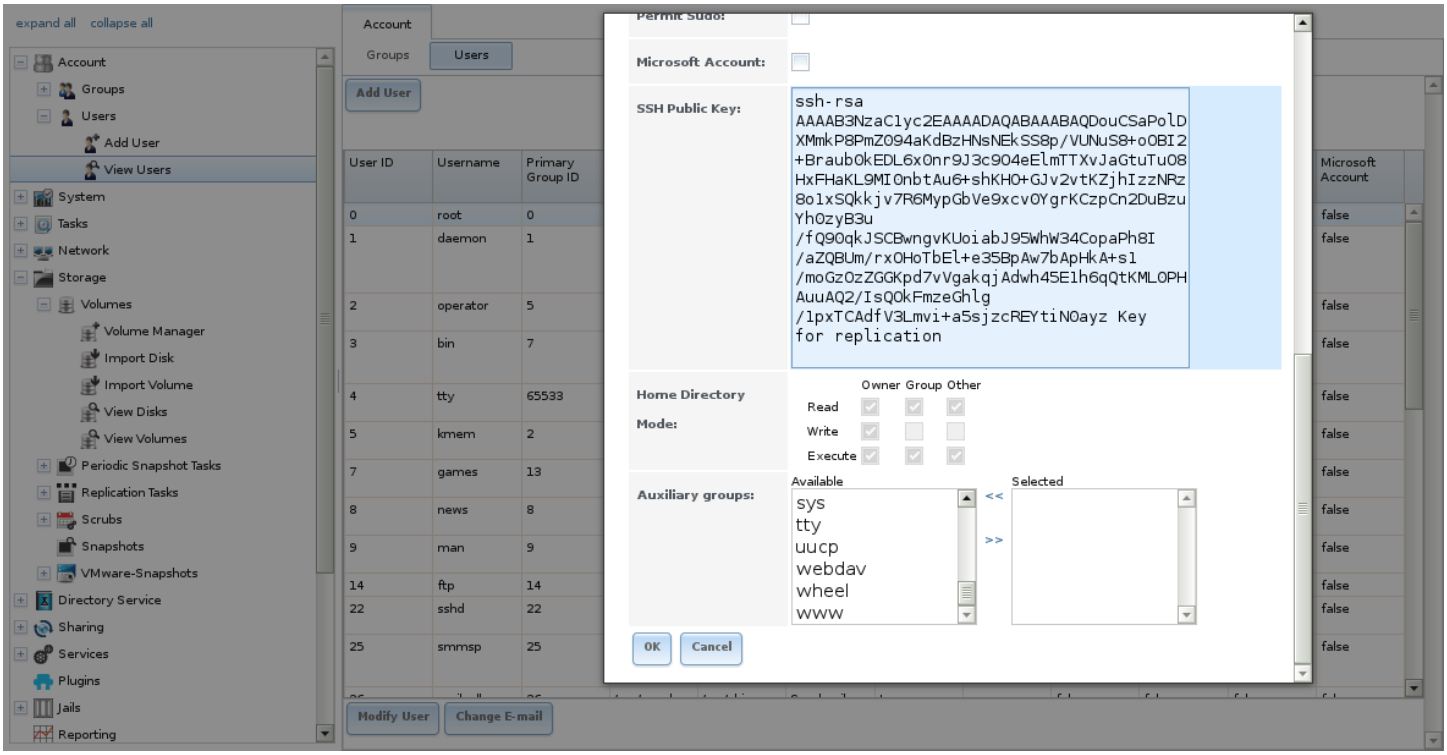
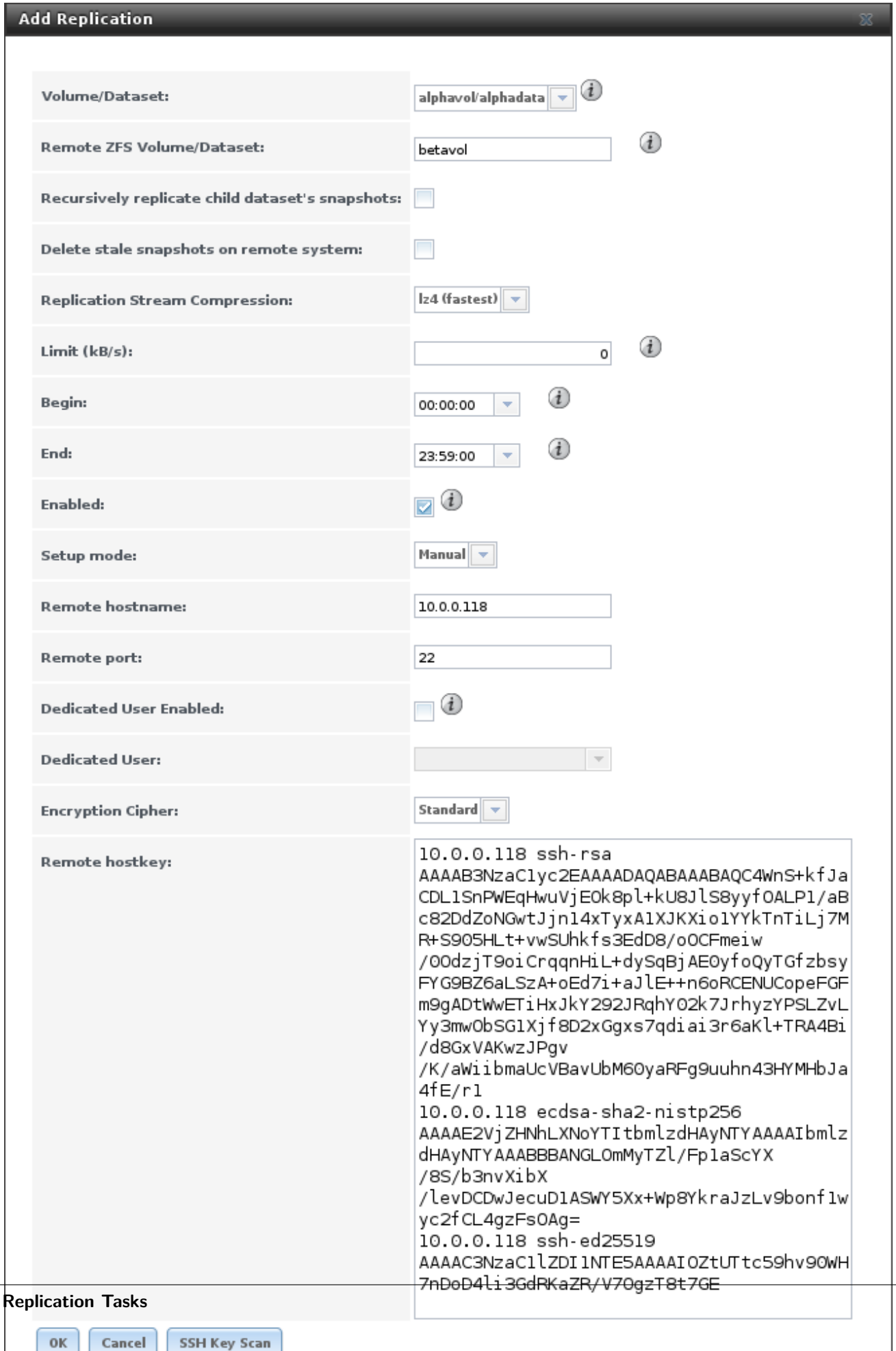


Fig. 8.28: Paste the Replication Key

Back on *Alpha*, create the replication task by clicking *Replication Tasks* and *Add Replication*. *alphavol/alphadata* is selected as the dataset to replicate. The destination volume is *betavol*. The *alphadata* dataset and snapshots are replicated there. The IP address of *Beta* is entered in the *Remote hostname* field as shown in Figure 8.29. A hostname can be entered here if local DNS resolves for that hostname.

Click the *SSH Key Scan* button to retrieve the SSH host keys from *Beta* and fill the *Remote hostkey* field. Finally, click *OK* to create the replication task. After each periodic snapshot is created, a replication task will copy it to the destination system. See *Limiting Replication Times* (page 153) for information about restricting when replication is allowed to run.


Add Replication
Volume/Dataset:
alphavol/alphadata
Remote ZFS Volume/Dataset:
betavol
Recursively replicate child dataset's snapshots:
Delete stale snapshots on remote system:
Replication Stream Compression:
lz4 (fastest)
Limit (kB/s):
0
Begin:
00:00:00
End:
23:59:00
Enabled:
Setup mode:
Manual
Remote hostname:
10.0.0.118
Remote port:
22
Dedicated User Enabled:
Dedicated User:
Encryption Cipher:
Standard
Remote hostkey:
10.0.0.118 ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABAQC4WnS+kfJa
CDL1SnPWEqHwuVjE0k8pl+kU8JlS8yyfOALP1/aB
c82DdZoNGwtJjn14xTyxA1XJKXio1YYkTnTiLj7M
R+S905HLt+vwSUhkfs3EdD8/oOCFmeiw
/OOdzjT9oiCrqqnHiL+dySqBjAE0yfoQyTGfzbsy
FYG9BZ6aLSzA+oEd7i+aJlE++n6oRCENUCopeFGF
m9gADtWwETiHxJkY292JRqhY02k7JrhyzYPSLZvL
Yy3mwObSG1Xjf8D2xGgxs7qdiai3r6aKl+TRA4Bi
/d8GxVAKwzJPgv
/K/aWiibmaUcVBavUbM60yaRFg9uuhn43HYMHbJa
4fE/r1
10.0.0.118 ecdsa-sha2-nistp256
AAAAE2VjZHNhLXNoYTItbmlzdHAyNTYAAAAIbmlz
dHAyNTYAAABBBANGLOmMyTZl/Fp1aScYX
/8S/b3nvXibX
/levDCDwJecuD1ASWY5Xx+Wp8YkraJzLv9bonf1w
yc2fCL4gzFsOAg=
10.0.0.118 ssh-ed25519
AAAAC3NzaC1lZDI1NTE5AAAAIOZtUTtc59hv90WH
7nDoD4li3GdRKaZR/V70gzT8t7GE
OK
Cancel
SSH Key Scan

8.3.5 Replication Options

Table 8.8 describes the options in the replication task dialog.

Table 8.8: Replication Task Options

Setting	Value	Description
Volume/Dataset	drop-down menu	On the source computer with snapshots to replicate, choose an existing ZFS pool or dataset with an active periodic snapshot task.
Remote ZFS Volume/Dataset	string	Enter the ZFS volume or dataset on the remote or destination computer which will store the snapshots. Example: poolname/datasetname, not the mount point or filesystem path.
Recursively replicate child dataset snapshots	checkbox	When enabled, include snapshots of child datasets from the primary dataset.
Delete stale snapshots	checkbox	Set to delete previous snapshots from the remote or destination system which are no longer present on the source computer.
Replication Stream Compression	drop-down menu	Choices are *lz4 (fastest)*, *pigz (all rounder)*, *plzip (best compression)*, or *Off* (no compression). Selecting a compression algorithm can reduce the size of the data being replicated.
Limit (kbps)	integer	Limit replication speed to the specified value in kilobits/second. Default of *0* is unlimited.
Begin	drop-down menu	Define a time to start the replication task.
End	drop-down menu	Define the point in time by which replication must start. A started replication task conitinues until it is finished.
Enabled	checkbox	Deselect to disable the scheduled replication task without deleting it.
Setup mode	drop-down menu	Choose the configuration mode for the remote. Choices are *Manual* or *Semi-automatic*. Note semi-automatic only works with remote version 9.10.2 or later.
Remote hostname	string	Enter the IP address or DNS name of remote system to receive the replication data.
Remote port	string	Enter the port number used by the SSH server on the remote or destination computer.
Dedicated User Enabled	checkbox	Select the user account other than root to be used for replication.
Dedicated User	drop-down menu	Only available if *Dedicated User Enabled* is enabled. Select the user account to be used for replication.
Encryption Cipher	drop-down menu	*Standard*, *Fast*, or *Disabled*.
Remote hostkey	string	Use the *SSH Key Scan* button to retrieve the public host key of the remote or destination computer and populate this field with that key.

The replication task runs after a new periodic snapshot is created. The periodic snapshot and any new manual snapshots of the same dataset are replicated onto the destination computer.

When multiple replications have been created, replication tasks run serially, one after another. Completion time depends on the number and size of snapshots and the bandwidth available between the source and destination computers.

The first time a replication runs, it must duplicate data structures from the source to the destination computer. This can take much longer to complete than subsequent replications, which only send differences in data.

Warning: Snapshots record incremental changes in data. If the receiving system does not have at least one snapshot that can be used as a basis for the incremental changes in the snapshots from the sending system, there is no way to identify only the data that has changed. In this situation, the snapshots in the receiving system target dataset are removed so a complete initial copy of the new replicated data can be created.

Selecting `Storage → Replication Tasks` displays Figure 8.30, the list of replication tasks. The *Last snapshot sent to remote side* column shows the name of the last snapshot that was successfully replicated, and *Status* shows the current status of each replication task. The display is updated every five seconds, always showing the latest status.

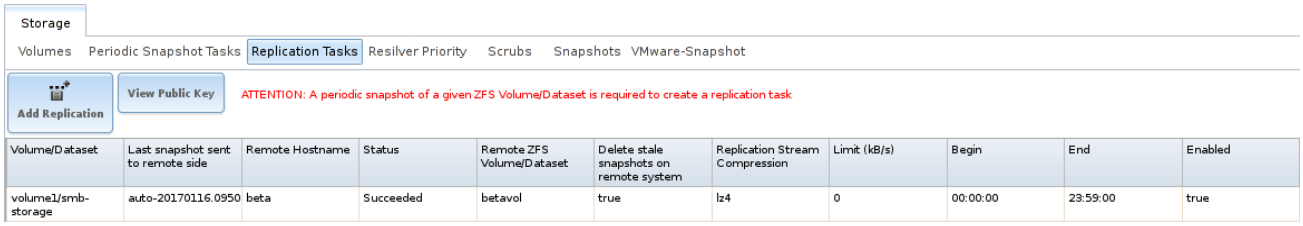


Fig. 8.30: Replication Task List

Note: The encryption key that was copied from the source computer (*Alpha*) to the destination computer (*Beta*) is an RSA public key located in the `/data/ssh/replication.pub` file on the source computer. The host public key used to identify the destination computer (*Beta*) is from the `/etc/ssh/ssh_host_rsa_key.pub` file on the destination computer.

8.3.6 Replication Encryption

The default *Encryption Cipher Standard* setting provides good security. *Fast* is less secure than *Standard* but can give reasonable transfer rates for devices with limited cryptographic speed. For networks where the entire path between source and destination computers is trusted, the *Disabled* option can be chosen to send replicated data without encryption.

8.3.7 Limiting Replication Times

The *Begin* and *End* times in a replication task make it possible to restrict when replication is allowed. These times can be set to only allow replication after business hours, or at other times when disk or network activity will not slow down other operations like snapshots or *Scrubs* (page 155). The default settings allow replication to occur at any time.

These times control when replication task are allowed to start, but will not stop a replication task that is already running. Once a replication task has begun, it will run until finished.

8.3.8 Troubleshooting Replication

Replication depends on SSH, disks, network, compression, and encryption to work. A failure or misconfiguration of any of these can prevent successful replication.

SSH

SSH (page 240) must be able to connect from the source system to the destination system with an encryption key. This can be tested from *Shell* (page 282) by making an *SSH* (page 240) connection from the source system to the destination system. From the previous example, this is a connection from *Alpha* to *Beta* at *10.0.0.118*. Start the *Shell* (page 282) on the source machine (*Alpha*), then enter this command:

```
ssh -vv -i /data/ssh/replication 10.0.0.118
```

On the first connection, the system might say

```
No matching host key fingerprint found in DNS.
Are you sure you want to continue connecting (yes/no)?
```

Verify that this is the correct destination computer from the preceding information on the screen and type `yes`. At this point, an *SSH* (page 240) shell connection is open to the destination system, *Beta*.

If a password is requested, SSH authentication is not working. See Figure 8.27 above. This key value must be present in the `/root/.ssh/authorized_keys` file on *Beta*, the destination computer. The `/var/log/auth.log` file can show diagnostic errors for login problems on the destination computer also.

Compression

Matching compression and decompression programs must be available on both the source and destination computers. This is not a problem when both computers are running FreeNAS®, but other operating systems might not have *lz4*, *pigz*, or *plzip* compression programs installed by default. An easy way to diagnose the problem is to set *Replication Stream Compression* to *Off*. If the replication runs, select the preferred compression method and check `/var/log/debug.log` on the FreeNAS® system for errors.

Manual Testing

On *Alpha*, the source computer, the `/var/log/messages` file can also show helpful messages to locate the problem.

On the source computer, *Alpha*, open a *Shell* (page 282) and manually send a single snapshot to the destination computer, *Beta*. The snapshot used in this example is named `auto-20161206.1110-2w`. As before, it is located in the *alphavol/alphadata* dataset. A `@` symbol separates the name of the dataset from the name of the snapshot in the command.

```
zfs send alphavol/alphadata@auto-20161206.1110-2w | ssh -i /data/ssh/replication 10.0.0.118 zfs recv␣
↪betavol
```

If a snapshot of that name already exists on the destination computer, the system will refuse to overwrite it with the new snapshot. The existing snapshot on the destination computer can be deleted by opening a *Shell* (page 282) on *Beta* and running this command:

```
zfs destroy -R betavol/alphadata@auto-20161206.1110-2w
```

Then send the snapshot manually again. Snapshots on the destination system, *Beta*, can be listed from the *Shell* (page 282) with `zfs list -t snapshot` or by going to `Storage → Snapshots`.

Error messages here can indicate any remaining problems.

8.4 Resilver Priority

Resilvering, or the process of copying data to a replacement disk, is best completed as quickly as possible. Increasing the priority of resilvers can help them to complete more quickly. The *Resilver Priority* tab makes it possible to increase the priority of resilvering at times where the additional I/O or CPU usage will not affect normal usage. Select `Storage → Resilver Priority` to display the screen shown in Figure 8.31. Table 8.9 describes the fields on this screen.

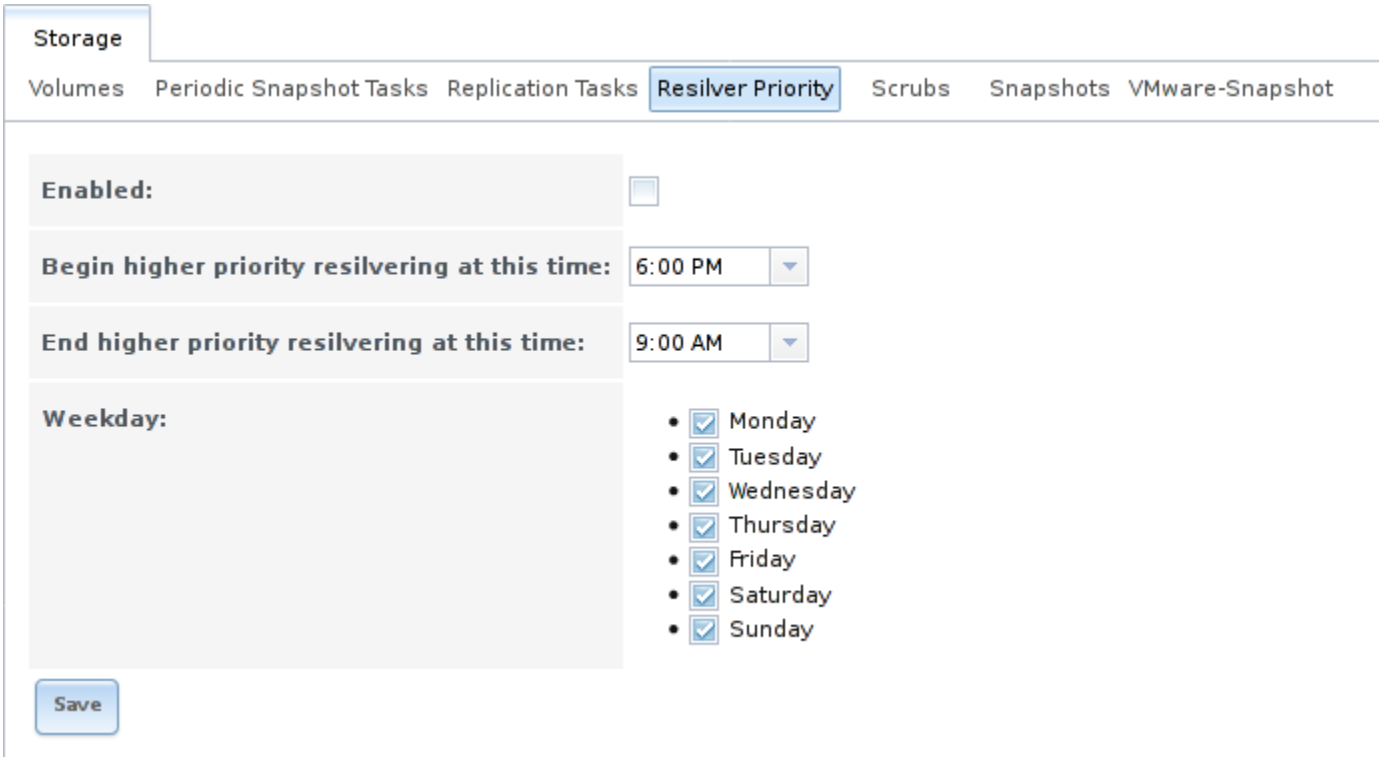


Fig. 8.31: Resilver Priority

Table 8.9: Resilver Priority Options

Setting	Value	Description
Enabled	checkbox	Set to enable higher-priority resilvering.
Begin higher priority resilvering at this time	drop-down	Start time to begin higher-priority resilvering.
End higher priority resilvering at this time	drop-down	End time to begin higher-priority resilvering.
Weekday	checkboxes	Use higher-priority resilvering on these days of the week.

8.5 Scrubs

A scrub is the process of ZFS scanning through the data on a volume. Scrubs help to identify data integrity problems, detect silent data corruptions caused by transient hardware issues, and provide early alerts of impending disk failures. FreeNAS® makes it easy to schedule periodic automatic scrubs.

Each volume should be scrubbed at least once a month. Bit errors in critical data can be detected by ZFS, but only when that data is read. Scheduled scrubs can find bit errors in rarely-read data. The amount of time needed for a scrub is proportional to the quantity of data on the volume. Typical scrubs take several hours or longer.

The scrub process is I/O intensive and can negatively impact performance. Schedule scrubs for evenings or weekends to minimize impact to users. Make certain that scrubs and other disk-intensive activity like *S.M.A.R.T. Tests* (page 102) are scheduled to run on different days to avoid disk contention and extreme performance impacts.

Scrubs only check used disk space. To check unused disk space, schedule *S.M.A.R.T. Tests* (page 102) of *Type Long Self-Test* to run once or twice a month.

Scrubs are scheduled and managed with `Storage → Scrubs`.

When a volume is created, a ZFS scrub is automatically scheduled. An entry with the same volume name is added to `Storage → Scrubs`. A summary of this entry can be viewed with `Storage → Scrubs → View Scrubs`. Figure 8.32 displays the default settings for the volume named `volume1`. In this example, the entry has been highlighted and the *Edit* button clicked to display the *Edit* screen. Table 8.10 summarizes the options in this screen.

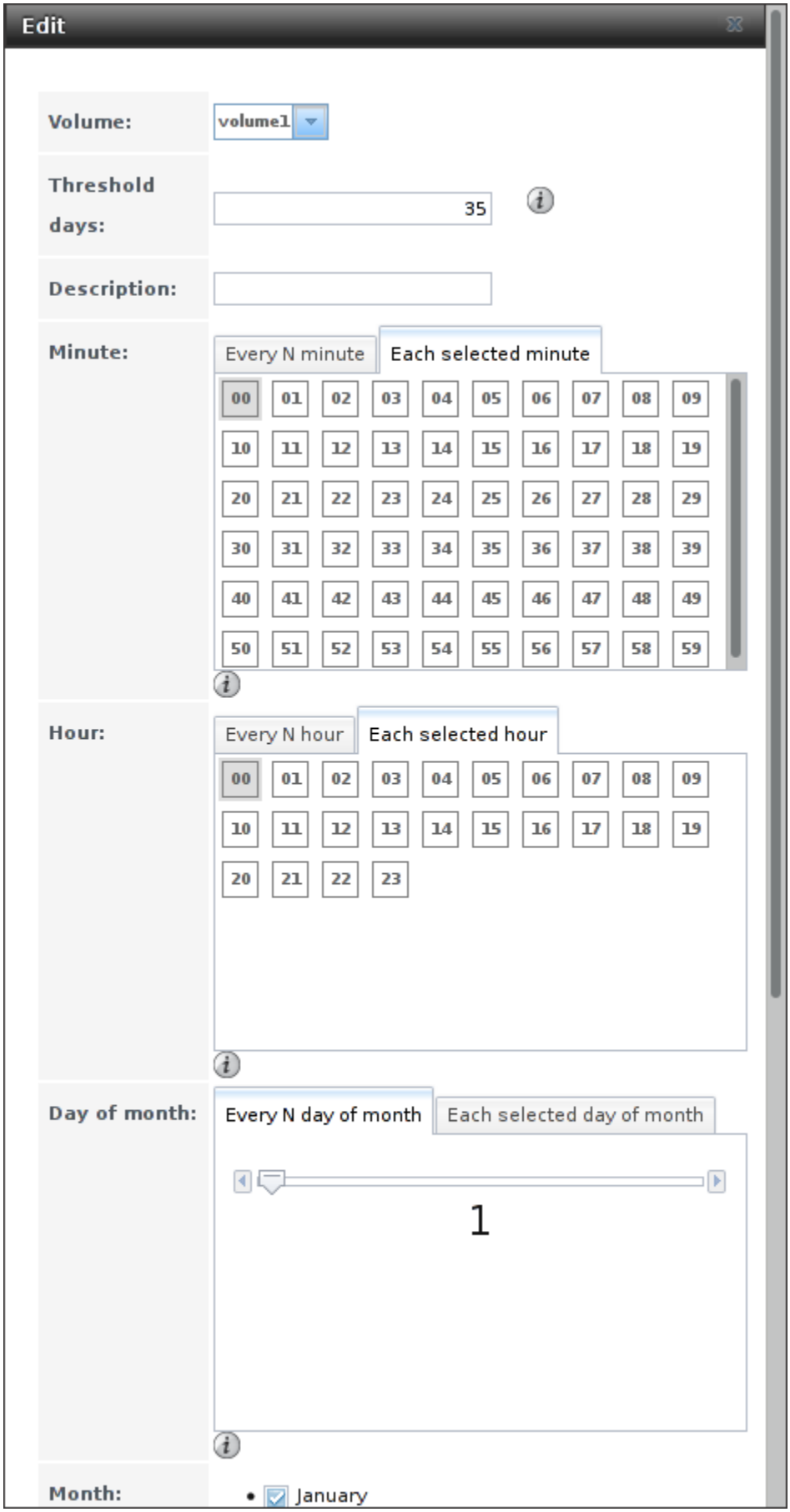


Fig. 8.32: Viewing Volume Default Scrub Settings

Table 8.10: ZFS Scrub Options

Setting	Value	Description
Volume	drop-down menu	Choose a volume to be scrubbed.
Threshold days	integer	Define the number of days to prevent a scrub from running after the last has completed. This ignores any other calendar schedule. The default is a multiple of 7 to ensure that the scrub always occurs on the same day of the week.
Description	string	Optional text description of scrub.
Minute	slider or minute selections	If the slider is used, a scrub occurs every N minutes. If specific minutes are chosen, a scrub runs only at the selected minute values.
Hour	slider or hour selections	If the slider is used, a scrub occurs every N hours. If specific hours are chosen, a scrub runs only at the selected hour values.
Day of Month	slider or month selections	If the slider is used, a scrub occurs every N days. If specific days of the month are chosen, a scrub runs only on the selected days of the selected months.
Month	checkboxes	Define the day of the month to run the scrub.
Day of week	checkboxes	A scrub occurs on the selected days. The default is *Sunday* to least impact users. Note that this field and the *Day of Month* field are ORed together: setting *Day of Month* to *01,15* and *Day of week* to *Thursday* will cause scrubs to run on the 1st and 15th days of the month, but also on any Thursday.
Enabled	checkbox	Unset to disable the scheduled scrub without deleting it.

Review the default selections and, if necessary, modify them to meet the needs of the environment. Note that the *Threshold* field is used to prevent scrubs from running too often, and overrides the schedule chosen in the other fields. Also, if a pool is locked or unmounted when a scrub is scheduled to occur, it will not be scrubbed.

Scheduled scrubs can be deleted with the *Delete* button, but this is not recommended. **Scrubs can provide an early indication of disk issues before a disk failure.** If a scrub is too intensive for the hardware, consider temporarily deselecting the *Enabled* button for the scrub until the hardware can be upgraded.

8.6 Snapshots

Snapshots are scheduled using `Storage → Periodic Snapshot Tasks`. To view and manage the listing of created snapshots, use `Storage → Snapshots`. An example listing is shown in Figure 8.33.

Note: If snapshots do not appear, check that the current time configured in *Periodic Snapshot Tasks* (page 143) does not conflict with the *Begin*, *End*, and *Interval* settings. If the snapshot was attempted but failed, an entry is added to `/var/log/messages`. This log file can be viewed in *Shell* (page 282).

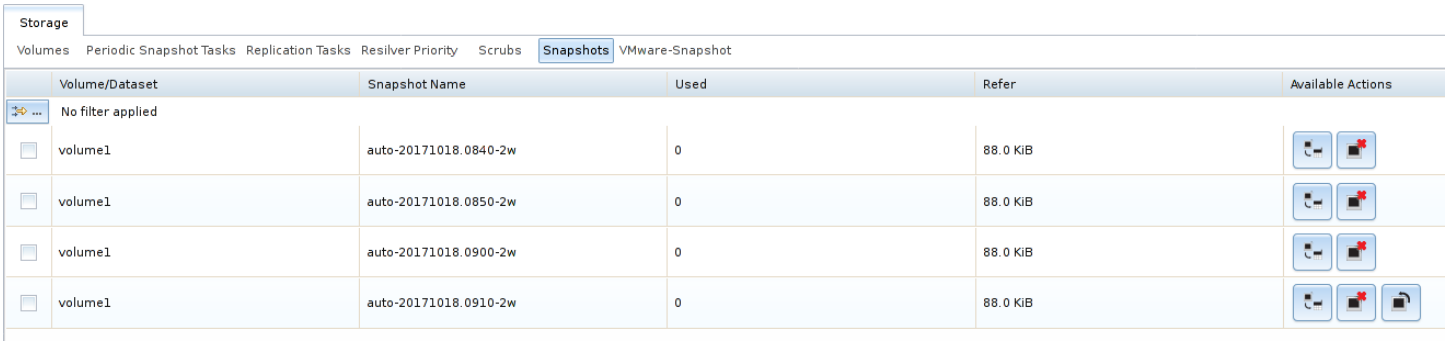


Fig. 8.33: Viewing Available Snapshots

The listing includes the name of the volume or dataset, the name of each snapshot, and the amount of used and referenced data.

Used is the amount of space consumed by this dataset and all of its descendants. This value is checked against the dataset quota and reservation. The space used does not include the dataset reservation, but does take into account the reservations of any descendent datasets. The amount of space that a dataset consumes from its parent, as well as the amount of space that are freed if this dataset is recursively destroyed, is the greater of its space used and its reservation. When a snapshot is created, the space is initially shared between the snapshot and the filesystem, and possibly with previous snapshots. As the filesystem changes, space that was previously shared becomes unique to the snapshot, and is counted in the used space of the snapshot. Additionally, deleting snapshots can increase the amount of space unique to (and used by) other snapshots. The amount of space used, available, or referenced does not take into account pending changes. While pending changes are generally accounted for within a few seconds, disk changes do not necessarily guarantee that the space usage information is updated immediately.

Tip: Space used by individual snapshots can be seen by running `zfs list -t snapshot` from *Shell* (page 282).

Refer indicates the amount of data accessible by this dataset, which may or may not be shared with other datasets in the pool. When a snapshot or clone is created, it initially references the same amount of space as the filesystem or snapshot it was created from, since its contents are identical.

Snapshots have icons on the right side for several actions.

Clone Snapshot prompts for the name of the clone to create. A clone is a writable copy of the snapshot. Since a clone is actually a dataset which can be mounted, it appears in the *Volumes* tab rather than the *Snapshots* tab. By default, `-clone` is added to the name of a snapshot when a clone is created.

Destroy Snapshot a pop-up message asks for confirmation. Child clones must be destroyed before their parent snapshot can be destroyed. While creating a snapshot is instantaneous, deleting a snapshot can be I/O intensive and can take a long time, especially when deduplication is enabled. In order to delete a block in a snapshot, ZFS has to walk all the allocated blocks to see if that block is used anywhere else; if it is not, it can be freed.

The most recent snapshot also has a **Rollback Snapshot** icon. Clicking the icon asks for confirmation before rolling back to this snapshot state. Confirming by clicking *Yes* causes any files that have changed since the snapshot was taken to be reverted back to their state at the time of the snapshot.

Note: Rollback is a potentially dangerous operation and causes any configured replication tasks to fail as the replication system uses the existing snapshot when doing an incremental backup. To restore the data within a snapshot, the recommended steps are:

1. Clone the desired snapshot.
2. Share the clone with the share type or service running on the FreeNAS® system.
3. After users have recovered the needed data, destroy the clone in the *Active Volumes* tab.

This approach does not destroy any on-disk data and has no impact on replication.

A range of snapshots can be selected with the mouse. Click on the option in the left column of the first snapshot, then press and hold `Shift` and click on the option for the end snapshot. This can be used to select a range of obsolete snapshots to be deleted with the *Destroy* icon at the bottom. Be cautious and careful when deleting ranges of snapshots.

Periodic snapshots can be configured to appear as shadow copies in newer versions of Windows Explorer, as described in *Configuring Shadow Copies* (page 197). Users can access the files in the shadow copy using Explorer without requiring any interaction with the FreeNAS® graphical administrative interface.

The ZFS Snapshots screen allows the creation of filters to view snapshots by selected criteria. To create a filter, click the *Define filter* icon (near the text *No filter applied*). When creating a filter:

- Select the column or leave the default of *Any Column*.

- Select the condition. Possible conditions are: *contains* (default), *is*, *starts with*, *ends with*, *does not contain*, *is not*, *does not start with*, *does not end with*, and *is empty*.
- Enter a value that meets your view criteria.
- Click the *Filter* button to save the filter and exit the define filter screen. Alternately, click the + button to add another filter.

When creating multiple filters, select the filter to use before leaving the define filter screen. After a filter is selected, the *No filter applied* text changes to *Clear filter*. Clicking *Clear filter* produces a pop-up message indicates that this removes the filter and all available snapshots are listed.

Warning: A snapshot and any files it contains will not be accessible or searchable if the mount path of the snapshot is longer than 88 ascii characters. The data within the snapshot will be safe, and the snapshot will become accessible again when the mount path is shortened. For details of this limitation, and how to shorten a long mount path, see *Path and Name Lengths* (page 5).

8.6.1 Browsing a snapshot collection

All snapshots for a dataset are accessible as an ordinary hierarchical filesystem, which can be reached from a hidden `.zfs` file located at the root of every dataset. A user with permission to access that file can view and explore all snapshots for a dataset like any other files - from the `CLI` or via `File Sharing` services such as `Samba`, `NFS` and `FTP`. This is an advanced capability which requires some `command line` actions to achieve. In summary, the main changes to settings that are required are:

- Snapshot visibility must be manually enabled in the ZFS properties of the dataset.
- In Samba auxiliary settings, the `veto files` command must be modified to not hide the `.zfs` file, and the setting `zfsacl:expose_snapdir=true` must be added.

The effect will be that any user who can access the dataset contents, will also be able to view the list of snapshots by navigating to the `.zfs` directory of the dataset, and to browse and search any files they have permission to access throughout the entire snapshot collection of the dataset. A user's ability to view files within a snapshot will be limited by any permissions or ACLs set on the files when the snapshot was taken. Snapshots are fixed as "read-only", so this access does not permit the user to change any files in the snapshots, or to modify or delete any snapshot, even if they had write permission at the time when the snapshot was taken.

Note: ZFS has a `zfs diff` command which can list the files that have changed between any two snapshot versions within a dataset, or between any snapshot and the current data.

8.7 VMware-Snapshot

`Storage` → `VMware-Snapshot` is used to coordinate ZFS snapshots when using FreeNAS® as a VMware datastore. Once this type of snapshot is created, FreeNAS® will automatically snapshot any running VMware virtual machines before taking a scheduled or manual ZFS snapshot of the dataset or zvol backing that VMware datastore. The temporary VMware snapshots are then deleted on the VMware side but still exist in the ZFS snapshot and can be used as stable resurrection points in that snapshot. These coordinated snapshots will be listed in *Snapshots* (page 158).

Figure 8.34 shows the menu for adding a VMware snapshot and Table 8.11 summarizes the available options.

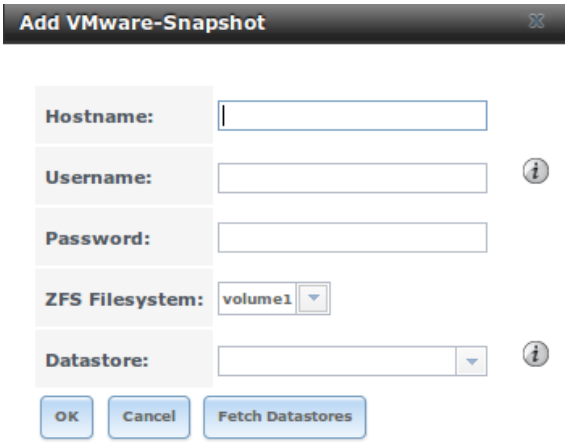


Fig. 8.34: Adding a VMware Snapshot

Table 8.11: VMware Snapshot Options

Setting	Value	Description
Hostname	string	Enter the IP address or hostname of VMware host. When clustering, this is the vCenter server for the cluster.
Username	string	Enter the username on the VMware host with permission to snapshot virtual machines.
Password	string	Enter the password associated with *Username*.
ZFS Filesystem	drop-down menu	Select the filesystem to snapshot.
Datastore	drop-down menu	After entering the *Hostname*, *Username*, and *Password*, click *Fetch Datastores* to populate the menu and select the datastore with which to synchronize.

CHAPTER

NINE

DIRECTORY SERVICES

FreeNAS® supports integration with these directory services:

- *Active Directory* (page 162) (for Windows 2000 and higher networks)
- *LDAP* (page 167)
- *NIS* (page 169)

It also supports *Kerberos Realms* (page 170), *Kerberos Keytabs* (page 171), and the ability to add more parameters to *Kerberos Settings* (page 172).

This section summarizes each of these services and their available configurations within the FreeNAS® GUI.

9.1 Active Directory

Active Directory (AD) is a service for sharing resources in a Windows network. AD can be configured on a Windows server that is running Windows Server 2000 or higher or on a Unix-like operating system that is running Samba version 4 (https://wiki.samba.org/index.php/Setting_up_Samba_as_an_Active_Directory_Domain_Controller#Provisioning_a_Samba_Active_Di
Since AD provides authentication and authorization services for the users in a network, it is not necessary to recreate these user accounts on the FreeNAS® system. Instead, configure the Active Directory service so that it can import the account information and imported users can be authorized to access the SMB shares on the FreeNAS® system.

Many changes and improvements have been made to Active Directory support within FreeNAS®. It is strongly recommended to update the system to the latest FreeNAS® 11.2 before attempting Active Directory integration.

Ensure name resolution is properly configured before configuring the Active Directory service. `ping` the domain name of the Active Directory domain controller from *Shell* (page 282) on the FreeNAS® system. If the `ping` fails, check the DNS server and default gateway settings in `Network → Global Configuration` on the FreeNAS® system.

Add a DNS record for the FreeNAS® system on the Windows server and verify the hostname of the FreeNAS® system can be pinged from the domain controller.

Active Directory relies on Kerberos, which is a time-sensitive protocol. The time on both the FreeNAS® system and the Active Directory Domain Controller cannot be out of sync by more than a few minutes. The best way to ensure the same time is running on both systems is to configure both systems to:

- use the same NTP server (set in `System → NTP Servers` on the FreeNAS® system)
- have the same timezone
- be set to either localtime or universal time at the BIOS level

Figure 9.1 shows the screen that appears when `Directory Service → Active Directory` is chosen. Table 9.1 describes the configurable options. Some settings are only available in Advanced Mode. To see these settings, either click *Advanced Mode* or configure the system to always display these settings by checking *Show advanced fields by default* in `System → Advanced`.

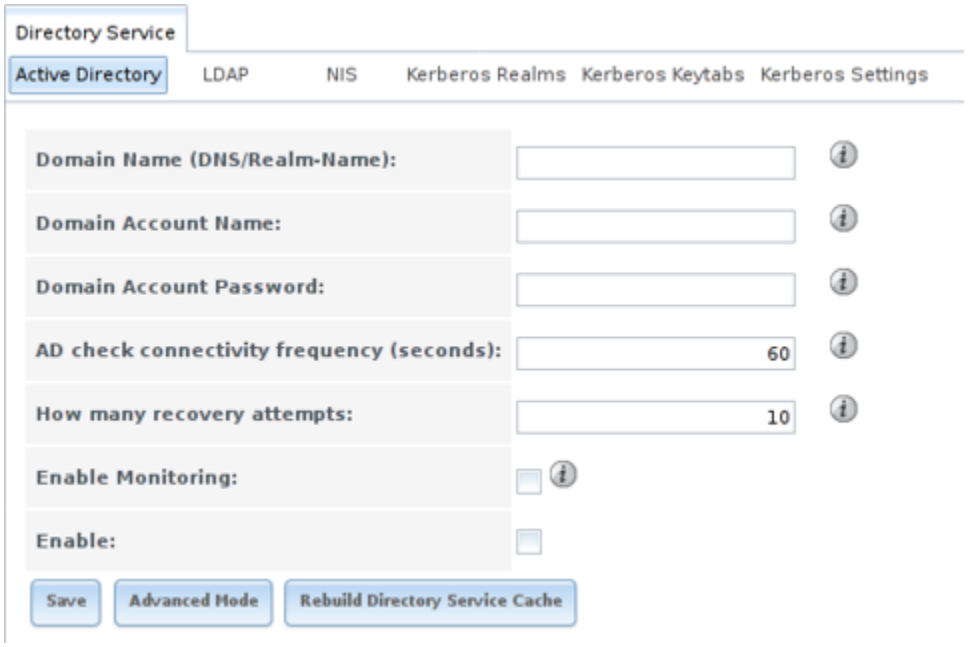


Fig. 9.1: Configuring Active Directory

Table 9.1: Active Directory Configuration Options

Setting	Value	Advanced Mode	Description
Domain Name (DNS/Realm-Name)	string		Name of Active Directory domain (*example.com*) or child domain (*sales.example.com*). This setting is mandatory and the GUI will refuse to save the settings if the domain controller for the specified domain cannot be found.
Domain Account Name	string		Name of the Active Directory administrator account. This setting is mandatory and the GUI will refuse to save the settings if it cannot connect to the domain controller using this account name.
Domain Account Password	string		Password for the Active Directory administrator account. This setting is mandatory and the GUI will refuse to save the settings if it cannot connect to the domain controller using this password
AD check connectivity frequency (seconds)	integer		How often to verify that Active Directory services are active.
How many recovery attempts	integer		Number of times to attempt reconnecting to the Active Directory server. Tries forever when set to *0*.
Enable Monitoring	checkbox		Restart Active Directory automatically if the service is disconnected.
Encryption Mode	drop-down menu	✓	Choices are *Off*, *SSL*, or *TLS*.
Certificate	drop-down menu	✓	Select the certificate of the Active Directory server if SSL connections are used. If a certificate does not exist yet, create a *CA* (page 79), then create a certificate on the Active Directory server and import it to the FreeNAS® system with *Certificates* (page 81).
Verbose logging	checkbox	✓	When checked, logs attempts to join the domain to `/var/log/messages`.

Continued on next page

Table 9.1 – continued from previous page

Setting	Value	Advanced Mode	Description
UNIX extensions	checkbox	✓	**Only** set if the AD server is explicitly configured to map permissions for UNIX users. Enabling provides persistent UIDs and GUIDs, otherwise, users/groups are mapped to the UID/GUID range configured in Samba.
Allow Trusted Domains	checkbox	✓	Only enable if the network has active domain/forest trusts (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2003/cc757352(v=ws.10)) and files need to be managed on multiple domains. Use with caution as it will generate more winbindd traffic, slowing down the ability to filter through user and group information.
Use Default Domain	checkbox	✓	Unset to prepend the domain name to the username. If *Allow Trusted Domains* is set and multiple domains use the same usernames, unset to prevent name collisions.
Allow DNS updates	checkbox	✓	Unset to disable Samba from doing DNS updates when joining a domain.
Disable Active Directory user/group cache	checkbox	✓	Set to disable caching of AD users and groups. This is useful if the system cannot bind to a domain with a large number of users or groups.
User Base	string	✓	Distinguished name (DN) of the user container in Active Directory.
Group Base	string	✓	Distinguished name (DN) of the group container in Active Directory.
Site Name	string	✓	The relative distinguished name of the site object in Active Directory.
Domain Controller	string	✓	Automatically be added to the SRV record for the domain and, when multiple controllers are specified, FreeNAS® selects the closest DC which responds. Uses the short form of the FQDN. An example is *sampleserver*.
Global Catalog Server	string	✓	If the hostname of the global catalog server to use is specified, make sure it is resolvable.
Kerberos Realm	drop-down menu	✓	Select the realm created using the instructions in *Kerberos Realms* (page 170).
Kerberos Principal	drop-down menu	✓	Browse to the location of the keytab created using the instructions in *Kerberos Keytabs* (page 171).
AD timeout	integer	✓	In seconds, increase if the AD service does not start after connecting to the domain.
DNS timeout	integer	✓	In seconds, increase if AD DNS queries timeout.
Idmap backend	drop-down menu and Edit	✓	Select the backend to use to map Windows security identifiers (SIDs) to UNIX UIDs and GIDs. See Table 9.2 for a summary of the available backends. Click the *Edit* link to configure the backend.
Windbind NSS Info	drop-down menu	✓	Defines the schema to use when querying AD for user/group info. *rfc2307* uses the RFC2307 schema support included in Windows 2003 R2, *sfu20* is for Services For Unix 3.0 or 3.5, and *sfu* is for Services For Unix 2.0.
SASL wrapping	drop-down menu	✓	Defines how LDAP traffic is transmitted. Choices are *plain* (plain text), *sign* (signed only), or *seal* (signed and encrypted). Windows 2000 SP3 and newer can be configured to enforce signed LDAP connections.
Enable	checkbox		Enable the Active Directory service.

Continued on next page

Table 9.1 – continued from previous page

Setting	Value	Advanced Mode	Description
NetBIOS name	string	✓	Limited to 15 characters. Automatically populated with the original hostname of the system. This **must** be different from the *Workgroup* name.
NetBIOS alias	string	✓	Limited to 15 characters.

Table 9.2 summarizes the backends which are available in the *Idmap backend* drop-down menu. Each backend has its own man page (http://samba.org.ru/samba/docs/man/manpages/) which gives implementation details. Since selecting the wrong backend will break Active Directory integration, a pop-up menu will appear whenever changes are made to this setting.

Table 9.2: ID Mapping Backends

Value	Description
ad	AD server uses RFC2307 or Services For Unix schema extensions. Mappings must be provided in advance by adding the uidNumber attributes for users and gidNumber attributes for groups in the AD.
autorid	Similar to *rid*, but automatically configures the range to be used for each domain, so there is no need to specify a specific range for each domain in the forest. The only needed configuration is the range of UID/GIDs to use for user/group mappings and an optional size for the ranges.
fruit	Generate IDs the way Apple Mac OS X does, so UID and GID can be identical on all FreeNAS® servers on the network. For use in *LDAP* (page 167) environments where Apple's Open Directory is the authoritative LDAP server.
ldap	Stores and retrieves mapping tables in an LDAP directory service. Default for LDAP directory service.
nss	Provides a simple means of ensuring that the SID for a Unix user is reported as the one assigned to the corresponding domain user.
rfc2307	An AD server is required to provide the mapping between the name and SID and an LDAP server is required to provide the mapping between the name and the UID/GID.
rid	Default for AD. Requires an explicit idmap configuration for each domain, using disjoint ranges where a writeable default idmap range is to be defined, using a backend like tdb or ldap.
script	Stores mapping tables for clustered environments in the winbind_cache tdb.
tdb	Default backend used by winbindd for storing mapping tables.
tdb2	Substitute for tdb used by winbindd in clustered environments.

Click *Rebuild Directory Service Cache* if a new Active Directory user needs immediate access to FreeNAS®. This occurs automatically once a day as a cron job.

Note: Active Directory places restrictions on which characters are allowed in Domain and NetBIOS names, a limits the length of those names to 15 characters. If there are problems connecting to the realm, verify (https://support.microsoft.com/en-us/help/909264/naming-conventions-in-active-directory-for-computers-domains-sites-and) the settings do not include any disallowed characters. The Administrator account password cannot contain the *$* character. If a *$* exists in the domain administrator's password, `kinit` will report a "Password Incorrect" error and `ldap_bind` will report an "Invalid credentials (49)" error.

It can take a few minutes after configuring the Active Directory service for the AD information to be populated to the FreeNAS® system. Once populated, the AD users and groups will be available in the drop-down menus of the *Permissions* screen of a volume/dataset. For performance reasons, every available user may not show in the listing. However, it will autocomplete all applicable users when typing in a username.

The Active Directory users and groups that are imported to the FreeNAS® system are shown by typing commands in the

FreeNAS® *Shell* (page 282):

- View users: `wbinfo -u`
- View groups: `wbinfo -g`

In addition, `wbinfo -t` tests the connection and, if successful, shows a message similar to:

```
checking the trust secret for domain YOURDOMAIN via RPC calls succeeded
```

To manually check that a specified user can authenticate, use `net ads join -S dcname -U username`.

`getent passwd` and `getent group` can provide more troubleshooting information if no users or groups are listed in the output.

Tip: Sometimes network users do not appear in the drop-down menu of a *Permissions* screen but the `wbinfo` commands display these users. This is typically due to the FreeNAS® system taking longer than the default ten seconds to join Active Directory. Increase the value of *AD timeout* to 60 seconds.

To change a certificate, set the *Encryption Mode* to *Off*, then disable AD by unchecking *Enable*. Click *Save*. Select the new *Certificate*, set the *Encryption Mode* as desired, check *Enable* to re-enable AD, and click *Save* to restart AD.

9.1.1 Troubleshooting Tips

When running AD in a 2003/2008 mixed domain, see this posting (https://forums.freenas.org/index.php?threads/2008r2-2003-mixed-domain.1931/) for instructions to prevent the secure channel key from becoming corrupt.

Active Directory uses DNS to determine the location of the domain controllers and global catalog servers in the network. Use `host -t srv _ldap._tcp.domainname.com` to determine the SRV records of the network and change the weight and/or priority of the SRV record to reflect the fastest server. More information about SRV records can be found in the Technet article How DNS Support for Active Directory Works (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2003/cc759550(v=ws.10)).

The realm used depends upon the priority in the SRV DNS record. DNS can override the system Active Directory settings. When unable to connect to the correct realm, check the SRV records on the DNS server.

If the cache becomes out of sync due to an AD server being taken off and back online, resync the cache using `Directory Service → Active Directory → Rebuild Directory Service Cache`.

An expired password for the administrator account will cause `kinit` to fail. Ensure the password is still valid. Also, double-check the password on the AD account being used does not include any spaces, special symbols, and is not unusually long.

If the Windows server version is lower than 2008 R2, try creating a *Computer* entry on the Windows server's OU. When creating this entry, enter the FreeNAS® hostname in the *name* field. Make sure it is under 15 characters, the same name as the one set in the *Hostname* field in `Network → Global Configuration`, and the same *NetBIOS Name* in `Directory Service → Active Directory` settings. Make sure the hostname of the domain controller is set in the *Domain Controller* field of `Directory Service → Active Directory`.

9.1.2 If the System Will not Join the Domain

If the system will not join the Active Directory domain, run these commands in the order listed. `echo` commands will return a value of *0* and `klist` will show a Kerberos ticket:

```
sqlite3 /data/freenas-v1.db "update directoryservice_activedirectory set ad_enable=1;"
echo $?
service ix-kerberos start
service ix-nsswitch start
service ix-kinit start
service ix-kinit status
```

```
echo $?
klist
```

If the cache becomes out of sync due to an AD server being taken off and back online, resync the cache using `Directory Service → Active Directory → Rebuild Directory Service Cache`.

Note: If any of the commands fail or result in a traceback, create a bug report at https://redmine.ixsystems.com/projects/freenas/issues that includes the commands in the order in which they were run and the exact wording of the error message or traceback.

Next, only run these two commands **if** *Unix extensions* is set in *Advanced Mode* and a keytab has been uploaded using *Kerberos Keytabs* (page 171):

```
service ix-sssd start
service sssd start
```

Finally, run these commands. `echo` returns a *0* unless something has gone wrong:

```
python /usr/local/www/freenasUI/middleware/notifier.py start cifs
service ix-activedirectory start
service ix-activedirectory status
echo $?
python /usr/local/www/freenasUI/middleware/notifier.py restart cifs
service ix-pam start
service ix-cache start &
```

9.2 LDAP

FreeNAS® includes an OpenLDAP (http://www.openldap.org/) client for accessing information from an LDAP server. An LDAP server provides directory services for finding network resources such as users and their associated permissions. Examples of LDAP servers include Microsoft Server (2000 and newer), Mac OS X Server, Novell eDirectory, and OpenLDAP running on a BSD or Linux system. If an LDAP server is running on the network, configure the FreeNAS® LDAP service so network users can authenticate to the LDAP server and have authorized access to the data stored on the FreeNAS® system.

Note: LDAP authentication for SMB shares is disabled unless the LDAP directory has been configured for and populated with Samba attributes. The most popular script for performing this task is smbldap-tools (https://wiki.samba.org/index.php/4.1_smbldap-tools). In addition, the LDAP server must support SSL/TLS and the certificate for the LDAP server CA must be imported with `System → Certificates → Import Certificate`. Note that non-CA certificates are not supported at this time.

Tip: Apple's Open Directory (https://manuals.info.apple.com/MANUALS/0/MA954/en_US/Open_Directory_Admin_v10.5_3rd_Ed.pdf) is an LDAP-compatible directory service into which FreeNAS® can be integrated. See FreeNAS with Open Directory in Mac OS X environments (https://forums.freenas.org/index.php?threads/howto-freenas-with-open-directory-in-mac-os-x-environments.46493/).

Figure 9.2 shows the LDAP Configuration screen that is seen after clicking `Directory Service → LDAP`.

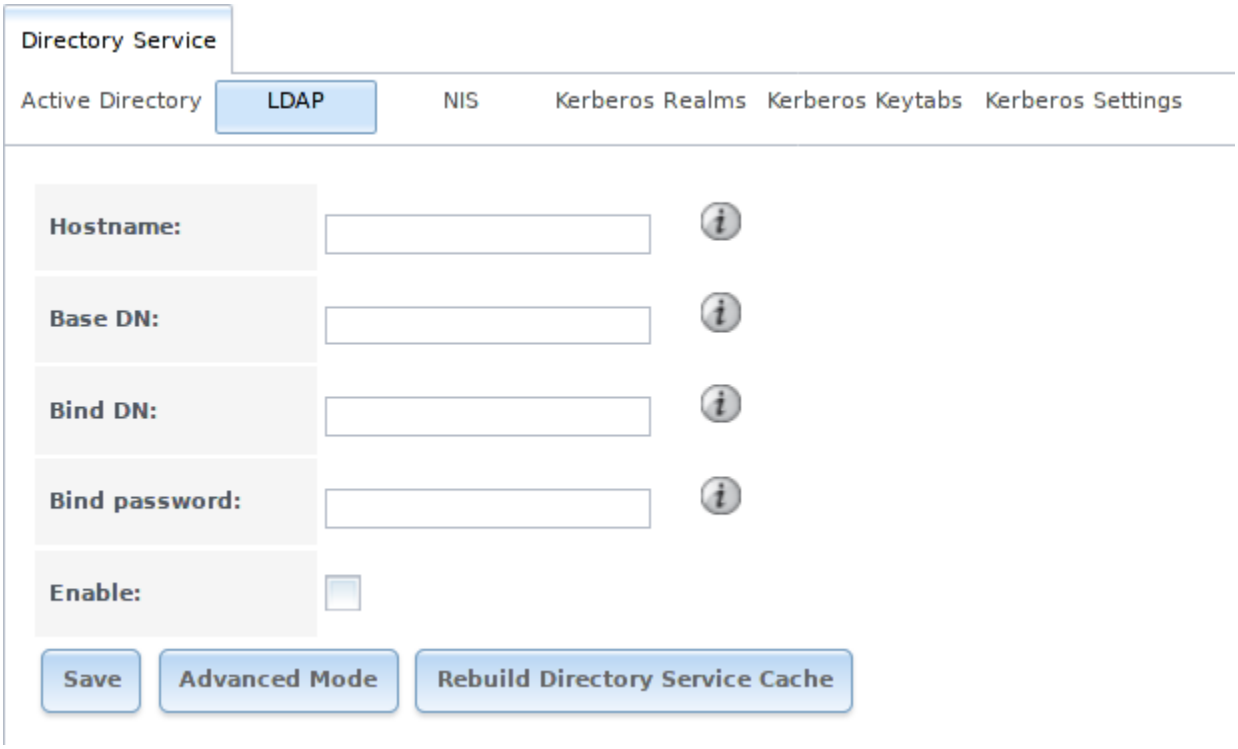


Fig. 9.2: Configuring LDAP

Table 9.3 summarizes the available configuration options. Some settings are only available in Advanced Mode. To see these settings, either click the *Advanced Mode* button or configure the system to always display these settings by checking the box *Show advanced fields by default* in `System → Advanced`.

Those new to LDAP terminology should read the OpenLDAP Software 2.4 Administrator's Guide (http://www.openldap.org/doc/admin24/).

Table 9.3: LDAP Configuration Options

Setting	Value	Advanced Mode	Description
Hostname	string		Hostname or IP address of the LDAP server.
Base DN	string		Top level of the LDAP directory tree to be used when searching for resources. Example: *dc=test,dc=org*.
Bind DN	string		Name of administrative account on the LDAP server. Example: *cn=Manager,dc=test,dc=org*.
Bind password	string		Password for *Root bind DN*.
Allow Anonymous Binding	checkbox	✓	Instructs the LDAP server to not provide authentication and to allow read and write access to any client.
User Suffix	string	✓	Optional. Can be added to the name when the user account is added to the LDAP directory. Example: dept. or company name.
Group Suffix	string	✓	Optional. Can be added to the name when the group is added to the LDAP directory. Example: dept. or company name.
Password Suffix	string	✓	Optional. Can be added to the password when the password is added to LDAP directory.
Machine Suffix	string	✓	Optional. Can be added to the name when the system added to the LDAP directory. Example: server, accounting.
SUDO Suffix	string	✓	Use if LDAP-based users need superuser access.

Continued on next page

Table 9.3 – continued from previous page

Setting	Value	Advanced Mode	Description
Kerberos Realm	drop-down menu	✓	Select the realm created using the instructions in *Kerberos Realms* (page 170).
Kerberos Principal	drop-down menu	✓	Browse to the location of the principal in the keytab created as described in *Kerberos Keytabs* (page 171).
Encryption Mode	drop-down menu	✓	Choices are *Off*, *SSL*, or *TLS*. Note that either *SSL* or *TLS* and a *Certificate* must be selected in order for authentication to work.
Certificate	drop-down menu	✓	Select the certificate of the LDAP CA (required if authentication is used). The certificate for the LDAP server CA must first be imported with `System → Certificates → Import Certificate`.
LDAP timeout	integer	✓	Increase this value (in seconds) if obtaining a Kerberos ticket times out.
DNS timeout	integer	✓	Increase this value (in seconds) if DNS queries timeout.
Idmap backend	drop-down menu and Edit	✓	Select the backend to use to map Windows security identifiers (SIDs) to UNIX UIDs and GIDs. See Table 9.2 for a summary of the available backends. Click the *Edit* link to configure the selected backend.
Samba Schema	checkbox	✓	Set if LDAP authentication for SMB shares is needed **and** the LDAP server is **already** configured with Samba attributes.
Auxiliary Parameters	string	✓	Additional options for sssd.conf(5) (https://jhrozek.fedorapeople.org/sssd/1.11.6/man/sssd.conf.5.html).
Schema	drop-down menu	✓	If *Samba Schema* is set, select the schema to use. Choices are *rfc2307* and *rfc2307bis*.
Enable	checkbox		Unset to disable the configuration without deleting it.
NetBIOS Name	string	✓	Limited to 15 characters. Automatically populated with the original hostname of the system. This **must** be different from the *Workgroup* name
NetBIOS Alias	string	✓	Limited to 15 characters.

Click the *Rebuild Directory Service Cache* button after adding a user to LDAP who needs immediate access to FreeNAS®. Otherwise this occurs automatically once a day as a cron job.

Note: FreeNAS® automatically appends the root DN. This means the scope and root DN are not to be included when configuring the user, group, password, and machine suffixes.

LDAP users and groups appear in the drop-down menus of the guilabel:*Permissions* screen of a dataset after configuring the LDAP service. Type `getent passwd` from *Shell* (page 282) to verify the users have been imported. Type `getent group` to verify the groups have been imported.

If the users and groups are not listed, refer to Common errors encountered when using OpenLDAP Software (http://www.openldap.org/doc/admin24/appendix-common-errors.html) for common errors and how to fix them. When troubleshooting LDAP, open *Shell* (page 282) and look for error messages in `/var/log/auth.log`.

9.3 NIS

The Network Information Service (NIS) maintains and distributes a central directory of Unix user and group information, hostnames, email aliases, and other text-based tables of information. If an NIS server is running on the network, the FreeNAS® system can be configured to import the users and groups from the NIS directory.

Note: In Windows Server 2016, Microsoft removed the Identity Management for Unix (IDMU) and NIS Server Role. See

Clarification regarding the status of Identity Management for Unix (IDMU) & NIS Server Role in Windows Server 2016 Technical Preview and beyond (https://blogs.technet.microsoft.com/activedirectoryua/2016/02/09/identity-management-for-unix-idmu-is-deprecated-in-windows-server/).

Figure 9.3 shows the configuration screen which opens after navigating `Directory Service → NIS`. Table 9.4 summarizes the configuration options.

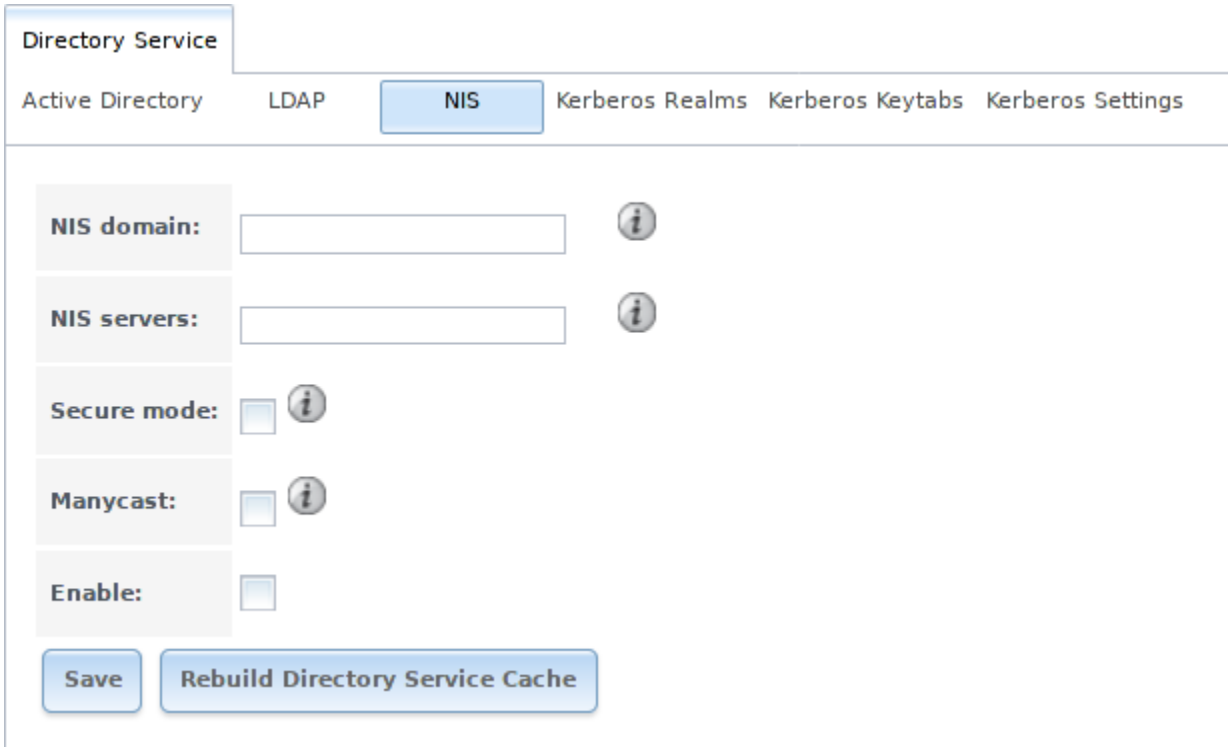


Fig. 9.3: NIS Configuration

Table 9.4: NIS Configuration Options

Setting	Value	Description
NIS domain	string	Name of NIS domain.
NIS servers	string	Comma-delimited list of hostnames or IP addresses.
Secure mode	checkbox	If set, ypbind(8) (https://www.freebsd.org/cgi/man.cgi?query=ypbind) will refuse to bind to any NIS server that is not running as root on a TCP port number over 1024.
Manycast	checkbox	If set, `ypbind` will bind to the server that responds the fastest. This is useful when no local NIS server is available on the same subnet
Enable	checkbox	Unset to disable the configuration without deleting it.

Click the *Rebuild Directory Service Cache* button after adding a user to NIS who needs immediate access to FreeNAS®. Otherwise this occurs automatically once a day as a cron job.

9.4 Kerberos Realms

A default Kerberos realm is created for the local system in FreeNAS®. `Directory Service → Kerberos Realms` can be used to view and add Kerberos realms. If the network contains a KDC, click *Add kerberos realm* to add the realm. This configuration screen is shown in Figure 9.4.

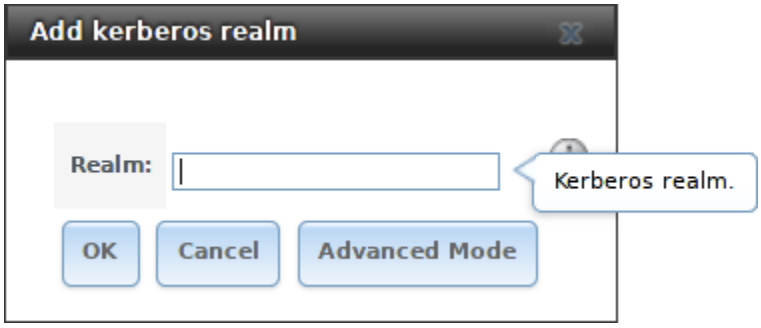


Fig. 9.4: Adding a Kerberos Realm

Table 9.5 summarizes the configurable options. Some settings are only available in Advanced Mode. To see these settings, either click *Advanced Mode* or configure the system to always display these settings by checking the box *Show advanced fields by default* in `System → Advanced`.

Table 9.5: Kerberos Realm Options

Setting	Value	Advanced Mode	Description
Realm	string		Mandatory. Name of the realm.
KDC	string	✓	Name of the Key Distribution Center.
Admin Server	string	✓	Server where all changes to the database are performed.
Password Server	string	✓	Server where all password changes are performed.

9.5 Kerberos Keytabs

Kerberos keytabs are used to do Active Directory or LDAP joins without a password. This means the password for the Active Directory or LDAP administrator account does not need to be saved into the FreeNAS® configuration database, which is a security risk in some environments.

When using a keytab, it is recommended to create and use a less privileged account for performing the required queries as the password for that account will be stored in the FreeNAS® configuration database. To create the keytab on a Windows system, use the ktpass (https://docs.microsoft.com/en-us/windows-server/administration/windows-commands/ktpass) command:

```
ktpass.exe /out freenas.keytab /princ http/useraccount@EXAMPLE.COM /mapuser useraccount /ptype KRB5_NT_
↪PRINCIPAL /crypto ALL /pass userpass
```

where:

- `freenas.keytab` is the file to upload to the FreeNAS® server.
- `useraccount` is the name of the user account for the FreeNAS® server generated in Active Directory Users and Computers (https://technet.microsoft.com/en-us/library/aa998508(v=exchg.65).aspx).
- `http/useraccount@EXAMPLE.COM` is the principal name written in the format *host/user.account@KERBEROS.REALM*. By convention, the kerberos realm is written in all caps, but make sure the case used for the *Kerberos Realm* (page 170) matches the realm name. See this note (https://docs.microsoft.com/en-us/windows-server/administration/windows-commands/ktpass#BKMK_remarks) about using `/princ` for more details.
- `userpass` is the password associated with `useraccount`.

Setting `/crypto` to *ALL* allows using all supported cryptographic types. These keys can be specified instead of *ALL*:

- *DES-CBC-CRC* is used for compatibility.

- *DES-CBC-MD5* adheres more closely to the MIT implementation and is used for compatibility.
- *RC4-HMAC-NT* uses 128-bit encryption.
- *AES256-SHA1* uses AES256-CTS-HMAC-SHA1-96 encryption.
- *AES128-SHA1* uses AES128-CTS-HMAC-SHA1-96 encryption.

This will create a keytab with sufficient privileges to grant tickets.

After the keytab is generated, use `Directory Service → Kerberos Keytabs → Add kerberos keytab` to add it to the FreeNAS® system.

To instruct the Active Directory service to use the keytab, select the installed keytab using the drop-down *Kerberos keytab* menu in `Directory Service → Active Directory`. When using a keytab with Active Directory, make sure that the "username" and "userpass" in the keytab matches the "Domain Account Name" and "Domain Account Password" fields in `Directory Service → Active Directory`.

To instruct LDAP to use a principal from the keytab, select the principal from the drop-down *Kerberos Principal* menu in `Directory Service → LDAP`.

9.6 Kerberos Settings

To configure additional Kerberos parameters, use `Directory Service → Kerberos Settings`. Figure 9.5 shows the fields available:

- **Appdefaults auxiliary parameters:** contains settings used by some Kerberos applications. The available settings and their syntax are listed in the [appdefaults] section of krb.conf(5) (http://web.mit.edu/kerberos/krb5-1.12/doc/admin/conf_files/krb5_conf.html#appdefaults).
- **Libdefaults auxiliary parameters:** contains settings used by the Kerberos library. The available settings and their syntax are listed in the [libdefaults] section of krb.conf(5) (http://web.mit.edu/kerberos/krb5-1.12/doc/admin/conf_files/krb5_conf.html#libdefaults).

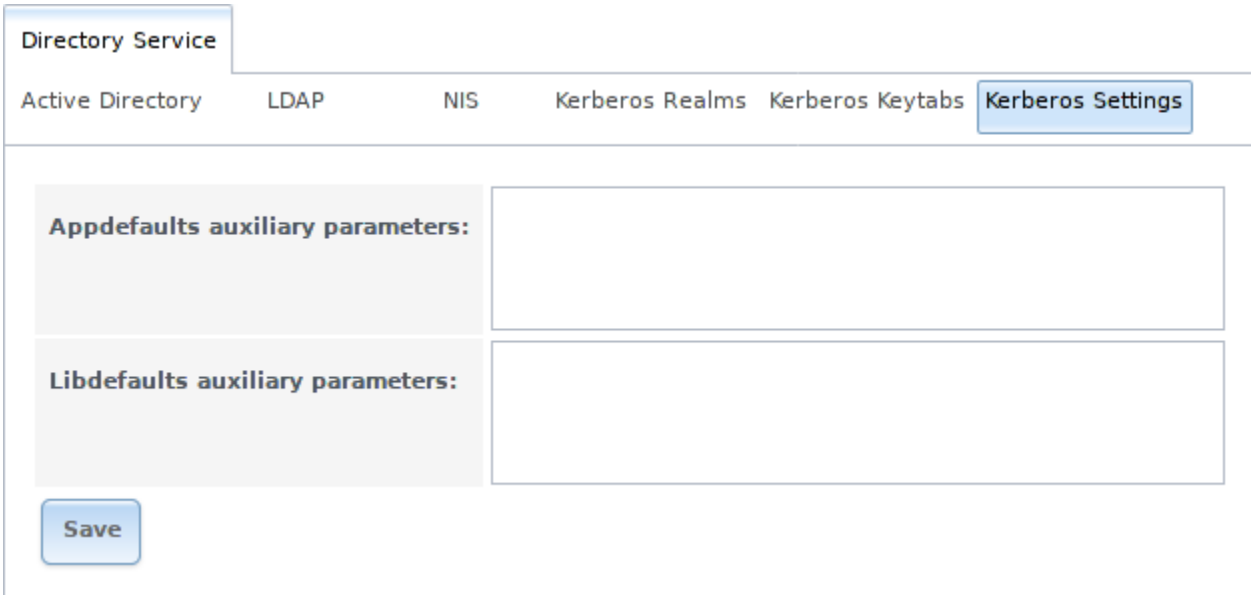


Fig. 9.5: Additional Kerberos Settings

CHAPTER

TEN

SHARING

Shares are created to make part or all of a volume accessible to other computers on the network. The type of share to create depends on factors like which operating systems are being used by computers on the network, security requirements, and expectations for network transfer speeds.

FreeNAS® provides a *Wizard* (page 274) for creating shares. The *Wizard* (page 274) automatically creates the correct type of dataset and permissions for the type of share, sets the default permissions for the share type, and starts the service needed by the share. It is recommended to use the Wizard to create shares, fine-tune the share settings using the instructions in the rest of this chapter if needed, then fine-tune the default permissions from the client operating system to meet the requirements of the network.

Note: Shares are created to provide and control access to an area of storage. Before creating shares, making a list of the users that need access to storage data, which operating systems these users are using, whether all users should have the same permissions to the stored data, and whether these users should authenticate before accessing the data is recommended. This information can help determine which type of shares are needed, whether multiple datasets are needed to divide the storage into areas with different access and permissions, and how complex it will be to set up those permission requirements. Note that shares are used to provide access to data. When a share is deleted, it removes access to data but does not delete the data itself.

These types of shares and services are available:

- *AFP* (page 174): Apple File Protocol shares are often used when the client computers all run macOS. Apple has slowly shifted to preferring *SMB* (page 189) for modern networks, although Time Machine still requires AFP.
- *Unix (NFS)* (page 181): Network File System shares are accessible from Mac OS X, Linux, BSD, and the professional and enterprise versions (but not the home editions) of Windows. This can be are a good choice when the client computers do not all run the same operating system but NFS client software is available for all of them.
- *WebDAV* (page 188): WebDAV shares are accessible using an authenticated web browser (read-only) or WebDAV client (https://en.wikipedia.org/wiki/WebDAV#Client_support) running on any operating system.
- *SMB* (page 189): Server Message Block shares, also known as Common Internet File System (CIFS) shares, are accessible by Windows, Mac OS X, Linux, and BSD computers. Access is slower than an NFS share due to the single-threaded design of Samba. SMB provides more configuration options than NFS and is a good choice on a network for Windows systems. However, it is a poor choice if the CPU on the FreeNAS® system is limited; if the CPU is maxed out, upgrade the CPU or consider another type of share.
- *Block (iSCSI)* (page 199): block or iSCSI shares appear as an unformatted disk to clients running iSCSI initiator software or a virtualization solution such as VMware. These are usually used as virtual drives.

Fast access from any operating system can be obtained by configuring the *FTP* (page 220) service instead of a share and using a cross-platform FTP file manager application such as Filezilla (https://filezilla-project.org/). Secure FTP can be configured if the data needs to be encrypted.

When data security is a concern and the network users are familiar with SSH command line utilities or WinSCP (https://winscp.net/eng/index.php), consider using the *SSH* (page 240) service instead of a share. It is slower than unencrypted FTP due to the encryption overhead, but the data passing through the network is encrypted.

Note: It is generally a mistake to share a volume or dataset with more than one share type or access method. Different types of shares and services use different file locking methods. For example, if the same volume is configured to use both NFS and FTP, NFS will lock a file for editing by an NFS user, but an FTP user can simultaneously edit or delete that file. This results in lost edits and confused users. Another example: if a volume is configured for both AFP and SMB, Windows users can be confused by the "extra" filenames used by Mac files and delete them. This corrupts the files on the AFP share. Pick the one type of share or service that makes the most sense for the types of clients accessing that volume, and use that single type of share or service. To support multiple types of shares, divide the volume into datasets and use one dataset per share.

This section demonstrates configuration and fine-tuning of AFP, NFS, SMB, WebDAV, and iSCSI shares. FTP and SSH configurations are described in *Services* (page 214).

10.1 Apple (AFP) Shares

FreeNAS® uses the Netatalk (http://netatalk.sourceforge.net/) AFP server to share data with Apple systems. This section describes the configuration screen for fine-tuning AFP shares created using the *Wizard* (page 274). It then provides configuration examples for using the *Wizard* (page 274) to create a guest share, configuring Time Machine to back up to a dataset on the FreeNAS® system, and for connecting to the share from a macOS client.

To view the AFP share created by the Wizard, click `Sharing → Apple (AFP)` and highlight the name of the share. Click its *Edit* button to see the configuration options shown in Figure 10.1. The values showing for these options will vary, depending upon the information given when the share was created.

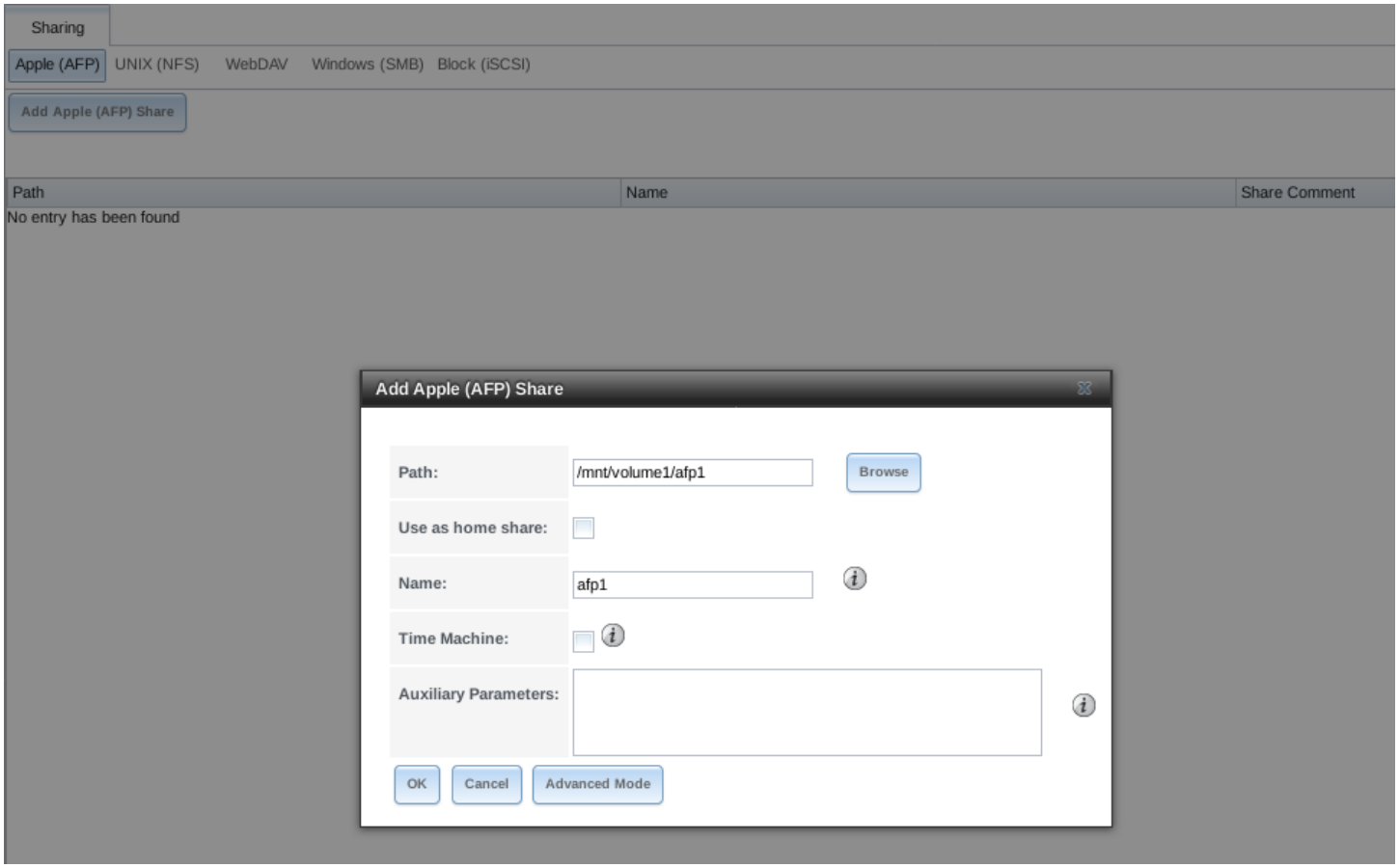


Fig. 10.1: Creating an AFP Share

Note: Table 10.1 summarizes the options available to fine-tune an AFP share. Leaving these options at the default settings is recommended as changing them can cause unexpected behavior. Most settings are only available with *Advanced Mode*. Do **not** change an advanced option without fully understanding the function of that option. Refer to Setting up Netatalk (http://netatalk.sourceforge.net/2.2/htmldocs/configuration.html) for a more detailed explanation of these options.

Table 10.1: AFP Share Configuration Options

Setting	Value	Advanced Mode	Description
Path	browse button		*Browse* to the volume/dataset to share. Do not nest additional volumes, datasets, or symbolic links beneath this path because Netatalk does not fully support that.
Use as home share	checkbox		Set to allow the share to host user home directories. Only one share can be used as the home share.
Name	string		Enter the volume name that appears in in macOS after selecting `Go → Connect to server` in the Finder menu. Limited to 27 characters and cannot contain a period.
Share Comment	string	✓	Enter an optional comment.
Allow List	string	✓	Comma-delimited list of allowed users and/or groups where groupname begins with a `@`. Note that adding an entry will deny any user/group that is not specified.
Deny List	string	✓	Comma-delimited list of denied users and/or groups where groupname begins with a `@`. Note that adding an entry will allow all users/groups that are not specified.
Read-only Access	string	✓	Comma-delimited list of users and/or groups who only have read access where groupname begins with a `@`.
Read-write Access	string	✓	Comma-delimited list of users and/or groups who have read and write access where groupname begins with a `@`.
Time Machine	checkbox		Set to advertise FreeNAS® as a Time Machine disk so it can be found by Macs. Setting multiple shares for Time Machine use is not recommended. When multiple Macs share the same pool, low diskspace issues and intermittently failed backups can occur.
Zero Device Numbers	checkbox	✓	Enable when the device number is not constant across a reboot.
No Stat	checkbox	✓	If enabled, AFP does not stat the volume path when enumerating the volumes list. Useful for automounting or volumes created by a preexec script.
AFP3 UNIX Privs	checkbox	✓	Set to enable Unix privileges supported by OSX 10.5 and higher. Do not enable this if the network contains macOS 10.4 clients or lower as they do not support this feature.
Default file permission	checkboxes	✓	Only works with Unix ACLs. New files created on the share are set with the selected permissions.
Default directory permission	checkboxes	✓	Only works with Unix ACLs. New directories created on the share are set with the selected permissions.
Default umask	integer	✓	Umask is used for newly created files. Default is *000* (anyone can read, write, and execute).
Hosts Allow	string	✓	Enter a list of allowed hostnames or IP addresses. Separate entries with a comma, space, or tab.
Hosts Deny	string	✓	Enter a list of denied hostnames or IP addresses. Separate entries with a comma, space, or tab.
Auxiliary Parameters	string		Additional afp.conf (http://netatalk.sourceforge.net/3.1/htmldocs/afp.conf.5.html) parameters not covered by other option fields.

10.1.1 Creating AFP Guest Shares

AFP supports guest logins, meaning that macOS users can access the AFP share without requiring their user accounts to first be created on or imported into the FreeNAS® system.

Note: When a guest share is created along with a share that requires authentication, AFP only maps users who log in as *guest* to the guest share. If a user logs in to the share that requires authentication, permissions on the guest share can prevent that user from writing to the guest share. The only way to allow both guest and authenticated users to write to a guest share is to set the permissions on the guest share to *777* or to add the authenticated users to a guest group and set the permissions to *77x*.

Before creating a guest share, go to `Services` → `AFP` and make sure that the *Guest Access* option is enabled.

To create the AFP guest share, click *Wizard*, then click the *Next* button twice to display the screen shown in Figure 10.2. Complete these fields in this screen:

1. **Share name:** enter a name for the share that is identifiable but less than 27 characters long. This name cannot contain a period. In this example, the share is named *afp_guest*.
2. Click the button for *Mac OS X (AFP)*.
3. Click the *Ownership* button. Click the drop-down *User* menu and select *nobody*. Click the *Return* button to return to the previous screen.
4. Click the *Add* button. **The share is not created until the button is clicked**. Clicking the *Add* button adds an entry to the *Name* frame with the name that was entered in *Share name*.

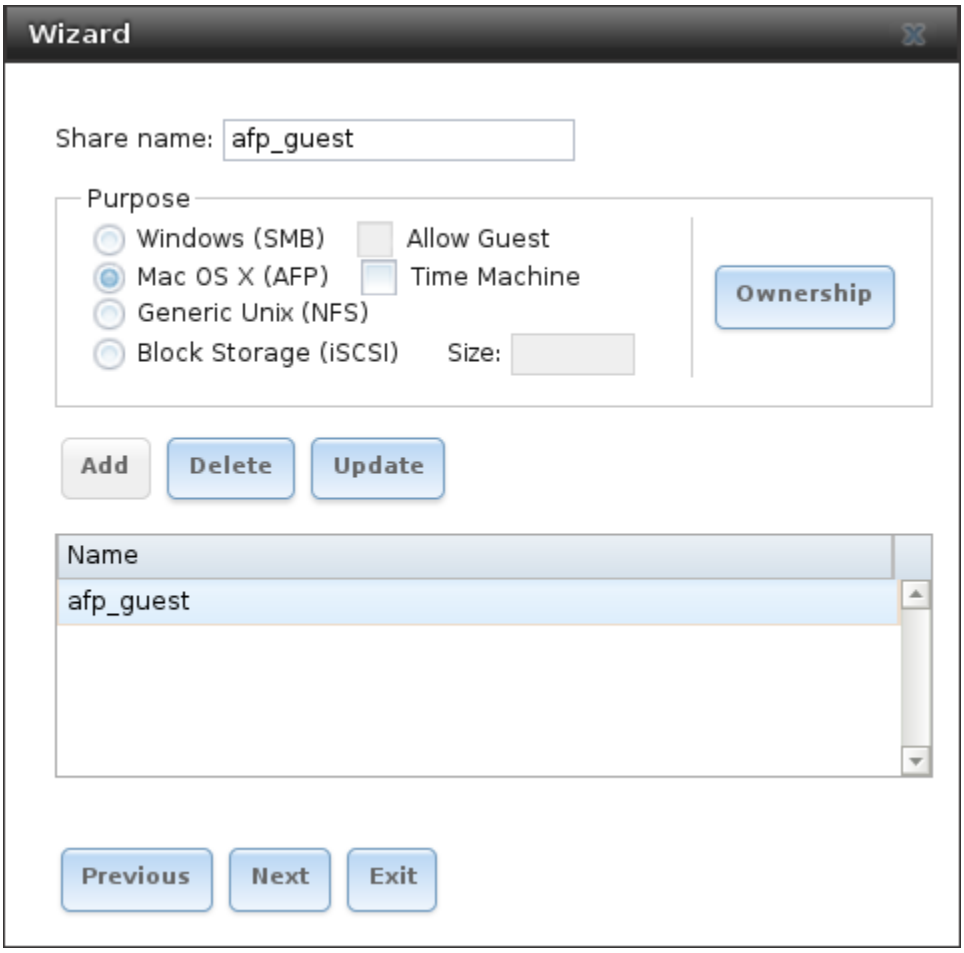


Fig. 10.2: Creating a Guest AFP Share

Click the *Next* button twice, then the *Confirm* button to create the share. The Wizard automatically creates a dataset for the share that contains the correct default permissions and starts the AFP service so the share is immediately available. The new share is also added as an entry to `Sharing → Apple (AFP)`.

macOS users can connect to the guest AFP share by navigating `Go → Connect to Server`. In the example shown in Figure 10.3, the user entered *afp://* followed by the IP address of the FreeNAS® system.

Click the *Connect* button. Once connected, Finder opens automatically. The name of the AFP share is displayed in the SHARED section in the left frame and the contents of any data saved in the share is displayed in the right frame.

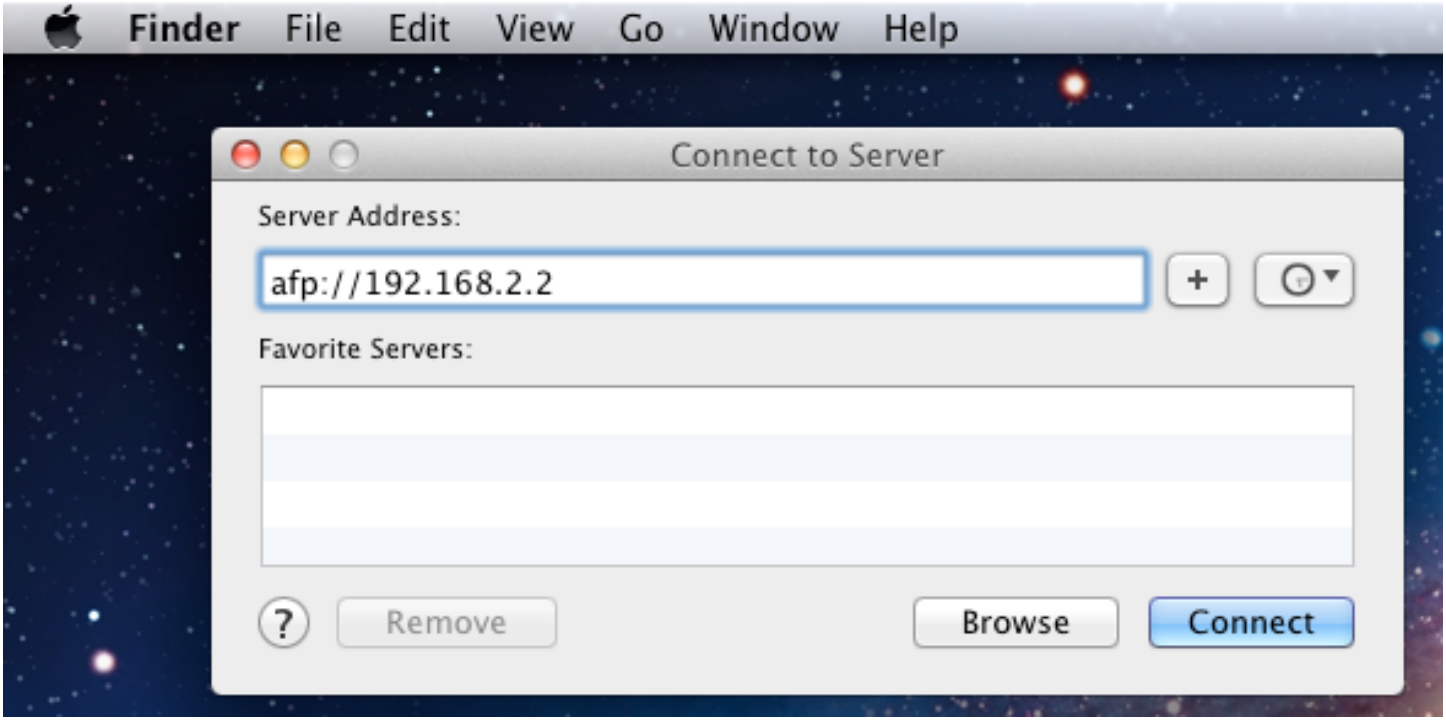


Fig. 10.3: Connect to Server Dialogue

To disconnect from the volume, click the *eject* button in the *Shared* sidebar.

10.1.2 Creating Authenticated and Time Machine Shares

macOS includes the Time Machine application which can be used to schedule automatic backups. In this configuration example, a Time Machine user will be configured to backup to an AFP share on a FreeNAS® system. Creating a separate Time Machine share for each user that will be using Time Machine to backup their macOS system to FreeNAS® is recommended. The process for creating an authenticated share for a user is the same as creating a Time Machine share for that user.

To use the Wizard to create an authenticated or Time Machine share, enter the following information, as seen in the example in Figure 10.4.

1. **Share name:** enter a name for the share that is identifiable but less than 27 characters long. The name cannot contain a period. In this example, the share is named *backup_user1*.
2. Click the button for *Mac OS X (AFP)* and enable the *Time Machine* option.
3. Click the *Ownership* button. If the user already exists on the FreeNAS® system, click the drop-down *User* menu to select their user account. If the user does not yet exist on the FreeNAS® system, type their name into the *User* field and enable the *Create User* option. If the user will be a member of a group that already exists on the FreeNAS® system, click the drop-down *Group* menu to select the group name. To create a new group to be used by Time Machine users, enter the name in the *Group* field and set the *Create Group* option. Otherwise, enter the same name as the user. In the example shown in Figure 10.5, both a new *user1* user and a new *tm_backups* group will be created. Since a new user

is being created, this screen prompts for the user password to be used when accessing the share. It also provides an opportunity to change the default permissions on the share. When finished, click *Return* to return to the screen shown in Figure 10.4.

4. Click the *Add* button. **Remember to do this or the share will not be created**. Clicking the *Add* button adds an entry to the *Name* frame with the name that was entered in *Share name*.

To configure multiple authenticated or Time Machine shares, repeat for each user, giving each user their own *Share name* and *Ownership*. When finished, click the *Next* button twice, then the *Confirm* button to create the shares. The Wizard automatically creates a dataset for each share with the correct ownership and starts the AFP service so the shares are immediately available. The new shares will appear in `Sharing → Apple (AFP)`.

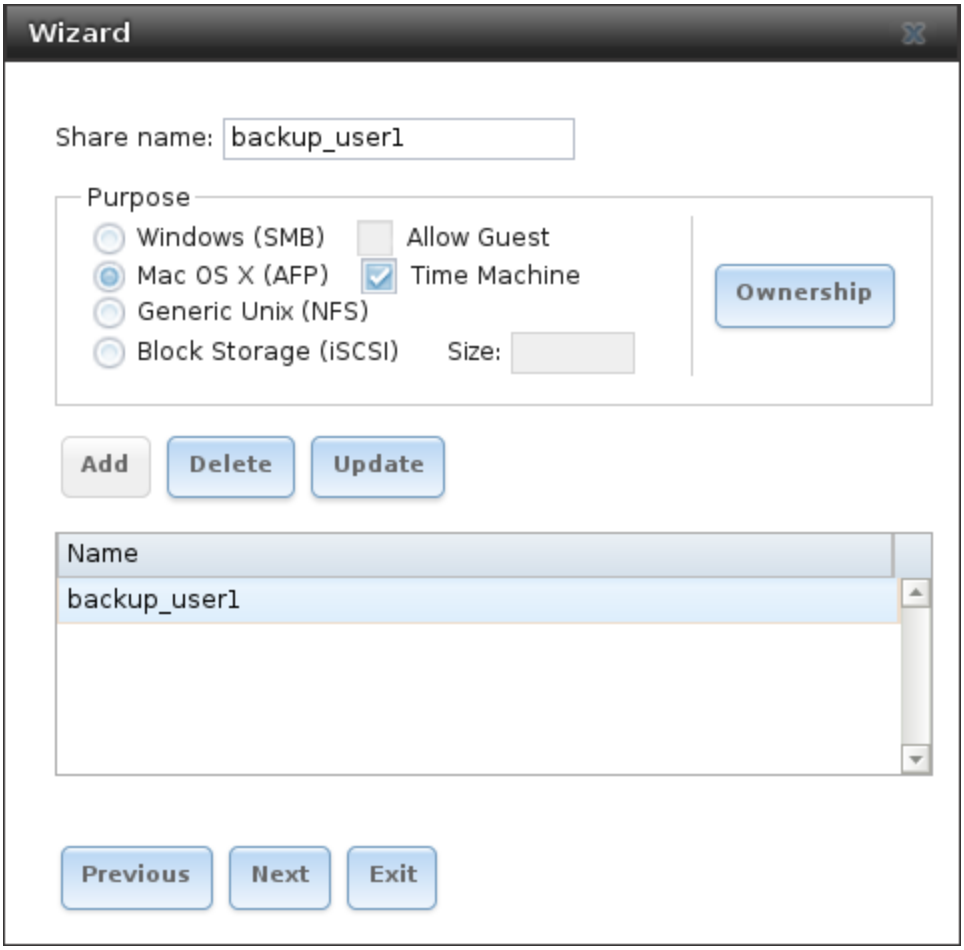


Fig. 10.4: Creating a Time Machine Share

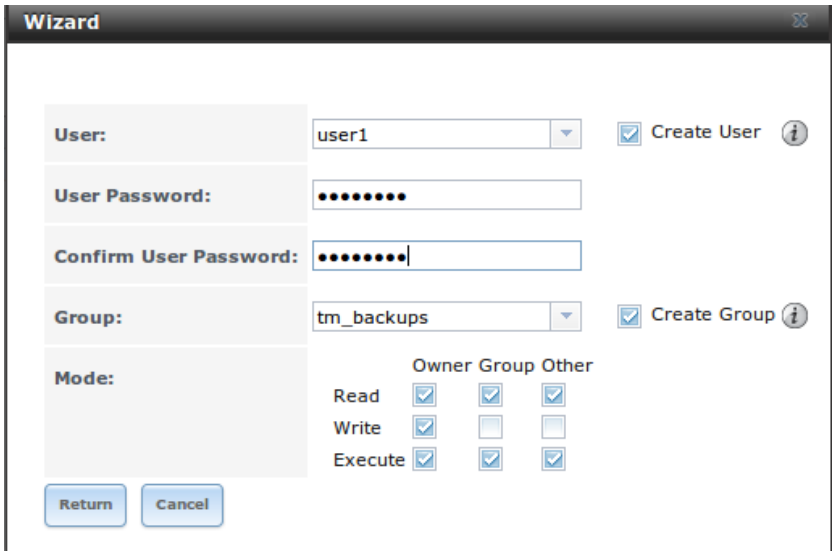


Fig. 10.5: Creating an Authenticated User

At this point, it may be desirable to configure a quota for each Time Machine share, to restrict backups from using all of the available space on the FreeNAS® system. The first time Time Machine makes a backup, it will create a full backup after waiting two minutes. It will then create a one hour incremental backup for the next 24 hours, and then one backup each day, each week and each month. **Since the oldest backups are deleted when a Time Machine share becomes full, make sure that the quota size is sufficient to hold the desired number of backups.** Note that a default installation of macOS is ~21 GB in size.

To configure a quota, go to `Storage → Volumes` and highlight the entry for the share. In the example shown in Figure 10.6, the Time Machine share name is *backup_user1*. Click the *Edit Options* button for the share, then *Advanced Mode*. Enter a value in the *Quota for this dataset* field, then click *Edit Dataset* to save the change. In this example, the Time Machine share is restricted to 200 GB.

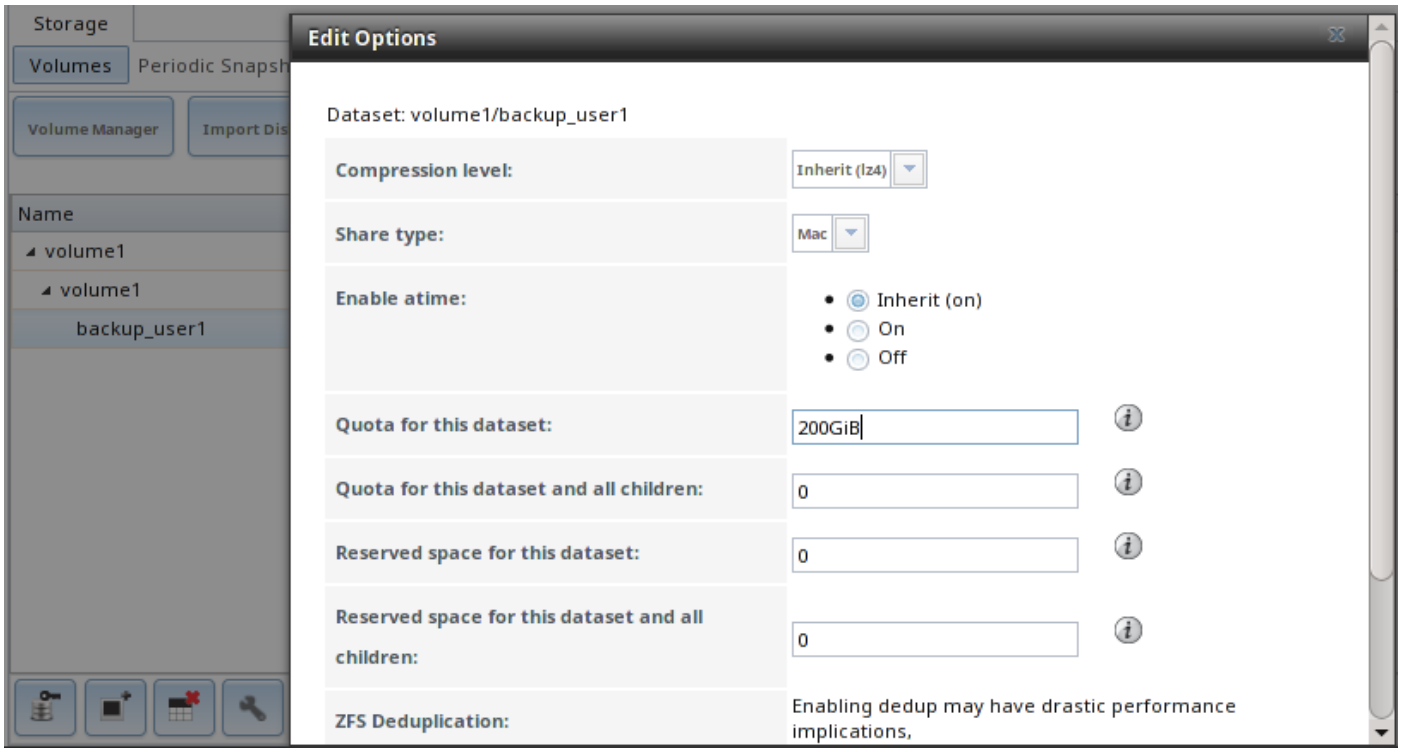


Fig. 10.6: Setting a Quota

Note: An alternative is to create a global quota using the instructions in Set up Time Machine for multiple machines with OSX Server-Style Quotas (https://forums.freenas.org/index.php?threads/how-to-set-up-time-machine-for-multiple-machines-with-osx-server-style-quotas.47173/).

To configure Time Machine on the macOS client, go to `System Preferences → Time Machine` which opens the screen shown in Figure 10.7. Click *ON* and a pop-up menu shows the FreeNAS® system as a backup option. In this example, it is listed as *backup_user1 on "freenas"*. Highlight the FreeNAS® system and click *Use Backup Disk*. A connection bar opens and prompts for the user account's password–in this example, the password that was set for the *user1* account.

Fig. 10.7: Configuring Time Machine on Mac OS X Lion

If *Time Machine could not complete the backup. The backup disk image could not be created (error 45)* is shown when backing up to the FreeNAS® system, a sparsebundle image must be created using these instructions (https://community.netgear.com/t5/Stora-Legacy/Solution-to-quot-Time-Machine-could-not-complete-the-backup/td-p/294697).

If *Time Machine completed a verification of your backups. To improve reliability, Time Machine must create a new backup for you.* is shown, follow the instructions in this post (http://www.garth.org/archives/2011,08,27,169,fix-time-machine-sparsebundle-nas-based-backup-errors.html) to avoid making another backup or losing past backups.

10.2 Unix (NFS) Shares

FreeNAS® supports sharing over the Network File System (NFS). Clients use the `mount` command to mount the share. Once mounted, the NFS share appears as just another directory on the client system. Some Linux distros require the installation of additional software in order to mount an NFS share. On Windows systems, enable Services for NFS in the Ultimate or Enterprise editions or install an NFS client application.

Note: For performance reasons, iSCSI is preferred to NFS shares when FreeNAS® is installed on ESXi.

To create an NFS share using the *Wizard* (page 274), click the *Next* button twice to display the screen shown in Figure 10.8. Enter a *Share name*. Spaces are not allowed in these names. Click the button for *Generic Unix (NFS)*, then click *Add* so the share name appears in the *Name* frame. When finished, click the *Next* button twice, then the *Confirm* button to create the

share. Creating an NFS share using the wizard automatically creates a new dataset for the share, starts the services required for NFS, and adds an entry in `Sharing → Unix (NFS) Shares`. Depending on the requirements, the IP addresses that are allowed to access the NFS share can be restricted, or the permissions adjusted.

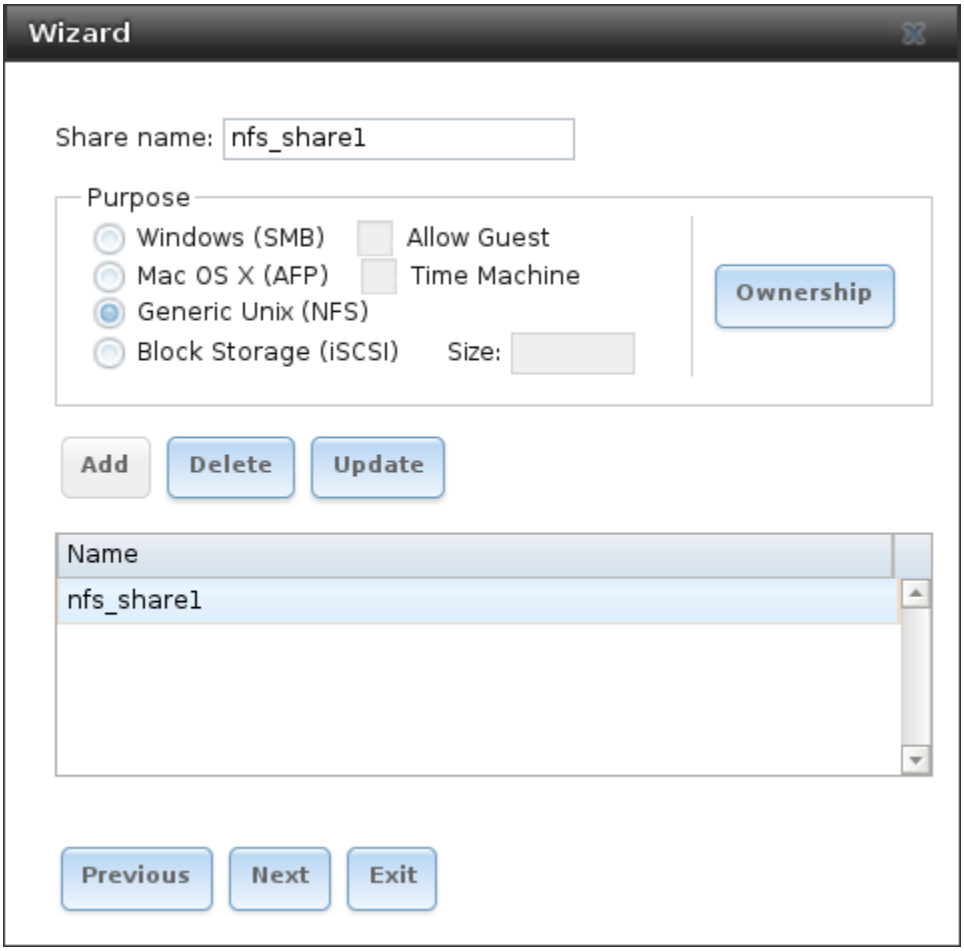


Fig. 10.8: NFS Share Wizard

NFS shares are edited by clicking `Sharing → Unix (NFS)`, highlighting the entry for the share, and clicking the *Edit* button. In the example shown in Figure 10.9, the configuration screen is open for the *nfs_share1* share.

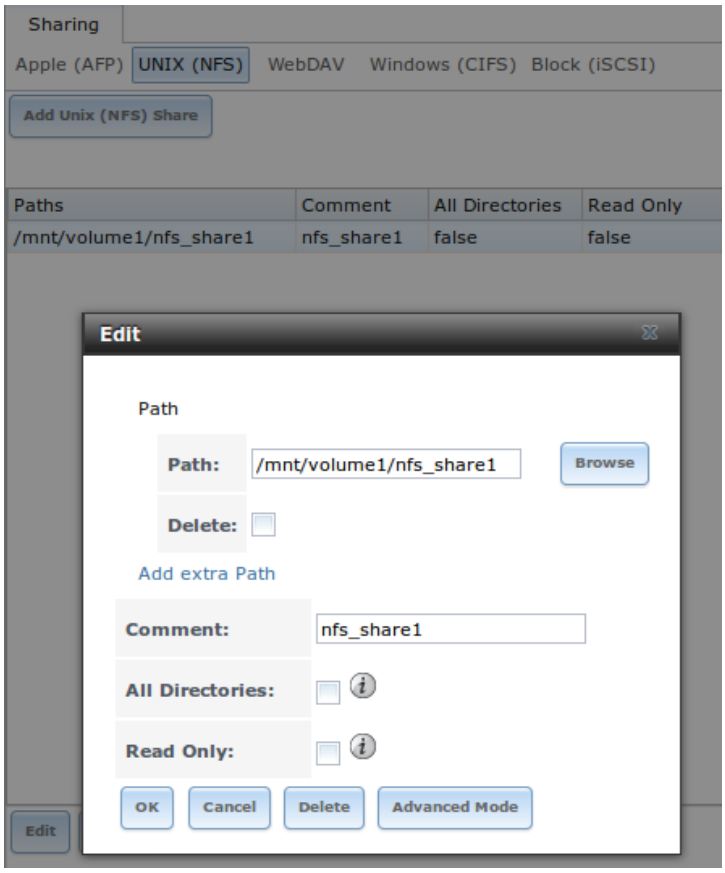


Fig. 10.9: NFS Share Settings

Table 10.2 summarizes the available configuration options in this screen. Some settings are only available by clicking the *Advanced Mode* button.

Table 10.2: NFS Share Options

Setting	Value	Advanced Mode	Description
Path	browse button		*Browse* to the volume or dataset to be shared. Click *Add extra path* to select multiple paths.
Comment	string		Set the share name. If left empty, share name is the list of selected *Path* entries.
Authorized networks	string	✓	Space-delimited list of allowed networks in network/mask CIDR notation. Example: *1.2.3.0/24*. Leave empty to allow all.
Authorized IP addresses or hosts	string	✓	Space-delimited list of allowed IP addresses or hostnames. Leave empty to allow all.
All directories	checkbox		Set to allow the client to mount any subdirectory within the *Path*.
Read only	checkbox		Set to prohibit writing to the share.
Quiet	checkbox	✓	Set to inhibit some syslog diagnostics to avoid some error messages. See exports(5) (https://www.freebsd.org/cgi/man.cgi?query=exports) for examples.
Maproot User	drop-down menu	✓	When a user is selected, the *root* user is limited to permissions of that user.

Continued on next page

Table 10.2 – continued from previous page

Setting	Value	Advanced Mode	Description
Maproot Group	drop-down menu	✓	When a group is selected, the *root* user is also limited to permissions of that group.
Mapall User	drop-down menu	✓	All clients use the permissions of the specified user.
Mapall Group	drop-down menu	✓	All clients use the permissions of the specified group.
Security	selection	✓	Only appears if *Enable NFSv4* is enabled in `Services → NFS`. Choices are *sys* or these Kerberos options: *krb5* (authentication only), *krb5i* (authentication and integrity), or *krb5p* (authentication and privacy). If multiple security mechanisms are added to the *Selected* column using the arrows, use the *Up* or *Down* buttons to list in order of preference.

When creating NFS shares, keep these points in mind:

1. Clients will specify the *Path* when mounting the share.
2. The *Maproot* and *Mapall* options are exclusive, meaning only one can be used was the GUI does not allow both. The *Mapall* options supersede the *Maproot* options. To restrict only the *root* user's permissions, set the *Maproot* option. To restrict permissions of all users, set the *Mapall* options.
3. Each volume or dataset is considered to be its own filesystem and NFS is not able to cross filesystem boundaries.
4. The network and host must be unique per share and per filesystem or directory. Since `/etc/exports` does not act like an ACL, the rule to apply is undefined among overlapping networks or when using the same share with multiple hosts.
5. The *All directories* option can only be used once per share per filesystem.

To better understand these restrictions, consider a scenario where there are:

- two networks, *10.0.0.0/8* and *20.0.0.0/8*
- a ZFS volume named `volume1` with 2 datasets named `dataset1` and `dataset2`
- `dataset1` contains a directory named `directory1`

Because of restriction #3, an error is shown when trying to create one NFS share like this:

- *Authorized networks* set to *10.0.0.0/8 20.0.0.0/8*
- *Path* set to `/mnt/volume1/dataset1` and `/mnt/volume1/dataset1/directory1`

Instead, set a *Path* of `/mnt/volume1/dataset1` and check the *All directories* box.

That directory could also be restricted to one of the networks by creating two shares instead:

First NFS share:

- *Authorized networks* set to *10.0.0.0/8*
- *Path* set to `/mnt/volume1/dataset1`

Second NFS share:

- *Authorized networks* set to *20.0.0.0/8*
- *Path* set to `/mnt/volume1/dataset1/directory1`

Note that this requires the creation of two shares. It cannot be done with only one share.

10.2.1 Example Configuration

By default, the *Mapall* fields are not set. This means that when a user connects to the NFS share, the user has the permissions associated with their user account. This is a security risk if a user is able to connect as *root* as they will have complete access to the share.

A better option is to do this:

1. Specify the built-in *nobody* account to be used for NFS access.
2. In the *Change Permissions* screen of the volume/dataset that is being shared, change the owner and group to *nobody* and set the permissions according to the desired requirements.
3. Select *nobody* in the *Mapall User* and *Mapall Group* drop-down menus for the share in `Sharing → Unix (NFS) Shares`.

With this configuration, it does not matter which user account connects to the NFS share, as it will be mapped to the *nobody* user account and will only have the permissions that were specified on the volume/dataset. For example, even if the *root* user is able to connect, it will not gain *root* access to the share.

10.2.2 Connecting to the Share

The following examples share this configuration:

1. The FreeNAS® system is at IP address *192.168.2.2*.
2. A dataset named `/mnt/volume1/nfs_share1` is created and the permissions set to the *nobody* user account and the *nobody* group.
3. An NFS share is created with these attributes:
   - *Path*: `/mnt/volume1/nfs_share1`
   - *Authorized Networks*: *192.168.2.0/24*
   - *All Directories* option is enabled
   - *MapAll User* is set to *nobody*
   - *MapAll Group* is set to *nobody*

From BSD or Linux

NFS shares are mounted on BSD or Linux clients with this command executed as the superuser (*root*) or with `sudo`:

```
mount -t nfs 192.168.2.2:/mnt/volume1/nfs_share1 /mnt
```

- **-t nfs** specifies the filesystem type of the share
- **192.168.2.2** is the IP address of the FreeNAS® system
- **/mnt/volume/nfs_share1** is the name of the directory to be shared, a dataset in this case
- **/mnt** is the mountpoint on the client system. This must be an existing, *empty* directory. The data in the NFS share appears in this directory on the client computer.

A successful mounting of the share returns to the command prompt without any status or error messages.

Note: If this command fails on a Linux system, make sure that the nfs-utils (https://sourceforge.net/projects/nfs/files/nfs-utils/) package is installed.

This configuration allows users on the client system to copy files to and from `/mnt` (the mount point). All files are owned by *nobody:nobody*. Changes to any files or directories in `/mnt` are written to the FreeNAS® system's `/mnt/volume1/nfs_share1` dataset.

Settings cannot be changed on the NFS share if it is mounted on any client computers. The `umount` command is used to unmount the share on BSD and Linux clients. Run it as the superuser or with `sudo` on each client computer:

```
umount /mnt
```

From Microsoft

Windows NFS client support varies with versions and releases. For best results, use *Windows (SMB) Shares* (page 189).

From macOS

To mount the NFS volume from a macOS client, go to `Go` → `Connect to Server`. In the *Server Address* field, enter *nfs://* followed by the IP address of the FreeNAS® system and the name of the volume/dataset being shared by NFS. The example shown in Figure 10.10 continues with our example of *192.168.2.2:/mnt/volume1/nfs_share1*.

Finder opens automatically after connecting. The IP address of the FreeNAS® system is displayed in the SHARED section in the left frame and the contents of the share are displayed in the right frame. In the example shown in Figure 10.11, `/mnt/data` has one folder named `images`. The user can now copy files to and from the share.

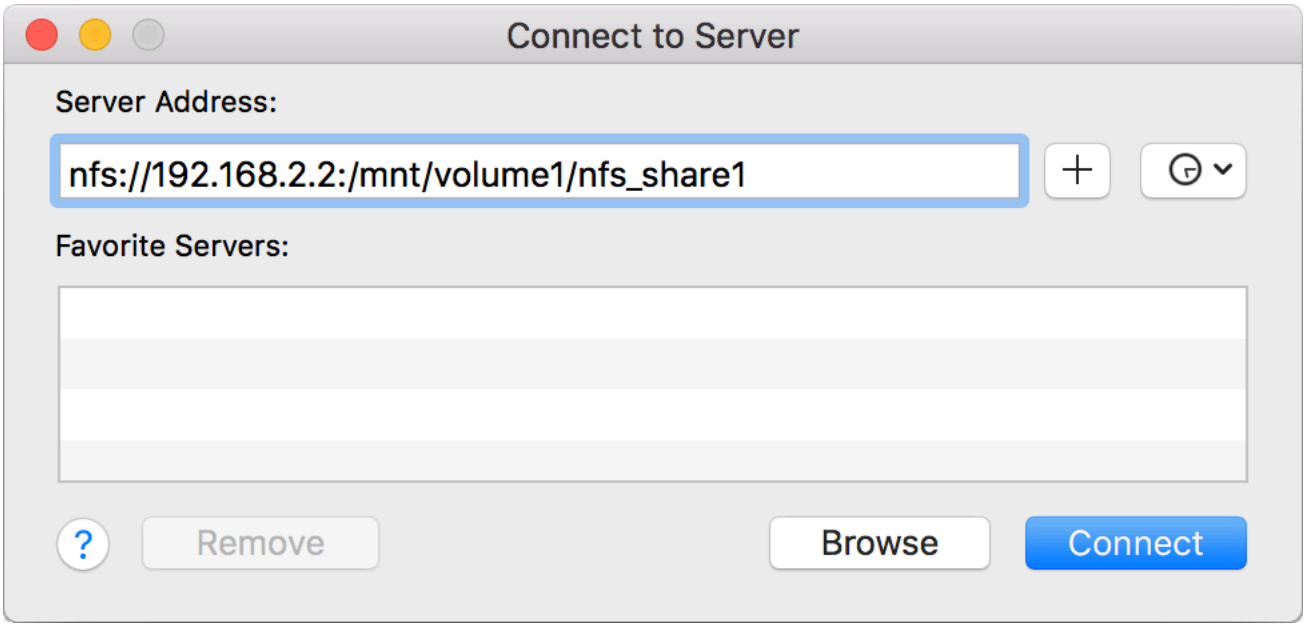


Fig. 10.10: Mounting the NFS Share from macOS

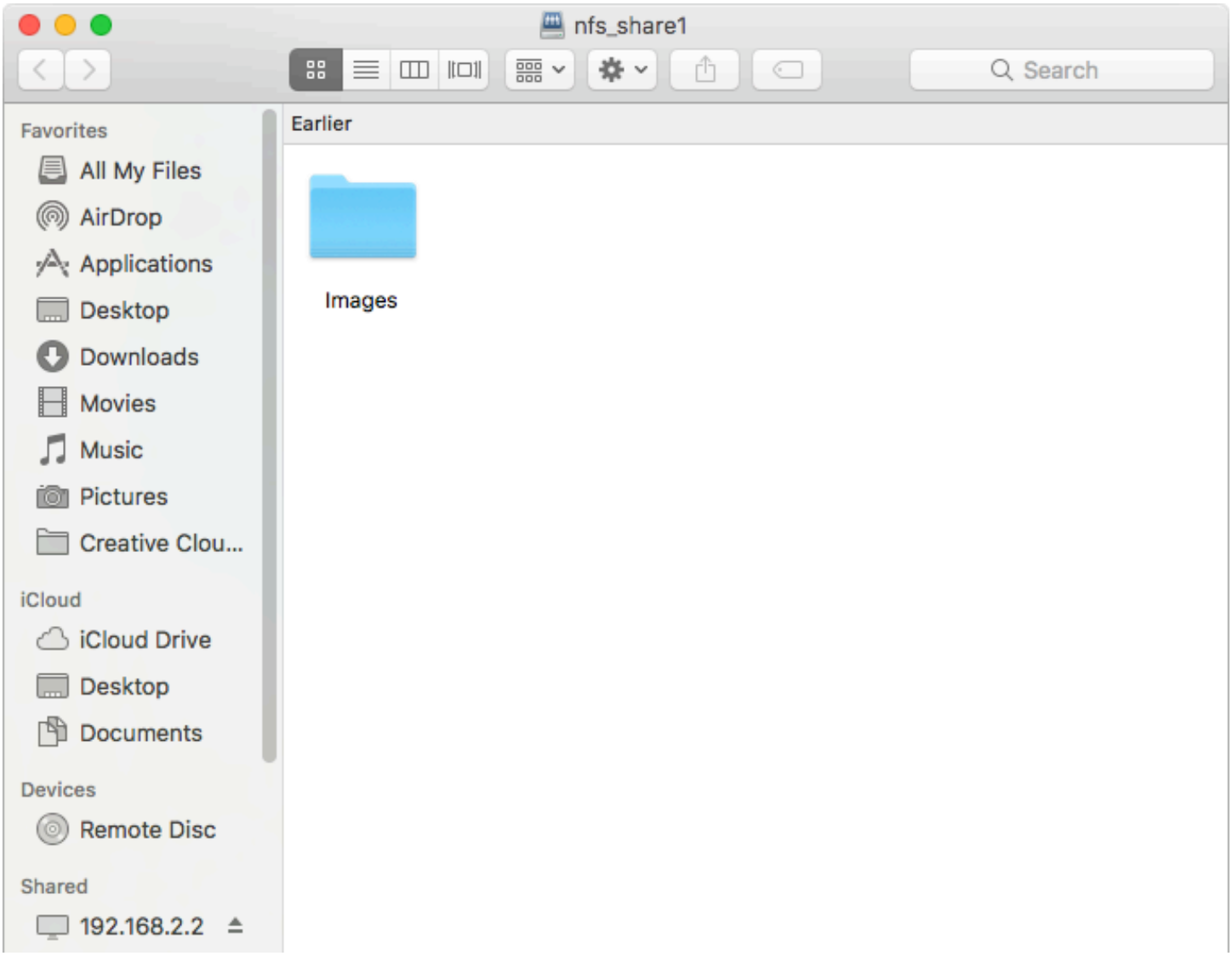


Fig. 10.11: Viewing the NFS Share in Finder

10.2.3 Troubleshooting NFS

Some NFS clients do not support the NLM (Network Lock Manager) protocol used by NFS. This is the case if the client receives an error that all or part of the file may be locked when a file transfer is attempted. To resolve this error, add the option **-o nolock** when running the `mount` command on the client to allow write access to the NFS share.

If a "time out giving up" error is shown when trying to mount the share from a Linux system, make sure that the portmapper service is running on the Linux client. If portmapper is running and timeouts are still shown, force the use of TCP by including **-o tcp** in the `mount` command.

If a "RPC: Program not registered" error is shown, upgrade to the latest version of FreeNAS® and restart the NFS service after the upgrade to clear the NFS cache.

If clients see "reverse DNS" errors, add the FreeNAS® IP address in the *Host name database* field of `Network → Global Configuration`.

If clients receive timeout errors when trying to mount the share, add the client IP address and hostname to the *Host name data base* field in `Network → Global Configuration`.

Some older versions of NFS clients default to UDP instead of TCP and do not auto-negotiate for TCP. By default, FreeNAS®

uses TCP. To support UDP connections, go to `Services → NFS` and enable the *Serve UDP NFS clients* option.

The `nfsstat -c` or `nfsstat -s` commands can be helpful to detect problems from the *Shell* (page 282). A high proportion of retries and timeouts compared to reads usually indicates network problems.

10.3 WebDAV Shares

In FreeNAS®, WebDAV shares can be created so that authenticated users can browse the contents of the specified volume, dataset, or directory from a web browser.

Configuring WebDAV shares is a two step process. First, create the WebDAV shares to specify which data can be accessed. Then, configure the WebDAV service by specifying the port, authentication type, and authentication password. Once the configuration is complete, the share can be accessed using a URL in the format:

```
protocol://IP_address:port_number/share_name
```

where:

- **protocol:** is either *http* or *https*, depending upon the *Protocol* configured in `Services → WebDAV`.
- **IP address:** is the IP address or hostname of the FreeNAS® system. Take care when configuring a public IP address to ensure that the network firewall only allows access to authorized systems.
- **port_number:** is configured in `Services → WebDAV`. If the FreeNAS® system is to be accessed using a public IP address, consider changing the default port number and ensure that the network's firewall only allows access to authorized systems.
- **share_name:** is configured in `Sharing → WebDAV Shares`.

Entering the URL in a web browser brings up an authentication pop-up message. Enter a username of *webdav* and the password configured in `Services → WebDAV`.

Warning: At this time, only the *webdav* user is supported. For this reason, it is important to set a good password for this account and to only give the password to users which should have access to the WebDAV share.

To create a WebDAV share, click `Sharing → WebDAV Shares → Add WebDAV Share` which will open the screen shown in Figure 10.12.

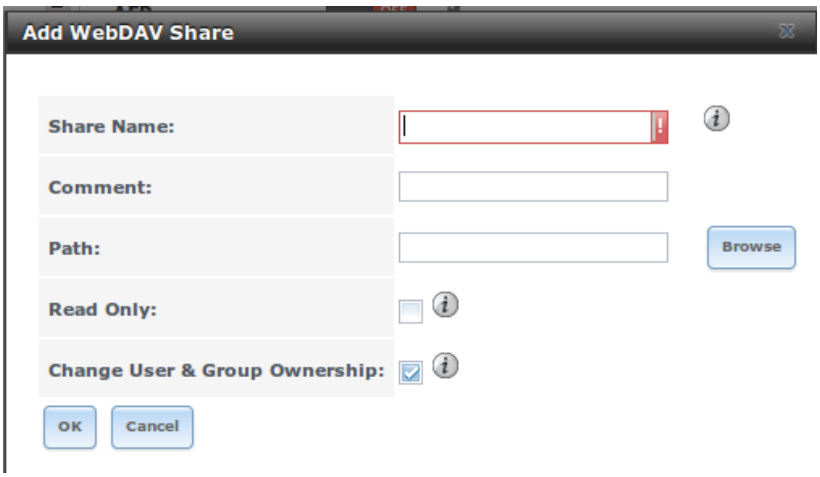


Fig. 10.12: Adding a WebDAV Share

Table 10.3 summarizes the available options.

Table 10.3: WebDAV Share Options

Setting	Value	Description
Share Path Name	string	Enter a name for the share.
Comment	string	Optional.
Path	browse button	*Browse* to the volume/dataset to share.
Read Only	checkbox	Set to prohibit users from writing to the share.
Change User & Group Ownership	checkbox	Enable to automatically set the share contents to the *webdav* user and group.

After clicking *OK*, a pop-up asks about enabling the service. Once the service starts, review the settings in `Services` → `WebDAV` as they are used to determine which URL is used to access the WebDAV share and whether or not authentication is required to access the share. These settings are described in *WebDAV* (page 247).

10.4 Windows (SMB) Shares

FreeNAS® uses Samba (https://www.samba.org/) to share volumes using Microsoft's SMB protocol. SMB is built into the Windows and macOS operating systems and most Linux and BSD systems pre-install the Samba client in order to provide support for SMB. If the distro did not, install the Samba client using the distro software repository.

The SMB protocol supports many different types of configuration scenarios, ranging from the simple to complex. The complexity of the scenario depends upon the types and versions of the client operating systems that will connect to the share, whether the network has a Windows server, and whether Active Directory is being used. Depending on the authentication requirements, it might be necessary to create or import users and groups.

Samba supports server-side copy of files on the same share with clients from Windows 8 and higher. Copying between two different shares is not server-side. Windows 7 clients support server-side copying with Robocopy (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2012-R2-and-2012/cc733145(v=ws.11)).

This chapter starts by summarizing the available configuration options. It demonstrates some common configuration scenarios as well as offering some troubleshooting tips. Reading through this entire chapter before creating any SMB shares is recommended to gain a better understanding of the configuration scenario that meets the specific network requirements.

Tip: SMB Tips and Tricks (https://forums.freenas.org/index.php?resources/smb-tips-and-tricks.15/) shows helpful hints for configuring and managing SMB networking. The FreeNAS and Samba (CIFS) permissions (https://www.youtube.com/watch?v=RxggaE935PM) and Advanced Samba (CIFS) permissions on FreeNAS (https://www.youtube.com/watch?v=QhwOyLtArw0) videos clarify setting up permissions on SMB shares. Another helpful reference is Methods For Fine-Tuning Samba Permissions (https://forums.freenas.org/index.php?threads/methods-for-fine-tuning-samba-permissions.50739/).

Tip: Run `smbstatus` from the *Shell* (page 282) for a list of active connections and users.

Figure 10.13 shows the configuration screen that appears after clicking `Sharing` → `Windows (SMB Shares)` → `Add Windows (SMB) Share`.

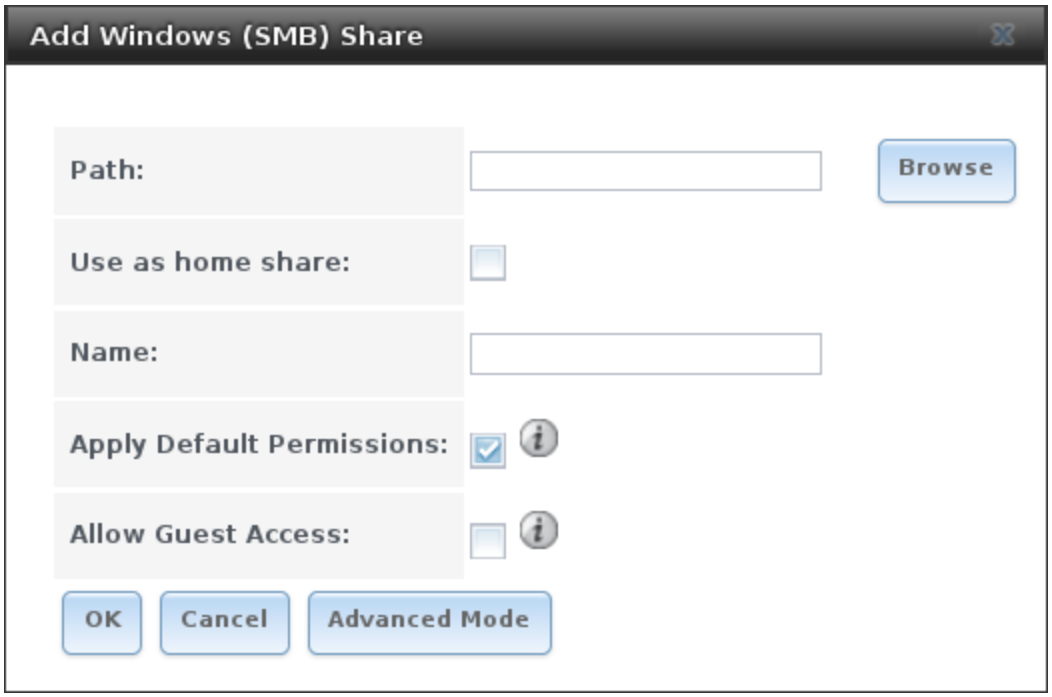


Fig. 10.13: Adding an SMB Share

Table 10.4 summarizes the options when creating a SMB share. Some settings are only available after clicking the *Advanced Mode* button. For simple sharing scenarios, *Advanced Mode* options are not needed. For more complex sharing scenarios, only change an *Advanced Mode* option after fully understanding the function of that option. smb.conf(5) (https://www.freebsd.org/cgi/man.cgi?query=smb.conf&manpath=FreeBSD+11.0-RELEASE+and+Ports) provides more details for each configurable option.

Table 10.4: Options for a SMB Share

Setting	Value	Advanced Mode	Description
Path	browse button		Select volume/dataset/directory to share.
Use as home share	checkbox		Set to allow this share to hold user home directories. Only one share can be the homes share.
Name	string		Enter a mandatory name for the share.
Comment	string	✓	Optional description.
Apply Default Permissions	checkbox		When enabled, the ACLs grant read and write for owner or group and read-only for others. Only leave unset when creating a share on a system that already has custom ACLs set.
Export Read Only	checkbox	✓	Set to prohibit write access to the share.
Browsable to Network Clients	checkbox	✓	When set, users see the contents of */homes*, which includes other home directories of other users. When unset, users see only their own home directory.
Export Recycle Bin	checkbox	✓	When set, deleted files are moved to a hidden `.recycle` in the root folder of the share. The `.recycle` directory can be deleted to reclaim space and is automatically recreated when a file is deleted.
Show Hidden Files	checkbox	✓	Set to disable the Windows *hidden* attribute on a new Unix hidden file. Unix hidden filenames start with a dot: `.foo`. Existing files are not affected. Existing files are not affected.

Continued on next page

Table 10.4 – continued from previous page

Setting	Value	Advanced Mode	Description
Allow Guest Access	checkbox		Set to allow access to this share without a password. See *SMB* (page 234) service for more information about guest user permissions.
Only Allow Guest Access	checkbox	✓	Requires *Allow guest access* to also be enabled. Forces guest access for all connections.
Access Based Share Enumeration	checkbox	✓	When enabled, users can only see the shares they have permission to access. To change the default that grants Everyone access, use the computer management MMC on Windows or the **sharesec** command-line utility.
Hosts Allow	string	✓	Enter a list of allowed hostnames or IP addresses. Separate entries with a space, comma, or tab.
Hosts Deny	string	✓	Enter a list of denied hostnames or IP addresses. Separate entries with a space, comma, or tab, Specify ALL and list any hosts from *Hosts Allow* to have those hosts take precedence.
VFS Objects	selection	✓	Adds virtual file system modules to enhance functionality. Table 10.5 summarizes the available modules.
Periodic Snapshot Task	drop-down menu	✓	Used to configure directory shadow copies on a per-share basis. Select the pre-configured periodic snapshot task to use for the shadow copies of the share. Periodic snapshot must be recursive.
Auxiliary Parameters	string	✓	Additional `smb4.conf` parameters not covered by other option fields.

Note the following regarding some of the *Advanced Mode* settings:

- Hostname lookups add some time to accessing the SMB share. If only using IP addresses, unset the *Hostnames lookups* option in `Services → SMB`.
- When the *Browsable to Network Clients* option is enabled (the default), the share is visible through Windows File Explorer or through `net view`. When the *Use as a home share* option is selected, deselecting the *Browsable to Network Clients* option hides the share named *homes* so that only the dynamically generated share containing the authenticated user home directory will be visible. By default, the *homes* share and the user home directory are both visible. Users are not automatically granted read or write permissions on browsable shares. This option provides no real security because shares that are not visible in Windows File Explorer can still be accessed with a *UNC* path.
- If some files on a shared volume should be hidden and inaccessible to users, put a *veto files*= line in the *Auxiliary Parameters* field. The syntax for the *veto files* option and some examples can be found in the smb.conf manual page (https://www.freebsd.org/cgi/man.cgi?query=smb.conf&manpath=FreeBSD+11.0-RELEASE+and+Ports).

Samba disables NTLMv1 authentication by default for security. Standard configurations of Windows XP and some configurations of later clients like Windows 7 will not be able to connect with NTLMv1 disabled. Security guidance for NTLMv1 and LM network authentication (https://support.microsoft.com/en-us/help/2793313/security-guidance-for-ntlmv1-and-lm-network-authentication) has information about the security implications and ways to enable NTLMv2 on those clients. If changing the client configuration is not possible, NTLMv1 authentication can be enabled by enabling the *NTLMv1 auth* option in `Services → SMB`.

Table 10.5 provides an overview of the available VFS modules. Be sure to research each module **before** adding or deleting it from the *Selected* column of the *VFS Objects* field of the share. Some modules need additional configuration after they are added. Refer to Stackable VFS modules (https://www.samba.org/samba/docs/old/Samba3-HOWTO/VFS.html) and the vfs_* man pages (https://www.samba.org/samba/docs/current/man-html/) for more details.

Table 10.5: Available VFS Modules

Value	Description
acl_tdb	Stores NTFS ACLs in a tdb file to enable full mapping of Windows ACLs.
acl_xattr	Stores NTFS ACLs in Extended Attributes (EAs) to enable the full mapping of Windows ACLs.
aio_fork	Enables async I/O.
aio_pthread	Implements async I/O in Samba vfs using a pthread pool instead of the internal Posix AIO interface.
audit	Logs share access, connects/disconnects, directory opens/creates/removes, and file opens/closes/renames/unlinks/chmods to syslog.
cacheprime	Primes the kernel file data cache.
cap	Translates filenames to and from the CAP encoding format, commonly used in Japanese language environments.
catia	Improves Mac interoperability by translating characters that are unsupported by Windows.
commit	Tracks the amount of data written to a file and synchronizes it to disk when a specified amount accumulates.
crossrename	Allows server side rename operations even if source and target are on different physical devices.
default_quota	Stores the default quotas that are reported to a windows client in the quota record of a user.
dfs_samba4	Distributed file system for providing an alternative name space, load balancing, and automatic failover.
dirsort	Sorts directory entries alphabetically before sending them to the client.
expand_msdfs	Enables support for Microsoft Distributed File System (DFS).
extd_audit	Sends *audit* logs to both syslog and the Samba log files.
fake_acls	Stores file ownership and ACLs as extended attributes.
fake_perms	Allows roaming profile files and directories to be set as read-only.
fruit	Enhances macOS support by providing the SMB2 AAPL extension and Netatalk interoperability. Automatically loads *catia* and *streams_xattr* but read the caveat in NOTE below table.
full_audit	Record selected client operations to the system log.
linux_xfs_sgid	Used to work around an old Linux XFS bug.
media_harmony	Allows Avid editorial workstations to share a network drive.
netatalk	Eases the co-existence of SMB and AFP shares.
offline	Marks all files in the share with the DOS *offline* attribute. This can prevent Windows Explorer from reading files just to make thumbnail images.
posix_eadb	Provides Extended Attributes (EAs) support so they can be used on filesystems which do not provide native support for EAs.
preopen	Useful for video streaming applications that want to read one file per frame.

Continued on next page

Table 10.5 – continued from previous page

Value	Description
readahead	Useful for Windows Vista clients reading data using Windows Explorer.
readonly	Marks a share as read-only for all clients connecting within the configured time period.
shadow_copy	Allows Microsoft shadow copy clients to browse shadow copies on Windows shares.
shadow_copy_test	Shadow copy testing.
shell_snap	Provides shell-script callouts for snapshot creation and deletion operations issued by remote clients using the File Server Remote VSS Protocol (FSRVP).
skel_opaque	Implements dummy versions of all VFS modules (useful to VFS module developers).
skel_transparent	Implements dummy passthrough functions of all VFS modules (useful to VFS module developers).
snapper	Provides the ability for remote SMB clients to access shadow copies of FSRVP snapshots using Windows Explorer.
streams_depot	**Experimental** module to store alternate data streams in a central directory. The association with the primary file can be lost due to inode numbers changing when a directory is copied to a new location (see https://marc.info/?l=samba&m=132542069802160&w=2).
streams_xattr	Enables storing of NTFS alternate data streams in the file system.
syncops	Ensures metadata operations are performed synchronously.
time_audit	Logs system calls that take longer than the number of defined milliseconds.
unityed_media	Allows multiple Avid clients to share a network drive.
winmsa	Emulate Microsoft's MoveSecurityAttributes=0 registry option, setting the ACL for file and directory hierarchies to inherit from the parent directory into which they are moved.
worm	Controls the writability of files and folders depending on their change time and an adjustable grace period.
xattr_tdb	Stores Extended Attributes (EAs) in a tdb file so they can be used on filesystems which do not provide support for EAs.
zfs_space	Correctly calculates ZFS space used by the share, including space used by ZFS snapshots, quotas, and reservations; enabled by default.
zfsacl	Provide ACL extensions for proper integration with ZFS. Enabled by default.

Note: Be careful when using multiple SMB shares, some with and some without *fruit*. macOS clients negotiate SMB2 AAPL protocol extensions on the first connection to the server, so mixing shares with and without fruit will globally disable AAPL if the first connection occurs without fruit. To resolve this, all macOS clients need to disconnect from all SMB shares and the first reconnection to the server has to be to a fruit-enabled share.

These VFS objects do not appear in the selection box:

- **recycle:** moves deleted files to the recycle directory instead of deleting them. Controlled by *Export Recycle Bin* in the *SMB share options* (page 190).

- **shadow_copy2:** a more recent implementation of *shadow_copy* with some additional features. *shadow_copy2* and the associated parameters are automatically added to the `smb4.conf` when a *Periodic Snapshot Task* is selected.

10.4.1 Configuring Unauthenticated Access

SMB supports guest logins, meaning that users can access the SMB share without needing to provide a username or password. This type of share is convenient as it is easy to configure, easy to access, and does not require any users to be configured on the FreeNAS® system. This type of configuration is also the least secure as anyone on the network can access the contents of the share. Additionally, since all access is as the guest user, even if the user inputs a username or password, there is no way to differentiate which users accessed or modified the data on the share. This type of configuration is best suited for small networks where quick and easy access to the share is more important than the security of the data on the share.

To configure an unauthenticated SMB share, click *Wizard*, then click the *Next* button twice to display the screen shown in Figure 10.14. Complete the following fields in this screen:

1. **Share name:** enter a name for the share that is useful. In this example, the share is named *smb_insecure*.
2. Click the button for *Windows (SMB)* and enable the *Allow Guest* option.
3. Click the *Ownership* button. Click the drop-down *User* menu and select *nobody*. Click the *Return* button to return to the previous screen.
4. Click the *Add* button. **If this step is forgotten, the share will not be created**. Clicking the *Add* button adds an entry to the *Name* frame with the name that was entered in *Share name*.

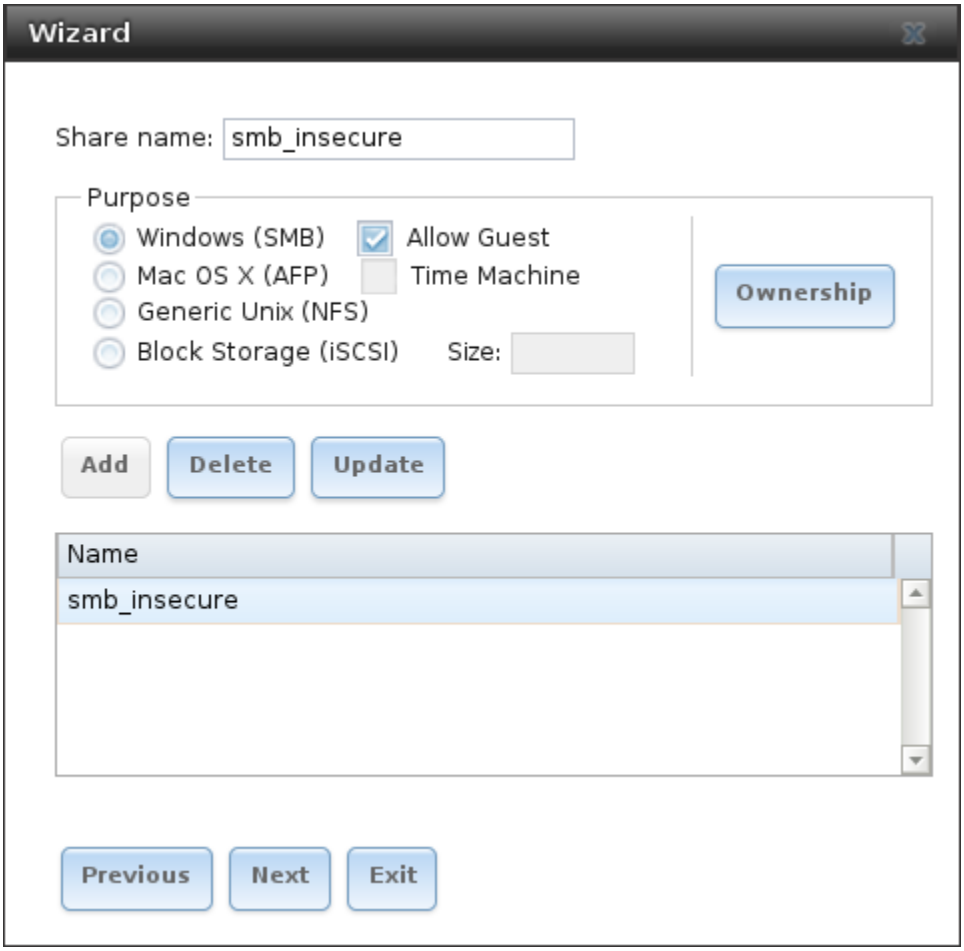


Fig. 10.14: Creating an Unauthenticated SMB Share

Click the *Next* button twice, then the *Confirm* button to create the share. The Wizard automatically creates a dataset for the share and starts the SMB service so the share is immediately available. The new share will appear in `Sharing → Windows (SMB)`.

Users can now access the share from any SMB client and will not be prompted for their username or password. For example, to access the share from a Windows system, open Explorer and click on *Network*. For this configuration example, a system named *FREENAS* appears with a share named *insecure_smb*. The user can copy data to and from the unauthenticated SMB share.

10.4.2 Configuring Authenticated Access Without a Domain Controller

Most configuration scenarios require each user to have their own user account and to authenticate before accessing the share. This allows the administrator to control access to data, provide appropriate permissions to that data, and to determine who accesses and modifies stored data. A Windows domain controller is not needed for authenticated SMB shares, which means that additional licensing costs are not required. However, since there is no domain controller to provide authentication for the network, each user account needs to be created on the FreeNAS® system. This type of configuration scenario is often used in home and small networks as it does not scale well if many users accounts are needed.

Before configuring this scenario, determine which users will need authenticated access. While not required for the configuration, it eases troubleshooting if the username and password that will be created on the FreeNAS® system matches that information on the client system. Next, determine if each user should have their own share to store their own data or if several users will be using the same share. The simpler configuration is to make one share per user as it does not require the creation of groups, adding the correct users to the groups, and ensuring that group permissions are set correctly.

To use the Wizard to create an authenticated SMB share, enter the following information, as shown in the example in Figure 10.15.

1. **Share name:** enter a name for the share that is useful. In this example, the share is named *smb_user1*.
2. Click the button for *Windows (SMB)*.
3. Click the *Ownership* button. To create the user account on the FreeNAS® system, type their name into the *User* field and enable the *Create User* option. The user's password is then entered and confirmed. **If the user will not be sharing this share with other users**, type their name into the *Group* field and click *Create Group*. **If, however, the share will be used by several users**, instead type in a group name and enable the *Create Group* option. In the example shown in Figure 10.16, *user1* has been used for both the user and group name, meaning that this share will only be used by *user1*. When finished, click *Return* to return to the screen shown in Figure 10.15.
4. Click the *Add* button. **If this step is forgotten, the share will not be created**. Clicking the *Add* button adds an entry to the *Name* frame with the name that was entered in *Share name*.

When configuring multiple authenticated shares, repeat for each user, giving each user their own *Share name* and *Ownership*. When finished, click *Next* twice, then *Confirm* to create the shares. The Wizard automatically creates a dataset with the correct ownership for each share and starts the SMB service so the shares are available immediately. The new shares are also added to `Sharing → Windows (SMB)`.

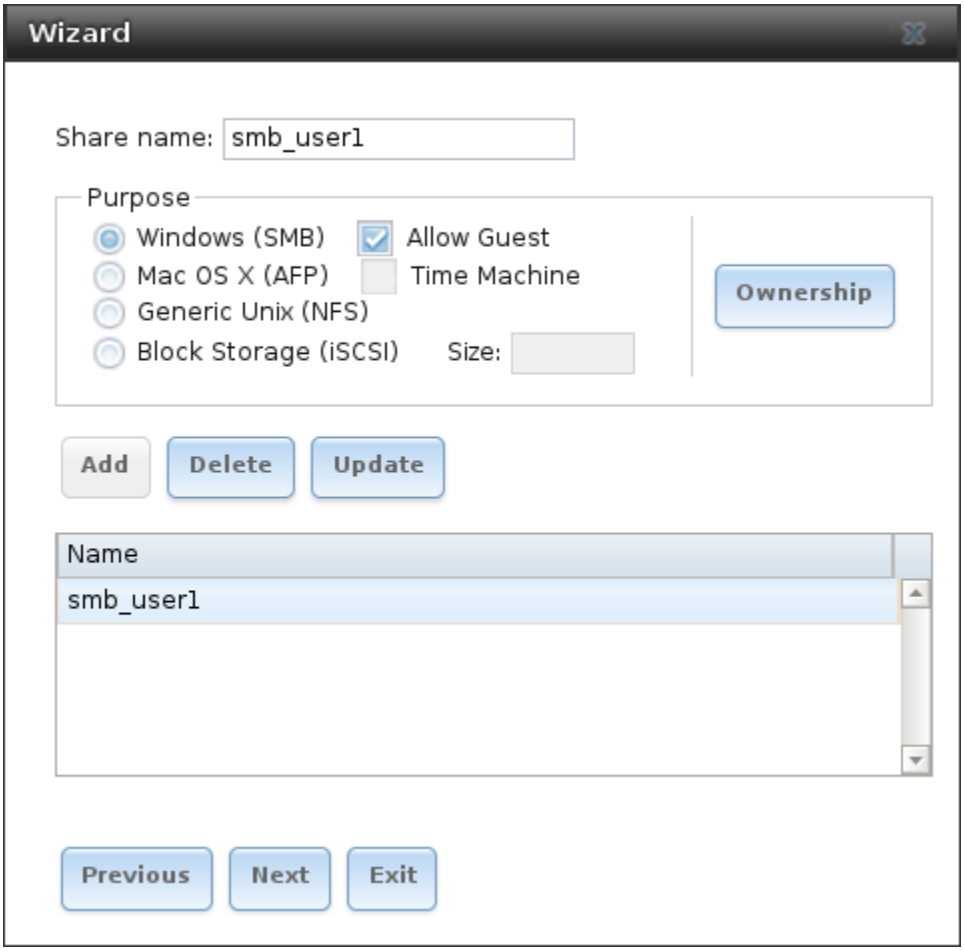


Fig. 10.15: Creating an Authenticated SMB Share

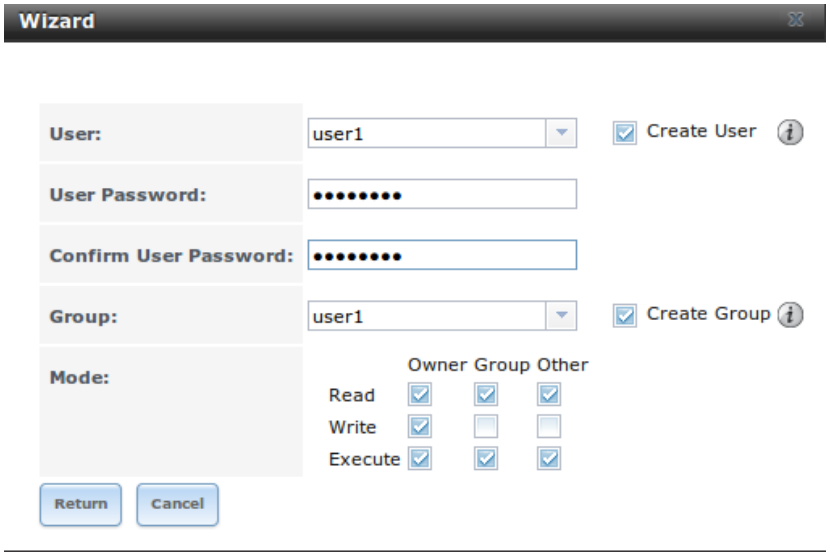


Fig. 10.16: Creating the User and Group

The authenticated share can now be tested from any SMB client. For example, to test an authenticated share from a Windows system, open Explorer and click on *Network*. For this configuration example, a system named *FREENAS* appears with a share named *smb_user1*. After clicking *smb_user1*, a Windows Security pop-up screen prompts for that user's username and

password. Enter the values that were configured for that share, in this case user *user1*. After authentication, the user can copy data to and from the SMB share.

To prevent Windows Explorer from hanging when accessing the share, map the share as a network drive. To do this, right-click the share and select *Map network drive...*. Choose a drive letter from the drop-down menu and click the *Finish* button.

Note that Windows systems cache a user's credentials. This can cause issues when testing or accessing multiple authenticated shares as only one authentication is allowed at a time. When authenticating to a share, if problems occur and the username and password are correct, type **cmd** in the *Search programs and files* box and use the following command to see if the share is already authenticated. In this example, the user has already authenticated to the *smb_user1* share:

```
net use
New connections will be remembered.

Status         Local    Remote                    Network
-------------------------------------------------------------------------------
OK                      \\FREENAS\smb_user1 Microsoft Windows Network
The command completed successfully.
```

To clear the cache:

```
net use * /DELETE
You have these remote connections:
               \\FREENAS\smb_user1
Continuing will cancel the connections.

Do you want to continue this operation? <Y/N> [N]: y
```

An additional warning is shown if the share is currently open in Explorer:

```
There are open files and/or incomplete directory searches pending on the connection
to \\FREENAS|smb_user1.

Is it OK to continue disconnecting and force them closed? <Y/N> [N]: y
The command completed successfully.
```

The next time a share is accessed with Explorer, a prompt to authenticate will occur.

10.4.3 Configuring Shadow Copies

Shadow Copies (https://en.wikipedia.org/wiki/Shadow_copy), also known as the Volume Shadow Copy Service (VSS) or Previous Versions, is a Microsoft service for creating volume snapshots. Shadow copies can be used to restore previous versions of files from within Windows Explorer. Shadow Copy support is built into Vista and Windows 7. Windows XP or 2000 users need to install the Shadow Copy client (http://www.microsoft.com/en-us/download/details.aspx?displaylang=en&id=16220).

When a periodic snapshot task is created on a ZFS volume that is configured as a SMB share in FreeNAS®, it is automatically configured to support shadow copies.

Before using shadow copies with FreeNAS®, be aware of the following caveats:

- If the Windows system is not fully patched to the latest service pack, Shadow Copies may not work. If no previous versions of files to restore are visible, use Windows Update to make sure that the system is fully up-to-date.
- Shadow copy support only works for ZFS pools or datasets. This means that the SMB share must be configured on a volume or dataset, not on a directory.
- Datasets are filesystems and shadow copies cannot traverse filesystems. To see the shadow copies in the child datasets, create separate shares for them.
- Shadow copies will not work with a manual snapshot. Creating a periodic snapshot task for the pool or dataset being shared by SMB or a recursive task for a parent dataset is recommended.

- The periodic snapshot task should be created and at least one snapshot should exist **before** creating the SMB share. If the SMB share was created first, restart the SMB service in `Services → Control Services`.
- Appropriate permissions must be configured on the volume/dataset being shared by SMB.
- Users cannot delete shadow copies on the Windows system due to the way Samba works. Instead, the administrator can remove snapshots from the FreeNAS® administrative GUI. The only way to disable shadow copies completely is to remove the periodic snapshot task and delete all snapshots associated with the SMB share.

To configure shadow copy support, use the instructions in *Configuring Authenticated Access Without a Domain Controller* (page 195) to create the desired number of shares. In this configuration example, a Windows 7 computer has two users: *user1* and *user2*. For this example, two authenticated shares are created so that each user account has their own share. The first share is named *user1* and the second share is named *user2*. Then:

1. Use `Storage → Periodic Snapshot Tasks → Add Periodic Snapshot` to create at least one periodic snapshot task. There are two options for snapshot tasks. One is to create a snapshot task for each user's dataset. In this example the datasets are `/mnt/volume1/user1` and `/mnt/volume1/user2`. Another option is to create one periodic snapshot task for the entire volume,:file:*/mnt/volume1* in this case. **Before continuing to the next step,** confirm that at least one snapshot for each defined task is displayed in the `Storage → Snapshots` tab. When creating the schedule for the periodic snapshot tasks, keep in mind how often the users need to access modified files and during which days and time of day they are likely to make changes.
2. Go to `Sharing → Windows (SMB) Shares`. Highlight a share and click *Edit*, then *Advanced Mode*. Click the *Periodic Snapshot Task* drop-down menu and select the periodic snapshot task to use for that share. Repeat for each share being configured as a shadow copy. For this example, the share named `/mnt/volume1/user1` is configured to use a periodic snapshot task that was configured to take snapshots of the `/mnt/volume1/user1` dataset and the share named `/mnt/volume1/user2` is configured to use a periodic snapshot task that was configured to take snapshots of the `/mnt/volume1/user2` dataset.
3. Verify that the SMB service is set to *ON* in `Services → Control Services`.

Figure 10.17 provides an example of using shadow copies while logged in as *user1* on the Windows system. In this example, the user right-clicked *modified file* and selected *Restore previous versions* from the menu. This particular file has three versions: the current version, plus two previous versions stored on the FreeNAS® system. The user can choose to open one of the previous versions, copy a previous version to the current folder, or restore one of the previous versions, overwriting the existing file on the Windows system.

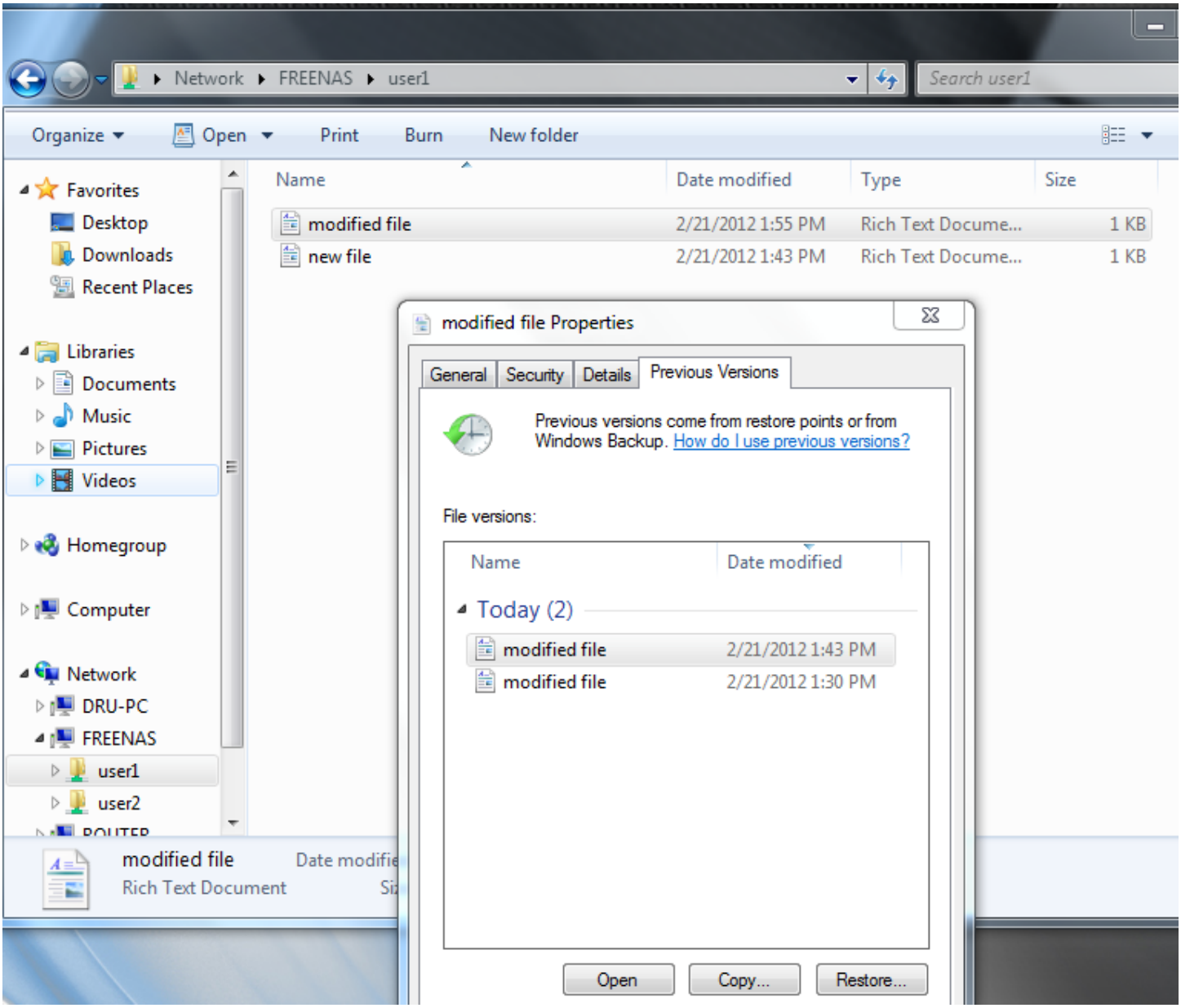


Fig. 10.17: Viewing Previous Versions within Explorer

10.5 Block (iSCSI)

iSCSI is a protocol standard for the consolidation of storage data. iSCSI allows FreeNAS® to act like a storage area network (SAN) over an existing Ethernet network. Specifically, it exports disk devices over an Ethernet network that iSCSI clients (called initiators) can attach to and mount. Traditional SANs operate over fibre channel networks which require a fibre channel infrastructure such as fibre channel HBAs, fibre channel switches, and discrete cabling. iSCSI can be used over an existing Ethernet network, although dedicated networks can be built for iSCSI traffic in an effort to boost performance. iSCSI also provides an advantage in an environment that uses Windows shell programs; these programs tend to filter "Network Location" but iSCSI mounts are not filtered.

Before configuring the iSCSI service, be familiar with this iSCSI terminology:

CHAP: an authentication method which uses a shared secret and three-way authentication to determine if a system is authorized to access the storage device and to periodically confirm that the session has not been hijacked by another system.

In iSCSI, the initiator (client) performs the CHAP authentication.

Mutual CHAP: a superset of CHAP in that both ends of the communication authenticate to each other.

Initiator: a client which has authorized access to the storage data on the FreeNAS® system. The client requires initiator software to initiate the connection to the iSCSI share.

Target: a storage resource on the FreeNAS® system. Every target has a unique name known as an iSCSI Qualified Name (IQN).

Internet Storage Name Service (iSNS): protocol for the automated discovery of iSCSI devices on a TCP/IP network.

Extent: the storage unit to be shared. It can either be a file or a device.

Portal: indicates which IP addresses and ports to listen on for connection requests.

LUN: *Logical Unit Number* representing a logical SCSI device. An initiator negotiates with a target to establish connectivity to a LUN. The result is an iSCSI connection that emulates a connection to a SCSI hard disk. Initiators treat iSCSI LUNs as if they were a raw SCSI or SATA hard drive. Rather than mounting remote directories, initiators format and directly manage filesystems on iSCSI LUNs. When configuring multiple iSCSI LUNs, create a new target for each LUN. Since iSCSI multiplexes a target with multiple LUNs over the same TCP connection, there can be TCP contention when more than one target accesses the same LUN. FreeNAS® supports up to 1024 LUNs.

In FreeNAS®, iSCSI is built into the kernel. This version of iSCSI supports Microsoft Offloaded Data Transfer (ODX) (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2012-R2-and-2012/hh831628(v=ws.11)), meaning that file copies happen locally, rather than over the network. It also supports the *VAAI* (page 318) (vStorage APIs for Array Integration) primitives for efficient operation of storage tasks directly on the NAS. To take advantage of the VAAI primitives, create a zvol using the instructions in *Create zvol* (page 128) and use it to create a device extent, as described in *Extents* (page 207).

To configure iSCSI:

1. Review the target global configuration parameters.
2. Create at least one portal.
3. Determine which hosts are allowed to connect using iSCSI and create an initiator.
4. Decide if authentication will be used, and if so, whether it will be CHAP or mutual CHAP. If using authentication, create an authorized access.
5. Create a target.
6. Create either a device or a file extent to be used as storage.
7. Associate a target with an extent.
8. Start the iSCSI service in `Services → Control Services`.

The rest of this section describes these steps in more detail.

10.5.1 Target Global Configuration

`Sharing → Block (iSCSI) → Target Global Configuration`, shown in Figure 10.18, contains settings that apply to all iSCSI shares. Table 10.6 summarizes the settings that are configured in the Target Global Configuration screen.

Some built-in values affect iSNS usage. Fetching of allowed initiators from iSNS is not implemented, so target ACLs must be configured manually. To make iSNS registration useful, iSCSI targets should have explicitly configured port IP addresses. This avoids initiators attempting to discover unconfigured target portal addresses like *0.0.0.0*.

The iSNS registration period is 900 seconds. Registered Network Entities not updated during this period are unregistered. The timeout for iSNS requests is 5 seconds.

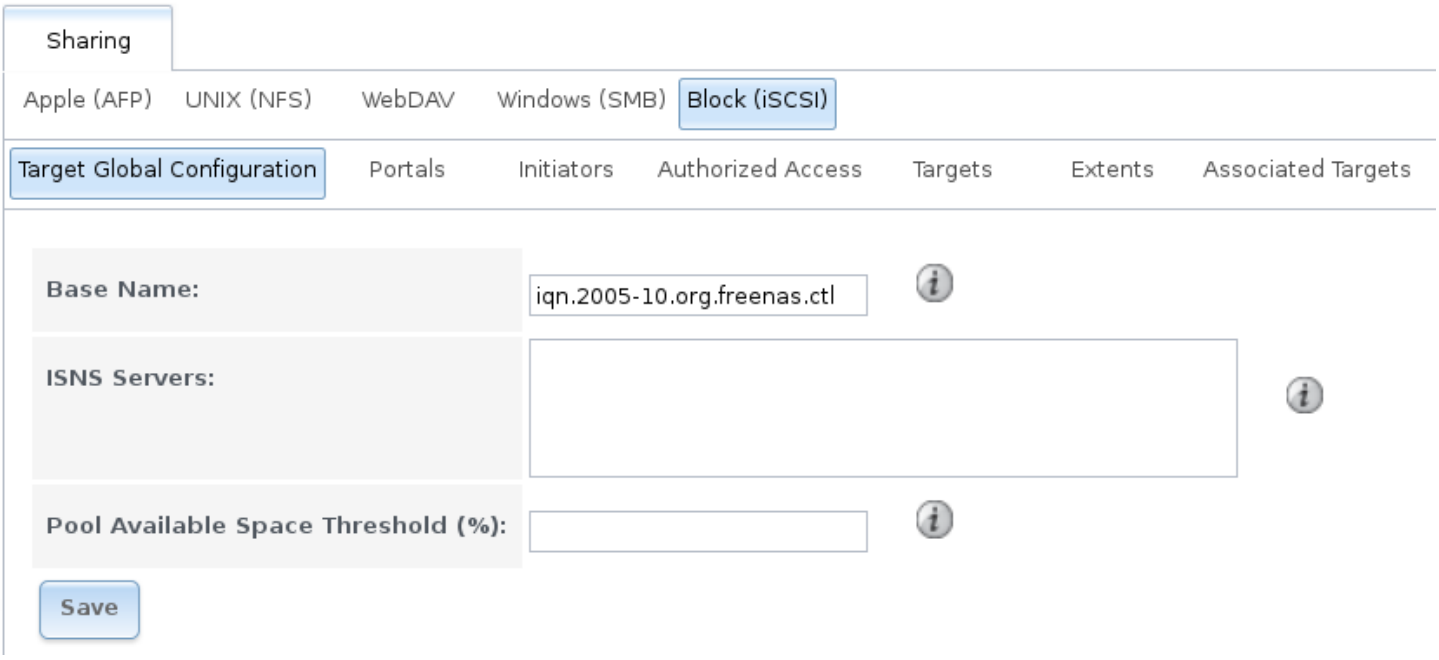


Fig. 10.18: iSCSI Target Global Configuration Variables

Table 10.6: Target Global Configuration Settings

Setting	Value	Description
Base Name	string	See the "Constructing iSCSI names using the iqn. format" section of **RFC 3721** (https://tools.ietf.org/html/rfc3721.html) if unfamiliar with this format.
ISNS Servers	string	Enter the hostnames or IP addresses of ISNS servers to be registered iSCSI targets and portals of the system.
Pool Available Space Threshold	integer	Enter the percentage of free space to remain in the pool. When this percentage is reached, the system issues an alert, but only if zvols are used. See *VAAI* (page 318) Threshold Warning for more information.

10.5.2 Portals

A portal specifies the IP address and port number to be used for iSCSI connections. `Sharing → Block (iSCSI) → Portals → Add Portal` brings up the screen shown in Figure 10.19.

Table 10.19 summarizes the settings that can be configured when adding a portal. To assign additional IP addresses to the portal, click the link *Add extra Portal IP*.

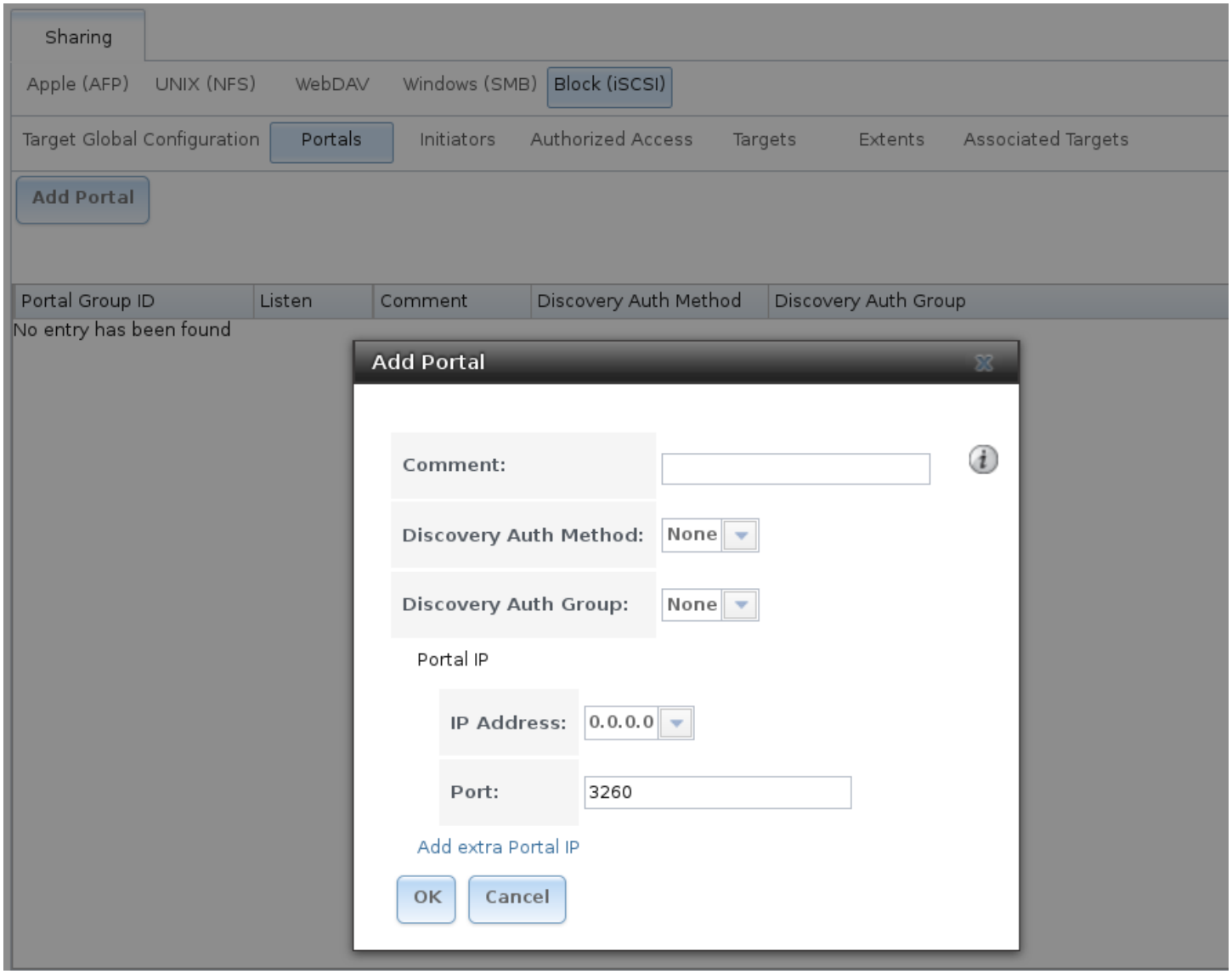


Fig. 10.19: Adding an iSCSI Portal

Table 10.7: Portal Configuration Settings

Setting	Value	Description
Comment	string	Optional description. Portals are automatically assigned a numeric group ID.
Discovery Auth Method	drop-down menu	*iSCSI* (page 225) supports multiple authentication methods that are used by the target to discover valid devices. *None* allows anonymous discovery while *CHAP* and *Mutual CHAP* both require authentication.
Discovery Auth Group	drop-down menu	Select a user created in *Authorized Access* if the *Discovery Auth Method* is set to *CHAP* or *Mutual CHAP*.
IP address	drop-down menu	Select the IP address associated with an interface or the wildcard address of *0.0.0.0* (any interface).
Port	integer	TCP port used to access the iSCSI target. Default is *3260*.

FreeNAS® systems with multiple IP addresses or interfaces can use a portal to provide services on different interfaces or subnets. This can be used to configure multi-path I/O (MPIO). MPIO is more efficient than a link aggregation.

If the FreeNAS® system has multiple configured interfaces, portals can also be used to provide network access control. For example, consider a system with four interfaces configured with the following addresses:

192.168.1.1/24

192.168.2.1/24

192.168.3.1/24

192.168.4.1/24

A portal containing the first two IP addresses (group ID 1) and a portal containing the remaining two IP addresses (group ID 2) could be created. Then, a target named A with a Portal Group ID of 1 and a second target named B with a Portal Group ID of 2 could be created. In this scenario, the iSCSI service would listen on all four interfaces, but connections to target A would be limited to the first two networks and connections to target B would be limited to the last two networks.

Another scenario would be to create a portal which includes every IP address **except** for the one used by a management interface. This would prevent iSCSI connections to the management interface.

10.5.3 Initiators

The next step is to configure authorized initiators, or the systems which are allowed to connect to the iSCSI targets on the FreeNAS® system. To configure which systems can connect, use `Sharing → Block (iSCSI) → Initiators → Add Initiator`, shown in Figure 10.20.

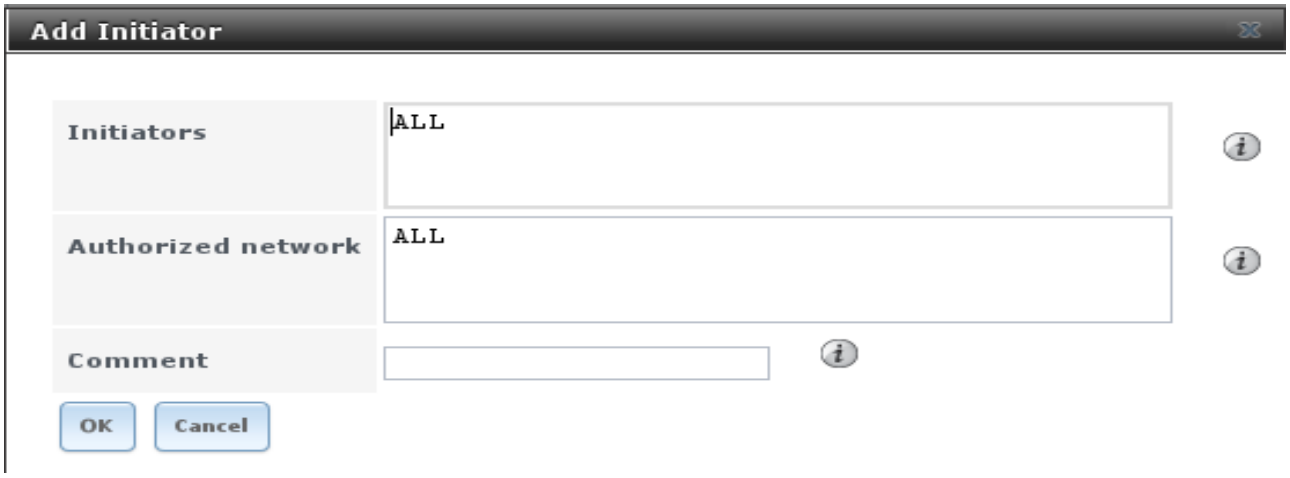


Fig. 10.20: Adding an iSCSI Initiator

Table 10.8 summarizes the settings that can be configured when adding an initiator.

Table 10.8: Initiator Configuration Settings

Setting	Value	Description
Initiators	string	Use *ALL* keyword or a list of initiator hostnames separated by spaces.
Authorized network	string	Use *ALL* keyword or a network address with CIDR mask such as *192.168.2.0/24*.
Comment	string	Enter an optional description.

In the example shown in Figure 10.21, two groups are created. Group 1 allows connections from any initiator on any network. Group 2 allows connections from any initiator on the *10.10.1.0/24* network. Click an initiator's entry to display its *Edit* and *Delete* buttons.

Note: Attempting to delete an initiator causes a warning that indicates if any targets or target/extent mappings depend upon the initiator. Confirming the delete causes these to be deleted also.

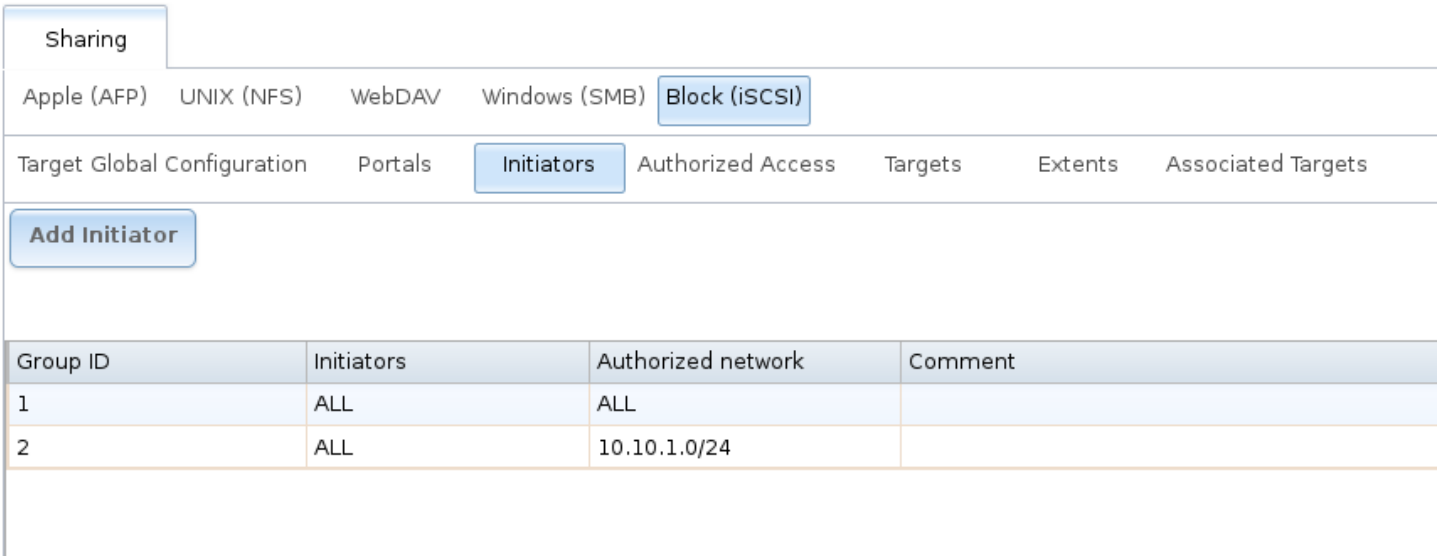


Fig. 10.21: Sample iSCSI Initiator Configuration

10.5.4 Authorized Accesses

When using CHAP or mutual CHAP to provide authentication, creating an authorized access in `Sharing → Block (iSCSI) → Authorized Accesses → Add Authorized Access` is recommended. This screen is shown in Figure 10.22.

Note: This screen sets login authentication. This is different from discovery authentication which is set in *Target Global Configuration* (page 200).

Fig. 10.22: Adding an iSCSI Authorized Access

Table 10.9 summarizes the settings that can be configured when adding an authorized access:

Table 10.9: Authorized Access Configuration Settings

Setting	Value	Description
Group ID	integer	Allows different groups to be configured with different authentication profiles. Example: all users with a Group ID of *1* will inherit the authentication profile associated with Group *1*.
User	string	Enter name of user account to create for CHAP authentication with the user on the remote system. Many initiators default to using the initiator name as the user.
Secret	string	Enter a password for *User*. The iSCSI standard requires that this be between 12 and 16 characters.
Peer User	string	Only input when configuring mutual CHAP. In most cases it will need to be the same value as *User*.
Peer Secret	string	Enter the mutual secret password which **must be different than the** *Secret*. Required if *Peer User* is set.

Note: CHAP does not work with GlobalSAN initiators on macOS.

As authorized accesses are added, they will be listed under *View Authorized Accesses*. In the example shown in Figure 10.23, three users (*test1*, *test2*, and *test3*) and two groups (*1* and *2*) are created, with group 1 consisting of one CHAP user and group 2 consisting of one mutual CHAP user and one CHAP user. Click an authorized access entry to display its *Edit* and *Delete* buttons.

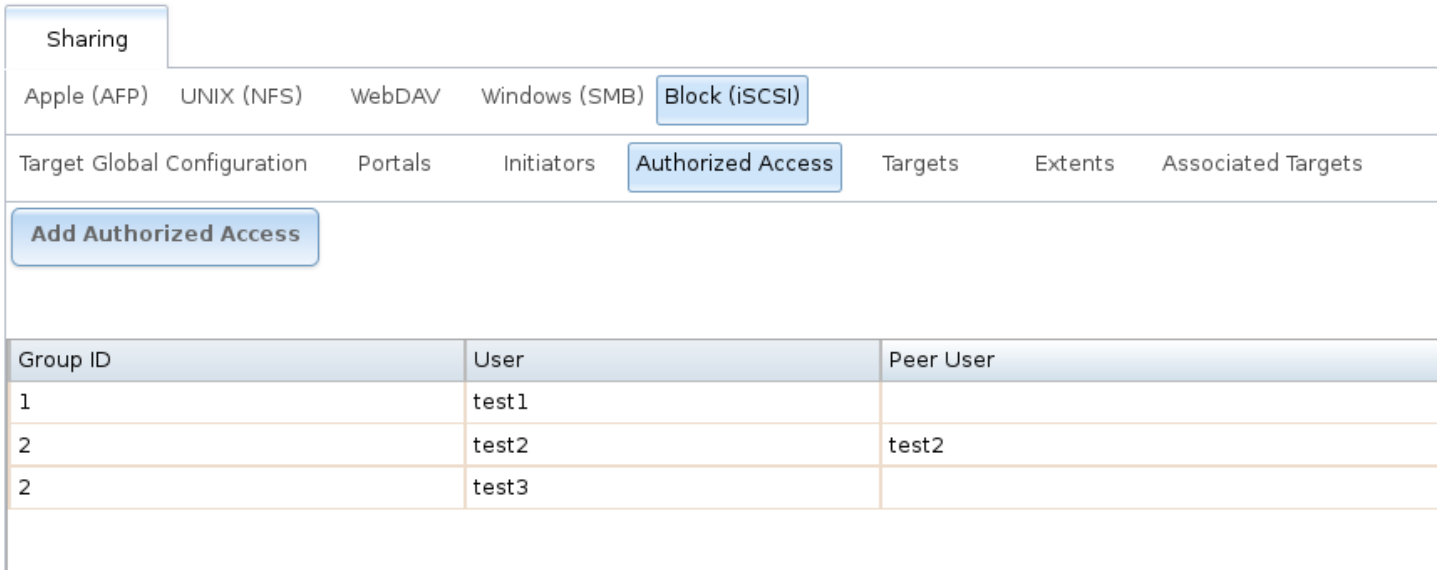


Fig. 10.23: Viewing Authorized Accesses

10.5.5 Targets

Next, create a Target using `Sharing → Block (iSCSI) → Targets → Add Target`, as shown in Figure 10.24. A target combines a portal ID, allowed initiator ID, and an authentication method. Table 10.10 summarizes the settings that can be configured when creating a Target.

Note: An iSCSI target creates a block device that may be accessible to multiple initiators. A clustered filesystem is required on the block device, such as VMFS used by VMware ESX/ESXi, in order for multiple initiators to mount the block device read/write. If a traditional filesystem such as EXT, XFS, FAT, NTFS, UFS, or ZFS is placed on the block device, care must be taken that only one initiator at a time has read/write access or the result will be filesystem corruption. If multiple clients need access to the same data on a non-clustered filesystem, use SMB or NFS instead of iSCSI, or create multiple iSCSI targets (one per client).

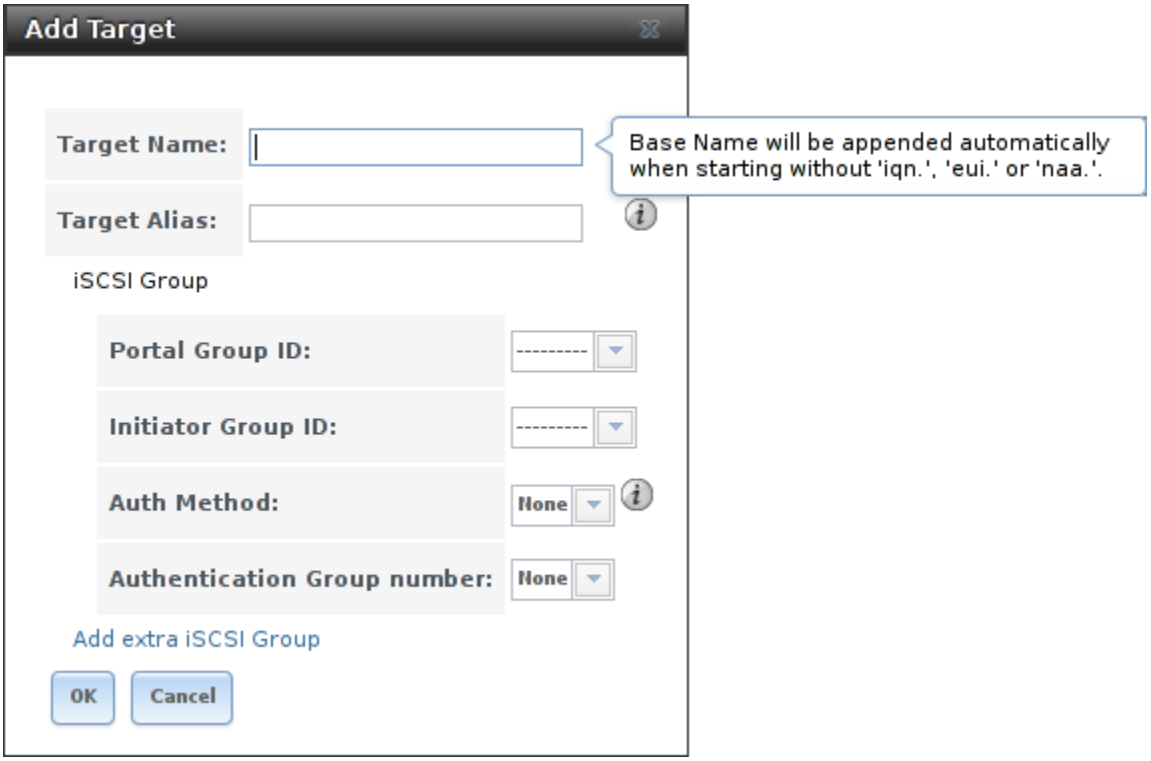


Fig. 10.24: Adding an iSCSI Target

Table 10.10: Target Settings

Setting	Value	Description
Target Name	string	Required value. Base name will be appended automatically if it does not start with *iqn*.
Target Alias	string	Enter an optional user-friendly name.
Portal Group ID	drop-down menu	Leave empty or select number of existing portal to use.
Initiator Group ID	drop-down menu	Select which existing initiator group has access to the target.
Auth Method	drop-down menu	Choices are *None*, *Auto*, *CHAP*, or *Mutual CHAP*.
Authentication Group number	drop-down menu	Select *None* or an integer representing number of existing authorized access.

10.5.6 Extents

iSCSI targets provide virtual access to resources on the FreeNAS® system. *Extents* are used to define resources to share with clients. There are two types of extents: *device* and *file*.

Device extents provide virtual storage access to zvols, zvol snapshots, or physical devices like a disk, an SSD, a hardware RAID volume, or a HAST device (https://www.freebsd.org/doc/en_US.ISO8859-1/books/handbook/disks-hast.html).

File extents provide virtual storage access to an individual file.

Tip: For typical use as storage for virtual machines where the virtualization software is the iSCSI initiator, device extents with zvols provide the best performance and most features. For other applications, device extents sharing a raw device can be appropriate. File extents do not have the performance or features of device extents, but do allow creating

multiple extents on a single filesystem.

Virtualized zvols support all the FreeNAS® *VAAI* (page 318) primitives and are recommended for use with virtualization software as the iSCSI initiator.

The ATS, WRITE SAME, XCOPY and STUN, primitives are supported by both file and device extents. The UNMAP primitive is supported by zvols and raw SSDs. The threshold warnings primitive is fully supported by zvols and partially supported by file extents.

Virtualizing a raw device like a single disk or hardware RAID volume limits performance to the abilities of the device. Because this bypasses ZFS, such devices do not benefit from ZFS caching or provide features like block checksums or snapshots.

Virtualizing a zvol adds the benefits of ZFS, such as read and write cache. Even if the client formats a device extent with a different filesystem, the data still resides on a ZFS volume and benefits from ZFS features like block checksums and snapshots.

Warning: For performance reasons and to avoid excessive fragmentation, keep the used space of the pool below 50% when using iSCSI. The capacity of an existing extent can be increased as shown in *Growing LUNs* (page 211).

To add an extent, go to `Sharing` → `Block (iSCSI)` → `Extents` → `Add Extent`. In the example shown in Figure 10.25, the device extent is using the `export` zvol that was previously created from the `/mnt/volume1` volume.

Table 10.11 summarizes the settings that can be configured when creating an extent. Note that **file extent creation fails when the name of the file to be created to the volume/dataset name.** is not appended.

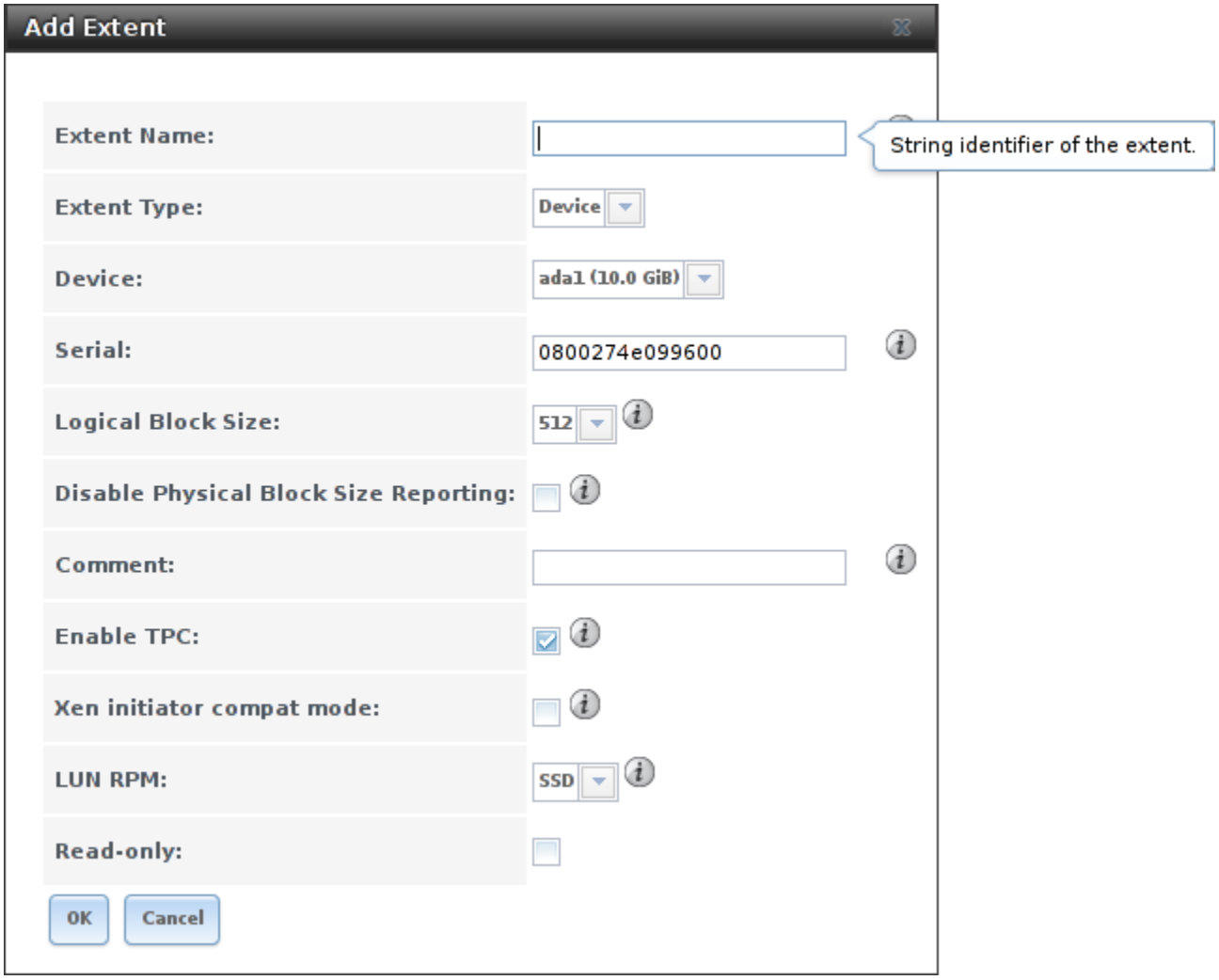


Fig. 10.25: Adding an iSCSI Extent

Table 10.11: Extent Configuration Settings

Setting	Value	Description
Extent Name	string	Enter the extent name. If the *Extent size* is not *0*, it cannot be an existing file within the volume/dataset.
Extent Type	drop-down menu	Select from *File* or *Device*.
Device	drop-down menu	Only appears if *Device* is selected. Select the unformatted disk, controller, zvol, zvol snapshot, or HAST device.
Serial	string	Unique LUN ID. The default is generated from the system MAC address.
Path to the extent	browse button	Only appears if *File* is selected. Browse to an existing file and use *0* as the *Extent size*, **or** browse to the volume or dataset, click *Close*, append the *Extent Name* to the path, and specify a value in *Extent size*. Extents cannot be created inside the jail root directory.
Extent size	integer	Only appears if *File* is selected. If the size is specified as *0*, the file must already exist and the actual file size will be used. Otherwise, specify the size of the file to create.
Logical Block Size	drop-down menu	Only override the default if the initiator requires a different block size.

Continued on next page

Table 10.11 – continued from previous page

Setting	Value	Description
Disable Physical Block Size Reporting	checkbox	Set if the initiator does not support physical block size values over 4K (MS SQL). Setting can also prevent constant block size warnings (https://www.virten.net/2016/12/the-physical-block-size-reported-by-the-device-is-not-supported/) when using this share with ESXi.
Available Space Threshold	string	Only appears if *File* or a zvol is selected. When the specified percentage of free space is reached, the system issues an alert. See *VAAI* (page 318) Threshold Warning for more information.
Comment	string	Enter an optional comment.
Enable TPC	checkbox	If enabled, an initiator can bypass normal access control and access any scannable target. This allows `xcopy` operations otherwise blocked by access control.
Xen initiator compat mode	checkbox	Set this option when using Xen as the iSCSI initiator.
LUN RPM	drop-down menu	Do **NOT** change this setting when using Windows as the initiator. Only needs to be changed in large environments where the number of systems using a specific RPM is needed for accurate reporting statistics.
Read-only	checkbox	Set to prevent the initiator from initializing this LUN .

10.5.7 Target/Extents

The last step is associating an extent to a target within `Sharing → Block (iSCSI) → Associated Targets → Add Target/Extent`. This screen is shown in Figure 10.26. Use the drop-down menus to select the existing target and extent. Click *OK* to add an entry for the LUN.

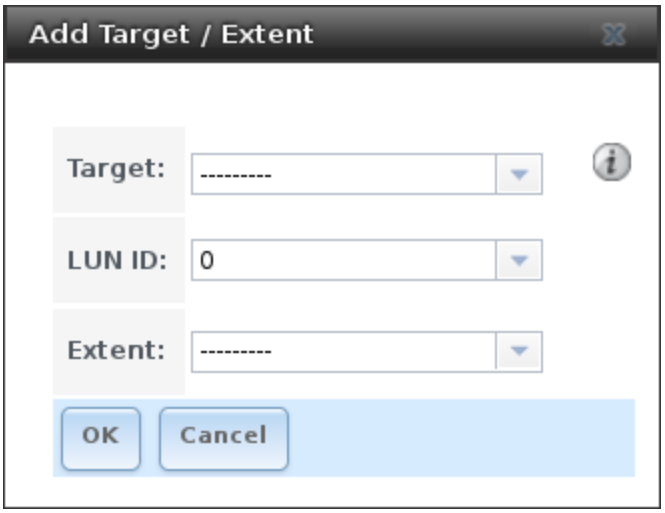


Fig. 10.26: Associating a Target With an Extent

Table 10.12 summarizes the settings that can be configured when associating targets and extents.

Table 10.12: Target/Extents Configuration Settings

Setting	Value	Description
Target	drop-down menu	Select an existing target.
LUN ID	drop-down menu	Select the value to use or type in a value between *1* and *1023*. Note that some initiators expect a value below *256*.
Extent	drop-down menu	Select an existing extent.

Always associating extents to targets in a one-to-one manner is recommended, even though the GUI will allow multiple extents to be associated with the same target.

Note: Each LUN entry has *Edit* and *Delete* buttons for modifying the settings or deleting the LUN entirely. A verification popup appears when the *Delete* button is clicked. If an initiator has an active connection to the LUN, it is indicated in red text. Clearing initiator connections to a LUN before deleting it is recommended.

After iSCSI has been configured, remember to start it in `Services → Control Services`. Click the red *OFF* button next to iSCSI. After a second or so, it will change to a blue *ON*, indicating that the service has started.

10.5.8 Connecting to iSCSI

To access the iSCSI target, clients must use iSCSI initiator software.

An iSCSI Initiator client is pre-installed with Windows 7. A detailed how-to for this client can be found here (http://techgenix.com/Connecting-Windows-7-iSCSI-SAN/). A client for Windows 2000, XP, and 2003 can be found here (http://www.microsoft.com/en-us/download/details.aspx?id=18986). This how-to (https://www.pluralsight.com/blog/software-development/freenas-8-iscsi-target-windows-7) shows how to create an iSCSI target for a Windows 7 system.

Mac OS X does not include an initiator. globalSAN (http://www.studionetworksolutions.com/globalsan-iscsi-initiator/) is a commercial, easy-to-use Mac initiator.

BSD systems provide command line initiators: iscontrol(8) (https://www.freebsd.org/cgi/man.cgi?query=iscontrol) comes with FreeBSD versions 9.x and lower, iscsictl(8) (https://www.freebsd.org/cgi/man.cgi?query=iscsictl) comes with FreeBSD versions 10.0 and higher, iscsi-initiator(8) (http://netbsd.gw.com/cgi-bin/man-cgi?iscsi-initiator++NetBSD-current) comes with NetBSD, and iscsid(8) (http://man.openbsd.org/cgi-bin/man.cgi/OpenBSD-current/man8/iscsid.8?query=iscsid) comes with OpenBSD.

Some Linux distros provide the command line utility `iscsiadm` from Open-iSCSI (http://www.open-iscsi.com/). Use a web search to see if a package exists for the distribution should the command not exist on the Linux system.

If a LUN is added while `iscsiadm` is already connected, it will not see the new LUN until rescanned with `iscsiadm -m node -R`. Alternately, use `iscsiadm -m discovery -t st -p portal_IP` to find the new LUN and `iscsiadm -m node -T LUN_Name -l` to log into the LUN.

Instructions for connecting from a VMware ESXi Server can be found at How to configure FreeNAS 8 for iSCSI and connect to ESX(i) (https://www.vladan.fr/how-to-configure-freenas-8-for-iscsi-and-connect-to-esxi/). Note that the requirements for booting vSphere 4.x off iSCSI differ between ESX and ESXi. ESX requires a hardware iSCSI adapter while ESXi requires specific iSCSI boot firmware support. The magic is on the booting host side, meaning that there is no difference to the FreeNAS® configuration. See the iSCSI SAN Configuration Guide (https://www.vmware.com/pdf/vsphere4/r41/vsp_41_iscsi_san_cfg.pdf) for details.

The VMware firewall only allows iSCSI connections on port 3260 by default. If a different port has been selected, outgoing connections to that port must be manually added to the firewall before those connections will work.

If the target can be seen but does not connect, check the *Discovery Auth* settings in *Target Global Configuration*.

If the LUN is not discovered by ESXi, make sure that promiscuous mode is set to *Accept* in the vSwitch.

10.5.9 Growing LUNs

The method used to grow the size of an existing iSCSI LUN depends on whether the LUN is backed by a file extent or a zvol. Both methods are described in this section.

Enlarging a LUN with one of the methods below gives it more unallocated space, but does not automatically resize filesystems or other data on the LUN. This is the same as binary-copying a smaller disk onto a larger one. More space is available on the new disk, but the partitions and filesystems on it must be expanded to use this new space. Resizing virtual disk images is usually done from virtual machine management software. Application software to resize filesystems is dependent on the

type of filesystem and client, but is often run from within the virtual machine. For instance, consider a Windows VM with the last partition on the disk holding an NTFS filesystem. The LUN is expanded and the partition table edited to add the new space to the last partition. The Windows disk manager must still be used to resize the NTFS filesystem on that last partition to use the new space.

Zvol Based LUN

To grow a zvol based LUN, go to `Storage → Volumes → View Volumes`, highlight the zvol to be grown, and click *Edit zvol*. In the example shown in Figure 10.27, the current size of the zvol named *zvol1* is 4GB.

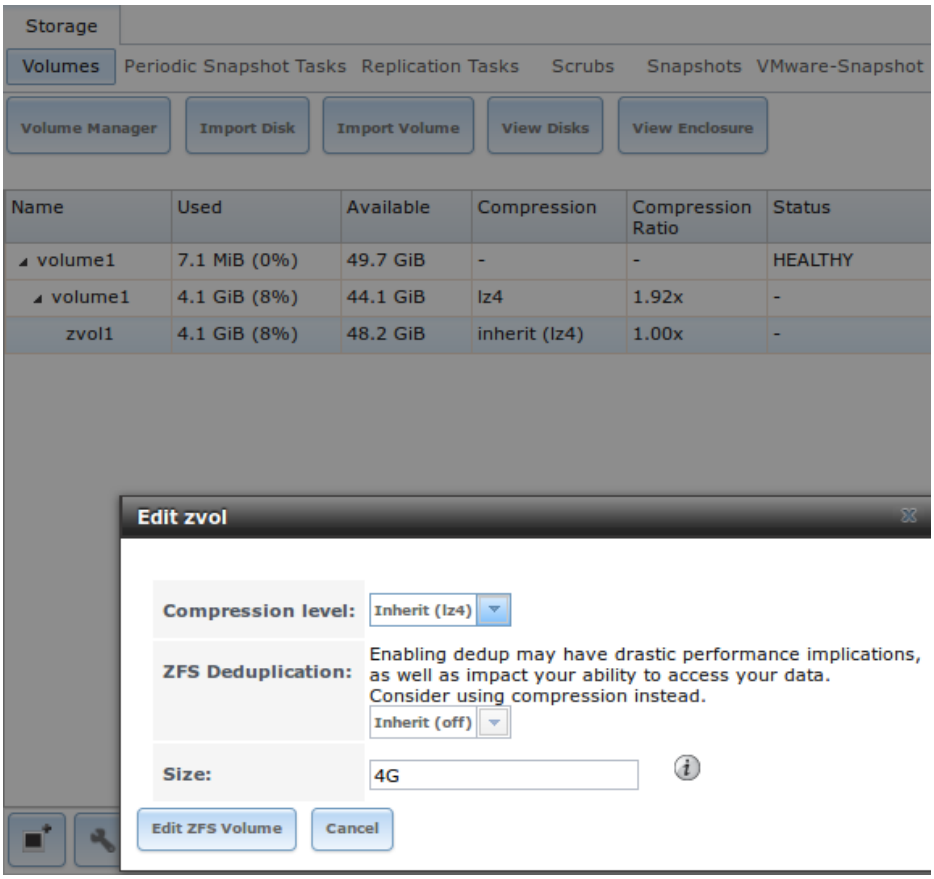


Fig. 10.27: Editing an Existing Zvol

Enter the new size for the zvol in the *Size* field and click *Edit ZFS Volume*. This menu closes and the new size for the zvol is immediately shown in the *Used* column of the *View Volumes* screen.

Note: The GUI does not allow reducing (shrinking) the size of the zvol, as doing so could result in loss of data. It also does not allow increasing the size of the zvol past 80% of the volume size.

File Extent Based LUN

To grow a file extent based LUN, go to `Services → iSCSI → File Extents → View File Extents` to determine the path of the file extent to grow. Open Shell to grow the extent. This example grows `/mnt/volume1/data` by 2 G:

```
truncate -s +2g /mnt/volume1/data
```

Go back to `Services → iSCSI → File Extents → View File Extents` and click the *Edit* button for the file extent. Set the size to *0* as this causes the iSCSI target to use the new size of the file.

CHAPTER

ELEVEN

SERVICES

Services that ship with FreeNAS® are configured, started, or stopped in *Services*. FreeNAS® includes these built-in services:

- *AFP* (page 216)
- *Domain Controller* (page 217)
- *Dynamic DNS* (page 219)
- *FTP* (page 220)
- *iSCSI* (page 225)
- *LLDP* (page 225)
- *Netdata* (page 226)
- *NFS* (page 227)
- *Rsync* (page 229)
- *S3* (page 231)
- *S.M.A.R.T.* (page 233)
- *SMB* (page 234)
- *SNMP* (page 238)
- *SSH* (page 240)
- *TFTP* (page 242)
- *UPS* (page 243)
- *WebDAV* (page 247)

This section demonstrates starting a FreeNAS® service and the available configuration options for each FreeNAS® service.

11.1 Control Services

`Services → Control Services`, shown in Figure 11.1, lists all services. It also shows where to start, stop, or configure the available services. The S.M.A.R.T. service is enabled by default, but only runs if the storage devices support S.M.A.R.T. data (https://en.wikipedia.org/wiki/S.M.A.R.T.) Other services default to off until started.

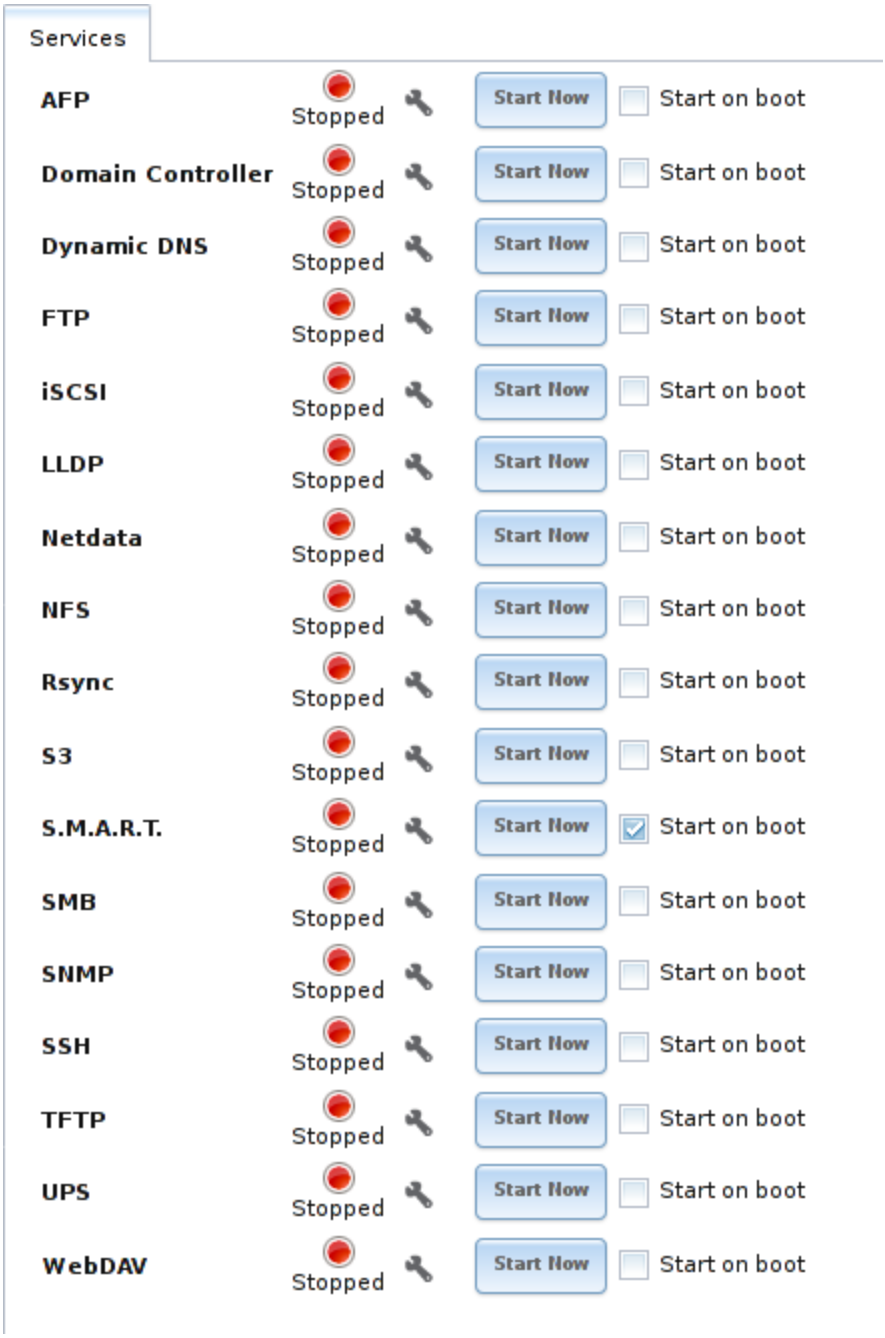


Fig. 11.1: Control Services

Stopped services show a red stop symbol and a *Start Now* button. Running services show a green light with a *Stop Now* button.

Tip: Using a proxy server can prevent the list of services from being displayed. If a proxy server is used, do not configure it to proxy local network connections or websocket connections. VPN software can also cause problems. If the list of services is displayed when connecting on the local network but not when connecting through the VPN, check the VPN software configuration.

Services are configured by clicking the wrench icon or the name of the service in the *Services* section of the tree menu.

If a service does not start, go to `System → Advanced` and enable *Show console messages in the footer*. Console messages

appear at the bottom of the browser. Clicking the console message area makes it into a pop-up window, allowing scrolling through or copying the messages. Watch these messages for errors when stopping or starting the problematic service.

To read the system logs for more information about a service failure, open *Shell* (page 282) and type `more /var/log/messages`.

11.2 AFP

The settings that are configured when creating AFP Shares in `Sharing → Apple (AFP) Shares → Add Apple (AFP) Share` are specific to each configured AFP Share. In contrast, global settings which apply to all AFP shares are configured in `Services → AFP`.

Figure 11.2 shows the available global AFP configuration options which are described in Table 11.1.

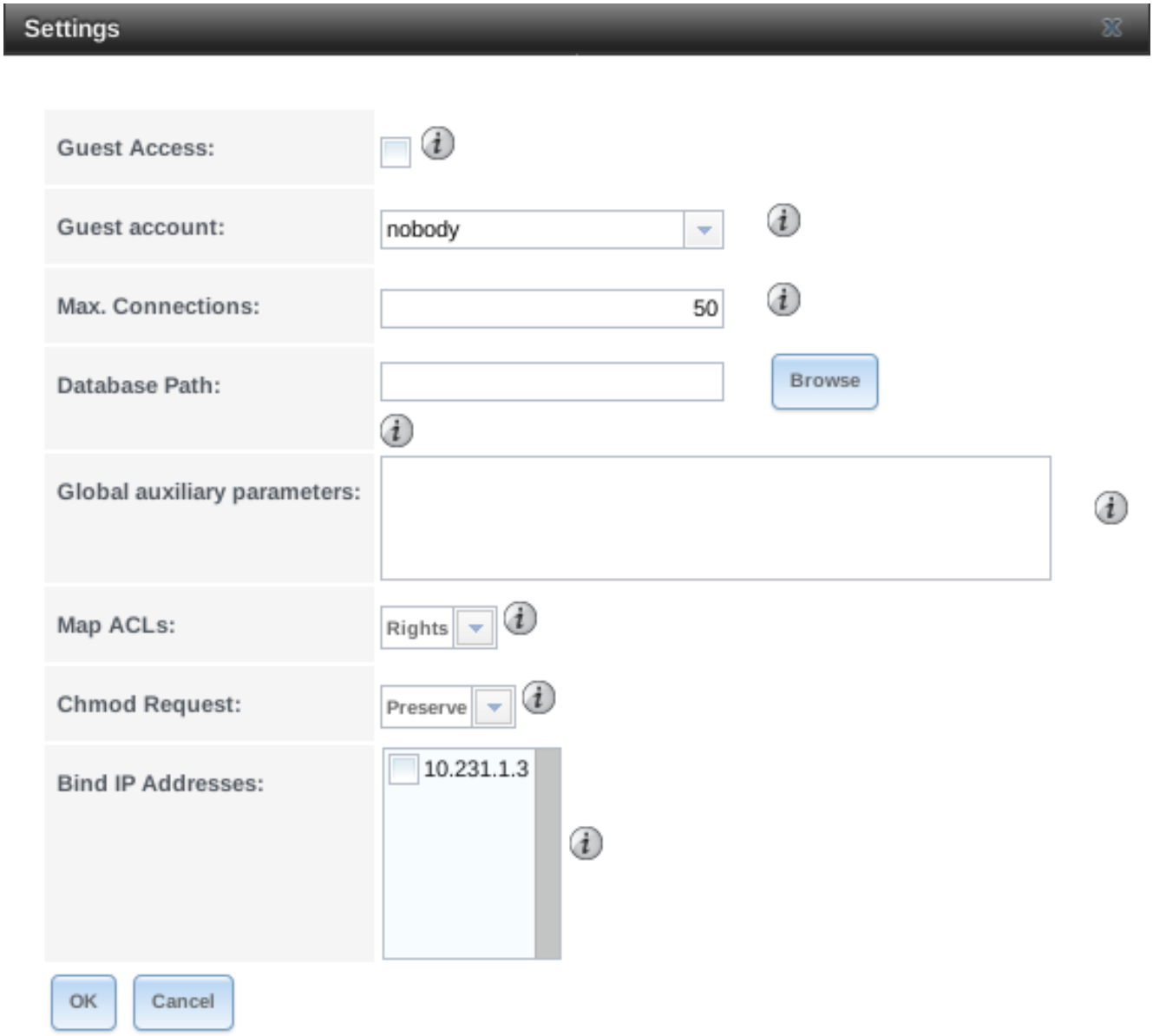


Fig. 11.2: Global AFP Configuration

Table 11.1: Global AFP Configuration Options

Setting	Value	Description
Guest Access	checkbox	Set to disable the password prompt that appears before clients access AFP shares.
Guest account	drop-down menu	Select an account to use for guest access. The account must have permissions to the volume or dataset being shared.
Max Connections	integer	Maximum number of simultaneous connections.
Database Path	browse button	Sets the database information to be stored in the path. Default is the root of the volume. The path must be writable even if the volume is read only.
Global auxiliary parameters	string	Add any additional afp.conf(5) (http://netatalk.sourceforge.net/3.0/htmldocs/afp.conf.5.html) parameters not covered elsewhere in this screen.
Map ACLs	drop-down menu	Choose mapping of effective permissions for authenticated users. Choices are: *Rights* (default, Unix-style permissions), *Mode* (ACLs), or *None*
Chmod Request	drop-down menu	Sets how Access Control Lists are handled. *Ignore*: ignores requests and gives the parent directory ACL inheritance full control over new items. *Preserve*: preserves ZFS Access Control Entries for named users and groups or the POSIX ACL group mask. *Simple*: is set to chmod() as requested without any extra steps.
Bind IP Addresses	selection	Specify the IP addresses to listen for FTP connections. Highlight the desired IP addresses in the *Available* list and use the >> button to add to the *Selected* list.

11.2.1 Troubleshooting AFP

Check for error messages in `/var/log/afp.log`.

Determine which users are connected to an AFP share by typing `afpusers`.

If *Something wrong with the volume's CNID DB* is shown, run this command from *Shell* (page 282), replacing the path to the problematic AFP share:

```
dbd -rf /path/to/share
```

This command can take some time, depending upon the size of the pool or dataset being shared. The CNID database is wiped and rebuilt from the CNIDs stored in the AppleDouble files.

11.3 Domain Controller

FreeNAS® can be configured to act either as the domain controller for a network or to join an existing *Active Directory* (page 162) network as a domain controller.

Note: This section demonstrates how to configure the FreeNAS® system to act as a domain controller. If the goal is to integrate with an existing *Active Directory* (page 162) network to access its authentication and authorization services, configure *Active Directory* (page 162) instead.

Note that configuring a domain controller is a complex process that requires a good understanding of how *Active Directory* (page 162) works. While `Services → Domain Controller` makes it easy to enter the needed settings into the administrative graphical interface, it is important to understand what those settings should be. Before beginning configuration, read through the Samba AD DC HOWTO (https://wiki.samba.org/index.php/Samba_AD_DC_HOWTO). After FreeNAS® is configured, use the RSAT utility from a Windows system to manage the domain controller. The Samba AD DC HOWTO includes instructions for installing and configuring RSAT.

Figure 11.3 shows the configuration screen for creating a domain controller and Table 11.2 summarizes the available options.

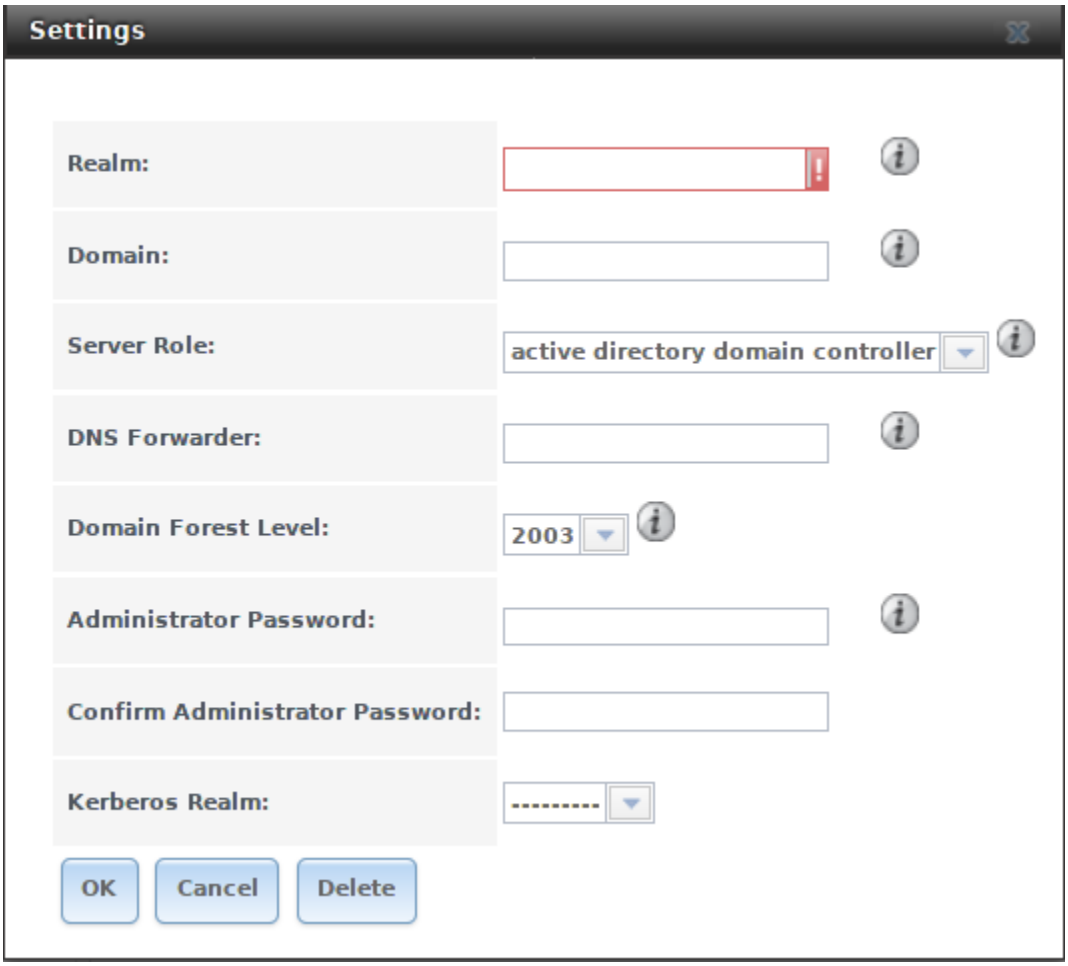


Fig. 11.3: Domain Controller Settings

Table 11.2: Domain Controller Configuration Options

Setting	Value	Description
Realm	string	Enter a capitalized DNS realm name.
Domain	string	Enter a capitalized domain name.
Server Role	drop-down menu	At this time, the only supported role is as the domain controller for a new domain.
DNS Forwarder	string	Enter the IP address of the DNS forwarder. Required for recursive queries when *SAMBA_INTERNAL* is selected.
Domain Forest Level	drop-down menu	Choices are *2000*, *2003*, *2008*, *2008_R2*, *2012*, or *2012_R2*. Refer to Understanding Active Directory Domain Services (AD DS) Functional Levels (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2008-R2-and-2008/cc754918(v=ws.10)).
Administrator password	string	Enter the password to be used for the *Active Directory* (page 162) administrator account.
Kerberos Realm	drop-down menu	Auto-populates with information from the *Realm* when the settings in this screen are saved.

11.3.1 Samba Domain Controller Backup

A `samba_backup` script is available to back up Samba4 domain controller settings is available. From the *Shell* (page 282), run `/usr/local/bin/samba_backup --usage` to show the input options.

11.4 Dynamic DNS

Dynamic DNS (DDNS) is useful if the FreeNAS® system is connected to an ISP that periodically changes the IP address of the system. With dynamic DNS, the system can automatically associate its current IP address with a domain name, allowing access to the FreeNAS® system even if the IP address changes. DDNS requires registration with a DDNS service such as DynDNS (https://dyn.com/dns/).

Figure 11.4 shows the DDNS configuration screen and Table 11.3 summarizes the configuration options. The values for these fields are provided by the DDNS provider. After configuring DDNS, remember to start the DDNS service in `Services → Control Services`.

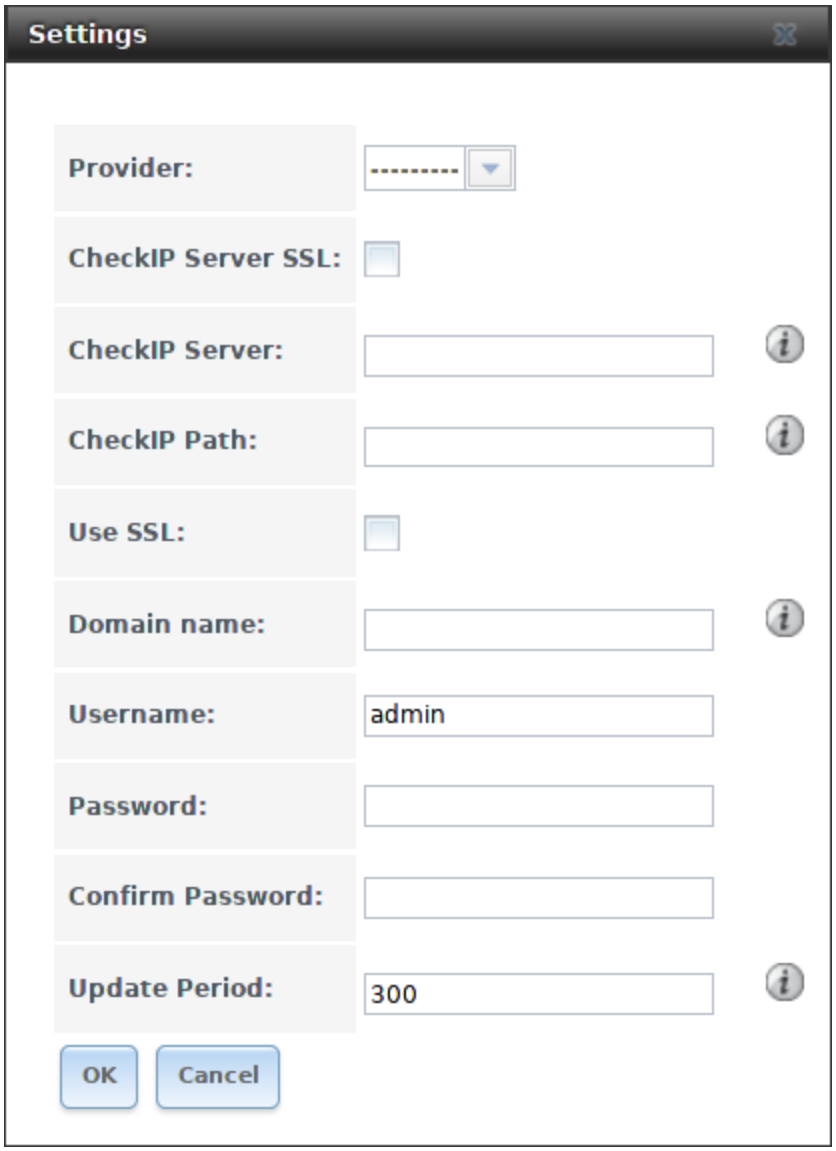


Fig. 11.4: Configuring DDNS

Table 11.3: DDNS Configuration Options

Setting	Value	Description
Provider	drop-down menu	Several providers are supported. If a specific provider is not listed, select *Custom Provider* and enter the information in the *Custom Server* and *Custom Path* fields.
CheckIP Server SSL	string	Set to use HTTPS for the connection to the *CheckIP Server*.
CheckIP Server	string	Enter the name and port of the server that reports the external IP address. Example: *server.name.org:port*.
CheckIP Path	string	Enter the path that is requested by the *CheckIP Server* to determine the user IP address.
Use SSL	checkbox	Set to use HTTPS for the connection to the server that updates the DNS record.
Domain name	string	Enter a fully qualified domain name. Example: *yourname.dyndns.org*.
Username	string	Enter the username used to log in to the provider and update the record.
Password	string	Enter the password used to log in to the provider and update the record.
Update period	integer	How often the IP is checked in seconds.

When using `he.net`, enter the domain name for *Username* and enter the DDNS key generated for that domain's A entry at the he.net (https://he.net) website for *Password*.

11.5 FTP

FreeNAS® uses the proftpd (http://www.proftpd.org/) FTP server to provide FTP services. Once the FTP service is configured and started, clients can browse and download data using a web browser or FTP client software. The advantage of FTP is that easy-to-use cross-platform utilities are available to manage uploads to and downloads from the FreeNAS® system. The disadvantage of FTP is that it is considered to be an insecure protocol, meaning that it should not be used to transfer sensitive files. If concerned about sensitive data, see *Encrypting FTP* (page 225).

This section provides an overview of the FTP configuration options. It then provides examples for configuring anonymous FTP, specified user access within a chroot environment, encrypting FTP connections, and troubleshooting tips.

Figure 11.5 shows the configuration screen for `Services → FTP`. Some settings are only available in *Advanced Mode*. To see these settings, either click the *Advanced Mode* button or configure the system to always display these settings by enabling the *Show advanced fields by default* setting in `System → Advanced`.

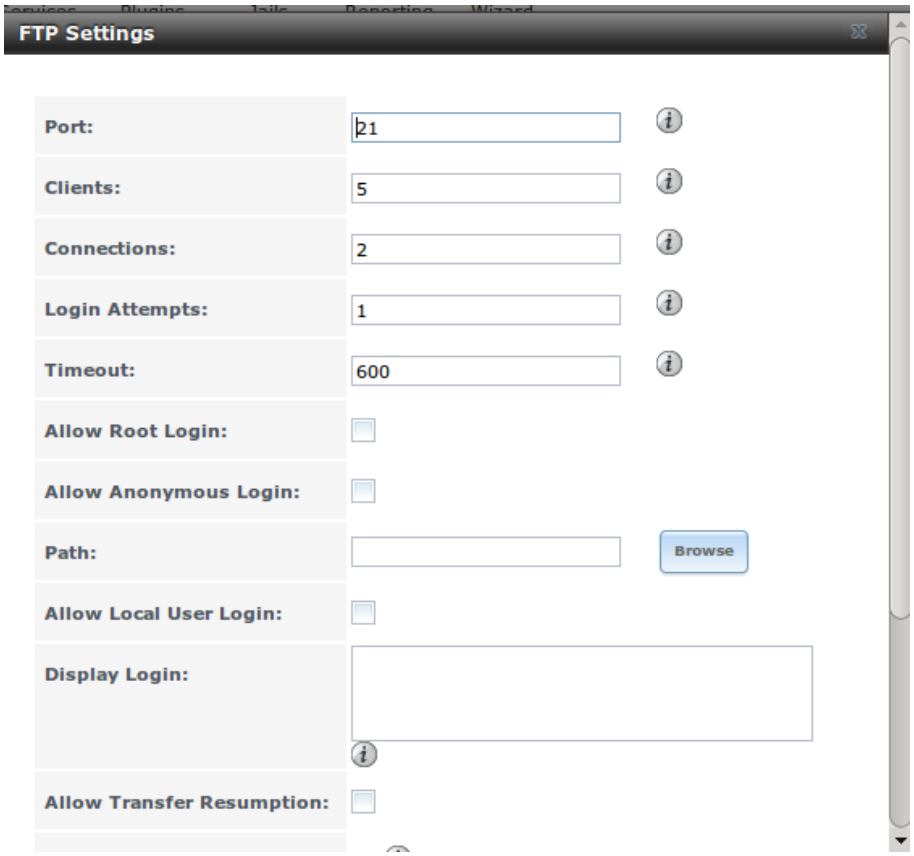


Fig. 11.5: Configuring FTP

Table 11.4 summarizes the available options when configuring the FTP server.

Table 11.4: FTP Configuration Options

Setting	Value	Advanced Mode	Description
Port	integer		Set the port the FTP service listens on.
Clients	integer		Set the maximum number of simultaneous clients.
Connections	integer		Set the maximum number of connections per IP address where *0* means unlimited.
Login Attempts	integer		Enter the maximum number of attempts before client is disconnected. Increase this if users are prone to typos.
Timeout	integer		Enter the maximum client idle time in seconds before client is disconnected.
Allow Root Login	checkbox		Enabling this option is discouraged as increases security risk.
Allow Anonymous Login	checkbox		Set to enable anonymous FTP logins with access to the directory specified in *Path*.
Path	browse button		Set the root directory for anonymous FTP connections.
Allow Local User Login	checkbox		Required if *Anonymous Login* is disabled.
Display Login	string		Specify the message displayed to local login users after authentication. Not displayed to anonymous login users.
File Permission	checkboxes	✓	Set the default permissions for newly created files.
Directory Permission	checkboxes	✓	Set the default permissions for newly created directories.

Continued on next page

Table 11.4 – continued from previous page

Setting	Value	Advanced Mode	Description
Enable FXP (https://en.wikipedia.org/wiki/File_eXchange_Protocol)	checkbox	✓	Set to enable the File eXchange Protocol. This setting makes the server vulnerable to FTP bounce attacks so it is not recommended
Allow Transfer Resumption	checkbox		Set to allow FTP clients to resume interrupted transfers.
Always Chroot	checkbox		When set, a local user is only allowed access to their home directory unless the user is a member of group *wheel*.
Require IDENT Authentication	checkbox	✓	Setting this option results in timeouts if `identd` is not running on the client.
Perform Reverse DNS Lookups	checkbox		Set to perform reverse DNS lookups on client IPs. Can cause long delays if reverse DNS is not configured.
Masquerade address	string		Public IP address or hostname. Set if FTP clients cannot connect through a NAT device.
Minimum passive port	integer	✓	Used by clients in PASV mode, default of *0* means any port above 1023.
Maximum passive port	integer	✓	Used by clients in PASV mode, default of *0* means any port above 1023.
Local user upload bandwidth	integer	✓	Defined in KB/s, default of *0* means unlimited.
Local user download bandwidth	integer	✓	Defined in KB/s, default of *0* means unlimited.
Anonymous user upload bandwidth	integer	✓	Defined in KB/s, default of *0* means unlimited.
Anonymous user download bandwidth	integer	✓	Defined in KB/s, default of *0* means unlimited.
Enable TLS	checkbox	✓	Set to enable encrypted connections. Requires a certificate to be created or imported using *Certificates* (page 81).
TLS policy	drop-down menu	✓	The selected policy defines whether the control channel, data channel, both channels, or neither channel of an FTP session must occur over SSL/TLS. The policies are described here (http://www.proftpd.org/docs/directives/linked/config_ref_TLSRequired.h
TLS allow client renegotiations	checkbox	✓	Enabling this option is **not** recommended as it breaks several security measures. For this and the rest of the TLS fields, refer to mod_tls (http://www.proftpd.org/docs/contrib/mod_tls.html) for more details.
TLS allow dot login	checkbox	✓	If set, the user home directory is checked for a `.tlslogin` file which contains one or more PEM-encoded certificates. If not found, the user is prompted for password authentication.
TLS allow per user	checkbox	✓	If set, the user password can be sent unencrypted.
TLS common name required	checkbox	✓	Set to require the common name in the certificate to match the FQDN of the host.
TLS enable diagnostics	checkbox	✓	If set when troubleshooting a connection, logs more verbosely.
TLS export certificate data	checkbox	✓	If set, exports the certificate environment variables.
TLS no certificate request	checkbox	✓	Try enabling this option if the client cannot connect and it is suspected the client software is not properly handling server certificate requests.
TLS no empty fragments	checkbox	✓	Enabling this option is **not** recommended as it bypasses a security mechanism.
TLS no session reuse required	checkbox	✓	Enabling this option reduces the security of the connection, so only use if the client does not understand reused SSL sessions.

Continued on next page

Table 11.4 – continued from previous page

Setting	Value	Advanced Mode	Description
TLS export standard vars	checkbox	✓	If enabled, sets several environment variables.
TLS DNS name required	checkbox	✓	If set, the client DNS name must resolve to its IP address and the cert must contain the same DNS name.
TLS IP address required	checkbox	✓	If set, the client certificate must contain the IP address that matches the IP address of the client.
Certificate	drop-down menu		The SSL certificate to be used for TLS FTP connections. To create a certificate, use `System → Certificates`.
Auxiliary parameters	string	✓	Add any additional proftpd(8) (https://linux.die.net/man/8/proftpd) parameters not covered elsewhere in this screen.

This example demonstrates the auxiliary parameters that prevent all users from performing the FTP DELETE command:

```
<Limit DELE>
DenyAll
</Limit>
```

11.5.1 Anonymous FTP

Anonymous FTP may be appropriate for a small network where the FreeNAS® system is not accessible from the Internet and everyone in the internal network needs easy access to the stored data. Anonymous FTP does not require a user account for every user. In addition, passwords are not required so it is not necessary to manage changed passwords on the FreeNAS® system.

To configure anonymous FTP:

1. Give the built-in ftp user account permissions to the volume/dataset to be shared in `Storage → Volumes` as follows:
   - *Owner(user)*: select the built-in *ftp* user from the drop-down menu
   - *Owner(group)*: select the built-in *ftp* group from the drop-down menu
   - *Mode*: review that the permissions are appropriate for the share

   Note: For FTP, the type of client does not matter when it comes to the type of ACL. This means that Unix ACLs are always used, even if Windows clients are accessing FreeNAS® via FTP.

2. Configure anonymous FTP in `Services → FTP` by setting the following attributes:
   - *Allow Anonymous Login*: enable this option
   - *Path*: browse to the volume/dataset/directory to be shared
3. Start the FTP service in `Services → Control Services`. Click the *Start Now* button next to *FTP*. The FTP service takes a second or so to start. The indicator changes to green when the service is running, and the button changes to *Stop Now*.
4. Test the connection from a client using a utility such as Filezilla (https://filezilla-project.org/).

In the example shown in Figure 11.6, the user has entered this information into the Filezilla client:

- IP address of the FreeNAS® server: *192.168.1.113*
- *Username*: *anonymous*
- *Password*: the email address of the user

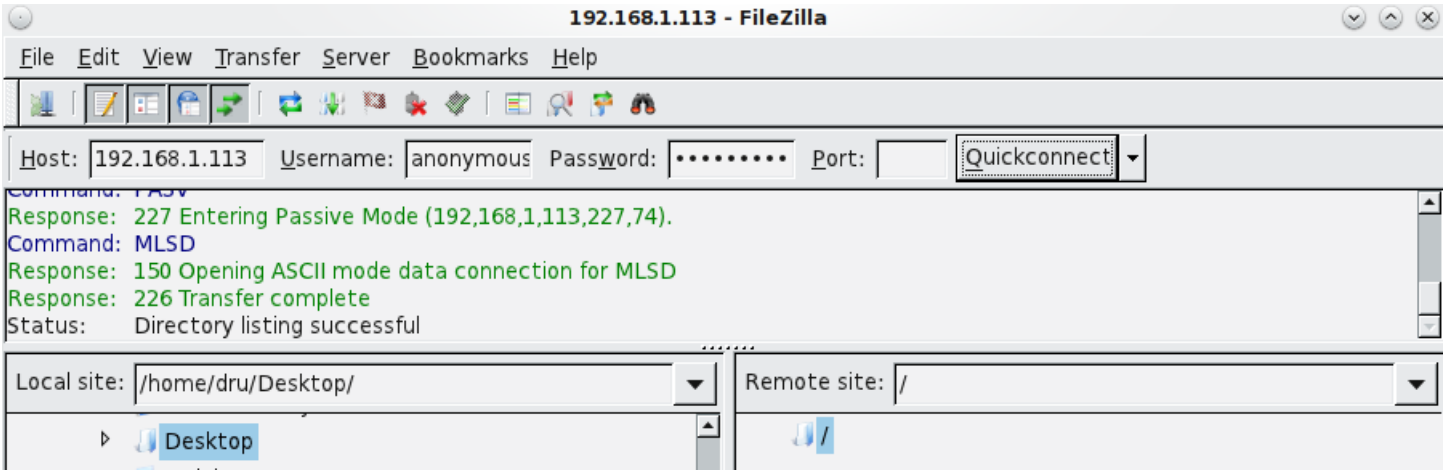


Fig. 11.6: Connecting Using Filezilla

The messages within the client indicate the FTP connection is successful. The user can now navigate the contents of the root folder on the remote site. This is the pool or dataset specified in the FTP service configuration. The user can also transfer files between the local site (their system) and the remote site (the FreeNAS® system).

11.5.2 FTP in chroot

If users are required to authenticate before accessing the data on the FreeNAS® system, either create a user account for each user or import existing user accounts using *Active Directory* (page 162) or *LDAP* (page 167). Then create a ZFS dataset for *each* user. Next, chroot each user so they are limited to the contents of their own home directory. Datasets provide the added benefit of configuring a quota so that the size of a user home directory is limited to the size of the quota.

To configure this scenario:

1. Create a ZFS dataset for each user in `Storage → Volumes`. Click an existing `ZFS volume → Create ZFS Dataset` and set an appropriate quota for each dataset. Repeat this process to create a dataset for every user that needs access to the FTP service.
2. When not using AD or LDAP, create a user account for each user in `Account → Users → Add User`. For each user, browse to the dataset created for that user in the *Home Directory* field. Repeat this process to create a user account for every user that needs access to the FTP service, making sure to assign each user their own dataset.
3. Set the permissions for each dataset in `Storage → Volumes`. Click the *Change Permissions* button for a dataset to assign a user account as *Owner* of that dataset and to set the desired permissions for that user. Repeat for each dataset.

   Note: For FTP, the type of client does not matter when it comes to the type of ACL. This means Unix ACLs are always used, even if Windows clients will be accessing FreeNAS® with FTP.

4. Configure FTP in `Services → FTP` with these attributes:
   - *Path*: browse to the parent volume containing the datasets.
   - Make sure the options for *Allow Anonymous Login* and *Allow Root Login* are **unselected**.
   - Select the *Allow Local User Login* option to enable it.
   - Enable the *Always Chroot* option.
5. Start the FTP service in `Services → Control Services`. Click the *Start Now* button next to *FTP*. The FTP service takes a second or so to start. The indicator changes to green to show that the service is running, and the button changes to *Stop Now*.

6. Test the connection from a client using a utility such as Filezilla.

To test this configuration in Filezilla, use the *IP address* of the FreeNAS® system, the *Username* of a user that is associated with a dataset, and the *Password* for that user. The messages will indicate the authorization and the FTP connection are successful. The user can now navigate the contents of the root folder on the remote site. This time it is not the entire pool but the dataset created for that user. The user can transfer files between the local site (their system) and the remote site (their dataset on the FreeNAS® system).

11.5.3 Encrypting FTP

To configure any FTP scenario to use encrypted connections:

1. Import or create a certificate authority using the instructions in *CAs* (page 79). Then, import or create the certificate to use for encrypted connections using the instructions in *Certificates* (page 81).
2. In `Services → FTP`, choose the certificate in the *Certificate*, and set the *Enable TLS* option.
3. Specify secure FTP when accessing the FreeNAS® system. For example, in Filezilla enter *ftps://IP_address* (for an implicit connection) or *ftpes://IP_address* (for an explicit connection) as the Host when connecting. The first time a user connects, they will be presented with the certificate of the FreeNAS® system. Click *OK* to accept the certificate and negotiate an encrypted connection.
4. To force encrypted connections, select *on* for the *TLS Policy*.

11.5.4 Troubleshooting FTP

The FTP service will not start if it cannot resolve the system hostname to an IP address with DNS. To see if the FTP service is running, open *Shell* (page 282) and issue the command:

```
sockstat -4p 21
```

If there is nothing listening on port 21, the FTP service is not running. To see the error message that occurs when FreeNAS® tries to start the FTP service, go to `System → Advanced`, check *Show console messages in the footer*, and click *Save*. Go to `Services → Control Services` and switch the FTP service off, then back on. Watch the console messages at the bottom of the browser for errors.

If the error refers to DNS, either create an entry in the local DNS server with the FreeNAS® system hostname and IP address, or add an entry for the IP address of the FreeNAS® system in the `Network → Global Configuration` *Host name database* field.

11.6 iSCSI

Refer to *Block (iSCSI)* (page 199) for instructions on configuring iSCSI. To start the iSCSI service, click its entry in *Services*.

Note: A warning message is shown if the iSCSI service is stopped when initiators are connected. Open the *Shell* (page 282) and type `ctladm islist` to determine the names of the connected initiators.

11.7 LLDP

The Link Layer Discovery Protocol (LLDP) is used by network devices to advertise their identity, capabilities, and neighbors on an Ethernet network. FreeNAS® uses the ladvd (https://github.com/sspans/ladvd) LLDP implementation. If the network contains managed switches, configuring and starting the LLDP service will tell the FreeNAS® system to advertise itself on the network.

Figure 11.7 shows the LLDP configuration screen and Table 11.5 summarizes the configuration options for the LLDP service.

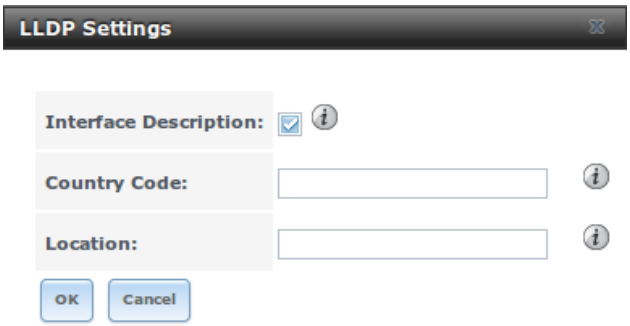


Fig. 11.7: Configuring LLDP

Table 11.5: LLDP Configuration Options

Setting	Value	Description
Interface Description	checkbox	Set to enable receive mode and to save received peer information in interface descriptions.
Country Code	string	Required for LLDP location support. Enter a two-letter ISO 3166 country code.
Location	string	Optional. Specify the physical location of the host.

11.8 Netdata

Netdata is a real-time performance and monitoring system. It displays data as web dashboards.

Start the Netdata service from the *Services* (page 214) screen. Click the wrench icon to display the Netdata settings dialog shown in Figure 11.8.

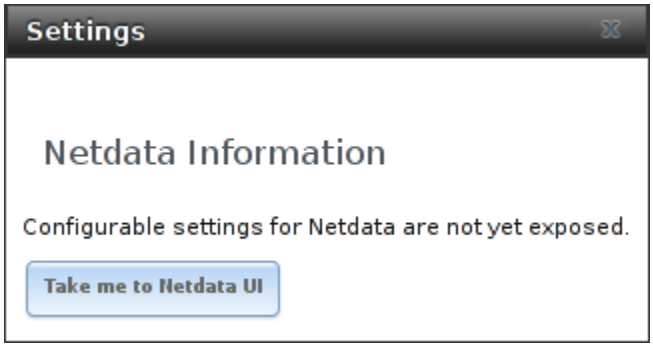


Fig. 11.8: Netdata Settings Dialog

Click the *Take me to the Netdata UI* button to view the web dashboard as shown in Figure 11.9.

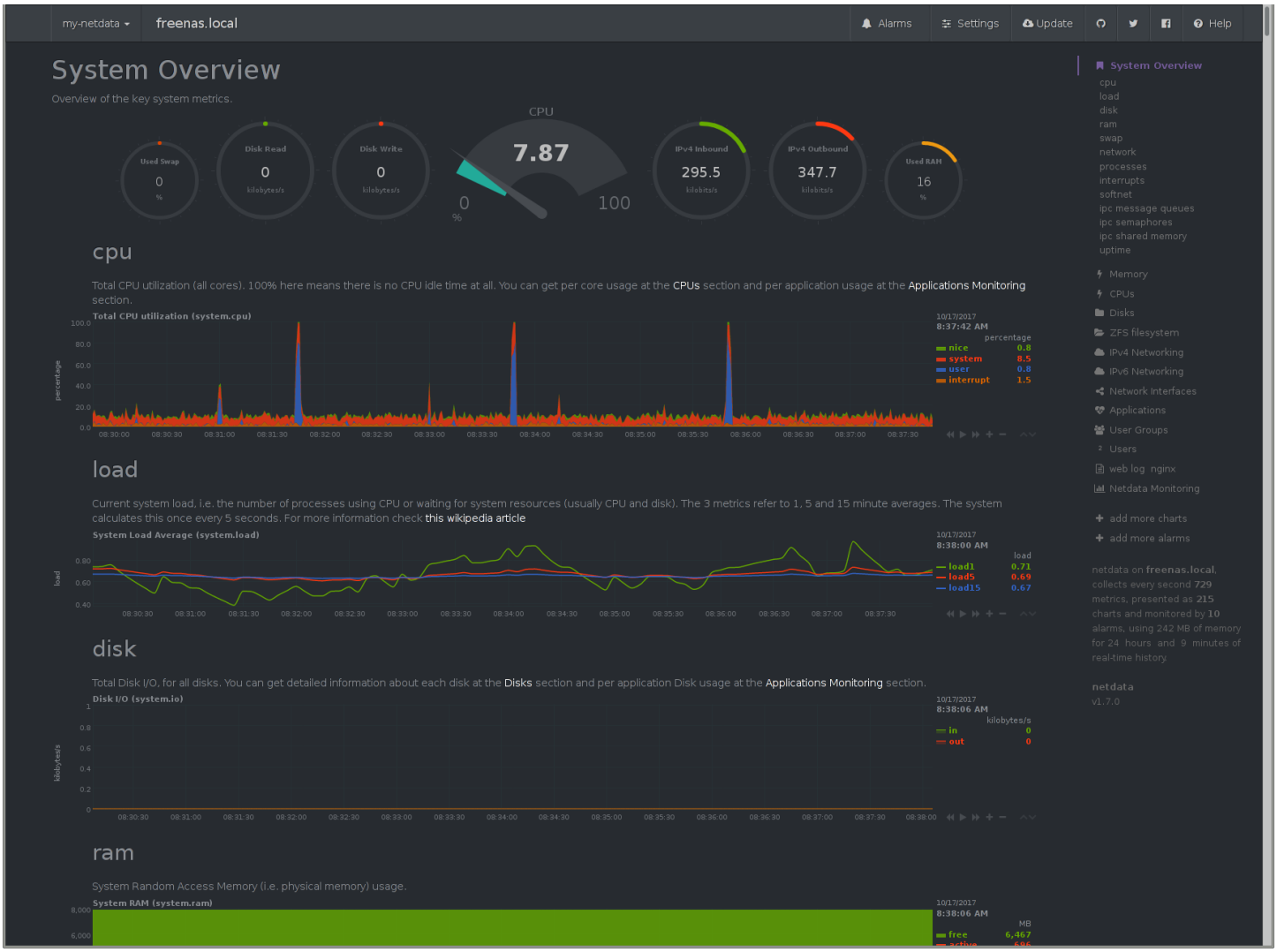


Fig. 11.9: Netdata Web Dashboard

More information on configuring and using Netdata is available at the Netdata website (https://my-netdata.io/).

11.9 NFS

The settings that are configured when creating NFS Shares in `Sharing → Unix (NFS) Shares → Add Unix (NFS) Share` are specific to each configured NFS Share. In contrast, global settings which apply to all NFS shares are configured in `Services → NFS`.

Figure 11.10 shows the configuration screen and Table 11.6 summarizes the configuration options for the NFS service.

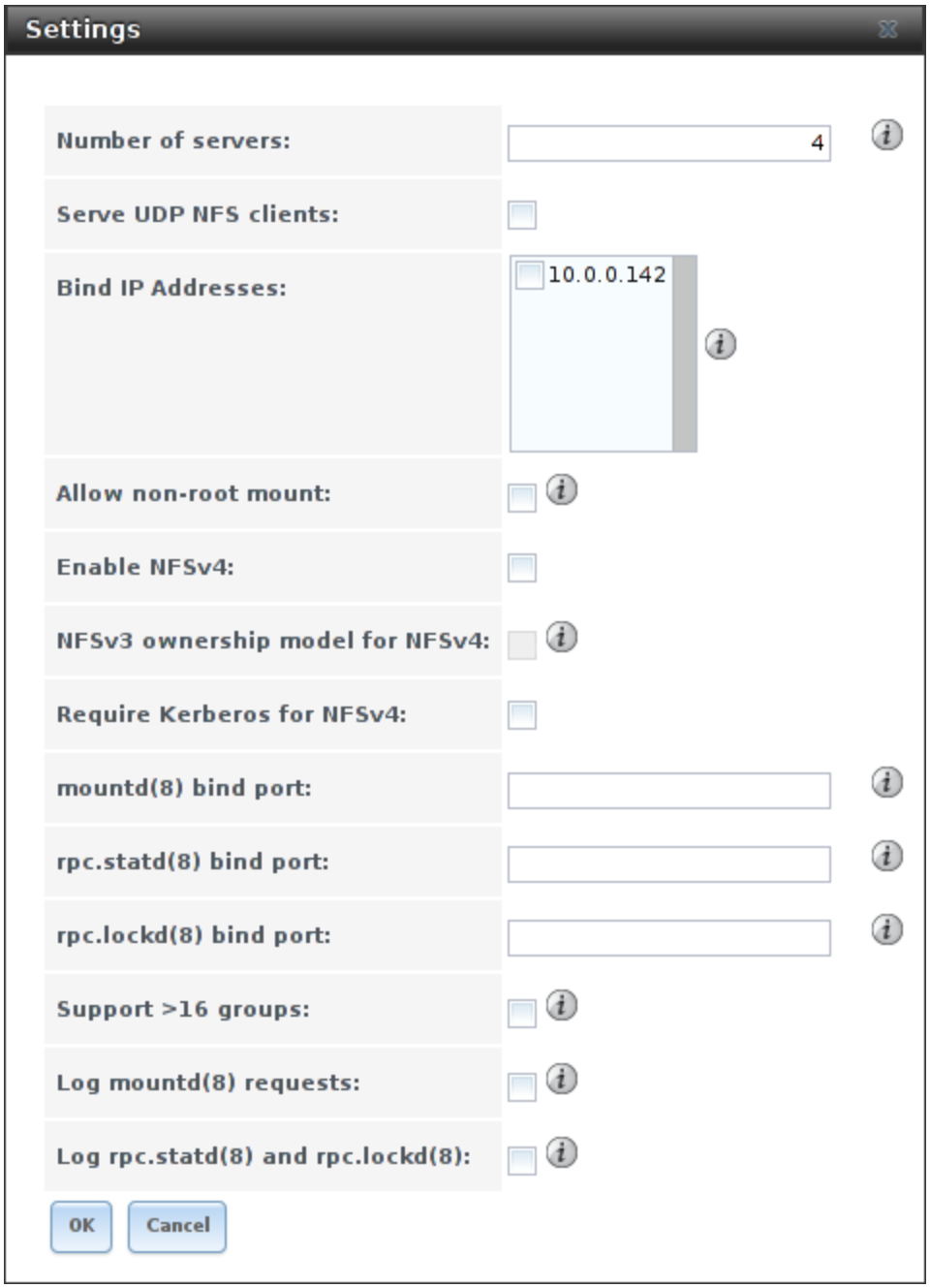


Fig. 11.10: Configuring NFS

Table 11.6: NFS Configuration Options

Setting	Value	Description
Number of servers	integer	Specify how many servers to create. Increase if NFS client responses are slow. To limit CPU context switching, keep this number less than or equal to the number of CPUs reported by `sysctl -n kern.smp.cpus`.
Serve UDP NFS clients	checkbox	Set if NFS clients need to use UDP.
Bind IP Addresses	checkboxes	Select the IP addresses to listen on for NFS requests. When unselected, NFS listens on all available addresses.

Continued on next page

Table 11.6 – continued from previous page

Setting	Value	Description
Allow non-root mount	checkbox	Set only if the NFS client requires it.
Enable NFSv4	checkbox	Set to switch from NFSv3 to NFSv4. The default is NFSv3.
NFSv3 ownership model for NFSv4	checkbox	Grayed out unless *Enable NFSv4* is checked and, in turn, grays out *Support>16 groups* which is incompatible. Set this option if NFSv4 ACL support is needed without requiring the client and the server to sync users and groups.
Require Kerberos for NFSv4	checkbox	Set to force NFS shares to fail if the Kerberos ticket is unavailable.
mountd(8) bind port	integer	Optional. Specify the port that mountd(8) (https://www.freebsd.org/cgi/man.cgi?query=mountd) binds to.
rpc.statd(8) bind port	integer	Optional. Specify the port that rpc.statd(8) (https://www.freebsd.org/cgi/man.cgi?query=rpc.statd) binds to.
rpc.lockd(8) bind port	integer	Optional. Specify the port that rpc.lockd(8) (https://www.freebsd.org/cgi/man.cgi?query=rpc.lockd) binds to.
Support>16 groups	checkbox	Set this option if any users are members of more than 16 groups (useful in AD environments). Note this assumes group membership is configured correctly on the NFS server.
Log mountd(8) requests	checkbox	Enable logging of mountd(8) (https://www.freebsd.org/cgi/man.cgi?query=mountd) requests by syslog.
Log rpc.statd(8) and rpc.lockd(8)	checkbox	Enable logging of rpc.statd(8) (https://www.freebsd.org/cgi/man.cgi?query=rpc.statd) and rpc.lockd(8) (https://www.freebsd.org/cgi/man.cgi?query=rpc.lockd) requests by syslog.

Note: NFSv4 sets all ownership to *nobody:nobody* if user and group do not match on client and server.

11.10 Rsync

`Services` → `Rsync` is used to configure an rsync server when using rsync module mode. Refer to *Rsync Module Mode* (page 99) for a configuration example.

This section describes the configurable options for the `rsyncd` service and rsync modules.

11.10.1 Configure Rsyncd

Figure 11.11 shows the rsyncd configuration screen which is accessed from `Services` → `Rsync` → `Configure Rsyncd`.

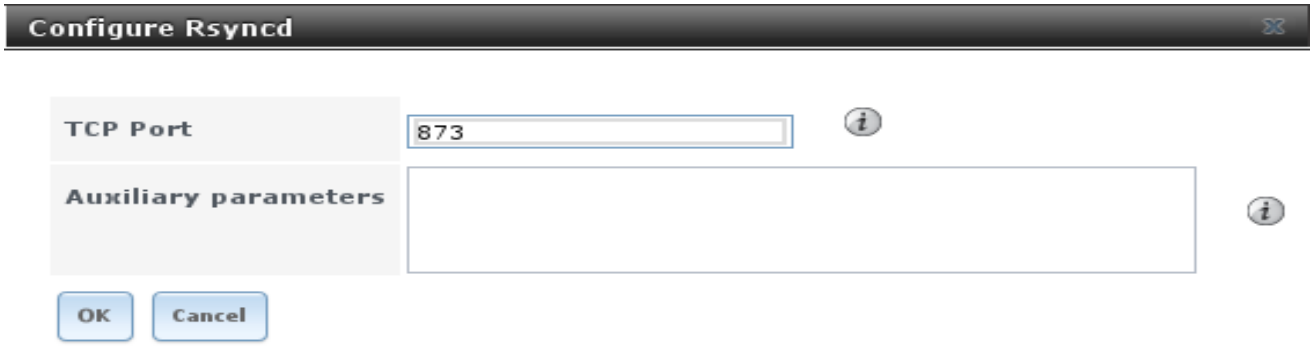


Fig. 11.11: Rsyncd Configuration

Table 11.7 summarizes the configuration options for the rsync daemon:

Table 11.7: Rsyncd Configuration Options

Setting	Value	Description
TCP Port	integer	Port for `rsyncd` to listen on. Default is *873*.
Auxiliary parameters	string	Enter any additional parameters from rsyncd.conf(5) (https://www.samba.org/ftp/rsync/rsyncd.conf.html).

11.10.2 Rsync Modules

Figure 11.12 shows the configuration screen that appears after clicking `Services → Rsync → Rsync Modules → Add Rsync Module`.

Table 11.8 summarizes the configuration options available when creating a rsync module.

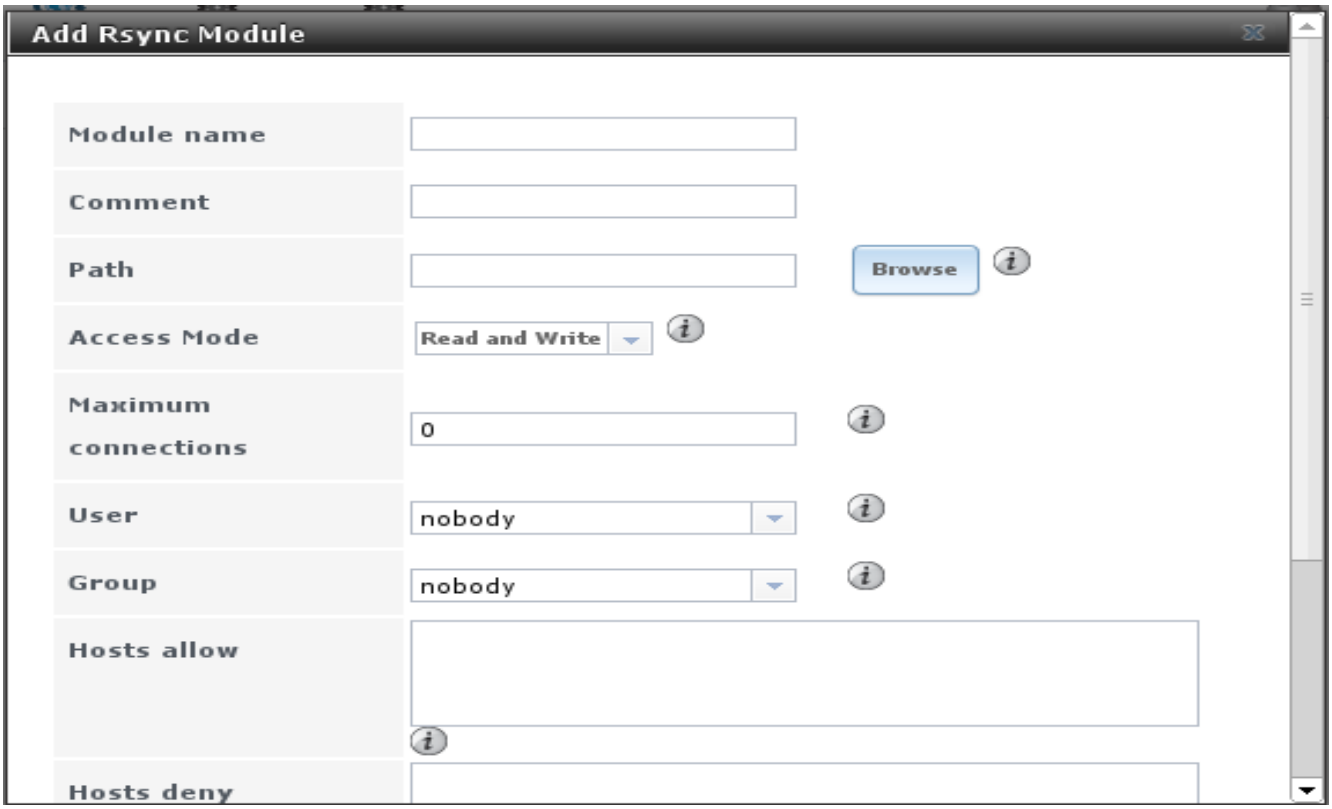


Fig. 11.12: Adding an Rsync Module

Table 11.8: Rsync Module Configuration Options

Setting	Value	Description
Module name	string	Mandatory. This is required to match the setting on the rsync client.
Comment	string	Optional description.
Path	browse button	Browse to the volume or dataset to hold received data.
Access Mode	drop-down menu	Choices are *Read and Write*, *Read-only*, or *Write-only*.
Maximum connections	integer	*0* is unlimited.
User	drop-down menu	Select the user to control file transfers to and from the module.
Group	drop-down menu	Select the group to control file transfers to and from the module.
Hosts allow	string	See rsyncd.conf(5) (https://www.samba.org/ftp/rsync/rsyncd.conf.html) Enter a list of patterns to match with the hostname and IP address of a connecting client. Separate patterns with whitespace or comma.
Hosts deny	string	See rsyncd.conf(5) for allowed formats.
Auxiliary parameters	string	Enter any additional parameters from rsyncd.conf(5) (https://www.samba.org/ftp/rsync/rsyncd.conf.html)

11.11 S3

S3 is a distributed or clustered filesystem protocol compatible with Amazon S3 cloud storage. The FreeNAS® S3 service uses Minio (https://minio.io/) to provide S3 storage hosted on the FreeNAS® system itself. Minio also provides features beyond the limits of the basic Amazon S3 specifications.

Figure 11.13 shows the S3 service configuration screen and Table 11.9 summarizes the configuration options. After config-

uring the S3 service, start it in `Services → Control Services`.

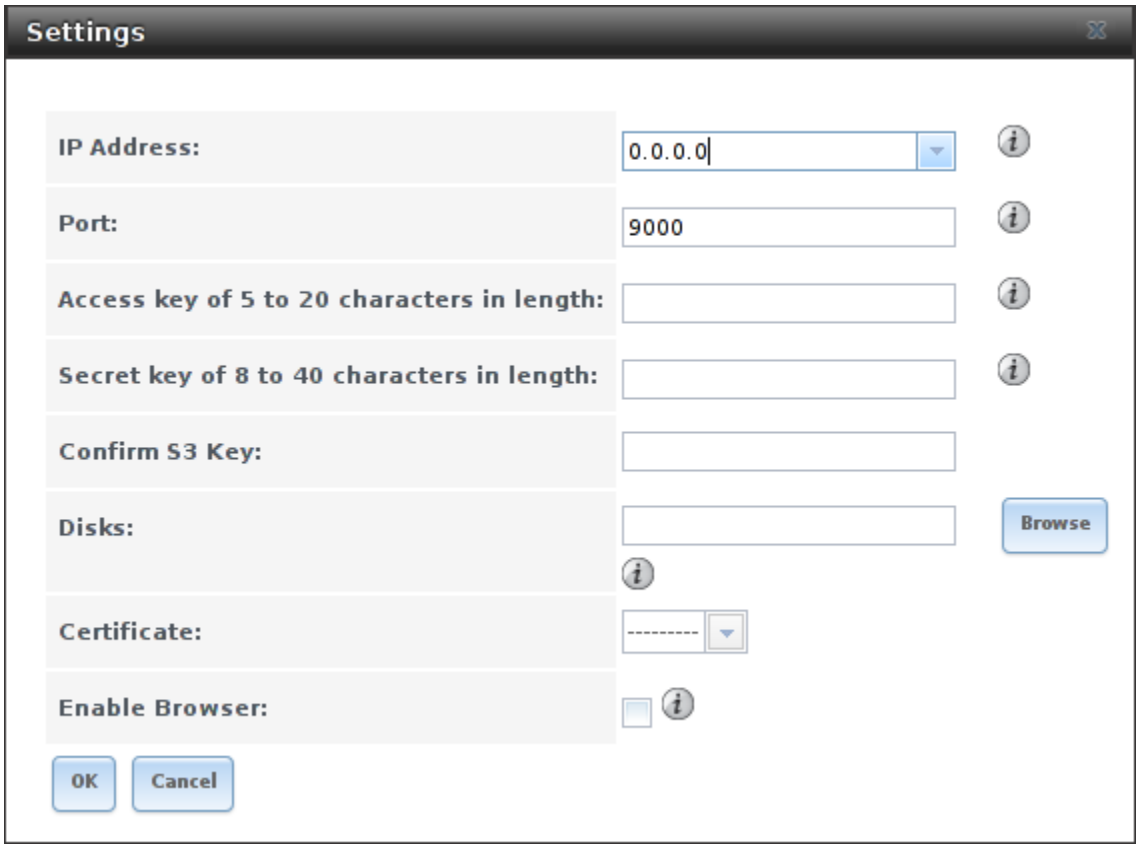


Fig. 11.13: Configuring S3

Table 11.9: S3 Configuration Options

Setting	Value	Description
IP Address	drop-down menu	Enter the IP address to run the S3 service. *0.0.0.0* sets the server to listen on all addresses.
Port	string	Enter the TCP port on which to provide the S3 service. Default is *9000*.
Access Key	string	Enter the S3 user name. This username must contain **only** alphanumeric characters and be between 5 and 20 characters long.
Secret Key	string	Enter the password to be used by connecting S3 systems. The key must contain **only** alphanumeric characters and be at least 8 but no more than 40 characters long.
Confirm S3 Key	string	Re-enter the S3 password to confirm.
Disks	string	The directory for S3 filesystem directory. This overrides all permissions of that directory and all of its subdirectories to *minio:minio*. *Create a separate dataset* (page 125) for Minio to avoid any issues with directory permissions.
Certificate	drop-down menu	The SSL certificate to be used for secure S3 connections. To create a certificate, use `System → Certificates`.
Enable Browser	checkbox	Set to enable the web user interface for the S3 service.

11.12 S.M.A.R.T.

S.M.A.R.T., or Self-Monitoring, Analysis, and Reporting Technology (https://en.wikipedia.org/wiki/S.M.A.R.T.), is an industry standard for disk monitoring and testing. Drives can be monitored for status and problems, and several types of self-tests can be run to check the drive health.

Tests run internally on the drive. Most tests can run at the same time as normal disk usage. However, a running test can greatly reduce drive performance, so they should be scheduled at times when the system is not busy or in normal use. It is very important to avoid scheduling disk-intensive tests at the same time. For example, do not schedule S.M.A.R.T. tests to run at the same time, or preferably, even on the same days as *Scrubs* (page 155).

Of particular interest in a NAS environment are the *Short* and *Long* S.M.A.R.T. tests. Details vary between drive manufacturers, but a *Short* test generally does some basic tests of a drive that takes a few minutes. The *Long* test scans the entire disk surface, and can take several hours on larger drives.

FreeNAS® uses the smartd(8) (https://www.smartmontools.org/browser/trunk/smartmontools/smartd.8.in) service to monitor S.M.A.R.T. information. A complete configuration consists of:

1. Scheduling when S.M.A.R.T. tests are run in `Tasks → S.M.A.R.T. Tests → Add S.M.A.R.T. Test`.
2. Enabling or disabling S.M.A.R.T. for each disk member of a volume in `Volumes → View Disks`. This setting is enabled by default for disks that support S.M.A.R.T.
3. Checking the configuration of the S.M.A.R.T. service as described in this section.
4. Starting the S.M.A.R.T. service with `Services → Control Services`.

Figure 11.14 shows the configuration screen that appears after clicking `Services → S.M.A.R.T.`

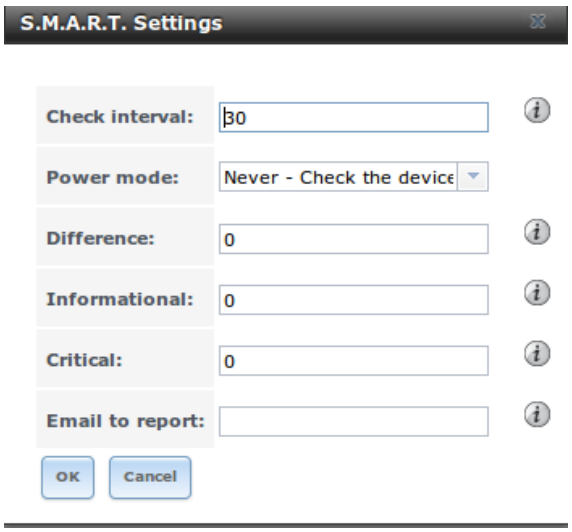


Fig. 11.14: S.M.A.R.T Configuration Options

Note: `smartd` wakes up at the configured *Check Interval*. It checks the times configured in `Tasks → S.M.A.R.T. Tests` to see if a test must begin. Since the smallest time increment for a test is an hour, it does not make sense to set a *Check Interval* value higher than 60 minutes. For example, if the *Check Interval* is set to *120* minutes and the smart test to every hour, the test will only be run every two hours because `smartd` only activates every two hours.

Table 11.10 summarizes the options in the S.M.A.R.T configuration screen.

Table 11.10: S.M.A.R.T Configuration Options

Setting	Value	Description
Check interval	integer	Define in minutes how often `smartd` activates to check if any tests are configured to run.
Power mode	drop-down menu	Tests are not performed if the system enters the specified power mode: *Never*, *Sleep*, *Standby*, or *Idle*.
Difference	integer in degrees Celsius	Enter number of degrees in Celsius. S.M.A.R.T reports if the temperature of a drive has changed by N degrees Celsius since the last report. Default of *0* disables this option.
Informational	integer in degrees Celsius	Enter a threshold temperature in Celsius. S.M.A.R.T will message with a log level of LOG_INFO if the temperature is higher than specified degrees in Celsius. Default of *0* disables this option.
Critical	integer in degrees Celsius	Enter a threshold temperature in Celsius. S.M.A.R.T will message with a log level of LOG_CRIT and send an email if the temperature is higher than specified degrees in Celsius. Default of *0* disables this option.
Email to report	string	Email address to receive S.M.A.R.T. alerts. Use a space to separate multiple email addresses.

11.13 SMB

The settings configured when creating SMB Shares in `Sharing → Windows (SMB) Shares → Add Windows (SMB) Share` are specific to each configured SMB Share. In contrast, global settings which apply to all SMB shares are configured in `Services → SMB`.

Note: After starting the SMB service, it can take several minutes for the master browser election (https://www.samba.org/samba/docs/old/Samba3-HOWTO/NetworkBrowsing.html#id2581357) to occur and for the FreeNAS® system to become available in Windows Explorer.

Figure 11.15 shows the global SMB configuration options which are described in Table 11.11. This configuration screen is really a front-end to smb4.conf (https://www.freebsd.org/cgi/man.cgi?query=smb4.conf&manpath=FreeBSD+11.0-RELEASE+and+Ports).

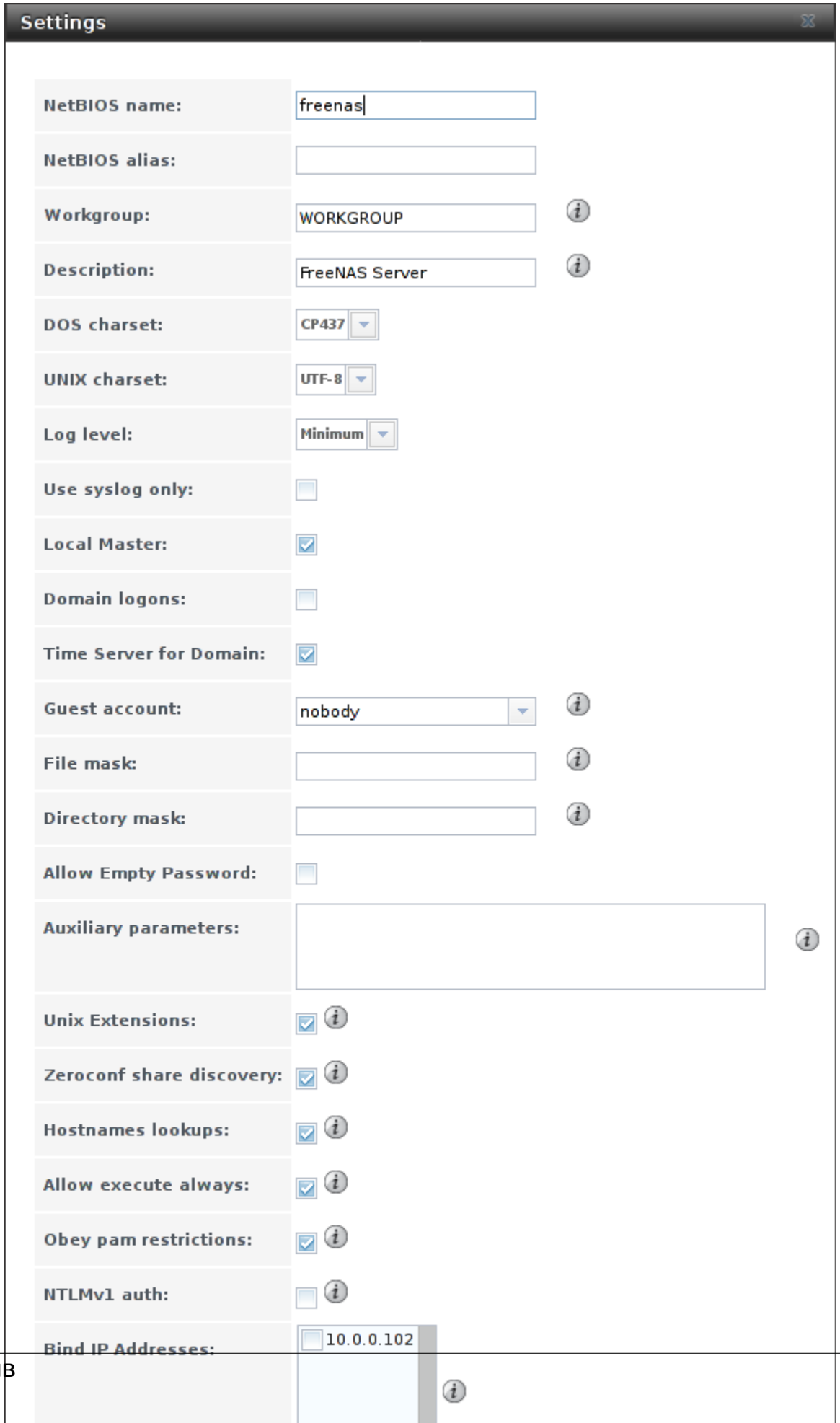

Settings
NetBIOS name:
freenas
NetBIOS alias:
Workgroup:
WORKGROUP
Description:
FreeNAS Server
DOS charset:
CP437
UNIX charset:
UTF-8
Log level:
Minimum
Use syslog only:
Local Master:
Domain logons:
Time Server for Domain:
Guest account:
nobody
File mask:
Directory mask:
Allow Empty Password:
Auxiliary parameters:
Unix Extensions:
Zeroconf share discovery:
Hostnames lookups:
Allow execute always:
Obey pam restrictions:
NTLMv1 auth:
Bind IP Addresses:
10.0.0.102

Table 11.11: Global SMB Configuration Options

Setting	Value	Description
NetBIOS Name	string	Automatically populated with the original hostname of the system. Limited to 15 characters. It **must** be different from the *Workgroup* name.
NetBIOS Alias	string	Enter an alias. Limited to 15 characters
Workgroup	string	Must match Windows workgroup name. This setting is ignored if the *Active Directory* (page 162) or *LDAP* (page 167) service is running.
Description	string	Enter an optional server description.
DOS charset	drop-down menu	The character set Samba uses when communicating with DOS and Windows 9x/ME clients. Default is *CP437*.
UNIX charset	drop-down menu	Default is *UTF-8* which supports all characters in all languages.
Log level	drop-down menu	Choices are *Minimum*, *Normal*, or *Debug*.
Use syslog only	checkbox	Set to log authentication failures to `/var/log/messages` instead of the default of `/var/log/samba4/log.smbd`.
Local Master	checkbox	Set to determine if the system will participate in a browser election. Disable when network contains an AD or LDAP server or Vista or Windows 7 machines are present.
Domain logons	checkbox	Set if it is necessary to provide the netlogin service for older Windows clients.
Time Server for Domain	checkbox	Determines if the system advertises itself as a time server to Windows clients. Disable when network contains an AD or LDAP server.
Guest Account	drop-down menu	Select the account to be used for guest access. Default is *nobody*. Account must have permission to access the shared volume/dataset. If Guest Account user is deleted, resets to *nobody*.
File mask	integer	Overrides default file creation mask of 0666 which creates files with read and write access for everybody.
Directory mask	integer	Overrides default directory creation mask of 0777 which grants directory read, write and execute access for everybody.
Allow Empty Password	checkbox	Set to allow users to press `Enter` when prompted for a password. Requires the username/password to be the same as the Windows user account.
Auxiliary parameters	string	Add any `smb.conf` options not covered elsewhere in this screen. See the Samba Guide (http://www.oreilly.com/openbook/samba/book/appb_02.html) for additional settings.
Unix Extensions	checkbox	Set to allow non-Windows SMB clients to access symbolic links and hard links, has no effect on Windows clients.
Zeroconf share discovery	checkbox	Enable if Mac clients will be connecting to the SMB share.
Hostname lookups	checkbox	Set to allow using hostnames rather than IP addresses in the *Hosts Allow* or *Hosts Deny* fields of a SMB share. Unset if IP addresses are used to avoid the delay of a host lookup.
Allow execute always	checkbox	If set, Samba will allow the user to execute a file, even if that user's permissions are not set to execute.
Obey pam restrictions	checkbox	Unset this option to allow: Cross-domain authentication. Users and groups to be managed on another forest. Permissions to be delegated from *Active Directory* (page 162) users and groups to domain admins on another forest.
NTLMv1 auth	checkbox	Set to allow NTLMv1 authentication. Required by Windows XP clients and sometimes by clients in later versions of Windows.
Bind IP Addresses	checkboxes	Select the IP addresses SMB will listen for.

Continued on next page

Table 11.11 – continued from previous page

Setting	Value	Description
Idmap Range Low	integer	The beginning UID/GID for which this system is authoritative. Any UID/GID lower than this value is ignored, providing a way to avoid accidental UID/GID overlaps between local and remotely defined IDs.
Idmap Range High	integer	The ending UID/GID for which this system is authoritative. Any UID/GID higher than this value is ignored, providing a way to avoid accidental UID/GID overlaps between local and remotely defined IDs.

Changes to SMB settings take effect immediately. Changes to share settings only take effect after the client and server negotiate a new session.

Note: Do not set the *directory name cache size* as an *Auxiliary parameter*. Due to differences in how Linux and BSD handle file descriptors, directory name caching is disabled on BSD systems to improve performance.

Note: *SMB* (page 234) cannot be disabled while *Active Directory* (page 162) is enabled.

11.13.1 Troubleshooting SMB

Do not connect to SMB shares as `root`, and do not add the root user in the SMB user database. There are security implications in attempting to do so, and Samba 4 and later take measures to prevent such actions. This can produce `auth_check_ntlm_password` and `FAILED with error NT_STATUS_WRONG_PASSWORD` errors.

Samba is single threaded, so CPU speed makes a big difference in SMB performance. A typical 2.5Ghz Intel quad core or greater should be capable of handling speeds in excess of Gb LAN while low power CPUs such as Intel Atoms and AMD C-30sE-350E-450 will not be able to achieve more than about 30-40MB/sec typically. Remember that other loads such as ZFS will also require CPU resources and may cause Samba performance to be less than optimal.

Samba's *write cache* parameter has been reported to improve write performance in some configurations and can be added to the *Auxiliary parameters* field. Use an integer value which is a multiple of _SC_PAGESIZE (typically *4096*) to avoid memory fragmentation. This will increase Samba's memory requirements and should not be used on systems with limited RAM.

Windows automatically caches file sharing information. If changes are made to an SMB share or to the permissions of a volume/dataset being shared by SMB and the share becomes inaccessible, try logging out and back in to the Windows system. Alternately, users can type `net use /delete` from the command line to clear their SMB sessions.

Windows also automatically caches login information. To require users to log in every time they access they system, reduce the cache settings on the client computers.

Where possible, avoid using a mix of case in filenames as this can cause confusion for Windows users. Representing and resolving filenames with Samba (http://www.oreilly.com/openbook/samba/book/ch05_04.html) explains in more detail.

If a particular user cannot connect to a SMB share, ensure their password does not contain the `?` character. If it does, have the user change the password and try again.

If permissions work for Windows users but not for macOS users, try disabling *Unix Extensions* and restarting the SMB service.

If the SMB service will not start, run this command from *Shell* (page 282) to see if there is an error in the configuration:

```
testparm /usr/local/etc/smb4.conf
```

If clients have problems connecting to the SMB share, go to `Services` → `SMB` and verify that *Server maximum protocol* is set to *SMB2*.

Using a dataset for SMB sharing is recommended. When creating the dataset, make sure that the *Share type* is set to Windows.

Do not use `chmod` to attempt to fix the permissions on a SMB share as it destroys the Windows ACLs. The correct way to manage permissions on a SMB share is to manage the share security from a Windows system as either the owner of the

share or a member of the group that owns the share. To do so, right-click on the share, click *Properties* and navigate to the *Security* tab. If the ACLs are already destroyed by using `chmod`, `winacl` can be used to fix them. Type `winacl` from *Shell* (page 282) for usage instructions.

The Common Errors (https://www.samba.org/samba/docs/old/Samba3-HOWTO/domain-member.html#id2573692) section of the Samba documentation contains additional troubleshooting tips.

The Samba Performance Tuning (https://wiki.samba.org/index.php/Performance_Tuning) page describes options to improve performance.

Directory listing speed in folders with a large number of files is sometimes a problem. A few specific changes can help improve the performance. However, changing these settings can affect other usage. In general, the defaults are adequate. **Do not change these settings unless there is a specific need.**

- *Hostname Lookups* and *Log Level* can also have a performance penalty. When not needed, they can be disabled or reduced in the *global SMB service options* (page 236).
- Make Samba datasets case insensitive by setting *Case Sensitivity* to *Insensitive* when creating them. This ZFS property is only available when creating a dataset. It cannot be changed on an existing dataset. To convert such datasets, back up the data, create a new case-insensitive dataset, create an SMB share on it, set the share level auxiliary parameter *case sensitive = true*, then copy the data from the old one onto it. After the data has been checked and verified on the new share, the old one can be deleted.
- If present, remove options for extended attributes and DOS attributes in *Auxiliary Parameters* (page 190) for the share.
- Disable as many *VFS Objects* as possible in the *share settings* (page 190). Many have performance overhead.

11.14 SNMP

SNMP (Simple Network Management Protocol) is used to monitor network-attached devices for conditions that warrant administrative attention. FreeNAS® uses Net-SNMP (http://net-snmp.sourceforge.net/) to provide SNMP. When starting the SNMP service, this port will be enabled on the FreeNAS® system:

- UDP 161 (listens here for SNMP requests)

Available MIBS are located in `/usr/local/share/snmp/mibs`.

Figure 11.16 shows the SNMP configuration screen. Table 11.12 summarizes the configuration options.

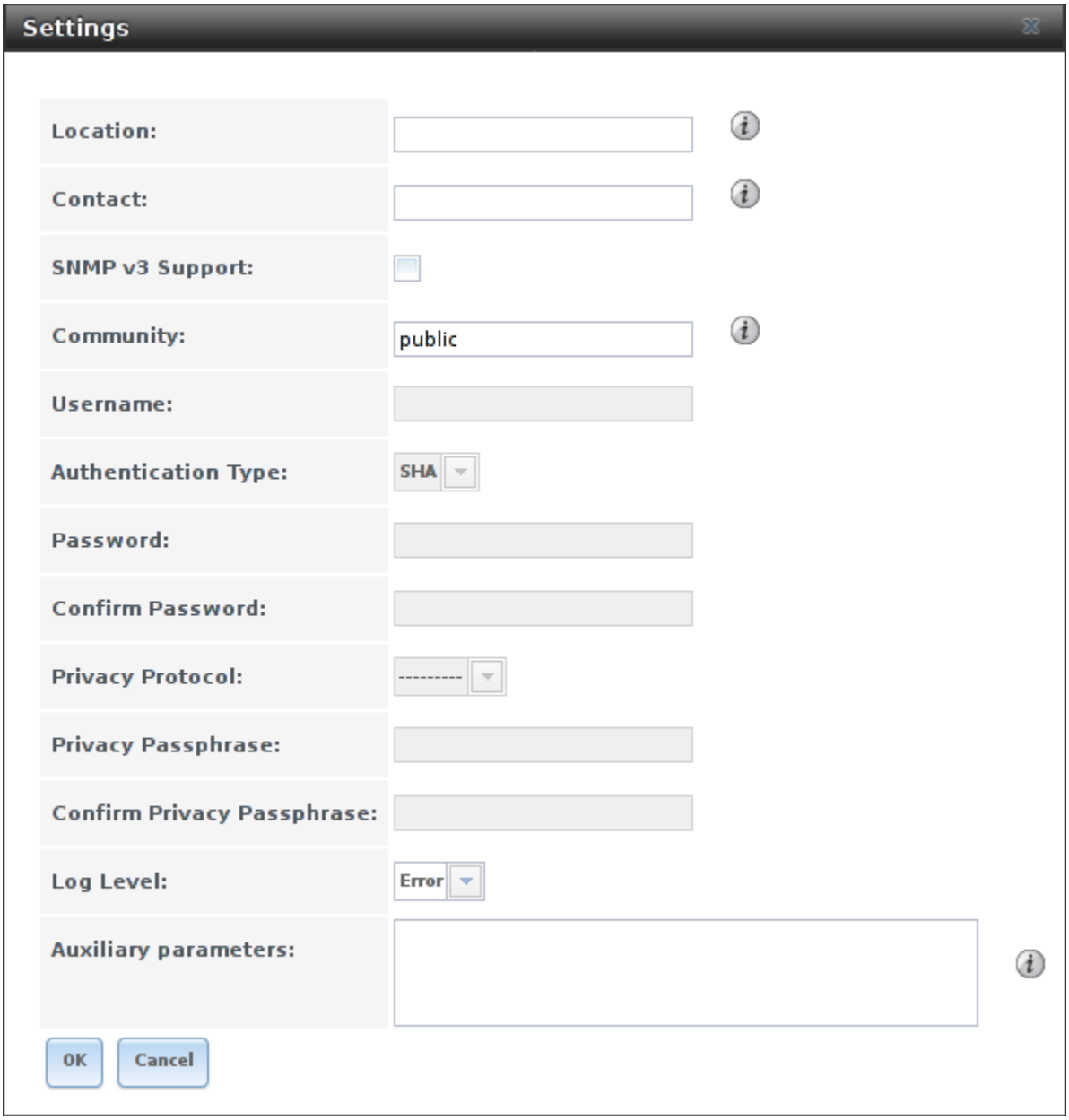


Fig. 11.16: Configuring SNMP

Table 11.12: SNMP Configuration Options

Setting	Value	Description
Location	string	Optional description of the system location.
Contact	string	Optional. Enter the administrator email address.
SNMP v3 Support	checkbox	Set to enable support for SNMP version 3.
Community	string	Default is *public*. **Change this for security reasons!** The value can only contain alphanumeric characters, underscores, dashes, periods, and spaces. This value can be empty for SNMPv3 networks.

Continued on next page

Table 11.12 – continued from previous page

Setting	Value	Description
Username	string	Only applies if *SNMP v3 Support* is set. Specify the username to register with this service. Refer to snmpd.conf(5) (http://net-snmp.sourceforge.net/docs/man/snmpd.conf.html) for more information about configuring this and the *Authentication Type*, *Password*, *Privacy Protocol*, and *Privacy Passphrase* fields.
Authentication Type	drop-down menu	Only applies if *SNMP v3 Support* is enabled. Choices are: *MD5* or *SHA*.
Password	string	Only applies if *SNMP v3 Support* is enabled. Specify and confirm a password of at least eight characters.
Privacy Protocol	drop-down menu	Only applies if *SNMP v3 Support* is enabled. Choices are: *AES* or *DES*.
Privacy Passphrase	string	If not specified, *Password* is used.
Log Level	drop-down menu	Choices range from fewest log entries (*Emergency*) to the most (*Debug*).
Auxiliary Parameters	string	Enter additional snmpd.conf(5) (http://net-snmp.sourceforge.net/docs/man/snmpd.conf.html) options not covered in this screen. One option per line.

11.15 SSH

Secure Shell (SSH) is used to transfer files securely over an encrypted network. When a FreeNAS® system is used as an SSH server, the users in the network must use SSH client software (https://en.wikipedia.org/wiki/Comparison_of_SSH_clients) to transfer files with SSH.

This section shows the FreeNAS® SSH configuration options, demonstrates an example configuration that restricts users to their home directory, and provides some troubleshooting tips.

Figure 11.17 shows the `Services → SSH` configuration screen. After configuring SSH, remember to start it in `Services → Control Services`.

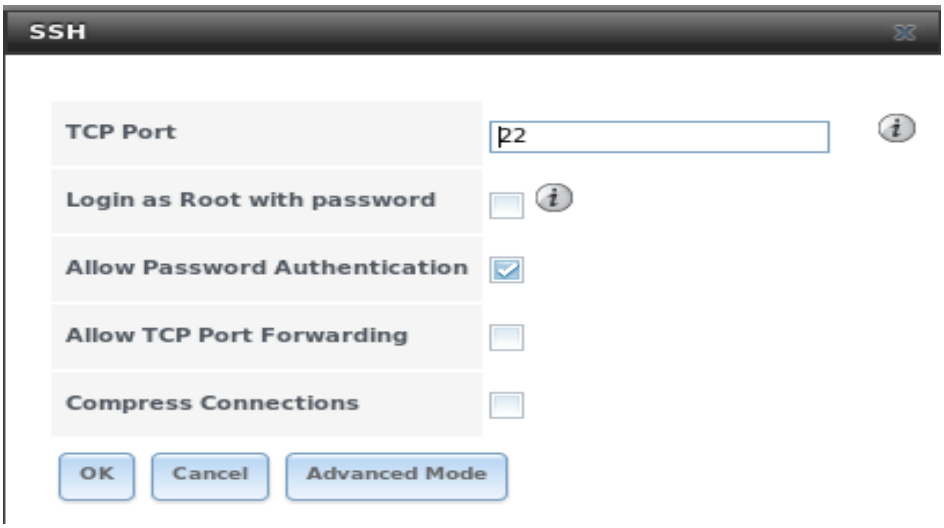


Fig. 11.17: SSH Configuration

Table 11.13 summarizes the configuration options. Some settings are only available in *Advanced Mode*. To see these settings, either click the *Advanced Mode* button, or configure the system to always display these settings by enabling the *Show advanced fields by default* option in `System → Advanced`.

Table 11.13: SSH Configuration Options

Setting	Value	Advanced Mode	Description
Bind Interfaces	selection	✓	By default, SSH listens on all interfaces unless specific interfaces are highlighted in the *Available* field and added to the *Selected* field.
TCP Port	integer		Port to open for SSH connection requests. *22* by default.
Login as Root with password	checkbox		**As a security precaution, root logins are discouraged and disabled by default.** If enabled, a password must be set for the *root* user in *View Users*.
Allow Password Authentication	checkbox		Unset to require key-based authentication for all users. Requires additional setup (http://the.earth.li/~sgtatham/putty/0.55/htmldoc/Chapter8.html) on both the SSH client and server.
Allow Kerberos Authentication	checkbox	✓	Before setting this option, ensure *Kerberos Realms* (page 170) and *Kerberos Keytabs* (page 171) are configured and FreeNAS® can communicate with the Kerberos Domain Controller (KDC).
Allow TCP Port Forwarding	checkbox		Set to allow users to bypass firewall restrictions using the SSH port forwarding feature (https://www.symantec.com/connect/articles/ssh-port-forwarding).
Compress Connections	checkbox		Set to attempt to reduce latency over slow networks.
SFTP Log Level	drop-down menu	✓	Select the syslog(3) (https://www.freebsd.org/cgi/man.cgi?query=syslog) level of the SFTP server.
SFTP Log Facility	drop-down menu	✓	Select the syslog(3) (https://www.freebsd.org/cgi/man.cgi?query=syslog) facility of the SFTP server.
Extra Options	string	✓	Add any additional sshd_config(5) (https://www.freebsd.org/cgi/man.cgi?query=sshd_config) options not covered in this screen, one per line. These options are case-sensitive and misspellings can prevent the SSH service from starting.

A few sshd_config(5) (https://www.freebsd.org/cgi/man.cgi?query=sshd_config) options that are useful to enter in the *Extra Options* field include:

- increase the *ClientAliveInterval* if SSH connections tend to drop
- *ClientMaxStartup* defaults to *10*. Increase this value if more concurrent SSH connections are required.

11.15.1 SCP Only

When SSH is configured, authenticated users with a user account created using `Account → Users → Add User` can use `ssh` to log into the FreeNAS® system over the network. The user home directory is the pool or dataset specified in the *Home Directory* field of the FreeNAS® account for that user. While the SSH login defaults to the user home directory, users are able to navigate outside their home directory, which can pose a security risk.

It is possible to allow users to use `scp` and `sftp` to transfer files between their local computer and their home directory on the FreeNAS® system, while restricting them from logging into the system using `ssh`. To configure this scenario, go to `Account → Users → View Users`, select the user, and click *Modify User*. Change the *Shell* to *scponly*. Repeat for each user that needs restricted SSH access.

Test the configuration from another system by running the `sftp`, `ssh`, and `scp` commands as the user. `sftp` and `scp` will work but `ssh` will fail.

Note: Some utilities like WinSCP and Filezilla can bypass the scponly shell. This section assumes that users are accessing the system using the command line versions of `scp` and `sftp`.

11.15.2 Troubleshooting SSH

Keywords listed in sshd_config(5) (https://www.freebsd.org/cgi/man.cgi?query=sshd_config) are case sensitive. This is important to remember when adding any *Extra options*. The configuration will not function as intended if the upper and lowercase letters of the keyword are not an exact match.

If clients are receiving "reverse DNS" or timeout errors, add an entry for the IP address of the FreeNAS® system in the *Host name database* field of `Network → Global Configuration`.

When configuring SSH, always test the configuration as an SSH user account to ensure the user is limited by the configuration and they have permission to transfer files within the intended directories. If the user account is experiencing problems, the SSH error messages are specific in describing the problem. Type this command within *Shell* (page 282) to read these messages as they occur:

```
tail -f /var/log/messages
```

Additional messages regarding authentication errors are found in `/var/log/auth.log`.

11.16 TFTP

Trivial File Transfer Protocol (TFTP) is a light-weight version of FTP typically used to transfer configuration or boot files between machines, such as routers, in a local environment. TFTP provides an extremely limited set of commands and provides no authentication.

If the FreeNAS® system will be used to store images and configuration files for network devices, configure and start the TFTP service. Starting the TFTP service opens UDP port 69.

Figure 11.18 shows the TFTP configuration screen and Table 11.14 summarizes the available options.

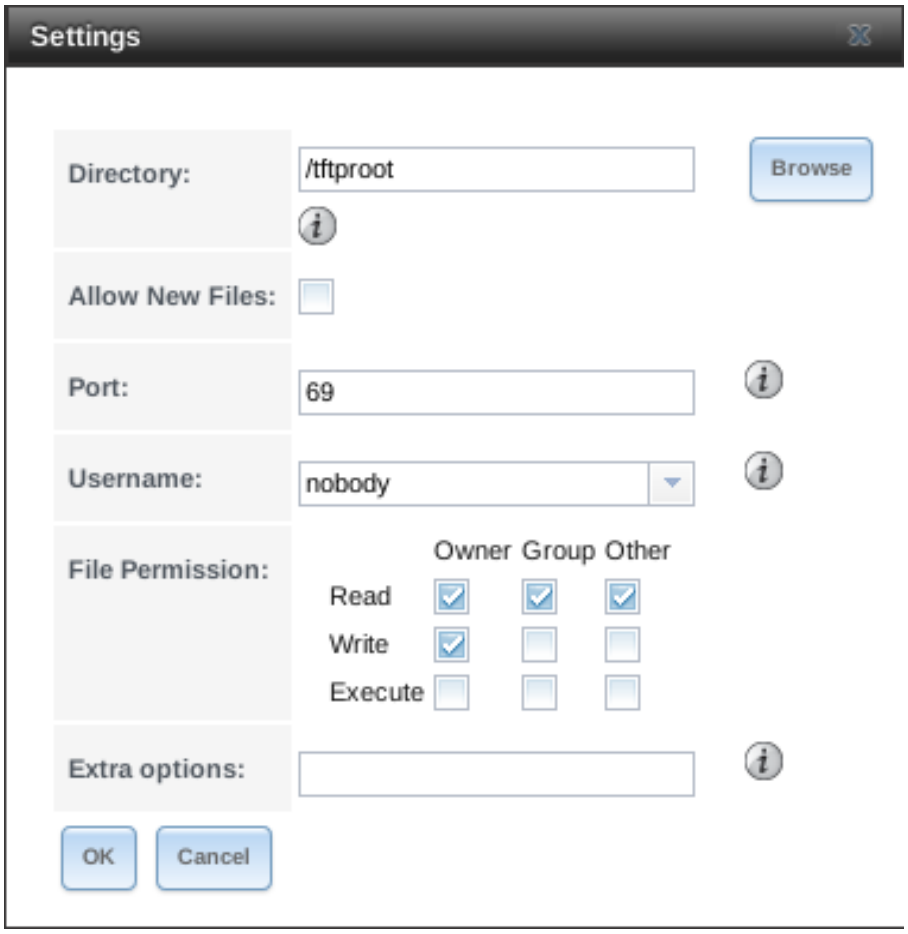


Fig. 11.18: TFTP Configuration

Table 11.14: TFTP Configuration Options

Setting	Value	Description
Directory	browse button	Browse to an **existing** directory to be used for storage. Some devices require a specific directory name, refer to the device documentation for details.
Allow New Files	checkbox	Enable if network devices need to send files to the system (for example, to back up their configuration).
Port	integer	Enter the UDP port to listen for TFTP requests. Default is *69*.
Username	drop-down menu	Select the account to be used for TFTP requests. The account must have permission to the *Directory*.
File Permissions	checkboxes	Set permissions for newly created files. The default is everyone can read and only the owner can write. Some devices require less strict permissions.
Extra options	string	Add any additional tftpd(8) (https://www.freebsd.org/cgi/man.cgi?query=tftpd) options not shown in this screen. Add one option on each line.

11.17 UPS

FreeNAS® uses NUT (http://networkupstools.org/) (Network UPS Tools) to provide UPS support. If the FreeNAS® system is connected to a UPS device, configure the UPS service then start it in `Services → Control Services`.

Figure 11.19 shows the UPS configuration screen:

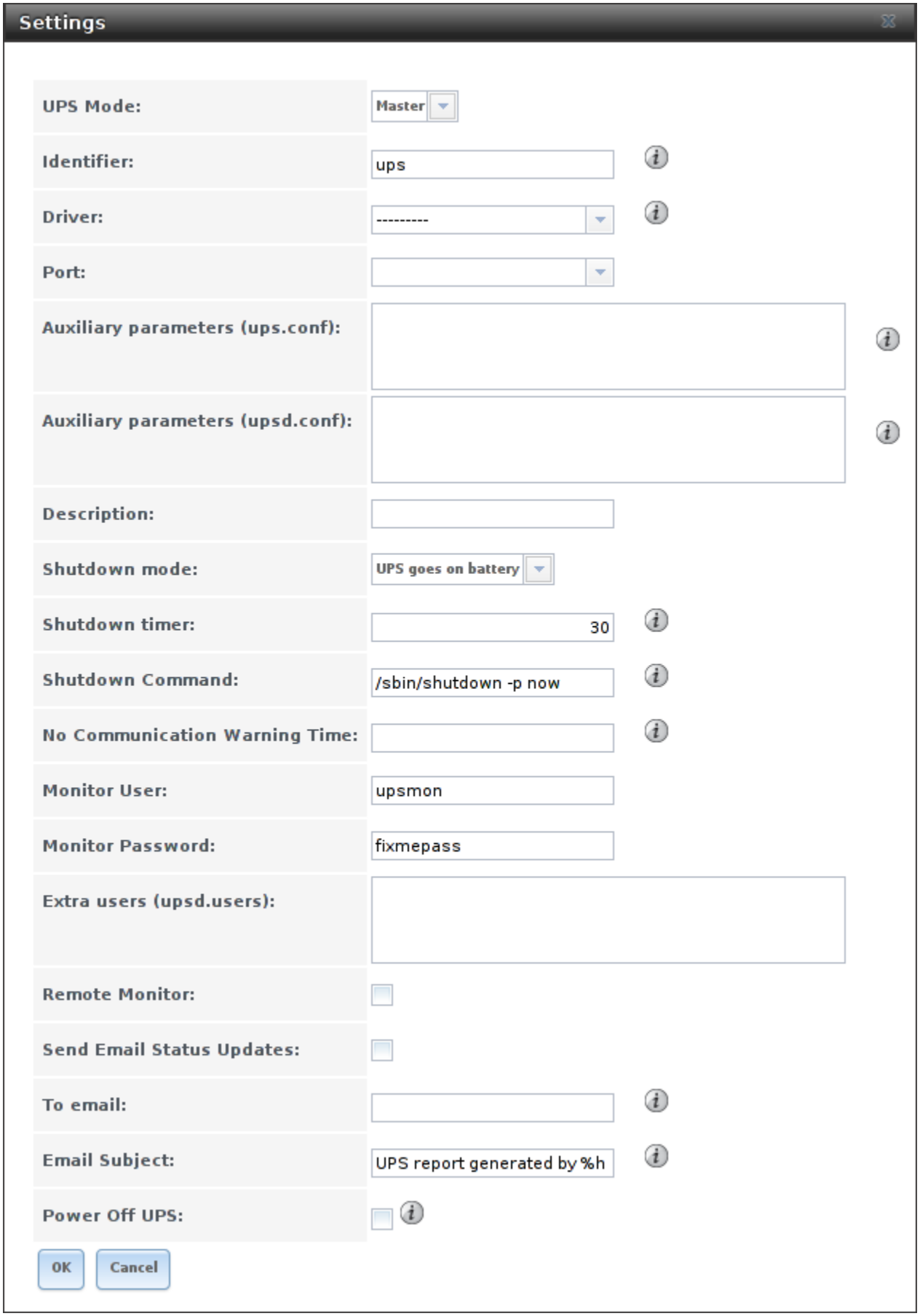


Fig. 11.19: UPS Configuration Screen

Table 11.15 summarizes the options in the UPS Configuration screen.

Table 11.15: UPS Configuration Options

Setting	Value	Description
UPS Mode	drop-down menu	Select *Master* if the UPS is plugged directly into the system serial port. The UPS will remain the last item to shut down. Select *Slave* to have the system shut down before *Master*.
Identifier	string	Describe the UPS device. Can contain alphanumeric, period, comma, hyphen, and underscore characters.
Driver	drop-down menu	Supported UPS devices are listed at http://networkupstools.org/stable-hcl.html.
Port	drop-down menu	Select the serial or USB port the UPS is plugged into (see *NOTE* (page 246)).
Auxiliary Parameters (ups.conf)	string	Enter any additional options from ups.conf(5) (http://networkupstools.org/docs/man/ups.conf.html).
Auxiliary Parameters (upsd.conf)	string	Enter any additional options from upsd.conf(5) (http://networkupstools.org/docs/man/upsd.conf.html).
Description	string	Optional. Enter any notes about the UPS service.
Shutdown mode	drop-down menu	Choose when the UPS initiates shutdown. Choices are *UPS goes on battery* and *UPS reaches low battery*.
Shutdown timer	integer	Select a value in seconds for the UPS to wait before initiating shutdown. Shutdown will not occur if the power is restored while the timer is counting down. The value only applies when *Shutdown Mode* is set to *UPS goes on battery*.
Shutdown Command	string	Enter the command to run to shut down the computer when battery power is low or shutdown timer runs out.
No Communication Warning Time	string	Enter a value in seconds to wait before alerting that the service cannot reach any UPS. Warnings continue until the situation is fixed.
Monitor User	string	Enter a user to associate with this service. The recommended default user is *upsmon*.
Monitor Password	string	Default is the known value *fixmepass*. Change this to enhance system security. Cannot contain a space or `#`.
Extra users	string	Enter the accounts with administrative access. See upsd.users(5) (http://networkupstools.org/docs/man/upsd.users.html) for examples.
Remote monitor	checkbox	Set for the default configuration to listen on all interfaces using the known values of user *upsmon* and password *fixmepass*.
Send Email Status Updates	checkbox	Set to enable the FreeNAS® system to send email updates to the configured *To email* address.
To email	email address	Enter the email address to receive status updates. Separate multiple email addresses with a semicolon (`;`).
Email Subject	string	Enter a subject line to be used in email status updates.
Power Off UPS	checkbox	Set to power off the UPS after shutting down the FreeNAS system.

Note: For USB devices, the easiest way to determine the correct device name is to enable the *Show console messages* option in `System → Advanced`. Plug in the USB device and look for a */dev/ugen* or */dev/uhid* device name in the console messages.

upsc(8) (http://networkupstools.org/docs/man/upsc.html) can be used to get status variables from the UPS daemon such as the current charge and input voltage. It can be run from *Shell* (page 282) using this syntax:

```
upsc ups@localhost
```

The *upsc(8)* man page gives some other usage examples.

upscmd(8) (http://networkupstools.org/docs/man/upscmd.html) can be used to send commands directly to the UPS, assum-

ing the hardware supports the command being sent. Only users with administrative rights can use this command. These users are created in the *Extra users* field.

11.17.1 Multiple Computers with One UPS

A UPS with adequate capacity can power multiple computers. One computer is connected to the UPS data port with a serial or USB cable. This *master* makes UPS status available on the network for other computers. These *slave* computers are powered by the UPS, but receive UPS status data from the master computer. See the NUT User Manual (http://networkupstools.org/docs/user-manual.chunked/index.html) and NUT User Manual Pages (http://networkupstools.org/docs/man/index.html#User_man).

11.18 WebDAV

The WebDAV service can be configured to provide a file browser over a web connection. Before starting this service, at least one WebDAV share must be created using `Sharing → WebDAV Shares → Add WebDAV Share`. Refer to *WebDAV Shares* (page 188) for instructions on how to create a share and connect to it when the service is configured and started.

Figure 11.20 shows the WebDAV configuration screen. Table 11.16 summarizes the available options.

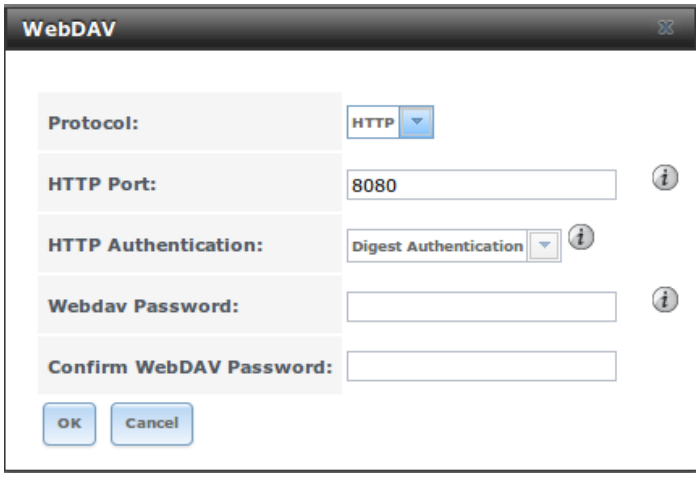


Fig. 11.20: WebDAV Configuration Screen

Table 11.16: WebDAV Configuration Options

Setting	Value	Description
Protocol	drop-down menu	*HTTP* keeps the connection always unencrypted. *HTTPS* always encrypts the connection. *HTTP+HTTPS* allows both types of connections.
HTTP Port	string	Specify a port for unencrypted connections. Only appears if the selected *Protocol* is *HTTP* or *HTTP+HTTPS*. The default of *8080* is recommended. **Do not** use a port number already being used by another service
HTTPS Port	string	Specify a port for encrypted connections. Only appears if the selected *Protocol* is *HTTPS* or *HTTP+HTTPS*. The default of *8081* is recommended. **Do not** reuse a port number.
Webdav SSL Certificate	drop-down menu	Select the SSL certificate to use for encrypted connections. Only appears if the selected *Protocol* is *HTTPS* or *HTTP+HTTPS*. To create a certificate, use `System → Certificates`.
HTTP Authentication	drop-down menu	Choices are *No Authentication*, *Basic Authentication* (unencrypted), or *Digest Authentication* (encrypted).

Continued on next page

Table 11.16 – continued from previous page

Setting	Value	Description
Webdav Password	string	Default is *davtest*. This is a known value and is recommended to be changed.

CHAPTER

TWELVE

PLUGINS

Warning: The legacy plugins infrastructure has been deprecated and is no longer supported. Plugins installation has been removed from the legacy UI but it can still be used to manage existing plugins. It is recommended to reinstall all legacy plugins using the new UI.

12.1 Installed Plugins

Entries for installed PBI will appear in these locations:

- the *Installed* tab of *Plugins*
- the *Plugins* section of the tree
- the *Jails* section of the tree

The entry in the *Installed* tab of Plugins displays the plugin name and version, the name of the PBI installed, the name of the jail, whether the application status is *ON* or *OFF*, and a button to delete the application and its associated jail.

Note: The *Service status* of a plugin must be turned to *ON* before the installed application is available. Before starting the service, check to see if it has a configuration menu by clicking its entry in the *Plugins* section of the tree. If the application is configurable, this will open a screen that contains the available configuration options. Plugins which are not configurable display a message with a hyperlink for accessing the software. However, that hyperlink does **not** work until the plugin is started.

Always review the configuration options of a plugin before attempting to start it. Some plugins have options that need to be set before their service will successfully start. If the application has not been configured before, check the website of the application to see what documentation is available.

If the application requires access to the data stored on the FreeNAS® system, click the entry for the associated jail in the *Jails* section of the tree and add a storage as described in *Add Storage* (page 256).

Access the shell of the jail containing the application by clicking the entry for the associated jail in the *Jails* section of the tree. You can then click its shell icon as described in *Managing Jails* (page 254).

Once the configuration is complete, click the red *OFF* button for the entry for the plugin. If the service starts successfully, it will change to a blue *ON*. If it fails to start, click the jail's *Shell* icon and type `tail /var/log/messages` to see if any errors were logged.

12.2 Deleting Plugins

Deleting a plugin deletes the associated jail as it is no longer required. **Before deleting a plugin,** make sure that there is no data or configuration options in the jail that need to be saved. Back up that data **before** deleting the plugin.

In the example shown in Figure 12.1, Sabnzbd is installed and the user has clicked the *Delete* button. A pop-up message displays. **This is the one and only warning.**

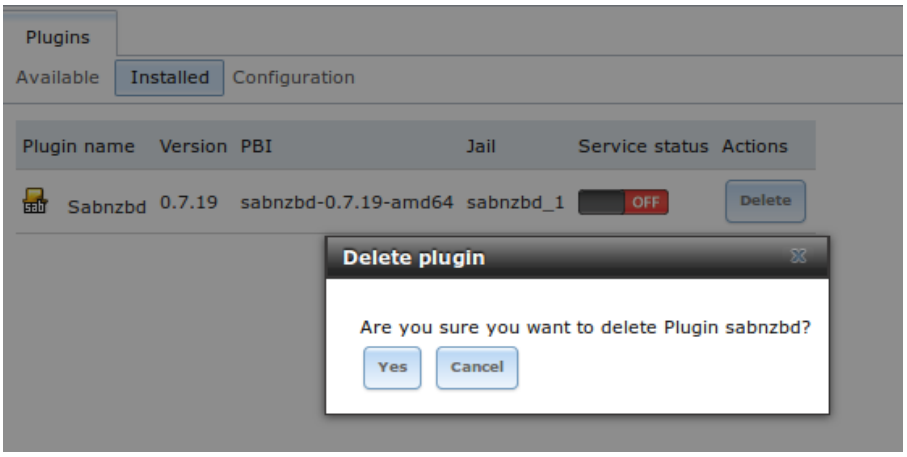


Fig. 12.1: Deleting an Installed Plugin

CHAPTER

THIRTEEN

JAILS

This section describes how to use Jails, which allow users who are comfortable with the command line to have more control over software installation and management.

Warning: The jails infrastructure now uses uses the iocage backend and the warden backend has been deprecated and is no longer supported. Jail creation has been removed from the legacy UI but it can still be used to manage existing warden jails. It is recommended to recreate all legacy jails using the new UI, copy over any existing configurations, and delete the old jail datasets once the new jails are working as expected. To create new Jails, log into the new UI.

By default, a FreeBSD jail (https://en.wikipedia.org/wiki/Freebsd_jail) is created. This provides a very light-weight, operating system-level virtualization. Consider it as another independent instance of FreeBSD running on the same hardware, without all of the overhead usually associated with virtualization. The jail installs the FreeBSD software management utilities so FreeBSD ports can be compiled and FreeBSD packages can be installed from the command line of the jail.

It is important to understand that any users, groups, installed software, and configurations within a jail are isolated from both the FreeNAS® operating system and any other jails running on that system.

The rest of this section describes:

- *Jails Configuration* (page 251)
- *Managing Jails* (page 254)
- *Starting Installed Software* (page 259)

13.1 Jails Configuration

Jails are stored in a volume or dataset. **Using a separate dataset for the** *Jail Root* **is strongly recommended**. The volume or dataset to be used must already exist or can be created with *Volume Manager* (page 118).

Note: The *Jail Root* volume or dataset cannot be created on a *Share* (page 173).

Begin global jail configuration by choosing `Jails` → `Configuration` to open the screen shown in Figure 13.1. Jails are automatically installed into their own dataset under the specified path as they are created. For example, if the *Jail Root* is set to `/mnt/volume1/dataset1` and a jail named *jail1* is created, it is installed into its own dataset named `/mnt/volume1/dataset1/jail1`.

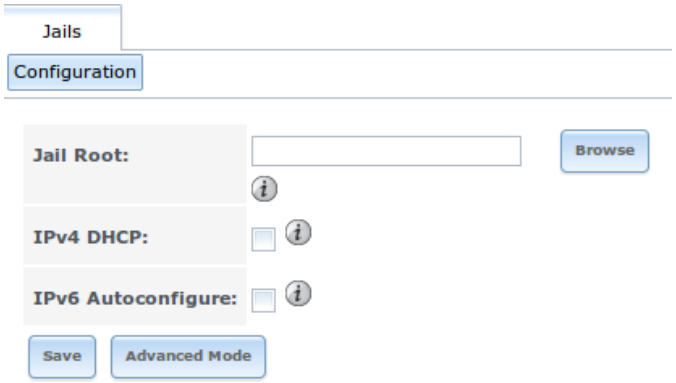


Fig. 13.1: Global Jail Configuration

Warning: If any *Plugins* (page 249) are already installed, the *Jail Root*, *IPv4 Network*, *IPv4 Network Start Address*, and *IPv4 Network End Address* are automatically filled. Double-check that the pre-configured IP address values are appropriate for the jails and do not conflict with addresses used by other systems on the network.

Table 13.1 summarizes the fields in this configuration screen. Refer to the text below the table for more details on how to properly configure the *Jail Root* and network settings. Some settings are only available in *Advanced Mode*. To see these settings, either click the *Advanced Mode* button or configure the system to always display these settings by checking the box *Show advanced fields by default* in `System → Advanced`.

Table 13.1: Jail Configuration Options

Setting	Value	Advanced Mode	Description
Jail Root	browse button		mandatory; jails cannot be added until this is set
IPv4 DHCP	checkbox		check this box if the network has a DHCP server
IPv4 Network	string	✓	format is IP address of *network/CIDR mask*
IPv4 Network Start Address	string	✓	enter the first IP address in the reserved range in the format *host/CIDR mask*
IPv4 Network End Address	string	✓	enter the last IP address in the reserved range in the format *host/CIDR mask*
IPv6 Autoconfigure	checkbox		check this box if the network has a DHCPv6 server and IPv6 will be used to access jails
IPv6 Network	string	✓	enter the network address for a properly configured IPv6 network
IPv6 Network Start Address	string	✓	enter the first IP address in the reserved range for a properly configured IPv6 network
IPv6 Network End Address	string	✓	enter the last IP address in the reserved range for a properly configured IPv6 network
Collection URL	string	✓	changing the default may break the ability to install jails

When selecting the *Jail Root*, ensure that the size of the selected volume or dataset is sufficient to hold the number of jails to be installed as well as any software, log files, and data to be stored within each jail. At a bare minimum, budget at least 2 GB per jail and do not select a dataset that is less than 2 GB in size.

Note: When adding storage to a jail, be aware that the path size is limited to 88 characters. Make sure that the length of the volume name plus the dataset name plus the jail name does not exceed this limit.

If the network contains a DHCP server, it is recommended to check the box *IPv4 DHCP* (or *IPv6 Autoconfigure*, for a properly configured IPv6 network). This prevents IP address conflicts on the network as the DHCP server automatically assigns the jail the next available lease and records the lease as in use.

If a static IP address is needed so that users always know the IP address of the jail, enter the start and end address for the IPv4 and/or IPv6 network. The range defined by the start and end addresses will be automatically assigned as jails are created. For example, when creating 5 jails on the 192.168.1.0 network, enter a *IPv4 Network Start Address* of *192.168.1.100* and a *IPv4 Network End Address* of *192.168.1.104*.

When creating a start and end range on a network that contains a DHCP server, it is important to also reserve those addresses on the DHCP server. Otherwise, the DHCP server is not aware that those addresses are being used by jails. This lead to IP address conflicts and weird networking errors on the network.

FreeNAS® automatically detects and displays the *IPv4 Network* to which the administrative interface is connected. This setting is important. The IP addresses used by the jails must be pingable from the FreeNAS® system for the jails and any installed software to be accessible. If the network topology requires changing the default value, a default gateway and possibly a static route need to be added to the specified network. After changing this value, ensure that the subnet mask value is correct, as an incorrect mask can make the IP network unreachable. When in doubt, keep the default setting for *IPv4 Network*. With VMware, make sure that the vswitch is set to "promiscuous mode". With VirtualBox, make sure `Network -> Advanced -> Promiscuous Mode` is not set to "Deny".

After clicking the *Save* button to save the configuration, the system is ready to create and manage jails as described in the rest of this chapter.

Table 13.2 summarizes the available options. Most settings are only available in *Advanced Mode* and are not needed if the intent is to create a FreeBSD jail. To see these settings, either click the *Advanced Mode* button or configure the system to always display these settings by checking the box *Show advanced fields by default* in `System → Advanced`.

Table 13.2: Jail Configuration Options

Setting	Value	Advanced Mode	Description
Jail Name	string		mandatory; can only contain letters, numbers, dashes, or the underscore character
Template	drop-down menu	✓	contains any created custom templates
IPv4 DHCP	checkbox	✓	if unchecked, make sure that the defined address does not conflict with the DHCP server's pool of available addresses
IPv4 address	integer	✓	this and the other IPv4 settings are grayed out if *IPv4 DHCP* is checked; enter a unique IP address that is in the local network and not already used by anyother computer
IPv4 netmask	drop-down menu	✓	select the subnet mask associated with *IPv4 address*
IPv4 bridge address	integer	✓	grayed out unless *VIMAGE* is checked; see NOTE below
IPv4 bridge netmask	drop-down menu	✓	select the subnet mask associated with *IPv4 bridge address*; grayed out unless *VIMAGE* is checked
IPv4 default gateway	string	✓	grayed out unless *VIMAGE* is checked
IPv6 Autoconfigure	checkbox	✓	if unchecked, make sure that the defined address does not conflict with the DHCP server's pool of available addresses
IPv6 address	integer	✓	this and other IPv6 settings are grayed out if *IPv6 Autoconfigure* is checked; enter a unique IPv6 address that is in the local network and not already used by any other computer
IPv6 prefix length	drop-down menu	✓	select the prefix length associated with *IPv6 address*
IPv6 bridge address	integer	✓	grayed out unless *VIMAGE* is checked; see NOTE below
IPv6 bridge prefix length	drop-down menu	✓	grayed out unless *VIMAGE* is checked; select the prefix length associated with *IPv6 address*

Continued on next page

Table 13.2 – continued from previous page

Setting	Value	Advanced Mode	Description
IPv6 default gateway	string	✓	grayed out unless *VIMAGE* is checked; used to set the jail's default gateway IPv6 address
MAC	string	✓	grayed out unless *VIMAGE* is checked; if a static MAC address is entered, unique static MAC addresses must be entered for every jail created
NIC	drop-down menu	✓	grayed out if *VIMAGE* is checked; can be used to specify the interface to use for jail connections
Sysctls	string	✓	comma-delimited list of sysctls to set inside jail (like *allow.sysvipc=1,allow.raw_sockets=1*)
Autostart	checkbox	✓	uncheck if the jail will be started manually
VIMAGE	checkbox	✓	gives a jail its own virtualized network stack; requires promiscuous mode be enabled on the interface
NAT	checkbox	✓	grayed out for Linux jails or if *VIMAGE* is unchecked; enables Network Address Translation for the jail

Note: The IPv4 and IPv6 bridge interface is used to bridge the epair(4) (https://www.freebsd.org/cgi/man.cgi?query=epair) device, which is automatically created for each started jail, to a physical network device. The default network device is the one that is configured with a default gateway. So, if *em0* is the FreeBSD name of the physical interface and three jails are running, these virtual interfaces are automatically created: *bridge0*, *epair0a*, *epair1a*, and *epair2a.* The physical interface *em0* will be added to the bridge, as well as each epair device. The other half of the epair is placed inside the jail and is assigned the IP address specified for that jail. The bridge interface is assigned an alias of the default gateway for that jail or the bridge IP, if configured; either is correct.

13.2 Managing Jails

Click *Jails* to view and configure the added jails. In the example shown in Figure 13.2, the list entry for the jail named *xdm_1* has been clicked to enable that jail's configuration options. The entry indicates the jail name, IP address, whether it will start automatically at system boot, if it is currently running, and jail type: *standard* for a FreeBSD jail, or *pluginjail* if it was installed using *Plugins* (page 249).

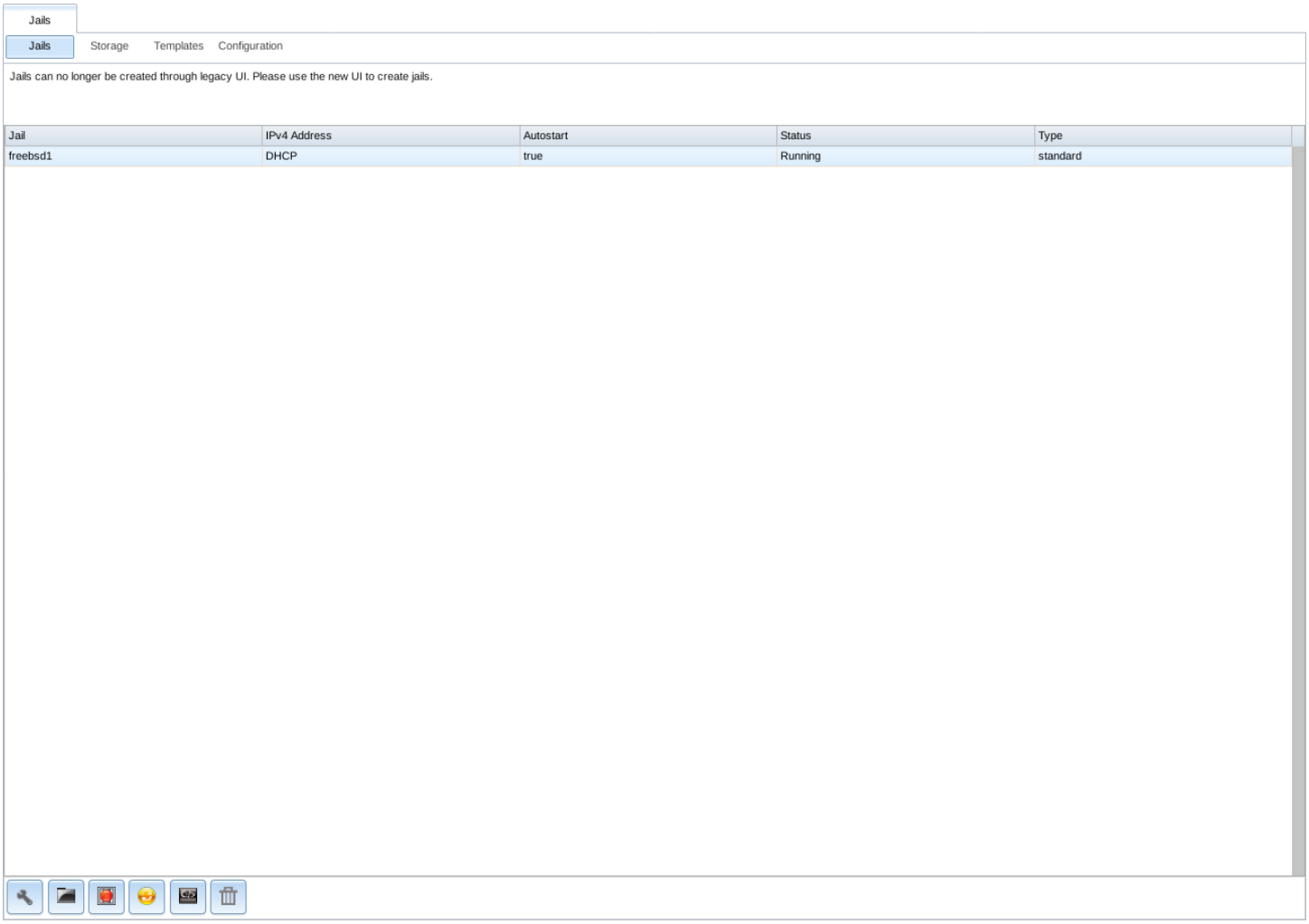


Fig. 13.2: Viewing Jails

From left to right, these configuration icons are available:

Edit Jail: edit the jail settings which were described in Table 13.2.

After a jail has been created, the jail name and type cannot be changed. These fields are grayed out.

Note: To modify the IP address information for a jail, use the *Edit Jail* button instead of the associated networking commands from the command line of the jail.

Add Storage: configure the jail to access an area of storage as described in *Add Storage* (page 256).

Start/Stop: this icon changes appearance depending on the current *Status* of the jail. When the jail is not running, the icon is green and clicking it starts the jail. When the jail is already running, the icon is red and clicking it stops the jail. A stopped jail and its applications are inaccessible until it is restarted.

Restart: restart the jail.

Shell: access a *root* command prompt to configure the selected jail from the command line. When finished, type `exit` to close the shell.

Delete: delete the jail and any periodic snapshots of it. The contents of the jail are entirely removed.

Warning: Back up data and programs in the jail before deleting it. There is no way to recover the contents of a jail after deletion.

13.2.1 Accessing a Jail Using SSH

`ssh` can be used to access a jail instead of the jail's *Shell* icon. This requires starting the `ssh` service and creating a user account for `ssh` access. Start by clicking the *Shell* icon for the desired jail.

Find the `sshd_enable=` line in the jail's `/etc/rc.conf` and set it to *"YES"*:

```
sshd_enable="YES"
```

Then start the SSH daemon:

```
service sshd start
```

The first time the service runs, the jail's RSA key pair is generated and the key fingerprint and random art image displayed.

Add a user account by typing `adduser` and following the prompts. If the user needs superuser privileges, they must be added to the *wheel* group. For those users, enter *wheel* at this prompt:

```
Login group is user1. Invite user1 into other groups? []: wheel
```

After creating the user, set the *root* password so that the new user will be able to use the `su` command to gain superuser privilege. To set the password, type `passwd` then enter and confirm the desired password.

Finally, test from another system that the user can successfully `ssh` in and become the superuser. In this example, a user named *user1* uses `ssh` to access the jail at 192.168.2.3. The first time the user logs in, they will be asked to verify the fingerprint of the host:

```
ssh user1@192.168.2.3
The authenticity of host '192.168.2.3 (192.168.2.3)' can't be established.
RSA key fingerprint is 6f:93:e5:36:4f:54:ed:4b:9c:c8:c2:71:89:c1:58:f0.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.2.3' (RSA) to the list of known hosts.
Password: type_password_here
```

Note: Each jail has its own user accounts and service configuration. These steps must be repeated for each jail that requires SSH access.

13.2.2 Add Storage

It is possible to give a FreeBSD jail access to an area of storage on the FreeNAS® system. This is useful for applications that store a large amount of data or if an application in a jail needs access to the data stored on the FreeNAS® system. One example is transmission, which stores torrents. The storage is added using the mount_nullfs(8) (https://www.freebsd.org/cgi/man.cgi?query=mount_nullfs) mechanism, which links data that resides outside of the jail as a storage area within the jail.

To add storage, click the *Add Storage* button for a highlighted jail entry to open the screen shown in Figure 13.3. This screen can also be accessed by expanding the jail name in the tree view and clicking `Storage → Add Storage`.

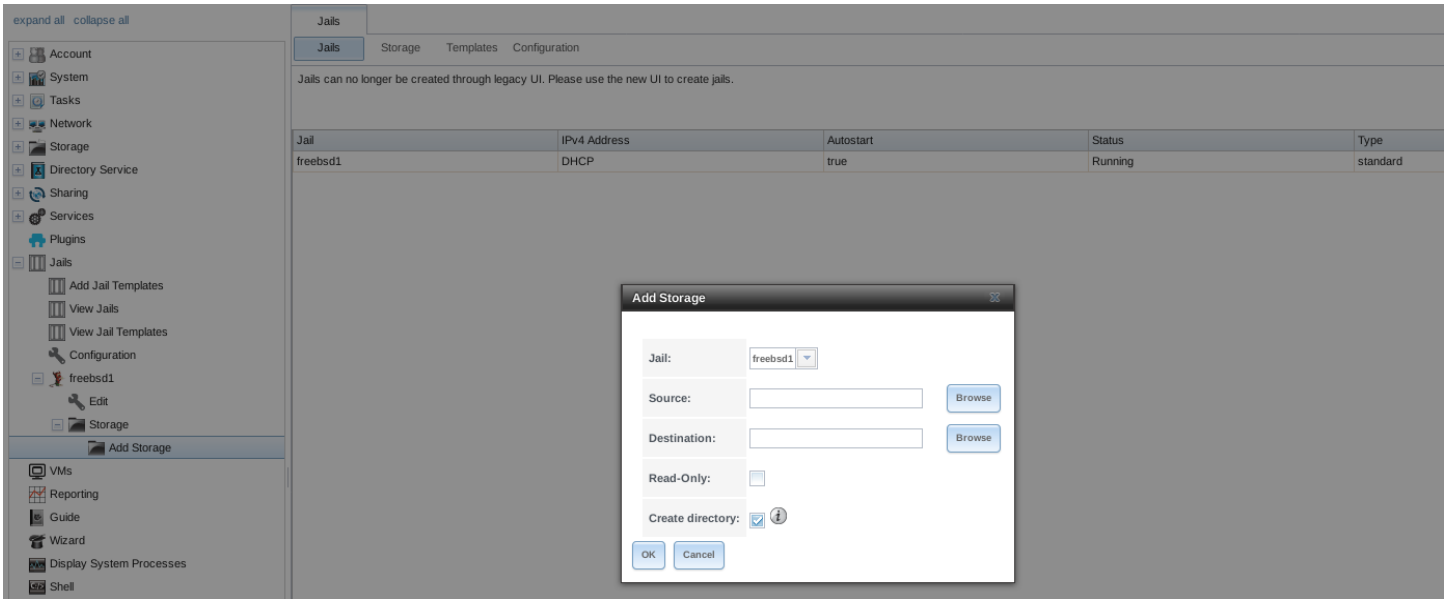


Fig. 13.3: Adding Storage to a Jail

Browse to the *Source* and *Destination*, where:

- **Source:** is the directory or dataset on the FreeNAS® system which will be accessed by the jail. This directory **must** reside outside of the volume or dataset being used by the jail. This is why it is recommended to create a separate dataset to store jails, so the dataset holding the jails is always separate from any datasets used for storage on the FreeNAS® system.
- **Destination:** select an **existing, empty** directory within the jail to link to the *Source* storage area. If that directory does not exist yet, enter the desired directory name and check the *Create directory* box.

Storage is typically added because the user and group account associated with an application installed inside of a jail needs to access data stored on the FreeNAS® system. Before selecting the *Source*, it is important to first ensure that the permissions of the selected directory or dataset grant permission to the user/group account inside of the jail. This is not the default, as the users and groups created inside of a jail are totally separate from the users and groups of the FreeNAS® system.

The workflow for adding storage usually goes like this:

1. Determine the name of the user and group account used by the application. For example, the installation of the transmission application automatically creates a user account named *transmission* and a group account also named *transmission*. When in doubt, check the files `/etc/passwd` (to find the user account) and `/etc/group` (to find the group account) inside the jail. Typically, the user and group names are similar to the application name. Also, the UID and GID are usually the same as the port number used by the service.

   A *media* user and group (GID 8675309) are part of the base system. Having applications run as this group or user makes it possible to share storage between multiple applications in a single jail, between multiple jails, or even between the host and jails.

2. On the FreeNAS® system, create a user account and group account that match the user and group names used by the application in the jail.
3. Decide whether the jail should have access to existing data or if a new area of storage will be set aside for the jail to use.
4. If the jail will access existing data, edit the permissions of the volume or dataset so the user and group accounts have the desired read and write access. If multiple applications or jails are to have access to the same data, create a new group and add each needed user account to that group.
5. If an area of storage is being set aside for that jail or individual application, create a dataset. Edit the permissions of that dataset so the user and group account has the desired read and write access.

6. Use the *Add Storage* button of the jail and select the configured volume/dataset as the *Source*.

To prevent writes to the storage, check the box *Read-Only*.

By default, the *Create directory* box is checked. This means that the directory will automatically be created under the specified *Destination* path if the directory does not already exist.

After storage has been added or created, it appears in the tree under the specified jail. In the example shown in Figure 13.4, a dataset named `tank/data` has been chosen as the *Source* as it contains the files stored on the FreeNAS® system. When the storage was created, the user browsed to `/usr/local/` in the *Destination* field, then entered *test* as the directory. Since this directory did not already exist, it was created, because the *Create directory* box was left checked. The resulting storage was added to the *freebsd1* entry in the tree as `/usr/local/test`. The user has clicked this `/usr/local/test` entry to access the *Edit* screen.

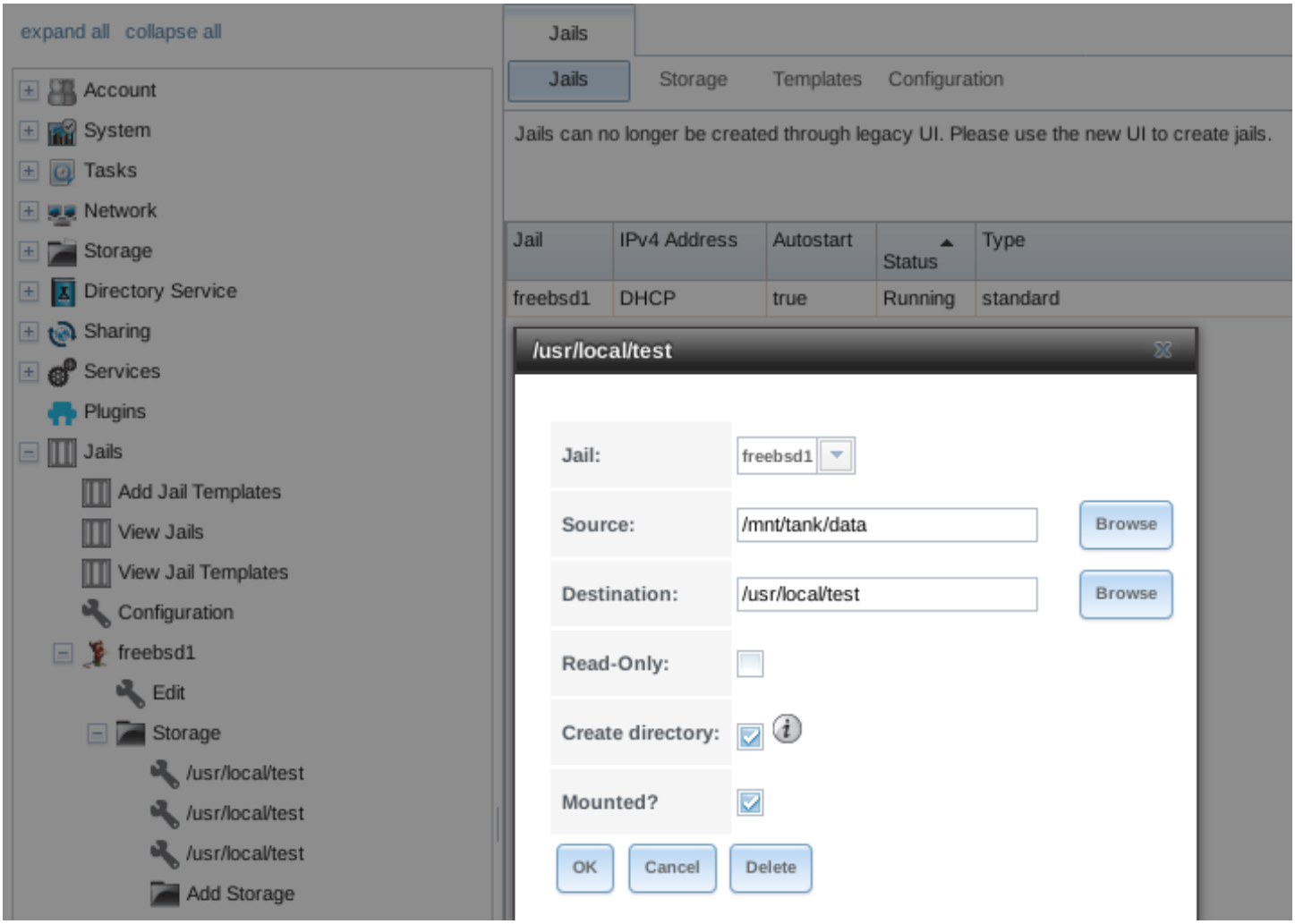


Fig. 13.4: Example Storage

Storage is normally mounted as it is created. To unmount the storage, uncheck the *Mounted?* box.

Note: A mounted dataset does not automatically mount any of its child datasets. While the child datasets may appear to be browsable inside the jail, any changes are not visible. Since each dataset is considered to be its own filesystem, each child dataset must have its own mount point. Separate storage must be created for any child datasets which need to be mounted.

To delete the storage, click the *Delete* button.

Warning: It is important to realize that added storage is really just a pointer to the selected storage directory on the FreeNAS® system. It does **not** copy that data to the jail. **Files that are deleted from the** *Destination* **directory in the jail are really deleted from the** *Source* **directory on the** FreeNAS® **system.** However, removing the jail storage entry only removes the pointer, leaving the data intact but not accessible from the jail.

13.3 Starting Installed Software

After packages or ports are installed, they need to be configured and started. If you are familiar with the software, look for the configuration file in `/usr/local/etc` or a subdirectory of it. Many FreeBSD packages contain a sample configuration file as a reference. If you are unfamiliar with the software, you will need to spend some time at the software's website to learn which configuration options are available and which configuration files require editing.

Most FreeBSD packages that contain a startable service include a startup script which is automatically installed to `/usr/local/etc/rc.d/`. After the configuration is complete, the starting of the service can be tested by running the script with the `onestart` option. As an example, if openvpn is installed into the jail, these commands run its startup script and verify that the service started:

```
/usr/local/etc/rc.d/openvpn onestart
Starting openvpn.

/usr/local/etc/rc.d/openvpn onestatus
openvpn is running as pid 45560.

sockstat -4
USER COMMAND          PID     FD      PROTO   LOCAL ADDRESS   FOREIGN ADDRESS
root openvpn          48386   4       udp4    *:54789         *:*
```

If it produces an error:

```
/usr/local/etc/rc.d/openvpn onestart
Starting openvpn.
/usr/local/etc/rc.d/openvpn: WARNING: failed to start openvpn
```

Run `tail /var/log/messages` to see if any error messages hint at the problem. Most startup failures are related to a misconfiguration: either a typo or a missing option in a configuration file.

After verifying that the service starts and is working as intended, add a line to `/etc/rc.conf` to start the service automatically when the jail is started. The line to start a service always ends in *_enable="YES"* and typically starts with the name of the software. For example, this is the entry for the openvpn service:

```
openvpn_enable="YES"
```

When in doubt, the startup script shows the line to put in `/etc/rc.conf`. This is the description in `/usr/local/etc/rc.d/openvpn`:

```
# This script supports running multiple instances of openvpn.
# To run additional instances link this script to something like
# % ln -s openvpn openvpn_foo

# and define additional openvpn_foo_* variables in one of
# /etc/rc.conf, /etc/rc.conf.local or /etc/rc.conf.d /openvpn_foo

#
# Below NAME should be substituted with the name of this script. By default
# it is openvpn, so read as openvpn_enable. If you linked the script to
# openvpn_foo, then read as openvpn_foo_enable etc.
#
```

```
# The following variables are supported (defaults are shown).
# You can place them in any of
# /etc/rc.conf, /etc/rc.conf.local or /etc/rc.conf.d/NAME
#
# NAME_enable="NO"
# set to YES to enable openvpn
```

The startup script also indicates if any additional parameters are available:

```
# NAME_if=
# driver(s) to load, set to "tun", "tap" or "tun tap"
#
# it is OK to specify the if_ prefix.
#
# # optional:
# NAME_flags=
# additional command line arguments
# NAME_configfile="/usr/local/etc/openvpn/NAME.conf"
# --config file
# NAME_dir="/usr/local/etc/openvpn"
# --cd directory
```

CHAPTER

FOURTEEN

VIRTUAL MACHINES

A Virtual Machine (*VM*) is an environment on a host computer that can be used as if it were a separate physical computer. VMs can be used to run multiple operating systems simultaneously on a single computer. Operating systems running inside a VM see emulated virtual hardware rather than the actual hardware of the host computer. This provides more isolation than *Jails* (page 251), although there is additional overhead. A portion of system RAM is assigned to each VM, and each VM uses a *zvol* (page 128) for storage. While a VM is running, these resources are not available to the host computer or other VMs.

FreeNAS® VMs use the bhyve(8) (https://www.freebsd.org/cgi/man.cgi?query=bhyve&manpath=FreeBSD+11.0-RELEASE+and+Ports) virtual machine software. This type of virtualization requires an Intel processor with Extended Page Tables (EPT) or an AMD processor with Rapid Virtualization Indexing (RVI) or Nested Page Tables (NPT).

To verify that an Intel processor has the required features, use *Shell* (page 282) to run `grep VT-x /var/run/dmesg.boot`. If the *EPT* and *UG* features are shown, this processor can be used with *bhyve*.

To verify that an AMD processor has the required features, use *Shell* (page 282) to run `grep POPCNT /var/run/dmesg.boot`. If the output shows the POPCNT feature, this processor can be used with *bhyve*.

Note: By default, new VMs have the bhyve(8) (https://www.freebsd.org/cgi/man.cgi?query=bhyve&manpath=FreeBSD+11.0-RELEASE+and+Ports) `-H` option is set. This causes the virtual CPU thread to yield when a HLT instruction is detected, and prevents idle VMs from consuming all of the host's CPU.

Note: AMD K10 "Kuma" processors include POPCNT but do not support NRIPS, which is required for use with bhyve. Production of these processors ceased in 2012 or 2013.

14.1 Creating VMs

Select `VMs` → `Add VM` for the *Add VM* dialog shown in Figure 14.1:

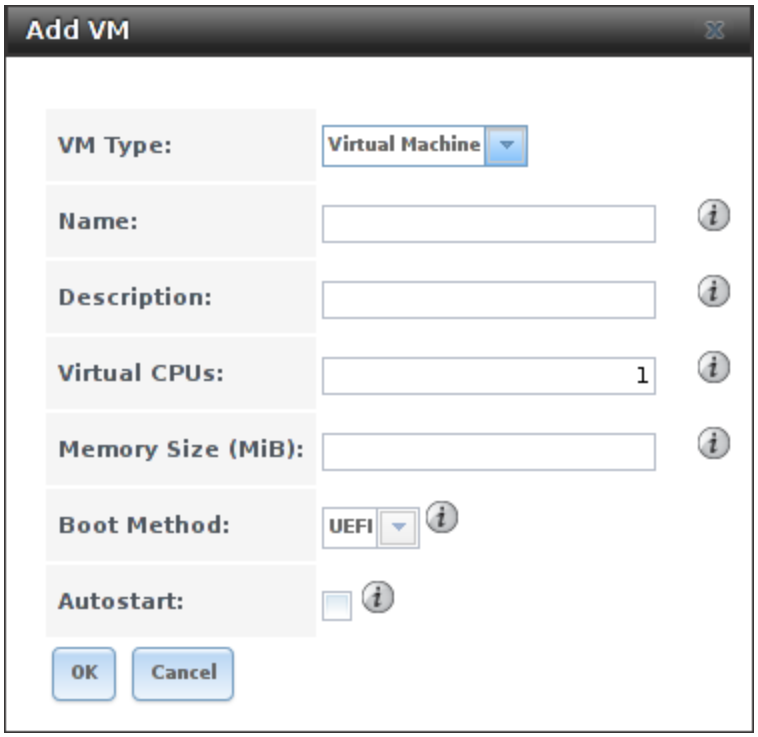


Fig. 14.1: Add VM

VM configuration options are described in Table 14.1.

Table 14.1: VM Options

Setting	Value	Description
VM Type	drop-down menu	Select the VM type. Choices are: *Virtual Machine* for a typical instance, or *Docker VM* for a special VM to run Docker.
Name	string	Enter a name to identify the VM.
Description	string	Enter a short description of the VM or its purpose.
Virtual CPUs	integer	Select the number of virtual CPUs to allocate to the VM. The maximum is 16 unless the host CPU limits the maximum. The VM operating system might also have operational or licensing restrictions on the number of CPUs.
Memory Size (MiB)	integer	Allocate the amount of RAM in mebibytes (https://simple.wikipedia.org/wiki/Mebibyte) for the VM.
Boot Method	drop-down menu	Select *UEFI* for newer operating systems, or *UEFI-CSM* for (Compatibility Support Mode) older operating systems that only understand BIOS booting.
Autostart	checkbox	Set to start the VM automatically when the system boots.

Tip: See this guide (https://github.com/FreeBSD-UPB/freebsd/wiki/How-to-launch-different-guest-OS) for more details about installing different Guest Operating Systems with a VM.

14.2 Adding Devices to a VM

After creating the VM, click it to select it, then click *Devices* and *Add Device* to add virtual hardware to it:

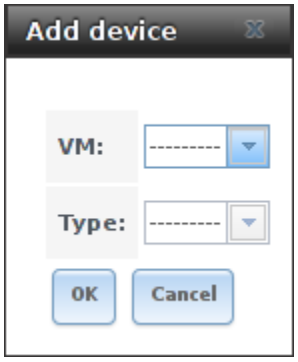


Fig. 14.2: Add Devices to a VM

Select the name of the VM from the *VM* drop-down menu, then select the *Type* of device to add. These types are available:

- *Network Interfaces* (page 263)
- *Disk Devices* (page 264)
- *Raw Files* (page 264)
- *CD-ROMs* (page 265)
- *VNC Interface* (page 265)

Note: *Docker VMs* (page 268) are not compatible with VNC connections.

Figure 14.3 shows the fields that appear when *Network Interface* is the selected *Type*.

14.2.1 Network Interfaces

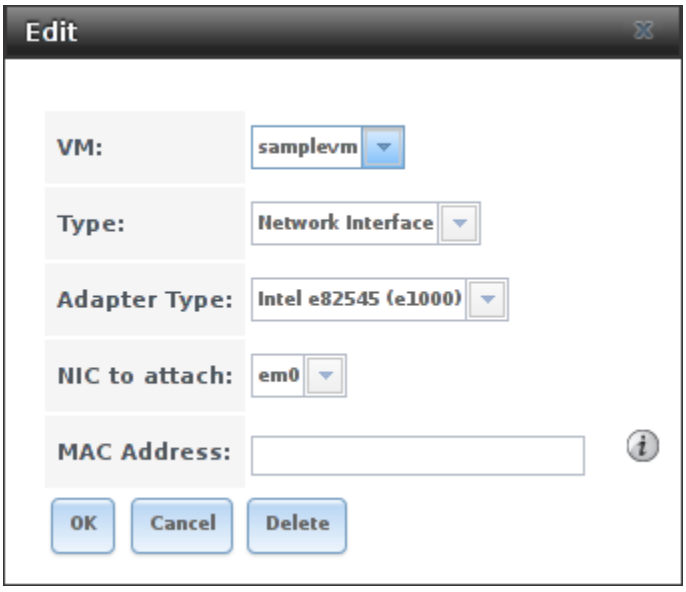


Fig. 14.3: VM Network Interface Device

The default *Adapter Type* emulates an Intel e82545 (e1000) Ethernet card for compatibility with most operating systems. *VirtIO* can provide better performance when the operating system installed in the VM supports VirtIO paravirtualized network drivers.

If the system has multiple physical network interface cards, use the *Nic to attach* drop-down menu to specify which physical interface to associate with the VM.

By default, the VM receives an auto-generated random MAC address. To override the default with a custom value, enter the desired address into the *MAC Address* field.

14.2.2 Disk Devices

Zvols (page 128) are typically used as virtual hard drives. After *creating a zvol* (page 128), associate it with the VM by selecting *Add device*, choose the *VM*, select a *Type* of *Disk*, select the created zvol, then set the *Mode*. If a specific sector size is required, enter the number of bytes into *Disk sector size*. The default of *0* leaves the sector size unset.

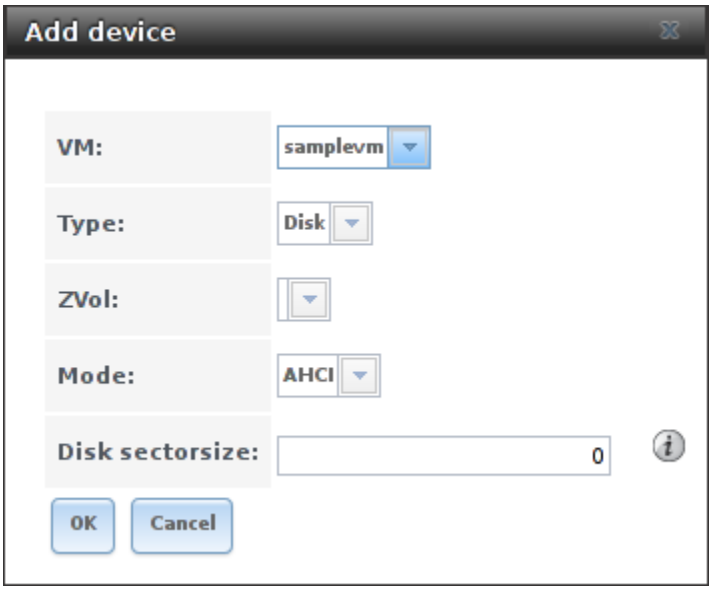


Fig. 14.4: VM Disk Device

AHCI emulates an AHCI hard disk for best software compatibility. *VirtIO* uses paravirtualized drivers and can provide better performance, but requires the operating system installed in the VM to support VirtIO disk devices.

14.2.3 Raw Files

Raw Files are similar to *Zvol* (page 128) disk devices, but the disk image comes from a file. These are typically used with existing read-only binary images of drives, like an installer disk image file meant to be copied onto a USB stick.

After obtaining and copying the image file to the FreeNAS® system, select *Add device*, choose the *VM*, select a *Type* of *Raw File*, browse to the image file, then set the *Mode*. *AHCI* emulates an AHCI hard disk for best software compatibility. *VirtIO* uses paravirtualized drivers and can provide better performance, but requires the operating system installed in the VM to support VirtIO disk devices.

If a specific sector size is required, enter the number of bytes into *Disk sectorsize*. The default of *0* leaves the sector size unset.

Fig. 14.5: VM Raw File Disk Device

14.2.4 CD-ROM Devices

Adding a CD-ROM device makes it possible to boot the VM from a CD-ROM image, typically an installation CD. The image must be present on an accessible portion of the FreeNAS® storage. In this example, a FreeBSD installation image is shown:

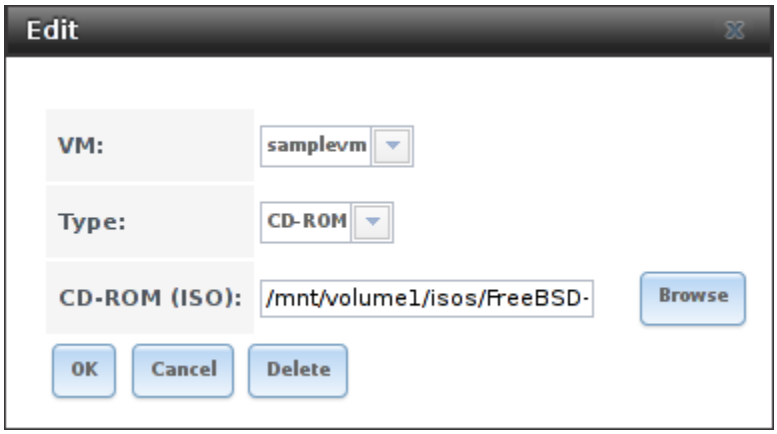


Fig. 14.6: VM CD-ROM Device

Note: VMs from other virtual machine systems can be recreated for use in FreeNAS®. Back up the original VM, then create a new FreeNAS® VM with virtual hardware as close as possible to the original VM. Binary-copy the disk image data into the *zvol* (page 128) created for the FreeNAS® VM with a tool that operates at the level of disk blocks, like dd(1) (https://www.freebsd.org/cgi/man.cgi?query=dd). For some VM systems, it is best to back up data, install the operating system from scratch in a new FreeNAS® VM, and restore the data into the new VM.

14.2.5 VNC Interface

VMs set to *UEFI* booting are also given a VNC (Virtual Network Computing) remote connection. A standard VNC (https://en.wikipedia.org/wiki/Virtual_Network_Computing) client can connect to the VM to provide screen output and key-

board and mouse input.

Figure 14.7 shows the fields that appear when *VNC* is the selected *Type*.

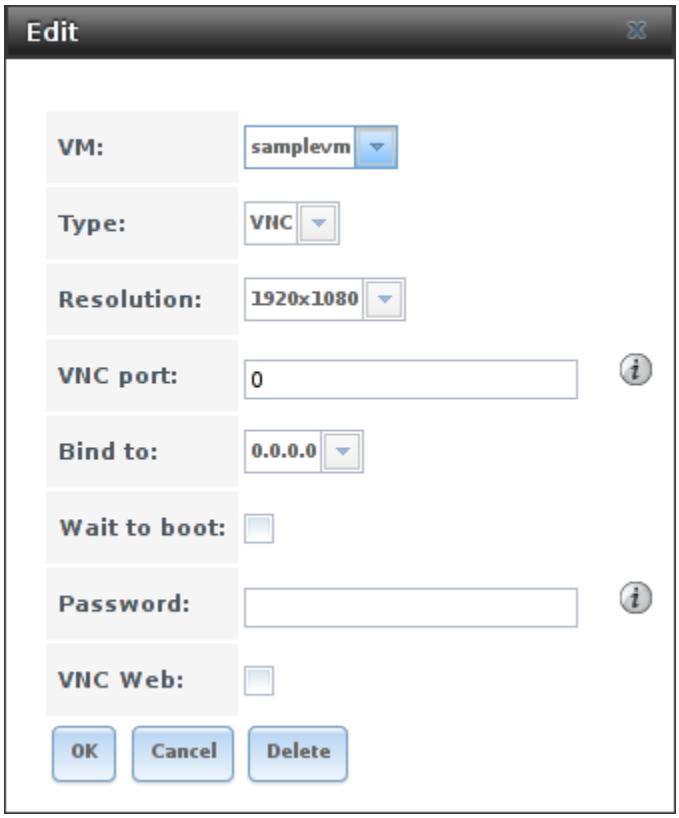


Fig. 14.7: VM VNC Device

The *Resolution* drop-down menu can be used to modify the default screen resolution used by the VNC session.

The *VNC port* can be set to *0*, left empty for FreeNAS® to assign a port when the VM is started, or set to a fixed, preferred port number.

Select the IP address for VNC to listen on with the *Bind to* drop-down menu.

Set *Wait to boot* to indicate that the VNC client should wait until the VM has booted before attempting the connection.

To automatically pass the VNC password, enter it into the *Password* field. Note that the password is limited to 8 characters.

To use the VNC web interface, set *VNC Web*.

Tip: If a RealVNC 5.X Client shows the error `RFB protocol error: invalid message type`, disable the *Adapt to network speed* option and move the slider to *Best quality*. On later versions of RealVNC, select `File → Preferences`, click *Expert*, *ProtocolVersion*, then select 4.1 from the drop-down menu.

14.2.6 Virtual Serial Ports

VMs automatically include a virtual serial port.

- `/dev/nmdm1B` is assigned to the first VM
- `/dev/nmdm2B` is assigned to the second VM

And so on. These virtual serial ports allow connecting to the VM console from the *Shell* (page 282).

Tip: The nmdm (https://www.freebsd.org/cgi/man.cgi?query=nmdm&manpath=FreeBSD+11.1-RELEASE+and+Ports) device is dynamically created. The actual `nmdm` name can differ on each system.

To connect to the first VM:

```
cu -s 9600 -l /dev/nmdm1B
```

See cu(1) (https://www.freebsd.org/cgi/man.cgi?query=cu) for more information on operating `cu`.

14.3 Running VMs

Select `VMs` to see a list of configured VMs. Configuration and control buttons appear at the bottom of the screen when an individual VM is selected with a mouse click:

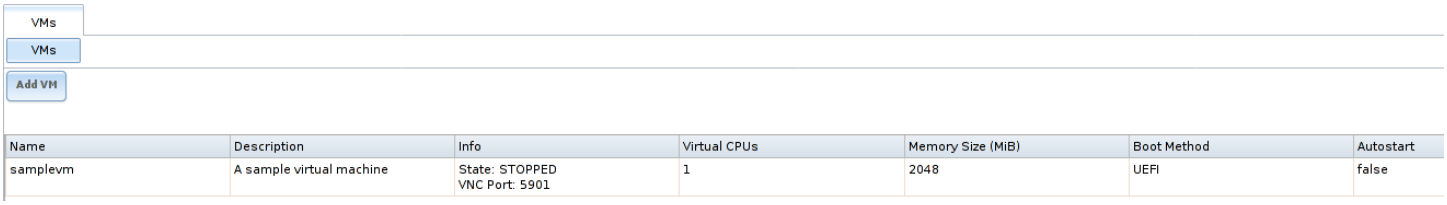


Fig. 14.8: VM Configuration and Control Buttons

The name, description, running state, VNC port (if present), and other configuration values are shown. Click on an individual VM for additional options.

Some standard buttons are shown for all VMs:

- *Edit* changes VM settings.
- *Delete removes the VM* (page 267).
- *Devices* is used to add and remove devices to this VM.

When a VM is not running, these buttons are available:

- *Start* starts the VM.
- *Clone clones* or copies the VM to a new VM. The new VM is given the same name as the original, with *_cloneN* appended.

When a VM is already running, these buttons are available:

- *Stop* shuts down the VM.
- *Power off* immediately halts the VM, equivalent to disconnecting the power on a physical computer.
- *Restart* restarts the VM.
- *Vnc via Web* starts a web VNC connection to the VM. The VM must have a VNC device and *VNC Web* enabled in that device.

14.4 Deleting VMs

A VM is deleted by clicking the VM, then *Delete* at the bottom of the screen. A dialog will show any related devices that will also be deleted and ask for confirmation.

Tip: *Zvols* (page 128) used in *disk devices* (page 264) and image files used in *raw file* (page 264) devices are *not* removed when a VM is deleted. These resources can be removed manually after it is determined that the data in them has been backed up or is no longer needed.

14.5 Docker/Rancher VM

Docker (https://www.docker.com/what-docker) is Open Source software for automating application deployment inside containers. A container provides a complete filesystem, runtime, system tools, and system libraries, so applications always see the same environment.

Rancher (https://rancher.com/) is a GUI tool for managing Docker containers.

FreeNAS® runs the Rancher GUI as a separate VM.

14.5.1 Rancher VM Requirements

The system BIOS **must** have virtualization support enabled for a Docker VM to run properly after installation. On Intel systems this is typically an option called *VT-x*. AMD systems generally have an *SVM* option.

20 GiB of storage space is required for the Rancher VM. For setup, the *SSH* (page 240) service must be enabled.

The Rancher VM requires 2 GiB of RAM while running.

14.5.2 Create the Rancher VM

Click *VMs*, then the *Add VM* button. Set the *VM Type* to *Docker VM*. Enter *RancherUI* for the name, *Rancher UI VM* for the *Description*, leave the number of *Virtual CPUs* at *1*, and enter *2048* for the *Memory Size*. To have the Rancher VM start when the FreeNAS® system boots, enable the *Autostart* option. Click *OK* to create the virtual machine.

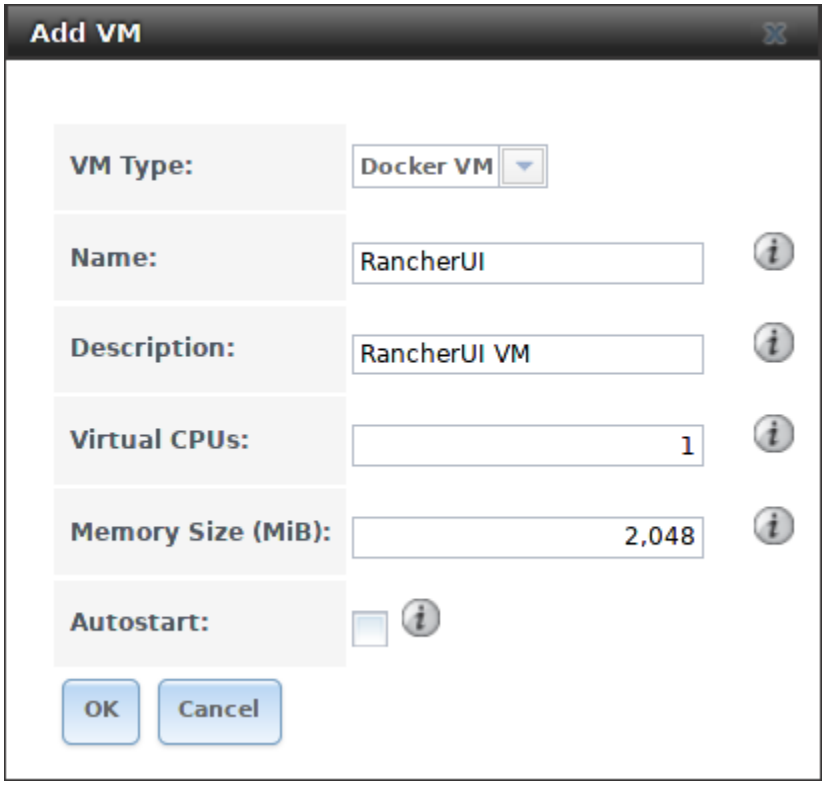


Fig. 14.9: Rancher VM Configuration

A location to store the disk image must now be chosen. In this example, a *dataset* (page 125) called *vm-storage* has already been created as a location to store VM data. Click *VMs*, then click on the *RancherUI* line to select it. Click on the *Devices* button to show the devices attached to that VM. Click on the *RAW* device to select it, then click the *Edit* button. In the *Raw File* field, browse to the dataset and select it. Then add a filename by typing */rancherui.img* at the end of the path in the text box.

Set the *Disk boot* option, enter a password for the `rancher` user in the *Password* field, then enter *20G* in the *Disk size* field. Click *OK* to save the device.

Note: The *Password* will fail if it contains a space.

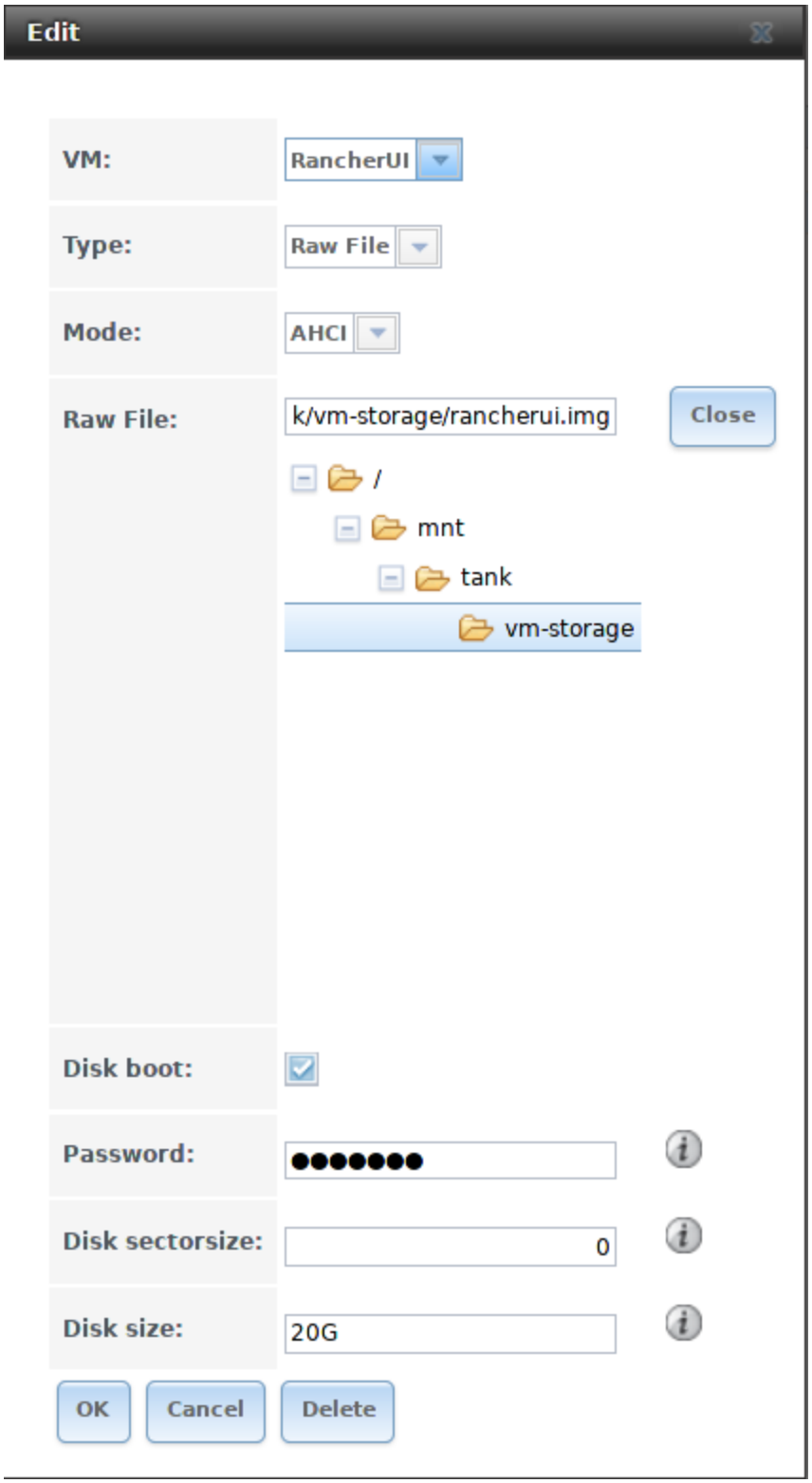


Fig. 14.10: Rancher Image Storage

14.5.3 Start the Rancher VM

Click *VMs*, then click on the *RancherUI* line to select it. Click the *Start* button and then *Yes* to start the VM.

The first time the Rancher VM is started, it downloads the Rancher disk image file. How long this takes to complete depends

on the speed of the network connection. A status dialog reports the progress of the download.

After the image is downloaded, the VM starts.

14.5.4 Installing the Rancher Server

Click *VMs* and locate the line for the RancherUI VM. The *Info* column shows the `Com Port` for the Rancher VM. In this example, `/dev/nmdm3B` is used.

Further setup of the Rancher VM is done from the command line. Use an SSH client to connect to the FreeNAS® server. Remember that this requires the *SSH* (page 240) service to be running. Depending on local configuration, it might also require changes to the setting of the service, like allowing root user login with a password.

At the FreeNAS® console prompt, connect to the Rancher VM with cu (https://www.freebsd.org/cgi/man.cgi?query=cu), replacing `/dev/nmdm3B` with the value from the RancherUI *Info* column:

```
cu -l /dev/nmdm3B
```

If the terminal does not show a `rancher login:` prompt, press `Enter`.

Enter *rancher* as the username, press `Enter`, then type the password that was entered when the raw file was created above and press `Enter` again. After logging in, a `[rancher@rancher ~]$` prompt is displayed.

Ensure Rancher has functional networking and can `ping` an outside website. Adjust the VM *Network Interface* (page 263) and reboot the VM if necessary.

Download and install the Rancher system with this command:

```
sudo docker run -d --restart=unless-stopped -p 8080:8080 rancher/server
```

Note: If the error `Cannot connect to the Docker daemon` is shown, run `sudo dockerd`. Then give the `sudo docker run` command above again.

Installation time varies with processor and network connection speed, but typically takes a few minutes. After the process finishes and a command prompt is shown, type this command:

```
ifconfig eth0 | grep 'inet addr'
```

The first value is the IP address of the Rancher server. Enter the IP address and port `8080` as the URL in a web browser. For example, if the IP address was `10.231.3.208`, enter `10.231.3.208:8080` as the URL in the web browser.

The Rancher server takes a few minutes to start. The web browser might show a connection error while the Rancher GUI is still starting. If the browser shows a `connection has timed out` or a similar error, wait one minute and try again.

In the Rancher GUI, click *Add a host* and enter the same IP address and port number. Click *Save* to save the information.

For more information on using Rancher, see the Rancher Quick Start Guide (https://rancher.com/docs/rancher/v1.6/en/quick-start-guide/).

CHAPTER

FIFTEEN

REPORTING

Reporting displays several graphs, as seen in Figure 15.1. Click the tab for a device type to see those specific graphs.

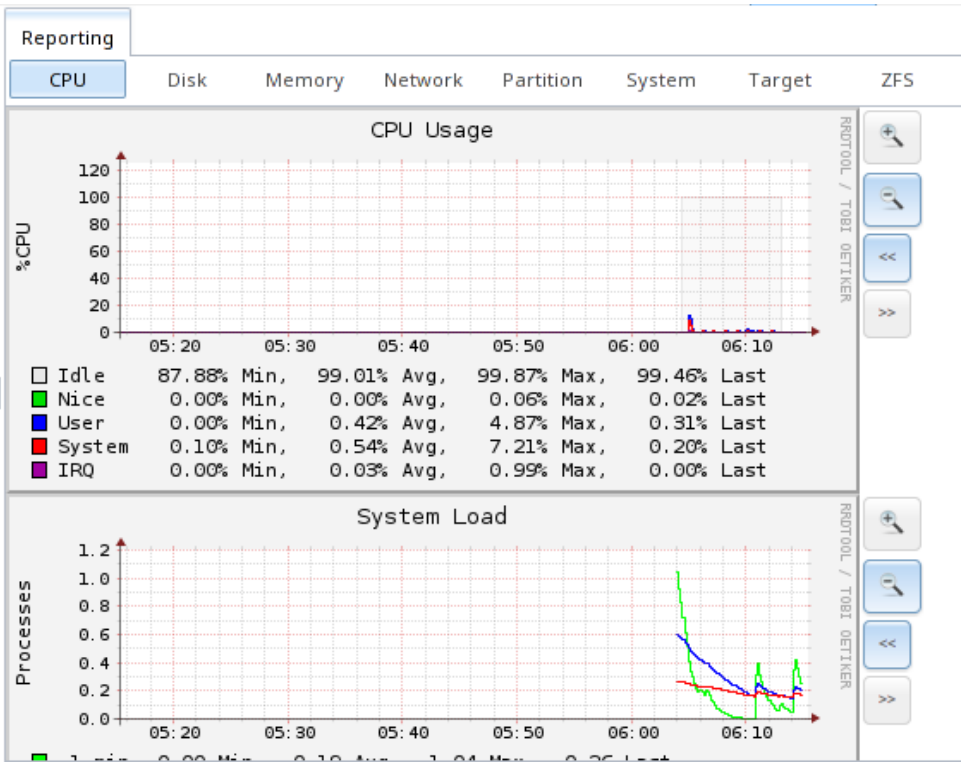


Fig. 15.1: Reporting Graphs

FreeNAS® uses collectd (https://collectd.org/) to provide reporting statistics. The resulting graphs are grouped into several tabs on the Reporting page:

- *CPU*
  - CPU (https://collectd.org/wiki/index.php/Plugin:CPU) shows the amount of time spent by the CPU in various states such as executing user code, executing system code, and being idle.
- *Disk*
  - Disk (https://collectd.org/wiki/index.php/Plugin:Disk) shows statistics on I/O, percent busy, latency, operations per second, pending I/O requests, and disk temperature.
- *Memory*
  - Memory (https://collectd.org/wiki/index.php/Plugin:Memory) displays memory usage.
  - Swap (https://collectd.org/wiki/index.php/Plugin:Swap) displays the amount of free and used swap space.

- *Network*
  - Interface (https://collectd.org/wiki/index.php/Plugin:Interface) shows received and transmitted traffic in bits per second for each configured interface.
- *Partition*
  - Disk space (https://collectd.org/wiki/index.php/Plugin:DF) displays free and used space for each volume and dataset. However, the disk space used by an individual zvol is not displayed as it is a block device.
- *System*
  - Processes and Uptime (https://collectd.org/wiki/index.php/Plugin:Processes) displays the number of processes. It is grouped by state.
  - Uptime (https://collectd.org/wiki/index.php/Plugin:Uptime) keeps track of the system uptime, the average running time, and the maximum reached uptime.
- *Target*
  - Target shows bandwidth statistics for iSCSI ports.
- *ZFS*
  - ZFS (https://collectd.org/wiki/index.php/Plugin:ZFS_ARC) shows ARC size, hit ratio, and requests.

Reporting data is saved to permit viewing and monitoring usage trends over time. This data is preserved across system upgrades and restarts.

Data files are saved in `/var/db/collectd/rrd/`.

The reporting data file recording method is controlled by the `System → System Dataset` *Reporting database* option. When deselected, data files are recorded in a temporary filesystem and copied hourly to on-disk files.

When `System → System Dataset` *Reporting database* is enabled, data files are written directly to the *System Dataset* (page 68).

Warning: Reporting data is frequently written and should not be stored on the boot pool or boot device.

Use the magnifier buttons next to each graph to increase or decrease the displayed time increment from 10 minutes, hourly, daily, weekly, or monthly. The << and >> buttons can be used to scroll through the output.

Update on using Graphite with FreeNAS (http://cmhramblings.blogspot.com/2015/12/update-on-using-graphite-with-freenas.html) contains instructions for sending the collected information to a Graphite (http://graphiteapp.org/) server.

CHAPTER

SIXTEEN

WIZARD

FreeNAS® provides a wizard which helps complete the steps needed to quickly configure FreeNAS® for serving data over a network. The wizard can be run at any time by clicking the *Wizard* icon.

Figure 16.1 shows the first wizard configuration screen.

Fig. 16.1: Configuration Wizard

Note: You can exit the wizard at any time by clicking the *Exit* button. However, exiting the wizard will not save any selections. The wizard can always be run again by clicking the *Wizard* icon. Alternately, the FreeNAS® GUI can be used to configure the system, as described in the rest of this Guide.

This screen can be used to change the default language, keyboard map, and timezone. After making your selections, click *Next*. The next screen depends on whether or not the storage disks have already been formatted into a ZFS pool.

Figure 16.2 shows the configuration screen that appears if the storage disks have not yet been formatted.

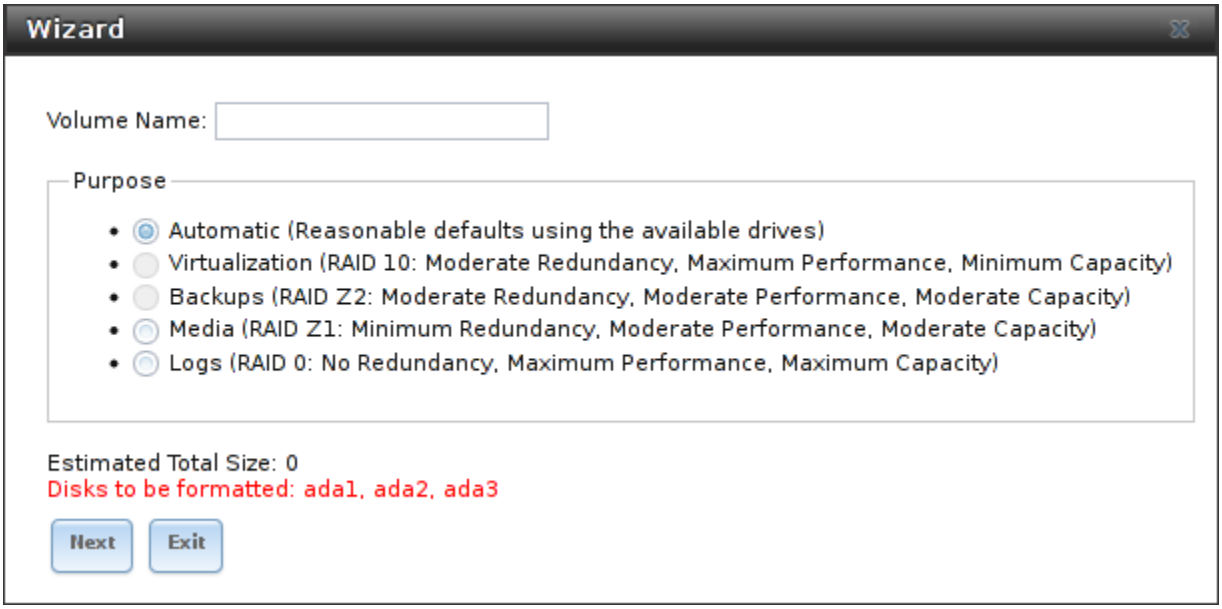


Fig. 16.2: Volume Creation Wizard

Note: The wizard will not recognize an **encrypted** ZFS pool. If your ZFS pool is GELI-encrypted, cancel the wizard and use the instructions in *Importing an Encrypted Pool* (page 131) to import the encrypted volume. You can then rerun the wizard afterwards, if you wish to use it for post-configuration, and it will recognize that the volume has been imported and will not prompt to reformat the disks.

Enter a name for the ZFS pool that conforms to these naming conventions (https://docs.oracle.com/cd/E23824_01/html/821-1448/gbcpt.html). It is recommended to choose a name that will stick out in the logs (e.g. **not** `data` or `freenas`).

Decide if the pool should provide disk redundancy, and if so, which type. The *ZFS Primer* (page 314) discusses RAIDZ redundancy in more detail. If you prefer to make a more complex configuration, click the *Exit* button to close the wizard and instead use *Volume Manager* (page 118).

These redundancy types are available:

- **Automatic:** automatically creates a mirrored, RAIDZ1, or RAIDZ2 pool, depending upon the number of disks. If you prefer to control the type of redundancy, select one of the other options.
- **RAID 10:** creates a striped mirror and requires a minimum of 4 disks.
- **RAIDZ2:** requires a minimum of 4 disks. Up to 2 disks can fail without data loss.
- **RAIDZ1:** requires a minimum of 3 disks. Up to 1 disk can fail without data loss.
- **Stripe:** requires a minimum of 1 disk. Provides **no** redundancy, meaning if any of the disks in the stripe fails, all data in the stripe is lost.

Once you have made your selection, click *Next* to continue.

If the disks have already been formatted with ZFS and the disks have **not** been encrypted, the next screen will instead prompt to import the volume, as shown in Figure 16.3.

Fig. 16.3: Volume Import Screen

Select the existing volume from the drop-down menu and click *Next* to continue.

The next screen in the wizard is shown in Figure 16.4.

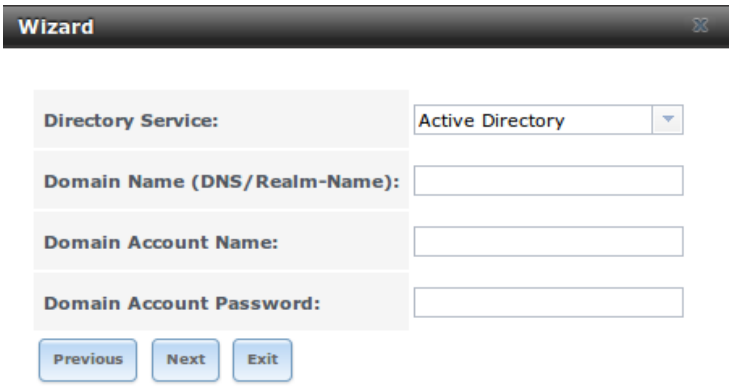


Fig. 16.4: Directory Service Selection

If the FreeNAS® system is on a network that does not contain an Active Directory, LDAP, or NIS server, click *Next* to skip to the next screen.

However, if the FreeNAS® system is on a network containing an Active Directory, LDAP, or NIS server and you wish to import the users and groups from that server, select the type of directory service in the *Directory Service* drop-down menu. The rest of the fields in this screen will vary, depending upon which directory service is selected. Available configuration options for each directory service are summarized in Tables 16.1 through 16.3.

Note: Additional configuration options are available for each directory service. The wizard can be used to set the initial values required to connect to that directory service. You can then review the other available options in *Directory Services* (page 162) to determine if additional configuration is required.

Table 16.1: Active Directory Options

Setting	Value	Description
Domain Name	string	name of Active Directory domain (e.g. *example.com*) or child domain (e.g. *sales.example.com*)
Domain Account Name	string	name of the Active Directory administrator account
Domain Account Password	string	password for the Active Directory administrator account

Table 16.2: LDAP Options

Setting	Value	Description
Hostname	string	hostname or IP address of LDAP server

Continued on next page

Table 16.2 – continued from previous page

Setting	Value	Description
Base DN	string	top level of the LDAP directory tree to be used when searching for resources (e.g. *dc=test,dc=org*)
Bind DN	string	name of administrative account on LDAP server (e.g. *cn=Manager,dc=test,dc=org*)
Base password	string	password for

Table 16.3: NIS Options

Setting	Value	Description
NIS domain	string	name of NIS domain
NIS servers	string	comma delimited list of hostnames or IP addresses
Secure mode	checkbox	if checked, ypbind(8) (https://www.freebsd.org/cgi/man.cgi?query=ypbind) will refuse to bind to any NIS server that is not running as root on a TCP port number over 1024
Manycast	checkbox	if checked, ypbind will bind to the server that responds the fastest; this is useful when no local NIS server is available on the same subnet

The next configuration screen, shown in Figure 16.5, is used to create network shares.

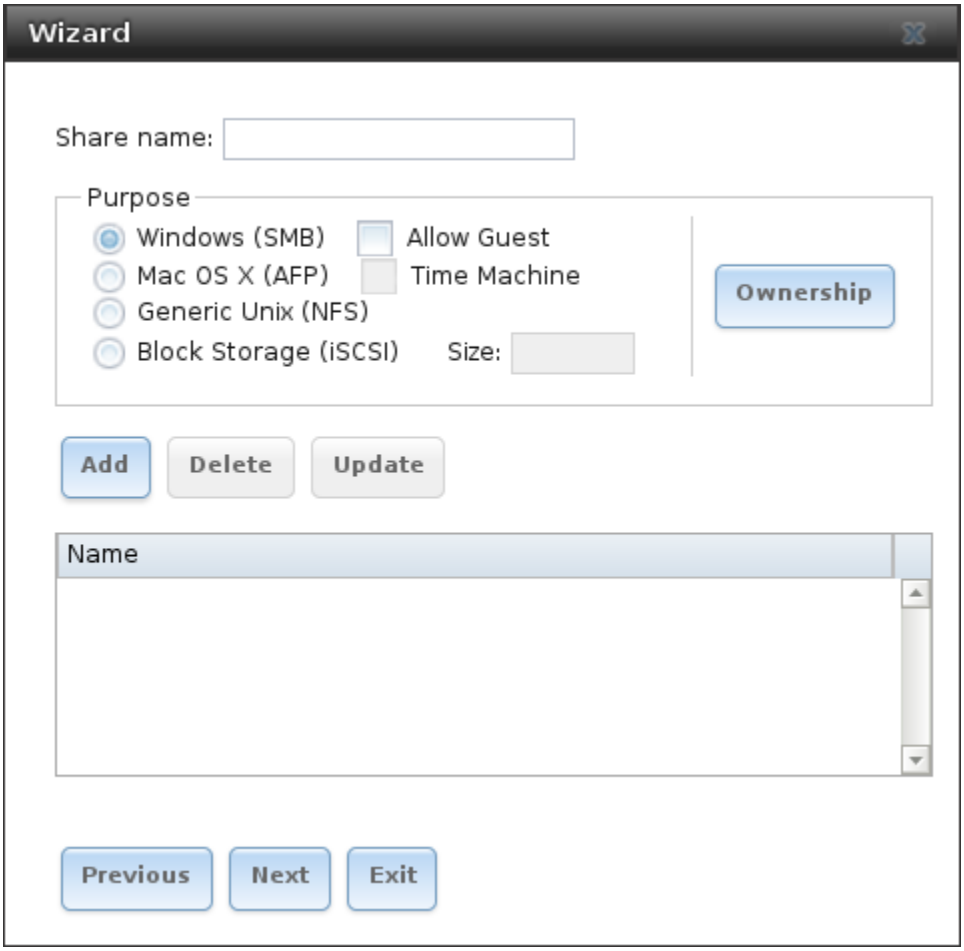


Fig. 16.5: Network Shares

FreeNAS® supports several types of shares for providing storage data to the clients in a network. The initial wizard can be

used to quickly make shares using default permissions which should "just work" for common scenarios. For more complex scenarios, refer to the section on *Sharing* (page 173).

To create a share using the wizard, enter a name for the share, then select the *Purpose* of the share:

- **Windows (SMB):** this type of share can be accessed by any operating system using a SMB client. Check the box for *Allow Guest* to allow users to access the share without a password. SMB shares created with the wizard can be fine-tuned afterward with *Windows (SMB) Shares* (page 189).
- **Mac OS X (AFP):** this type of share can be accessed by Mac OS X users. Check the box for *Time Machine* if Mac users will be using the FreeNAS® system as a backup device. AFP shares created with the wizard can be fine-tuned afterward with *Apple (AFP) Shares* (page 174).
- **Generic Unix (NFS):** this type of share can be accessed by any operating system using a NFS client. NFS shares created using the wizard can be fine-tuned afterward with *Unix (NFS) Shares* (page 181).
- **Block Storage (iSCSI):** this type of share can be accessed by any operating system using iSCSI initiator software. Enter the size of the block storage to create in the format *20G* (for 20 GB). iSCSI shares created with the wizard can be fine-tuned afterward with *iSCSI* (page 225).

After selecting the *Purpose*, click the *Ownership* button to see the screen shown in Figure 16.6.

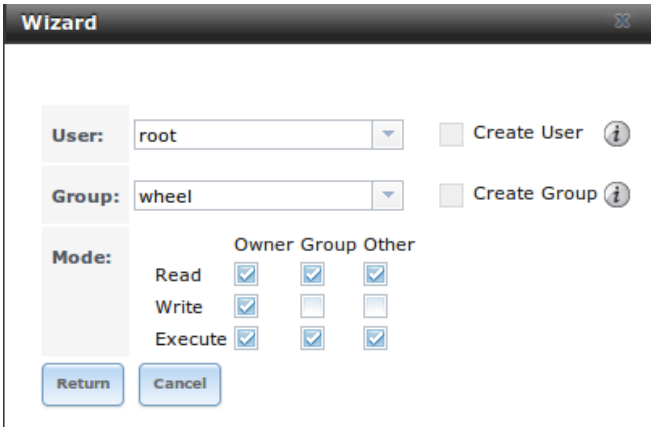


Fig. 16.6: Share Permissions

The default permissions for the share are displayed. To create a user or group, enter the desired name, then check the *Create User* box to create that user and the *Create Group* box to create the group. Check or uncheck the boxes in the *Mode* section to set the initial access permissions for the share. When finished, click the *Return* button to return to the share creation screen. Click the *Add* button to finish creating that share, which will then appear in the *Name* frame.

The *Delete* button can be used to remove the share highlighted in the *Name* frame. To edit a share, highlight it, make the change, then press the *Update* button.

When finished making shares, click the *Next* button to advance to the screen shown in Figure 16.7.

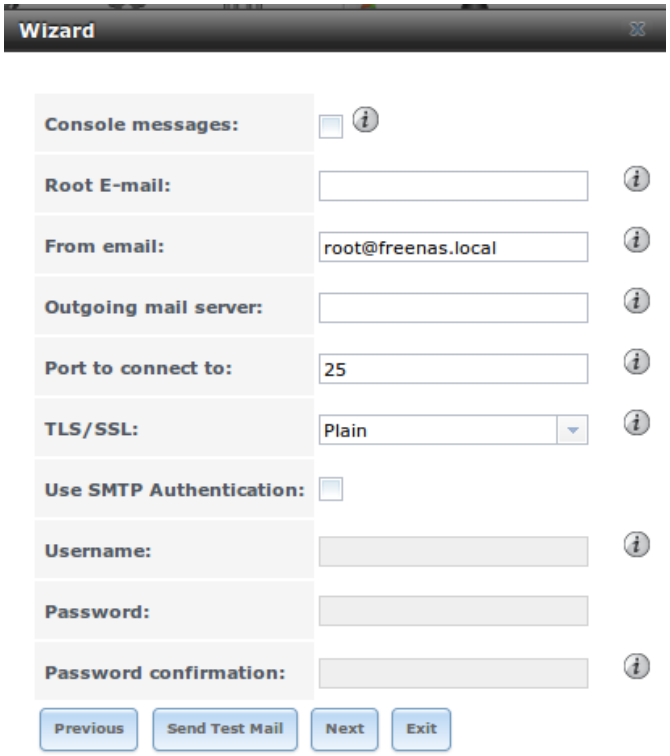


Fig. 16.7: Miscellaneous Settings

This screen can be used to configure these settings:

- **Console messages:** check this box if you would like to view system messages at the bottom of the graphical administrative interface. This can be handy when troubleshooting a service that will not start. When using the console message view, if you click the console messages area, it will pop-up as a window, allowing you to scroll through the output and to copy its contents.
- **Root E-mail:** FreeNAS® provides an "Alert" icon in the upper right corner to provide a visual indication of events that warrant administrative attention. The alert system automatically emails the *root* user account whenever an alert is issued. **It is important** to enter the email address of the person to receive these alerts and other administrative emails. The rest of the email settings in this screen should also be reviewed and edited as necessary. Before leaving this screen, click the "Send Test Mail" button to ensure that email notifications are working correctly.
- **From email:** the from email address to use when sending email notifications.
- **Outgoing mail server:** hostname or IP address of SMTP server.
- **Port to connect to:** port number used by the SMTP server.
- **TLS/SSL:** encryption type used by the SMTP server.
- **Use SMTP Authentication:** check this box if the SMTP server requires authentication.
- **Username:** enter the username if the SMTP server requires authentication.
- **Password:** enter the password if the SMTP server requires authentication.

When finished, click *Next*. A message will indicate that the wizard is ready to perform all of the saved actions. To make changes, click the *Return to Wizard* button to review your edits. If you click the *Exit without saving* button, none of your selections will be saved. To save your edits, click the *Confirm* button. A status bar will indicate when the wizard has completed applying the new settings.

In addition to the settings that you specify, the wizard will automatically enable *S.M.A.R.T. Tests* (page 102), create a boot environment, and add the new boot environment to the boot menu. If you also wish to save a backup of the configuration database to the system being used to access the administrative graphical interface, go to `System → General`, click the

Save Config button, and browse to the directory where the configuration will be saved. **Always back up your configuration after making any configuration changes**.

The rest of this Guide describes the FreeNAS® graphical interface in more detail. The layout of this Guide follows the order of the menu items in the tree located in the left frame of the graphical interface.

Note: It is important to use the GUI (or the Console Setup menu) for all configuration changes. FreeNAS® uses a configuration database to store its settings. While it is possible to use the command line to modify your configuration, changes made at the command line **are not** written to the configuration database. This means that any changes made at the command line will not persist after a reboot and will be overwritten by the values in the configuration database during an upgrade.

CHAPTER

SEVENTEEN

DISPLAY SYSTEM PROCESSES

Clicking *Display System Processes* opens a screen showing the output of top(1) (https://www.freebsd.org/cgi/man.cgi?query=top). An example is shown in Figure 17.1.

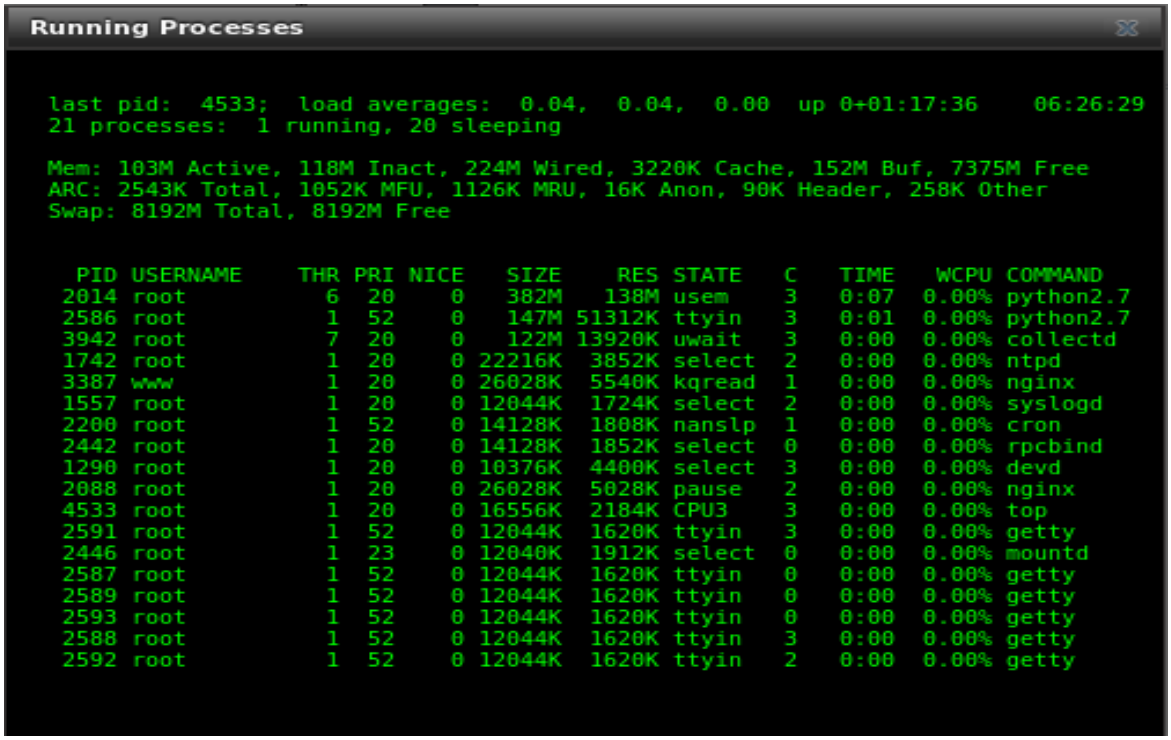


Fig. 17.1: System Processes Running on FreeNAS®

The display automatically refreshes itself. The display is read-only.

CHAPTER

EIGHTEEN

SHELL

Beginning with version 8.2.0, the FreeNAS® GUI provides a web shell, making it convenient to run command line tools from the web browser as the *root* user. The link to Shell is the fourth entry from the bottom of the menu tree. In Figure 18.1, the link has been clicked and Shell is open.

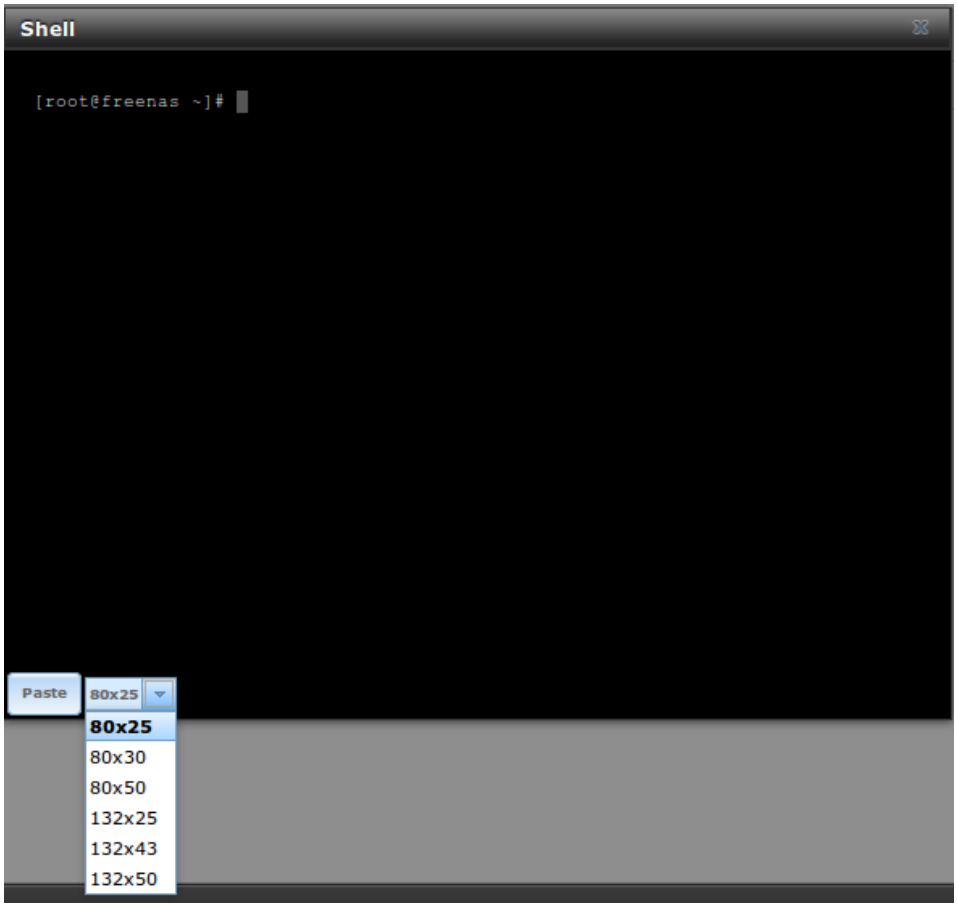


Fig. 18.1: Web Shell

The prompt indicates that the current user is *root*, the hostname is *freenas*, and the current working directory is `~` (*root*'s home directory).

To change the size of the shell, click the *80x25* drop-down menu and select a different size.

To copy text from shell, highlight the text, right-click, and select *Copy* from the right-click menu. To paste into the shell, click the *Paste* button, paste the text into the box that opens, and click the *OK* button to complete the paste operation.

Shell provides history (use your up arrow to see previously entered commands and press `Enter` to repeat the currently displayed command) and tab completion (type a few letters and press tab to complete a command name or filename in the

current directory). When you are finished using Shell, type `exit` to leave the session.

While you are in Shell, you will not have access to any of the other GUI menus. If you need to have access to a prompt while using the GUI menus, use *tmux* (page 308) instead as it supports multiple shell sessions and the detachment and reattachment of sessions.

Note: Not all of Shell's features render correctly in Chrome. Firefox is the recommended browser for using Shell.

Most FreeBSD command line utilities are available in Shell. Additional troubleshooting utilities that are provided by FreeNAS® are described in *Command Line Utilities* (page 294).

CHAPTER

NINETEEN

LOG OUT

Click the *Log Out* entry in the FreeNAS® GUI to log out.

After logging out, a message appears with a link to log back in.

CHAPTER

TWENTY

REBOOT

Clicking the *Reboot* entry in the tree shows the warning message in Figure 20.1. The browser screen color changes to red to indicate that this option will negatively impact current users of the FreeNAS® system.

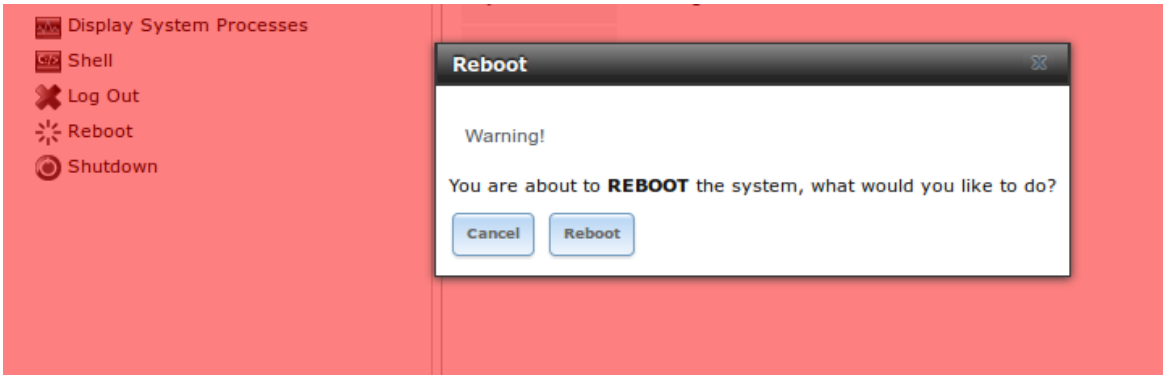


Fig. 20.1: Reboot Warning Message

An additional warning message appears when a restart is attempted on a system with a scrub or resilver in progress. In this case, it is recommended to *Cancel* the reboot request and to periodically run `zpool status` from Shell until it is verified that the scrub or resilver process is complete. Once complete, the reboot request can be reissued.

Click the *Cancel* button to cancel the reboot request. Otherwise, click the *Reboot* button to reboot the system. Rebooting the system disconnects all clients, including the web administration GUI. The URL in the web browser changes to add */system/reboot/* to the end of the IP address. Wait a few minutes for the system to boot, then use the back button in the browser to return to the IP address of the FreeNAS® system. The GUI login screen appears after a successful reboot. If the login screen does not appear, using a monitor and keyboard to physically access the FreeNAS® system is required to determine the problem that is preventing the system from resuming normal operation.

CHAPTER

TWENTYONE

SHUTDOWN

Clicking the *Shutdown* entry in the tree opens the warning message shown in Figure 21.1. The browser window color changes to red to indicate that this command will negatively impact current users of the FreeNAS® system.

Fig. 21.1: Shutdown Warning Message

If a scrub or resilver is running, a warning is shown. Clicking *Cancel* is recommended. `zpool status` can be run from the *Shell* (page 282) to watch for the scrub or resilver to complete. Then the system can be shut down normally.

Confirm the command and click *Shutdown* to shutdown the system. Shutting down the system disconnects all clients, including the web administration GUI. Physical access to the FreeNAS® system is required to turn it back on.

CHAPTER

TWENTYTWO

SUPPORT ICON

The *Support* icon, the third icon from the left in the top menubar, provides a shortcut to `System → Support`. This screen can be used to create a support ticket. Refer to *Support* (page 84) for detailed usage instructions.

CHAPTER

TWENTYTHREE

GUIDE

The *Documentation* icon, the second icon from the left in the top menubar, provides a built-in browser to the FreeNAS® User Guide (this documentation).

CHAPTER

TWENTYFOUR

ALERT

The FreeNAS® alert system provides a visual warning of any conditions that require administrative attention. The *Alert* button in the far right corner flashes red when there is an outstanding alert. In the example alert shown in Figure 24.1, the system is warning that the S.M.A.R.T. service is not running.

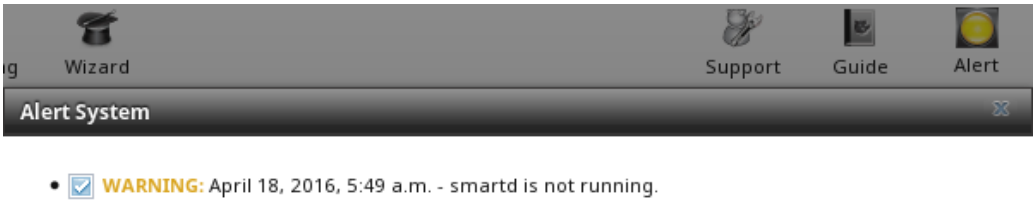


Fig. 24.1: Example Alert Message

Informational messages have a green *OK*, warning messages flash yellow, and messages requiring attention are listed as a red *CRITICAL*. CRITICAL messages are also emailed to the root user account. To remove the flashing alert for a message, deselect the option next to it.

Behind the scenes, an alert daemon checks for various alert conditions, such as volume and disk status, and writes the current conditions to `/var/tmp/alert`. The daemon retrieves the current alert status every minute and changes the solid green alert icon to flashing red when a new alert is detected.

Current alerts are viewed from the Shell option of the Console Setup Menu (Figure 3.1) or from the Web Shell (Figure 18.1) by running `alertcli.py`.

Some of the conditions that trigger an alert include:

- used space on a volume, dataset, or zvol goes over 80%; the alert goes red at 95%
- new OpenZFS feature flags are available for the pool; this alert can be unchecked if a pool upgrade is not desired at present
- a new update is available
- the system reboots itself
- non-optimal multipath states are detected
- ZFS pool status changes from *HEALTHY*
- a S.M.A.R.T. error occurs
- the system dataset does not reside on the boot pool
- the system is unable to bind to the *WebGUI IPv4 Address* set in `System → General`
- the system can not find an IP address configured on an iSCSI portal
- the NTP server cannot be contacted
- a periodic snapshot or replication task fails

- a VMware login or a *VMware-Snapshot* (page 160) task fails
- deleting a VMware snapshot fails
- a Certificate Authority or certificate is invalid or malformed
- an update failed, or the system needs to reboot to complete a successful update
- a re-key operation fails on an encrypted pool
- LDAP failed to bind to the domain
- any member interfaces of a lagg interface are not active
- the status of an Avago MegaRAID SAS controller has changed; mfiutil(8) (https://www.freebsd.org/cgi/man.cgi?query=mfiutil) is included for managing these devices
- a scrub is paused

CHAPTER

TWENTYFIVE

SUPPORT RESOURCES

FreeNAS® has a large installation base and an active user community. This means that many usage questions have already been answered and the details are available on the Internet. If an issue occurs while using FreeNAS®, it can be helpful to spend a few moments searching the Internet for the word *FreeNAS* with some keywords that describe the error message or the function that is being implemented.

This section discusses resources available to FreeNAS® users:

- *Website and Social Media* (page 291)
- *Forums* (page 291)
- *IRC* (page 292)
- *Videos* (page 292)
- *Professional Support* (page 293)

25.1 Website and Social Media

The FreeNAS® website (http://www.freenas.org/) contains links to all of the available documentation, support, and social media resources. Major announcements are also posted to the main page.

Users are welcome to network on the FreeNAS® social media sites:

- LinkedIn (https://www.linkedin.com/groups/3903140/profile)
- Google+ (https://plus.google.com/110373675402281849911/posts)
- Facebook FreeNAS Community (https://www.facebook.com/freenascommunity)
- Facebook FreeNAS Consortium (please request to be added) (https://www.facebook.com/groups/1707686686200221)
- Twitter (https://twitter.com/freenas)

25.2 Forums

The FreeNAS Forums (https://forums.freenas.org/index.php) are an active online resource where people can ask questions, receive help, and share findings with other FreeNAS® users. New users are encouraged to post a brief message about themselves and how they use FreeNAS® in the Introductions (https://forums.freenas.org/index.php?forums/introductions.25/) forum.

The Resources (https://forums.freenas.org/index.php?resources/) section contains categorized, user-contributed guides on many aspects of building and using FreeNAS® systems.

Language-specific categories are available under **International**.

- Chinese (https://forums.freenas.org/index.php?forums/chinese-%E4%B8%AD%E6%96%87.60/)
- Dutch - Nederlands (https://forums.freenas.org/index.php?forums/dutch-nederlands.35/)

- French - Francais (https://forums.freenas.org/index.php?forums/french-francais.29/)
- German - Deutsch (https://forums.freenas.org/index.php?forums/german-deutsch.31/)
- Italian - Italiano (https://forums.freenas.org/index.php?forums/italian-italiano.30/)
- Portuguese - Português (https://forums.freenas.org/index.php?forums/portuguese-portugu%C3%AAs.44/)
- Romanian - Română (https://forums.freenas.org/index.php?forums/romanian-rom%C3%A2n%C4%83.53/)
- Russian - Русский (https://forums.freenas.org/index.php?forums/russian-%D0%A0%D1%83%D1%81%D1%81%D0%BA%D0%B
- Spanish - Español (https://forums.freenas.org/index.php?forums/spanish-espa%C3%B1ol.33/)
- Swedish - Svenske (https://forums.freenas.org/index.php?forums/swedish-svenske.51/)
- Turkish - Türkçe (https://forums.freenas.org/index.php?forums/turkish-t%C3%BCrk%C3%A7e.36/)

To join the forums, create an account with the *Sign Up Now!* link.

Before asking a question on the forums, check the Resources (https://forums.freenas.org/index.php?resources/) to see if the information is already there. See the Forum Rules (https://forums.freenas.org/index.php?threads/updated-forum-rules-4-11-17.45124/) for guidelines on posting your hardware information and how to ask questions that will get a response.

25.3 IRC

To ask a question in real time, use the *#freenas* channel on IRC Freenode (http://freenode.net/). Depending on the time of day and your time zone, FreeNAS® developers or other users may be available to provide assistance. If no one answers right away, remain on the channel, as other users tend to read the channel history to answer questions as time permits.

Typically, an IRC client (https://en.wikipedia.org/wiki/Comparison_of_Internet_Relay_Chat_clients) is used to access the *#freenas* IRC channel. Alternately, use webchat (http://webchat.freenode.net/?channels=freenas) from a web browser.

To get the most out of the IRC channel, keep these points in mind:

- Do not ask "Can anyone help me?". Just ask the question.
- Do not ask a question and then leave. Users who know the answer cannot help you if you disappear.
- If no one answers, the question may be difficult to answer or it has been asked before. Research other resources while waiting for the question to be answered.
- Do not post error messages in the channel. Instead, use a pasting service such as pastebin (https://pastebin.com/) and paste the resulting URL into the IRC discussion.

25.4 Videos

A series of instructional videos are available for FreeNAS®:

- Install Murmur (Mumble server) on FreeNAS/FreeBSD (https://www.youtube.com/watch?v=aAeZRNfarJc)
- FreeNAS® 9.10 - Certificate Authority & SSL Certificates (https://www.youtube.com/watch?v=OT1Le5VQIc0)
- How to Update FreeNAS® 9.10 (https://www.youtube.com/watch?v=2nvb90AhgL8)
- FreeNAS® 9.10 LAGG & VLAN Overview (https://www.youtube.com/watch?v=wqSH_uQSArQ)
- FreeNAS 9.10 and Samba (SMB) Permissions (https://www.youtube.com/watch?v=RxggaE935PM)
- FreeNAS® 11 - What's New (https://www.youtube.com/watch?v=-uJ_7eG88zk)
- FreeNAS® 11 - How to Install (https://www.youtube.com/watch?v=R3f-Sr6y-c4)

25.5 Professional Support

In addition to free community resources, support might be available in your area through third-party consultants. Submit a support inquiry using the form at https://www.ixsystems.com/freenas-commercial-support/.

CHAPTER

TWENTYSIX

COMMAND LINE UTILITIES

Several command line utilities which are provided with FreeNAS® are demonstrated in this section.

These utilities are used for benchmarking and performance testing:

- *Iperf* (page 294): used for measuring maximum TCP and UDP bandwidth performance
- *Netperf* (page 297): a tool for measuring network performance
- *IOzone* (page 298): filesystem benchmark utility used to perform a broad filesystem analysis
- *arcstat* (page 300): used to gather ZFS ARC statistics

These utilities are specific to RAID controllers:

- *tw_cli* (page 305):_used to monitor and maintain 3ware RAID controllers
- *MegaCli* (page 307): used to configure and manage Broadcom MegaRAID SAS family of RAID controllers

This section also describes these utilities:

- *freenas-debug* (page 307): the backend used to dump FreeNAS® debugging information
- *tmux* (page 308): a terminal multiplexer similar to GNU screen
- *Dmidecode* (page 308): reports information about system hardware as described in the system's BIOS

26.1 Iperf

Iperf is a utility for measuring maximum TCP and UDP bandwidth performance. It can be used to chart network throughput over time. For example, it can be used to test the speed of different types of shares to determine which type best performs on the network.

FreeNAS® includes the Iperf server. To perform network testing, install an Iperf client on a desktop system that has network access to the FreeNAS® system. This section demonstrates how to use the xjperf GUI client (https://code.google.com/archive/p/xjperf/downloads) as it works on Windows, macOS, Linux, and BSD systems.

Since this client is Java-based, the appropriate JRE (http://www.oracle.com/technetwork/java/javase/downloads/index.html) must be installed on the client computer.

Linux and BSD users can install the Iperf package using the package management system for their operating system.

To start xjperf on Windows: unzip the downloaded file, start Command Prompt in Run as administrator mode, `cd` to the unzipped folder, and run `jperf.bat`.

To start xjperf on macOS, Linux, or BSD, unzip the downloaded file, `cd` to the unzipped directory, type `chmod u+x jperf.sh`, and run `./jperf.sh`.

Once the client is ready, start the Iperf server on FreeNAS®.

Note: Beginning with FreeNAS® version 11.1, both iperf2 (https://sourceforge.net/projects/iperf2/) and iperf3 (http://software.es.net/iperf/) are pre-installed. To use iperf2, use `iperf`. To use iperf3, instead type `iperf3`. The examples below are for iperf2.

To see the available server options, open Shell and type:

```
iperf --help | more
```

or:

```
iperf3 --help | more
```

For example, to perform a TCP test and start the server in daemon mode (to get the prompt back), type:

```
iperf -sD
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 64.0 KByte (default)
------------------------------------------------------------
Running Iperf Server as a daemon
The Iperf daemon process ID: 4842
```

Note: The daemon process stops when *Shell* (page 282) closes. Set up the environment, for example, shares configured and started, **before** starting the Iperf process.

From the desktop, open the client. Enter the IP of address of the FreeNAS® system, specify the running time for the test under `Application layer options` → `Transmit` (the default test time is 10 seconds), and click the *Run Iperf!* button. Figure 26.1 shows an example of the client running on a Windows system while an SFTP transfer is occurring on the network.

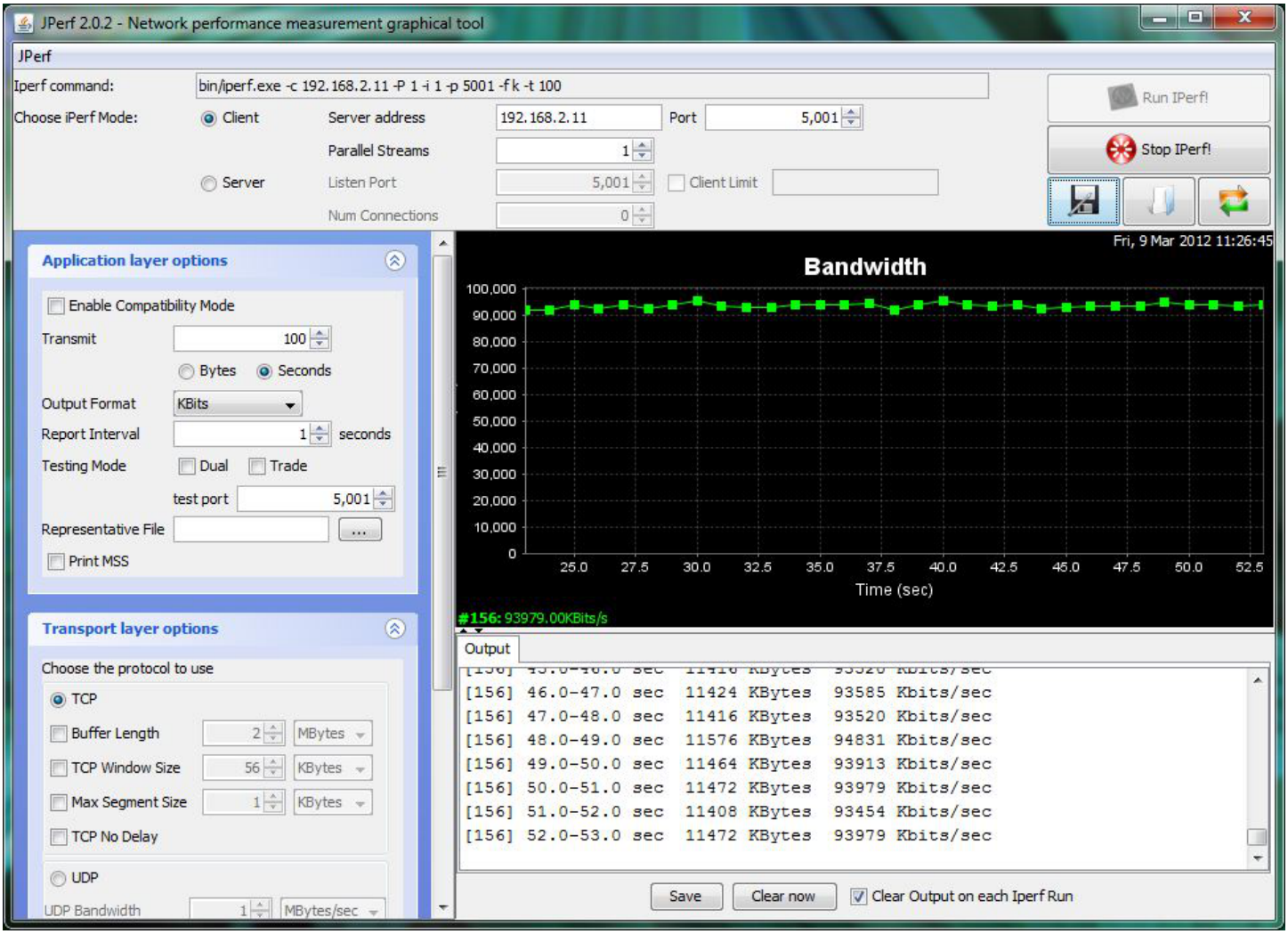


Fig. 26.1: Viewing Bandwidth Statistics Using xjperf

Depending upon the traffic being tested, for example, the type of share running on the network, UDP may need to be tested instead of TCP. To start the Iperf server in UDP mode, use `iperf -sDu` as the **u** specifies UDP; the startup message should indicate that the server is listening for UDP datagrams. If unsure whether the traffic to be tested is UDP or TCP, run this command to determine which services are running on the FreeNAS® system:

```
sockstat -4 | more
USER     COMMAND  PID   FD  PROTO      LOCAL ADDRESS         FOREIGN ADDRESS
root     iperf    4870  6   udp4       *:5001                *:*
root     iperf    4842  6   tcp4       *:5001                *:*
www      nginx    4827  3   tcp4       127.0.0.1:15956       127.0.0.1:9042
www      nginx    4827  5   tcp4       192.168.2.11:80       192.168.2.26:56964
www      nginx    4827  7   tcp4       *:80                  *:*
root     sshd     3852  5   tcp4       *:22                  *:*
root     python   2503  5   udp4       *:*                   *:*
root     mountd   2363  7   udp4       *:812                 *:*
root     mountd   2363  8   tcp4       *:812                 *:*
root     rpcbind  2359  9   udp4       *:111                 *:*
root     rpcbind  2359  10  udp4       *:886                 *:*
root     rpcbind  2359  11  tcp4       *:111                 *:*
root     nginx    2044  7   tcp4       *:80                  *:*
root     python   2029  3   udp4       *:*                   *:*
root     python   2029  4   tcp4       127.0.0.1:9042        *:*
```

```
root     python  2029    7  tcp4         127.0.0.1:9042  127.0.0.1:15956
root     ntpd    1548    20 udp4         *:123           *:*
root     ntpd    1548    22 udp4         192.168.2.11:123*:*
root     ntpd    1548    25 udp4         127.0.0.1:123   *:*
root     syslogd 1089    6  udp4         127.0.0.1:514   *:*
```

When testing is finished, either type `killall iperf` or close Shell to terminate the Iperf server process.

26.2 Netperf

Netperf is a benchmarking utility that can be used to measure the performance of unidirectional throughput and end-to-end latency.

Before using the `netperf` command, start its server process with this command:

```
netserver
Starting netserver with host 'IN(6)ADDR_ANY' port '12865' and family AF_UNSPEC
```

The following command displays the available options for performing tests with the `netperf` command. The Netperf Manual (https://hewlettpackard.github.io/netperf/) describes each option in more detail and explains how to perform many types of tests. It is the best reference for understanding how each test works and how to interpret the results. When you are finished with the tests, type `killall netserver` to stop the server process.

```
netperf -h |more
Usage: netperf [global options] -- [test options]
Global options:
    -a send,recv       Set the local send,recv buffer alignment
    -A send,recv       Set the remote send,recv buffer alignment
    -B brandstr        Specify a string to be emitted with brief output
    -c [cpu_rate]      Report local CPU usage
    -C [cpu_rate]      Report remote CPU usage
    -d                 Increase debugging output
    -D [secs,units] *  Display interim results at least every secs seconds
                       using units as the initial guess for units per second
    -f G|M|K|g|m|k     Set the output units
    -F fill_file       Pre-fill buffers with data from fill_file
    -h                 Display this text
    -H name|ip,fam *   Specify the target machine and/or local ip and family
    -i max,min         Specify the max and min number of iterations (15,1)
    -I lvl[,intvl]     Specify confidence level (95 or 99) (99)
                       and confidence interval in percentage (10)
    -j                 Keep additional timing statistics
    -l testlen         Specify test duration (>0 secs) (<0 bytes|trans)
    -L name|ip,fam *   Specify the local ip|name and address family
    -o send,recv       Set the local send,recv buffer offsets
    -O send,recv       Set the remote send,recv buffer offset
    -n numcpu          Set the number of processors for CPU util
    -N                 Establish no control connection, do 'send' side only
    -p port,lport*     Specify netserver port number and/or local port
    -P 0|1             Don't/Do display test headers
    -r                 Allow confidence to be hit on result only
    -s seconds         Wait seconds between test setup and test start
    -S                 Set SO_KEEPALIVE on the data connection
    -t testname        Specify test to perform
    -T lcpu,rcpu       Request netperf/netserver be bound to local/remote cpu
    -v verbosity       Specify the verbosity level
    -W send,recv       Set the number of send,recv buffers
    -v level           Set the verbosity level (default 1, min 0)
    -V                 Display the netperf version and exit
```

For those options taking two parms, at least one must be specified; specifying one value without a comma will set both parms to that value, specifying a value with a leading comma will set just the second parm, a value with a trailing comma will set just the first. To set each parm to unique values, specify both and separate them with a comma.

For these options taking two parms, specifying one value with no comma will only set the first parms and will leave the second at the default value. To set the second value it must be preceded with a comma or be a comma-separated pair. This is to retain previous netperf behavior.

26.3 IOzone

IOzone is a disk and filesystem benchmarking tool. It can be used to test file I/O performance for the following operations: read, write, re-read, re-write, read backwards, read strided, fread, fwrite, random read, pread, mmap, aio_read, and aio_write.

FreeNAS® ships with IOzone, meaning that it can be run from Shell. When using IOzone on FreeNAS®, `cd` to a directory in a volume that you have permission to write to, otherwise an error about being unable to write the temporary file will occur.

Before using IOzone, read through the IOzone documentation PDF (http://www.iozone.org/docs/IOzone_msword_98.pdf) as it describes the tests, the many command line switches, and how to interpret the results.

These resources provide good starting points on which tests to run, when to run them, and how to interpret the results:

- How To Measure Linux Filesystem I/O Performance With iozone (https://www.cyberciti.biz/tips/linux-filesystem-benchmarking-with-iozone.html)
- Analyzing NFS Client Performance with IOzone (http://www.iozone.org/docs/NFSClientPerf_revised.pdf)
- 10 iozone Examples for Disk I/O Performance Measurement on Linux (https://www.thegeekstuff.com/2011/05/iozone-examples)

Type the following command to receive a summary of the available switches. As you can see from the number of options, IOzone is comprehensive so it can take some time to learn how to use the tests effectively.

Starting with version 9.2.1, FreeNAS® enables compression on newly created ZFS pools by default. Since IOzone creates test data that is compressible, this can skew test results. To configure IOzone to generate incompressible test data, include the options **-+w 1 -+y 1 -+C 1**.

Alternatively, consider temporarily disabling compression on the ZFS pool or dataset when running IOzone benchmarks.

Note: If a visual representation of the collected data is preferred, scripts are available to render IOzone's output in Gnuplot (http://www.gnuplot.info/).

```
iozone -h | more
iozone: help mode
Usage: iozone[-s filesize_Kb] [-r record_size_Kb] [-f [path]filename] [-h]
             [-i test] [-E] [-p] [-a] [-A] [-z] [-Z] [-m] [-M] [-t children]
             [-l min_number_procs] [-u max_number_procs] [-v] [-R] [-x] [-o]
             [-d microseconds] [-F path1 path2...] [-V pattern] [-j stride]
             [-T] [-C] [-B] [-D] [-G] [-I] [-H depth] [-k depth] [-U mount_point]
             [-S cache_size] [-O] [-L cacheline_size] [-K] [-g maxfilesize_Kb]
             [-n minfilesize_Kb] [-N] [-Q] [-P start_cpu] [-e] [-c] [-b Excel.xls]
             [-J milliseconds] [-X write_telemetry_filename] [-w] [-W]
             [-Y read_telemetry_filename] [-y minrecsize_Kb] [-q maxrecsize_Kb]
             [-+u] [-+m cluster_filename] [-+d] [-+x multiplier] [-+p # ]
             [-+r] [-+t] [-+X] [-+Z] [-+w percent dedupable] [-+y percent_interior_dedup]
             [-+C percent_dedup_within]
         -a  Auto mode
         -A  Auto2 mode
         -b Filename  Create Excel worksheet file
         -B  Use mmap() files
```

```
        -c  Include close in the timing calculations
        -C  Show bytes transferred by each child in throughput testing
        -d #  Microsecond delay out of barrier
        -D  Use msync(MS_ASYNC) on mmap files
        -e  Include flush (fsync,fflush) in the timing calculations
        -E  Run extension tests
        -f  filename to use
        -F  filenames for each process/thread in throughput test
        -g #  Set maximum file size (in Kbytes) for auto mode (or #m or #g)
        -G  Use msync(MS_SYNC) on mmap files
        -h  help
        -H #  Use POSIX async I/O with # async operations
        -i #  Test to run (0=write/rewrite, 1=read/re-read, 2=random-read/write
              3=Read-backwards, 4=Re-write-record, 5=stride-read, 6=fwrite/re-fwrite
              7=fread/Re-fread, 8=random_mix, 9=pwrite/Re-pwrite, 10=pread/Re-pread
              11=pwritev/Re-pwritev, 12=preadv/Re-preadv)
        -I  Use VxFS VX_DIRECT, O_DIRECT,or O_DIRECTIO for all file operations
        -j #  Set stride of file accesses to (# * record size)
        -J #  milliseconds of compute cycle before each I/O operation
        -k #  Use POSIX async I/O (no bcopy) with # async operations
        -K  Create jitter in the access pattern for readers
        -l #  Lower limit on number of processes to run
        -L #  Set processor cache line size to value (in bytes)
        -m  Use multiple buffers
        -M  Report uname -a output
        -n #  Set minimum file size (in Kbytes) for auto mode (or #m or #g)
        -N  Report results in microseconds per operation
        -o  Writes are synch (O_SYNC)
        -O  Give results in ops/sec.
        -p  Purge on
        -P #  Bind processes/threads to processors, starting with this cpu
        -q #  Set maximum record size (in Kbytes) for auto mode (or #m or #g)
        -Q  Create offset/latency files
        -r #  record size in Kb
           or -r #k .. size in Kb
           or -r #m .. size in Mb
           or -r #g .. size in Gb
        -R  Generate Excel report
        -s #  file size in Kb
           or -s #k .. size in Kb
           or -s #m .. size in Mb
           or -s #g .. size in Gb
        -S #  Set processor cache size to value (in Kbytes)
        -t #  Number of threads or processes to use in throughput test
        -T  Use POSIX pthreads for throughput tests
        -u #  Upper limit on number of processes to run
        -U  Mount point to remount between tests
        -v  version information
        -V #  Verify data pattern write/read
        -w  Do not unlink temporary file
        -W  Lock file when reading or writing
        -x  Turn off stone-walling
        -X filename  Write telemetry file. Contains lines with (offset reclen compute_time) in ascii
        -y #  Set minimum record size (in Kbytes) for auto mode (or #m or #g)
        -Y filename  Read telemetry file. Contains lines with (offset reclen compute_time) in ascii
        -z  Used in conjunction with -a to test all possible record sizes
        -Z  Enable mixing of mmap I/O and file I/O
        -+E Use existing non-Iozone file for read-only testing
        -+K Sony special. Manual control of test 8.
        -+m Cluster_filename  Enable Cluster testing
        -+d File I/O diagnostic mode. (To troubleshoot a broken file I/O subsystem)
```

```
        -+u Enable CPU utilization output (Experimental)
        -+x # Multiplier to use for incrementing file and record sizes
        -+p # Percentage of mix to be reads
        -+r Enable O_RSYNC|O_SYNC for all testing.
        -+t Enable network performance test. Requires -+m
        -+n No retests selected.
        -+k Use constant aggregate data set size.
        -+q Delay in seconds between tests.
        -+l Enable record locking mode.
        -+L Enable record locking mode, with shared file.
        -+B Sequential mixed workload.
        -+A # Enable madvise. 0 = normal, 1=random, 2=sequential 3=dontneed, 4=willneed
        -+N Do not truncate existing files on sequential writes.
        -+S # Dedup-able data is limited to sharing within each numerically identified file set
        -+V Enable shared file. No locking.
        -+X Enable short circuit mode for filesystem testing ONLY
            ALL Results are NOT valid in this mode.
        -+Z Enable old data set compatibility mode. WARNING.. Published
            hacks may invalidate these results and generate bogus, high values for results.
        -+w ## Percent of dedup-able data in buffers.
        -+y ## Percent of dedup-able within & across files in buffers.
        -+C ## Percent of dedup-able within & not across files in buffers.
        -+H Hostname  Hostname of the PIT server.
        -+P Service  Service of the PIT server.
        -+z Enable latency histogram logging.
```

26.4 arcstat

Arcstat is a script that prints out ZFS ARC (https://en.wikipedia.org/wiki/Adaptive_replacement_cache) statistics. Originally it was a perl script created by Sun. That perl script was ported to FreeBSD and was then ported as a Python script for use on FreeNAS®.

Watching ARC hits/misses and percentages will provide an indication of how well the ZFS pool is fetching from the ARC rather than using disk I/O. Ideally, there will be as many things fetching from cache as possible. Keep the load in mind while reviewing the stats. For random reads, expect a miss and having to go to disk to fetch the data. For cached reads, expect it to pull out of the cache and have a hit.

Like all cache systems, the ARC takes time to fill with data. This means that it will have a lot of misses until the pool has been in use for a while. If there continues to be lots of misses and high disk I/O on cached reads, there is cause to investigate further and tune the system.

The FreeBSD ZFS Tuning Guide (https://wiki.freebsd.org/ZFSTuningGuide) provides some suggestions for commonly tuned `sysctl` values. It should be noted that performance tuning is more of an art than a science and that any changes made will probably require several iterations of tune and test. Be aware that what needs to be tuned will vary depending upon the type of workload and that what works for one person's network may not benefit yours.

In particular, the value of pre-fetching depends upon the amount of memory and the type of workload, as seen in this example:

- Understanding ZFS: Prefetch (http://cuddletech.com/?p=204)

FreeNAS® provides two command line scripts which can be manually run from *Shell* (page 282):

- `arc_summary.py`: provides a summary of the statistics
- `arcstat.py`: used to watch the statistics in real time

The advantage of these scripts is that they can be used to provide real time (right now) information, whereas the current GUI reporting mechanism is designed to only provide graphs charted over time.

This forum post (https://forums.freenas.org/index.php?threads/benchmarking-zfs.7928/) demonstrates some examples of using these scripts with hints on how to interpret the results.

To view the help for arcstat.py:

```
arcstat.py -h
Usage: arcstat [-hvx] [-f fields] [-o file] [-s string] [interval [count]]
-h: Print this help message
-v: List all possible field headers and definitions
-x: Print extended stats
-f: Specify specific fields to print (see -v)
-o: Redirect output to the specified file
-s: Override default field separator with custom character or string

Examples:
arcstat -o /tmp/a.log 2 10
arcstat -s "," -o /tmp/a.log 2 10
arcstat -v
arcstat -f time,hit%,dh%,ph%,mh% 1
```

To view ARC statistics in real time, specify an interval and a count. This command will display every 1 second for a count of five.

```
arcstat.py 1 5
    time  read  miss  miss%  dmis  dm%  pmis  pm%  mmis  mm%  arcsz     c
06:19:03     7     0      0     0    0     0    0     0    0   153M  6.6G
06:19:04   257     0      0     0    0     0    0     0    0   153M  6.6G
06:19:05   193     0      0     0    0     0    0     0    0   153M  6.6G
06:19:06   193     0      0     0    0     0    0     0    0   153M  6.6G
06:19:07   255     0      0     0    0     0    0     0    0   153M  6.6G
```

Table 26.1 briefly describes the columns in the output.

Table 26.1: arcstat Column Descriptions

Column	Description
read	total ARC accesses/second
miss	ARC misses/second
miss%	ARC miss percentage
dmis	demand data misses/second
dm%	demand data miss percentage
pmis	prefetch misses per second
pm%	prefetch miss percentage
mmis	metadata misses/second
mm%	metadata miss percentage
arcsz	arc size
c	arc target size

To receive a summary of statistics, use:

```
arcsummary.py
System Memory:
       2.36%   93.40   MiB Active,     8.95%   353.43  MiB Inact
       8.38%   330.89  MiB Wired,      0.15%   5.90    MiB Cache
       80.16%  3.09    GiB Free,       0.00%   0       Bytes Gap
       Real Installed:                         4.00    GiB
       Real Available:                 99.31%  3.97    GiB
       Real Managed:                   97.10%  3.86    GiB
       Logical Total:                          4.00    GiB
       Logical Used:                   13.93%  570.77  MiB
```

```
       Logical Free:                    86.07%  3.44    GiB
Kernel Memory:                                  87.62   MiB
       Data:                            69.91%  61.25   MiB
       Text:                            30.09%  26.37   MiB
Kernel Memory Map:                              3.86    GiB
       Size:                            5.11%   201.70  MiB
       Free:                            94.89%  3.66    GiB
ARC Summary: (HEALTHY)
       Storage pool Version:                    5000
       Filesystem Version:                      5
       Memory Throttle Count:                   0
ARC Misc:
       Deleted:                                 8
       Mutex Misses:                            0
       Evict Skips:                             0
ARC Size:                               5.83%   170.45  MiB
       Target Size: (Adaptive)          100.00% 2.86    GiB
       Min Size (Hard Limit):           12.50%  365.69  MiB
       Max Size (High Water):           8:1     2.86    GiB
ARC Size Breakdown:
       Recently Used Cache Size:        50.00%  1.43    GiB
       Frequently Used Cache Size:      50.00%  1.43    GiB
ARC Hash Breakdown:
       Elements Max:                            5.90k
       Elements Current:                100.00% 5.90k
       Collisions:                              72
       Chain Max:                               1
       Chains:                                  23
ARC Total accesses:                                     954.06k
       Cache Hit Ratio:                 99.18%  946.25k
       Cache Miss Ratio:                0.82%   7.81k
       Actual Hit Ratio:                98.84%  943.00k
       Data Demand Efficiency:          99.20%  458.77k
       CACHE HITS BY CACHE LIST:
         Anonymously Used:              0.34%   3.25k
         Most Recently Used:            3.73%   35.33k
         Most Frequently Used:          95.92%  907.67k
         Most Recently Used Ghost:      0.00%   0
         Most Frequently Used Ghost:    0.00%   0
       CACHE HITS BY DATA TYPE:
         Demand Data:                   48.10%  455.10k
         Prefetch Data:                 0.00%   0
         Demand Metadata:               51.56%  487.90k
         Prefetch Metadata:             0.34%   3.25k
       CACHE MISSES BY DATA TYPE:
         Demand Data:                   46.93%  3.66k
         Prefetch Data:                 0.00%   0
         Demand Metadata:               49.76%  3.88k
         Prefetch Metadata:             3.30%   258
ZFS Tunable (sysctl):
       kern.maxusers                            590
       vm.kmem_size                             4141375488
       vm.kmem_size_scale                       1
       vm.kmem_size_min                         0
       vm.kmem_size_max                         1319413950874
       vfs.zfs.vol.unmap_enabled                1
       vfs.zfs.vol.mode                         2
       vfs.zfs.sync_pass_rewrite                2
       vfs.zfs.sync_pass_dont_compress          5
       vfs.zfs.sync_pass_deferred_free          2
       vfs.zfs.zio.exclude_metadata             0
```

```
vfs.zfs.zio.use_uma                     1
vfs.zfs.cache_flush_disable             0
vfs.zfs.zil_replay_disable              0
vfs.zfs.version.zpl                     5
vfs.zfs.version.spa                     5000
vfs.zfs.version.acl                     1
vfs.zfs.version.ioctl                   5
vfs.zfs.debug                           0
vfs.zfs.super_owner                     0
vfs.zfs.min_auto_ashift                 9
vfs.zfs.max_auto_ashift                 13
vfs.zfs.vdev.write_gap_limit            4096
vfs.zfs.vdev.read_gap_limit             32768
vfs.zfs.vdev.aggregation_limit          131072
vfs.zfs.vdev.trim_max_active            64
vfs.zfs.vdev.trim_min_active            1
vfs.zfs.vdev.scrub_max_active           2
vfs.zfs.vdev.scrub_min_active           1
vfs.zfs.vdev.async_write_max_active     10
vfs.zfs.vdev.async_write_min_active     1
vfs.zfs.vdev.async_read_max_active      3
vfs.zfs.vdev.async_read_min_active      1
vfs.zfs.vdev.sync_write_max_active      10
vfs.zfs.vdev.sync_write_min_active      10
vfs.zfs.vdev.sync_read_max_active       10
vfs.zfs.vdev.sync_read_min_active       10
vfs.zfs.vdev.max_active                 1000
vfs.zfs.vdev.async_write_active_max_dirty_percent60
vfs.zfs.vdev.async_write_active_min_dirty_percent30
vfs.zfs.vdev.mirror.non_rotating_seek_inc1
vfs.zfs.vdev.mirror.non_rotating_inc    0
vfs.zfs.vdev.mirror.rotating_seek_offset1048576
vfs.zfs.vdev.mirror.rotating_seek_inc   5
vfs.zfs.vdev.mirror.rotating_inc        0
vfs.zfs.vdev.trim_on_init               1
vfs.zfs.vdev.larger_ashift_minimal      0
vfs.zfs.vdev.bio_delete_disable         0
vfs.zfs.vdev.bio_flush_disable          0
vfs.zfs.vdev.cache.bshift               16
vfs.zfs.vdev.cache.size                 0
vfs.zfs.vdev.cache.max                  16384
vfs.zfs.vdev.metaslabs_per_vdev         200
vfs.zfs.vdev.trim_max_pending           10000
vfs.zfs.txg.timeout                     5
vfs.zfs.trim.enabled                    1
vfs.zfs.trim.max_interval               1
vfs.zfs.trim.timeout                    30
vfs.zfs.trim.txg_delay                  32
vfs.zfs.space_map_blksz                 4096
vfs.zfs.spa_slop_shift                  5
vfs.zfs.spa_asize_inflation             24
vfs.zfs.deadman_enabled                 1
vfs.zfs.deadman_checktime_ms            5000
vfs.zfs.deadman_synctime_ms             1000000
vfs.zfs.recover                         0
vfs.zfs.spa_load_verify_data            1
vfs.zfs.spa_load_verify_metadata        1
vfs.zfs.spa_load_verify_maxinflight     10000
vfs.zfs.check_hostid                    1
vfs.zfs.mg_fragmentation_threshold      85
vfs.zfs.mg_noalloc_threshold            0
```

```
vfs.zfs.condense_pct                    200
vfs.zfs.metaslab.bias_enabled           1
vfs.zfs.metaslab.lba_weighting_enabled  1
vfs.zfs.metaslab.fragmentation_factor_enabled1
vfs.zfs.metaslab.preload_enabled        1
vfs.zfs.metaslab.preload_limit          3
vfs.zfs.metaslab.unload_delay           8
vfs.zfs.metaslab.load_pct               50
vfs.zfs.metaslab.min_alloc_size         33554432
vfs.zfs.metaslab.df_free_pct            4
vfs.zfs.metaslab.df_alloc_threshold     131072
vfs.zfs.metaslab.debug_unload           0
vfs.zfs.metaslab.debug_load             0
vfs.zfs.metaslab.fragmentation_threshold70
vfs.zfs.metaslab.gang_bang              16777217
vfs.zfs.free_bpobj_enabled              1
vfs.zfs.free_max_blocks                 18446744073709551615
vfs.zfs.no_scrub_prefetch               0
vfs.zfs.no_scrub_io                     0
vfs.zfs.resilver_min_time_ms            3000
vfs.zfs.free_min_time_ms                1000
vfs.zfs.scan_min_time_ms                1000
vfs.zfs.scan_idle                       50
vfs.zfs.scrub_delay                     4
vfs.zfs.resilver_delay                  2
vfs.zfs.top_maxinflight                 32
vfs.zfs.delay_scale                     500000
vfs.zfs.delay_min_dirty_percent         60
vfs.zfs.dirty_data_sync                 67108864
vfs.zfs.dirty_data_max_percent          10
vfs.zfs.dirty_data_max_max              4294967296
vfs.zfs.dirty_data_max                  426512793
vfs.zfs.max_recordsize                  1048576
vfs.zfs.zfetch.array_rd_sz              1048576
vfs.zfs.zfetch.max_distance             8388608
vfs.zfs.zfetch.min_sec_reap             2
vfs.zfs.zfetch.max_streams              8
vfs.zfs.prefetch_disable                1
vfs.zfs.mdcomp_disable                  0
vfs.zfs.nopwrite_enabled                1
vfs.zfs.dedup.prefetch                  1
vfs.zfs.l2c_only_size                   0
vfs.zfs.mfu_ghost_data_lsize            0
vfs.zfs.mfu_ghost_metadata_lsize        0
vfs.zfs.mfu_ghost_size                  0
vfs.zfs.mfu_data_lsize                  26300416
vfs.zfs.mfu_metadata_lsize              1780736
vfs.zfs.mfu_size                        29428736
vfs.zfs.mru_ghost_data_lsize            0
vfs.zfs.mru_ghost_metadata_lsize        0
vfs.zfs.mru_ghost_size                  0
vfs.zfs.mru_data_lsize                  122090496
vfs.zfs.mru_metadata_lsize              2235904
vfs.zfs.mru_size                        139389440
vfs.zfs.anon_data_lsize                 0
vfs.zfs.anon_metadata_lsize             0
vfs.zfs.anon_size                       163840
vfs.zfs.l2arc_norw                      1
vfs.zfs.l2arc_feed_again                1
vfs.zfs.l2arc_noprefetch                1
vfs.zfs.l2arc_feed_min_ms               200
```

```
        vfs.zfs.l2arc_feed_secs                 1
        vfs.zfs.l2arc_headroom                  2
        vfs.zfs.l2arc_write_boost               8388608
        vfs.zfs.l2arc_write_max                 8388608
        vfs.zfs.arc_meta_limit                  766908416
        vfs.zfs.arc_free_target                 7062
        vfs.zfs.arc_shrink_shift                7
        vfs.zfs.arc_average_blocksize           8192
        vfs.zfs.arc_min                         383454208
        vfs.zfs.arc_max                         3067633664
```

When reading the tunable values, 0 means no, 1 typically means yes, and any other number represents a value. To receive a brief description of a "sysctl" value, use `sysctl -d`. For example:

```
sysctl -d vfs.zfs.zio.use_uma
vfs.zfs.zio.use_uma: Use uma(9) for ZIO allocations
```

The ZFS tunables require a fair understanding of how ZFS works, meaning that reading man pages and searching for the meaning of acronyms is required. **Do not change a tunable's value without researching it first.** If the tunable takes a numeric value (rather than 0 for no or 1 for yes), do not make one up. Instead, research examples of beneficial values that match your workload.

If any of the ZFS tunables are changed, continue to monitor the system to determine the effect of the change. Using `sysctl` at the command line to test the changes first is recommended. For example, to disable pre-fetch (i.e. change disable to *1* or yes):

```
sysctl vfs.zfs.prefetch_disable=1
vfs.zfs.prefetch_disable: 0 -> 1
```

The output will indicate the old value followed by the new value. If the change is not beneficial, change it back to the original value. If the change turns out to be beneficial, it can be made permanent by creating a *sysctl* using the instructions in *Tunables* (page 69).

26.5 tw_cli

FreeNAS® includes the `tw_cli` command line utility for providing controller, logical unit, and drive management for AMCC/3ware ATA RAID Controllers. The supported models are listed in the man pages for the twe(4) (https://www.freebsd.org/cgi/man.cgi?query=twe) and twa(4) (https://www.freebsd.org/cgi/man.cgi?query=twa) drivers.

Before using this command, read its man page (https://www.cyberciti.biz/files/tw_cli.8.html) as it describes the terminology and provides some usage examples.

When `tw_cli` is entered in Shell, the prompt will change, indicating interactive mode is enabled where all sorts of maintenance commands on the controller and its arrays can be run.

Alternately, you can specify one command to run. For example, to view the disks in the array:

```
tw_cli /c0 show
Unit   UnitType        Status  %RCmpl  %V/I/M  Stripe  Size(GB)        Cache   AVrfy
------------------------------------------------------------------------------
u0     RAID-6          OK      -       -       256K    5587.88         RiW     ON
u1     SPARE           OK      -       -       -       931.505         -       OFF
u2     RAID-10         OK      -       -       256K    1862.62         RiW     ON

VPort Status   Unit    Size            Type    Phy Encl-Slot   Model
------------------------------------------------------------------------------
p8     OK      u0      931.51 GB SAS   -       /c0/e0/slt0     SEAGATE ST31000640SS
p9     OK      u0      931.51 GB SAS   -       /c0/e0/slt1     SEAGATE ST31000640SS
p10    OK      u0      931.51 GB SAS   -       /c0/e0/slt2     SEAGATE ST31000640SS
```

```
p11    OK      u0      931.51 GB SAS   -       /c0/e0/slt3     SEAGATE ST31000640SS
p12    OK      u0      931.51 GB SAS   -       /c0/e0/slt4     SEAGATE ST31000640SS
p13    OK      u0      931.51 GB SAS   -       /c0/e0/slt5     SEAGATE ST31000640SS
p14    OK      u0      931.51 GB SAS   -       /c0/e0/slt6     SEAGATE ST31000640SS
p15    OK      u0      931.51 GB SAS   -       /c0/e0/slt7     SEAGATE ST31000640SS
p16    OK      u1      931.51 GB SAS   -       /c0/e0/slt8     SEAGATE ST31000640SS
p17    OK      u2      931.51 GB SATA  -       /c0/e0/slt9     ST31000340NS
p18    OK      u2      931.51 GB SATA  -       /c0/e0/slt10    ST31000340NS
p19    OK      u2      931.51 GB SATA  -       /c0/e0/slt11    ST31000340NS
p20    OK      u2      931.51 GB SATA  -       /c0/e0/slt15    ST31000340NS

Name   OnlineState     BBUReady        Status  Volt    Temp    Hours   LastCapTest
---------------------------------------------------------------------------
bbu    On              Yes             OK      OK      OK      212     03-Jan-2012
```

Or, to review the event log:

```
tw_cli /c0 show events
Ctl    Date                            Severity        AEN Message
------------------------------------------------------------------------------
c0     [Thu Feb 23 2012 14:01:15]      INFO            Battery charging started
c0     [Thu Feb 23 2012 14:03:02]      INFO            Battery charging completed
c0     [Sat Feb 25 2012 00:02:18]      INFO            Verify started: unit=0
c0     [Sat Feb 25 2012 00:02:18]      INFO            Verify started: unit=2,subunit=0
c0     [Sat Feb 25 2012 00:02:18]      INFO            Verify started: unit=2,subunit=1
c0     [Sat Feb 25 2012 03:49:35]      INFO            Verify completed: unit=2,subunit=0
c0     [Sat Feb 25 2012 03:51:39]      INFO            Verify completed: unit=2,subunit=1
c0     [Sat Feb 25 2012 21:55:59]      INFO            Verify completed: unit=0
c0     [Thu Mar 01 2012 13:51:09]      INFO            Battery health check started
c0     [Thu Mar 01 2012 13:51:09]      INFO            Battery health check completed
c0     [Thu Mar 01 2012 13:51:09]      INFO            Battery charging started
c0     [Thu Mar 01 2012 13:53:03]      INFO            Battery charging completed
c0     [Sat Mar 03 2012 00:01:24]      INFO            Verify started: unit=0
c0     [Sat Mar 03 2012 00:01:24]      INFO            Verify started: unit=2,subunit=0
c0     [Sat Mar 03 2012 00:01:24]      INFO            Verify started: unit=2,subunit=1
c0     [Sat Mar 03 2012 04:04:27]      INFO            Verify completed: unit=2,subunit=0
c0     [Sat Mar 03 2012 04:06:25]      INFO            Verify completed: unit=2,subunit=1
c0     [Sat Mar 03 2012 16:22:05]      INFO            Verify completed: unit=0
c0     [Thu Mar 08 2012 13:41:39]      INFO            Battery charging started
c0     [Thu Mar 08 2012 13:43:42]      INFO            Battery charging completed
c0     [Sat Mar 10 2012 00:01:30]      INFO            Verify started: unit=0
c0     [Sat Mar 10 2012 00:01:30]      INFO            Verify started: unit=2,subunit=0
c0     [Sat Mar 10 2012 00:01:30]      INFO            Verify started: unit=2,subunit=1
c0     [Sat Mar 10 2012 05:06:38]      INFO            Verify completed: unit=2,subunit=0
c0     [Sat Mar 10 2012 05:08:57]      INFO            Verify completed: unit=2,subunit=1
c0     [Sat Mar 10 2012 15:58:15]      INFO            Verify completed: unit=0
```

If the disks added to the array do not appear in the GUI, try running this command:

```
tw_cli /c0 rescan
```

Use the drives to create units and export them to the operating system. When finished, run `camcontrol rescan all` and they should now be available in the FreeNAS® GUI.

This forum post (https://forums.freenas.org/index.php?threads/3ware-drive-monitoring.13835/) contains a handy wrapper script that will notify you of errors.

26.6 MegaCli

`MegaCli` is the command line interface for the Broadcom :MegaRAID SAS family of RAID controllers. FreeNAS® also includes the mfiutil(8) (https://www.freebsd.org/cgi/man.cgi?query=mfiutil) utility which can be used to configure and manage connected storage devices.

The `MegaCli` command is quite complex with several dozen options. The commands demonstrated in the Emergency Cheat Sheet (http://tools.rapidsoft.de/perc/perc-cheat-sheet.html) can get you started.

26.7 freenas-debug

The FreeNAS® GUI provides an option to save debugging information to a text file using `System → Advanced → Save Debug`. This debugging information is created by the `freenas-debug` command line utility and a copy of the information is saved to `/var/tmp/fndebug`.

This command can be run manually from *Shell* (page 282) to gather specific debugging information. To see a usage explanation listing all options, run the command without any options:

```
freenas-debug
Usage: /usr/local/bin/freenas-debug <options>
Where options are:

 -A  Dump all debug information
 -B  Dump System Configuration Database
 -C  Dump SMB Configuration
 -D  Dump Domain Controller Configuration
 -G  Dump Grub Configuration
 -I  Dump IPMI Configuration
 -M  Dump SATA DOMs Information
 -N  Dump NFS Configuration
 -S  Dump SMART Information
 -T  Loader Configuration Information
 -Z  Remove old debug information
 -a  Dump Active Directory Configuration
 -c  Dump (AD|LDAP) Cache
 -e  Email debug log to this comma-delimited list of email addresses
 -f  Dump AFP Configuration
 -g  Dump GEOM Configuration
 -h  Dump Hardware Configuration
 -i  Dump iSCSI Configuration
 -j  Dump Jail Information
 -l  Dump LDAP Configuration
 -n  Dump Network Configuration
 -s  Dump SSL Configuration
 -t  Dump System Information
 -v  Dump Boot System File Verification Status and Inconsistencies
 -y  Dump Sysctl Configuration
 -z  Dump ZFS Configuration
```

Individual tests can be run alone. For example, when troubleshooting an Active Directory configuration, use:

```
freenas-debug -a
```

To collect the output of every module, use `-A`:

```
freenas-debug -A
```

26.8 tmux

`tmux` is a terminal multiplexer which enables a number of :terminals to be created, accessed, and controlled from a single :screen. `tmux` is an alternative to GNU `screen`. Similar to screen, `tmux` can be detached from a screen and continue running in the background, then later reattached. Unlike *Shell* (page 282), `tmux` allows you to have access to a command prompt while still providing access to the graphical administration screens.

To start a session, simply type `tmux`. As seen in Figure 26.2, a new session with a single window opens with a status line at the bottom of the screen. This line shows information on the current session and is used to enter interactive commands.

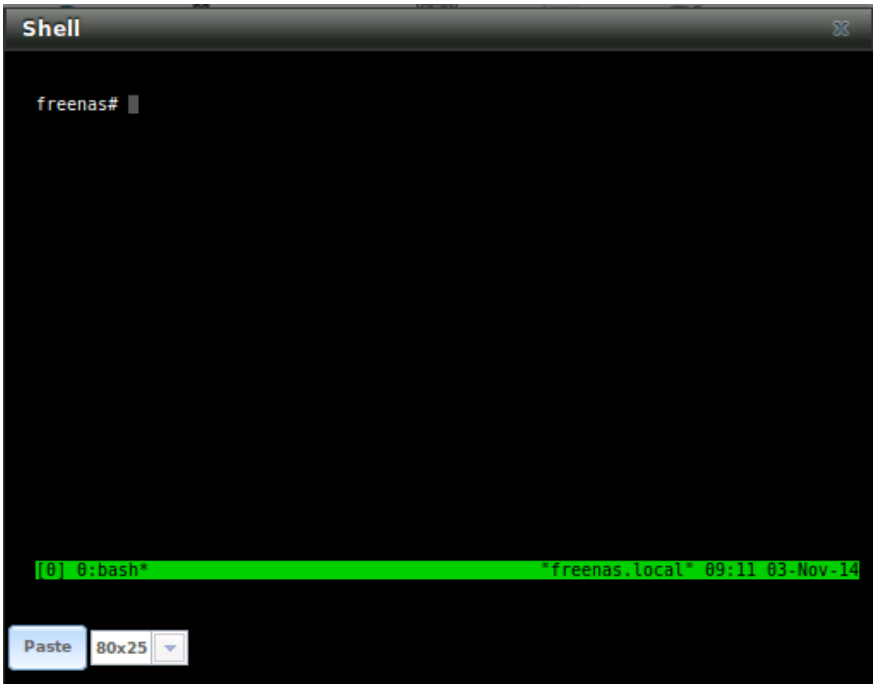


Fig. 26.2: tmux Session

To create a second window, press `Ctrl+b` then `"`. To close a window, type `exit` within the window.

tmux(1) (http://man.openbsd.org/cgi-bin/man.cgi/OpenBSD-current/man1/tmux.1?query=tmux) lists all of the key bindings and commands for interacting with `tmux` windows and sessions.

If *Shell* (page 282) is closed while `tmux` is running, it will detach its session. The next time Shell is open, run `tmux attach` to return to the previous session. To leave the `tmux` session entirely, type `exit`. If multiple windows are running, `exit` out of each first.

These resources provide more information about using `tmux`:

- A tmux Crash Course (https://robots.thoughtbot.com/a-tmux-crash-course)
- TMUX - The Terminal Multiplexer (http://blog.hawkhost.com/2010/06/28/tmux-the-terminal-multiplexer/)

26.9 Dmidecode

Dmidecode reports hardware information as reported by the system BIOS. Dmidecode does not scan the hardware, it only reports what the BIOS told it to. A sample output can be seen here (http://www.nongnu.org/dmidecode/sample/dmidecode.txt).

To view the BIOS report, type the command with no arguments:

```
dmidecode | more
```

dmidecode(8) (https://linux.die.net/man/8/dmidecode) describes the supported strings and types.

CHAPTER

TWENTYSEVEN

CONTRIBUTING TO FREENAS®

FreeNAS® is an open source community, relying on the input and expertise of its users to help grow and improve FreeNAS®. When you take time to assist the community, your contributions benefit everyone who uses FreeNAS®.

This section describes some areas of participation to get you started. It is by no means an exhaustive list. If you have an idea that you think would benefit the FreeNAS® community, bring it up on one of the resources mentioned in *Support Resources* (page 291).

This section demonstrates how you can:

- *Help with Translation* (page 310)

27.1 Translation

Not everyone speaks English, and having a complete translation of the user interface into native languages can make FreeNAS® much more useful to communities around the world.

FreeNAS® uses Weblate (https://weblate.org/en/) to manage the translation of text shown in the FreeNAS® graphical administrative interface. Weblate provides an easy-to-use web-based editor and commenting system, making it possible for individuals to assist with translation or comment on existing translations.

To see the status of translations, open https://weblate.trueos.org/projects/freenas/, as shown in Figure 27.1.

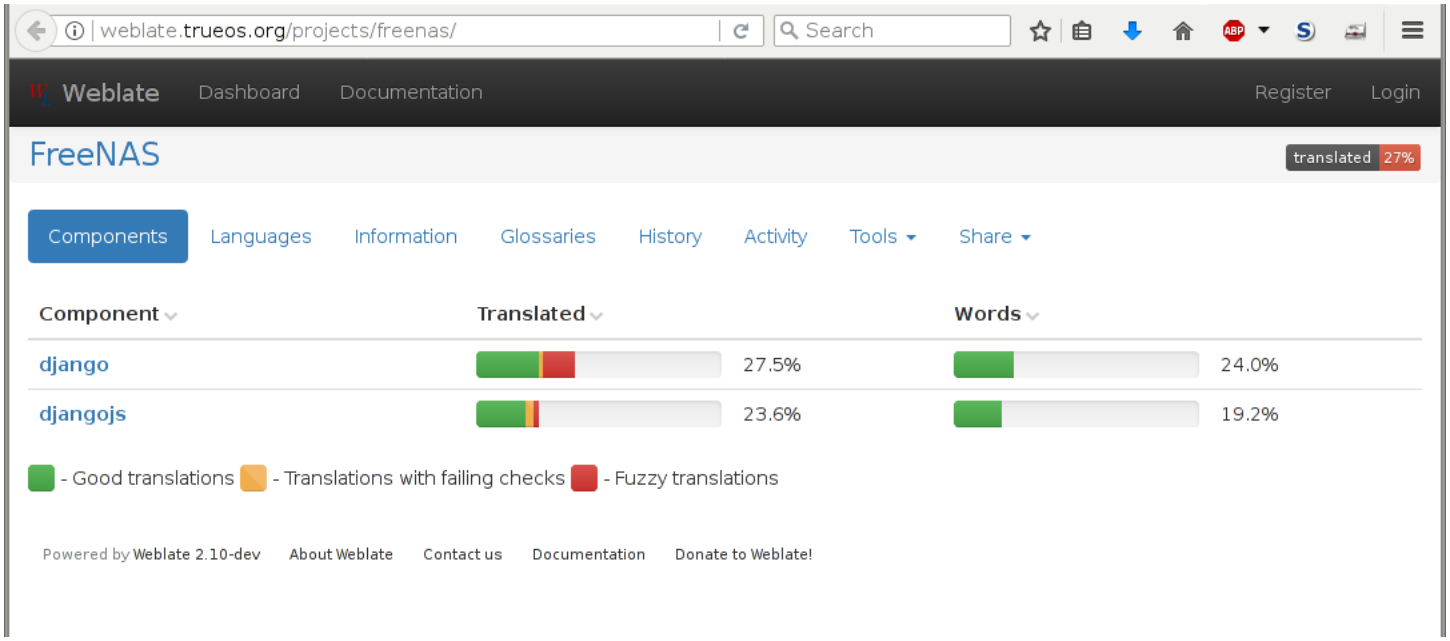


Fig. 27.1: FreeNAS® Translation System

To assist with translating FreeNAS®, create an account by clicking the *Register* button. Enter the information requested, then a confirmation email will be sent. Follow the link in the email to set a password and complete the account creation. The Dashboard screen is shown after logging in:

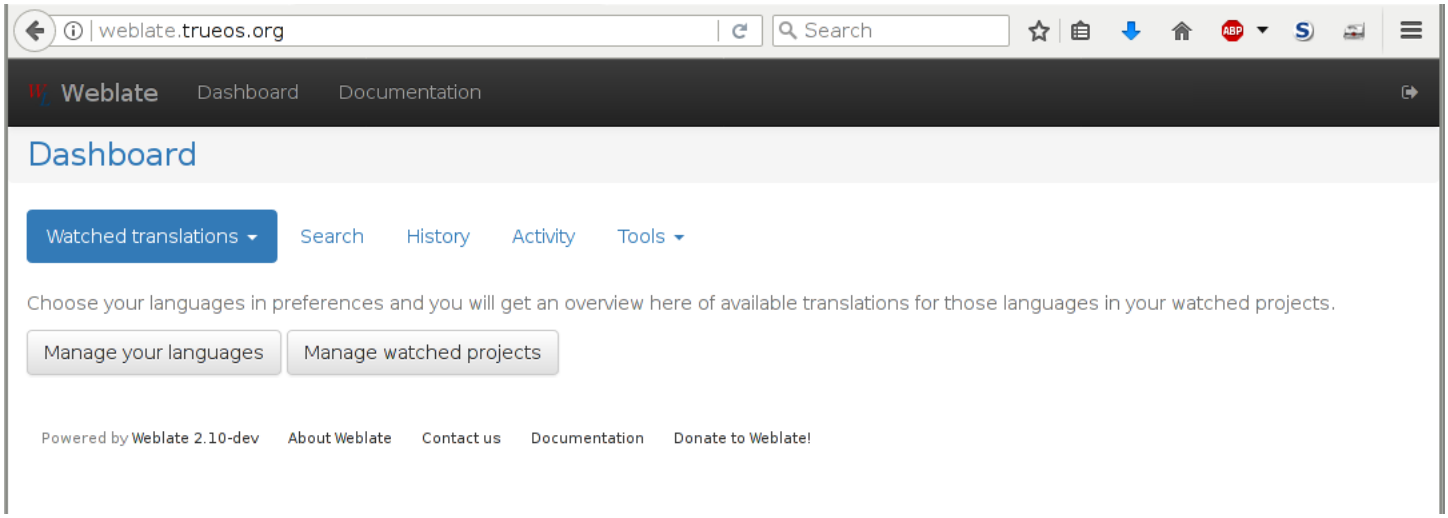


Fig. 27.2: Weblate Dashboard

Click *Manage your languages* to choose languages for translation. Select languages, then click *Save*. Click the *Dashboard* link at the top of the screen to go back to the dashboard, then choose *Your languages* from the drop-down menu:

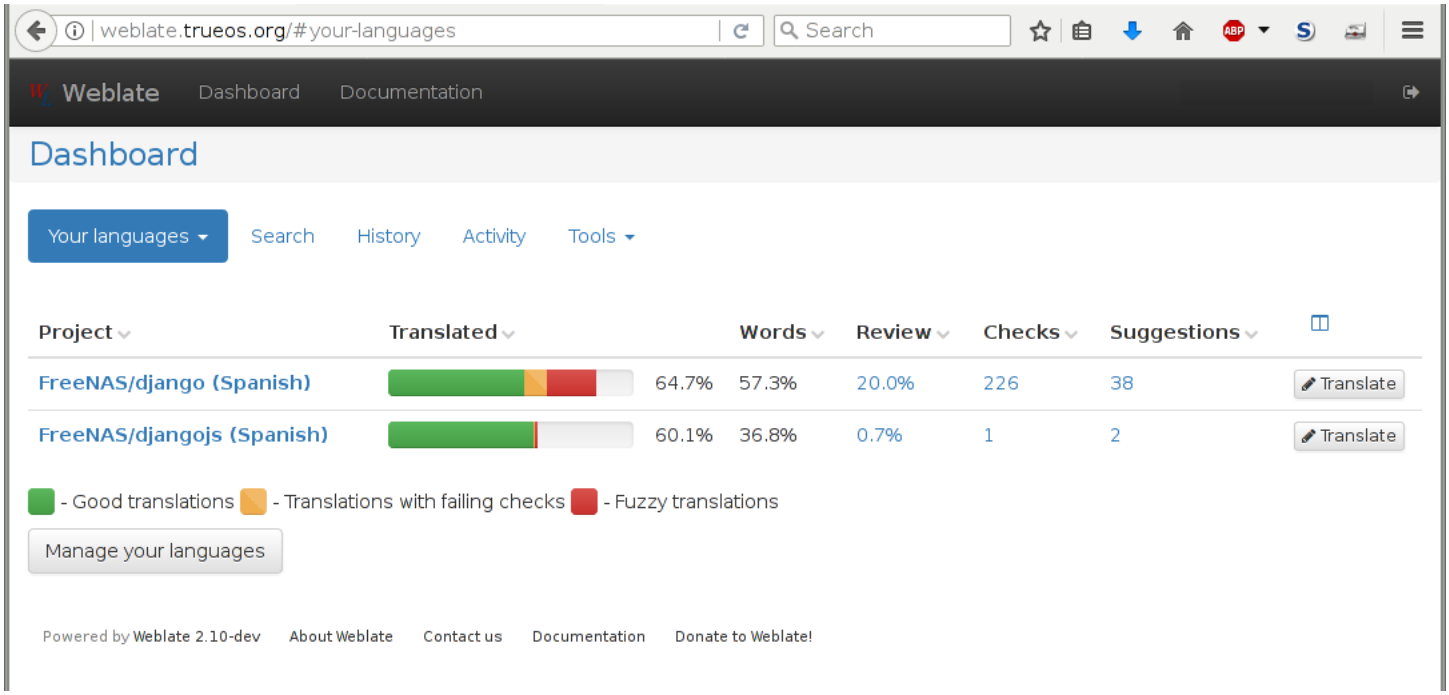


Fig. 27.3: Selected Languages

Projects are a collection of text to be translated. In this example, the Django and DjangoJS projects have both been partially translated into Spanish. Click one of the entries under *Project* to help translate that project.

The *Overview* screen shows the current translation status along with categories of translatable strings:

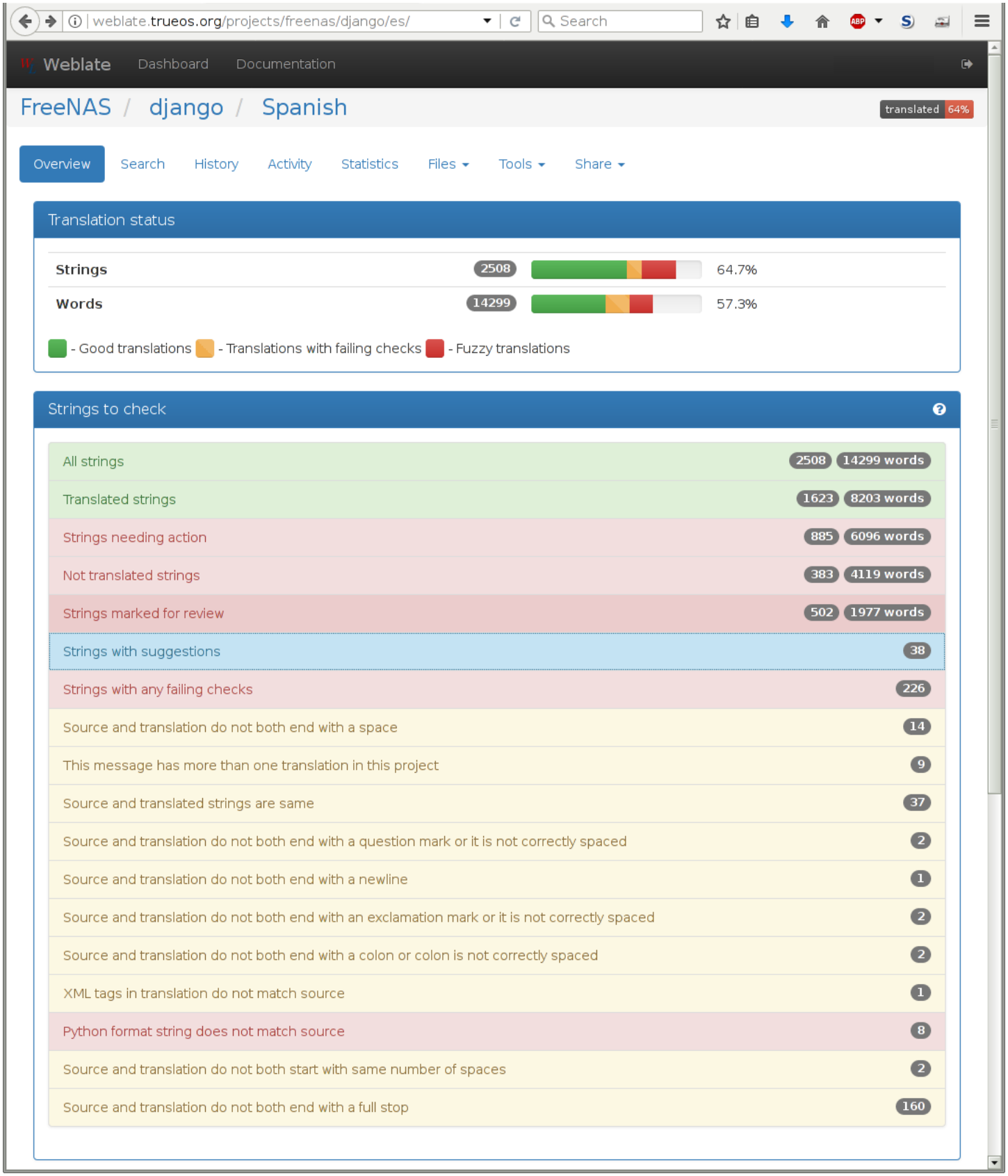


Fig. 27.4: Translation Overview

Click on a category of string, like *Strings needing action*, to see the translation screen:

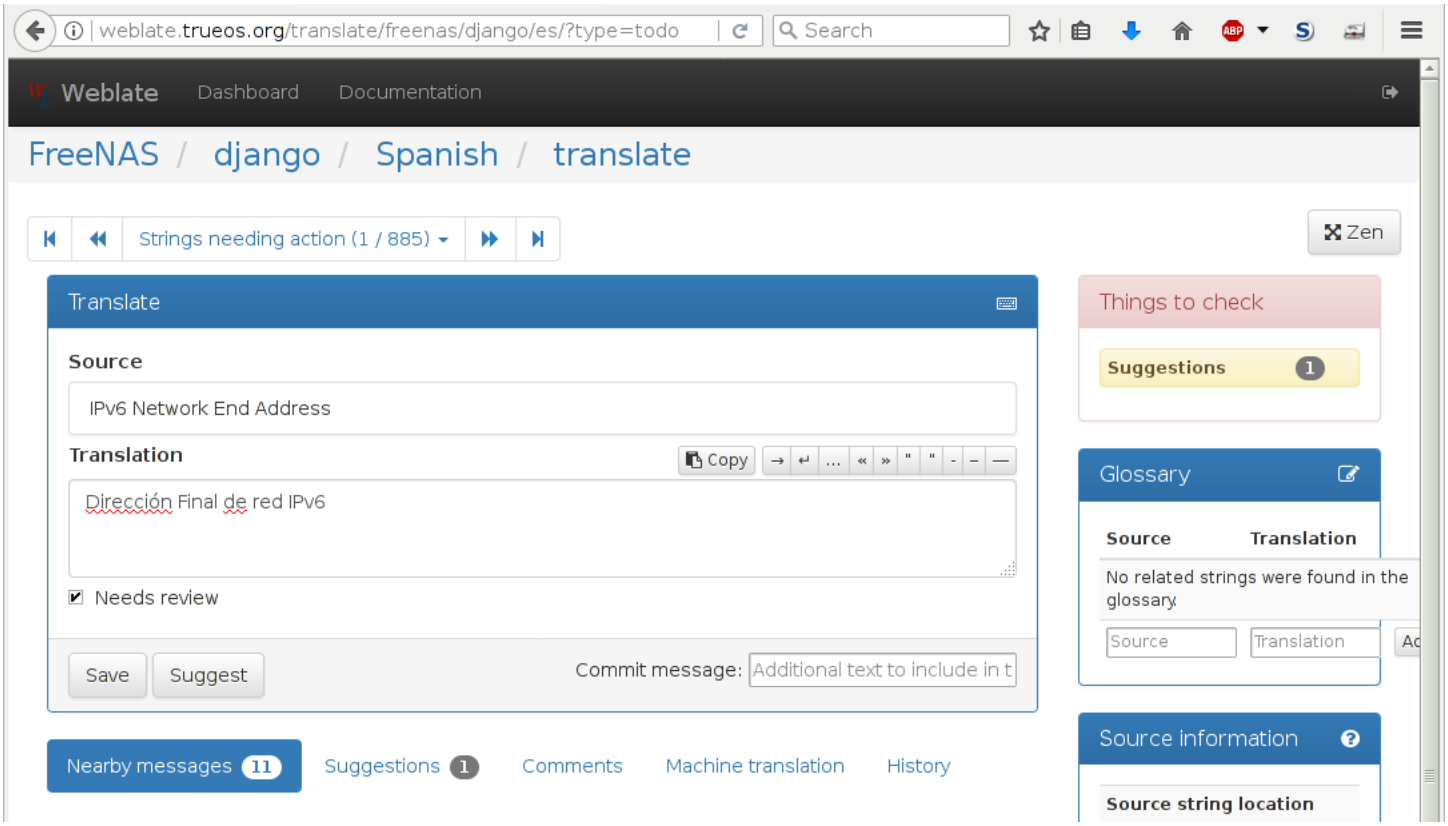


Fig. 27.5: Translate Strings

Enter translations here, clicking *Save* to save the work. The controls at the top of the screen can be used to skip forward and back in the list of strings to be translated. Click *Dashboard* at the top of the screen to return to the Dashboard.

All assistance with translations helps to benefit the FreeNAS® community. Thank you!

CHAPTER

TWENTYEIGHT

ZFS PRIMER

ZFS is an advanced, modern filesystem that was specifically designed to provide features not available in traditional UNIX filesystems. It was originally developed at Sun with the intent to open source the filesystem so that it could be ported to other operating systems. After the Oracle acquisition of Sun, some of the original ZFS engineers founded OpenZFS (http://open-zfs.org/wiki/Main_Page) to provide continued, collaborative development of the open source version. To differentiate itself from Oracle ZFS version numbers, OpenZFS uses feature flags. Feature flags are used to tag features with unique names in order to provide portability between OpenZFS implementations running on different platforms, as long as all of the feature flags enabled on the ZFS pool are supported by both platforms. FreeNAS® uses OpenZFS and each new version of FreeNAS® keeps up-to-date with the latest feature flags and OpenZFS bug fixes.

Here is an overview of the features provided by ZFS:

ZFS is a transactional, Copy-On-Write (COW) (https://en.wikipedia.org/wiki/ZFS#Copy-on-write_transactional_model) filesystem. For each write request, a copy is made of the associated disk blocks and all changes are made to the copy rather than to the original blocks. When the write is complete, all block pointers are changed to point to the new copy. This means that ZFS always writes to free space, most writes are sequential, and old versions of files are not unlinked until a complete new version has been written successfully. ZFS has direct access to disks and bundles multiple read and write requests into transactions. Most filesystems cannot do this, as they only have access to disk blocks. A transaction either completes or fails, meaning there will never be a write-hole (https://blogs.oracle.com/bonwick/raid-z) and a filesystem checker utility is not necessary. Because of the transactional design, as additional storage capacity is added, it becomes immediately available for writes. To rebalance the data, one can copy it to re-write the existing data across all available disks. As a 128-bit filesystem, the maximum filesystem or file size is 16 exabytes.

ZFS was designed to be a self-healing filesystem. As ZFS writes data, it creates a checksum for each disk block it writes. As ZFS reads data, it validates the checksum for each disk block it reads. Media errors or "bit rot" can cause data to change, and the checksum no longer matches. When ZFS identifies a disk block checksum error on a pool that is mirrored or uses RAIDZ, it replaces the corrupted data with the correct data. Since some disk blocks are rarely read, regular scrubs should be scheduled so that ZFS can read all of the data blocks to validate their checksums and correct any corrupted blocks. While multiple disks are required in order to provide redundancy and data correction, ZFS will still provide data corruption detection to a system with one disk. FreeNAS® automatically schedules a monthly scrub for each ZFS pool and the results of the scrub are displayed by selecting the *Volume* (page 118) and clicking *Volume Status*. Checking scrub results provides an early indication of potential disk problems.

Unlike traditional UNIX filesystems, **it is not necessary to define partition sizes when filesystems are created**. Instead, a group of disks, known as a *vdev*, are built into a ZFS *pool*. Filesystems are created from the pool as needed. As more capacity is needed, identical vdevs can be striped into the pool. In FreeNAS®, *Volume Manager* (page 118) is used to create or extend ZFS pools. After a pool is created, it can be divided into dynamically-sized datasets or fixed-size zvols as needed. Datasets can be used to optimize storage for the type of data being stored as permissions and properties such as quotas and compression can be set on a per-dataset level. A zvol is essentially a raw, virtual block device which can be used for applications that need raw-device semantics such as iSCSI device extents.

ZFS supports real-time data compression. Compression happens when a block is written to disk, but only if the written data will benefit from compression. When a compressed block is accessed, it is automatically decompressed. Since compression happens at the block level, not the file level, it is transparent to any applications accessing the compressed data. ZFS pools created on FreeNAS® version 9.2.1 or later use the recommended LZ4 compression algorithm.

ZFS provides low-cost, instantaneous snapshots of the specified pool, dataset, or zvol. Due to COW, snapshots initially take no additional space. The size of a snapshot increases over time as changes to the files in the snapshot are written to

disk. Snapshots can be used to provide a copy of data at the point in time the snapshot was created. When a file is deleted, its disk blocks are added to the free list; however, the blocks for that file in any existing snapshots are not added to the free list until all referencing snapshots are removed. This makes snapshots a clever way to keep a history of files, useful for recovering an older copy of a file or a deleted file. For this reason, many administrators take snapshots often, store them for a period of time, and store them on another system. Such a strategy allows the administrator to roll the system back to a specific time. If there is a catastrophic loss, an off-site snapshot can restore the system up to the last snapshot interval, within 15 minutes of the data loss, for example. Snapshots are stored locally but can also be replicated to a remote ZFS pool. During replication, ZFS does not do a byte-for-byte copy but instead converts a snapshot into a stream of data. This design means that the ZFS pool on the receiving end does not need to be identical and can use a different RAIDZ level, volume size, or compression settings.

ZFS boot environments provide a method for recovering from a failed upgrade. In FreeNAS®, a snapshot of the dataset the operating system resides on is automatically taken before an upgrade or a system update. This saved boot environment is automatically added to the GRUB boot loader. Should the upgrade or configuration change fail, simply reboot and select the previous boot environment from the boot menu. Users can also create their own boot environments in `System → Boot` as needed, for example before making configuration changes. This way, the system can be rebooted into a snapshot of the system that did not include the new configuration changes.

ZFS provides a write cache in RAM as well as a ZFS Intent Log (ZIL (http://www.freenas.org/blog/zfs-zil-and-slog-demystified/)). The ZIL is a storage area that temporarily holds *synchronous* writes until they are written to the ZFS pool (https://pthree.org/2013/04/19/zfs-administration-appendix-a-visualizing-the-zfs-intent-log/). Adding a fast (low-latency), power-protected SSD as a SLOG (*Separate Log*) device permits much higher performance. This is a necessity for NFS over ESXi, and highly recommended for database servers or other applications that depend on synchronous writes. More detail on SLOG benefits and usage is available in these blog and forum posts:

- The ZFS ZIL and SLOG Demystified (http://www.freenas.org/blog/zfs-zil-and-slog-demystified/)
- Some insights into SLOG/ZIL with ZFS on FreeNAS® (https://forums.freenas.org/index.php?threads/some-insights-into-slog-zil-with-zfs-on-freenas.13633/)
- ZFS Intent Log (http://nex7.blogspot.com/2013/04/zfs-intent-log.html)

Synchronous writes are relatively rare with SMB, AFP, and iSCSI, and adding a SLOG to improve performance of these protocols only makes sense in special cases. The `zilstat` utility can be run from *Shell* (page 282) to determine if the system will benefit from a SLOG. See this website (http://www.richardelling.com/Home/scripts-and-programs-1/zilstat) for usage information.

ZFS currently uses 16 GB of space for SLOG. Larger SSDs can be installed, but the extra space will not be used. SLOG devices cannot be shared between pools. Each pool requires a separate SLOG device. Bandwidth and throughput limitations require that a SLOG device must only be used for this single purpose. Do not attempt to add other caching functions on the same SSD, or performance will suffer.

In mission-critical systems, a mirrored SLOG device is highly recommended. Mirrored SLOG devices are *required* for ZFS pools at ZFS version 19 or earlier. The ZFS pool version is checked from the *Shell* (page 282) with `zpool get version poolname`. A version value of - means the ZFS pool is version 5000 (also known as *Feature Flags*) or later.

ZFS provides a read cache in RAM, known as the ARC, which reduces read latency. FreeNAS® adds ARC stats to top(1) (https://www.freebsd.org/cgi/man.cgi?query=top) and includes the `arc_summary.py` and `arcstat.py` tools for monitoring the efficiency of the ARC. If an SSD is dedicated as a cache device, it is known as an L2ARC (http://www.brendangregg.com/blog/2008-07-22/zfs-l2arc.html). Additional read data is cached here, which can increase random read performance. L2ARC does *not* reduce the need for sufficient RAM. In fact, L2ARC needs RAM to function. If there is not enough RAM for a adequately-sized ARC, adding an L2ARC will not increase performance. Performance actually decreases in most cases, potentially causing system instability. RAM is always faster than disks, so always add as much RAM as possible before considering whether the system can benefit from an L2ARC device.

When applications perform large amounts of *random* reads on a dataset small enough to fit into L2ARC, read performance can be increased by adding a dedicated cache device. SSD cache devices only help if the active data is larger than system RAM but small enough that a significant percentage fits on the SSD. As a general rule, L2ARC should not be added to a system with less than 32 GB of RAM, and the size of an L2ARC should not exceed ten times the amount of RAM. In some cases, it may be more efficient to have two separate pools: one on SSDs for active data, and another on hard drives for rarely used content. After adding an L2ARC device, monitor its effectiveness using tools such as `arcstat`. To increase the size of an existing L2ARC, stripe another cache device with it. The GUI will always stripe L2ARC, not mirror it, as the contents of L2ARC

are recreated at boot. Failure of an individual SSD from an L2ARC pool will not affect the integrity of the pool, but may have an impact on read performance, depending on the workload and the ratio of dataset size to cache size. Note that dedicated L2ARC devices cannot be shared between ZFS pools.

ZFS was designed to provide redundancy while addressing some of the inherent limitations of hardware RAID such as the write-hole and corrupt data written over time before the hardware controller provides an alert. ZFS provides three levels of redundancy, known as *RAIDZ*, where the number after the *RAIDZ* indicates how many disks per vdev can be lost without losing data. ZFS also supports mirrors, with no restrictions on the number of disks in the mirror. ZFS was designed for commodity disks so no RAID controller is needed. While ZFS can also be used with a RAID controller, it is recommended that the controller be put into JBOD mode so that ZFS has full control of the disks.

When determining the type of ZFS redundancy to use, consider whether the goal is to maximize disk space or performance:

- RAIDZ1 maximizes disk space and generally performs well when data is written and read in large chunks (128K or more).
- RAIDZ2 offers better data availability and significantly better mean time to data loss (MTTDL) than RAIDZ1.
- A mirror consumes more disk space but generally performs better with small random reads. For better performance, a mirror is strongly favored over any RAIDZ, particularly for large, uncacheable, random read loads.
- Using more than 12 disks per vdev is not recommended. The recommended number of disks per vdev is between 3 and 9. With more disks, use multiple vdevs.
- Some older ZFS documentation recommends that a certain number of disks is needed for each type of RAIDZ in order to achieve optimal performance. On systems using LZ4 compression, which is the default for FreeNAS® 9.2.1 and higher, this is no longer true.

These resources can also help determine the RAID configuration best suited to the specific storage requirements:

- Getting the Most out of ZFS Pools (https://forums.freenas.org/index.php?threads/getting-the-most-out-of-zfs-pools.16/)
- A Closer Look at ZFS, Vdevs and Performance (https://constantin.glez.de/2010/06/04/a-closer-look-zfs-vdevs-and-performance/)

Warning: RAID AND DISK REDUNDANCY ARE NOT A SUBSTITUTE FOR A RELIABLE BACKUP STRATEGY. BAD THINGS HAPPEN AND A GOOD BACKUP STRATEGY IS STILL REQUIRED TO PROTECT VALUABLE DATA. See *Periodic Snapshot Tasks* (page 143) and *Replication Tasks* (page 145) to use replicated ZFS snapshots as part of a backup strategy.

ZFS manages devices. When an individual drive in a mirror or RAIDZ fails and is replaced by the user, ZFS adds the replacement device to the vdev and copies redundant data to it in a process called *resilvering*. Hardware RAID controllers usually have no way of knowing which blocks were in use and must copy every block to the new device. ZFS only copies blocks that are in use, reducing the time it takes to rebuild the vdev. Resilvering is also interruptable. After an interruption, resilvering resumes where it left off rather than starting from the beginning.

While ZFS provides many benefits, there are some caveats:

- At 90% capacity, ZFS switches from performance- to space-based optimization, which has massive performance implications. For maximum write performance and to prevent problems with drive replacement, add more capacity before a pool reaches 80%. If using iSCSI, it is recommended to not let the pool go over 50% capacity to prevent fragmentation issues.
- When considering the number of disks to use per vdev, consider the size of the disks and the amount of time required for resilvering, which is the process of rebuilding the vdev. The larger the size of the vdev, the longer the resilvering time. When replacing a disk in a RAIDZ, it is possible that another disk will fail before the resilvering process completes. If the number of failed disks exceeds the number allowed per vdev for the type of RAIDZ, the data in the pool will be lost. For this reason, RAIDZ1 is not recommended for drives over 1 TB in size.
- Using drives of equal sizes is recommended when creating a vdev. While ZFS can create a vdev using disks of differing sizes, its capacity will be limited by the size of the smallest disk.

For those new to ZFS, the Wikipedia entry on ZFS (https://en.wikipedia.org/wiki/Zfs) provides an excellent starting point to learn more about its features. These resources are also useful for reference:

- FreeBSD ZFS Tuning Guide (https://wiki.freebsd.org/ZFSTuningGuide)
- ZFS Administration Guide (https://docs.oracle.com/cd/E19253-01/819-5461/index.html)
- Becoming a ZFS Ninja (video) (https://www.youtube.com/watch?v=6_K55Ira1Cs)
- Slideshow explaining VDev, zpool, ZIL and L2ARC and other newbie mistakes! (https://forums.freenas.org/index.php?threads/slideshow-explaining-vdev-zpool-zil-and-l2arc-for-noobs.7775/)
- A Crash Course on ZFS (http://www.bsdnow.tv/tutorials/zfs)
- ZFS: The Last Word in File Systems - Part 1 (video) (https://www.youtube.com/watch?v=uT2i2ryhCio)
- The Zettabyte Filesystem (https://www.youtube.com/watch?v=ptY6-K78McY)

CHAPTER

TWENTYNINE

VAAI

VMware's vStorage APIs for Array Integration, or *VAAI*, allows storage tasks such as large data moves to be offloaded from the virtualization hardware to the storage array. These operations are performed locally on the NAS without transferring bulk data over the network.

29.1 VAAI for iSCSI

VAAI for iSCSI supports these operations:

- *Atomic Test and Set* (*ATS*) allows multiple initiators to synchronize LUN access in a fine-grained manner rather than locking the whole LUN and preventing other hosts from accessing the same LUN simultaneously.
- *Clone Blocks* (*XCOPY*) copies disk blocks on the NAS. Copies occur locally rather than over the network. The operation is similar to Microsoft ODX (https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2012-R2-and-2012/hh831628(v=ws.11)).
- *LUN Reporting* allows a hypervisor to query the NAS to determine whether a LUN is using thin provisioning.
- *Stun* pauses running virtual machines when a volume runs out of space. The space issue can then be fixed and the virtual machines can continue rather than reporting write errors.
- *Threshold Warning* the system reports a warning when a configurable capacity is reached. In FreeNAS®, this threshold can be configured at the pool level when using zvols (see Table 10.6) or at the extent level (see Table 10.11) for both file- and device-based extents. Typically, the warning is set at the pool level, unless file extents are used, in which case it must be set at the extent level.
- *Unmap* informs FreeNAS® that the space occupied by deleted files should be freed. Without unmap, the NAS is unaware of freed space created when the initiator deletes files. For this feature to work, the initiator must support the unmap command.
- *Zero Blocks* or *Write Same* zeros out disk regions. When allocating virtual machines with thick provisioning, the zero write is done locally, rather than over the network. This makes virtual machine creation and any other zeroing of disk regions much quicker.

CHAPTER

THIRTY

USING THE API

A REST (https://en.wikipedia.org/wiki/Representational_state_transfer) API is provided to be used as an alternate mechanism for remotely controlling a FreeNAS® system.

REST provides an easy-to-read, HTTP implementation of functions, known as resources, which are available beneath a specified base URL. Each resource is manipulated using the HTTP methods defined in **RFC 2616** (https://tools.ietf.org/html/rfc2616.html), such as GET, PUT, POST, or DELETE.

As shown in Figure 30.1, an online version of the API is available at api.freenas.org (http://api.freenas.org).

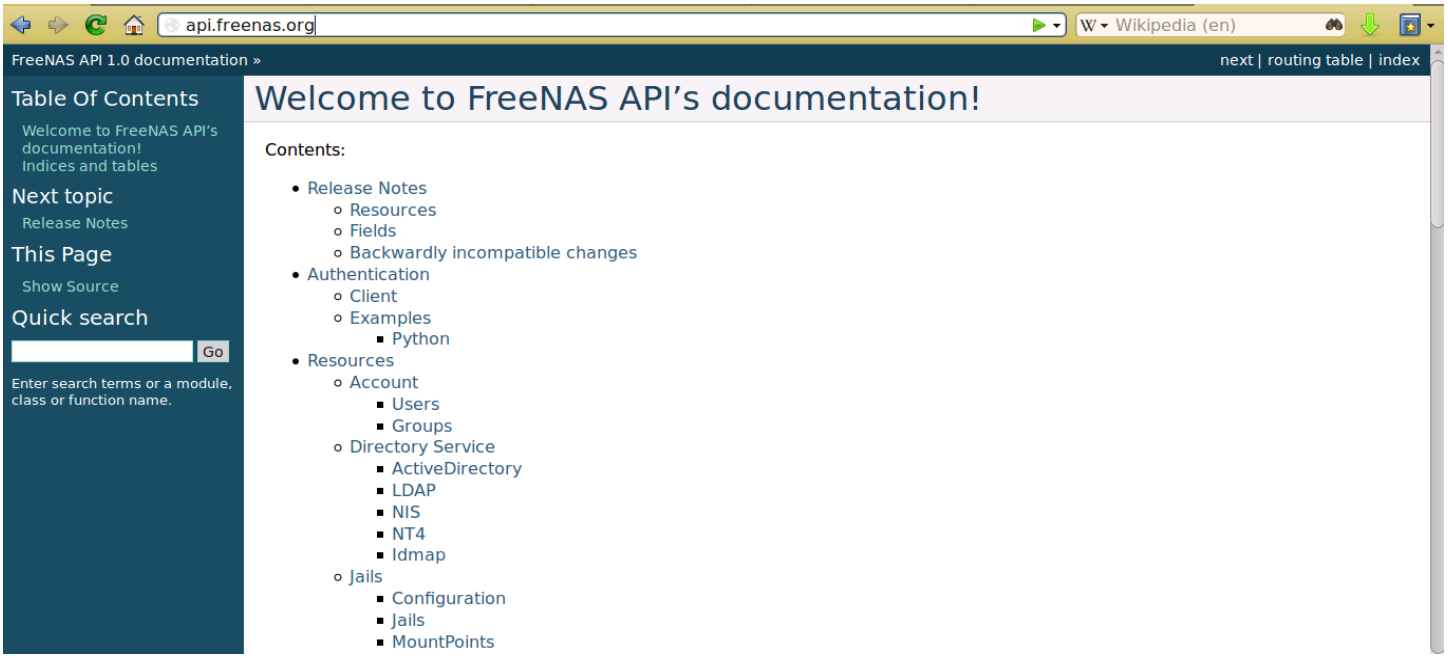


Fig. 30.1: API Documentation

The rest of this section shows code examples to illustrate the use of the API.

Note: A new API was released with FreeNAS® 11.1. The previous API is still present and in use because it is feature-complete. Documentation for the new API is available on the FreeNAS® system at the */api/docs/* URL. For example, if the FreeNAS® system is at IP address 192.168.1.119, enter *http://192.168.1.119/api/docs/* in a browser to see the API documentation. Work is under way to make the new API feature-complete. The new APIv2 uses WebSockets (https://developer.mozilla.org/en-US/docs/Web/API/WebSockets_API). This advanced technology makes it possible to open interactive communication sessions between web browsers and servers, allowing event-driven responses without the need to poll the server for a reply. When APIv2 is feature complete, the FreeNAS® documentation will include relevant examples that make use of the new API.

30.1 A Simple API Example

The api directory of the FreeNAS® github repository (https://github.com/freenas/freenas/tree/master/examples/api) contains some API usage examples. This section provides a walk-through of the `newuser.py` script, shown below, as it provides a simple example that creates a user.

A FreeNAS® system running at least version 9.2.0 is required when creating a customized script based on this example. To test the scripts directly on the FreeNAS® system, create a user account and select an existing volume or dataset for the user's *Home Directory*. After creating the user, start the SSH service using `Services → Control Services`. That user will now be able to `ssh` to the IP address of the FreeNAS® system to create and run scripts. Alternately, scripts can be tested on any system with the required software installed as shown in the previous section.

To customize this script, copy the contents of this example into a filename that ends in `.py`. The text that is highlighted in red below can be modified in the new version to match the needs of the user being created. The text in black should not be changed. After saving changes, run the script by typing `python scriptname.py`. If all goes well, the new user account will appear in `Account → Users → View Users` in the FreeNAS® GUI.

Here is the example script with an explanation of the line numbers below it.

```
1  import json
2  import requests
3  r = requests.post(
4    'https://freenas.mydomain/api/v1.0/account/users/',
5    auth=('root', 'freenas'),
6    headers={'Content-Type': 'application/json'},
7    verify=False,
8    data=json.dumps({
9          'bsdusr_uid': '1100',
10         'bsdusr_username': 'myuser',
11         'bsdusr_mode': '755',
12         'bsdusr_creategroup': 'True',
13         'bsdusr_password': '12345',
14         'bsdusr_shell': '/usr/local/bin/bash',
15         'bsdusr_full_name': 'Full Name',
16         'bsdusr_email': 'name@provider.com',
17     })
18  )
19  print r.text
```

Where:

Lines 1-2: import the Python modules used to make HTTP requests and handle data in JSON format.

Line 4: replace *freenas.mydomain* with the *Hostname* value in `System → System Information`. Note that the script will fail if the machine running it is not able to resolve that hostname. Change *https* to *http* to use HTTP rather than HTTPS to access the FreeNAS® system.

Line 5: replace *freenas* with the password used to access the FreeNAS® system.

Line 7: if you are using HTTPS and want to force validation of the SSL certificate, change *False* to *True*.

Lines 8-16: set the values for the user being created. The Users resource (http://api.freenas.org/resources/account.html#users) describes this in more detail. Allowed parameters are listed in the JSON Parameters section of that resource. Since this resource creates a FreeBSD user, the values entered must be valid for a FreeBSD user account.

Table 30.1 summarizes acceptable values. This resource uses JSON, so the boolean values are *True* or *False*.

Table 30.1: JSON Parameters for Users Create Resource

JSON Parameter	Type	Description
bsdusr_username	string	maximum 32 characters, though a maximum of 8 is recommended for interoperability; can include numerals but cannot include a space

Continued on next page

Table 30.1 – continued from previous page

JSON Parameter	Type	Description
bsdusr_full_name	string	may contain spaces and uppercase characters
bsdusr_password	string	can include a mix of upper and lowercase letters, characters, and numbers
bsdusr_uid	integer	by convention, user accounts have an ID greater than 1000 with a maximum allowable value of 65,535
bsdusr_group	integer	if *bsdusr_creategroup* is set to *False*, specify the numeric ID of the group to create
bsdusr_creategroup	boolean	if set to *True*, a primary group with the same numeric ID as *bsdusr_uid* will be created automatically
bsdusr_mode	string	sets default numeric UNIX permissions of user's home directory
bsdusr_shell	string	specify full path to a UNIX shell that is installed on the system
bsdusr_password_disabled	boolean	if set to *True*, user is not allowed to log in
bsdusr_locked	boolean	if set to *True*, user is not allowed to log in
bsdusr_sudo	boolean	if set to *True*, `sudo` is enabled for the user
bsdusr_sshpubkey	string	contents of SSH authorized keys file

Note: When using boolean values, JSON returns raw lowercase values but Python uses uppercase values. So use *True* or *False* in Python scripts even though the example JSON responses in the API documentation are displayed as *true* or *false*.

30.2 A More Complex Example

This section provides a walk-through of a more complex example found in the `startup.py` script. Use the searchbar within the API documentation to quickly locate the JSON parameters used here. This example defines a class and several methods to create a ZFS volume, create a ZFS dataset, share the dataset over CIFS, and enable the CIFS service. Responses from some methods are used as parameters in other methods. In addition to the import lines seen in the previous example, two additional Python modules are imported to provide parsing functions for command line arguments:

```
import argparse
import sys
```

It then creates a *Startup* class which is started with the hostname, username, and password provided by the user via the command line:

```
class Startup(object):
  def __init__(self, hostname, user, secret):
        self._hostname = hostname
        self._user = user
        self._secret = secret
        self._ep = 'http://%s/api/v1.0' % hostname
  def request(self, resource, method='GET', data=None):
        if data is None:
            data = ''
        r = requests.request(
            method,
            '%s/%s/' % (self._ep, resource),
            data=json.dumps(data),
            headers={'Content-Type': "application/json"},
            auth=(self._user, self._secret),
        )
        if r.ok:
            try:
                return r.json()
            except:
```

```
                return r.text
        raise ValueError(r)
```

A *get_disks* method is defined to get all the disks in the system as a *disk_name* response. The *create_pool* method uses this information to create a ZFS pool named *tank* which is created as a stripe. The *volume_name* and *layout* JSON parameters are described in the "Storage Volume" resource of the API documentation.:

```
def _get_disks(self):
        disks = self.request('storage/disk')
        return [disk['disk_name'] for disk in disks]

def create_pool(self):
        disks = self._get_disks()
        self.request('storage/volume', method='POST', data={
            'volume_name': 'tank',
            'layout': [
                {'vdevtype': 'stripe', 'disks': disks},
            ],
})
```

The *create_dataset* method is defined which creates a dataset named `MyShare`:

```
def create_dataset(self):
        self.request('storage/volume/tank/datasets', method='POST', data={
            'name': 'MyShare',
        })
```

The *create_cifs_share* method is used to share `/mnt/tank/MyShare` with guest-only access enabled. The *cifs_name*, *cifs_path*, *cifs_guestonly* JSON parameters, as well as the other allowable parameters, are described in the "Sharing CIFS" resource of the API documentation.:

```
def create_cifs_share(self):
        self.request('sharing/cifs', method='POST', data={
            'cifs_name': 'My Test Share',
            'cifs_path': '/mnt/tank/MyShare',
            'cifs_guestonly': True
})
```

Finally, the *service_start* method enables the CIFS service. The *srv_enable* JSON parameter is described in the Services resource.

```
def service_start(self, name):
        self.request('services/services/%s' % name, method='PUT', data={
            'srv_enable': True,

})
```

Symbols

802.1Q, 115

A

Add Group, 50
Add User, 53
Adding Devices to a VM, 262
AFP, 174, 216
Alert, 288
Alert Services, 77
Alerts, 76
API, 318
Apple Filing Protocol, 174, 216
arcstat, 300
Autotune, 65

B

Boot Environments, 60
Burn ISO, 10

C

CA, 78
Certificate Authority, 78
Certificates, 81
Checksum, 10
CIFS, 189, 234
Cloud Credentials, 74
Cloud Sync, 87
Compression, 128
Create Dataset, 125
Create Group, 50
Create the Rancher VM, 268
Create User, 53
Creating VMs, 261
Cron Jobs, 91

D

DC, 217
DDNS, 219
Deduplication, 127
Delete Group, 51
Delete User, 55
Deleting VMs, 267
Dell PERC H330, 8
Dell PERC H730, 8
Dmidecode, 308
Docker/Rancher VM, 268
Domain Controller, 217
Download, 10
Dynamic DNS, 219

E

Email, 67
Encryption, 120
EtherChannel, 110

F

File Transfer Protocol, 220
Forums, 291
freenas-debug, 307
FTP, 220

G

Getting FreeNAS\ :sup:‘®‘, 10
Groups, 49
Guide, 287

H

Hardware Recommendations, 6
Highpoint RAID, 8
Hot Spares, 143

I

Install, 12
Internet Small Computer System Interface, 199
IOzone, 298
Iperf, 294
IRC, 292
iSCSI, 199
ISO, 10

J

Jails, 250

L

LACP, 110
LAGG, 110
Link Aggregation, 110
Link Layer Discovery Protocol, 225
LLDP, 225

Localize, 310
Log Out, 283

M

MegaCli, 306
Minio, 231
Mirroring the Boot Device, 62
Multiple Boot Environments, 60

N

Netdata, 226
Netperf, 297
Network File System, 181, 227
Network Settings, 104
New Group, 50
New User, 53
NFS, 181, 227

P

Path and Name Lengths, 5
Periodic Snapshot, 143
Plugin, 248
Professional Support, 292

R

Rancher VM Requirements, 268
Reboot, 284
Remove Group, 51
Remove User, 55
Replace Failed Drive, 140
Replication, 145
Reporting, 271
RFC
    RFC 2616, 319
    RFC 3721, 201
Route, 115
Rsync, 229
Rsync Tasks, 95
Running VMs, 267

S

S.M.A.R.T., 232
S.M.A.R.T. Tests, 102
S3, 231
Samba, 189, 234
SCP, 241
Scrub, 155
Secure Copy, 241
Secure Shell, 240
Self-Encrypting Drives, 66
Services, 213
Shadow Copies, 197
Shell, 281
Shutdown, 285
Simple Network Management Protocol, 238
SMB, 189, 234
Snapshot, 143
Snapshots, 158
SNMP, 238
Spares, 143
SSH, 240
Start Service, 214
Static Route, 115
Stop Service, 214
Support, 84, 286
System Dataset, 68

T

Tasks, 86
TFTP, 242
Time Machine, 177
tmux, 307
Translate, 310
Translation, 310
Trivial File Transfer Protocol, 242
Trunking, 115
Tunables, 69
tw_cli, 305

U

Uninterruptible Power Supply, 243
Upgrade, 20
Upgrade ZFS Pool, 27
UPS, 243
USB Stick, 10
Users, 51

V

VAAI, 317
VAAI for iSCSI, 318
Virtualization, 28
VLAN, 115
VM, 28
VMs, 260
VMware Snapshot, 160
Volumes, 118

W

WebDAV, 188, 247
Windows File Share, 234
Windows Shares, 189
Wizard, 273

Z

ZVOL, 128