Dell FS8600 with VMware vSphere

Deployment and Configuration Best practices

Dell Engineering
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Revisions

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1 Preface

1.1 Audience
This document is intended for system, network and/or storage administrators and integrators who plan to deploy the FS8600 as a storage solution for VMware vSphere-based virtualization platform.

It is assumed throughout the document that the reader is familiar with the following topics:

1. FS8600 network attached storage platform functionality, features, installation, user interface and operation.
2. Architecture, configuration and deployment of VMware’s vSphere platform.
3. Network File System (NFS) protocol implementation and terminology.
4. Network infrastructure design, configuration and deployment.

1.2 Purpose
This document outlines key points to consider throughout the design, deployment and ongoing maintenance of a vSphere solution with Dell’s FS8600 file-level storage. The topics included in this document provide the reader with fundamental knowledge and tools needed to make vital decisions to optimize the solution.

This guide constitutes a conceptual approach with directives to set up and tune the environment. The reader should not expect to find step-by-step procedures for recommended configurations. It is assumed that these are described in other documents, which are referenced throughout the document when necessary.

1.3 Additional Resources
FS8600 Administrator’s Guide (available in the Compellent Knowledge Center http://kc.compellent.com):


vSphere Web Plugin for NFS (Part 1) – Installation (http://en.community.dell.com/techcenter/extras/m/white_papers/20441351)
vSphere Web Plugin for NFS (Part 2) - Overview and Functionality (http://en.community.dell.com/techcenter/extras/m/white_papers/20441352)
Dell Fluid File System Overview
FS8600 Snapshot and Volume Cloning Best Practices
Dell Compellent FluidFS (FS8600) Networking Best Practices
Other publications:
1.4 Terms and Abbreviations

The following table summarizes terms and abbreviations used in this document:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tr>
<td>Adaptive Load Balancing (ALB)</td>
<td>MAC address-based mechanism that balances client connections across all available network interfaces within an FS8600 system.</td>
</tr>
<tr>
<td>Network File System (NFS)</td>
<td>A standard protocol for file and directory sharing over a network.</td>
</tr>
<tr>
<td>NFS Datastore</td>
<td>A logical container of Virtual Machine files that represents a remote file system accessed over NFS.</td>
</tr>
<tr>
<td>NFS Datastore Traffic</td>
<td>Refers to the virtual machine file I/O generated by ESX hosts on an NFS Datastore server. NFS datastore traffic is created by the creation or cloning of virtual machines as well as guest OS level I/O operations on virtual machines’ virtual hard disk.</td>
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<tr>
<td>NFS Export</td>
<td>A directory shared by an NFS server for remote client access.</td>
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<tr>
<td>Virtual IP (VIP)</td>
<td>An IP address that connects the NAS cluster solution to the client or LAN network. The VIP address allows clients highly-available access to the NAS solution as a single entity, thereby providing access to the file system. It enables the FS8600 system solution to perform load balancing between controllers, and ensures that the service continues even if a controller fails.</td>
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<tr>
<td>Virtual Machine Files</td>
<td>A set of files that store, among others, virtual machine configuration, virtual hard disk data and snapshots.</td>
</tr>
<tr>
<td>Thin clone</td>
<td>Fast and space efficient Virtual machine clone. Compared to a full copy, the thin cloned VM shares data with the source and only consumes disk space when data is written to it.</td>
</tr>
<tr>
<td>Application and User Files</td>
<td>Output files created by a client or user in applications on top of the operating system, such as documents, browser data, media files, and so on.</td>
</tr>
<tr>
<td>VMDK</td>
<td>A file containing a virtual machine’s virtual hard disk.</td>
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<tr>
<td>VMFS</td>
<td>VMware’s clustered file system.</td>
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<tr>
<td>VMknic/VMkernel port</td>
<td>A virtual network device in the VMkernel. VMkernel ports are used by the TCP/IP stack that services Motion, NFS and software iSCSI clients that run at the VMkernel level, and remote console traffic. In the context of NFS datastore traffic, VMkernel ports are referred to as interfaces for I/O over NFS.</td>
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<tr>
<td>VMNIC</td>
<td>ESX host physical network interface card.</td>
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1.5 Disclaimer

The information contained within this best practices document is intended to provide general recommendations only. Actual configurations in customer environments may vary due to individual circumstances, budget constraints, service level agreements, applicable industry-specific regulations, or other factors. Configurations should be tested before implementing them in a production environment.
2 Introduction

In vSphere-based solutions, virtual machine data is stored in a set of files holding information such as virtual hardware configuration, virtual hard disks and snapshot data. ESX hosts store this data in logical data containers called ‘datastores’. Datastores are representations of some underlying physical storage space either in the ESX server’s local hard drives or in external storage systems.

External storage system options supported by vSphere include block devices presenting LUNs (via iSCSI or Fiber Channel) formatted with VMware’s VMFS file system, and external file systems that support remote access via NFS (Network File System protocol). The later are incorporated into the virtualization solution by ESX hosts, which are able to mount folders exported by the external file system (or NFS exports) as datastores.

This document addresses the deployment of the FS8600 as a complete storage solution for a vSphere platform implementation. As such, the FS8600 can act as the storage both for virtual machine data files via NFS (datastores) and virtual machine user files via NFS and/or CIFS.
3 Solution Overview

3.1 Benefits
Using standard network infrastructure, Dell’s FS8600 offers a scalable, flexible and highly available storage solution for vSphere. The key advantages of the solution are:

- A single FS8600 system can act as an NFS datastore server for ESX hosts and at the same time as a file server for Windows/Linux/UNIX clients, virtual or otherwise. The combination of these two functions best leverages the FS8600 file-level storage, access, protection and management features on client data, and constitutes a cost-effective solution for storage of both virtual machine files and user files in vSphere.

- Independent management of storage capacity for virtual machine files and application data, even though they reside all in the same storage system

- Fast and simple datastore provisioning and management. The creation of NAS volumes in the FS8600 is a metadata operation regardless of their size.

- Datastores residing in FS8600 NAS volumes can be rapidly and non-disruptively scaled up to meet a virtual data center’s growing requirements. Adding capacity to a NAS volume doesn’t require ANY disruption of the IO on the hosts that access the datastore.

- FS8600 file cloning features can be leveraged to deploy fast and space efficient VM clones.

- Since all datastores in the FS8600 reside within a single file system, they can be cloned quickly and easily. NAS volume cloning in the FS8600 is a metadata operation. A clone volume consists of a new set of pointers to its parent volume data blocks. New data written either to the base or the cloned volume will be exclusively owned and referenced by it, while they continue sharing their common data blocks.

3.2 Architecture
From the bottom up, the first building block of an FS8600 NFS storage solution for vSphere is the storage array. As an administrator, you just need to tell the Dell Storage Manager what is the initial size of your NAS LUN Space, which is the storage capacity that you want to allocate to the solution. The Dell storage manager automatically performs an optimized configuration of the LUNs and the FS8600 appliance formats them with the Fluid File System (FluidFS). This process results in the presentation of a NAS pool, which is the net space available for file level storage. The size of the NAS LUN space can be increased non-disruptively when your storage demands grow.

The NAS pool in FluidFS is managed using elastic virtual storage containers called NAS volumes. You can create, delete, shrink or expand NAS volumes in an instant because all their provisioning processes are
based exclusively on metadata operations. Since NFS datastores in FluidFS reside in NAS volumes, they inherit the NAS volume elasticity properties. This means you can modify the size of datastores without any impact to its virtual machines or the ESX hosts mounting them. Furthermore, scaling the environment with more datastores or hosts is easy because there are no discovery procedures involved.

Data stored in the NAS pool is evenly distributed by FluidFS among all the underlying LUNs regardless of the number of datastores. There is no need to worry about balancing space between physical volumes when performing capacity management operations.

NAS volumes in FluidFS are also administrative domains. All data stored within a NAS volume is subject to common data protection, data reduction, accessibility and security policies. Since NAS volumes have their own folder hierarchy it is possible to create more than one datastore in a single NAS volume. This is particularly useful to categorize virtual machines in vSphere, while keeping them under the same storage management policies.

Virtual machines provisioning becomes fast and efficient using FluidFS file cloning technologies. FluidFS can create numerous amount of clones in an instant out of source virtual machines or templates. These are functional copies of virtual machines that share data with their source, so they can be created instantly and save significant amounts of disk space.
The value that the FS8600 adds as backend storage to the vSphere solution doesn’t come at the expense of its unique NAS functions and features. It can simultaneously act as the storage platform to store and manage unstructured data generated by both virtual and physical machine clients. You can create as many NAS volumes as needed for user and application files and share their folders using SMB or NFS. This is the ultimate way to optimize the solution and leverage all FluidFS native file-level features.

Error! Reference source not found. shows a sample solution design scheme for environments where source templates are cloned to provision large amounts of virtual clients. Assuming that all source templates can reside under the same space boundaries and they all submit to common data protection and accessibility policies, we allocate a single NAS volume to store them. To differentiate template classes and purposes you can map multiple datastores to the NAS volume. It is best practice to keep source templates intact and separated from the production clones to be able to change them whenever required without affecting live VMs. This strategy can be achieved by provisioning a full copy of the template (replica) to the production datastores and using it as the source image for the production clones. The later are fast and space efficient virtual machines that share image with their source replica (thin clones).

### 3.3 Fluid File System Overview

Fluid File System (FluidFS) is an enterprise-class, fully distributed file system that provides customers with the tools necessary to manage file data in an efficient and simple manner. The underlying software architecture leverages a symmetric clustering model with distributed metadata, native load balancing, advanced caching capabilities and a rich set of enterprise-class features. FluidFS removes the scalability limitations such as limited volume size associated with traditional file systems, and supports high capacity, performance-intensive workloads via scaling up (adding capacity to the system) and by scaling out (adding nodes, or performance, to the system).
4  Network Infrastructure and Configuration

This section describes various considerations and recommendations related to the physical network infrastructure as well as its logical configuration.

4.1  Managing Client Files and Datastores in a Single File System

The FS8600 in a vSphere environment can act as an NFS datastore server for virtual machine files and at the same time as a file server for application and user files. Storing client files outside virtual machine hard drives and directly in the FS8600 is the best way to leverage the FS8600 native file-level features on application and user data. This methodology has several benefits:

- Seamless differentiation and separate management of guest operating system data and application and user data.
- Faster and more flexible application and user data recovery from corruption and loss using snapshots.
- Increased efficiency of application and user data replication.
- Accessibility of application and user data is independent of the virtual machine.

Dell recommends logically separating virtual machine files from application and user data in different NAS volumes to consistently implement the aforementioned benefits. Achieve this by creating a set of NAS volumes, one for each datastore, and a different set of volumes with their corresponding CIFS shares and/or NFS exports for client files.

![Network Schema](image)

Figure 1  Network Schema

In addition, for better security and management, Dell recommends segmenting the network paths physically and logically. Assign separate physical NIC teams for each path and split the traffic logically into VLANs. See Figure 1 for reference.
It is VMware’s best practice to minimize the number of hops on the NFS datastore network. Routing between ESX host NFS datastore traffic links and the FS8600 client ports should be avoided. VLANs and subnets can and should be used to logically separate workloads and load-share the network throughput as long as the links between the ESX hosts and the FS8600 reside in the same broadcast domain.

### 4.2 Switch Topology

The switch infrastructure that connects to the FS8600 should be redundant (See example on Figure 2) in order to support and maintain the appliance’s high availability. Architecturally, three guiding principles should be used to construct a best practice switch connectivity topology:

- Avoid any single points of failure.
- Ensure sufficient inter-switch throughput.
- Keep the FS8600 client ports and ESX hosts datastore traffic ports in the same broadcast domain.

![Switch Topology Diagram](image)

**Figure 2**  Sample ESX Host to FS8600 Interconnect Network Switch Topology

### 4.3 ESX Host NICs for Datastore Traffic

Dell recommends assigning at least one pair of VMNICs (both of the same line speed) on every ESX host to exclusively transport NFS datastore traffic between the host and the FS8600. These links will provide the network infrastructure required for the creation, deletion and cloning of virtual machines, as well as their I/O workload on their virtual hard drives. Determining the VMNIC throughput required for this type of workload should take into consideration the environment and throughput requirements of the virtual machines in use. The VMNICs should be teamed to provide both fault tolerance as well as increased
aggregated throughput by applying ESX host load sharing methods (See “NFS Datastore Traffic Load Sharing” on Page 14).

4.4 FS8600 Client Network Configuration

The client network in the FS8600 should be configured to accommodate the logical separation of guest OS data and application/user data into VLANs and subnets. Dell recommends having at least two subnets, each in a different VLAN, to allocate these two main workloads. Additional subnets may be needed to support the NFS datastore traffic load sharing methodology chosen for the solution (See “NFS Datastore Traffic Load Sharing” on Page 14). Since these subnets are primarily used for traffic load sharing, they can be allocated in the same VLAN as illustrated in Figure 3.

The FS8600 can be configured with multiple network (subnet) access to/from the client network links. The configuration of each client network requires at least one virtual IP (VIP) and one IP address for each node. Client networks have optional VLAN tagging configuration. All networks configured in the FS8600 are accessible to/from all client network ports simultaneously, thus granting high availability and no single point of failure.

![Figure 3  FS8600 Client Network Configuration](image)
5  NFS Datastore Traffic Load Sharing

Using more than a single physical NIC on each ESX host provides fault tolerance and, when properly set up, can significantly increase the aggregated logical link throughput. The NICs on each ESX host that are allocated for NFS datastore traffic should be configured as a team when the user desires traffic distribution among them.

5.1  Subnet-Based Load Sharing

For outbound NFS datastore traffic, an ESX host uses a VMkernel port on the same subnet as the destination NFS server IP. If several available VMkernel ports exist in the same subnet, the host will only use a single VMkernel port and a single VMNIC. The subnet-based load sharing method uses multiple destination subnets and VMkernel ports to access them.

NFS datastore traffic from an ESX host can be distributed among its physical links if the following conditions are met:

a. The corresponding NICs are teamed.

b. VMkernel ports are configured with IP addresses in different subnets.

Note: When applying subnet-based load sharing, the load balancing method of the VMkernel port group should be set to “Route based on originating virtual port” (See “NFS Datastore Traffic Configuration” on Page 17)

In a subnet-based load sharing configuration, first determine the number of subnets required to effectively distribute the traffic among the links on a team. All hosts then share the same subnets.
For example, a host with two teamed VMNICs and two VMkernel ports vmk_0 → 10.0.0.1/24 and vmk_1 → 10.0.1.1/24 will use vmk_0 to reach 10.0.0.10/24 and vmk_1 to reach 10.0.1.10/24, as shown in Figure 5. When the traffic to each destination subnet is routed via a different VMkernel, it is also transmitted via a different physical VMNIC accordingly. The configuration of other ESX hosts in the cluster should be done following the same principle and sharing the same subnets.

Therefore, the number of subnets required to effectively share NFS datastore traffic among teamed VMNICs on an ESX host needs to be equal to the number of NICs on the team. In a solution where multiple hosts have different numbers of VMNICs assigned for datastore traffic, choose the number of subnets according to the host with the largest number of VMNICs.

Finally, configure the corresponding subnets in the FS8600 client network with the necessary VIPs (See “FS8600 Client Network Configuration” on Page 13)

### 5.2 Load Balancing Between FS8600 Controllers

The FS8600 automatically distributes client connections among all controllers in the cluster and their physical network links. Uniform distribution is guaranteed when many clients are served by the appliance, where each is assigned a node and a physical interface. However, in environments such as vSphere where only few ESX hosts are served, Dell recommends these two practices to help optimize connection balancing across controllers in the FS8600.

a. Configure one VIP for each FS8600 controller in every client network subnet. Two connections from a single VMkernel IP address, each to a different VIP in the FS8600, are very likely to target two different controllers. Therefore, Dell recommends that you alternate (round-robin) between different VIPs in the subnet each time you mount a datastore (See Figure 6 for an illustrative example).

b. Review the ESX hosts connection balance and manually adjust when necessary. Dell recommends monitoring the connection assignments after mounting/unmounting several datastores, when changing NFS network configuration settings or performing maintenance operations. Verify that connections are evenly balanced among controllers and their interfaces and
adjust as necessary using the FS8600 automatic and/or manual connection rebalancing mechanisms.

Figure 6  Using VIPs to Load Balance Connections Between Controllers in the FS8600

Figure 8 shows an example of three ESX hosts load balanced between the two controllers in the FS8600 appliance. Ideally, each ESX host connection should target a different controller, and all connections with a controller should be load balanced among its client network interfaces.

Figure 7  Load Balancing Datastores Connections Between FS8600 Controllers
6 Virtual Network Configuration

As mentioned in “Managing Client Files and Datastores” on Page 11, segmentation of traffic types is desired for better management and increased security. The implementation of this approach starts with the vSphere virtual network configuration, as described below.

6.1 NFS Datastore Traffic Configuration

Dell recommends creating a vSwitch (can be standard or distributed) exclusively for NFS datastore traffic in its own VLAN with the following configuration:

1. Add the VMNICs associated with NFS datastore traffic to the physical side of the vSwitch.
2. Configure one port group on the virtual side with the proper VLAN configuration destined to include the VMkernel ports.
3. Add one VMkernel port per subnet to the port group in accordance to the load sharing method on the ESX host (See “5 NFS Datastore Traffic Load Sharing” on Page 14).

Set the load balancing policy under the teaming and failover of the VMkernel port group settings to “Route based on originating virtual port”.

See Figure 9 for sample screen shot of the teaming and failover settings for port groups.

Figure 8  Sample Configuration of an NFS Datastore Traffic Switch
6.2 Virtual Machine Traffic Configuration

Ideally, use a separate virtual switch with separate physical links and in a separate VLAN for the virtual machines’ outbound traffic to the FS8600 client data exports and shares.
7 Datastores Configuration
NFS Datastores in vSphere represent ESX host mounts, each accessing an NFS export over an IP address. Note that an ESX host creates a single I/O connection to the FS8600 for every individual datastore. Regardless of the teaming or load sharing method, this connection is given (and limited to) a single physical path to the FS8600, composed of one physical link from the ESX host to the switch and one from the switch to the FS8600 controller. As described in this section, creating a minimum number of datastores allows you to fully utilize the paths between ESX hosts and the FS8600, maximize the aggregated throughput and add an additional level of throughput management across the physical links.

7.1 Determining the Number of Datastores in the Environment
The recommended number of datastores in an environment varies, and depends on several considerations:

1. Number of physical links between the ESX host and the switch: Creating at least one datastore per link ensures full utilization of the maximum aggregate throughput. Their configuration depends on the load sharing method in use (See “NFS Datastore Traffic Load Sharing” on Page 14). For subnet-based load sharing, configure at least one datastore per subnet.

2. Link speed distribution among the ESX host links: Two or more datastores in the same subnet will maintain their connections over the same physical link; hence their aggregated throughput will be limited by the link speed. This mode of operation adds an additional level of throughput management that, if leveraged, can also impact the number of datastores. For example, on an ESX host with a two physical link connection, an administrator can grant maximum link speed to a single datastore by creating it in the first subnet and all others in the second.

7.2 Increasing the Maximum Number of NFS Datastores per ESX Host
The parameter that defines the maximum number of NFS mounts (datastores) on each ESX host is set to 8 by default. In environments where more than 8 NFS datastores are needed, this parameter can be increased (up to 256). When increasing this number, VMware recommends increasing the TCP/IP heap size, which is the amount of memory in megabytes allocated up front by the VMkernel to TCP/IP as heap.

The maximum number of NFS mounts an ESX host can have is determined by the \texttt{NFS.MaxVolumes} parameter.
When setting it to 256, also set the Net.TcpipHeapSize to 32 and Net.TcpipHeapMax to 128. The configuration of these parameters is done via the ESX host advanced settings.

**Note:** Changes on **Net.TcpipHeapSize** and **Net.TcpipHeapMax** require a host reboot to take effect.

### 7.3 Configuring NFS Datastores

NFS datastores in FluidFS reside in NAS volumes. These are elastic virtual storage containers used to manage the entire NAS pool. There are two typical approaches when it comes to the association of NFS datastores with the FluidFS namespace. The two can coexist in the same solution and they lie in both ends of the simplicity vs. management granularity axis. The first one consists of accommodating several datastores in a single NAS volume. You can export any number of folders in a NAS volume and create an NFS datastore in each. Since NAS volumes are also administrative domains, these datastores not only share storage space boundaries but also have common data management policies. Multiple datastores in a single NAS volume are useful when you need to categorize VMs in vSphere, without managing their data separately.

The second approach allocates a dedicated NAS volume for every NFS datastore. This method keeps every datastore under different space constraints and management policies.

Dell recommends configuring datastores using the vSphere Web Client plugin. The plugin greatly minimizes the effort involved in the configuration and management of datastores by automating these processes. For more information and tutorial videos refer to “Additional Resources” on page 5.

It is an FS8600 best practice to keep NAS volumes with datastores exclusively for storage of virtual machine files. Create separate NAS volumes for storage of user and application files (See “Managing Client Files and Datastores in a Single File System” on Page 11).

#### 7.3.1 Manual Creation of NFS Datastores

The association of datastores with NAS volumes is part of the vSphere Web Client plugin datastore wizards. If the vSphere Web Client is not present, configure the FS8600 NAS volumes as follows:

1. Create NAS volumes destined to be used as datastores and configure them with native UNIX security style.
2. Export the root folder of each NAS volume.
3. On each export, grant read and write access for “everybody” to the ESX hosts IP addresses.
4. Mark the NAS volume as VMware application aware

It is an FS8600 best practice to group virtual machines with common management policies in the same datastores.

### 7.4 Provisioning Virtual Machines

Dell recommends cloning virtual machines using the vSphere Web Client plugin. The plugin is designed to create multiple copies of VMs at once whether as full copies or as space efficient thin clones. For more information and tutorial videos refer to “Additional Resources” on page 5.

While vSphere has its own cloning methodologies to provision virtual machines out of templates, vCenter cloning operations offloaded to the FS8600 via VAAI results in the creation of a full copy of the source VM. Dell recommends cloning virtual machines using the vSphere Web Client plugin. The plugin leverages the FS8600 file level cloning features, allowing fast and space efficient virtual machine cloning.

### 7.5 Taking Datastore Snapshots

Datastores snapshots in the FS8600 constitute a basis for data protection, replication and cloning. Datastore snapshots are essentially NAS volume snapshots taken after attempting to bring live virtual machines residing on them to a quiescent state. The FS8600 asks vCenter to take a snapshot of the live VMs after quiescing their guest OS, and upon vCenter acknowledge it takes a snapshot of the NAS volume. This behavior is triggered in NAS volumes with the “VM Application Aware” flag set and requires that you provide the FS8600 with vCenter server connection information. Dell recommends that you set the “VM Application Aware” in every NAS volume that stores live VMs.

### 7.6 Cloning Datastores

The built-in thin cloning feature of the FS8600 is a time- and space-efficient way to create a replica of a NAS volume. NAS volume clones are essentially writable snapshots created by means of metadata operations. The result of volume cloning is a new set of pointers to parent data blocks, making the space costs of volume cloning negligible. From the moment a volume is cloned, new data written either to the base or the cloned volume will be exclusively owned and referenced by it, while they continue to share their common data blocks.
To ensure consistency, use the following procedure to clone datastores:

1. Ensure the virtual machines residing in the base datastore are shut down.
2. In the FS8600, take a snapshot of the datastore NAS volume.
3. Take a consistent snapshot of the NAS volume where the datastore resides.
4. Make a NAS volume clone from the snapshot.
5. Export the root folder of the clone volume and grant permissions to the ESX hosts IP addresses to access it.
6. Using the vSphere Web Plugin, create a new datastore using the export.
7. Browse the new datastore and import the Virtual Machines to the vCenter inventory.
8. Restore the VMs to the latest snapshot prefixed with "FluidFS".

7.7 Migrating Datastores/Virtual Machines to the FS8600

When the FS8600 is deployed in an existing environment and virtual machines or datastores need to be migrated from another backend to the FS8600, Dell recommends performing the migration process using vSphere migration. Virtual machine files written to the FS8600 by the ESX hosts will be better distributed among the file system resources and result in better overall performance. Dell does not recommend bypassing the hosts and using external clients or tools to migrate virtual machine files.
Summary

The deployment of the FS8600 as a storage system for a vSphere solution is a multi-layered process consisting of network infrastructure considerations, configuration procedures and management of multiple workloads over different protocols. As such, it is key to make a preliminary design based on the topics listed in this document to achieve maximum resource utilization and high availability.

A deployment, design and implementation based on the information included in this guide help maximize the solution’s robustness and administration simplicity, as well as to minimize ongoing management efforts and improve time efficiency of overall operations.