Optimizing Storage Performance, Provisioning, and Manageability for Microsoft SQL Server

Introduction

Microsoft® SQL Server™ has become very popular as a database environment driving a broad range of mid-level business applications, ranging from Customer Relationship Management (CRM) to eCommerce and from Enterprise Resource Planning (ERP) to supply chain integration. The combination of affordability, performance, ease of deployment, and sophisticated analytical features has led to a significant proliferation of SQL Server databases in many organizations. In many cases, these databases include applications that have become a critical component of business operations.

Unfortunately, in many cases these databases are stored in native internal or direct-attached storage that is spread over multiple Windows® servers—a storage environment that cannot deliver the performance, scalability, availability and manageability required by mission critical data today. Issues can be compounded when server administrators, not database administrators (DBAs), are responsible for managing these database environments.

To optimize storage performance for SQL Server, organizations need a consolidated networked storage environment, well-matched to the price and
performance characteristics of the database servers, that can meet the demanding service level requirements of the business and that can simplify the management of the distributed SQL Server database environment dramatically.

This IBM® Redpaper describes the SQL Server benefits that are available from storage consolidation using best-in-class IP SAN (iSCSI) storage.

Microsoft SQL Server 2005

Nearly all of today’s business applications are data-centric, requiring fast and reliable access to intelligent information architectures that can often be provided only by a high-performance relational database system. In its latest release, Microsoft SQL Server 2005 offers significant architectural enhancements in performance, scalability, availability, and security. As such, SQL Server environments can be expected to continue to proliferate and become more complex as they are deployed to address increasingly complex data challenges.

Organizations face numerous data challenges today. Employees need to make faster and more data-driven decisions, developers need to be more productive and flexible, and managers need to reduce their overall IT budgets even as they scale their data infrastructure to meet ever-increasing demands. SQL Server 2005 is designed to help enterprises address these specific challenges by delivering increased security, scalability, and availability to enterprise data and analytical applications, while making these applications easier to build, deploy, and manage.

Extending the strengths of SQL Server 2000, SQL Server 2005 provides an integrated data management and analysis solution that enables IT staff to:

- Build, deploy, and manage enterprise applications that are more secure, scalable, and reliable.
- Maximize IT productivity by reducing the complexity of developing and supporting database applications.
- Share data across multiple platforms, applications, and devices to make it easier to connect internal and external systems.
- Control costs without sacrificing performance, availability, scalability, or security.
Storage challenges for SQL Server environments

As the consumption of data increases, so do the demands placed on IT professionals. Database and storage administrators are confronted with numerous challenges when attempting to right-size their database storage for effective space and throughput utilization.

Many organizations add numerous RAID devices to their environments, creating many islands of storage, with utilization rates estimated by industry analysts at roughly 30% to 40%. Consequently, storage is fragmented and management costs increase significantly with the addition of every new database server. Considerable space and throughput horsepower is also lost, greatly reducing the return of the overall storage investment.

Direct-attached storage in particular rapidly becomes a serious business risk as the rate of data growth and the number of servers increase driven by lack of capacity and performance scalability, complexity of data protection, and cost of operational support.

Traditional SANs have helped to consolidate RAID devices into a central location used by many servers. Still, even in many SAN environments, adding more disks to boost IOPS and to more effectively distribute database workload remains inseparable from adding more dedicated space to a given database environment. Sizing for growth and throughput of heavily loaded online transaction processing and decision support systems remains a real challenge for database administrators. Forecasting space requirements for enterprise database applications is often more of an art than a science.

With traditional storage environments, careful planning to size throughput and space utilization correctly is needed prior to the deployment of an application. Frequently, despite meticulous and careful planning, projected sizing proves to be either grossly over or under specified for the real world space, growth, and access patterns of the databases that support today's critical ERP, CRM, and eCommerce applications. To compound the problem, making subsequent changes to the database storage layout is cumbersome and comes at the price of reducing system and application availability.

DBAs also encounter weighty challenges when it comes to patches, upgrades, or modifications to their database environments. Despite careful planning and investments in testing environments, sizable risks in upgrading and modifying production environments remain. This challenge becomes greatly magnified when database transactions are tied directly to revenue generation. Downtime to make adjustments to storage layout and run unpredictable upgrades can be very disruptive to business operations.
IBM System Storage™ N series enterprise-class storage provides the optimum storage environment for SQL Server by:

- Making storage provisioning fast, efficient and flexible
- Integrating tightly with the familiar Microsoft Windows and SQL Server administrative interfaces
- Simplifying and automating backup, restore, and disaster recovery operations for SQL Server.

In addition, the ability to deploy System Storage N series in either a Fibre Channel SAN or an affordable iSCSI environment minimizes risk and provides unmatched flexibility.

**IP SAN topology for SQL Server consolidation**

Although SANs can provide significant advantages for SQL Server environments, most are still using direct-attached storage. (SQL Server requires a block interface to storage. NAS is not a supported option.) There are two primary reasons for this predominance of direct-attached storage:

- Most SQL Server instances run on small affordable Windows server platforms, for which the cost of traditional SAN infrastructure is usually viewed as prohibitive.
- SQL Server is most often deployed outside of the large enterprise core data center (for example, in distributed environments such as regional, departmental and remote data centers). This type of deployment is also very popular with smaller and medium size enterprises. In each of these environments the perceived complexity of Fibre Channel fabrics and the lack of appropriate administrative skills is a major consideration.

However, with the emergence of iSCSI this situation has changed.

*iSCSI* is a standard SCSI block storage protocol that is designed to operate over TCP/IP rather than over Fibre Channel. iSCSI-based IP SANs address both of the issues that we list here. They deliver lower total cost of ownership than traditional SANs through lower cost of acquisition and lower complexity and require no additional expertise. In most cases, companies have TCP/IP networking expertise and most Windows administrators know how to configure Ethernet services.

IP SANs provide all the benefits of a SAN and more than enough performance to support typical SQL Server environments.
Figure 1 shows a typical IP SAN environment.

Each of the SQL Server host systems are provisioned with an *iSCSI initiator*. This initiator is most often simply a software driver that Microsoft supplies as part of the Windows operating system, which works with the server's built-in Gigabit Ethernet ports or with an external TOE card (a network interface card with built-in TCP/IP offload chips). Alternatively, you can use iSCSI host bus adapters (HBA), which come with their own drivers (in much the same way you would with Fibre Channel). Most people find Microsoft’s built-in driver acceptable, except when they want to do boot-from-SAN, which currently requires a TOE card or iSCSI HBA.

The Gigabit Ethernet switching environment can either be dedicated switches in the data center, completely separated from the data communications network, or it can be a subnet of the corporate Gigabit Ethernet switching environment, in which case traffic is usually isolated and protected by VLANs.

The storage systems present virtual disks (LUNs) to the host systems by implementing what is known as an *iSCSI target*. These targets are usually just
referred to as *iSCSI-native storage*, and Microsoft publishes a list of systems they have tested and qualified in the Microsoft Catalog on their Web site. Zoning, LUN masking, and host authentication are accomplished easily using widely understood Ethernet administrative tools and capabilities.

All of the System Storage N series primary storage, secondary storage (System Storage N series with NearStore® option), and gateway (G models) systems support the iSCSI protocol. See Figure 2.

![Figure 2 System Storage N series storage architecture](image)

**Fast, Simple, Reliable**

Plus...

- SAN Protocols
- LUN Storage Objects
- Dynamic LUN Expansion
- Host-based SnapSuite™ Management

System Storage N series primary storage systems deliver all the features that you would expect from enterprise-capable arrays:

- Fully redundant hardware
- Dual active controllers with failover
- Fibre Channel or SATA disk drives
- Automatic RAID storage
- *Phone home* capabilities

However, the real magic is in the built-in software that underlies each of these systems.

The heart of System Storage N series is the storage operating system (Data ONTAP®), which is designed specifically to offload host-side data management complexity. This built-in software provides a sophisticated storage virtualization engine (FlexVol™ and FlexClone), and state-of-the-art data protection and management capabilities (Snapshot, SnapRestore®, SnapMirror®, SnapVault®,
and SnapLock) from a plug-and-play, self-tuning, highly reliable, modular storage platform.

The architecture not only supports network-attached storage environments, but also SAN environments with support for Fibre Channel and IP SAN protocols and LUN storage objects. The result is a more flexible SAN storage solution, complemented by host-side plug-ins (SnapDrive® and SnapManager®) to take maximum advantage of the System Storage N series data management capabilities. System Storage N series can efficiently support Fibre Channel SAN, IP SAN, and NAS, or all three environments simultaneously with management through a single, unified management interface (Figure 3).

**Figure 3   Multiprotocol capabilities**

System Storage N series’s data management software stack enables organizations to gain unbeatable automation, productivity, and flexibility benefits using the following advanced technologies:

- **SnapShots** (a patented space-efficient, high performance technology) enable you to completely eliminate backup windows.
- SnapRestore significantly boosts administrative and user productivity through almost instantaneous data restores.
- SnapMirror (asynchronous or synchronous) makes disaster recovery feasible and affordable for your entire global IT infrastructure.
SnapDrive enables one-click storage provisioning integrated with your host operating system environments.

SnapManager for SQL Server integrates Snapshot, SnapRestore, and SnapMirror with SQL Server, ensuring data integrity for automated and minimal downtime, data protection, and disaster recovery.

For the remainder of this Redpaper, we focus more specifically on how some of these capabilities can optimize storage performance and provisioning, can simplify and automate data protection, and can reduce the administrative overhead associated with your SQL Server environment.

Performance and provisioning optimization

Although SANs provide significantly better performance and provisioning flexibility than direct-attached storage, traditional disk arrays often have limitations:

- LUNs are typically associated with a single RAID group; therefore, performance is limited by the number of disks in the RAID group.
- Administrators need to guess the maximum size of each LUN and allocate all that space.

Data ONTAP (7G) addresses these issues, revolutionizing the landscape for customers who want to use the maximum spindle count on their SAN environments without forgoing control of space management. Before describing these capabilities, it is useful to define some new terms:

- An **aggregate** is a logical entity containing a pool of one or more RAID or RAID-DP™ groups.
- A **flexible volume** is a logical storage entity that resides within an aggregate. Flexible volumes can be sized appropriately anytime for the unique requirements of each SQL Server database instance. In addition, they can be grown and shrunk as needed with no impact to system and database availability.
- A **FlexClone** is generated from a Snapshot™ copy of a FlexVol, providing a transparent, writable copy of its ancestor or parent (as shown in Figure 4). The underlying data of the FlexClone, less its changes, requires no immediate additional space because it physically points to the underlying blocks in the ancestor. As the data in the FlexClone begins to diverge from its ancestor, additional space is occupied to hold the related changes.
A FlexClone can also be *split* and become an entirely new physical copy of its ancestor. One of the most powerful benefits of the FlexClone split is that it can occur while the clone is mounted and being written to by a DBMS, similar to SQL Server. In the case of SQL Server, an administrator might have several attached LUNs that reside in one or more flexible volumes that are actively servicing thousands of transactions while a split procedure is taking place without losing data.

Unlike traditional environments in which databases have to complete a physical copy before they can be mounted again, database administrators can quickly clone a given database environment, mount it for service, and then trigger a split to reallocate the database’s underlying blocks to another volume, all while servicing requests from applications and users. Split processes can also be scheduled and executed during off hours to minimize the resource utilization impacts of copying data to an entirely new volume.

**FlexVol in the SQL Server environment**

SQL Server administrators are confronted with a variety of challenges:

- Space management and predictive growth
- I/O sizing for performance
- Managing database upgrades and patches
- Managing data-centric application upgrades such as SAP®, Siebel®, and Remedy

Administrators can grow or shrink a FlexVol as needed, lending a greater level of granularity in managing the inevitable changes in database space requirements.
If volumes are too large for one database, an administrator can reallocate the unused space quickly to another server. By contrast, particularly in direct-attached storage environments, space allocated to a SQL Server remains dedicated regardless of whether space or throughput is used. As more databases are added to an environment in this manner, storage asset utilization decreases.

Flexible volumes allow administrators to aggregate massive spindle counts across all their SQL Server databases, effectively boosting performance and throughput to unprecedented levels without sacrificing control over space management. Consider Figure 5, in which six SQL Server databases have consolidated all their volumes into 12 flexible volumes contained within one large 100+ disk aggregate.

![Figure 5](FlexVol for SQL Server)

Each database uses the power and reliability of over 100 disk spindles and multiple RAID groups, transcending many of the inherent performance and reliability challenges of direct-attached storage or even traditional SAN environments. If, for example, the databases on the servers SQL1 through SQL6 required additional space for any of their databases, the administrator can grown their respective LUNs easily (using SnapDrive) with no impact to database availability.

The previous challenges of storage inflexibility and low utilization associated with dedicated physical volumes are virtually eliminated. Thus, flexible volumes allow administrators to scale their infrastructure up and out quickly and effectively, with
virtually no impact to system availability. Because space and IOPS reside in a shared environment, storage asset utilization quickly surpasses that of traditional volume environments.

**FlexClone in the SQL Server environment**

FlexClone uses the unique System Storage N series with Snapshot technology to enable DBAs to create instantaneous database clones, providing a replica of production data in a risk-free designated *sandbox*. The DBA can create a FlexClone in seconds, whether the `clone` command is executed on a small 10 MB volume or an enormous 16 TB volume.

Using conventional methods and traditional storage, a DBA would be forced to recover an entire backup from tapes or nearline devices into a test environment. When databases grow to several hundred gigabytes or more, organizations are forced to create an entirely new instance of equal or greater storage capacity in the test environment to effectively test upgrades and modifications before they go to production. The conventional method is time consuming, more costly, and less efficient than using a FlexClone.

Figure 6 compares tape, mirroring, and FlexClone technologies and demonstrates how FlexClone dramatically shortens test and development cycle time.

![Figure 6](image)

In the example illustrated in Figure 6, in the time it takes to create one tape-generated test environment, eight clone environments were generated and tested using FlexClone. While array mirroring provides a slightly better recovery
rate than that of tape, it is still significantly less efficient than using FlexClone for testing purposes.

FlexClone increases ROI of the overall storage investment by providing fast and dynamic instances of production data without the awkward, expensive, and time-consuming recovery processes associated with conventional data recovery. Database upgrades, schema modifications, and patch testing can all be tested quickly against a FlexClone, enabling the IT organization to investigate quickly the repercussions of making changes, without adversely affecting the production environment. Unpredictable upgrades, patches, and modifications are validated quickly and economically, thereby minimizing the risks of such changes. FlexClones enable DBAs to play out many what if scenarios against production data until they produce expected or acceptable results.

**Simplifying and automating data management**

Having investigated the significant benefits of System Storage N series with FlexVol and FlexClone features for SQL Server environments, we now look at SnapDrive and SnapManager for SQL Server—host-side software that integrates tightly the Windows and SQL Server administrative interface with System Storage N series built-in Snapshot, SnapRestore, and SnapMirror technology.

**About System Storage N series with Snapshot**

The System Storage N series with Snapshot technology is a patented space-efficient, high performance method of creating point-in-time replicas of data on disk. Snapshots provide a means of creating a backup image of data at a particular point in time. A snapshot backup occurs in a matter of seconds, and typically each copy consumes only the amount of data that has changed since the last copy was created. Thus, a snapshot consumes minimal disk space while providing up to 255 online point-in-time images. A related capability, SnapRestore, can recover a previous point-in-time image almost instantaneously.
These features, together with two host-side software plug-ins, can simplify and automate the backup and recovery of SQL Server databases. Figure 7 illustrates a typical configuration.

**Figure 7  Simplifying and automating SQL server backup and recovery**

### About SnapManager for SQL Server

SnapManager for SQL Server integrates Microsoft's storage administration interface for SQL Server with the System Storage N series built-in data management features. This integration makes it possible to accomplish the instantaneous backup and very fast recovery of entire SQL Server databases and full text indexes. SnapManager for SQL Server includes *easy migration* wizards to move databases from direct-attached storage to Fibre Channel SAN and IP SAN environments. Its features include an easy-to-use, intuitive graphical user interface and rich backup scheduling and reporting capabilities.

In accomplishing a database backup, SnapManager for SQL Server ensures that:

- Snapshot copies of all volumes used by the databases that are being backed up are created.
- System databases are backed up using conventional streaming-based backup.
- User databases placed in a LUN that also contain system databases are backed up using streaming-based backup.
- Backup of transaction logs always use streaming-based backup to provide point-in-time restores.
In restoring a database, SnapManager for SQL Server follows these steps:

1. Triggers SnapDrive to request a Single_File_SnapRestore to restore all LUNs used by the database or databases.
2. Restores selected databases out of many sharing one or two LUNs. (The most efficient configuration is one user database per LUN.)
3. Requests SQL Server to restore the databases.
4. Requests SQL Server to apply selected backed-up transaction logs. This is configurable and can conduct either point-in-time or up-to-the-minute restores.

In conjunction with SnapMirror for wide area data replication, SnapManager for SQL Server also makes it possible to create affordable automated disaster recovery for SQL Server environments.

Figure 8 shows a typical scenario.

![Typical disaster recovery configuration](image)

**Summary**

System Storage N series IP SAN storage solutions for SQL Server provide an enterprise-capable consolidated SAN environment, well-matched to the price and performance characteristics of the database servers, that can meet the demanding service level requirements of the business and that can simplify
management of the distributed SQL Server database environment. With unique
technologies such as Snapshot, FlexVol, FlexClone, SnapDrive, and
SnapManager for SQL Server, administrators can use System Storage N series
to optimize storage performance and provisioning, to simplify and automate data
protection, and to reduce the administrative overhead associated with your SQL
Server environment.

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