Virtualizing Microsoft SQL Server 2008 R2 Using VMware vSphere 5 on Hitachi Compute Rack 220 and Hitachi Unified Storage 150 Reference Architecture Guide

Reference Architecture Guide

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Feedback

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Virtualizing Microsoft SQL Server 2008 R2 Using VMware vSphere 5 on Hitachi Compute Rack 220 and Hitachi Unified Storage Reference Architecture Guide

This paper tells you how to create an architecture using Hitachi Unified Storage 150 in a building block approach. This database storage architecture helps a large or enterprise deployment achieve the following business objectives.

- Maintain acceptable user experience levels
- Meet service level agreements
- Optimize capital and operational costs

The storage solution in this paper for virtualized applications that is the following:

- Easier to deploy and maintain
- Highly available
- Provide flexible scalability
- Deliver predictable performance
- Introduce consolidation-related savings

In addition, read the recommended practices to deploy Microsoft® SQL Server 2008 R2 successfully in a virtualized environment using VMware vSphere 5.0 on Hitachi Compute Rack 220 servers with Hitachi Unified Storage 150. This paper addresses the challenges of moving beyond managing underutilized, sprawling servers and storage silos that traditional Microsoft SQL Server 2008 R2 implementations can generate.
The solution is intended for you if you are an IT administrator responsible for Microsoft SQL Server 2008 R2, virtualization, or storage systems. You need some familiarity with the following:

- VMware vSphere 5.0 and VMware vCenter Server
- Hitachi Storage Navigator Modular 2
- Microsoft Windows Server 2008 R2 and Microsoft SQL Server 2008 R2

This documented solution used Hitachi Unified Storage 150 for testing. However, any member of the Hitachi Unified Storage family provides a reliable, flexible, and cost-effective storage platform for supporting applications like Microsoft SQL Server 2008 R2.

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**Note**—Testing was done in a lab environment. Many things affect production environments beyond prediction or duplication in a lab environment. Follow recommended practice by conducting proof-of-concept testing for acceptable results before solution implementation in your production environment. This means to test applications in a non-production, isolated test environment that otherwise matches your production environment.
Solution Overview

This configuration validated a Microsoft SQL Server design using a VMware vSphere 5.0 cluster. It hosted three SQL servers to test the performance benefits when deploying Hitachi server and storage solutions.

The three SQL Servers used to validate the building block design had the following three different database sizes:

- 250 GB
- 500 GB
- 1 TB

Using a 250 GB building block for the database storage, testing demonstrated how this solution can scale up to meet increasing requirements.

The reference architecture tested in the Hitachi Data Systems lab consisted of the following infrastructure:

- **Compute infrastructure**—Two Hitachi Compute Rack 220 servers to deploy a VMware vSphere 5 high availability cluster
- **Storage infrastructure**—One Hitachi Unified Storage 150 to provide a highly redundant disk storage resource for the VMware vSphere cluster

Figure 1 shows the configuration used to host the architecture.
Figure 1
Key Solution Components

This is a description of the key components used in this solution.

Table 1 and Table 2 list the components used in this reference architecture.

Table 1. Reference Architecture Hardware Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Version</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compute Server</td>
<td>Hitachi Compute Rack 220</td>
<td>7TTSHE-F9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- Form Factor 2U (rack mountable)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 × Quad-Core Intel® Xeon® 2.4 GHz, E5620 processor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 96 GB RAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 12 × 8 GB DDR3 RDIMM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 × 1000BASE-T/100BASE-TX/10BASE-T ports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage System</td>
<td>Hitachi Unified Storage 150</td>
<td>0915/B-H</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- 35 × 600 GB 10k RPM SAS drives (2 disks configured as hot spares)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 × SFF standard disk expansion tray</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 × controllers with 16 GB cache each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Host Bus Adapter</td>
<td>Emulex LightPulse</td>
<td>LPe12002-M8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- 8 Gb/sec dual port</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PCI Express 2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In your environment, use the following:

- The latest or the most recent Hitachi-supported levels of microcode and FOS levels
- The latest available Hitachi and Microsoft-supported BIOS firmware level
Install the license key for Hitachi Dynamic Provisioning on Hitachi Unified Storage 150.

**Hardware Components**

This solution uses these hardware components.

**Hitachi Unified Storage 150**

Hitachi Unified Storage is a midrange storage platform for all data. It helps businesses meet their service level agreements for availability, performance, and data protection.

The performance provided by Hitachi Unified Storage is reliable, scalable, and available for block and file data. Unified Storage is simple to manage, optimized for critical business applications, and efficient.

Using Unified Storage requires a lower investment in storage. Deploy this storage, which grows to meet expanding requirements and service level agreements, for critical business applications. Simplify your operations with integrated set-up and management for a quicker time to value.

Unified Storage enables extensive cost savings through file and block consolidation. Build a cloud infrastructure at your own pace to deliver your services.

Hitachi Unified Storage 150 provides a reliable, flexible, scalable, and cost-effective modular storage. Its symmetric active-active controllers provide input-output load balancing that is integrated, automated, and hardware-based.

Both controllers in Unified Storage 150 dynamically and automatically assign the access paths from the controller to a logical unit (LU). All LUs are accessible, regardless of the physical port or the server that requests access.

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### Table 2. Reference Architecture Software Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual machine guest operating system</td>
<td>Microsoft Windows Server 2008 R2 SP2, Enterprise Edition (64-Bit)</td>
</tr>
<tr>
<td>Hypervisor</td>
<td>VMware ESXi Server 5.0</td>
</tr>
<tr>
<td>Virtual infrastructure management Software</td>
<td>VMware vCenter 5.0</td>
</tr>
<tr>
<td>Database software</td>
<td>Microsoft SQL Server 2008 R2 SP1, Enterprise edition (64-Bit)</td>
</tr>
<tr>
<td>Storage management software</td>
<td>Hitachi Command Suite version 7</td>
</tr>
<tr>
<td></td>
<td>Hitachi Storage Navigator Module 2 version 11.5</td>
</tr>
</tbody>
</table>
Hitachi Compute Rack 220
Hitachi Compute Rack 220 is an Intel Xeon processor-based midrange rack mountable server platform, providing advanced systems management and redundancy options. It is datacenter friendly, with a 2U footprint while delivering the performance that is required to meet enterprise level challenges.

The benefits of Hitachi Compute Rack 220 are the following:

- Web-based management interface
- RAID level configuration, with up to six 3.5 inch internal drives
- Eco-friendly power-saving capabilities
- 2 socket Intel based server
- Configuration flexibility to meet business needs
- Dense 2U rack mountable design

This reference architecture used Hitachi Compute Rack 220 for the following reasons:

- High processing power in a dense 2U design
- Meets the requirements for VMware ESX Server for processor, RAM, and network capability

Hitachi Compute Rack 220 has optional local disks that this reference architecture does not use.

Software Components
This solution uses these software components.

Hitachi Dynamic Provisioning
On Hitachi storage systems, Hitachi Dynamic Provisioning provides wide striping and thin provisioning functionalities.

Using Hitachi Dynamic Provisioning is like using a host-based logical volume manager (LVM), but without incurring host processing overhead. It provides one or more wide-stripping pools across many RAID groups. Each pool has one or more dynamic provisioning virtual volumes (DP-VOLs) of a logical size you specify of up to 60TB created against it without allocating any physical space initially.

Deploying Hitachi Dynamic Provisioning avoids the routine issue of hot spots that occur on logical devices (LDEVs). These occur within individual RAID groups when the host workload exceeds the IOPS or throughput capacity of that RAID group. Dynamic provisioning distributes the host workload across many RAID groups, which provides a smoothing effect that dramatically reduces hot spots.
When used with Hitachi Unified Storage, Hitachi Dynamic Provisioning has the benefit of thin provisioning. Physical space assignment from the pool to the DP-VOL happens as needed using 1 GB chunks, up to the logical size specified for each DP-VOL. There can be a dynamic expansion or reduction of pool capacity without disruption or downtime. You can rebalance an expanded pool across the current and newly added RAID groups for an even striping of the data and the workload.

The wide-striping technology in Hitachi Data Provisioning improves performance, capacity utilization, and management of your environment. Using dynamic provisioning volumes (DP-VOLs) from storage pools created with Hitachi Dynamic Provisioning on Hitachi Unified Storage gives you the following benefits:

- An improved I/O buffer to burst into during peak usage times or intense maintenance activities, like content indexing or database integrity checks
- A smoothing effect to the Microsoft SQL Server workload that can eliminate hot spots across the different RAID groups, resulting in reduced data migration moves related to performance or capacity constraints
- Elimination of excess, unutilized capacity, by leveraging the combined capabilities all disks comprising a storage pool
- Elimination of the need to manage the placement of heavy load databases

For more information, see the Hitachi Dynamic Provisioning datasheet and Hitachi Dynamic Provisioning on the Hitachi Data Systems website.

**Hitachi Storage Navigator Modular 2**

Hitachi Storage Navigator Modular 2 enables essential management and optimization of storage system functions. Using Java agents, Storage Navigator Modular 2 runs on most browsers. A command line interface is available.

Use Storage Navigator Modular 2 for the following:

- RAID-level configurations
- LUN creation and expansion
- Online microcode updates and other system maintenance functions
- Performance metrics

The performance monitor feature, part of Storage Navigator Modular 2, acquires information on the performance of RAID groups, LUs, and other elements of the storage system. It tracks the utilization rates of resources, such as hard disk drives and processors. Information displays with line graphs in the Performance Monitor windows. You may save information in a comma separated value (.csv) file for later analysis. Performance Monitor monitored the underlying storage system to see how much the SQL Server environment taxed it.

For more information, see Hitachi Storage Navigator Modular 2 on the Hitachi Data Systems website.
VMware vSphere 5
VMware vSphere 5 is a virtualization platform that provides a datacenter infrastructure. It features vSphere Distributed Resource Scheduler (DRS), high availability, and fault tolerance.

VMware vSphere 5 has the following components:

- **ESXi 5.0** — This is a hypervisor that loads directly on a physical server. It partitions one physical machine into many virtual machines that share hardware resources.

- **vCenter Server** — This allows management of the vSphere environment through a single user interface. With vCenter, there are features available such as vMotion, Storage vMotion, Storage Distributed Resource Scheduler, High Availability, and Fault Tolerance.

For more information, see the [VMware vSphere](https://www.vmware.com/) website.

Microsoft SQL Server 2008 R2
Microsoft SQL Server 2008 R2 facilitates data management.

Used with Hitachi Unified Storage 150, SQL Server 2008 provides a scalable, high-performance database engine for any midrange to enterprise level application that requires the highest level of availability and security. It reduces the total cost of ownership through enhanced enterprise-class manageability for OLTP deployments at a midrange price.

Figure 2 illustrates the integration capabilities of SQL Server 2008.

![Figure 2](Microsoft Data Vision Platform diagram used with permission from Microsoft Corporation)
Solution Design

This describes the design of the reference architecture validated in this solution.

For ease of management, scalability, and predictable performance, this solution uses a building block approach for the storage required for the SQL databases. A single virtual machine running Microsoft Windows Server 2008 R2 and Microsoft SQL Server 2008 R2, with underlying storage from Hitachi Unified Storage 150, makes up each of the following three architecture sizes described in this paper.

- 250 GB
- 500 GB
- 1 TB

The basis of these architectures is on the size of the SQL database they can host. They were built using the 250 GB architecture as the basic building block.

The underlining storage resources for this reference architecture are configured from Hitachi Unified Storage 150 using dynamic provisioning pools (DP-VOLs) created by Hitachi Dynamic Provisioning. DP-VOLs are logical partitions of the dynamic provisioning pool that are allocated to the ESX hosts. They are formatted as virtual machine file system (VMFS) volumes from which virtual disks are created.

The virtual disks (vDisks) are presented to the Microsoft Windows Server 2008 R2 guest operating system. They can be partitioned and used in NTFS file systems for the following:

- Microsoft SQL Server 2008 databases
- tempdb
- Transaction logs
- Blob storage (outside this paper’s scope)

The 1 TB database capacity is not a limitation of the building block scalability. More resources can be assigned to a given environment from a storage and host perspective.

When deploying the environment, a single dynamic provisioning pool with groups of RAID-10 (3D+3D) configuration was created for the Microsoft SQL Server database and tempdb volumes. There was an additional pool using a single group with RAID-10 (2D+2D) configuration for transactional logs.

The pool used for database and tempdb volumes can be expanded later by adding an additional building block to support the scale up design for performance requirement.
Dedicated volumes within the pool simplify backup operations due to their granularity. It also provided an easier way to monitor the capacity utilization of each of the volume types.

This configuration provides the best performance by striping the LUs across all disks in a single dynamic provisioning pool. Wide striping reduces or eliminates hot spots caused by skewed workloads while ensuring the same level of RAID protection. In cases where log LUs are less busy than database LUs, I/Os are distributed across all disks so more IOPS capability is available for a given SQL server instance.

Table 3 describes the LU configuration for the Hitachi Dynamic Provisioning environments.

### Table 3. Reference Architecture with Three Different Size Using Hitachi Dynamic Provisioning

<table>
<thead>
<tr>
<th>Resource</th>
<th>Details for 250 GB</th>
<th>Details for 500 GB</th>
<th>Details for 1 TB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Virtual machines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ 16 GB memory</td>
<td></td>
<td>▪ 32 GB memory</td>
<td>▪ 64 GB memory</td>
</tr>
<tr>
<td>▪ 1 vCPU</td>
<td></td>
<td>▪ 2 vCPU</td>
<td>▪ 4 vCPU</td>
</tr>
<tr>
<td><strong>Storage system</strong> (Hitachi Unified Storage 150)</td>
<td>Scale up design:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP Pool 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ 1 × RAID-5 (4D+1P) for virtual machine guest operating system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP Pool 1 (250 GB Building Block)</td>
<td>1 × RAID-10 (3D+3D) for database and tempdb dynamic provisioning pool</td>
<td>2 × RAID-10 (3D+3D) for database and tempdb dynamic provisioning pool</td>
<td>4 × RAID-10 (3D+3D) for database and tempdb dynamic provisioning pool</td>
</tr>
<tr>
<td>DP Pool 2</td>
<td></td>
<td>1 × RAID-10 (2D+2D) for Transaction Logs Dynamic Provisioning pool</td>
<td>1 × RAID-10 (2D+2D) for Transaction Logs Dynamic Provisioning pool</td>
</tr>
</tbody>
</table>
It is possible to create a pool with other RAID group types in the Hitachi Unified Storage family. However, the RAID-10 (3D+3D) configuration provides the following:

- The required protection level and performance that Microsoft recommends for a SQL Server environment
- A scalability increment for the pool.

At least two ESX hosts are needed to achieve high availability. Additional SQL server virtual machines can be added to an ESX host along with additional dynamic provisioning pools on Hitachi Unified Storage to scale up to a larger architecture. To scale beyond the amount of resources a given ESX host can provide to an environment, you must add ESX hosts to make sure that sufficient ESX hosts are employed to achieve redundancy or high availability.

### Storage Configuration

From a storage perspective, designing a SQL server implementation on a virtual server environment is no different than performing the same activities on a non-virtualized environment. Deploying Microsoft SQL Server 2008 R2, using a building block approach for the database storage requirements, allows you to easily manage and scale your environment. Additional virtual machines are easier to deploy using templates, and storage can be provisioned on a per RAID group basis.

While the use of 600 GB disk drives in this solution results in larger than required disk capacity, the solution requires the number of spindles to provide the necessary performance and disk throughput to support the OLTP workload used to validate this reference architecture.

### Table 3. Reference Architecture with Three Different Size Using Hitachi Dynamic Provisioning

<table>
<thead>
<tr>
<th>Resource</th>
<th>Details for 250 GB</th>
<th>Details for 500 GB</th>
<th>Details for 1 TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUs</td>
<td>1 × 100 GB DP-VOL for virtual machine operating system</td>
<td>1 × 100 GB DP-VOL for virtual machine operating system</td>
<td>1 × 100 GB DP-VOL for virtual machine operating system</td>
</tr>
<tr>
<td></td>
<td>1 × 320 GB DP-VOL for database files</td>
<td>2 × 320 GB DP-VOL for database files</td>
<td>4 × 320 GB DP-VOL for database files</td>
</tr>
<tr>
<td></td>
<td>1 × 32 GB DP-VOL for tempdb files</td>
<td>2 × 32 GB DP-VOL for tempdb files</td>
<td>4 × 32 GB DP-VOL for tempdb files</td>
</tr>
<tr>
<td></td>
<td>1 × 80 GB DP-VOL for transaction logs</td>
<td>1 × 160 GB DP-VOL for transaction logs</td>
<td>1 × 320 GB DP-VOL for transaction logs</td>
</tr>
<tr>
<td></td>
<td>1 × 100 GB DP-VOL for virtual machine operating system</td>
<td>2 × 320 GB DP-VOL for database files</td>
<td>4 × 320 GB DP-VOL for database files</td>
</tr>
<tr>
<td></td>
<td>2 × 32 GB DP-VOL for tempdb files</td>
<td>1 × 160 GB DP-VOL for transaction logs</td>
<td>1 × 320 GB DP-VOL for transaction logs</td>
</tr>
<tr>
<td></td>
<td>1 × 320 GB DP-VOL for transaction logs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All the dynamic provisioning pools and LUs for this environment were built by using the following guidelines:

- Place database and log files on separate dynamic provisioning pool for best performance
- Place tempdb files on the same dynamic provisioning pool as the database files but on separate LU.
- Use the following RAID level for the creation of dynamic provisioning pool for the best performance and availability:
  - RAID-10 (2D+2D) for SQL log files
  - RAID-10 (3D+3D) for database and tempdb files
- Account for approximately 20 percent additional overhead for the database, tempdb, and transaction logs LUs when planning from a capacity perspective,
- Make sure that adding capacity to the environment follows the same RAID-10 drive configuration to meet performance requirements.

Using these guidelines, you can build a scalable architecture that meets your performance and capacity requirements. It also helps you to plan a scalable and highly available environment.

Figure 3 shows the RAID configuration of the dynamic provisioning pools. The architecture starts at 250 GB. It increases to a 1 TB solution by adding additional RAID 10 (3D+3D) RAID groups.
Table 4 lists the configuration of dynamic provisioning pools and LUs for the three architectures.

Table 4. Detailed Storage Configuration for 250 GB, 500 GB, and 1 TB architectures

<table>
<thead>
<tr>
<th>Architecture</th>
<th>DP Pool</th>
<th>LU</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 GB -Building Block</td>
<td>DP-00</td>
<td>00</td>
<td>100 GB</td>
<td>VIRTUAL MACHINE operating system LU</td>
</tr>
<tr>
<td></td>
<td>DP-01</td>
<td>01</td>
<td>325 GB</td>
<td>Database LU</td>
</tr>
<tr>
<td></td>
<td>DP-01</td>
<td>02</td>
<td>32 GB</td>
<td>tempdb LU</td>
</tr>
<tr>
<td></td>
<td>DP-02</td>
<td>03</td>
<td>80 GB</td>
<td>Transaction logs LU</td>
</tr>
<tr>
<td>Drive Tray 0</td>
<td></td>
<td></td>
<td></td>
<td>Added RAID group for 500 GB solution</td>
</tr>
<tr>
<td>Drive Tray 1</td>
<td></td>
<td></td>
<td></td>
<td>Added RAID groups for 1TB solution</td>
</tr>
</tbody>
</table>
Figure 4 shows how to scale up a SQL server architecture built on Hitachi Unified Storage 150 using the building block approach. This solution begins with a 250 GB building block. It scales up to the desired capacity by adding additional system and storage resources. By starting with a smaller building block, you can deploy a minimal configuration initially and scale up based on capacity and performance requirements later when needed.
LUs from dynamic provisioning pools are presented to the VMware ESX host and made into VMFS. An additional 20 percent of capacity is accounted for on each of the LUs, following best practice recommendations from Microsoft.
There is additional capacity provided to make sure that the architecture continues to meet performance requirements for the environment. As capacity increases, it might be necessary to increase the amount of vCPUs and memory to a virtual machine that is a SQL server to maintain the same performance levels achieved for your initial building block.

Storage for the SQL Server databases is configured for the following:

- First for performance
- Second for capacity requirements for the medium to high performance levels that a given SQL server virtual machine can handle

This is no different from what happens when sizing SQL server for physical server deployments. The architectures described in this architecture require deriving the following calculations from the requirements of an existing or planned SQL Server 2008 environment:

- Overall capacity needed for databases and transaction logs, including planned growth for SQL server instances
- IOPS needed for SQL server databases and transaction logs
- SQL Server instance host CPU and memory requirements for expected database workloads

**Design Goals**

This solution's architecture achieves the following design goals:

- Reach a minimum of 50 percent CPU utilization on the provisioned Microsoft SQL Server 2008 virtual machines.
- Optimize storage configuration on Hitachi Unified Storage 150 for best I/O throughput and ease of management for Hitachi Dynamic Provisioning configuration.
- Deliver sustainable and acceptable levels of IOPS within 20 msec response time for database and 1 msec response time for transaction logs.
- Use an OLTP workload environment to simulate a stock brokerage scenario. Windows Performance Monitor and SQL Server Management Studio reported this environment, accommodating burst and peak activities. SQL Server Dynamic Management Views (DMVs) determined if the SQL server database met performance recommendations from Microsoft.
- Deliver at least 80 percent disk capacity utilization for the database volumes.

For example, in a 500 GB database configuration, a dynamic provisioning pool consisting of two groups of RAID-10 (3D+3D) configuration hosts the database and the tempdb LUs, while a another dynamic provisioning pool with a group configured with a RAID-10 (2D+2D) group hosts the transaction logs LU.
To increase the capacity of the database by 500 GB, expand the dynamic provisioning pool used for the database file by adding additional groups with a RAID-10 (3D+3D) configuration. Provision LUs to host the additional database files and possibly additional tempdb volumes, if the number of tempdb files is not aligned with the number of CPU cores due to the increase of resources made available to a SQL server virtual machine.

In this case, an additional RAID group for the transaction logs is not necessary. This is because of the unused capacity still available from the original RAID group provisioned for this purpose. An additional increase of 500 GB to the database capacity requires two additional RAID-10 (3D+3D) groups for the database volumes.

**Multipathing**

To maintain a constant connection between the ESX hosts and storage, ESX supports multipathing. This allows multiple physical or logical connections from the host to the storage.

In ESX, several types of multipathing policies are available through the VMware Native Multipathing Plug-in (NMP), as follows:

- **Fixed (Default)** — This uses the designated preferred path, if it is configured. Otherwise, this uses the first working path discovered at system boot time.
  
  If the host cannot use the preferred path, it selects a random alternative available path. The host automatically reverts to the preferred path as soon as that path becomes available.
  
  This is the default setting on ESX and requires manual load balancing and path distribution across SAN fabrics and storage controllers.

- **Round-robin (Recommended)** — This uses a path selection algorithm that rotates through all available paths, enabling load distribution across the paths.
  
  Round-robin is the best choice for Hitachi Unified Storage due to its symmetric active-active controller design. This makes sure to use all resources within the storage system while maintaining the path failover capability of the environment. It simplifies the setup because all LUs are mapped to all ports assigned to an ESX host.

- **Most recently used (MRU)** — This selects the path the ESX host used most recently to access the given device. If this path becomes unavailable, the host switches to a different path and continues to use the new path while it is available.
Disk Management
ESX hosts can access LUs in two ways, as follows:

- VMFS
- Raw device mapping (RDM)

Virtual disks are files stored on a datastore. This is a logical container for the .vmdk files. The datastores are deployed on storage devices. They make up the VMFS. The optimization for VMFS is for virtual machines, hiding the specifics of the underlying storage.

VMFS can be accessed by several ESX hosts. The cluster feature allows for distributed file locking for the virtual machines. The VMFS can be extended while the client is running and can extend across multiple LUs. Using Storage VMotion, you can move the .vmdk file to another datastore non-disruptively.

As an alternative, you can map LUs as a raw device mapping (RDM). This allows a LU to be mapped directly to a virtual machine. RDMs are useful for command devices and any other device that requires direct communication to the storage processor.

For more information about VMFS and RDM, see Fibre Channel SAN Configuration Guide from VMware.

Path Configuration
All LUs are presented to both HBA ports on each of the ESX hosts. The presentation uses four dedicated Fibre Channel ports on Hitachi Unified Storage 150.

The high port capacity of Hitachi Unified Storage 150 eliminates the use of Fibre Channel switches while direct connecting the ESX hosts for cost benefits.

The use of Fibre Channel switches for configuration flexibility is a supported configuration. However, it was not tested on this environment.

Table 5 lists the connections between the ESX hosts and the storage system ports.

<table>
<thead>
<tr>
<th>ESX Host</th>
<th>Host HBA Number/ESX Port Name</th>
<th>Hitachi Unified Storage 150 Port</th>
<th>Hitachi Unified Storage 150 Host Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESX 1</td>
<td>HBA 1 port 1 vmHBA 1</td>
<td>0A</td>
<td>ESX_primary_vmHBA_1</td>
</tr>
<tr>
<td>ESX 1</td>
<td>HBA 1 port 2 vmHBA 2</td>
<td>1A</td>
<td>ESX_primary_vmHBA_2</td>
</tr>
</tbody>
</table>
On each ESX host, the round robin multipath algorithm was used for all LUs presented to the hosts.

Scaling Microsoft SQL Server 2008

These are the planning and deployment considerations to scale your Microsoft SQL Server environment.

Planning

Scaling Microsoft SQL Server databases and instances requires planning and testing from a server and storage perspective. When scaling up, capacity and performance are concerns. Test any production environment to verify it satisfies end-user requirements.

From an ESX perspective, calculate the maximum number of virtual machines that a single ESX host can run using the total number of CPUs and total memory requirements. Do not allocate more resources to the virtual machines than exist on the physical ESX host. The ESX service console requires one CPU and at least 400 MB of memory.

Scaling the Storage

Start with a database in which the performance and capacity requirements fit within the described 250 GB reference architecture. Then add groups configured as RAID-10 (3D+3D) to the environment as a scaling step.

Alternatively, start with the 500 GB or 1 TB reference architecture.

You can mix various drive combinations and capacity values with this reference architecture as long as you follow the building guidelines for the storage block described in "Storage Configuration."

In a dynamic provisioning environment, you can provision and assign additional LUs to a given port. When the dynamic provisioning pool nears its limit, create a second dynamic provisioning pool to ensure full utilization of the wide striping capabilities of Hitachi Dynamic Provisioning.

Transaction log LUs follow the same growth factor. Typically, you need to account for the sum of the capacity of the transaction log LUs to be between five and 10 percent of the space provisioned for database LUs.

<table>
<thead>
<tr>
<th>ESX Host</th>
<th>Host HBA Number/ESX Port Name</th>
<th>Hitachi Unified Storage 150 Port</th>
<th>Hitachi Unified Storage 150 Host Group</th>
</tr>
</thead>
</table>
| ESX 2    | HBA 1 port 1
vmHBA 1   | 0B                            | ESX_secondary_vmHBA_1         |
| ESX 2    | HBA 1 port 2
vmHBA 2   | 1B                            | ESX_secondary_vmHBA_2         |

On each ESX host, the round robin multipath algorithm was used for all LUs presented to the hosts.
Table 6 shows the resources used for the building block architecture with a 250 GB capacity.

### Table 6. Building Block Resources for 250 GB SQL Server

<table>
<thead>
<tr>
<th>Resource</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual machines</td>
<td>For one virtual machine:</td>
</tr>
<tr>
<td></td>
<td>- 16 GB memory</td>
</tr>
<tr>
<td></td>
<td>- 1 × vCPU</td>
</tr>
<tr>
<td>Storage system</td>
<td>Hitachi Unified Storage 150:</td>
</tr>
<tr>
<td></td>
<td>- 15 x 600 GB 10k RPM SAS disks</td>
</tr>
<tr>
<td></td>
<td>- Use 2 additional disks as hot spares</td>
</tr>
<tr>
<td>Dynamic provisioning pools</td>
<td>DP Pool 00 for virtual machine operating system:</td>
</tr>
<tr>
<td></td>
<td>- 1 × RAID-5 (4D+1P)</td>
</tr>
<tr>
<td></td>
<td>DP Pool 01 for database and tempdb files:</td>
</tr>
<tr>
<td></td>
<td>- 1 × RAID-10 (3D+3D)</td>
</tr>
<tr>
<td></td>
<td>DP Pool 02 for transaction log files:</td>
</tr>
<tr>
<td></td>
<td>- 1 × RAID-10 (2D+2D)</td>
</tr>
<tr>
<td>LUs</td>
<td>DP Pool 00</td>
</tr>
<tr>
<td></td>
<td>- 1 × 100 GB for virtual machine operating system*</td>
</tr>
<tr>
<td></td>
<td>DP Pool 01</td>
</tr>
<tr>
<td></td>
<td>- 1 × 320 GB for database files</td>
</tr>
<tr>
<td></td>
<td>- 1 × 32 GB for tempdb files</td>
</tr>
<tr>
<td></td>
<td>DP Pool 02</td>
</tr>
<tr>
<td></td>
<td>- 1 × 80 GB for transaction logs</td>
</tr>
</tbody>
</table>

*The remainder of the space within the group configured as RAID-5 (4D+1P) is used for additional virtual machines that were hosted on the same ESX server.

As with any other Microsoft SQL Server deployment, always test before deploying your architecture in a production environment. Additional adjustments for things such as unanticipated growth, protection methods, and service level agreements may be necessary.

For testing Hitachi Data Systems used industry-standard OLTP workloads to push the virtual servers to 60 percent or more of their percent processor time on Windows Performance Monitor while maintaining latency levels at or below Microsoft recommended levels.
Failover and Recovery
You might need a second Hitachi Unified Storage for more complex environments when needing a failover capability to meet your business and regulatory requirements. VMware vCenter Site Recovery Manager (SRM) and Hitachi Storage Replication Adapter (SRA) allow you to failover Microsoft SQL Servers to a secondary ESX host and Hitachi Unified Storage 150.

For more information, see Hitachi Storage Replication Adapter Software - VMware vCenter Site Recovery Manager Deployment Guide.

System Monitoring
Use Hitachi and VMware tools to monitor resource utilization in your environment.

On the storage side, Hitachi Tuning Manager provides a holistic view of the Hitachi Unified Storage performance related counters.

On the server side, the Performance tab on VMware vCenter Server provides information on the CPU and memory utilization of the ESX hosts to monitor whether the system is over committed.

Use these tools to monitor the system closely to so that your environment utilizes all available resources efficiently. With these tools, you can identify potential bottlenecks that might require the adding of disks to the environment to remedy.

Recommended Practices
These recommended practices for the design of the virtualized Microsoft SQL Server 2008 environment are based on Hitachi Data Systems testing.

For a deployment of SQL Server 2008 R2 using VMware vSphere 5.0 and a member of the Hitachi Unified Storage family, follow these recommended practices:

- For enhanced storage utilization and usability, use Hitachi Dynamic Provisioning.

- When using dynamically provisioned LUs, do the following:
  - Create separate pools for database and transaction log LUs.
  - Use RAID-10 for all pools used for SQL Server files.
    - RAID-10 (3D+3D) for SQL server database LUs to provide the required performance to support the architecture
    - RAID-10 (2D+2D) for SQL server transaction logs LUs
- Adjust the size of the dynamic provisioning pool for scalability.
  - When using 600 GB disks, using RAID-10 provides the best scaling and performance option for Microsoft SQL Server 2008 environments.

- When increasing the number of Microsoft SQL Server virtual machines in an environment, create two additional dynamic provisioning pools, as follows:
  - One pool for the additional databases
  - One pool for the other for the additional logs

- When the dynamic provisioning pool nears its limit, create a second dynamic provisioning pool to make sure there is full utilization of the wide striping capabilities of Hitachi Dynamic Provisioning.

- Use a minimum of two VMware vSphere servers to take full advantage of vSphere features such as the following:
  - High Availability
  - Dynamic Resource Allocation
  - Fault Tolerance

- Configure at least two redundant paths to Hitachi Unified Storage from each ESX host.

- To support multipathing, contain at least two HBAs on the physical host contain to connect to at least one Fibre Channel port on each storage system controller.

- Use the building block architecture for easy scaling.

- Use round robin multipathing policy to take best advantage of Hitachi Unified Storage symmetric active-active front-end ports.

- Use virtual disks for disk management.

- Do not use RDM for Microsoft SQL Server environments because the enhanced performance and features of VMFS are not available.

- Do not allocate more resources to the virtual machines than exist on the physical ESX host.
Engineering Validation

This explains the validation of the reference architecture in the Hitachi Data Systems labs.

Test Methodology

This is the methodology used to test the reference architecture.

Figure 5 is an illustration of the test environment.
Figure 5
Table 7 lists the OLTP workload parameters used as a baseline for the tests.

### Table 7. OLTP Workload Test Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test scenario</td>
<td>OLTP workload for a stock brokerage firm</td>
</tr>
<tr>
<td>Virtual machine CPU utilization</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>Minimum database LU capacity usage</td>
<td>80%</td>
</tr>
<tr>
<td>Minimum individual disk busy rate</td>
<td>50%</td>
</tr>
<tr>
<td>Number of active users</td>
<td>Variable, scaling with architecture size</td>
</tr>
<tr>
<td>Test type</td>
<td>Performance</td>
</tr>
<tr>
<td>Test duration</td>
<td>≥ 4 hours</td>
</tr>
</tbody>
</table>

For validation testing, the following happened:

1. Configure the 250 GB solution using a virtual machine configured with the required memory and CPU resources.
2. Test the 250 GB solution using the information in Table 7.
3. Add additional storage resources to create a 500 GB database, mapping the storage to another virtual machine with additional memory and CPU resources.
4. Test the 500 GB solution using the information in Table 7.
5. Add additional storage resources to create a 1 TB database, mapping the added storage to another virtual machine with additional memory and CPU resources.
6. Test the 1 TB solution using the information in Table 7.

### Test Results

The results show that the IOPS levels doubled, at a minimum, as doubling the database capacity while maintaining the latency levels at or below Microsoft recommendations while scaling up the architecture.

Testing shows that this solution meets or exceeds all design goals for the reference architectures.

Table 8 describes the success criteria for the scale up design using Hitachi Dynamic Provisioning established by Microsoft’s best practice recommendations and monitored using Windows Performance Monitor.
Table 8. OLTP Workload Success Criteria and Test Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average achieved database IOPS</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>▪ 250 GB architecture</td>
<td></td>
<td>1134 IOPS</td>
</tr>
<tr>
<td>▪ 500 GB architecture</td>
<td></td>
<td>2638 IOPS</td>
</tr>
<tr>
<td>▪ 1 TB architecture</td>
<td></td>
<td>4784 IOPS</td>
</tr>
<tr>
<td>Database Average Disk seconds per read</td>
<td>≤ 20ms</td>
<td>Average 10-20ms</td>
</tr>
<tr>
<td>▪ Disk sec/Write</td>
<td>≤ 20ms</td>
<td>Maximum 20ms</td>
</tr>
<tr>
<td>Transaction Log Average disk seconds per read</td>
<td>≤ 5ms</td>
<td>Average 1-5ms</td>
</tr>
<tr>
<td>▪ Average disk seconds per write</td>
<td>≤ 5ms</td>
<td>Maximum 5ms</td>
</tr>
</tbody>
</table>
Conclusion

The virtualization of a SQL Server environment can be implemented with solutions and features provided by Hitachi Data Systems and VMware. The few additional tasks needed during setup, when compared to a non-virtual environment, pay off with reduced data center server sprawl and full environment utilization.

This solution offers these other benefits, including the following:

- Reduced complexity
- Simplified management and scalability

The building block architecture described in this document optimizes memory, storage, and CPU utilization for your Microsoft SQL Server environment while providing an easily managed environment.

From a database perspective, these tests show that each of the reference architectures appropriately increases the amount of IOPS from one configuration to the next while maintaining latency values at or below recommended levels from Microsoft.
For More Information

Hitachi Data Systems Global Services offers experienced storage consultants, proven methodologies and a comprehensive services portfolio to assist you in implementing Hitachi products and solutions in your environment. For more information, see the Hitachi Data Systems Global Services website.

Live and recorded product demonstrations are available for many Hitachi products. To schedule a live demonstration, contact a sales representative. To view a recorded demonstration, see the Hitachi Data Systems Corporate Resources website. Click the Product Demos tab for a list of available recorded demonstrations.

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