Executive summary

HP LeftHand Storage changes the way storage is procured in the enterprise by offering a scale out, clustered iSCSI storage, which uses storage nodes as building blocks. With thin provisioning technology, customers can overprovision their storage pools, defer storage investments, and buy capacity when needed. HP LeftHand Storage enables linear growth in capacity and performance simply by adding nodes to a storage cluster online and without downtime. Leveraging built-in high availability features allows for 99.999% availability and beyond for the entire scalable storage pool, which is managed by the simple and easy-to-use HP LeftHand Centralized Management Console.

Snapshots empower customers to keep point-in-time representation of their application data to roll back to a previously saved state. Customers can use them for a quick recovery to an earlier state of the volume or use the snapshots to facilitate backups without affecting the applications running on the original volume. In HP LeftHand Storage, snapshots are created instantaneously while maintaining high capacity utilization as they are always thin provisioned and require no space reservation. Snapshots on HP LeftHand Storage can be used to roll back entire volumes, or mounted to servers for backup and other operations with the data.

In addition to regular snapshots, application-managed snapshots help customers to mitigate the risk of inconsistent or invalid application data in snapshots. By integrating into the application stack on a server, HP LeftHand Storage helps customers to bring applications into a consistent state without taking applications offline when creating the snapshot. Business critical applications, such as database servers, email service, Web servers, or virtual machines in Microsoft Hyper-V and VMware vSphere environments, especially benefit from an application-consistent and predictable state. The only component required on the server is HP LeftHand Application-aware Snapshot Manager when creating snapshots centrally from the HP LeftHand Centralized Management Console.

Using HP LeftHand Recovery Manager, customers can quickly recover files and folders in Microsoft Windows from snapshots on HP LeftHand Storage. It dramatically reduces the time and effort required for an administrator to restore a single or thousands of files from snapshots. With a few clicks in a single and easy-to-use application, server administrators are put in a position to recover these files themselves without involving storage administrators.

This white paper is intended for system administrators who are looking to enable application-managed snapshots for virtual machines and applications in Microsoft and VMware environments.

Snapshot technology in HP LeftHand Storage

Snapshots can be created via the HP LeftHand Centralized Management Console (figure 1), HP LeftHand CLIQ (command-line interface), or via schedules. They are also the technological foundation for SmartClones and Remote Copy in HP LeftHand Storage. The snapshot feature is available for all volumes on a storage cluster without an upfront reservation space.

Figure 1. Creating a snapshot with HP LeftHand Centralized Management Console

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1 Source: “HP storage quality review weekly data,” HP Internal study, August 2012. The 99.999% metric comes from internal analysis of reported downtime by customers.
Snapshots are pointer-based representations of a volume at a certain point in time and are created using the redirect-on-write approach. When a snapshot is created, data stays in place, and a new writable space is created for new writes (figure 2).

**Figure 2.** Creating a snapshot

![Figure 2. Creating a snapshot](image)

A change to an existing block of data after taking a snapshot results in (1) copying of the original block and (2) applying the change to the block (figure 3). As a result, the volume now is made up of pointers to data in its original location as well as the changed blocks and new data in the new writable space. This is transparent to a server accessing the volume: For incoming reads, blocks are still read from its original location, while changed and new blocks are read from the new location.

**Figure 3.** Changing data on volumes with snapshots

![Figure 3. Changing data on volumes with snapshots](image)

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From a capacity viewpoint (table 1), a fully provisioned volume will consume the capacity as defined in the volume properties and its data protection characteristics by Network RAID. The snapshot itself contains only the data, which was on the volume at the point in time when the snapshot was taken. Thin provisioning of volumes helps to reduce the capacity reserved for the volume; starting with a small initial allocation (dependent on replication, in this example 1 GB) and thin provisioned volumes grow as required.

**Example:** 100 GB volume in Network RAID 10; 10 GB of data capacity before and after the snapshot
Table 1. Capacity utilization with snapshots

<table>
<thead>
<tr>
<th>Volume Provisioning</th>
<th>Volume</th>
<th>Snapshot</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Provisioning</td>
<td>200 GB</td>
<td>n/a</td>
<td>200 GB</td>
</tr>
<tr>
<td>with Snapshot 1</td>
<td>200 GB</td>
<td>20 GB</td>
<td>220 GB</td>
</tr>
<tr>
<td>Thin Provisioning</td>
<td>20 GB</td>
<td>n/a</td>
<td>20 GB</td>
</tr>
<tr>
<td>without Snapshot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin Provisioning</td>
<td>1 GB</td>
<td>20 GB</td>
<td>21 GB</td>
</tr>
<tr>
<td>with Snapshot 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unlike other storage systems, HP LeftHand Storage does not reserve capacity upfront for snapshots (typically a percentage of the volume’s size). If capacity is reserved for snapshots ahead of time, this means that not only is that space not available for other volumes, it means that a system administrator must plan how many snapshots of a volume need to be retained. With HP LeftHand snapshots, capacity is only allocated when snapshots are created.

When creating multiple snapshots of the same volume, snapshots are space-efficient and only contain the changed blocks between two consecutive snapshots—no additional space is reserved. During snapshot deletion, blocks that are needed by a new snapshot are merged with newer snapshots and blocks that are superseded by changed data in newer snapshot are discarded (figure 4).

Figure 4. Thin provisioned snapshots and snapshot deletion

As a best practice, no more than 50 snapshots per volume should be retained. Scheduling snapshots with HP LeftHand Snapshots allows for two different retention policies: to keep snapshots over a defined period of time or a specific number of snapshots per volume. For more information, consult the HP LeftHand User Manual.
The need for application integration

Snapshots on block storage, like HP LeftHand Storage, save all blocks that are on the volume at that given point in time. Applications typically do not flush changes to persistent storage after each operation, and blocks on the volume may not represent the true state of the application. Depending on the environment or application, blocks in a snapshot may no longer represent valid application data. Application-level recovery procedures might be required to work with data in the snapshot for further use. For this reason, normal snapshots are typically considered crash consistent—meaning that data in regular snapshots might be equivalent to data as a result of a system crash (instead of a graceful shutdown).

Application-consistent snapshots can be achieved by establishing a consistent state on the volume and creating a snapshot afterwards. To reach a state which is considered application consistent, the application needs to be either gracefully shutdown or put in online backup modes (resulting in flushed buffers, released file lock, etc.).

*Figure 5. Application stack for VSS-aware applications*

*Figure 6. Application stack for applications in virtual machines*
The ideal solution is to integrate into the application stack on the server itself. In HP LeftHand Storage, application-consistent snapshots are called “application-managed snapshots” and are enabled by HP LeftHand Application-aware Snapshot Manager, which is installed on application servers. This software component facilitates the communication between the application server, HP LeftHand Centralized Management Console and HP LeftHand Storage. It handles the entire application-integration by orchestrating Microsoft Volume Shadow Copy Service (VSS) framework on Microsoft Windows, and VMware vSphere hosts through VMware vCenter Server integration.

As a result, HP LeftHand Storage can create application-managed snapshots for VSS-aware application (figure 5) on Microsoft Windows (such as Exchange Server, SQL Server, SharePoint, and virtual machines on Hyper-V) and virtual machines on VMware vSphere.

Application consistency inside virtual machines, either Hyper-V or vSphere, is dependent on the level of integration with the hypervisors’ mechanism to snapshot virtual machines (figure 6). VMware tools (VMware vSphere) or Hyper-V Guest Integration Services (Microsoft Hyper-V) can cascade request for snapshots into the virtual machines to quiesce the operating system and applications inside the virtual machine in addition to the virtual disk consistency, which is achieved on the hypervisor level.

**Application-managed snapshots**

In HP LeftHand Storage, application-managed snapshots provide application-consistent snapshots by integrating into the application stack during snapshot creation. When initiating an application-managed snapshot, the HP LeftHand Centralized Management Console or HP LeftHand Storage communicates with the application server(s), which uses the volume.

To simplify the creation of application-managed snapshots, administrators create application-managed snapshots using the same mechanisms to create regular snapshots (figure 7).

**Figure 7.** Creating an application-managed snapshot using HP LeftHand Centralized Management Console

By checking the application-managed snapshot checkbox, the HP LeftHand Centralized Management Console will communicate with the application server using the volume, and trigger the required steps to establish application-consistent data on the volume before initiating the snapshot creation.

On the server(s), the HP LeftHand Application-aware Snapshot Manager communicates with applications to quiesce the volumes to an application-consistent state. Subsequently, HP LeftHand Application-aware Snapshot Manager creates the snapshot on HP LeftHand Storage, which now holds this consistent state of the application.

HP LeftHand Storage also uses application-managed snapshots in other functionalities, such as snapshot schedules and Remote Copy. These features can be configured to create application-managed snapshots without involving the HP LeftHand Centralized Management Console.

In figure 8, the blue arrows denote communication to trigger an application-managed snapshot and the red arrows represent the actual command to create a snapshot on HP LeftHand Storage.
In this architecture, application servers and HP LeftHand Storage can also communicate directly for snapshot scheduling and Remote Copy. Manual effort by the storage administrator or running HP LeftHand Centralized Management Console or HP LeftHand CLIQ is not required. This means that application-managed snapshots can be automated and scheduled according to the customer’s need without requiring scripting on application servers.

In the following examples, the HP LeftHand Centralized Management Console will be used; however, as explained earlier the HP LeftHand CLIQ and the HP LeftHand Storage are equally capable of triggering application-managed snapshots.

**Installation and configuration of HP LeftHand Application-aware Snapshot Manager**

Whether application-managed snapshots are to be created for applications on Microsoft Windows or virtual machines on VMware vSphere, HP LeftHand Application-aware Snapshot Manager needs to be installed on the Windows machine running the VSS-aware application or VMware vCenter.

To install HP LeftHand Application-aware Snapshot Manager, Microsoft Windows Server 2003 or higher is required. For integration in VMware vSphere, VMware vCenter Server 4.0, or higher is required on the Windows server.

**Figure 9. Installation wizard**
The installation process is simplified using an installation wizard (figure 9), which helps to specify the installation directory and a TCP port that is used for Common Information Model (CIM) communication (figure 10) between application server and HP LeftHand Storage. Port 5989 is the default and in most cases, it remains unchanged. It is used for communication between storage and application server, the HP LeftHand Centralized Management Console, and application server. Once installed, the component runs as a Windows service in the background.

To allow snapshots to be created by HP LeftHand Application-aware Snapshot Manager, the authentication console needs to be configured with storage credentials of the HP LeftHand Management Group to allow for communication between server and storage. The authentication console window will list all management group credentials cached by the HP LeftHand Application-aware Snapshot Manager (figure 11). The authentication console is installed as part of the Application-aware Snapshot Manager and can be accessed via the start menu on the server.

Using the credentials wizard, which is the first item in actions panel on the right hand side of the authentication console window, credentials for multiple management groups are easily configured. To verify the entered credentials, the authentication console allows testing of these credentials against the HP LeftHand Management Group. In the example shown in figure 11, there is only a set of default credentials specified in the authentication console. Default credentials are used for any HP LeftHand Management Group for which there is no explicitly defined set of credentials.

This completes the step on the Windows server for VSS applications. For VMware vSphere integration, there is one additional configuration required on the HP LeftHand Management Group. Refer to the integration in VMware vCenter (configuring server connections) section of this white paper.
The following sections will cover platform-specific information for Microsoft Windows and VMware vSphere. It will explain how the integration into each of these two platforms works in more detail.

Integration in Microsoft Volume Shadow Copy Service

When creating an application-managed snapshot for VSS-aware applications, the HP LeftHand Centralized Management Console will connect with the server(s), which are currently accessing the volume. On the server(s), the HP LeftHand Application-aware Snapshot Manager will communicate with the HP LeftHand Centralized Management Console and HP LeftHand Storage.

HP LeftHand Application-aware Snapshot Manager uses the Volume Shadow Copy Service to enable application consistency on NTFS volumes (figure 12). In Microsoft environments, the Volume Shadow Copy Service (VSS) framework that is built into Windows Server 2003 and higher, is used to make applications aware that a consistent state needs to be established on an NTFS volume and also triggers the snapshot creation.

Figure 12. Architecture of Microsoft Volume Shadow Copy Service

The framework allows HP LeftHand Application-aware Snapshot Manager to integrate into that process after a consistent state on the volume has been established. It consists of three elements: VSS requestors, VSS writers, and VSS providers.

- **VSS requestors** request a snapshot for an application volume; usually backup software or a tool like DiskShadow on Windows Server. HP LeftHand Application-aware Snapshot fills the role of the requestor when an application-managed snapshot is triggered by HP LeftHand Storage, HP LeftHand Centralized Management Console, or CLIQ.

- **VSS writers** are application specific and handle the consistency on the volume. Applications such as Microsoft SQL Server and Microsoft Hyper-V implement the appropriate behavior when a snapshot of a volume is requested. After the VSS writer completes the steps required for application consistency, the VSS provider has up to 10 seconds to complete the snapshot of the volume on the underlying storage.

- **VSS providers** are storage specific and create the snapshot on the storage system. There is a VSS provider for HP 3PAR Storage, HP LeftHand Storage, HP EVA Storage, and HP MSA Storage. HP LeftHand VSS provider communicates with HP LeftHand Storage to create the snapshot.

For more information on VSS, consult Microsoft’s documentation of the VSS framework.

To update to a new version of the VSS provider for HP LeftHand Storage, install a new version of HP LeftHand Application-aware Snapshot Manager.
Validation of VSS integration

To ensure a successful installation of the VSS provider of HP LeftHand Storage, you should verify the list of all the installed providers on the application server.

Figure 13. List of all the installed VSS providers with vssadmin

Open a command prompt and execute vssadmin list providers. The output should list a version of HP LeftHand VSS provider or HP P4000 VSS provider (figure 13) matching the LeftHand operating system (formerly known as SAN/iQ) on HP LeftHand Storage.
Integration in VMware vCenter

When creating an application-managed snapshot for VMware vSphere, HP LeftHand Centralized Management Console communicates with VMware vCenter to integrate with VMware vSphere. As a result, for VMware vSphere integration, there is an additional step required for the HP LeftHand Centralized Management Console to communicate with the vCenter server. The section “configuring server connections” will cover this step in detail.

On the vCenter server, the HP LeftHand Application-aware Snapshot Manager communicates with the local instance of vCenter, HP LeftHand Centralized Management Console, and HP LeftHand Storage (figure 14).

**Figure 14. Architecture of HP LeftHand Integration in VMware environments**

On a VMware vSphere level, application-consistency state is achieved by snapshotting all virtual machines on data stores with VMware’s Virtual Machine File Systems (VMFS). VMware snapshots result in unlocked Virtual Machine Disk (VMDK) files in VMFS, which are then included in the snapshot on HP LeftHand Storage. As mentioned above, the application integration beyond the vSphere level is dependent on the virtual machine’s integration with VMware snapshots.

By using VMware tools inside the virtual machine for instance, Windows guests are requested to quiesce their file system, which is contained in the VMDK file. This leads to guest-level consistency in addition to the VMDK level. As a result, the file systems on the VMDK as well as the VMDK on the VMFS data store are consistent.

HP LeftHand Application-aware Snapshot Manager requests quiescing of the guest through VMware tools and a snapshot of the virtual machine’s memory for all virtual machines on a volume (= VMFS datastore).

For more information on VMware snapshots and HP LeftHand Storage, consult VMware documentation and the VMware vSphere on HP LeftHand Storage white paper.
Configuring server connections

As VMware vCenter is controlling the application-managed snapshot for VMware virtual machines, the IP address of VMware vCenter server needs to be known to HP LeftHand Storage. This is done by introducing the vCenter server as a controlling server in the server connection for the vSphere hosts (figure 15).

Figure 15. Server connection for a single VMware vSphere host

This setting needs to be set for all vSphere hosts, which are managed by vCenter. This includes all vSphere hosts accessing a shared volume when using vSphere clusters.
Creating an application-managed snapshot

The process of creating an application-managed snapshot for the storage administrator is easily accessible from HP LeftHand Centralized Management Console after the HP LeftHand Application-aware Snapshot Manager has been configured on the server running the VSS-aware application or VMware vCenter Server. To create a snapshot, right-click on the volume in the HP LeftHand Centralized Management Console for which a new snapshot should be created.

Figure 16. Snapshot context menu

By checking the application-managed box in the dialog, the application-managed snapshot will be created (figure 17).

Figure 17. Creating a new application-managed snapshot

In CLIQ, the command to create a snapshot is extended with the parameter/value-pair managed=1 to trigger application-managed snapshots (figure 18).
After the application-managed snapshot has been negotiated with HP LeftHand Application-aware Snapshot Manager, the snapshot will appear in the list of snapshots for the volume as well as in the volume and snapshots list in the cluster.

As application-managed snapshots are dependent on VMware Snapshots, it might take a while for these to be completed successfully. While the status of VMware Snapshots may be monitored in vCenter, the HP LeftHand Centralized Management Console also shows that the snapshot creation is pending in the volume’s details (figure 20).
Figure 20. Volume details showing a pending application-managed snapshot for VMware vSphere

<table>
<thead>
<tr>
<th>Name:</th>
<th>Datastore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>Cluster:</td>
<td>vsaccluster01</td>
</tr>
<tr>
<td>Status:</td>
<td>Normal, Application-Managed Snapshot, Datestore_SS_2, pending completion, started on 05.08.11 14:53 Uhr MESZ</td>
</tr>
<tr>
<td>Server:</td>
<td>F4000-ESX1, P4000-ESX2</td>
</tr>
<tr>
<td>Type:</td>
<td>Primary</td>
</tr>
<tr>
<td>Reported Size:</td>
<td>10 GB</td>
</tr>
<tr>
<td>Data Protection Level:</td>
<td>Network RAID-10 (2-Way Mirror)</td>
</tr>
<tr>
<td>Consumed Space:</td>
<td>21.00 GB</td>
</tr>
<tr>
<td>Provisioning:</td>
<td>Full</td>
</tr>
<tr>
<td>Created by:</td>
<td>Manual</td>
</tr>
<tr>
<td>Created:</td>
<td>04.08.11 06:17 Uhr GMT</td>
</tr>
</tbody>
</table>

The details tab for snapshot will display application managed as type.

Figure 21. Application managed is listed as type in snapshot details

<table>
<thead>
<tr>
<th>Name:</th>
<th>Datastore_SS_1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Created by P4000 application-managed client software</td>
</tr>
<tr>
<td>Cluster:</td>
<td>vsaccluster01</td>
</tr>
<tr>
<td>Status:</td>
<td>Normal</td>
</tr>
<tr>
<td>Type:</td>
<td>Primary, Application-Managed</td>
</tr>
<tr>
<td>Snapshot Set:</td>
<td>None</td>
</tr>
<tr>
<td>Reported Size:</td>
<td>10 GB</td>
</tr>
<tr>
<td>Provisioning:</td>
<td>Thin</td>
</tr>
<tr>
<td>Created by:</td>
<td>Manual</td>
</tr>
<tr>
<td>Created:</td>
<td>05.08.11 12:52 Uhr GMT</td>
</tr>
</tbody>
</table>
**Snapshot sets**

If VSS applications span multiple NTFS volumes, like databases on Microsoft SQL Server with separate volumes for data files and logs, snapshots should be created for all volumes. HP LeftHand Storage supports snapshot sets, which quiesces multiple volumes and creates snapshots for these volumes at the same time (figure 22).

**Figure 22.** Snapshot sets represent an application-consistent state on multiple volumes

![Snapshot sets represent an application-consistent state on multiple volumes](image)

When creating an application-managed snapshot, the VSS writers for applications will pass information regarding all dependent volumes to the HP LeftHand Application-aware Snapshot Manager. Should the VSS writers have more than one volume which need to be quiesced for the application to be consistent, a notification will be displayed to the user to make sure that these other volumes are included in the snapshot set (figure 23). The snapshot set as a whole represents the consistent state of the application.

**Figure 23.** Associated volumes result in snapshot sets

![Associated volumes result in snapshot sets](image)

Once the snapshot set is created, the details tab for a snapshot that is part of a snapshot set will show information about the snapshot set as well (figure 24). The type of all snapshots in the set should be application managed.
Note: Snapshots of VMFS data stores with extends does not create snapshot sets.

**Scheduling and Remote Copy**

As mentioned previously, application-managed snapshots can also be created by a snapshot schedule (via volume context menu). The benefit of snapshot schedules in HP LeftHand is that the administrator defines the schedules once and then the application-managed snapshots are created automatically (figure 25). Remote Copy is a special variant of snapshots schedules, which include replication to another HP LeftHand Management Group.

During the setup of schedules, the HP LeftHand Centralized Management Console will verify the volume association for snapshot sets. That is, if a snapshot set is required for an application, the schedule will be created for the snapshot set rather than the individual volume. The schedule, however, is owned by only one volume (figure 26).
When an application server is offline or unavailable, schedules will create regular snapshots on HP LeftHand Storage and alarms will notify the storage administrator about a potential issue with the application server or schedule.

The creation of a Remote Copy schedule also works with application-managed snapshots; the only difference being that a replication target is required for Remote Copy. In that set-up, application-managed snapshots are copied to another management group in a remote location (e.g. a disaster recovery data center). For more information on snapshot schedules and Remote Copy, consult HP LeftHand documentation on snapshots.

### Restore and recovery from snapshots

There are two different strategies to recover data using snapshots.

1. **Rolling back the entire volume to a snapshot**
   
   This is done if the entire application data on the volume should be restored to an earlier point in time. All changes since then are lost. Typically use cases for rollbacks if the volume has been used for tests. It can also be used to roll back changes to multiple virtual machines, which reside on the same volume.

2. **Recovering single items from the snapshot**

   By assigning a snapshot to the application server or separate server, application data or files can be recovered on a single-item basis. This allows for more granular restores of files and folders and is often used to recover single virtual machines while maintaining the original machine.

Rollback and single item recovery work for application-managed snapshots as well as regular snapshots. If a regular snapshot does not contain a consistent data set, application-level recovery may be required. Please consult the application vendor for more details.
The following sections will describe rollback operations for a volume (this is application independent) and single file recovery for Microsoft Windows and VMware vSphere.

Rolling back a volume

When rolling back a volume to a snapshot, all changes on the volume since the snapshot was taken are discarded (this includes any consecutive snapshot). The volume stack will look like a new snapshot has just been taken (figure 27). The snapshot to which the volume was rolled back to is still in place to conserve that point-in-time representation; and all new blocks will be written to a new writable space. Verify that the snapshot to which the volume is rolled back contains the correct set of data.

Figure 27. Roll back of a snapshot

Before rolling back a snapshot, make sure to disconnect all application servers from the volume (i.e., no active iSCSI session). If there are any iSCSI sessions to the volume, the HP LeftHand Centralized Management Console will warn the storage administrator who is attempting the rollback operation.

To roll back a volume, select and right-click the snapshot “Roll Back Volume” (figure 28).

Figure 28. Roll back to snapshot in the HP LeftHand Centralized Management Console
When working with snapshot sets, typically all snapshots in the set are rolled back as only their combination reflects a valid set of application data. Even though there might be exceptions to this rule, HP LeftHand Centralized Management Console will warn storage administrators when a snapshot that should be rolled is part of a snapshot set (figure 29).

**Figure 29.** Options when rolling back to a snapshot as part of a set.

For more information, consult HP LeftHand documentation.

**Mounting snapshots to host for single-item recovery**

Mounting individual snapshots to servers allows customers to browse the content of a volume at the point in time that the snapshot was originally taken. Whether it is a NTFS or VMFS volume, the snapshots can be assigned and accessed on servers that understand the file system in the snapshot to help with data recovery.

Regular snapshots as well as application-managed snapshots can be used for single item restore. Certain file types, such as database files, may need additional steps for successful recovery. Contact the application vendor for more detailed information.

The general procedure to access a snapshot and its data is:

1. Assign snapshot to one (or more) server connections
2. Connect to the iSCSI target of the snapshot
3. Access the data in the snapshot.

The server that is used for the recovery procedure must have a corresponding server profile in the HP LeftHand Management Group, network access to HP LeftHand Storage and proper configuration of the iSCSI initiator.

To assign a snapshot to a server, right-click the snapshot in the HP LeftHand Centralized Management Console and select assign or unassign servers to assign the snapshot to a recovery server (figure 30). The process is exactly the same as assigning volumes to servers.
Figure 30. Assign a snapshot to a server

The snapshot will appear in the servers list of iSCSI targets. After connecting to the iSCSI target, the snapshot will show up as disk in the operating system, and it may be taken online for single item recovery from the snapshot.

Figure 31. iSCSI Initiator in Microsoft Windows with snapshots in list of “discovered targets”
For Microsoft Windows (figure 31), typically it is required to hit refresh in the iSCSI Initiator properties window to refresh the list of available iSCSI targets. If the snapshot is not listed in the discovered targets, check the discovery portals (in the discovery tab) for the correct VIP address(es) and the volume assignment on HP LeftHand Storage. When the snapshot is listed, it can be corrected by clicking connect and performing the same as when connecting to a volume.

Similarly in VMware vSphere (figure 32), the iSCSI Software Adapter (under configuration—storage adapters) needs to be rescanned by right-clicking on the adapter and selecting rescan. In the appearing dialog, choose to scan for new storage devices and scan for new VMFS volumes. If the snapshot is not listed in the iSCSI adapter’s details, it is advised to check the for the correct VIP address(es) (in iSCSI adapter’s properties) and the volume assignment on HP LeftHand Storage.

For more detailed information, consult how to connect to volumes and snapshots, consult the HP LeftHand Storage white papers on Microsoft Windows or VMware vSphere.

The next sections will focus on platform specifics when recovering data from snapshots.
Simple file and folder recovery with HP LeftHand Recovery Manager

In Microsoft Windows, HP LeftHand Recovery Manager can be used to simplify the recovery of single files and folders. This separate piece of software is installed on systems, which are used for the recovery of single files from snapshot in a Windows environment. It automates the steps required to bring snapshots online on a Windows server and also allows to search and recover files in mounted snapshots. In addition, auto-mount policies can keep a number snapshot (between 1 and 5) most recent snapshots for a volume mounted to the server. This helps administrators, especially server administrators, to reduce time and effort required for file and folder restoration process.

Figure 33. User interface of HP LeftHand Recovery Manager

When running HP LeftHand Recovery Manager for the first time, it needs to be configured to communicate with HP LeftHand Storage. While HP LeftHand management group credential can be added at various places in the user interface, the easiest way to add new credentials is to go to file in the main menu, choose manage group credentials from the menu and a dialog that manages the credential cache appears (figure 34).

Figure 34. Manage group credentials

Manage group credentials can be added by discovering HP LeftHand Storage automatically using UDP broadcasts (“add management group by name”) or specifying IP addresses of storage nodes (“add management group by IP”). The dialog
can also be used to test credentials against a management group. It is also used to delete or edit cached credentials. After at least one management group has been added to HP LeftHand Recovery Manager, the software is ready for use.

HP LeftHand Recovery Manager organizes the steps to recovery in three tasks (figure 33):

- Recover files or folders
- Manage snapshots
- Auto-mount policies

Managing snapshots in HP LeftHand Recovery Manager allows users to list snapshots in a selected management group (figure 35). Filters help to look for snapshots by specifying original volume and time frames. An overview of already mounted snapshots on the same system helps to identify which data is already available on that recovery server.

Figure 35. Snapshot management in HP LeftHand Recovery Manager

To keep most recent snapshots mounted on the system, per-volume auto-mount policies (figure 36) help to keep a number of snapshots accessible on the server. New policies are defined by picking the volumes from the list of volumes and specifying the number of snapshots to be mounted. A Windows service will automatically mount snapshots in the background; the HP LeftHand Recovery Manager software does not need to be running.
Keeping most recent snapshots mounted on the server further reduces the time required to recover single files from Windows volumes. Server administrator can immediately search for files using HP LeftHand Recovery Manager or Windows Explorer to browse through the contents of the mounted snapshots.

**Figure 37. Locate files and folders using filters**
In the "recover files and folders" task (figure 37) in HP LeftHand Recovery Manager, administrators can search for files, which they want to recover. Using filters on the search, such as file name, volume name, and a timeframe will make it more precise.

From a list of search results, the administrator may compile a list of files, which they want to recover (figure 38). The search results will be displayed with time and time of file modification date and snapshot creation.

In the next step, the administrator defines a location where the files need to be restored. Recovered files and folders can be restored to virtually any location: volumes on HP LeftHand Storage, a file share, removable drive, or other locations. The time required to recover files depends on the number of elements and their size, comparable to a copy operation on the file system.

The high level of automation in HP LeftHand Recovery Manager helps administrators to save time and manual effort dramatically when recovering files from volumes on HP LeftHand Storage.

For more detailed information, consult the user guide for HP LeftHand Recovery Manager.

**Recovering single files manually in Microsoft Windows environment**

Alternatively, if HP LeftHand Recovery Manager is not available as an option for file and folder recovery, snapshots can be handled manually in Microsoft Windows Server. Just like regular volumes, there are additional steps to be taken on the system after assigning the snapshot to a Windows server and connecting to the iSCSI target using Microsoft iSCSI Initiator.

In Microsoft Windows’s Disk Management (figure 38), typically an administrator needs to:

1. Rescan for additional disk resources
2. Bring disk resource online
3. Assign a drive letter or mount point to volume(s) on the disk
4. Use Windows Explorer to browse the snapshot
Figure 39. Mounting a snapshot with disk management

Alternatively, diskpart.exe can be used to perform the required steps to make the snapshot accessible. Assuming that disk 4 is the HP LeftHand snapshot, which contains a file system that should be used to recover data. These steps are required for each snapshot assigned to the server.

1. Type in select disk 4 to work with disk number 4
   (If the disk number is unknown, list all disks by typing list disk)
2. Enter online disk to bring the disk online
3. Select the file system on the drive by entering select volume 4
   (If the volume number is unknown, list all volumes by typing list volume)
4. Enter assign letter=f to define drive letter F: for the volume
   -Or-
   Enter assign path=c:snapshots to mount the volume to the empty folder C:snapshots
5. To exit the utility, type exit

Now the snapshot can be accessed using Windows Explorer.
Figure 40. Mounting snapshots with Microsoft DiskPart

For more information, please consult HP LeftHand white papers on Microsoft Windows and Microsoft documentation on storage management in Windows and diskpart.exe.
Recovering single files and virtual machines in VMware vSphere

To recover virtual machines from a snapshot, similar tasks to those outlined above for Windows server are required. After assigning the snapshot to a VMware vSphere host for recovery and rescanning the iSCSI Software Adapter for the snapshot, the VMFS data store needs to be made accessible. The steps below can be used to copy entire virtual machines or just single virtual disk files from application-managed snapshots on HP LeftHand Storage.

1. Add the snapshot to the list of data stores (in configuration—storage) using the add storage wizard. Select the snapshot from the list of disks (the path should show the iSCSI-qualified name, which contains the snapshot name) and complete the wizard using the option assign a new signature if the original data store is also mounted somewhere else on the same vSphere data center.
2. After the snapshot has been added to the list of storage, the VMFS datastore’s name should appear prefixed with “snap-XXX-”. Using the data store browser, entire virtual machines (or individual files) can be copied to another location.

3. When adding recovered virtual machines to the virtual machine inventory, the snapshot manager for the virtual machine will show at least one snapshot, which was taken during the creation of application-managed snapshot.
When restoring entire virtual machines, the recovered virtual machine is typically added to the virtual machine inventory. VMware vSphere will detect that the location of the virtual machine has changed and offers the option to maintain its current unique identifier or to assign a new one. In most cases, it is recommended to assign a new UUID; however, all other identity characteristics such as host name, active directory member attributes, and IP addresses on already-defined interfaces are maintained. Be aware that this might have side effects especially when the original virtual machine is still online on the same network segments.

For more information, consult HP LeftHand white papers on VMware vSphere and VMware’s documentation on how to restore, move, and migrate virtual machines.

**Recovery from Remote Copy**

If a volume has been replicated to another management group using Remote Copy, the data which resides in the snapshots can be easily accessed. To allow read and write access on remote volume, the remote volume needs to be turned into a primary volume—either manually in the volume properties (figure 40) or in the failover/-back wizards in the HP LeftHand Centralized Management Console. However, in most cases it is sufficient to recovery data from individual remote snapshot without going through the failover/-back procedure.

**Figure 41.** Changing the volume type to primary for a remote volume

To recover files from a remote snapshot, assigning the snapshot to a server connection with read/write access in the HP LeftHand Centralized Management Console (figure 41). This will make the data available to the server. Follow procedures outlined above in section “recovering single files manually in Microsoft Windows environment” or “recovering single files and virtual machines in VMware vSphere” to restore files to a new location. Note that remote snapshots are currently not supported with HP LeftHand Recovery Manager.
For more information, consult HP LeftHand product documentation on handling remote snapshots and Remote Copy.

**Summary**

This white paper described the snapshot technology used in HP LeftHand Storage, application integration with HP LeftHand Application-aware Snapshot Manager for Windows and vSphere, and how to recover from snapshots. Snapshots allow customers to be more flexible, not just to go back to a point-in-time representation of data, but also to quickly recover single items from snapshots with HP LeftHand Recovery Manager and for update and deployment tests.

**For more information**

To deploy HP LeftHand Storage in your environment and know about the best practices and other resources, visit [hp.com/go/lefthand](http://hp.com/go/lefthand).

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4AA4-3129ENW, Created October 2012