SQL Server on VMware
Availability and Recovery Options
# SQL Server on VMware

## Availability and Recovery Options

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1. Introduction

Running Microsoft SQL Server 2012 on VMware® vSphere® offers many options for database availability and disaster recovery utilizing the best features from both VMware and Microsoft. For example, VMware vSphere vMotion® and VMware vSphere Distributed Resource Scheduler™ (DRS) can help to reduce planned downtime and balance workloads dynamically, and VMware vSphere High Availability (HA) can help to recover SQL Servers in the case of host failure.

At the application level, all SQL Server features and techniques are supported on vSphere, including AlwaysOn Availability Groups, AlwaysOn Failover Cluster Instances, Database Mirroring, and Log Shipping. SQL Server 2012 high availability features can be combined with vSphere features to create flexible availability and recovery scenarios, applying the most efficient and appropriate tools for each use case.

The following table lists SQL Server 2012 availability options and their ability to meet various recovery time objectives (RTO) and recovery point objectives (RPO). Before choosing any one option, evaluate your business requirements to determine which scenario best meets your specific needs.

Table 1. SQL Server 2012 High Availability Options

<table>
<thead>
<tr>
<th>Technology</th>
<th>Granularity</th>
<th>Storage Type</th>
<th>RPO – Data Loss</th>
<th>RTO – Downtime</th>
</tr>
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<tbody>
<tr>
<td>AlwaysOn Availability Groups</td>
<td>Database</td>
<td>Non-shared</td>
<td>None (with synchronous commit mode)</td>
<td>~3 seconds or Administrator Recovery</td>
</tr>
<tr>
<td>AlwaysOn Failover Cluster Instances</td>
<td>Instance</td>
<td>Shared</td>
<td>None</td>
<td>~30 seconds</td>
</tr>
<tr>
<td>Database Mirroring</td>
<td>Database</td>
<td>Non-shared</td>
<td>None (with high safety mode)</td>
<td>&lt; 3 seconds or Administrator Recovery</td>
</tr>
<tr>
<td>Log Shipping</td>
<td>Database</td>
<td>Non-shared</td>
<td>Possible transaction log</td>
<td>Administrator Recovery</td>
</tr>
</tbody>
</table>

This document provides a description of the following topics:

- vSphere Platform Advantages.
- Increase Availability Across the SQL Server Lifecycle.
- Local Site Availability Options.
- Remote Site Availability Options.
- Backup and Restore Options.
- Patch Management Options.
- Best Practices and Deployment Considerations.
2. vSphere Platform Advantages

Although application-level clustering has been the prevalent solution for most SQL Server implementations, features of the vSphere platform can enhance the overall availability of SQL Server by providing options that help to limit both planned and unplanned downtime. In fact, for many organizations, the features provided by vSphere may satisfy the availability requirements of the business without needing to follow traditional clustering approaches. For other organizations that require greater availability, application-level clustering can be combined with vSphere features to create an extremely flexible environment, with options for failover and recovery at both the hardware and application levels. Some advantages of the vSphere platform include:

- **Virtual machines are portable** – This means that your SQL Server installation is no longer bound to a particular piece of hardware, which can enhance availability as follows:
  - Design decisions are no longer permanent – You can adjust your CPU and memory requirements on a running virtual machine with hot add (SQL Server 2008 or later, on Windows Server 2008 or later) or through a quick configuration change and reboot of the virtual machine (earlier versions of SQL Server).
  - Easily upgrade to newer hardware – As your application requirements change, easily move the SQL Server virtual machine to newer hardware to accommodate increased workloads.

- **Virtual machines are hardware independent** – Hardware independence means increased flexibility when designing both production and disaster recovery components. Cluster nodes and recovery servers can be virtualized, eliminating the need for identical hardware.

- **vSphere HA protects your server from hardware failure** – If your physical server or any critical component within the server fails for any reason, vSphere HA will automatically reboot the SQL Server virtual machine on another physical server, acting as a first line of defense against service outage. By combining vSphere HA with traditional clustering approaches, you can mitigate both hardware and software failures for maximum availability.

- **vSphere DRS can balance workloads and speed recovery** – As application workloads increase, DRS can move a bottlenecked virtual machine to another host with more available resources automatically and without downtime. DRS can also help to recover more quickly after server hardware failure. For example, if a physical server fails, vSphere HA reboots the virtual machine on another physical server. When the failed server is replaced, DRS migrates the virtual machine back to its original location with no downtime and no interruption to the end user.

- **VMware vSphere Storage DRS™ in vSphere 5.x allows for intelligent initial placement and on-going space and load balancing of virtual machines based on disk latency and storage capacity. vSphere Storage DRS continuously monitors storage space and I/O utilization across a pre-assigned pool of datastores and intelligently aligns storage resources to meet your business growth objectives. With Storage DRS, you can specify how storage resources are allocated to virtual machines with rules and policies. When one or more datastores in a datastore cluster exceeds the user-configurable space utilization or I/O latency thresholds. Storage DRS uses Storage vMotion® to move one or more virtual machine disk files to achieve its goals without interruption to the SQL Server service.**

- **VMware offers consolidation opportunities** – Underutilized application and SQL Server components can be consolidated onto fewer physical servers for maximum hardware utilization and lower costs.
### 3. Increase Availability Across the SQL Server Lifecycle

The following sections describe how to simplify upgrades using VMware, and some of the performance and recovery advantages for SQL Server on VMware.

#### 3.1 Simplify Upgrades and Reduce or Eliminate Downtime

Traditional, physical environment upgrades and scale-up activities require significant resources, including:

- Planning and implementation time from engineering resources, including application administration, server administration, and SAN administration.
- Sizing and acquisition of new hardware.
- Downtime required to perform an upgrade, which results in higher costs and risks.

In comparison, scaling your environment using vSphere requires only adding more SQL Server virtual machines as the workload increases.

Physical SQL Server environments are tightly bound to a storage technology and are extremely difficult to scale. Adding more storage capacity to SQL Server virtual machines is less complex because vSphere virtualizes storage to a simple SCSI device. The end result is that the SQL Server environment can be upgraded regardless of the underlying storage technologies (iSCSI or Fibre Channel).

With VMware vSphere VMFS, the storage capacity serving SQL Server environments can be reduced or increased on the fly with the hot add/remove storage functionality in vSphere.

Virtualized SQL Server environments can be serviced (for example, adding more memory or upgrading CPU) without interruption with shared storage functionality from VMFS and vSphere vMotion.

#### 3.2 Performance and Recovery Advantages

Virtualized SQL Server environments can recover from the following events:

- Planned and/or unplanned hardware outages, using vSphere HA.
- Hardware degradation, by using the DRS capability to automatically balance workloads.
- Application failure, using SQL Server native availability features, such as SQL Server AlwaysOn.

With built-in multipathing capability and advanced queuing techniques available in virtual machine architectures, virtualized SQL Server environments can leverage advanced configuration options to achieve the following:

- Increase the IOPS or transactions to service more clients.
- Balance the workloads of multiple SQL Server virtual machines sharing the same physical server to use multiple SAN paths and storage processor ports.

High I/O, memory- and CPU-intensive applications such as SQL Server can better recover from SAN errors because the applications reside on VMFS, which hides SAN errors from guest operating systems.
4. Local Site Availability Options

When deploying SQL Server, the high availability options available in the physical environment continue to be available in a virtual environment. vSphere features that provide high availability and load distribution are also available to increase performance and speed recovery in the case of a host failure.

4.1 vSphere HA, vSphere DRS, and vSphere vMotion for High Availability

The following sections describe using vSphere HA, vSphere DRS, and vSphere vMotion in high availability scenarios.

4.1.1 vSphere HA

vSphere HA provides easy-to-use, cost-effective, high availability for applications running in virtual machines. In the event of physical server failure, affected virtual machines are automatically restarted on other production servers that have spare capacity. Additionally, if there is an operating system-related failure within a virtual machine, the failure is detected by vSphere HA and the affected virtual machine is restarted on the same physical server.

4.1.2 vSphere DRS

vSphere DRS collects resource usage information for all hosts and virtual machines, and generates recommendations for virtual machine placement. These recommendations can be applied manually or automatically. vSphere DRS can dynamically load balance all virtual machines in the environment by shifting workloads across the entire pool of vSphere hosts. This provides critical SQL Server virtual machines in the environment with the CPU and RAM resources needed to maintain optimal performance.

4.1.3 vSphere vMotion

vSphere vMotion leverages the complete virtualization of servers, storage, and networking to move a running virtual machine from one physical server to another. This migration is performed with no impact to running workloads or connected users. During a vSphere vMotion migration, the active memory and execution state of the virtual machine is rapidly transmitted over the network to the new physical server, all while maintaining its network identity and connections.

Example: Standalone SQL Server Virtual Machine with vSphere HA, vSphere DRS, and vSphere vMotion

Out of the box, vSphere features can help to protect your standalone SQL Server virtual machine from server host failure. vSphere HA automatically reboots your SQL Server virtual machine on another server if the current one fails, so your virtual machine can be restored to normal operation in the time that it takes to reboot the operating system and start the SQL Server services. After the original server hardware is fixed or replaced, DRS and vSphere vMotion can be used to quickly move the virtual machine back to its original vSphere host, with no additional downtime.
4.2 Application Aware vSphere HA

As of vSphere 4.1, an application programming interface (API) was introduced to provide third-party vendors with the ability to integrate with vSphere HA. Symantec was the first partner to develop an agent for providing application awareness within a vSphere cluster. The capability to allow application monitoring agents to interact with vSphere HA is enabled per vSphere cluster with additional configuration options available per virtual machine. When enabled, this feature allows application monitoring agents to send application heartbeats to vSphere HA. In the event of an application-level failure the application monitoring agent can take action either to bring the application back online, or to stop the application heartbeat, causing vSphere HA to initiate a restart of the virtual machine. Prior to vSphere 4.1, only VMware Tools™ heartbeats could trigger vSphere HA restarts.

Example: Standalone SQL Server with Symantec ApplicationHA

The Symantec ApplicationHA agent runs inside an SQL Server virtual machine to monitor the health of SQL Server resources. If a configured SQL Server instance or associated services become unavailable, the agent automatically detects it and tries to start the SQL Server services for a configurable number of attempts. If the SQL Server services do not start, the agent considers this to be an application failure and reports the status to vSphere HA. vSphere HA can then restart the virtual machine. After the virtual machine restarts, the agent starts the application services and brings the configured resources online on the system.

Symantec ApplicationHA fully integrates with vSphere HA and vCenter for monitoring and recovering an SQL Server service.
4.3 AlwaysOn Availability Groups

AlwaysOn is a collection of high availability and disaster recovery features introduced in SQL Server 2012 that minimize Recovery Point Objective (RPO), Recovery Time Objective (RTO), and maximize availability of database. SQL Server 2012 AlwaysOn includes a non-shared storage solution, AlwaysOn Availability Groups, and a shared storage solution, AlwaysOn Failover Cluster Instances.

AlwaysOn Availability Groups protect databases and allow multiple databases to fail over as a single unit, and provide support for the following:

- One primary database replica and up to four secondary database replica targets.
- Mixed of synchronous and asynchronous data replication between primary and multiple secondary replicas.
- Multiple databases in a single failover unit.
- Offload backup to secondary.
- Ability to read from secondary replicas.
- Faster application failover is provided by availability group listeners.
- Flexible failover policy with Windows Server Failover Clustering (WSFC).

The AlwaysOn Availability Groups feature is built on non-shared disk architecture. Each availability group replica has its own copy of the database. Log streams are replicated from the primary to the secondary replicas either synchronously or asynchronously. Up to two synchronous replicas are allowed. AlwaysOn Availability Groups uses Windows Server Failover Cluster (WSFC) for failover policy or quorum management. Each availability group replica is also a WSFC node.

Note Although WSFC is required by AlwaysOn Availability Groups, there is no requirement for using shared disk.

Figure 2. Windows Server Failover Cluster
VMware availability features such as vSphere vMotion, vSphere HA, and vSphere DRS are fully compatible with AlwaysOn Availability Groups. With vSphere vMotion, host hardware can be taken down for service at any time without interruption to the availability group session. vSphere HA quickly reboots an SQL Server virtual machine and rejoins a replica to the AlwaysOn Availability Group session if an unexpected hardware failure occurs.

**Example: vSphere HA, vSphere vMotion with AlwaysOn Availability Groups to Maximize Availability**

The AlwaysOn Availability Groups feature is a non-shared disk solution that can be deployed on VMFS or RDM. You may achieve better than physical availability by running AlwaysOn Availability Groups with vSphere HA, and vSphere vMotion.

In a planned maintenance scenario, vSphere vMotion can be used to move an availability group replica from a host to be serviced without requiring a failover. With an unplanned failure, your SQL Server environment could be vulnerable to further failures during the time between loss of a replica and its restoration. Resynchronizing the replica could take substantial time. vSphere HA helps to alleviate these issues by restarting the failed replica on another available host in the vSphere cluster. This quickly restores full protection to the database and reduces the amount of time spent in the failover state.

**Figure 3. vSphere HA, vSphere vMotion with AlwaysOn Availability Groups to Maximize Availability**

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4.4 **AlwaysOn Failover Cluster Instances**

In SQL Server 2012, the AlwaysOn Failover Cluster Instances feature is built on Windows Server Failover Cluster (WSFC) technologies to provide high availability protection for SQL Server at the instance level. In SQL Server 2012, using an FCI enhances SQL Server failover clustering as compared with earlier versions by providing built-in support for multisite clustering across a subnet.

Using an FCI is the SQL Server high availability solution that is built on a shared storage architecture. A single instance of SQL Server is installed across multiple WSFC nodes within a local network, or across multiple subnets. A single copy of the data is shared among all nodes. The SQL Server instance can run on a single node within the cluster at any point in time. The active instance takes ownership of the data. If the active node experiences hardware or software failure, a passive node takes over the ownership of the data.

**Figure 4. Microsoft Failover Clustering**

<table>
<thead>
<tr>
<th>Normal Operation</th>
<th>Cluster Failover</th>
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</thead>
<tbody>
<tr>
<td>Failover Cluster (2-node, active/passive)</td>
<td>Failover Cluster (2-node, active/passive)</td>
</tr>
</tbody>
</table>

**Example: vSphere HA/Administrator Recovery with SQL Server Failover Clustering**

Microsoft failover clustering protects the SQL Server at the instance level rather than at the database level. One SQL Server instance serves as the primary or active node, while the other serves as a passive node. Both nodes are connected to a shared disk architecture, whereby only one node is accessing/updating the data at any given time.

vSphere vMotion cannot be used for Microsoft failover cluster nodes running on a host’s Fibre Channel storage network. However, a cold migration is possible when executed manually by an administrator. This quickly restores full protection to the database and reduces the amount of time spent in the failover state. As of vSphere v4.1, using vSphere HA with Microsoft failover clustering is a supported configuration.


Figure 5. vSphere HA/Administrator Recovery with Microsoft Failover Clustering

4.5 SQL Server Database Mirroring

The database mirroring option provides complete protection against data loss and fast recovery through automatic failover. Database mirroring maintains a redundant database by shipping log streams to a mirror server.

Use database mirroring when you need to maintain multiple copies of your data and to create a warm standby of your SQL Server database environment. You should note that SQL Server database mirroring is performed at the database level. Only user databases can be mirrored. This can give you flexibility over SQL Server failover clustering in that you do not need to include all of your databases in the instance because you can choose which databases to mirror. Also, there is no single point of failure, as with SQL Server failover clustering where storage can become unavailable or corrupted. Database mirroring operates in the following modes:

- High safety mode with automatic failover.
- High safety mode without automatic failover.
- High performance mode.
4.5.1 High Safety Mode with Automatic Failover

A principal server, mirror server, and witness server are required. This mode sets the transaction safety to FULL, using synchronous I/O between the principal and mirror servers. The principal server waits for an acknowledgement from the mirror server that the shipped transaction has been applied on the mirror server. In the event of failure at the principal server, the witness server forms a quorum and fails over to the mirror server. You do not lose any data as a result of the transaction safety mode being configured as FULL.

4.5.2 High Safety Mode without Automatic Failover

A principal server and mirror server are required. Transaction safety mode is set to FULL. This uses synchronous I/O between the principal and mirror servers. In the event of a failure of the principal server, you must manually fail over to the mirror server as there is no witness server to form a quorum and automate failover.

4.5.3 High Performance Mode

A principal server and a mirror server are required. Transaction safety is set to OFF, and as a result, asynchronous I/O is used between the principal and mirror servers. In this mode, the principal server does not wait for an acknowledgement from the mirror server that all transactions have been recorded on the mirror server. The client application gets a confirmation that a transaction has been committed as soon as the principal server writes the transaction to the log. In the event of failure or unavailability of the principal server, you must manually fail over to the mirror server. There is the possibility of data loss as some transactions might be “in flight” during the failure of the principal server.

Figure 6. SQL Server Database Mirroring

VMware availability features such as vSphere vMotion, vSphere HA, and vSphere DRS are fully supported in combination with database mirroring, offering the greatest level of protection for your SQL Server virtual machines. With database mirroring, you can eliminate a single point of failure in storage by locating the mirrored data on another physical array.
Example: vSphere HA with SQL Server Database Mirroring for Faster Recovery

Database Mirroring can be combined with vSphere HA to provide the maximum in SQL Server protection and flexibility. If configured in High-Safety Mode, log streams are replicated synchronously from the active database to one or more passive database copies which are kept in real-time lockstep with the active database. Upon SQL Server or operating system failure, the environment can be failed over to the mirrored database copy. If configured with Automatic Failover, failover to a mirrored database copy is automatic, facilitated by a server role known as the witness.

During the time between loss of a node and its restoration, your SQL Server environment is vulnerable to further failures. Resynchronizing the mirrored nodes could take substantial time after the failed node is restored. vSphere HA helps to alleviate this issue by restarting the failed primary node on another available host in the vSphere cluster. This quickly restores the database to full protection and reduces the amount of time spent in the failover state.

Database mirroring can also be safely used in combination with vSphere vMotion, HA, and DRS.

Figure 7. vSphere HA with SQL Server Database Mirroring for Faster Recovery
4.6 Log Shipping

The *log shipping* availability option typically provides lower-cost automated transaction log backup and restore functionality, which provides redundancy at the database level. SQL Server provides the underlying framework for doing automated backup, copy, and restore of transaction log files. SQL Server 2008 provides a sub-minute scheduling interval that enables quick backup and restores. Backups are performed on the primary SQL Server instance and restore is performed on secondary SQL Server instances. Scheduling is done through SQL Server Agent jobs.

As an availability strategy, the log shipping option does not provide any automatic failover capability and may allow some data loss, but the time synchronization interval is configurable, which gives users some level of control. (This data loss can occur due to transaction log data that was corrupted, missing, or possibly not sent to the backup log file on the secondary server.) Log shipping can be used in conjunction with failover clustering to provide good site failure redundancy with a low-cost solution.

You can use SQL Server log shipping to create multiple copies of your databases that can be used as a warm standby for recovery, or to provide a database that can be used for reporting and to offload reporting and query functions from the primary server, thereby improving overall performance and providing a better end-user experience of the production SQL Server.
5. Remote Site Availability Options

Incorporating disaster recovery has become a leading business objective for new deployments and upgrades. For protecting a single business critical application from disaster, it is ideal to leverage built-in solutions. Some environments require application- and hardware-agnostic methods for protecting their mission critical applications and data. Deploying on vSphere provides the flexibility to meet all of these requirements.

5.1 VMware vCenter Site Recovery Manager

VMware vCenter™ Site Recovery Manager™ makes disaster recovery rapid, reliable, manageable, and affordable. By using VMware vSphere Replication or third-party storage-based replication technology, vCenter Site Recovery Manager delivers centralized management of recovery plans, enables automation of the recovery process, and dramatically improved testing of recovery plans. It transforms the complex hardcopy run books associated with traditional disaster recovery into an integrated element of virtual infrastructure management. vCenter Site Recovery Manager enables organizations to take risk and worry out of disaster recovery—yet another reason the VMware virtualization platform is the safest platform for datacenter applications.

Figure 8. VMware vCenter Site Recovery Manager
Example: vCenter Site Recovery Manager with AlwaysOn

Using SQL Server AlwaysOn solutions within the datacenter to provide high availability may meet the requirements of most organizations. With AlwaysOn, a failover can occur automatically at the instance or database level and can take place within a few seconds of a detected failure. When designing a disaster recovery solution, automated failover is usually not a desirable feature. In many cases, a DR facility is designed with a lower SLA and has a slightly delayed version of data than the production facility. Making the choice to activate the DR facility should be a conscious decision that follows an organization’s change process. With a vCenter Site Recovery Manager and storage replication solution, disaster recovery can be implemented to protect the entire virtual datacenter, including SQL Server. vCenter Site Recovery Manager provides you with the flexibility to customize the recovery plan, and an AlwaysOn session can be restored on a secondary datacenter with simple scripting. Failover testing can be accomplished with no production impact to confirm that the recovery time and recovery point objectives are being met.

Figure 9. vCenter Site Recovery Manager with SQL Server Database Mirroring
5.2 SQL Server 2012 AlwaysOn Availability Group for HA and DR

With SQL Server 2012 AlwaysOn Availability Group’s new capabilities for supporting multiple replicas for a mixture of synchronous and asynchronous data replication between primary and multiple mirrors, the AlwaysOn Availability Groups feature is an ideal solution for building high availability and disasters recovery solution in vSphere.

Example: SQL Server 2012 AlwaysOn Availability Group for HA and DR

This is a purely non-shared storage solution. The primary datacenter hosts two availability replicas in synchronous commit mode for high availability. The secondary datacenter hosts one replica, running in asynchronous mode for disaster recovery protection. vSphere HA is used in both production and DR sites to protect virtual machines from host failure and to facilitate rapid recovery.

The architecture allows for variations to this topology using multiple datacenters as well as multiple replicas (up to five).

Figure 10. SQL Server 2012 AlwaysOn Availability Group for HA and DR

5.3 SQL Server Log Shipping with SQL Server Database Mirroring

For a description of Log Shipping, see section 4.6 Log Shipping.

Example: SQL Server Log Shipping with SQL Server Database Mirroring

Log shipping can be used to provide off-site disaster recovery capabilities in addition to the local site high availability you get from database mirroring. In the production site, database mirroring is configured in High Safety Mode with Automatic Failover, allowing the system to recover from application failure. Log shipping is configured to replicate lagged copies of the databases to a standby SQL Server installation running at the DR site. Because the logs are sent asynchronously to the recovery server, there is some possibility of data loss in the case of site failure. vSphere HA is used in both production and DR sites to protect virtual machines from host failure and facilitate rapid recovery.
Figure 11. SQL Server Log Shipping with SQL Server Database Mirroring

Normal Operation

- Logs are shipped to recovery target periodically
- Recovery VMs are active/running

Failover Operation

- Administrator manually activates the recovered databases
- Databases will come online
- Administrator can manipulate logs to adjust recovery point
- Redundancy lost until new passive databases are established
6. Backup and Restore Options

The feature set available to an application, when deployed in a virtual environment, is no different than what is available with a physical deployment. In fact, there are more options available for protecting entire virtual machines. This is especially useful for applications that require extensive configuration. For SQL Server, the standard methods for backup are supported. These tend to be deployed using a third-party backup agent that uses a VSS requestor to coordinate with the VSS writer to prepare the database files for backup. Regardless of the backup solution required, VMware and VMware partners have provided solutions for most situations.

6.1 In-Guest Software Solutions

Many organizations have dedicated backup support teams or requirements that might not allow them to integrate the backup solution to the level that is available with vSphere. In these situations, traditional backup methods are used, and a virtualized environment allows that. Many of the leading backup software providers are VMware partners and provide full support for using their backup solutions within a virtualized guest operating system. Backup administrators can continue to deploy and manage the backup agents, jobs, and restores as though they were running on physical systems.

6.1.1 Example: In-Guest SQL Server-Aware Backup Solution

Centralized backup management software controls the backup schedule, save set, and target location for all systems virtual and physical. The backup agent software loaded within the guest operating system allows the virtual machine guest operating system to be managed the same way as all other systems. Additional plug-ins from backup software vendors provide application-aware support.

![Figure 12. In-Guest SQL Server-Aware Backup Solution](image)
6.2 VMware Data Recovery

VMware Data Recovery protects your data at the virtual machine level, capturing application and system data as a full virtual machine image. Data Recovery runs at the vSphere host level as a virtual appliance to provide streamlined deployment and full integration with VMware vCenter Server™. Data Recovery stores multiple restore points for each virtual machine using deduplication technology to provide point-in-time restore capabilities, and use available disk space efficiently.

**Figure 13. VMware Data Recovery Backup Process**

![Backup Process Diagram](image)

**Figure 14. VMware Data Recovery Restore Process**

![Restore Process Diagram](image)
With vSphere v4.1 and above, Data Recovery supports VSS (Microsoft Volume Shadow Copy Service) for SQL Server with the following conditions:

  - (no additional conditions)
  - The UUID attribute must be enabled. This is enabled by default on virtual machines created on vSphere 4.1 or later hosts. For virtual machines created on older hosts, refer to http://www.vmware.com/pdf/vdr_12_admin.pdf for enabling Application Consistent Quiescing.
  - The virtual machine must use only SCSI disks. For example, application-consistent quiescing is not supported for virtual machines with IDE disks.
  - The virtual machine must not use dynamic disks.

### 6.2.1 Considerations for Using VMware Data Recovery

When evaluating Data Recovery as the backup solution for the SQL Server environment, consider the following vSphere and SQL Server limitations.

Recovery is supported on vSphere for use with the following:

- VMDK- or RDM-based deduplication stores of up to 1TB, or CIFS-based deduplication stores of up to 500GB.
- Backing up virtual machines that are protected by VMware vSphere Fault Tolerance.
- Backing up virtual machines with third-party multipathing enabled where shared SCSI buses are in use.
- Raw device mapped (RDM) disks in physical compatibility mode in virtual machines to be backed up.

Data Recovery supports SQL Server VSS Writer non-component-based backup as follows:

- Only databases in simple recover mode are supported.
- Log backups are not supported.
- File and filegroup backup are not supported.
- Page restore is not supported.

Carefully evaluate the business requirements for your SQL Server applications. While Data Recovery can be a good solution for some SQL Server workloads, it might not fit the needs for a Tier 1 mission-critical SQL Server system.

### 6.3 Array-Based Backup Solutions

As is the case with the in-guest solutions, array-based solutions provided by many of the leading storage vendors continue to work with vSphere deployments of SQL Server. Array-based backup solutions for SQL Server use the Volume Shadow Copy Service (VSS) to produce near-instant, application-aware clones or snapshots of SQL Server databases. These local clones or snapshots can then be backed up to disk, tape or cloned off-site for disaster recovery purposes. Guidance on proper deployment methods and any additional considerations when running in a virtualized environment must be provided by the storage vendor. VMware can provide a comprehensive list of ISV partners that provide array-based replication of SQL Servers for backup and restore operations.
### 6.3.1 Example: Array-Based SQL Server-Aware Backup Solution

**Example: Array-Based SQL Server-Aware Backup Solution**

An array-based backup solution provides integration with the SQL Server application and the underlying storage solution. A software agent provided by your backup vendor coordinates with the SQL Server VSS writers to create a supported backup image of your SQL Server databases. These databases can later be streamed to tape as flat files for compliance or archive requirements with no I/O impact to the production data.

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**Figure 15. Array-Based SQL Server-Aware Backup Solution**

![Array-Based SQL Server-Aware Backup Solution Diagram]
7. Patch Management Options

Applying SQL Server critical fixes or service patches causes application downtime. The following sections discuss SQL Server and vSphere capabilities that reduce downtime for patching an SQL Server.

7.1 Rolling Upgrade using SQL Server Native Features

Some SQL Server native availability features, such as AlwaysOn Availability Groups, Failover Cluster, and Database Mirroring, support rolling upgrades and patching of SQL Server. You can apply a service pack or critical fix to the passive nodes or secondary replicas. After the installation is complete on all passive nodes or secondaries, you can conduct a manual failover and apply the service pack or critical fix to the primary. Refer to the following Microsoft documentation on the rolling upgrade process:

- Minimize Downtime for Mirrored Databases When Upgrading Server Instances.  
- How to: Upgrade a SQL Server Failover Cluster Instance (Setup).  

7.2 Rolling Upgrade Using a Standby Virtual Machine

To minimize downtime for applying SQL Server patches without AlwaysOn Availability Groups, Failover Cluster, or Database Mirroring, you can create a rolling patch upgrade solution by using a standby virtual machine.

With VMware vSphere, a virtual disk can be hot removed or hot added onto a virtual machine without impacting services running in the virtual machine. You can create a rolling patch upgrade solution similar to the SQL Server failover cluster shared-everything architecture by using a standby virtual machine. This custom solution consists of a primary and standby virtual machine pair with identical software images, the set of VMDKs containing the database data and log files. The VMDKs are owned by the primary virtual machine. When a patch upgrade is needed on the primary virtual machine, the VMDKs can be hot removed from the primary virtual machine and hot added to the standby virtual machine, and the standby virtual machine can take over the primary role to continue servicing application requests.
The following procedure describes the steps and process flows for this kind of rolling patch upgrade using a standby virtual machine.

**To configure a standby virtual machine and perform a rolling patch upgrade**

1. Configure the standby virtual machine, as follows:
   a. Create a standby SQL Server virtual machine, if one does not yet exist, using VMware templates or cloning technologies.
   b. Confirm that SQL Server login, job, and other instance level configurations are identical between the standby and primary virtual machine.

2. Apply service patches to the standby SQL Server virtual machine.
3. Hot remove SQL Server resources from the primary virtual machine, as follows:
   a. On the primary virtual machine, stop client connections to the databases. One way to accomplish this is to disable the virtual machine network interface. A connection to the virtual machine can be made using a management interface for Remote Desktop Services, or with a VMware vSphere Client™ console connection.
   b. Detach the databases from the primary SQL Server by issuing the `sp_detach_db` T-SQL command.
   c. From Windows Disk Management, right-click the data and log volumes and select **Offline** to prepare them for hot remove.
   d. From the VMware vSphere client, remove SQL Server data and log virtual disks from the running primary SQL Server virtual machine.
4. Hot add resources to the SQL Server standby virtual machine, as follows:
   a. From the vCenter client, add the virtual disks containing the SQL Server data and log files to the standby virtual machine.
   b. From Windows Disk Management, bring the disks online if needed and confirm that the disks are mounted with the correct drive letters assigned.
   c. Attach SQL Server databases by issuing the `create database...for attach` T-SQL commands.
5. Switch roles of the virtual machines, as follows:
   a. On the standby virtual machine, enable application network traffic to the virtual machine.
   b. The old standby virtual machine is the new primary, and SQL Server service is resumed for the applications.
   c. The old primary virtual machine is ready for service patching and may be left in the standby role if desired until the next patch cycle.

   ![Diagram of SQL Server and ESX/ESXi](image)

   During steps 3 through 5, applications experience temporary connection issues to the SQL Server. Similar to the failover clustering or database mirroring requirements, reconnection is expected to be handled by the application layer, with zero data loss, and any in-flight transactions would need to be resubmitted. All operations in steps 3 through 5 are metadata only operations, and are expected to execute instantaneously.
8. **Best Practices and Deployment Considerations**

When deploying SQL Server on vSphere with high availability features, consider the following guidelines to increase the availability and performance of your deployment.

### 8.1 Cluster Virtual Machine Placement

vSphere HA and DRS automatically manage virtual machine placement under system failure or resource contention. When running clustered virtual machines in a vSphere HA or DRS environment, to avoid a single point of failure, cluster virtual machines should be kept apart on different physical hosts. The following practices can help to achieve this:

- Create a DRS anti-affinity rule to keep virtual machines on different hosts.
- Enable Strict Enforcement of Affinity Rules (MSCS).
- Set the DRS Automation Level for MSCS virtual machines.


### 8.2 EagerZeroedThick Disk

Virtual machine disk files can be deployed in three different formats: thin, thick, or eagerzeroedthick. Thin and thick disk files use lazy zeroing where the initial zeroing of the disk is delayed until the first write. An eagerzeroedthick disk on the other hand pre-allocates and zeros the disk at the time of disk provisioning. Therefore, it is unnecessary to zero the disk during run time.

Given that most SQL Server high availability features are highly sensitive to system response time, the overhead for disk zeroing during runtime may cause a false cluster failover. If you are deploying AlwaysOn Availability Groups, failover cluster instances, or Database Mirroring, consider using eagerzeroedthick disks for SQL Server data, transaction log, and tempdb files.

### 8.3 Network Considerations

The network is a critical component required for cluster node communication. For SQL Server cluster solutions, a private heartbeat network is required for cluster "keep-alive." SQL Server non-shared disk high availability solutions, such as AlwaysOn Availability Groups, also use the network to manage data replication between replicas. In synchronous replication mode, the performance of SQL Server is highly dependent on the network bandwidth and latency. Consider the following network configuration guidelines for optimal performance:

- Install enough network adapters to separate networks used for different purposes. For example, separate network for data replication, heartbeat, vSphere vMotion, VMkernel and so forth.
- If using iSCSI, the network adapters should be dedicated to either network communication or iSCSI, not both.
- Use the VMXNET3 paravirtualized NIC. VMXNET3 is optimized for virtual environments and designed to provide high performance.
- Enable jumbo frames for the iSCSI or vSphere vMotion network.
- Follow Microsoft guidelines for configuring private "heartbeat" network. See [Recommended private "Heartbeat" configuration on a cluster server](http://support.microsoft.com/kb/258750).

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• Use static IP addresses for network interfaces managing client connections and heartbeat links in a Microsoft Windows server cluster. Using a dynamic configuration through DHCP is not recommended, as the failure to renew a DHCP lease could disrupt cluster operations. See Cluster may fail if IP address used from DHCP server (http://support.microsoft.com/kb/170771).

• If deploying AlwaysOn Availability Groups in synchronous commit mode or database mirroring in high safety with automatic failover mode, a high speed network should be used for replication traffic. Confirm that the bandwidth and latency of the network is sufficient for supporting the amount of SQL Server transaction traffic.

8.4 Database Recovery Mode

SQL Server non-shared disk high availability solutions such as AlwaysOn Availability Groups, database mirroring, and log shipping uses log steam or log record replication technologies for database redundancy. Full recovery mode must be enabled on the database for these solutions. Log truncation does not happen until a log backup. Sufficient disk space must be planned to allow for transaction log growth.

8.5 Impacts of Readable Secondary

With SQL Server 2012 AlwaysOn Availability Groups, a secondary replica can be made readable. Read-only access to secondary replicas is useful if your read-only workloads can tolerate some data latency. In situations where data latency is unacceptable, consider running read-only workloads against the primary replica.

When a secondary replica is configured for read access, the read-only workloads on the secondary replica consume system resources, such as CPU, memory, and I/O, from the read queries as well as the redo threads. The workload on the secondary often is completely different than the workload on the primary. The read-only queries are generally more analytical in nature. Analytics queries typically generate a high number of sequential large block I/Os, and do more aggregation operations that consume a large amount of CPU and memory. Analytics queries can also benefit from parallel processing threads. Because the workload on a readable secondary often is completely different than the workload on the primary, additional indexes might be necessary to get to optimal query plans. If the read-only workload executed against a secondary replica requires additional indexes, those would need to be created on the primary replica to get transferred subsequently to the secondary replica. Sufficient disk space should be planned to accommodate the additional indexes.

Consider the impact of enabling read access on a secondary replica, as well as the characteristics of a read-only workload when capacity planning. A readable secondary replica could potentially demand more resources than the primary.

8.6 Tempdb Considerations

Tempdb is the temporary work space for SQL Server. Tempdb is re-created every time SQL Server is started so that the system always starts with a clean copy of the database. There is never anything in tempdb to be saved from one session of SQL Server to another.

8.6.1 Optimize with Device Separation

Given the nature of tempdb, there is no need to include tempdb in a virtual machine level backup, or replicate tempdb in a multisite DR solution. Consider placing tempdb on its own dedicated VMDK to exclude tempdb from any unnecessary operations.
8.6.2 Capacity Planning

When deploying AlwaysOn Availability Groups with a readable secondary, consider the tempdb space increase due to the following:

- Snapshot isolation level copies row versions into tempdb.
- Temporary statistics created by SQL Server on secondary databases.

SQL Server automatically enables snapshot isolation level when a secondary is set to readable. A 14 byte overhead is added to the row on the primary if a row version was not already enabled. A 14 byte overhead is also added to the row on the secondary replica. Additionally, a row version is generated by REDO thread on tempdb of the secondary replica as it processes the UPDATE/DELETE operation from the primary.

Because the workload on a readable secondary is often completely different than the workload on the primary, additional indexes and column statistics might be necessary to get to optimal query plans. SQL Server 2012 automatically creates additional column statistics and stores them in tempdb of the readable secondary replica.

Tempdb is an SQL Server instance level resource. If you configure multiple databases as a single failover unit, the capacity of the tempdb should be able to accommodate demands from the aggregate of databases.

8.7 Client Connectivity

When deploying SQL Server 2012 AlwaysOn Availability Groups, you have a better way to connect your applications with the SQL Server. You can connect your application to the database replica using an availability group listener. An availability group listener is a virtual network name (VNN) that directs read-write requests to the primary replica and read-only requests to the read-only secondary replica. Always create an availability group listener when deploying AlwaysOn Availability Groups on vSphere. That enables application clients to connect to an availability replica without knowing the name of the physical instance of the SQL Server installation. The application connection string does not need to be modified in case of a failover.

Refer to Prerequisites, Restrictions, and Recommendations for AlwaysOn Client Connectivity (SQL Server) (http://technet.microsoft.com/en-us/library/ff878487.aspx) for additional information on creating an availability group listener.

8.8 Considerations for Quorum Mode

Quorum is extremely important for any high availability solution. If you deploy any of the SQL Server 2012 AlwaysOn solutions, you can take advantage of the newer quorum models in Windows Server 2008 or later.

The Quorum models are as follows:

- Node Majority quorum mode – This model requires an odd number of nodes. This is less common.
- Node and Disk Majority quorum mode – This is a combination of Node and Quorum disk. This Quorum Model requires using RDM for the Quorum disk. This is not ideal for the vSphere environment due to the limitations of RDM disks.
- Node and File Share Majority quorum mode – This model uses a combination of Node and File Share as witness. This is recommended for deploying AlwaysOn on vSphere.
- No Majority: Disk Only quorum mode – This is the traditional Windows Server 2003 Quorum Disk Model. VMware recommends discontinuing use of this Model.

Refer to Appendix B: Additional Information About Quorum Modes (http://technet.microsoft.com/en-us/library/cc770830(WS.10).aspx) for additional details of the quorum models.
Each customer environment is different, so depending on your particular deployment scenario, you might choose different Quorum model. The node majority and the node and file majority modes do not require RDM disk for disk quorum, which would provide better flexibility and compatibility with vSphere. vSphere vMotion, DRS, and HA features are fully supported if you deploy AlwaysOn Availability Groups with these quorum modes.


### 9. Additional Information

vSphere offers many tools and features to increase the availability of SQL Server 2012. vSphere vMotion, vSphere HA, DRS, and Storage DRS can help to reduce downtime and improve flexibility in your application architecture while lowering costs. In some cases, VMware and SQL Server features can be combined to improve overall availability. However, consider the following when architecting a solution:

- AlwaysOn Availability Groups and database mirroring can be used in combination with vSphere vMotion, vSphere HA, and DRS to maximize SQL Server availability.
- vSphere vMotion cannot be used for Microsoft failover cluster nodes running on a host Fibre Channel storage network.
- As of vSphere 5.1, the number of nodes supported for SQL Failover Cluster increased to five. See *Microsoft Clustering on VMware vSphere: Guidelines for Supported Configurations* ([http://kb.vmware.com/kb/1037959](http://kb.vmware.com/kb/1037959)).