Microsoft Cross-Site Disaster Recovery Solutions

*End-to-End Solutions Enabled by Windows Server 2008 Failover Clustering, Hyper-V, and Partner Solutions for Data Replication*

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**Introduction**: This white paper describes various end-to-end disaster recovery solutions for Windows virtualized environments. These solutions are enabled by Windows Server 2008 Failover Clustering, Hyper-V technology, and partner solutions for data replication. These solutions demonstrate automated failover capabilities in a geographically dispersed virtualized Microsoft environment.
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Executive Summary

This white paper discusses how organizations can build effective and highly available disaster recovery (DR) solutions using Microsoft virtualization and failover capabilities complemented with partner data replication products. It showcases various available end-to-end disaster recovery solutions for different scenarios. Each scenario enables organizations to select a Microsoft partner product to provide cross-site data management and replication that is appropriate for a company’s particular environment. The solutions discussed in this document are generic approaches for structuring DR solutions in a geographically dispersed Hyper-V environment with the help of clustering.

The solutions discussed are intended to provide disaster recovery solution configuration examples that customers can use to evaluate and select end-to-end disaster recovery solutions that best fit their needs. However, this white paper is not intended to be an exhaustive study of specific architectures for every environment. To evaluate specific data center disaster recovery requirements, please contact a Microsoft sales representative.

This paper is written for those who have a working knowledge of Windows Server 2008 and virtualized Windows Server environments. This paper also assumes that the reader understands replication and clustering terminology.

Introduction

For Information Technology (IT), mitigating the risks to critical data, systems, and applications (in addition to computing infrastructures in the event of system outages or complete disasters) presents an ongoing challenge from both a technological and a business perspective. Organizations need to consistently find solutions that not only meet application and data requirements for capacity, performance, and availability, but also have proven return on investment (ROI) and cost reduction capabilities.

Virtualization has been a game changer for many companies. It has allowed companies that previously were unable to afford DR to begin implementing DR solutions. Virtualization has also enabled companies to justify costs by providing full DR for additional applications. In addition, it has provided more flexible options for effective DR.

The business challenge is to acquire the ability to create a cost-effective, highly available, and protected virtual server infrastructure. This infrastructure needs to make certain that applications meet business-defined service-level agreements (SLAs) for availability and disaster recovery preparedness. This white paper discusses several options that meet these requirements.

Windows Server 2008 Failover Clustering and Hyper-V technology, coupled with partner data replication solutions can be used to build end-to-end robust, highly available, and cost-effective DR solutions. In order to understand these solutions, key business continuity planning and DR concepts, as well as the key technical components of the solutions, need to be understood.
Key Concepts

Business continuity planning is the ability to minimize scheduled and unscheduled downtime for IT systems in an organization. Hyper-V™ technology from Microsoft includes powerful business continuity features, such as live migration, which enable businesses to deliver rigorous uptime and response service levels.

In order to minimize damage and quickly return to a normal operative state after a scheduled downtime or a disaster, good business continuity planning is required. An understanding of the systems that require protection and the required level of protection is necessary. This knowledge is usually formalized into a service-level agreement (SLA), which becomes the responsibility of the IT department to uphold. The SLA consists of recovery time objectives (RTO) and recovery point objectives (RPO), which are defined for each system that requires protection. The RTO is the duration of time and the service level that a business process must be restored to after a disaster or disruption in order to avoid unacceptable consequences associated with a break in business continuity. The RPO is the point in time when data must be recovered as defined by an organization.

DR is a key component of business continuity that facilitates IT operations resumption of key systems after a site level crisis per the SLA as shown in Figure 1 below. Hyper-V utilizes the clustering capabilities of Windows Server 2008 to provide support for disaster recovery within IT environments and across data centers, using geographically dispersed clustering capabilities.
In order to understand how DR can be optimized in a virtualized environment, it is important to understand some important technical aspects. These aspects include related server and replication functionality in a DR environment, which is described in the following sections.

**DR Server Functionality**

Clustering is a key server function in a DR environment. In addition to clustering, the addition of virtualization enhances DR capabilities and can improve DR performance. To be complete, a DR plan needs to include Multipath I/O support to ensure the high availability of the connected storage.

**Clustering**

Clustering is normally divided into three conceptual types: failover cluster, load balancing cluster, and grid computing. Microsoft has all three clustering capabilities in the Windows Server operating system. In this paper, failover clustering is the focus. Failover clustering is a very mature technology that can be used for mission-critical applications such as file and print servers, application servers, database servers, and so on. A cluster enables two or more servers to work together as a computer group. This can provide failover and increase the availability of the application and data in any situation. In the event of a primary node going down, failover software based on a heartbeat technique triggers an automatic restart of services on the secondary nodes of the cluster. There are two types of failover clustering: local clustering and stretch clustering.

- **Local Clustering**: With local clustering, all cluster participant nodes are at the same facility or data center and are physically coupled with the heartbeat link. This configuration can provide application failover, but cannot sustain hosting during downtime that affects the entire facility or data center. For example, if the whole data center is affected by a catastrophic event, the entire facility is subjected to downtime and does not provide maximum uptime. Still, local clustering is a preferred solution for applications that need to be failed over immediately. Authentication domain servers and financial transaction Web servers are examples of servers that can negatively affect the infrastructure if there is failover delay.

- **Stretch Clustering**: Stretch clustering or geographically dispersed clustering mitigates the issues involved with local clustering. When a primary site goes down due to natural or man-made disasters, local clustering is not enough to achieve the required uptime of mission-critical applications. If a specific site has clusters spanning different seismic zones, applications can be failed over to the secondary site that is unaffected by the primary site downtime. Stretch clustering writes data to both the primary storage system and the remote storage system. This extends the capabilities of a single failover cluster solution and guards against downtime with Windows Server Failover Clustering (WSFC) failover.

**Virtualization**

WSFC supports physical and virtual environments, including physical-to-physical, virtual-to-virtual, and physical-to-virtual configurations. By supporting virtual environments, the new functionality assists the DR solutions. For example, Windows Server 2008 R2 has extended its WSFC feature set with the Clustered Shared Volume
(CSV) feature. This feature enables concurrent access to the Virtual Hard Drive (VHD) files on a Logical Unit Number (LUN) of the CSV. This is highly beneficial during live migration. With concurrent access to the VHD files, there is no access delay in site disaster scenarios. This assists greatly in trimming down the RTO.

**Multipath I/O Support**

Windows Server 2008 R2 includes many enhancements for the connectivity of a computer running a Windows Server–class operating system to storage area network (SAN) devices. Among the enhancements that enable high availability for connecting Windows-based servers to SANs is integrated Multipath I/O (MPIO) support. Microsoft MPIO architecture supports iSCSI, fiber channel, and serial-attached storage (SAS) SAN connectivity by establishing multiple sessions or connections to the storage array.

Companies can take advantage of MPIO to implement an infrastructure for a reliable shared storage solution with built-in redundancy and tight integration of virtualization management capabilities. The Microsoft MPIO framework provides high availability and dynamic load balancing to SAN devices through a redundant network or fabric connections. Microsoft MPIO dynamically routes input/output (I/O) to the best path and protects against failures at any connection point between a Hyper-V host and shared storage, including NICs/adapter cards, switches, or array ports.

**DR Replication Functionality**

Microsoft partner data replication products help organizations to maintain consistent data sets between sites to avoid data loss during cross-site failovers. As existing data replication techniques support both fiber channel and Gigabit Ethernet technology, they can be easily integrated into any existing IT infrastructure without major modifications. Data replication modes are generally classified as synchronous replication or asynchronous replication. Both synchronous and asynchronous replication techniques can use either byte-level or block-level copy methods. Byte-level copy maintains a copy of the data on each node of the cluster and updates each copy as the data changes. Block-level copy gives continuous data protection that enables the data to be restored at any point in time, ensuring that the whole process of replication is quick and efficient. The following sections discuss synchronous and asynchronous replication in detail.

**Synchronous Replication**

With synchronous replication, the I/O updates in the cache at the remote storage array precede updates at the primary location. The remote storage array confirms the I/O completion to the primary site, which in turn initiates the process at the primary site. Thus, the writing application only receives a write-completed response from the storage system when the I/O write operation is completed at both the remote storage location and the local storage location. Its performance heavily depends on network bandwidth, network latency, and distance. For minimum delay of data round-trip time, network bandwidth should be high and distance and network latency should be low. This makes synchronous mirroring a viable replication solution only for shorter distances up to 100 miles. It also has the extra overhead of requiring faster network bandwidth. Synchronous remote mirroring enables the highest possible level of RPO and RTO.
Asynchronous Replication

In asynchronous replication, I/O is completed at the primary site without any acknowledgement requirement from the secondary site. The distance limitation of synchronous replication can be overcome in an asynchronous replication mode by delta set architecture that helps long-distance replication with customizable synchronization times. Delta sets are collections of writes that have occurred in a specific amount of time. Unlike the synchronous replication mode, hosts are not involved in the replication process that also helps to achieve better I/O performance on the hosts. Performance is greatly increased, but at the risk of potentially losing data. If the local storage is lost due to failure, asynchronous replication does not guarantee that the remote storage has the most current data copy. Therefore, the most recent data might be lost depending on the configuration and the circumstances.

Microsoft partner products available today support both synchronous as well as asynchronous replication modes along with byte-level or block-level copy modes to maintain data connectivity even during hardware, link, or complete hosting facility downtime. The user has the liberty to select a single storage vendor or a multi-storage vendor-based product, or a completely software-based product to deploy a DR-ready IT environment.

Microsoft DR Solution Components

When considering DR options, virtualization is a game changer. Virtualization makes DR affordable to companies that could not afford it before. Because it is cost effective, DR planning can be expanded further into the application pool to offer better service levels to more applications for which the investment was not previously justifiable. With Windows Server 2008, everything required to start using virtualization is available. Virtualization functionality is built right into Windows Server 2008 as the Hyper-V role.

The key Microsoft components of the DR solutions include:

- Windows Server 2008 with Hyper-V
- Windows Server Failover Clustering
- Microsoft System Center Virtual Machine Manager
Windows Server 2008 with Hyper-V

Hyper-V is the hypervisor-based virtualization technology from Microsoft that is integrated into all Windows Server 2008 x64 Edition operating systems. As a virtualization solution, Hyper-V enables users to take maximum advantage of the server hardware by providing the capability to run multiple operating systems (on virtual machines) on a single physical server.

The availability of Hyper-V as a role in a standard Windows operating system provides several key advantages:

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-in technology</td>
<td>Hyper-V enables enterprises to easily utilize the benefits of virtualization without adopting a new technology.</td>
</tr>
<tr>
<td>Broad device driver support</td>
<td>The new 64-bit micro-kernelized hypervisor architecture uses the broad device driver support in the Windows Server 2008 parent partition to extend support to a broad array of servers, storage, and devices.</td>
</tr>
<tr>
<td>SMP support</td>
<td>Hyper-V supports symmetric multiprocessors (SMP) in virtual machines.</td>
</tr>
<tr>
<td>Host high availability</td>
<td>Windows Server 2008 clustering provides high availability to virtual machines to minimize unplanned downtime.</td>
</tr>
<tr>
<td>Shared storage high availability</td>
<td>Microsoft MPIO dynamically routes I/O to the best path and safeguards against connection failures at any point between a Hyper-V host and shared storage, including NICs/adapters, switches, or array ports.</td>
</tr>
<tr>
<td>Easy virtual machine migration</td>
<td>Live migration capability to support business continuity during planned and unplanned downtime and over a distance.</td>
</tr>
<tr>
<td>Volume Shadow Copy Service (VSS)</td>
<td>Robust host-based backup of virtual machines by utilizing the existing Windows VSS-based infrastructure.</td>
</tr>
<tr>
<td>Easy extensibility</td>
<td>Easy extensibility using the standards-based Windows Management Instrumentation (WMI) interfaces and APIs.</td>
</tr>
<tr>
<td>Simplified integrated management</td>
<td>With its tight integration into the Microsoft System Center family of products, customers have end-to-end physical and virtual infrastructure management capability for Hyper-V environments.</td>
</tr>
</tbody>
</table>

Table 1. Hyper-V Features
Windows Server Failover Clustering

Failover clustering in Windows Server 2008 helps to ensure that mission-critical applications and services, such as e-mail and line-of-business applications, are available when required. Beyond the capabilities already mentioned in the previous stretch clustering section, some other important capabilities of WSFC for DR solutions include:

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>No single-subnet limitation</td>
<td>Enable cluster nodes to communicate across network routers. It is no longer necessary to connect nodes with virtual local area networks (VLANs).</td>
</tr>
<tr>
<td>Configurable heartbeat timeouts</td>
<td>Increase to extend geographically dispersed clusters over greater distances. Decrease to detect failures faster and take recovery actions for quicker failover.</td>
</tr>
<tr>
<td>Common toolset</td>
<td>Similar management experience to managing local cluster.</td>
</tr>
<tr>
<td>Automated failover</td>
<td>Automatic failover on complete disaster in one site.</td>
</tr>
<tr>
<td>VSS support</td>
<td>VSS support to back cluster settings.</td>
</tr>
<tr>
<td>Automation support</td>
<td>Automation support starting Windows Server 2008 R2 with Cluster PowerShell.</td>
</tr>
<tr>
<td>Cross-site replication tool combination</td>
<td>Mirrored storage between stretched locations. Seamless integration with partner hardware or software-based data replication solutions.</td>
</tr>
</tbody>
</table>

Table 2. Windows Server Failover Clustering Features

System Center Virtual Machine Manager

Microsoft System Center Virtual Machine Manager 2008 is enterprise-class management software that enables administrators to easily and effectively manage both the physical and virtual environments from a single management console and thus avoid the complexity of using multiple consoles typically associated with managing an IT infrastructure. The key capabilities of Virtual Machine Manager 2008 include:
<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise-class management suite</td>
<td>Manages both Hyper-V and VMware ESX virtualization environments.</td>
</tr>
<tr>
<td>Intelligent virtual machine placement</td>
<td>Supports intelligent placement of virtual machines.</td>
</tr>
<tr>
<td>System Center Operations Manager 2007 integration</td>
<td>Works with System Center Operations Manager 2007 to provide proactive management of both virtual and physical environments through a single console by leveraging Performance and Resource Optimization (PRO).</td>
</tr>
<tr>
<td>Native physical-to-virtual/virtual-to-virtual migration</td>
<td>Offers native capability for physical-to-virtual and virtual-to-virtual migrations.</td>
</tr>
<tr>
<td>Failover integration</td>
<td>Works with failover clustering to support the high availability and live migration of virtual machines.</td>
</tr>
<tr>
<td>Automation</td>
<td>Offers easy automation capabilities that utilize Windows PowerShell.</td>
</tr>
</tbody>
</table>

Table 3. System Center Virtual Machine Manager Features

System Center Virtual Machine Manager 2008 can be configured in multiple ways, depending on the implementation requirements. A basic configuration will have Virtual Machine Manager 2008 installed and running on a standalone server with local disks on the server as storage. Attaching a storage enclosure to the standalone server hosting Virtual Machine Manager is recommended if the deployment requires a relatively large library server. The library server is a capability built into Virtual Machine Manager for storing VHD templates, inactive virtual machine files, ISO images, and so on.

DR Solutions in Hyper-V Environments

Even though high availability can be achieved with local clustering, this will not safeguard a company from the entire data center or hosting facility going down. In this event, a DR solution needs to have geographically dispersed clusters as well as the means to replicate data over these distances and restart the total infrastructure from the secondary cluster site.

Virtualization solutions addressing DR including data replication can be classified into three categories. As shown in Figure 2, these types include:

- **Software-based solutions**: Software-based data replication solutions are third-party software suites hosted by the application server, which replicate data over the wide area network (WAN).

- **Appliance-based solutions**: With appliance-based data replication solutions, all intelligence needed to perform the replication is housed in an appliance that resides in the I/O path between the host and the storage, typically in a SAN.
Disaster Recovery Solution Types
Protection Zone or Site-level Crisis

**Software-Based**
Host-based solutions to manage storage replication and failover.

**Appliance-Based**
Data replication and storage fail over based on the SAN controller/appliance.

**Array-Based**
Data replication and storage fail over based on a mid-range and enterprise SAN infrastructure.

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**Software-Based Solutions**

Software-based solutions use third-party software applications that work with Windows Server Failover Clustering technology to provide synchronous or asynchronous data replication. Software-based replication uses patented technologies to replicate data over the WAN. This enables clusters to be spanned across different geographic locations as well as different seismographic zones, thereby eliminating a single point of failure. These solutions can work equally well with or without the use of shared storage within the cluster. Such software suites coupled with WSFC can provide a cost-effective DR solution for Hyper-V–based setups.

These solutions are also called host-based solutions because they reside on the application server that needs to have its data replicated. Therefore, an issue with host-based replication is that it takes processing cycles away from the applications running on the host. Another issue is that as more servers need to use replication, the cost goes up, including the initial cost of each software license, implementation, and service, as well as ongoing maintenance. On the other hand, the major benefits for a host-based solution are that the cost can be very low because a SAN is not required and heterogeneous storage can be used.
As shown in Figure 3, in the event of any failure that causes heartbeat timeout, WSFC automatically and seamlessly fails over to the second node. The software maintains a copy of the data on each node of the cluster and uses a patented replication technology to update each copy as the data changes. These replication technologies can range from byte-to-byte copy or block-level copy operations. The software senses application failover by WSFC and mounts the replicated volumes at secondary sites with read/write access. Virtual machines are automatically restarted on the backup node with minimal downtime.

The integration of the user interface with WSFC further simplifies the management and monitoring of the events. For example, open file replication technology is used to back up files that are currently being used and applications that are open. This eliminates the need to bring the virtual machines offline to replicate the data.
Appliance-Based Solutions

Appliance-based replication technology, like host-based, will support all the types of replication. Unlike the host-based solutions, all the intelligence needed to perform the replication is housed in an appliance. This appliance resides in the I/O path between the host and the storage, typically in a SAN.

Appliance-based replication has many advantages over host-based replication. For example, there is no replication overhead on the application server. In fact, the application has little or no knowledge that the appliance exists or that the replication is taking place. In addition, replication management is centralized on the appliance, and like host-based solutions, a heterogeneous storage pool can be utilized.

However, there are some major issues with an appliance-based solution. For a highly available solution, there should be at least two appliances in the local site, configured as failover for each other, and at least one appliance available remotely. Because the appliance is involved with every I/O and not just the replicated data, each appliance should use at least four switch ports. This can add significant cost and complexity to the SAN infrastructure. In addition, modern disk subsystems can deliver huge I/Os per second and megabytes per second. This enables application servers to drive these appliances to their max. Therefore, a SAN appliance in the stream of the I/O can become a major bottleneck. An environment with large I/O needs can easily overpower a pair of appliances. Some appliance-based solutions are limited to a pair of appliances while others can scale beyond two. As additional appliances are added, the cost of the solution rises, including the cost of each appliance and SAN switch port, as well as support and other incidentals.

With appliance-based replication, when data is being written to the primary storage, the appliance saves the data temporarily in the local hardware cache and then transfers it to the local hard drives. When the data is ready to be synchronized, it is placed in the mirror queue. With the help of the network link, data is then copied to the peer array. Generally, destination arrays are unavailable for direct access or are given read-only access to avoid corrupting the golden copy of the data at the destination. Customers can deploy this type of robust infrastructure coupled with WSFC and Hyper-V virtualization to withstand any catastrophic events.

The data replication link has to be configured between the primary site array and secondary site array. Replication link setup is necessary in order to establish paths between the primary and secondary storage system for appliance-based data replication.
As shown in Figure 4, both sites will lose communication with sudden network or site disruption scenarios. After missing the next heartbeat, WSFC will fail the application over to the peer Hyper-V server. On the storage side, replicated LUNs in the consistency group on the secondary array are made available to the peer Hyper-V server for I/O. This process can be manually intervened or completely automated. Automation can be in the form of customized scripts or storage vendor-specific automation enablers. LUNs having Hyper-V virtual machines can be replicated in either a synchronous or asynchronous mode as required to support the SLA. Some storage vendors also provide a data logging or journaling feature with the help of time stamping to avoid any kind of repetition. This feature also improves the resynchronization time during failback to the original cluster node.

Array-Based Solutions

Array-based data replication combines the aspects of software-based and appliance-based solutions. As with appliance-based replication, there is no overhead on the application servers. Management is centralized and any host supported by the storage system can use the replication functions of the storage device. Unlike appliance-based solutions, no extra SAN switch ports are needed to implement storage-based replication. Since the replication is native to the storage controllers, the impact is minimal to the application servers utilizing the storage. The only drawback to storage-based replication is that replication can only take place between homogeneous storage...
systems. In the past, homogeneous-only support could be costly, but today, many storage devices enable replication from more expensive fiber channel drives to less expensive Serial Advanced Technology Attachment (SATA) drives, and also support remote replication from a higher-end model to a lower-end model.

There is an interesting exception to the homogeneous-only support. When using SAN controllers that support virtualized heterogeneous storage pools, heterogeneous replication is typically also supported. In this case, SAN administrators can virtualize heterogeneous storage into one storage pool by configuring the replication at volume levels. Volumes to be replicated are grouped in replication groups to ensure that all similar volume entities are managed together. The storage pooling techniques also minimize management overhead and reduce setup complexity.

As shown in Figure 5, the hardware controller works at the network layer of the SAN and distributes the I/O from the hosts to storage as well as to the hardware controller. In the event of server, hardware, or network failure, WSFC initiates failover actions based on the policy used, and will restart the resource group in the cluster. In this stretch cluster scenario, every cluster node sees quorum as a local resource and stores all configuration information on a local disk. WSFC ensures cluster integrity by replicating changes across cluster nodes. WSFC guards against server hardware failure and network outages and initiates failover actions to resource group restart, whereas hardware data replicators provide remote mirroring in asynchronous or synchronous mode to replicate virtual machines on Hyper-V. During cluster configuration, the cluster
administrator has to define applications, services, IP, or even disks in the resource group so that they can be transferred to a backup node during actual failover.

When the active node at the primary site fails or the complete site fails, a heartbeat timeout occurs. At this point in time, the cluster reforms between the secondary site and the FSW node. The backup cluster node at the secondary site brings resource groups online with the help of FSW. The hardware data replicator recovers volumes listed in the cluster resource group at the secondary site and mounts on the backup node with read/write access. Applications mentioned in the resource group are automatically started by WSFC on the backup cluster node. Once everything is done, virtual machines on the backup cluster node at recovery sites are automatically restarted and operations resume from the point of failure. Total automated failover and failback can be achieved with customized scripts or with automation enablers provided by the hardware data replicator vendor.

In conjunction with vendor-based enablers, the array-based solutions can seamlessly work with WSFC for remote mirroring operations. This single product can help increase efficiency, simplify storage management practices, and mitigate risk with business objectives in a heterogeneous storage pool.

Key Benefits of Windows Server 2008 Hyper-V and WSFC in DR

The combination of Hyper-V and WSFC can reduce the impact of hardware outages in case of failure of any hardware component by relocating the virtual machines to the working node. By stretching the cluster geographically and adding a data replication partner solution, the high availability solution is turned into a complete end-to-end DR solution.

Virtualization coupled with stretch clustering is a cost-effective and differentiated solution for maintaining almost 100 percent uptime for mission-critical, high availability applications. Windows Server 2008 with Hyper-V enables any organization to benefit from virtualization and WSFC technology across different geographic locations. Hyper-V provides an inherently security-enhanced architecture that seamlessly merges into the existing IT environment, simplifying processes, provisioning, and management.

Other high availability advantages of virtualization with Hyper-V include operating system updates. Updates are considerably simplified because the virtual machines can be migrated to the peer node with live migration whenever a restart of the primary node is necessary. This helps ensure that there is no downtime for the end user. CSV support with live migration in Hyper-V further enhances failover with minimal to no downtime.

Some of the additional benefits of Hyper-V for overall IT organization are:

- 64-bit micro-kernel architecture.
- Multiple operating system support.
- Symmetric multiprocessor support.
- Network load balancing with a virtual switch.
- New virtual service provider/virtual service client hardware sharing architecture.
• Virtual machine snapshot.
• Windows Management Instrumentation (WMI) interfaces and APIs provide the extensibility to develop custom tools or utilities.
• Live backup with VSS.

Conclusion
The reasons that a DR plan is a necessity for any global organization are obvious, but cost has always been a prohibitive factor that has limited the existence and breadth of these plans. Virtualization is now a game changer for DR planning, providing DR solutions for a fraction of the nonvirtualized costs. This is enabling companies that previously could not afford DR to implement flexible and effective solutions. Furthermore, its affordability is enabling companies to justify full DR for additional applications, further improving their SLAs. In addition, virtualization has created more options for effective DR to address a wider range of needs.

The DR solutions discussed in this white paper utilize the power of Hyper-V and WSFC from Microsoft, combined with partner data replication solutions. The approach provides credible solutions that cover any DR requirements. However, actual selection of possible DR approaches in a Hyper-V environment depend on important factors like cost, criticality, and the distance between sites and should be discussed with a Microsoft representative trained to assist in DR solution planning.

Additional Information
The Microsoft extensive partner ecosystem complements and extends its virtualization toolset with products for desktops, servers, applications, storage, and networks. Together with the partners, Microsoft delivers robust and complete solutions for a virtualized DR-ready infrastructure.

Windows Server 2008 with Hyper-V and WSFC, paired with the right partner software, appliance, or array-based data replication product, provides a range of promising solutions for critical DR needs.

For more information, see:
• Microsoft Virtualization Solutions: www.microsoft.com/virtualization/solutions
• Microsoft Virtualization Partners: www.microsoft.com/virtualization/partners