Consolidation of Microsoft SQL Server Instances on the IBM System x3850 X5 with Microsoft Hyper-V

Redguides
for Business Leaders

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- Shows how the IBM System x3850 X5 and DS5000 make an ideal platform for consolidating underutilized SQL Server instances
- Provides best practice recommendations for consolidating on a high-availabilty cluster
- Shows how the latest enhancements in Intel and IBM technologies allow for consolidating large databases not considered until now

Redbooks

Executive overview

An increasing number of customers are adopting server consolidation these days to curb the growing cost of managing and maintaining their exploding infrastructure. IT administrators are surrounded by physical servers that run at low utilizations levels. With significant developments in server virtualization technology in the last few years, the timing is right to implement a server consolidation strategy. This strategy can help solve multiple issues that many IT administrators find themselves grappling with, such as the need to:

- Maximize the investment in server hardware.
- Rapidly respond to changing IT needs
- Improve business continuity.
- Simplify administration
- Save space and power.

In this IBM® Redguide™ publication we present a consolidation platform using IBM System x3850 X5 4-socket server, an IBM System Storage™ DS5300 mid-range storage subsystem and Microsoft® Windows® Server 2008 R2 with Hyper-V. A viable solution is to virtualize multiple underutilized Microsoft SQL Server systems, each on separate two-way or four-way servers, onto a high-performance server such as the x3850 X5 running Hyper-V. This IT model provides several key elements such as flexibility, high availability, and standardized configuration.

There are several approaches that you can take to implement a server consolidation strategy. This Redguide focuses on the consolidation of existing physical servers on IBM System x3850 X5 servers using Microsoft Hyper-V virtualization. Each SQL Server instance runs in an isolated virtual machine that is made highly available (HA) by configuring the host servers in the Microsoft HA cluster. With the ability to hold 1 TB of memory and 64 logical processors, the physical resources of the x3850 X5 can support the greatest density of high-performance virtual machines in the industry.

The proof of concept depicted in this Redguide shows SQL Servers running in 16 virtual machines on a pair of clustered x3850 X5 servers with 256 GB memory on each. Each virtual machine is configured with up to four virtual processors and 16 GB of memory. The ability of the x3850 X5 servers to be configured with up to 1 TB memory and 64 logical processors provides the flexibility to consolidate a larger number of very high-performance database virtual machines with up to four virtual processors and 64 GB or memory in a highly available environment.

Introduction

There are a number of factors that drive an organization's consolidation effort. Some of the key areas that the industry is seeing include:

- Improving business continuity and IT flexibility
- Maximizing capital investment in hardware
- Standardization and centralization of compute resources
- Saving money on space, power, and cooling

As an organization's IT environments become increasingly dynamic, IT administrators must find new ways to maintain and improve business continuity, as well as remain flexible and able to respond to the changing needs of the organization. Server consolidation has been around a long time, but has taken a key role in helping IT staff maintain this dynamic environment.

The newest high-performance servers from IBM, the System x3850 X5, have a state-of-the-art design to maximize hardware acceleration of a virtualized environment. Using virtualization technology such as Microsoft Hyper-V, IT administrators can maximize their investment in System x® server platforms, increasing utilization to optimal levels for each hardware resource.

Migrating physical production servers into a virtual machine significantly eases the tasks such as moving between physical hosts, load balancing during seasonal demand spikes, or replacing old hardware as part of the IT life cycle. Many of these same benefits also lend to an improved disaster recovery (DR) plan, allowing rapid redeployment of virtual machines in the event of a catastrophic failure.

Server consolidation scenarios improve system utilization, maximizing your return on investment. However, finding the best way to place multiple compute tasks on a single physical server has proved challenging for years. Several methods have been utilized, such as application silos (keeping similar applications on a single server) or running multiple instances of a given application (such as SQL Server). Virtualization goes a step further by giving administrators the ability to run multiple virtual standalone servers with their own operating system instances and providing applications to an encapsulated environment on a single physical server.

Initially, only smaller low-resource established servers were virtualized. As comfort with virtualization has grown, along with system capacity and virtual machine performance, more challenging workloads are now being considered. Business continuity plans are increasingly leveraging virtualization to meet the objectives of minimizing downtime and maximizing flexibility.

One example of high-performance consolidation taking place is with SQL Server. Database server consolidation can take one of several separate paths:

- A single database server instance running multiple databases
- Multiple database server instances running multiple databases
- Virtualization of a complete operating system and SQL environments in a virtual machine

Two additional benefits of server virtualization can be quickly realized as well. First, centralized and standardized computing resources can improve manageability, simplify documenting procedures, and streamline training. Second, reducing the number of physical servers needed to support your environment can result in significant savings in datacenter space with fewer physical servers to power and cool.

Why database server consolidation makes sense

Before servers with large numbers of processors and large amounts of memory became affordable, clients kept adding physical servers as their database needs increased. This resulted in many low-capacity, underutilized SQL Server database servers being deployed throughout many companies. In time, the issues with *database sprawl* became evident:

- Systems were not always highly available
- Many physical systems became difficult to manage
- The costs for hosting, powering, and cooling these systems skyrocketed

The solution is to consolidate these many servers onto one large, highly reliable, highly available server with plenty of processor and memory capacity. Consolidation can be accomplished using one of several strategies:

- Running multiple databases under one instance of the SQL server
- Running multiple instances of the SQL Server under a single operating system instance
- Running SQL Server instances in multiple independent virtual machines

Simple database server consolidation involves running multiple databases under a single instance of the SQL Server. This allows the highest level of consolidation, but requires all applications running in this instance to share the SQL Server version, patch level, and service account. Due to the smaller number of SQL Server instances being run, significant savings can be achieved in reduced management and licensing costs. However, this is also the least flexible consolidation approach.

Instance-level consolidation involves running multiple databases on a single physical server running multiple instances of SQL Server. With each database contained within its own SQL instance, there is separation between each application that can be maintained across various patch levels according to the requirements of the given application.

SQL Server consolidation through server virtualization involves a single physical machine running Windows Server 2008 R2 with Hyper-V enabled. Each SQL Server instance is then run in a virtual machine, with its own system resources and operating system instance. Each virtual machine is entirely isolated. Security and isolation are maintained because client access and communication between VMs is through the network only. In addition, these VMs can be made highly available with Microsoft Clustering and Hyper-V Live Migration. This method of consolidation provides the greatest degree of flexibility and business continuity.

Advantages of SQL Server virtualization

The advantages of virtualizing with SQL Server include:

- Improved manageability

  Many small servers with software installed locally are difficult and expensive to manage and maintain. Any required patches and updates to hardware and software must be applied to each server. Virtualizing your workloads on a smaller number of large servers in a highly available configuration helps minimize this work. Fewer virtual systems to physical systems to update and the ability to Live Migrate your running virtual machines to another server for maintenance windows helps improve uptime and minimize impacts to users. Having application servers encapsulated in virtual machines that can be easily backed up and restored can improve the response time in a disaster recovery strategy.

- Power savings

  Running multiple servers at low levels of utilization is not a good use of power when compared to running a single server at a higher level of utilization. The CPUs, disks, memory, and I/O devices consume a minimum level of power that begins when the server is turned on. In addition, significant improvements in server power supply technology and efficiency have been made. New Energy Star rated power supplies run at rated efficiencies consistently from 20% to 100% of their operational envelope. The IBM System x3850 X5 system has Energy Star rated power supplies rated at 90% efficiency. Server consolidation through virtualization helps maximize your return per unit of power consumption.

- Isolation and security

  With server virtualization, each database server operates in its own operating system instance, which provides the benefits of increased security and the ability to tightly control access to the host platform.

Consolidation components

In this section we discuss the various major components to our solution.

IBM System x3850 X5

The release of the latest IBM System x3850 X5 server marks another significant advance in server technology. These new systems incorporate the latest in hardware acceleration and scalability providing resource configurations that push the boundaries of x86/x64-based systems while providing industry-leading flexibility.

The x3850 X5 is powered by the highly intelligent and massively scalable Intel® Xeon processor 7500 series. Built to handle your most demanding applications, the Intel Xeon® processor 7500 series delivers a quantum leap in enterprise computing performance. The Intel Xeon processor 7500 series features Intel Advanced Reliability Technology that provides automatic detection and correction of errors, dynamic reassignment of workloads across processors, interconnect error detection/recovery, and individual virtual machine recovery in virtualized environments.

Figure 1 shows the IBM System x3850 X5.

Figure 1 IBM System x3850 X5

The 4-socket server IBM System x3850 X5 now offers up to 32 cores or 64 logical processors with Intel Hyper-Threading Technology and up to 1 TB of memory per chassis. In addition, two modular IBM System x3850 X5 servers can be connected together in a cache-coherent way to build configurations with up to 64 cores or 128 logical processors and up to 2 TB of memory. These scale-up servers with improved reliability and availability now make it viable for consolidating large SQL databases. These kinds of features provide the reliability and high availability necessary for the most demanding virtualization requirements.

Virtualization has matured in recent years. Hypervisors have been significantly improved in terms of performance, resource utilization, and guest machine support. The newest is Microsoft Hyper-V, which is capable of running virtual machines with up to four virtual processors and 64 GB of memory per virtual machine.

The IBM System x3850 X5 is the fifth generation of our scalable architecture built on over 40 years of innovation and virtualization experience. Key features are:

- Integrated Management Module that supports out-of-band management and connectivity
- Industry-leading predictive failure analysis on all major components that allow administrators to address reported issues before system failure actually occurs.
- Chipkill and ECC memory provide better memory reliability for the high demands of virtualization by detecting and correcting multiple-bit memory DIMM errors.
- IBM Memory ProteXion Redundant Bit Steering utilizes unused bits in memory as *hot spares* independently of the operating system (a benefit included at no additional cost).
- Memory mirroring and sparing technologies increase uptime and flexibility on scheduled maintenance windows.

A single x3850 X5 chassis consists of:

- Four Intel Xeon X7500 series processors with a total of up to 32 cores and 64 threads
- Sixty-four DIMM slots that can be populated with 1, 2, 4, 8, or 16 GB DDR3 1066 MHz RDIMMS
- Seven PCI-E 2.0 slots: one full-length x16, five x8, and one x4

IBM System Storage DS5000

The IBM System Storage DS5000 family, comprising the DS5100 and DS5300, sets new standards for performance, scalability, reliability, availability, and flexibility for midrange storage systems. As the most powerful IBM midrange storage system, the DS5000 is the ideal platform for a virtualized environment that can keep pace with your business growth. Figure 2 shows the IBM System Storage DS5300.

Figure 2 IBM System Storage DS5300

Organizations can initially buy only the capacity needed, and can then dynamically upgrade and reconfigure additional capacity and features later to meet the changing business requirements, all without any system downtime.

The DS5000 is ideal for virtualization and consolidation, delivering industry-leading performance, and is equally adept at supporting transactional applications such as databases and OLTP environments. The DS5000 is architected to provide the highest levels of reliability and availability, allowing it to meet the most demanding service level agreements (SLAs) based on technologies such as:

- Dual redundant controllers
- Two performance levels (DS5100 and DS5300) with the ability to field upgrade
- Flexible host interface options that are 8 Gbps Fibre Channel and iSCSI ready
- Up to 16 host interfaces and 448 FC/SATA drives using EXP5000 drive expansion units
- Up to 32 GB of dedicated data cache per controller
- Supports RAID 6, 5, 3, 10, 1, and 0
- Remote volume mirroring and FlashCopy® premium features for Volume Shadow Copy (VSS) supported backups and flexible DR scenarios.
- Full Microsoft MPIO support via a custom DSM
- Management support via Microsoft System Center Operations Manager (3Q10)

Microsoft Hyper-V

Microsoft Hyper-V is a native hypervisor first released in September 2008 and then significantly updated with the release of Windows Server 2008 R2. Hyper-V leverages a 64-bit operating system environment running as one of the installed roles in the Windows Server 2008 R2 product in either GUI or core configurations. It is also shipped as a standalone console-based hypervisor in the Microsoft Hyper-V Server 2008 R2 product, which is available for download from:

http://microsoft.com/hvs

Hyper-V can support the following host resources:

- Up to eight processor sockets
- Sixty-four cores or logical processors
- Up to 1 TB of memory (Standard Edition limited to 32 GB)

Virtual machines hosted by Hyper-V can support up to four virtual processors and 64 GB of memory, depending on the operating system loaded. Each virtual machine has its own operating system instance and is completely isolated from the host operating system as well as from other virtual machines.

High-availability features, such as Live Migration, Cluster Share Volumes, and VM Failover, are an option when running the Enterprise or Datacenter Edition of Windows Server 2008 R2 with Microsoft Clustering installed.

The version of Hyper-V used for this Redguide is included is the RTM version of Windows Server 2008 R2 Enterprise Edition. The high-availability features such as Live Migration and VM failover rely on Microsoft clustering found in only the Enterprise and Datacenter versions of the product.

There are several significant improvements in this latest release that are key to this solution:

- Live Migration: the ability to move running VM between physical hosts
- Cluster Shared Volumes: the ability for storage LUNs to be accessed by multiple physical hosts simultaneously
- Second Level Address Translation: the ability for VMs to have direct access to their respective memory segments

Proof of concept

A proof of concept was conducted to validate the virtualization concept of consolidating SQL Server. The host platform is a pair of clustered IBM System x3850 X5 servers running Hyper-V and attached to a DS5300 SAN controller. Sixteen virtual machines were then created running a variety of Windows Server 2003 and 2008 operating systems. Each operating system instance ran one of several versions of SQL Server 2005 and 2008, performing a variety of database tasks. Sufficient resources were reserved on the servers to allow for the ability to relocate all virtual machines to a single server as needed, as well as to allow for future growth. Figure 3 shows a diagram of a host configuration.

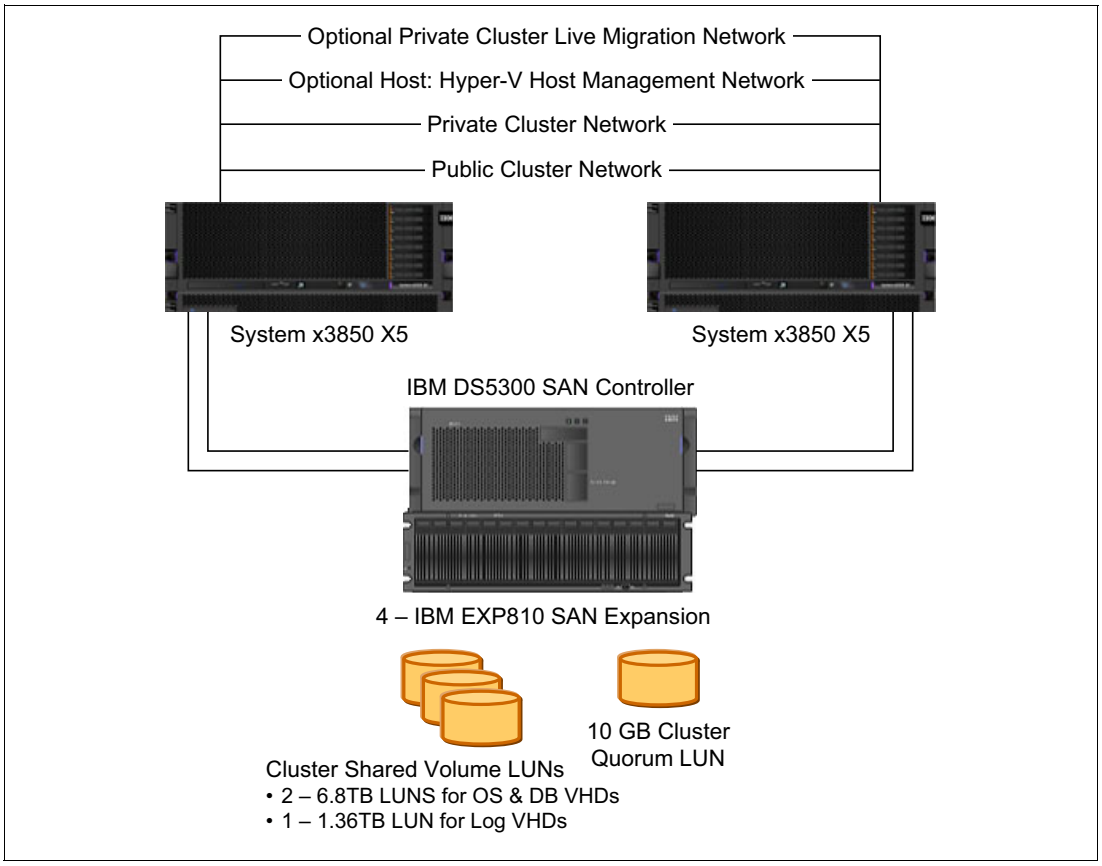

Figure 3 Host configuration diagram

Tested consolidation environment

The consolidated solution consists of two x3850 X5 servers in a 2-node (active/active) cluster, each with:

- Four Intel Xeon X7560 processors at 2.26 GHz with a total of 32 cores and 64 threads
- 256 GB memory with 4 GB DDR3 1066 MHz RDIMMs
- One Emulex 8 Gb Fibre Channel Dual-Port HBA
- One Broadcom dual-port Gigabit NIC onboard
- One Intel Gigabit dual-port NIC
- One IBM System Storage DS5300 controller and four EXP810 disk enclosures with sixty-four 146 GB 15 K RPM Fibre Channel drives

We created 16 Hyper-V virtual machines with 2–4 virtual processors and 2–16 GB of memory.

Workloads

The 16 VMs were configured to run the following workloads:

- Online Transaction Processing (OLTP)
- Decision Support System (DSS)
- Batch applications, characterized by the importing and exporting of large volumes of data, updating large amounts of data using business rules or interface files from other applications
- Maintenance, characterized by off-hours or background tasks that the IT administrators perform (for example, backing up, checking, and reorganizing the data)

The virtual machines and the workloads set up for the PoC were as follows:

- Virtual machines 1-4:
  - Four virtual processors, 16 GB memory
  - Windows Server 2008 x64
  - SQL Server 2008 64-bit
  - OLTP, Backup, DB REINDEX, Restore workloads
- Virtual machines 5-8:
  - Four virtual processors, 8 GB memory
  - Windows Server 2008 x64
  - SQL Server 2008 64-bit
  - DSS, Backup, Restore, SQLIOSIM workloads
- Virtual machines 9-12:
  - Two virtual processors, 4 GB memory
  - Windows Server 2008 R2 x64
  - SQL Server 2005 64-bit
  - DSS, Backup, Restore, CHECKDB workload
- Virtual machines 13-16:
  - Two virtual processors, 2 GB memory
  - Windows Server 2003 R2 x86
  - SQL Server 2005 32-bit
  - OLTP, Backup, Restore, DB REINDEX workloads

Host software

For the purposes of this PoC, each host had a version of Windows Server 2008 R2 Enterprise Edition installed, along with the Hyper-V role, and the clustering features enabled. The cluster *public* network was connected to an Active Directory domain controller to support cluster operations, and a second cluster *private* network was configured to offload Live Migration traffic. Before the cluster was created, the cluster validation wizard was run from the Failover Cluster Manager tool to validate that the systems, storage, and networking met the requirements to support a cluster. The necessary Multi-Path IO (MPIO) drivers were also installed. Lastly, Cluster Shared Volumes were enabled on the cluster to simplify LUN management.

Host configuration setup

Running SQL database servers on clustered servers running Windows Server 2008 R2 with Hyper-V provided a high-availability environment with a reduced number of physical machines to manage. The active database servers were moved between nodes using Hyper-V live migration with no loss of connections or transactions. This capability greatly increases the database environment's flexibility, availability, and security by:

- Allowing rapid provisioning of database servers as needed
- Providing a highly available environment with the ability to move servers among cluster nodes with ease
- Supporting load balancing
- Allowing for maintenance of physical machines
- Enabling each server to maintain a degree of isolation as required by IT operating procedures

SQL Server configuration

The IBM System x3850 X5 server based on the Intel Xeon processor 7500 series provides an ideal platform on which to consolidate underutilized SQL Servers in a highly available, easy-to-manage configuration using Microsoft Windows Server and Hyper-V.

In this configuration, a total of 16 SQL Servers were consolidated on a pair of x3850 X5 systems clustered together for high availability:

- Eight virtual machines running Windows Server 2008 SP2 x64 and SQL Server 2008 SP1
- Four virtual machines running Windows Server 2003 R2 x64 and SQL Server 2005 SP3
- Four running Windows Server 2003 R2 x86 with SQL 2005 SP3

See "Workloads" on page 8 for the specifics of the VMs.

Results

Using the IBM System x3850 X5 maximizes your capability with enough logical processors, memory, and I/O to host high-performance VMs in a clustered environment. The physical SQL servers were easily virtualized on the two x3850 X5 servers, leaving plenty of headroom for future growth. There was also sufficient capacity to allow all VMs to be migrated to a single system if needed. The result is fewer physical systems to manage, coupled with improved reliability, availability, and flexibility.

Creating a high-performance virtual machine environment is a new step for many enterprises. Experience in server consolidation can provide helpful familiarity with creating your virtualized machines, but might also encourage certain less-beneficial habits. A high-performance virtual machine environment must be set up using several basic guidelines. Develop these with input gathered by profiling the physical systems being replaced, as well as from the customer that will be dependent on the virtual machine.

Basic recommendations for high-performance virtual machines such as SQL are:

- Minimize over-commitment of the logical processors on the host system.

  This is likely different from past experience with server consolidation of earlier servers in which over-commitment of processors often ranged from three to four times their capacity. However, over-committed processors pay a performance penalty as they are switched between virtual machines, and have a larger impact on high performance applications.

- Do not over-commit memory.

  In addition to memory allocated to the VMs, the host system requires memory reserved to support virtualization operations. Leaving a minimum of 1 GB + the number of VMs * 32 MB for the host OS. Memory must be reserved to support any additional VMs that might need to be migrated. If there is not enough physical memory for all the VMs, migration fails.

- Install the operating system for the virtual machine on a dedicated *fixed* virtual hard disk.

  This virtual hard disk is attached to the IDE controller in the virtual machine. Ideally, the virtual disk will be backed by a fault-tolerant physical disk.

- Install applications on one or more dedicated fixed virtual disks.

  Install them to disks attached to a SCSI controller in the virtual machine, again backed by a fault-tolerant physical disk. Your I/O requirements will help you determine the number of spindles required to sustain operations at the desired level.

- Allow for sufficient network I/O.

  Consider dedicated NICs for particularly heavy workloads. The physical NICs can be used to create virtual network switches on the host and can be assigned to virtual machines on an as-needed basis.

- Have a dedicated network card for Live Migration.

  This is configured as a second private network in your cluster. This keeps Live Migration traffic off your cluster's public network.

Summary

The IBM System x3850 X5 can provide the processing power and reliability necessary as the foundation of your SQL Server consolidation environment. These systems allow you to maximize your highly available SQL Server virtual machines running under Hyper-V with high-performance virtual machines.

The proof-of-concept depicted in this Redguide showed the SQL Server running in 16 virtual machines with up to four virtual processors and 16 GB of memory each. These x3850 X5 servers can be configured with up to 1 TB of memory to consolidate much larger database VMs, such as eight 64 GB VMs per host, or many more VMs, such as thirty-two 16 GB VMs per host.

More information about IBM System x can be found at:

http://ibm.com/systems/x/

The IBM System Storage DS5000 systems provide excellent performance, availability, and scalability for your most demanding SQL Server applications. Consolidation of disparate storage systems often results in increased utilization, more cohesive backup and recovery implementations, and reduced management complexity.

Furthermore, the ability to intermix high-capacity SATA II drives (currently up to 2 TB) with high-performance SSDs and Fibre Channel drives allows for tiered storage implementation within a single array. Advanced copy services such as FlashCopy and Remote Volume Mirroring allow for nondisruptive backups and advanced disaster recover scenarios.

When combined with products such as Tivoli® Storage Manager or FlashCopy Manager, your virtualized SQL Server environment is completely and easily protected.

For additional guidance on deploying SQL Server on IBM System Storage products go to:

http://ibm.com/systems/storage/solutions/isv/#microsoft

Whereas running the SQL Server in a virtual machine might not be the answer for all your database needs, it might be the solution that suits a large number of database server consolidation scenarios. Investing in this solution can make your environment more robust and easier to manage and can reduce costs by using fewer physical servers, which in turn requires less power, cooling, and physical space.

The team who wrote this guide

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