

# **Storage and File Services Overview**

## **Open Enterprise Server 11 SP1**

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**Novell.**

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1800 South Novell Place  
Provo, UT 84606  
U.S.A.  
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# About This Guide

This guide discusses storage and file services solutions available in Novell Open Enterprise Server (OES) 11 Support Pack 1 (SP1).

- ♦ [Chapter 1, “Storage Solutions,” on page 7](#)
- ♦ [Chapter 2, “Storage Architectures,” on page 23](#)
- ♦ [Chapter 3, “Storage Documentation Quick Reference,” on page 35](#)
- ♦ [Appendix A, “Documentation Updates,” on page 41](#)

## Audience

This guide is intended for system administrators.

## Feedback

We want to hear your comments and suggestions about this manual and the other documentation included with this product. Please use the User Comment feature at the bottom of each page of the online documentation.

## Documentation Updates

For the most recent version of the *Storage and File Services Overview*, see the [OES 11 SP1 documentation Web site \(http://www.novell.com/documentation/oes11/index.html\)](http://www.novell.com/documentation/oes11/index.html).

## Additional Documentation

A list of all storage services and file services documents is provided in [Chapter 3, “Storage Documentation Quick Reference,” on page 35](#).



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# 1 Storage Solutions

Businesses depend on their data. You need a storage solution that easily adapts to your changing business needs. Novell Open Enterprise Server (OES) 11 SP1 supports several configured solutions and provides a variety of storage services that allow you implement a wide range of storage architectures, from the simplest small office file server to a complex, fault-tolerant, highly available data center. Whether you measure storage in gigabytes or terabytes, OES can help you implement the storage solution that meets your needs.

To find the right storage solution, you first need to identify your data requirements by accurately assessing your data and understanding its business relevance. Compare your list of requirements to the typical storage criteria described in this document to identify features in OES that address those needs.

The information in this section can help you find the right components of OES to create a variety of secure, flexible, scalable, and highly available storage solutions.

- ♦ [Section 1.1, “General Storage,” on page 7](#)
- ♦ [Section 1.2, “File Access and Collaboration Services,” on page 9](#)
- ♦ [Section 1.3, “Compatibility,” on page 11](#)
- ♦ [Section 1.4, “Reliability,” on page 12](#)
- ♦ [Section 1.5, “Scalability,” on page 13](#)
- ♦ [Section 1.6, “File Space Virtualization,” on page 13](#)
- ♦ [Section 1.7, “Availability,” on page 14](#)
- ♦ [Section 1.8, “Data Protection and Security,” on page 15](#)
- ♦ [Section 1.9, “Performance,” on page 17](#)
- ♦ [Section 1.10, “Data Consolidation,” on page 18](#)
- ♦ [Section 1.11, “Storage Monitoring and Maintenance,” on page 20](#)
- ♦ [Section 1.12, “What’s Next,” on page 21](#)

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**IMPORTANT:** For a quick reference to all documents mentioned in this section, see [Chapter 3, “Storage Documentation Quick Reference,” on page 35](#).

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## 1.1 General Storage

Your storage solution must meet your basic file system management needs. In addition to the operating platform, servers store software and data. The primary challenge is to store the data efficiently while making it available to users when and where they need it. To simplify that task, your storage solutions should abstract diverse storage devices into a single logical storage space.

Storage solutions must be flexible and scalable. Flexibility lets you apply the storage solution to a variety of equipment. Scalability lets you continue to grow and adapt your solution as your business needs change.

The following table describes general storage requirements and OES solutions.

Storage Requirement	Novell OES Solution
<b>Virtualized storage management:</b> The ability to manage diverse storage devices from multiple vendors and to present the combined space as a single resource that you can subdivide and allocate according to your data management needs.	Novell Storage Services (NSS) virtualizes the file storage to take advantage of all space available on disks. NSS supports a variety of storage device technologies and vendor products.  For information, see <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a> .
<b>Flexibility:</b> The ability to implement different storage solutions to meet a variety of workplace scenarios and to modify the storage solution easily as business needs change.	NSS supports a variety of storage architectures, including direct-attached storage (DAS), network-attached storage (NAS) servers, and storage area networks (SANs). For information, see the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a> .  NSS supports both Fibre Channel and iSCSI SANs that allow authorized access to any device in the SAN fabric and optimization of available storage.  The Linux solution for iSCSI storage is available. For information about the iSCSI Target and iSCSI Initiator software, see "Mass Storage Over IP Networks: iSCSI" ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html">http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html</a> ) in the <a href="#">SLES 11 SP2 Storage Administration Guide</a> . ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a> ).  Novell Cluster Services supports server clusters. Data for the cluster can be shared as DAS or in SANs. For information see the <a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a> .

## 1.1.1 Diverse Storage Devices

OES is compatible with a wide variety of storage devices such as disk drives, JBOD (just-a-bunch-of-disks) arrays, RAID arrays, storage subsystems, tape drives, and tape libraries.

Storage devices can be SCSI, Fibre Channel, iSCSI, SATA, or ATA/IDE, depending on your performance and reliability requirements. In general, SCSI devices are faster and more reliable than ATA devices. Today's ATA devices can be used for primary and near-line storage or as staging areas in a disk-to-disk-to-tape backup strategy.

OES supports both Fibre Channel and iSCSI SAN solutions. In a Fibre Channel SAN, the SAN equipment and connections are based on Fibre Channel interconnect technologies. In an iSCSI SAN, the equipment and connections are based on conventional Ethernet and IP interconnect technologies.

For information about Linux POSIX file systems such as Btrfs, Ext3, Reiser and XFS, see "[Overview of Linux POSIX File Systems](#)" in the [OES 11 SP1: Linux POSIX Volume Administration Guide](#).

## 1.1.2 Flexible Storage Architectures

For more information about general storage solutions such as DAS, NAS servers, SANs, and clusters, see "[Storage Architectures](#)" on page 23.



## 1.2 File Access and Collaboration Services

Users need to access data securely from a variety of locations including in the office and home, throughout the business or university campus, and on the road. Security and resources management should be easy to use for administrators and users. Security should protect the network resources but not impair the users' ability to do their job anywhere, at any time.

Storage Requirement	Novell OES Solution
<b>Authorized access to data:</b> The ability to restrict access to data based on user and applications rights.	Novell eDirectory provides a trustee-based rights and access control system that maintains access control rights throughout the enterprise. Trustee management is integrated into the NSS file system. NCP volumes for OES also support the file system trustee model for access control.  For information, see the <a href="#">Novell eDirectory 8.8 SP7 Administration Guide</a> .
<b>Authorized access to data in the event that media is stolen:</b> The ability to meet the legal standard of making data inaccessible to software that circumvents normal access control, such as if the media were stolen.	NSS provides Encrypted Volume Support that requires password access to activate an encrypted NSS volume on server boot or restart.  For information, see the “ <a href="#">Managing Encrypted NSS Volumes</a> ” in the <i>OES2: NSS File System Administration Guide</i> .
<b>Heterogeneous client and application support with transparent read/write access to network storage areas:</b> The ability to access network data regardless of client or server operating system, the file storage system, or the database format.	OES supports file access protocols for Windows, Linux, Macintosh, and UNIX clients. Native Linux protocols (such as Samba and NFS) and NCP are available for NSS and Linux POSIX file systems (such as Btrfs, Ext3, Reiser, and XFS). It also provides Novell CIFS and Novell AFP for the NSS file system.  For information see the following: <ul style="list-style-type: none"><li>♦ <a href="#">OES 11 SP1: NCP Server for Linux Administration Guide</a>.</li><li>♦ <a href="#">OES 11 SP1: Novell CIFS for Linux Administration Guide</a></li><li>♦ <a href="#">OES 11 SP1: Novell AFP for Linux Administration Guide</a></li><li>♦ <a href="#">OES 11 SP1: Novell Samba Administration Guide</a>.</li><li>♦ “<a href="#">Novell FTP (Pure-FTPd) and OES 11 SP1</a>” in the <i>OES 11 SP1: Planning and Implementation Guide</i></li></ul>
<b>Heterogeneous client and application support in an Active Directory domain:</b> The ability to access network data using the Novell trustee model in an Active Directory domain.	Domain Services for Windows allows CIFS/Samba users in an Active Directory domain to access their data on NSS volumes and NCP volumes on OES 2 SP1 or later servers. For information, see the <a href="#">OES 11 SP1: Domain Services for Windows Administration Guide</a> .
<b>Secure access to network data from anywhere, at any time:</b> The ability to securely access network data using a standard Web browser from anywhere at any time without requiring special software on the workstation.	Novell NetStorage provides Internet-based access to network files. You can set up a NetStorage server to provide users with secure Web-based access to their files from anywhere, at any time. For information, see the <a href="#">OES 11 SP1: NetStorage Administration Guide for Linux</a> .  NetStorage also provides access to previous file versions if you implement the Novell Archive and Version Services as part of your overall storage solution. For information, see the <a href="#">OES 11 SP1: Novell Archive and Version Services 2.1 Administration Guide</a> .

Storage Requirement	Novell OES Solution
<p><b>Secure access to local data from anywhere, at any time:</b> The ability to access local data using a standard Web browser from anywhere at any time without requiring special software on the workstation.</p> <p><b>Secure access to local data from specified workstations at any time:</b> The ability to access local data from different locations on the network.</p>	<p>Novell iFolder provides Web-based and network-based access to local files stored on network servers. iFolder provides users transparent, cross-platform file transfer by synchronizing files across multiple workstations from a secure, centralized network server.</p> <p>Users can use the iFolder client on specified workstations to access their local files wherever they are working and know that they have the most current version of a file to work with.</p> <p>Data transfers between the server and clients are encrypted for secure data transfer.</p> <p>Users can use a Web browser to access files from anywhere using a secure sockets layer (SSL) connection; it does not require a virtual private network (VPN) connection.</p> <p>Novell iFolder 3x supports shared access to i Folders. For information, see the <a href="http://www.novell.com/documentation/ifolder3">Novell iFolder 3.x documentation Web site (http://www.novell.com/documentation/ifolder3)</a>.</p>
<p><b>Secure file access for data:</b> The ability to provide secure file access to data for clients in a heterogeneous client environment.</p>	<p>The Novell Client provides secure file access from clients using NCP. NCP access is available for NSS volumes and NCP volumes. Users can also see a merged file view of a Dynamic Storage Technology shadow volume pair. For information, see the <a href="#">Novell Client 4.91 SP5 for Windows XP/2003 Installation and Administration Guide</a>, the <a href="#">Novell Client 2 SP1 for Windows Administration Guide</a>, and the <a href="#">Novell Client 2.0 SP3 for Linux Administration Guide</a>.</p> <p>Novell CIFS is available for NSS volumes. It supports cross-protocol file locking with NCP and AFP. Novell CIFS can also access files with a merged file view of a Dynamic Storage Technology shadow volume pair of NSS volumes. For information, see the <a href="#">OES 11 SP1: Novell CIFS for Linux Administration Guide</a>.</p> <p>Novell AFP (Apple Filing Protocol) is available for NSS volumes. It supports cross-protocol file locking with NCP and CIFS. For information, see the <a href="#">OES 11 SP1: Novell AFP for Linux Administration Guide</a>.</p>
<p><b>Secure file access to data via FTP:</b> The ability to provide authenticated and anonymous FTP access on the NSS file system and Linux POSIX file systems.</p>	<p>OES provides an integration of the PureFTPd file access protocol with eDirectory with the Novell FTP service option. This provides secure authentication of eDirectory users that are enabled with Linux User Management. For information, see “<a href="#">Novell FTP (Pure-FTPd) and OES 11 SP1</a>” in the <a href="#">OES 11 SP1: Planning and Implementation Guide</a>.</p>

Storage Requirement	Novell OES Solution
<b>Secure file access to data on Linux file systems:</b> The ability to provide secure file access to data on Linux file systems for clients in a heterogeneous client environment.	<p>OES provides the NCP Server for Linux, which provides the ability to create NCP volumes as shares over the Linux POSIX file system. For information, see the <a href="#">OES 11 SP1: NCP Server for Linux Administration Guide</a>.</p> <p>The Novell Client provides secure file access from clients using NCP for NCP volumes. For information, see the <a href="#">Novell Client 4.91 SP5 for Windows XP/2003 Installation and Administration Guide</a>, the <a href="#">Novell Client 2 SP1 for Windows Administration Guide</a>, and the <a href="#">Novell Client 2.0 SP3 for Linux Administration Guide</a>.</p> <p>OES provides an integration of the Samba file access protocol with eDirectory with the Novell Samba service option. This provides secure authentication of eDirectory users that are enabled with Linux User Management. For information, see the <a href="#">OES 11 SP1: NCP Server for Linux Administration Guide</a>.</p> <p>OES provides an integration of the PureFTPd file access protocol with eDirectory with the Novell FTP service option. This provides secure authentication of eDirectory users that are enabled with Linux User Management. For information, see “Novell FTP (Pure-FTPd) and OES 11 SP1” in the <a href="#">OES 11 SP1: Planning and Implementation Guide</a>.</p> <p>OES supports native file access protocols such as NFS. For information, see “Sharing File Systems with NFS” (<a href="http://www.suse.com/documentation/sles11/book_sle_admin/data/cha_nfs.html">http://www.suse.com/documentation/sles11/book_sle_admin/data/cha_nfs.html</a>) in the <a href="#">SLES 11 SP2 Administration Guide</a> (<a href="http://www.suse.com/documentation/sles11/book_sle_admin/data/book_sle_admin_pre.html">http://www.suse.com/documentation/sles11/book_sle_admin/data/book_sle_admin_pre.html</a>).</p> <p>Domain Services for Windows provides CIFS access for users. For information, see the <a href="#">OES 11 SP1: Domain Services for Windows Administration Guide</a>.</p>

## 1.3 Compatibility

Your storage solution must be compatible with the network architecture. It must use the same or compatible protocols and technologies for connecting servers and devices and for communicating with other networking equipment, servers, and clients in a cross-platform environment.

Storage Requirement	Novell OES Solution
<b>Compatible with existing security solution:</b> The ability to work with the preferred secure access solution or directory service.	<p>Novell eDirectory provides an integrated trustee rights and access control system.</p> <p>For information, see the <a href="#">Novell eDirectory 8.8 SP7 Administration Guide</a>.</p>
<b>Compatible with network communications protocols:</b> The ability to access network data regardless of the network equipment and interconnects.	<p>OES servers operate in an Ethernet and TCP/IP network environment. For information, see “Basic Networking” (<a href="http://www.suse.com/documentation/sles11/book_sle_admin/data/cha_basicnet.html">http://www.suse.com/documentation/sles11/book_sle_admin/data/cha_basicnet.html</a>) in the <a href="#">SLES 11 SP2 Administration Guide</a> (<a href="http://www.suse.com/documentation/sles11/book_sle_admin/data/book_sle_admin_pre.html">http://www.suse.com/documentation/sles11/book_sle_admin/data/book_sle_admin_pre.html</a>).</p>

Storage Requirement	Novell OES Solution
<b>Compatible with SAN communications protocols:</b> The ability to access network data regardless of the SAN equipment and interconnects	<p>OES supports SAN solutions with popular interconnect protocols such as Fibre Channel and iSCSI.</p> <p>SUSE Linux provides iSCSI Target and iSCSI Initiator software options. For information about using iSCSI on Linux, see “<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html">Mass Storage Over IP Networks: iSCSI</a>” (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html">http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html</a>) in the <i>SLES 11 SP2 Storage Administration Guide</i>. (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a>).</p> <p>SUSE Linux provides Fibre Channel over Ethernet (FCoE) Initiator software options in YaST 2. For information about using FCoE on Linux, see “<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html">Fibre Channel over Ethernet Networks</a>” (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html">http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html</a>) in the <i>SLES 11 SP2 Storage Administration Guide</i>. (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a>).</p>
<b>Compatible with cross-platform environments:</b> The ability to access network data regardless of client or server operating system, the file storage system, or the database format.	<p>OES supports clients and servers natively with the NetWare Core Protocol (NCP), Novell CIFS, Novell AFP, Novell Samba, Novell FTP, and Linux NFS.</p> <p>OES fits into any environment with support for open source technologies, directory integration, and synchronization. It natively supports multiple client and server platforms including Windows, Macintosh, and UNIX/Linux.</p>

## 1.4 Reliability

Your storage solution must provide reliable access to data for users and applications. One way to improve reliability is through redundancy of components to avoid single points of failure in your network design. OES supports redundant devices, connections, and servers.

Storage Requirement	Novell OES Solution
<b>Reliable access to data in the event of disk failure:</b> The ability to provide fault-tolerant solutions to allow users and applications to access data in the event of disk failure.	<p>NSS software RAID 1 and RAID 5 devices provide disk fault tolerance. NSS supports software RAIDs 0, 1, and 5.</p> <p>For information, see “<a href="#">Managing NSS Software RAID Devices</a>” in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>.</p>
<b>Reliable access to data in the event of connection failure:</b> The ability to provide fault-tolerant solutions to allow users and applications to access data in the event of connection failure.	<p>On Linux, you can manage multipath I/O with Device Mapper Multipath tools. For information, “<a href="http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html">Managing Multipath I/O for Devices</a>” (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html">http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html</a>) in the <i>SLES 11 SP2 Storage Administration Guide</i>. (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a>).</p>
<b>Reliable access to data in the event of server and application failure:</b> The ability to provide fault-tolerant solutions to allow users and applications to access data in the event of server or application failure.	<p>Novell Cluster Services provides server and application fault-tolerance options. See the <i>OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</i>.</p>

## 1.5 Scalability

Your storage solution must be able to grow with your business.

Storage Requirement	Novell OES Solution
<b>Rapid access to data:</b> The ability to rapidly mount and access data regardless of file, directory, or volume size.	<p>NSS allows you to aggregate and manage large amounts of storage without any degradation in performance. NSS can recognize and store massive files (up to 8 terabytes) and large numbers of them (up to 8 trillion). Up to one million files can be open concurrently (server RAM permitting).</p> <p>You can mount up to 255 NSS volumes concurrently on a given server, plus the system volume.</p> <p>Volumes can be mounted with a minimum amount of RAM. It takes only seconds to mount a volume of any size.</p> <p>For information, see the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>.</p>
<b>Scalable storage structures:</b> The ability to expand storage solutions with minimal service interruptions.	<p>You can create and expand NSS pools and volumes while the servers are up and running and the volumes are mounted and online. NSS supports up to 8 terabytes per volume.</p> <p>You can add devices to a SAN while the SAN and servers are up and running and the volumes are mounted and online.</p> <p>For clusters, you can add servers incrementally to increase processing power or expand resources without system interruption.</p> <p>For information, see the <a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a>.</p>
<b>Modifiable storage structures:</b> The ability to easily modify storage solutions to reorganize data and to optimize and expand capacity.	<p>NSS Distributed File Services supports moving and splitting volumes to reorganize data and to optimize and expand capacity.</p> <p>For information, see the <a href="#">OES 11 SP1: Novell Distributed File Services Administration Guide for Linux</a>.</p>

## 1.6 File Space Virtualization

Storage Requirement	Novell OES Solution
<b>Hierarchy of Tiered Storage:</b> The ability to move low-activity or inactive files to a hierarchy of lower-cost storage with an efficient storage capacity management solution based on rule-driven migration policies	<p>Dynamic Storage Technology for Linux allows you to create a virtual shadow volume that consists of a primary storage area on high-performance storage media for current and recently used files, and a secondary storage area on lower-cost storage media for low-activity or inactive files. You can specify policies based on age, file type, and so on.</p> <p>For information, see the <a href="#">OES 11 SP1: Dynamic Storage Technology Administration Guide</a>.</p>

Storage Requirement	Novell OES Solution
<b>Virtual Storage Solutions:</b> The ability to move data to satisfy storage needs without impacting users.	Novell Distributed File Services is available for NSS volumes. DFS uses junctions and a volume location database to support the relocation of data behind the scenes without impacting users.  For information, see the <a href="#">OES 11 SP1: Novell Distributed File Services Administration Guide for Linux</a> .

## 1.7 Availability

Your users must be able to access network data on demand. Your storage solution must remain available through server, connection, and device failures. Automatic failover solutions empower the administrator to set failover policies so that the network continues to work transparently to users whenever a failures occur.

Beyond the day-to-day failures and outages, most businesses today must provide high availability solutions and business continuance solutions to ensure continuous data access and network security in the event of site failures and disasters. Your solution should ensure that your mission-critical data is never at risk.

Storage Requirement	Novell OES Solution
<b>High availability of access to data in the event of server failure:</b> The ability to provide highly available solutions to allow users and applications to access data via alternate servers in the event of server failure.	Novell Cluster Services supports up to 32 cluster nodes for service and storage failover in the cluster. It also supports Web service-enabled failover, quarantine of failing service, maintenance mode, and XML (Extensible Markup Language) management. A read-only shared cluster volume capability is also available.  For information, see the <a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a> .
<b>High availability of access to data in the event of connection or device failure:</b> The ability to provide highly available solutions to allow users and applications to access data via alternate routes or resources.	NSS supports both Fibre Channel (FC) and iSCSI SAN solutions. It also supports full Novell Cluster Services with devices in SAN solutions.  The Linux operating systems can boot with the system volume on a local hard drive or on a Fibre Channel storage device if your server BIOS supports booting from a SAN. Booting from an remote storage device allows administrators to immediately swap out server hardware in the event of a disaster and directly boot without re-installing the operating system. The automatic hardware detection in the operating system allows for a new server to have updated or different controllers when booting from a FC SAN.  For information about using iSCSI on Linux, see “ <a href="#">Mass Storage Over IP Networks: iSCSI</a> ” ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html">http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html</a> ) in the <a href="#">SLES 11 SP2 Storage Administration Guide</a> . ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a> ).

Storage Requirement	Novell OES Solution
<b>High availability of access to data in the event of device failure:</b> The ability to provide highly available solutions to allow users and applications to access data via alternate routes in the event of a single device failure.	<p>NSS supports software RAIDs 1 (mirroring) and 5 (striping with parity), which allow a single device failure at a time without data loss. It also supports complex nesting RAIDs such as software RAIDs 10 and 15.</p> <p>For information, see “<a href="#">Managing NSS Software RAID Devices</a>” in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>.</p>
<b>High availability of access to data in the event of connection failure:</b> The ability to provide highly available solutions to allow users and applications to access data via alternate routes in the event of connection failure.	<p>Multipath I/O solutions allow for redundant storage interconnects in all storage architectures. It automatically identifies all paths and lets you set the primary path and priorities for failover sequence to the alternate paths. Failover is automatic.</p> <p>For Linux, see “<a href="http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html">Managing Multipath I/O for Devices</a>” (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html">http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html</a>) in the <i>SLES 11 SP2 Storage Administration Guide</i>. (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a>).</p>

## 1.8 Data Protection and Security

Today’s businesses must be able to survive the loss of data by planning recovery alternatives. Backup and restore services focus on fault tolerance of data by preventing disastrous data loss.

Your storage solution must protect against catastrophes or data erasure, whether malicious or accidental. Typically, you need to provide a regular backup solution. In addition, snapshot technology can defend against data loss by maintaining a point-in-time version of files until you can back up the data or until you need to clear the space for other purposes.

Storage Requirement	Novell OES Solution
<b>Data protection against major loss:</b> The ability to back up, archive, and restore network data.	<p>The Novell Storage Management Services (SMS) infrastructure is supported by all the major backup/restore application vendors. Novell SMS allows backup/restore application vendors to fully protect all Novell metadata, including file system access control lists, inherited rights filters, and complex data such as databases, e-mail post offices and mailboxes, and Novell eDirectory objects and attributes. For information, see the <i>OES 11 SP1: Storage Management Services Administration Guide for Linux</i>.</p>
<b>Data protection against intermediate loss:</b>  The ability to make immediate, anytime backup of network data with snapshots of storage pools.	<p>NSS pool snapshots allow you to back up active data at any time. Snapshot tools are integrated into the Web-based management interfaces.</p> <p>The snapshot function is independent of hardware vendors, even for a mix of vendors. Users can view and select file versions from active snapshot volumes. Snapshot data inherits the rights of the original data.</p> <p>For information, see “<a href="#">Managing NSS Pool Snapshots</a>” in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>.</p>



Storage Requirement	Novell OES Solution
<b>Data protection for local user data:</b> The ability to back up, archive, and restore user data that is stored locally on the desktop or laptop.	<p>Novell iFolder 3.x enables users to be more productive from work and home by providing resources to back up their local files, synchronize them, and make them accessible anywhere, anytime, from any computer.</p> <p>For information, see the <a href="http://www.novell.com/documentation/ifolder3">Novell iFolder 3.x Administration Guide</a> (<a href="http://www.novell.com/documentation/ifolder3">http://www.novell.com/documentation/ifolder3</a>).</p>
<b>File version archive and retrieval:</b> The ability to save versions of files at scheduled times and store them in an archive database for easy retrieval by users to recover lost, deleted, or modified files.	<p>Novell Archive and Version Services provides support for self-service file versioning. It allows users to locate and restore earlier versions of files on specified volumes. The archive database can be on the same or different server than the source volumes.</p> <p>A browser-based, self-service interface allows users to view and restore a previous file version. This can be done at a subdirectory level, a file type level, multiple subdirectories, volume, or any combination. It also shows who the last modifier of the file was.</p> <p>For information, see the <a href="#">OES 11 SP1: Novell Archive and Version Services 2.1 Administration Guide</a>.</p>
<b>Safeguards against inadvertent access to data:</b> The ability to protect against configuration mistakes by restricting which storage areas a server can access.	<p>NSS provides virtualized LUN masking in SANs. Whenever you allocate devices to a server, NSS makes them unavailable to other servers.</p> <p>NSS multiple server access prevention (MSAP) prevents against accidental activation of physically shared pools of storage on multiple servers at the same time. For information, see “<a href="#">Preventing Pools from Activating on Multiple Servers</a>” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>.</p>
<b>Data protection for a variety of file systems:</b> The ability to protect data stored in a variety of file system formats and levels of data storage formats.	<p>Novell SMS supports backing up and restoring of NSS, Traditional, and DOS file systems. It also supports higher-level data such as the data in GroupWise and eDirectory.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>
<b>Back up and restore data to a variety of storage media:</b> The ability to back up and restore data to multiple possible storage media.	<p>Novell SMS supports tape drives and tape libraries in addition to other storage media devices such as direct-attached disks, network drives, CDs, and DVDs. These options provide the ability to create a backup onto media other than tape, if desired, or as a fault-tolerant alternative in the event of a tape drive failure.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>



Storage Requirement	Novell OES Solution
<b>Scheduled backup:</b> The ability to schedule and manage backup jobs.	<p>Novell SMS provides the infrastructure for third-party backup/restore applications to schedule jobs and manage them. Scheduling management makes it easy to handle tape rotation methods and media management computations.</p> <p>For example, scheduling management features are present in Veritas Backup Exec, SyncSort Backup Express, Computer Associates BrightStor, and many others.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>
<b>Management alerts:</b> The ability to send out a notification if the backup process fails.	<p>Novell SMS provides the infrastructure for third-party backup/restore applications to alert administrators or management utilities in the event that the backup process fails.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>
<b>Remote backup:</b> The ability to back up a remote system's data.	<p>Novell SMS includes an RPC mechanism for remote backup. Most third-party backup/restore applications leverage this mechanism.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>
<b>Online or database catalog:</b> The ability to create an online or database catalog of the backed-up data.	<p>Novell SMS provides the infrastructure for third-party backup/restore applications to create an online or database catalog. The vendor software solution determines whether the catalog is stored on the backup media or if it is created dynamically whenever you want to access the media.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>
<b>Backup strategies:</b> The ability to implement a variety of backup strategies.	<p>Novell SMS provides the infrastructure for third-party backup/restore applications to implement a variety of backup strategies, including normal, incremental, differential, copy, and daily.</p> <p>Backup strategies are made easier with the SMS TSA being enabled to utilize the NSS Event File List (EFL). Backup software can use the file system journals to track which files have changed since the last backup. A change journal can track changes in file content, file or directory name, and file or directory permissions.</p> <p>For information, see the <a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>.</p>

## 1.9 Performance

You need to be able to improve the I/O performance for your storage solution and to make the best use of the storage resources you have available. Your system must perform well for the number of users and amount and type of data served. As the number of users increases, the amount of storage space and the performance demands also increase.

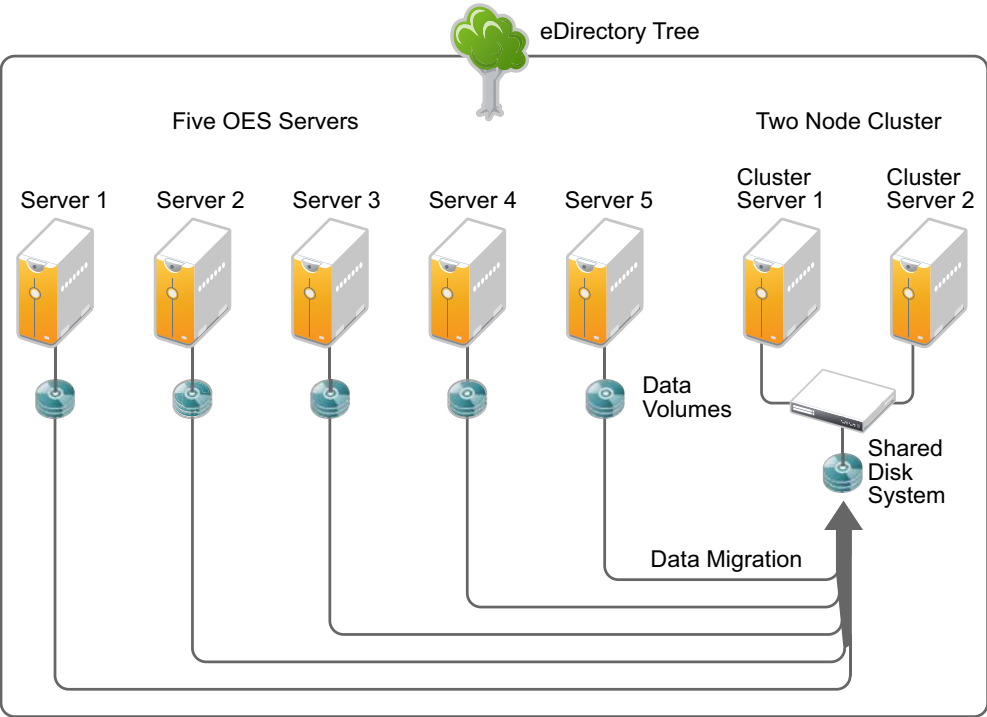
Storage Requirement	Novell OES Solution
<b>Enhanced I/O performance:</b> The ability to improve the I/O performance as experienced by your customers and users.	<p>OES supports software RAIDs, which allows multiple disk I/O access. NSS supports RAIDs 0, 1, and 5. For Linux, NSS supports RAIDs 0 and 1. For information, see <a href="#">“Managing NSS Software RAID Devices”</a> the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>.</p> <p>Novell Cluster Services provides I/O access to data via multiple servers.</p>
<b>Optimized storage capability:</b> The ability to grow, reorganize, reallocate, and restrict use of storage space, as needed, with minimal service interruption.	<p>You can dynamically expand an existing NSS pool up to its 8 TB maximum by simply adding space to it. NSS volumes support volume, directory, and user quotas to govern space use.</p> <p>OES 11 allows you to use the GPT (GUID Partition Table) partitioning scheme to specify devices up to 8 TB in size for NSS pools. The maximum pool size is 8 TB. Previously, NSS recognized devices only up to 2 TB in size.</p>

## 1.10 Data Consolidation

Your storage solution must allow you to reorganize and consolidate storage resources to improve manageability and to lower costs. For example, you can consolidate NetWare servers, applications, and operations into an OES 11 cluster built with commodity components (such as iSCSI SANs, storage subsystems, and IP networks) to help lower costs.

For many organizations, the first step in a business continuity plan or disaster recovery plan is to consolidate existing resources in order to simplify management and reduce administration variables. A good business continuity plan accommodates remote, mobile, and distributed systems with virtual centralized management while providing comprehensive and automatic failover and redundancy.

**Figure 1-1** Example of Server Consolidation



Storage Requirement	Novell OES Solution
<b>Data consolidation:</b> The ability to consolidate files, data, and other network resources to leverage SAN and other high-availability solutions while reducing the number of software and hardware configurations you need to manage.	For a general discussion of migration issues in OES, see <a href="#">“Migrating and Consolidating Existing Servers and Data”</a> in the <i>OES 11 SP1: Planning and Implementation Guide</i> .
<b>Cost effectiveness:</b> The ability to make the best of the storage resources you have by adapting them to a variety of solutions in your network.	Because NSS supports a variety of storage architectures, as outlined in <a href="#">Chapter 2, “Storage Architectures,”</a> on page 23, you can easily use the resources you have whenever you modify your existing storage solution. For information, see the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i> .

## 1.11 Storage Monitoring and Maintenance

Your storage solution must be monitored and maintained. The ability to monitor from a distance allows you to centralize your storage administration tasks.

Storage Requirement	Novell OES Solution
<b>Centralized storage management:</b> The ability to perform storage management tasks remotely to reduce complexity and costs.	<p>The browser-based Novell iManager allows IT staff to manage servers, storage, directory, users, security, and the network from any location.</p> <p>iManager provides role-based management of the environment. Different people in the organization can have rights to manage different parts of the enterprise, even if they are not IT staff.</p> <p>For general information about iManager, see the <a href="#">Novell iManager 2.7.6 Administration Guide</a>.</p> <p>For information about the storage-related plug-ins, see “<a href="#">Novell iManager and Storage-Related Plug-Ins</a>” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>.</p>
<b>Local storage management:</b> The ability to perform storage management tasks on the server when the operating system volume is not mounted.	<p>The NSS Management Utility (NSSMU) is used to manage storage when the Web-based tools cannot be used.</p> <p>For information, see “<a href="#">NSS Management Utility (NSSMU) Quick Reference</a>” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>.</p>
<b>Unified resource management:</b> The ability to centrally maintain and manage access authorization and information about network resources.	<p>Novell eDirectory is the cornerstone of a business continuity solution. eDirectory is a repository for all intelligence about network resources and access authorization information, settings, rights, locations, control variables, etc.</p> <p>Because of its architectural design, eDirectory is not tied to any specific domain, volume, or hard drive. This makes it possible for disk drives, servers, clusters, and even multiple locations to fail, but eDirectory and all of the intelligence contained therein remains intact for recovery and continued functionality. A network can continue to exist and rebuild itself using contingency solutions, providing full capability as long as one simple segment of the network remains intact.</p> <p>For information, see the <a href="#">Novell eDirectory 8.8 SP7 Administration Guide</a>.</p>
<b>Mixed environment data exchange and management:</b> The ability to securely synchronize, transform, and distribute data across applications, databases, and directories on the network and across firewalls to partner systems.	<p>Novell Identity Manager (formerly DirXML) provides a means to synchronize, transform, and distribute information across applications, directories, databases on the network and across firewalls to partner systems.</p> <p>Identity Manager achieves uniform data integrity and automated efficiency by helping to eliminate the manual and repetitive tasks of creating and modifying user identities in different systems and applications within an enterprise. It makes automatic changes based on business rules and preserves authoritative data sources.</p> <p>For information, see <a href="#">Identity Manager 4.0.2 Overview Guide</a>.</p>

Storage Requirement	Novell OES Solution
<b>Monitor and manage system performance:</b> The ability to monitor and manage server and storage performance.	The Novell Remote Manager interface includes many system performance monitoring and graphing tools. For information, see the <a href="#">OES 11 SP1: Novell Remote Manager Administration Guide</a> .
<b>Remotely monitor and manage system performance:</b> The ability to remotely monitor and manage server and storage performance.	Novell Cluster Services management provides remote cluster resources management from any Web browser enabled for Java. Server storage can be dynamically assigned or reassigned, as needed. Administrators are automatically notified of cluster events and cluster state changes. For information, see the <a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a> .
<b>Monitoring tools:</b> The ability to monitor and report space usage, events, and policies for quotas and access.	The iManager Plug-In for NSS provides reports of volume quotas and user space restrictions. For information, see “ <a href="#">Managing Space Quotas for Volumes, Directories, and Users</a> ” and “ <a href="#">Monitoring Quotas and Space Usage for NSS Pools and Volumes</a> ” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a> .

## 1.12 What’s Next

To learn more about storage architectures, see [Chapter 2, “Storage Architectures,” on page 23](#).



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# 2 Storage Architectures

The Novell Storage Services (NSS) file system supports the following types of storage architecture for your Novell Open Enterprise Server 11 SP1 servers:

- ♦ [Section 2.1, “NSS File System,” on page 23](#)
- ♦ [Section 2.2, “Direct Attached Storage Solutions,” on page 24](#)
- ♦ [Section 2.3, “Network Attached Storage Solutions,” on page 24](#)
- ♦ [Section 2.4, “Storage Area Network Solutions,” on page 26](#)
- ♦ [Section 2.5, “Fault-Tolerant and High-Availability Architectures,” on page 27](#)
- ♦ [Section 2.6, “Business Continuance Architectures,” on page 33](#)

## 2.1 NSS File System

The NSS file System simplifies the ever-increasing demands of storage growth, provisioning, and management. NSS is a proven journaled file system that maintains its performance for large numbers of files and for small to large volume sizes.

NSS virtualizes all of the space available on the server’s storage devices. You can allocate segments of those resources to pools that span multiple devices, using your hardware to its maximum potential. NSS allow volumes to grow dynamically up to 8 terabytes (TB) within a pool of storage, based on your storage policies. You can also restrict space usage by pool, volume, directory, and user quotas.

OES 11 and later allows you to use the GPT (GUID Partition Table) partitioning scheme to create devices of any size. When you create an NSS pool, partitions up to 8 TB in size are allowed. The maximum pool size is 8 TB. Previously, NSS recognized only DOS devices up to 2 TB in size, so multiple partitions were required to create an 8 TB pool.

Regardless of the volume’s size or its number of files, NSS requires only 4 to 10 MB of server memory to mount the volume. NSS mounts an NSS volume in just three seconds and recovers it in under ten seconds, regardless of the size of the volume, for server crashes where no data is corrupted. If repairs are needed, file system repairs following a hardware failure take only minutes. Recovery of volumes where data corruption has occurred can take several minutes to several hours, depending on the size of the volume.

NSS can dynamically assign storage devices to a server to expand capacity. This means you can add, format, or partition new drives when the system is up and running.

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**NOTE:** For Linux, the NSS file system volumes are used for data volumes only, not as system volumes. The Linux operating system requires a Linux file system that can be used as root (/) such as Btrfs, Ext2, Ext3, Reiser, or XFS.

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## 2.2 Direct Attached Storage Solutions

In direct attached storage (DAS) solutions, the storage media attach directly to a server, either internally or externally. Generally, external server storage refers to hardware storage arrays such as RAID arrays and JBOD arrays. These arrays connect through an external SCSI bus.

In a cross-platform environment, your DAS storage architecture can support native File Access Protocols (NFAPs). This enables data services to be accessed by clients using a variety of operating platforms. For an explanation of NFAPs, see [“Native File Access Protocols” on page 25](#). The key difference between a DAS solution and a NAS solution is that the NAS server’s only job is to serve files to application servers or users; no applications run on the NAS server.

An OES server can use Novell eDirectory, NCP Server, and Novell Storage Services to assign user access rights for directories and files. NSS also allows you to manage space restrictions for volumes, directories, and users.

### 2.2.1 Planning Considerations for DAS

DAS solutions are typical of small offices and distributed network storage solutions. The DAS architecture creates islands of storage because the disks belong to the server and are not available for any overflow and support needs for other servers.

With DAS solutions, the server must be operational for its attached data to be accessible to users. If the server is offline or if the external storage device is offline, the server’s data is not available.

As your data grows, you can attach additional devices to the server up to the number of available slots on the SCSI bus. You also must consider the impact on I/O performance of adding additional devices on an already-busy SCSI bus. DAS works well for a few servers, each with a few hundred gigabytes of data.

## 2.3 Network Attached Storage Solutions

A network attached storage (NAS) solution is a dedicated data server or appliance that provides centralized storage access for users and application servers. A NAS server attaches directly to the existing network using traditional LAN protocols such as Ethernet and TCP/IP. At Gigabit Ethernet rates, access speeds from other servers are on parity with direct attached storage devices.

- ♦ [Section 2.3.1, “Planning Considerations for NAS,” on page 24](#)
- ♦ [Section 2.3.2, “NetStorage,” on page 25](#)
- ♦ [Section 2.3.3, “Native File Access Protocols,” on page 25](#)

### 2.3.1 Planning Considerations for NAS

NAS provides a cost-effect centralized solution for small and branch offices. If you need more storage, simply add more devices to your existing NAS solution. Small offices, enterprise branch offices, and small to midsize businesses might use NAS servers to store e-mail files, software installation information, and any data they would rather not store in more expensive storage area network (SAN) solutions.

A disadvantage of NAS is that it adds bandwidth demands to your existing network. Because data requests travel on the same pipes as the data itself in a NAS solution, the network performance might be inhibited by competing resources. Depending on your current network load, you might need to make some changes in the infrastructure to use high-speed Gigabit Ethernet interconnects.



An OES NAS server is able to drop into and integrate with your OES environments seamlessly. It can also bridge between these environments. Although NAS servers can be configured as appliances (stripped-down versions of the operating system and fixed storage media), you can configure any server as a NAS device.

You can configure the storage media in the server as a software RAID 1 storage device for data protection. With RAID 1, you have a hot spare in waiting ready to replace a failed drive.

## 2.3.2 NetStorage

OES includes NetStorage for Linux, which allows for Web-based sharing of and access to files. Whatever protocol governs the file access, users can also access the files from a wide variety of Web browsers using HTTP, HTTPS, and FTP. From any Web client, or through WebDAV for sharing, all your data is securely accessible.

NetStorage works with Novell eDirectory and the Novell Storage Services (NSS) file system to assign user access rights, space restrictions, and passwords, just as you would for any OES server. Windows, Macintosh, and UNIX users must have a User object and password before they can access network resources using native protocols. A User object specifies attributes and information about which network resources the user can access.

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**NOTE:** Windows users can also be managed through a Windows Domain Controller, and UNIX users can be managed through Network Information Service (NIS).

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For information about using NetStorage, see the [OES 11 SP1: NetStorage Administration Guide for Linux](#).

## 2.3.3 Native File Access Protocols

The OES server supports native File Access Protocols to enable data services to be shared between different types of servers and accessed by different types of clients using any of those servers. In a cross-platform environment, multi-platform clients and application servers can access NSS storage using their native protocols.

The OES server supports the following file access protocols:

Type of Networking	File Access Protocol
Windows	Common Internet File System (CIFS) with Novell CIFS, Linux Samba, or Domain Services for Windows
Novell	NetWare Core Protocol (NCP) with the Novell Client
UNIX and Linux	Network File System (NFS) using native Linux NFS solutions
Macintosh	Apple Filing Protocol (AFP) with Novell AFP
Web access	Hypertext Transfer Protocol (HTTP)
Secure Web access	Secure Hypertext Transfer Protocol (HTTPS)
Web file transfer	File Transfer Protocol (FTP)
Shared Web access	Web Distributed Authoring and Versioning (WebDAV)

With multi-protocol file system services, clients with disparate operating platforms can store and access data in the same file system without compromising the data's respective file attributes, security models, or performance.

For more information about using native file access protocols on Linux, see the following guides:

- ♦ [OES 11 SP1: Novell AFP for Linux Administration Guide](#)
- ♦ [OES 11 SP1: Novell CIFS for Linux Administration Guide](#)
- ♦ [OES 11 SP1: NCP Server for Linux Administration Guide](#)
- ♦ [OES 11 SP1: Novell Samba Administration Guide](#)
- ♦ [OES 11 SP1: Domain Services for Windows Administration Guide](#)

## 2.4 Storage Area Network Solutions

A storage area network (SAN) solution provides a separate, dedicated network of storage media interconnected by high-speed connections. Instead of sharing the normal network bandwidth, data queries travel between servers and the storage media on these connections. Because SANs create a neighborhood in which vital corporate data resides, a secure SAN should be a gated community with restricted and verifiable access.

- ♦ [Section 2.4.1, "Planning Considerations for SANs," on page 26](#)
- ♦ [Section 2.4.2, "Security Issues in the SAN," on page 26](#)
- ♦ [Section 2.4.3, "Fibre Channel SAN," on page 27](#)
- ♦ [Section 2.4.4, "iSCSI SAN," on page 27](#)

### 2.4.1 Planning Considerations for SANs

The top reasons for implementing SANs are as follows:

- ♦ Improving backup and restore
- ♦ Improving disaster recovery
- ♦ Consolidating existing data capacity, typically as a result of server consolidation (Server Consolidation Utility)
- ♦ Supporting data sharing and collaboration
- ♦ Improving data access performance
- ♦ Managing data growth
- ♦ Improving storage management

### 2.4.2 Security Issues in the SAN

Unlike conventional IP networking security issues, security breaches in a SAN can have a permanent and devastating effect. Corruption of current data on disk or tape is absolute and recoverable only to the latest snapshot or backup version. For the highest degree of data integrity, synchronous data replication at least ensures that a current copy of real-time data is secured elsewhere.

Access Control Lists (ACLs) are another option for providing rudimentary verification. For example, you can prevent a newly introduced server from automatically logging on to the SAN fabric.

Cryptographic techniques (authentication and data encryption) add an incremental level of security for data in transmission and at rest, but cannot provide an absolute safeguard for storage. For data in transmission, authentication and encryption can ensure that sniffing the SAN transport does not yield usable data. This is especially applicable to IP storage environments, where data might be traveling over untrusted local or wide area network segments.

### 2.4.3 Fibre Channel SAN

For OES, the Linux operating system supports booting the server directly with the operating system on a local hard drive or on a Fibre Channel SAN if the hardware supports booting from a SAN. Booting from a Fibre Channel SAN allows administrators to immediately swap out server hardware in the event of a disaster and directly boot without reinstalling the operating system. The automatic hardware detection in the operating system allows for a new server to have updated or different controllers when booting from a Fibre Channel SAN.

SUSE Linux Enterprise Server 11 SP2 and later supports Fibre Channel over Ethernet (FCoE), and provides the FCoE initiator management in YaST 2. For information, see “[Fibre Channel over Ethernet Networks](http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html)” ([http://www.suse.com/documentation/sles11/stor\\_admin/data/cha\\_fcoe.html](http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html)) in the *SUSE Linux Enterprise Server 11 Storage Administration Guide* ([http://www.suse.com/documentation/sles11/stor\\_admin/data/bookinfo.html](http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)).

For Linux, the file system for the system volume must be one that can be used as root (/), such as Ext3, Reiser, or XFS. You cannot use NSS or OCFS2 file systems for booting Linux. Bootloader support for /boot on Btrfs is planned to be available beginning in SUSE Linux Enterprise 12.

### 2.4.4 iSCSI SAN

The SAN interconnect fiber is typically a technology that offers faster transmission (bigger pipes) than is available in direct-attached-storage buses or in the LAN bandwidth. In addition to Fibre Channel, NSS supports iSCSI (Internet SCSI). An iSCSI SAN typically uses Gigabit Ethernet interconnects, adapters, and switches and IP routing to connect storage devices. At present, the Fibre Channel equipment costs are many times that of standard Ethernet equipment that can support iSCSI traffic.

A Novell iSCSI SAN can operate at standard Fast Ethernet speeds, or you can implement a higher-speed infrastructure for the SAN. Typically, high-speed Gigabit Ethernet devices are necessary to meet SAN performance requirements. An iSCSI SAN can be a low-cost alternative SAN solution. It provides the long-distance storage connectivity for multiple applications, including disaster recovery for business continuity, storage consolidation, data migration, and remote mirroring.

The Linux iSCSI solution uses a YaST interface to manage iSCSI resources. You can manage the SAN from anywhere with a separate management console or disk controller. Administrators use the same well-known methods in eDirectory for granting trustee rights and user file access.

For more information, see “[Mass Storage over IP Networks](http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html)” ([http://www.suse.com/documentation/sles11/stor\\_admin/data/cha\\_inst\\_system\\_iscsi.html](http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html)) in the *SUSE Linux Enterprise Server 11 Storage Administration Guide* ([http://www.suse.com/documentation/sles11/stor\\_admin/data/bookinfo.html](http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)).

## 2.5 Fault-Tolerant and High-Availability Architectures

To achieve fault tolerance and high availability in your storage architecture, you should consider incorporating one or more of the following technologies:

- ♦ [Multiple Path I/O](#)

- ♦ [Software RAIDs](#)
- ♦ [Server Clusters](#)

## 2.5.1 Multiple Path I/O

Multiple paths (multipathing) between the CPU/server and the disks can help to avoid a single point of failure in the connection between the CPU and the storage device. SUSE Linux Enterprise Server 10 provides automatic path failover with its Linux multipath tools such as Device Mapper - Multipath I/O.

Multipath I/O is available in DAS, NAS server, and SAN storage solutions.

- ♦ In the case of external DAS and NAS server solutions, you can set up separate adapters in the server to attach to separate ports on the storage device.
- ♦ In SAN configurations, the number of paths between the server and the storage disks is more difficult to track manually. Typically, you have at least two host bus adapters in each server. Each adapter connects to your fabric through a different switch for redundancy and performance. Each switch connects to the storage device through separate ports.

For more information, see “[Managing Multipath I/O for Devices](http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html)” ([http://www.suse.com/documentation/sles11/stor\\_admin/data/multipathing.html](http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html)) in the *SLES 11 SP2 Storage Administration Guide*. ([http://www.suse.com/documentation/sles11/stor\\_admin/data/bookinfo.html](http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)).

## 2.5.2 Software RAIDs

Building fault-tolerant disks can help maximize reliability. You can use RAID 1 (mirroring) to eliminate a single point of failure such as the failure of a physical disk. By using disk duplexing, each disk in the mirror set is on a separate controller. This eliminates another single point of failure such as the failure of a bus.

Data needs to be protected against losses that result from hardware failure. Typically, you need to configure devices with a software or hardware RAID 1 or RAID 5 solution. RAID 1 provides mirroring of the entire storage area. On failure of a single device, the mirror takes over and all data is immediately available to users.

RAID 5 provides striping with parity to allow recovery of data on the failure of a single hard disks. Service is degraded during the recovery, but all data is eventually reconstructed without data loss. Use RAID 5 when you want to optimize file access for a server, while also providing for protection against the loss of a single disk.

For more information, see “[Managing NSS Software RAID Devices](#)” in the *OES 11 SP1: NSS File System Administration Guide for Linux*.

SUSE Linux Enterprise Server 11 also provides a Linux software RAID solution for RAID 0, 1, and 5. For information, see “[Software RAID Configuration](http://www.suse.com/documentation/sles11/stor_admin/data/raidvast.html)” ([http://www.suse.com/documentation/sles11/stor\\_admin/data/raidvast.html](http://www.suse.com/documentation/sles11/stor_admin/data/raidvast.html)) in the *SLES 11 SP2 Storage Administration Guide*. ([http://www.suse.com/documentation/sles11/stor\\_admin/data/bookinfo.html](http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)).

## 2.5.3 Server Clusters

Novell Cluster Services combines two or more servers into a single group, known as a cluster. If one server in the cluster fails, another server automatically recovers the downed server's resources (applications, services, IP addresses, and volumes) and runs in its place. With Novell Cluster Services, you can configure up to 32 OES 11 SP1 servers into a high-availability cluster where resources are dynamically allocated to any server in the cluster.

Resources can be configured to automatically switch in the event of a server failure, or can be moved manually to troubleshoot hardware, balance workloads, or perform maintenance. This frees IT organizations to perform maintenance and upgrades during production hours and eliminates scheduling down time with customer organizations.

In the event of an unplanned failure, any server in the cluster can restart resources from a failed server in the cluster. Typically, the failover occurs transparently to users with seamless access to authorized resources.

### High-Availability Clusters

To configure a fault-tolerant Novell Cluster Services solution, a shared disk system is required for each cluster. All servers in the cluster are configured with the IP protocol and are on the same IP subnet in the same eDirectory tree. Additional IP addresses are required for each cluster resource and cluster-enabled volume.

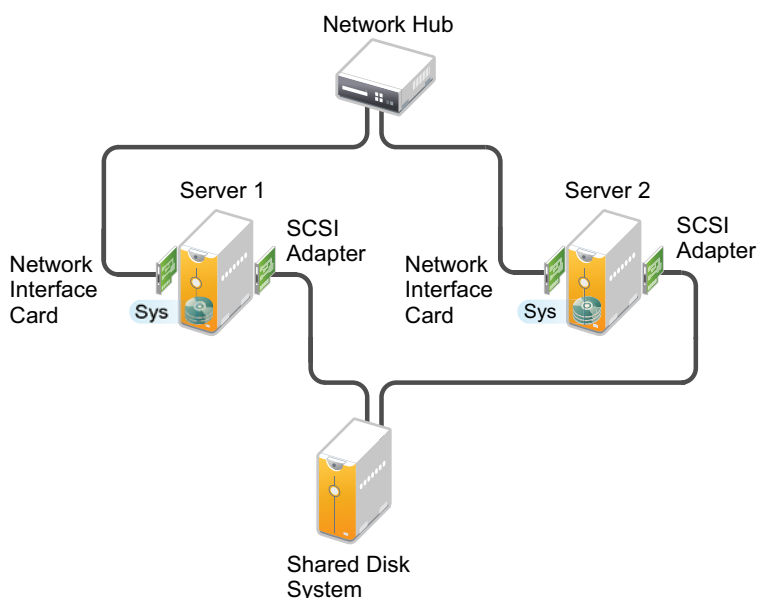
There are three basic ways to share a volume:

- ♦ [Shared Volume on Direct Attached Storage](#)
- ♦ [Shared Volume in an iSCSI SAN](#)
- ♦ [Shared Volume in a Fibre Channel SAN](#)

### Shared Volume on Direct Attached Storage

For less complex needs, you can create a cluster using a the shared volume on direct attached storage.

**Figure 2-1** Example of a Shared Volume Cluster Using Direct Attached Storage

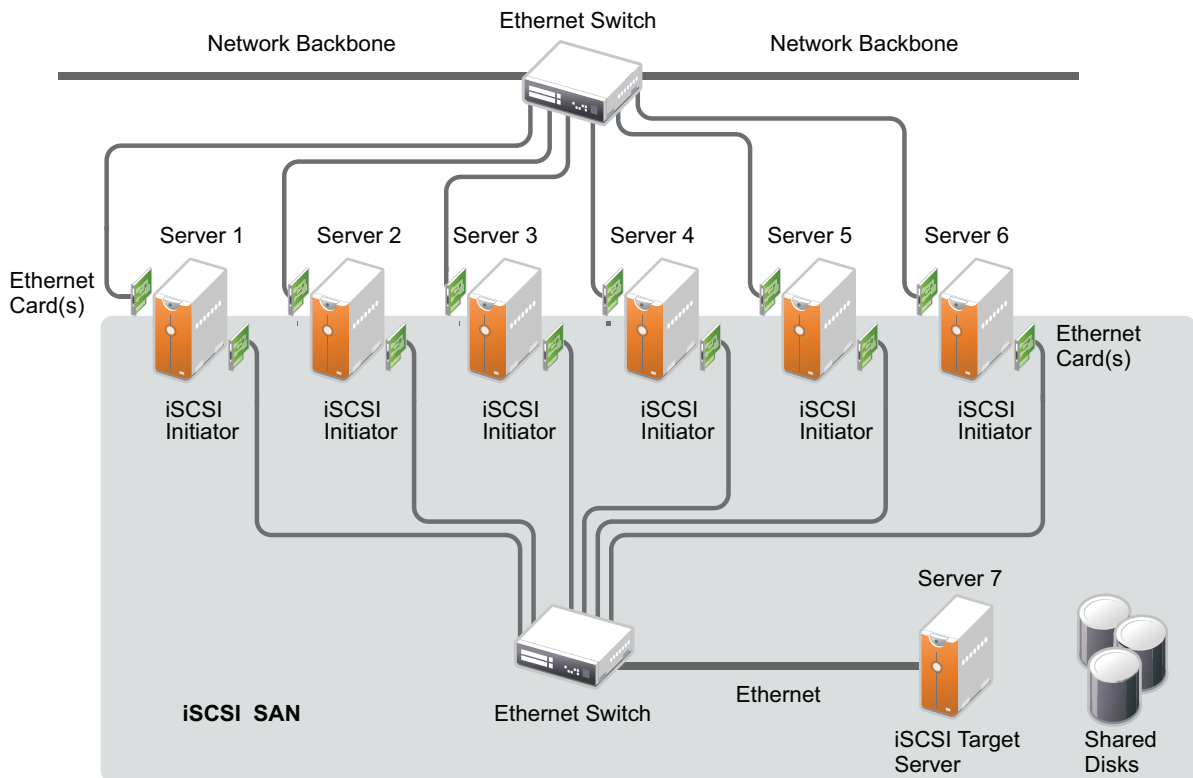


## Shared Volume in an iSCSI SAN

A new high-availability solution for shared volume clusters uses iSCSI protocols to connect the servers to the shared volume over commodity Ethernet and TCP/IP networks. Using these standard LAN technologies, iSCSI SANs can be centralized, distributed over multiple geographical locations, or configured as distributed mirrors so that one SAN continues in the event of failure of the other.

For information, see “Mass Storage over IP Networks - iSCSI” ([http://www.suse.com/documentation/sles11/stor\\_admin/data/cha\\_inst\\_system\\_iscsi.html](http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html)) in the *SUSE Linux Enterprise Server 11 SP2 Storage Administration Guide* ([http://www.suse.com/documentation/sles11/stor\\_admin/data/bookinfo.html](http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)).

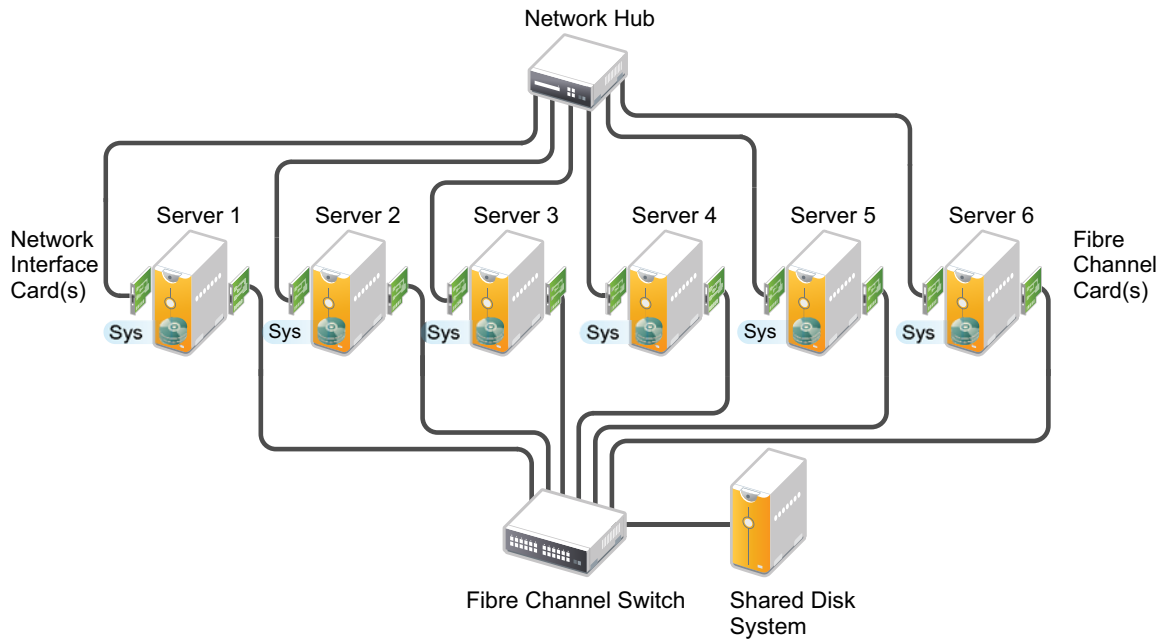
**Figure 2-2** Example of a Shared Volume Cluster Using an iSCSI SAN



## Shared Volume in a Fibre Channel SAN

The Fibre Channel SAN is the conventional method of creating high-availability clusters. For more information, see the [OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide](#).

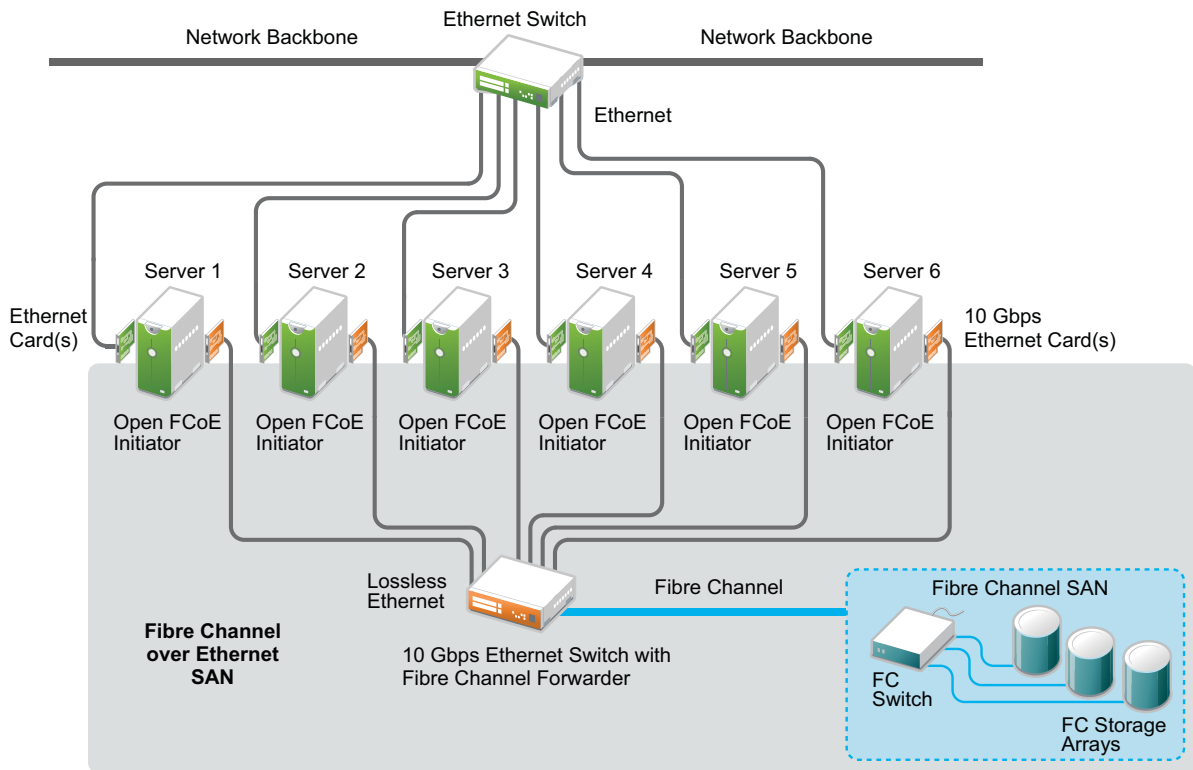
**Figure 2-3** Example of a Shared Volume Cluster Using a Fibre Channel SAN



The Fibre Channel over Ethernet (FCoE) protocol makes it possible to connect your Fibre Channel storage arrays to the enterprise servers by using a 10 Gbps (gigabit per second) Ethernet switch equipped with Fibre Channel Forwarder technology. The servers can use 10 Gbps Ethernet adapters

that have converged Fibre Channel capability, or they can use 10 Gbps Ethernet adapters and run OpenFCoE Initiator open source software on the server. OpenFCoE Initiator software is available on the SUSE Linux Enterprise Server 11 SP2 and platforms that are used by OES 11 SP1 and later.

**Figure 2-4** Fibre Channel over Ethernet SAN



## 2.5.4 Novell Cluster Services

Novell Cluster Services ensures high availability and manageability of critical network resources including data (volumes), applications, server licenses, and services and provides the ability to tailor a cluster to the specific applications and hardware infrastructure for any organization. The Novell Cluster Services installation program automatically creates a new cluster object in eDirectory and installs Novell Cluster Services software on any servers specified to be part of the cluster. You can configure SANs and shared NSS pools in conjunction with clustered servers to create high availability networks.

Novell Cluster Services management provides remote cluster resources management from any Java-enabled Web browser. Server storage can be dynamically assigned or reassigned on an as-needed basis and administrators are automatically notified of cluster events and cluster state changes.

For information, see the [OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide](#) and the [OES 11 SP1: Novell Cluster Services 2.1 NetWare to Linux Conversion Guide](#).



## 2.6 Business Continuance Architectures

Today's organizations are dispersed across multiple geographies, with increasing demands for flexible user access, application integration, and information backup. Business survival necessitates planning for every type of business disruption, including natural disasters, hardware and communication failures, and internal or external sabotage or acts of terrorism.

OES uniquely supplies the technologies to solve business continuity problems through intelligent consolidation strategies, redundancy, and automated failover. A viable disaster protection solution can be integrated without complexity and without draining scarce IT resources.

You can implement the fault-tolerance, data-protection, and high-availability features to improve the reliability, security, and availability of your storage solution. For information, see the following features:

For information about:	Go here:
Fault tolerance and data integrity features, including multipathing, distributed file services for moving and splitting volumes, and Multiple Server Access Prevention.	See the following in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i> <ul style="list-style-type: none"><li>♦ "Managing Multipath I/O for Devices" (<a href="http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html">http://www.suse.com/documentation/sles11/stor_admin/data/multipathing.html</a>)</li><li>♦ <i>OES 11 SP1: Novell Distributed File Services Administration Guide for Linux</i></li><li>♦ "Preventing Pools from Activating on Multiple Servers"</li></ul>
Data fault tolerance and high performance features such as software RAID 0, 1, 5, 10, and 15	"Managing NSS Software RAID Devices" in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>
Data protection features including backup/restore applications, pool snapshots, and the file snapshot volume attribute	"Managing NSS Pool Snapshots" in the <i>OES 11 SP1: NSS File System Administration Guide for Linux</i>
Data backup and restore features	<i>OES 11 SP1: Storage Management Services Administration Guide for Linux</i>
Highly available data solutions	<i>OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</i>
Mission-critical data solutions	All of the above references.



# 3 Storage Documentation Quick Reference

To learn more about storage provisioning and management with OES 11, refer to storage-related documents in this section.

- ♦ [Table 3-1, “File Systems,” on page 35](#)
- ♦ [Table 3-2, “Storage Solutions,” on page 35](#)
- ♦ [Table 3-3, “Archiving and Backup,” on page 36](#)
- ♦ [Table 3-4, “User Access to File Services,” on page 37](#)
- ♦ [Table 3-5, “Storage Management Tools,” on page 38](#)

**Table 3-1** *File Systems*

Storage Solution	Reference
<b>Linux POSIX File Systems</b> POSIX file systems on Linux, such as Btrfs, Ext3, XFS, and Reiser.	<a href="#">OES 11 SP1: Linux POSIX Volume Administration Guide</a> <a href="#">OES 11 SP1: NLVM Reference</a> <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">SLES 11 SP2 Storage Administration Guide. (http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)</a>
<b>NCP Server and NCP Volumes for Linux</b> A special-purpose service that provides secure file services for NSS volumes and NCP volumes on Linux.	<a href="#">OES 11 SP1: NCP Server for Linux Administration Guide</a>
<b>Novell Storage Services File System</b> Offers the same familiar file system and features that you enjoyed on NetWare.	<a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a> <a href="#">OES 11 SP1: NLVM Reference</a>

**Table 3-2** *Storage Solutions*

Storage Solution	Reference
<b>FCoE for Linux</b> Support for Fibre Channel over Ethernet (FCoE) SANs on Linux. Servers can be FCOE initiators.	<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html">“Fibre Channel over Ethernet Networks” (http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html)</a> in the <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">SLES 11 SP2 Storage Administration Guide. (http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)</a>

Storage Solution	Reference
<b>iSCSI for Linux</b>  Support for iSCSI SANs on Linux. Servers can be iSCSI initiators or targets.	<a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html">"Mass Storage Over IP Networks: iSCSI" (http://www.suse.com/documentation/sles11/stor_admin/data/cha_inst_system_iscsi.html)</a> in the <i>SLES 11 SP2 Storage Administration Guide</i> . ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a> )
<b>Novell Cluster Services</b>  Server clustering application for 2 to 32 servers using shared or unshared volumes on direct attached storage devices or in Fibre Channel or iSCSI storage area networks.	<a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a>  <a href="#">OES 11 SP1: Novell Cluster Services 2.1 NetWare to Linux Conversion Guide</a>
<b>Novell Distributed File Services</b>  This NSS technology allows you to use junctions and a volume location data base to present a virtual file space view of data to users.	<a href="#">OES 11 SP1: Novell Distributed File Services Administration Guide for Linux</a>
<b>Dynamic Storage Technology</b>  Shadow volumes that provide tiered storage transparently to users. A shadow volume is a virtual storage space that consists of a primary storage area on high-performance storage media for current and recently used files and a secondary storage area on less-expensive storage media for less-used files.	<a href="#">OES 11 SP1: Dynamic Storage Technology Administration Guide</a>
<b>Novell iFolder 3.9</b>  A special-purpose server that provides file synchronization of users' local data and provides users secure access to their local data from anywhere, at any time.	<a href="#">Novell iFolder 3.9.1 Administration Guide</a>  <a href="#">Novell iFolder 3.9.1 Deployment Guide</a>
<b>Server and Data Consolidation</b>  Information for consolidating servers and data.	<a href="#">OES 11 SP1: Planning and Implementation Guide</a>  <a href="#">OES 11 SP1: Migration Tool Administration Guide</a>

**Table 3-3** *Archiving and Backup*

Storage Solution	Reference
<b>Novell Archive and Version Services</b>  A special-purpose server that copies versions of files at specified intervals or times to its file version archive. Saved file versions are available to users via NetStorage and File Version utilities for secure, on demand user data recovery.	<a href="#">OES 11 SP1: Novell Archive and Version Services 2.1 Administration Guide</a>  <a href="#">OES 11 SP1: Novell Archive and Version Services 2.1 User Guide</a>
<b>Novell Storage Management Services</b>  A basic server backup utility and interface for vendor backup/restore applications.	<a href="#">OES 11 SP1: Storage Management Services Administration Guide for Linux</a>

**Table 3-4** *User Access to File Services*

Storage Solution	Reference
<b>File Systems Management</b>  File systems management and access control for directories and files, using file system trustees and trustee rights for NSS volumes on Linux.	<a href="#">OES 11 SP1: File Systems Management Guide</a>
<b>Linux Access Control Lists</b>  Local access control for Linux POSIX file systems.	<a href="http://www.suse.com/documentation/sles11/book_security/data/cha_acls.html">"Access Control Lists in Linux" (http://www.suse.com/documentation/sles11/book_security/data/cha_acls.html)</a> in the <a href="http://www.suse.com/documentation/sles11/book_security/data/book_security.html">SLES 11 SP2 Security Guide (http://www.suse.com/documentation/sles11/book_security/data/book_security.html)</a>
<b>NCP Server and NCP Volumes for Linux</b>  A special-purpose service that provides secure file services for NSS volumes and NCP volumes on Linux POSIX file systems.	<a href="#">OES 11 SP1: NCP Server for Linux Administration Guide</a>  <a href="#">Novell Client 4.91 SP5 for Windows XP/2003 Installation and Administration Guide</a>  <a href="#">Novell Client 2 SP1 for Windows Administration Guide</a>  <a href="#">Novell Client 2.0 SP3 for Linux Administration Guide</a>
<b>Novell eDirectory</b>  A powerful directory services application that provides secure user access and network resources management.	<a href="#">Novell eDirectory 8.8 SP7 Administration Guide</a>
<b>Novell AFP for Linux</b>  A special-purpose Linux service that provides secure, native AFP file access on NSS volumes.	<a href="#">OES 11 SP1: Novell AFP for Linux Administration Guide</a>
<b>Novell CIFS for Linux</b>  A special-purpose Linux service that provides secure, native CIFS file access on NSS volumes.	<a href="#">OES 11 SP1: Novell CIFS for Linux Administration Guide</a>
<b>Novell Domain Services for Windows</b>  A special-purpose Linux service that provides secure, native CIFS/Samba file access in an Active Directory domain.	<a href="#">OES 11 SP1: Domain Services for Windows Administration Guide</a>
<b>Novell NetStorage</b>  A special-purpose server that provides secure Web-based access to network data and optionally to archived file versions (requires Novell Archive and Version Services).	<a href="#">OES 11 SP1: NetStorage Administration Guide for Linux</a>
<b>Novell Linux User Management</b>  A service that enables eDirectory users to access volumes on Linux using non-NCP protocols and Linux utilities, commands, and services.	<a href="#">OES 11 SP1: Novell Linux User Management Administration Guide</a>

Storage Solution	Reference
<b>Novell FTP (PureFTPd) for Linux</b>  Provides authenticated and anonymous FTP access for Linux and Windows users. Novell FTP provides PureFTPd with Novell eDirectory for authentication.	“Novell FTP (Pure-FTPd) and OES 11 SP1” in the <a href="#">OES 11 SP1: Planning and Implementation Guide</a>
<b>Samba for Linux</b>  Provides CIFS access for Linux and Windows users. Requires the service and users to be enabled for Linux User Management.	<a href="#">OES 11 SP1: Novell Samba Administration Guide</a>

**Table 3-5** *Storage Management Tools*

Storage Solution	Reference
<b>Linux System Configuration with YaST</b>  YaST is a management tool for a variety of services on Linux.	<a href="http://www.suse.com/documentation/sles11/book_sle_deployment/data/book_sle_deployment.html">SLES 11 SP2 Deployment Guide (http://www.suse.com/documentation/sles11/book_sle_deployment/data/book_sle_deployment.html)</a>  <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">SLES 11 SP2 Storage Administration Guide. (http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html)</a>
<b>Novell iManager</b>  A Web-based network resources management tool used to manage storage solutions	<a href="#">Novell iManager 2.7.6 Administration Guide</a>
<b>Novell Remote Manager</b>  A Web-based monitoring and management tool for network resources.  The NCP Server and Dynamic Storage Technology plug-ins for Novell Remote Manager for Linux are the management tools for managing NCP on Linux.  You can also use this tool for managing file system trustees and trustee rights for directories and files in NSS volumes and NCP volumes.	<a href="#">OES 11 SP1: Novell Remote Manager Administration Guide</a>
<b>Novell Linux Volume Manager</b>  A command line interface management tool that supports command line creation of NSS and Linux POSIX file systems.	<a href="#">OES 11 SP1: NLVM Reference</a>
<b>Linux POSIX Volume Management using Novell Linux Volume Manager Commands</b>  Uses the NLVM command line interface to create and manage and Linux POSIX file systems.	“Managing Linux Volumes with NLVM Commands” in the <a href="#">OES 11 SP1: Linux POSIX Volume Administration Guide</a>

Storage Solution	Reference
<b>Novell Storage Services Management Utility</b> A management tool to configure storage devices when the Web-based Novell iManager tool is not available (such as when the <code>sys :</code> volume is not mounted). NSSMU supports creating and mounting encrypted NSS volumes.	“NSS Management Utility (NSSMU) Quick Reference” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>
<b>Linux POSIX Volume Management in the Novell Storage Services Management Utility</b> Uses the NSSMU management tool to create and manage and Linux POSIX file systems.	“Managing Linux Volumes with NSSMU” in the <a href="#">OES 11 SP1: Linux POSIX Volume Administration Guide</a>
<b>Storage-Related Plug-Ins for iManager</b> Plug-ins for storage-related management.	“Storage Plug-In Quick Reference” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>  “Files and Folders Plug-In Quick Reference” in the <a href="#">OES 11 SP1: NSS File System Administration Guide for Linux</a>  “Distributed File Services Plug-In” in the <a href="#">OES 11 SP1: Novell Distributed File Services Administration Guide for Linux</a>  “Clusters Plug-in for iManager” in the <a href="#">OES 11 SP1: Novell Cluster Services 2.1 for Linux Administration Guide</a>  <a href="#">Archive Versioning Plug-in for iManager</a>  <a href="#">CIFS Plug-in for iManager</a>  <a href="#">AFP Plug-in for iManager</a>





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# A Documentation Updates

This section contains information about documentation content changes made to the *Storage and File Services Overview* since the initial release of Novell Open Enterprise Server (OES) 11.

This document was updated on the following dates:

- ♦ [Section A.1, “December 3, 2013,” on page 41](#)
- ♦ [Section A.2, “September 19, 2013,” on page 41](#)
- ♦ [Section A.3, “July 31, 2013,” on page 41](#)
- ♦ [Section A.4, “August 28, 2011,” on page 41](#)

## A.1 December 3, 2013

The new site for iManager 2.7.6 and earlier is at <https://www.netiq.com/documentation/imanager27>.

## A.2 September 19, 2013

Modified Novell eDirectory 8.8 SP7 links to point to the [NetIQ eDirectory 8.8 SP7 Web site \(http://www.netiq.com/documentation/edir887\)](http://www.netiq.com/documentation/edir887).

## A.3 July 31, 2013

Removed links to outdated guides for Novell Client.

## A.4 August 28, 2011

Updates were made to the following section. The changes are explained below.

- ♦ [Section A.4.1, “Storage Architectures,” on page 42](#)
- ♦ [Section A.4.2, “Storage Documentation Quick Reference,” on page 42](#)
- ♦ [Section A.4.3, “Storage Solutions,” on page 42](#)

## A.4.1 Storage Architectures

Location	Change
<a href="#">Section 2.4.3, “Fibre Channel SAN,” on page 27</a>	SUSE Linux Enterprise Server 11 SP2 and later supports Fibre Channel over Ethernet (FCoE), and provides the FCoE initiator management in YaST 2. For information, see <a href="#">“Fibre Channel over Ethernet Networks”</a> ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html">http://www.suse.com/documentation/sles11/stor_admin/data/cha_fcoe.html</a> ) in the <i>SUSE Linux Enterprise Server 11 Storage Administration Guide</i> ( <a href="http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html">http://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html</a> ).
<a href="#">“Shared Volume in a Fibre Channel SAN” on page 31</a>	Added an example of a FCoE deployment.

## A.4.2 Storage Documentation Quick Reference

Location	Change
<a href="#">Table 3-1, “File Systems,” on page 35</a>	<i>OES 11 SP1: Linux POSIX Volume Administration Guide</i>
<a href="#">Table 3-2, “Storage Solutions,” on page 35</a>	FCoE (Fibre Channel over Ethernet) Initiator tool in YaST 2 is new in SUSE Linux Enterprise Server 11 SP2.  Added a link for the <i>OES 11 SP1: Novell Cluster Services 2.1 NetWare to Linux Conversion Guide</i> .
<a href="#">Table 3-5, “Storage Management Tools,” on page 38</a>	Added links:  “Managing Linux Volumes with NLVM Commands” in the <i>OES 11 SP1: Linux POSIX Volume Administration Guide</i>  “Managing Linux Volumes with NSSMU” in the <i>OES 11 SP1: Linux POSIX Volume Administration Guide</i>

## A.4.3 Storage Solutions

Location	Change
<a href="#">Section 1.1.1, “Diverse Storage Devices,” on page 8</a>	For information about Linux POSIX file systems such as Btrfs, Ext3, Reiser and XFS, see <a href="#">“Overview of Linux POSIX File Systems”</a> in the <i>OES 11 SP1: Linux POSIX Volume Administration Guide</i> .
Multiple	Added Btrfs to the list of Linux POSIX file systems that are supported in OES 11 SP1.