Abstract

This white paper describes how SQL Server 2008 consolidation can solve problems associated with multiple SQL servers in an organization. The paper offers several methods for consolidating applications using Microsoft SQL Server 2008 and compares those methods by linking key decision points to business requirements.
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Executive summary

Business case
Microsoft SQL Server has rapidly become the database of choice for a large number of prepackaged and custom-built business applications due to its robust feature set, ease of use, and highly competitive pricing. In some cases, these applications are introduced to small groups within a company, and are not given the infrastructure support that is provided to larger projects. These applications that are initially small and non-business-critical can gradually grow into business-critical resources that require proper support. In other cases, the applications may be unknown outside the user community until there is a problem. At that time, the business must try to resolve an issue in an application that the IT department did not know about.

In both cases, it is very common to find that the database applications are not using their resources as efficiently as they should. A study in September 2005 revealed that the average processor utilization for Microsoft data center servers was only 9.75 percent and these servers were utilizing 100 percent of their power and cooling requirements. The processor utilization is estimated to drop by 2 percent based on the estimation of the processor demands against the fast-growing processor potentials. The study was part of the RightSizing Initiative by Microsoft.

Product solution
In such an environment, it makes good business sense to try to consolidate database applications and resources to improve efficiency. There are several ways to approach this problem ranging from native SQL Server-based solutions to hypervisor-based virtualization. This white paper presents several approaches and examines how they differ in terms of cost, manageability, security, and performance.
Introduction

Purpose
This white paper compares native SQL Server, and hypervisor-based virtualization with VMware® ESX® Server and Microsoft Windows Server 2008 R2 with Hyper-V based on ease of use, cost, and performance.

Scope
This white paper is not intended to provide a complete guide to implement a consolidation project, but it can help with the decision-making process from a business perspective.

Audience
The audience of this paper includes:
- Customers, including IT planners, storage architects and administrators involved in evaluating, acquiring, managing, operating, or designing a database consolidation strategy
- EMC staff and partners for guidance and development of proposals related to database consolidation

Terminology
The following table explains the terms used in this white paper:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidation</td>
<td>Consolidation is the process of combining the workloads of under-utilized systems into a smaller number of systems to improve the utilization of resources. Consolidation helps to reduce wasted capacity in an environment and leads to a reduction in maintenance costs, required power and cooling capacity, and administrative overhead.</td>
</tr>
<tr>
<td>Consolidation candidate</td>
<td>A consolidation candidate is a server, typically a small system that has been identified for consolidation within the consolidation server.</td>
</tr>
<tr>
<td>Consolidation server</td>
<td>The consolidation server is the target server for the consolidation project. At the end of consolidation, this server will host all the databases previously served by the consolidation candidates.</td>
</tr>
<tr>
<td>Consolidated database or system</td>
<td>The consolidated database or system is the logical entity on the consolidation server that corresponds to an individual consolidation candidate.</td>
</tr>
</tbody>
</table>
Business challenges

Most SQL Server deployments have a single application database residing on a physical server. This is a simple way to create new applications for immediate use and this helps to set the stage for consolidation.

As businesses expand, these simple deployments of single applications can become more important. The application that was designed for one or two people to keep track of some important information can evolve into a business-critical application that can cripple the functioning of the organization if it is unavailable. Typically, when this happens, the application is moved to a data center and supported as a critical resource. At this point, the application server is either moved physically to a data center, or the application is moved to server-class hardware in the data center.

The problem associated with this process may not be immediately apparent. However, after the databases are moved to the data center the following concerns arise:

- If the applications and their servers are moved to a data center, there are heterogeneous hardware in the data center, which may not be designed for such use. This can lead to increased maintenance and administrative costs.
- If the applications are moved to server-class hardware, it may not be using the resources efficiently. These servers are typically much more powerful than those found outside the data center. They use power and cooling at a fixed rate, and if their processors are not utilized properly, the power and cooling capacity is wasted.

Regardless of how the applications are moved to the data center, the individual applications and servers may waste significant resources.

This white paper provides an overview of several methods of database consolidation that are available to an organization and are intended to help in the decision-making process. It highlights the pros and cons of each consolidation method and the feasibility of each solution.
Prospective solutions

Overview

The following are the three main solutions for consolidation of SQL databases in an environment:

• Multiple databases single instance
• Single database multiple instances
• Hypervisor-based consolidation

Multiple databases single instance

Implementation

In this solution, a single powerful machine is selected as the consolidation server. Then a single default or named instance of SQL Server is installed on a Windows server.

The databases from individual consolidation candidates are migrated from the physical servers to the consolidation server by using one of the following approaches:

• Detach and attach
• Backup and restore
• Data replication

Most database administrators will be familiar with these approaches. For more information, refer to Microsoft SQL Server Books Online. The following figure shows the consolidation of multiple databases into a single consolidation server.

This solution has many advantages in terms of cost and the amount of effort required for consolidation. However, this solution may increase the challenges associated with ongoing database maintenance and security.
Single database multiple instances

Implementation

In this solution, the databases from the individual physical servers or consolidation candidates are moved to a respective named instance of SQL Server on a single, powerful machine that has been selected as the consolidation server.

Just like the multiple databases, databases from individual consolidation candidates are migrated from the physical servers to the consolidation server by using one of the following approaches:

- Detach and attach
- Backup and restore
- Data replication

The following figure shows the consolidation of a single database with multiple instances.

This solution is more secure and helps to isolate each database but it can be very resource-intensive when compared to the other solutions.
Hypervisor-based consolidation

Implementation

This solution converts consolidation candidates to virtual machines using physical to virtual conversion, an approach more commonly known as P2V. In this solution, the physical systems hosting SQL Server consolidation candidates are converted into virtual machines hosted either on a VMware ESX server or Windows Server 2008 R2 with Hyper-V. Thus, the entire database system is moved to the consolidation hypervisor machine.

The following figure shows the hypervisor-based consolidation.

This third solution is entirely different from the first two. It eliminates the security-related concerns of the first solution and is not as resource-intensive as the second solution. However, it can be more expensive. It also enables high-availability and advanced management functionality that may not have been present in the original systems. The approach has minimal or no downtime associated with it for the P2V process.

Note: Hypervisor-based solutions introduce the ability to overcommit physical resources like memory. The testing described in this document did not allow overcommitment of physical server memory and used static memory reservations for all consolidation candidate virtual machines.
Differences in solutions

Overview

The prospective solutions must be weighed on various scales to understand their feasibility in a particular environment. Which solution to use must be based on the business requirements for the system and the technical details of each consolidation method. The solutions for consolidation are weighed on the following criteria to arrive at a decision to choose a particular solution for an environment.

- Direct cost
- Ease of consolidation
- Ease of administration
- Application performance

This section describes the factors for each prospective solution, and the reason that one solution is favored over another.

Direct cost

The cost of a solution in terms of hardware and software is important in any consolidation effort. Each potential solution has different requirements in this area.

The primary components of direct costs are the consolidation server hardware and the software licenses that are required. If we assume that the consolidation candidate server is either an existing server, or a fixed cost for all of the consolidation scenarios, then the software licensing cost is the primary factor to consider.

The two solutions involving SQL Server native consolidation methods (single instance and multiple instances) are equivalent in cost and both are less expensive than the hypervisor-based scenario. Both solutions require a Windows Server license and a SQL Server license for the consolidation server.

Based on the Microsoft SQL Server licensing page, multiple instances on the same SQL server are free, so the multiple-instance solution is not more expensive than the single-instance solution. Both scenarios are likely to save costs over the existing configuration because each of the consolidation candidate servers had to be licensed separately for both the operating system and the SQL Server. Therefore, fewer licenses will be required for the environment.

The hypervisor-based virtualization scenario tends to incur more direct costs. The operating system from the consolidation candidates will still be used. Fortunately, Windows Server 2008 R2 licensing is designed for virtualization; each server license allows a number of virtual machines on the same physical hardware to share the license. The numbers that are allowed depend on the server edition that you select. If you select a VMware ESX hypervisor, there will be an additional license cost for that software.
The following table shows the cost comparison of the three solutions.

<table>
<thead>
<tr>
<th></th>
<th>Single instance</th>
<th>Multiple instance</th>
<th>Hypervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost compared with pre-consolidation environment</td>
<td>Less expensive</td>
<td>Less expensive</td>
<td>More expensive</td>
</tr>
</tbody>
</table>

Each potential solution takes a different amount of effort for implementation in an environment. Although it is not as obvious as the software and hardware costs, each solution also differs in terms of the amount of time and effort required to complete the consolidation process.

Often when a new process is implemented on an existing system, the length and complexity of the process over a period of time are not studied. It is the same with consolidation. Each consolidation candidate needs to be shepherded through a consolidation process. This ensures that the data remains safe and secure, and users can employ the data in the same way after consolidation.

**Data migration**

There are many ways to migrate data. This paper covers the two major methods of migrating databases from consolidation candidates to the consolidation server. You can migrate the data all at once using a detach, copy, attach sequence or a backup and restore sequence. You can also create a replicated database on the consolidation server and allow it to gradually catch up with the production site by using technologies like transactional replication, log shipping, or database mirroring. At some point, you can transition to the consolidation server copy.

The good news is that while the choice of a migration method is important, it is not directly related to the choice of a consolidation method. Both of the migration methods work the same way with any of the consolidation methods.

**Data security**

Security is often overlooked until it is too late. Consolidation can have a significant impact on the security of data, so it needs to be evaluated before choosing a consolidation method. In the preconsolidation environment, each server was managed separately, which means that each database could be secured separately using different rules depending on the data requirements. This is clearly a highly flexible model.

The hypervisor consolidation model retains the flexibility and provides the advantages of consolidation. Each database is still running inside a virtual machine, and each virtual machine can be managed and secured separately. The other two solutions compromise this model. In the multiple-instance solution, the server administrator still has a high level of access to the data.
for all consolidated databases. This may not be acceptable for some kinds of sensitive data. In the single-instance solution, not only does the server level administrator have access to all of the data, but the database server administrative roles are also shared. This further reduces the flexibility of the security model.

**Data availability**

The database is useless if the users are unable to access information. Any serious discussion of consolidation must address the changes that are required by the user community and their database applications when consolidation is done.

In this situation, the hypervisor solution is again the least invasive option. Each virtual machine can retain the network identity of the original machine and the client programs can continue to access data in a different location without any changes. However, for the other two solutions, the network identity and database connection string of the database both change as a result of consolidation. Depending on the construction of the client application, this can be fixed with a simple change in an ODBC connector, or using a new version of the application. The user applications for each consolidation candidate system must be evaluated independently, so that all necessary revisions are well understood before making any change to a working system.

The following table compares the consolidation methods based on data availability.

<table>
<thead>
<tr>
<th></th>
<th>Single instance</th>
<th>Multiple instance</th>
<th>Hypervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data migration</strong></td>
<td>Similar across all methods</td>
<td>Similar across all methods</td>
<td>Similar across all methods</td>
</tr>
<tr>
<td><strong>Data security</strong></td>
<td>Server and database administrators are shared across all instances</td>
<td>Server-level administrators are shared across all instances</td>
<td>Highly flexible</td>
</tr>
<tr>
<td><strong>Data availability</strong></td>
<td>Network identity and connection string will change</td>
<td>Network identity and connection string will change</td>
<td>No changes required</td>
</tr>
</tbody>
</table>
In addition to the costs and efforts associated with the consolidation process, the systems still must be maintained after consolidation. The point of a consolidation process is to reduce not only the hardware footprint of the applications, which reduces the associated maintenance, power, and cooling costs, but to also reduce or not increase management challenges associated with the system.

After database applications are consolidated, they need to be maintained. The good news is that regardless of the consolidation solution adopted, the same tools will be used to manage the databases. SQL Server Management Studio (SSMS) is still the primary administrative interface to the database engine, and Remote Desktop can still give an administrator access to the underlying Windows Server operating system. However, there are some differences that need to be considered. The security concerns listed in the Ease of consolidation section still exist, and they will exist for the life of the system. In addition, a hypervisor-based solution may add additional layers of software that need management. This will include new tools such as VMware vCenter Server and Microsoft System Center Virtual Machine Manager (SCVMM).

<table>
<thead>
<tr>
<th></th>
<th>Single instance</th>
<th>Multiple instance</th>
<th>Hypervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing management</td>
<td>Security concerns need to be managed across the life of the system.</td>
<td>Security concerns need to be managed across the life of the system.</td>
<td>Additional management of tools such as VMware vCenter Server or Microsoft SCVMM are required.</td>
</tr>
</tbody>
</table>
Application performance

The impact on application performance is often a major source of concern in any significant consolidation project. There is fear of breaking a system that is working and performing well in exchange for a gain that may not be worth the cost if the performance suffers. The performance of the system after consolidation should be at least similar, if not better, than the performance prior to consolidation. Every application is different, and their performance may react differently to consolidation. However, in an effort to help remove confusion from the process, EMC has conducted a series of tests with a sample OLTP workload.

Note: The OLTP workload is similar to the TPC-C benchmark. However, this is not a benchmark run.

To determine the workload for the consolidation performance tests, the target system was characterized. Because the main purpose is to compare the consolidation methods, it is reasonable to ensure that the aggregated workload is within the capabilities of the target system.

The consolidation server workload is scaled until the average user response time reaches two seconds, which is considered a standard threshold for unacceptable response. This value is the maximum workload that can be supported on the physical configuration.

The workload is divided among consolidation candidates such that each consolidation candidate manages some percentage of the maximum load of the system. In this case, seven consolidation candidates were used to maximize the efficiency of the load testing environment.

When executing the consolidation procedure, each consolidation candidate workload was added to the consolidation server separately so that the behavior of the system can be observed as the workload scales up. Based on the initial testing, the server was expected to handle the aggregate workload. Therefore, the test series was well suited to study the performance differences between the consolidation methods. The consolidation methods add some non-zero amount of overhead to the system, so that at the edge, the system is expected not to scale. The degree to which the system fails to scale and how quickly it enters this state help to examine the efficiency of the consolidation methods at the edge of the performance envelope.

The primary comparison was based on the number of transactions per second (TPS) that was achieved by the system.
From the figure, it is observed that the two native SQL Server methods were closest to the baseline server in terms of TPS performance. The hypervisor methods displayed some level of additional overhead.

The following table shows the percentage of TPS degradation with all consolidation candidate systems running after consolidation.

<table>
<thead>
<tr>
<th>Method</th>
<th>TPS degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single instance</td>
<td>3.6%</td>
</tr>
<tr>
<td>Multiple instance</td>
<td>6.5%</td>
</tr>
<tr>
<td>VMware RDM</td>
<td>33.8%</td>
</tr>
<tr>
<td>VMware VMFS</td>
<td>20.1%</td>
</tr>
<tr>
<td>Hyper-V R2 Passthrough</td>
<td>38.3%</td>
</tr>
<tr>
<td>Hyper-V R2 NTFS</td>
<td>34%</td>
</tr>
</tbody>
</table>

While this test sequence explores the edge of the performance envelope, this is not a sizing recommendation. In order to account for sudden spikes in traffic, backup, maintenance, and other activities, size the system much closer to the middle of the performance range. In this region (50 percent of the maximum load), the consolidation methods exhibited less than 10 percent degradation in TPS with respect to the baseline.

<table>
<thead>
<tr>
<th>Performance</th>
<th>Single instance</th>
<th>Multiple instance</th>
<th>Hypervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales easily as consolidation workloads are added</td>
<td>Scales easily as consolidation workloads are added</td>
<td>Scales easily but exhibits greater overhead than other methods.</td>
<td></td>
</tr>
</tbody>
</table>
Note: The performance of the two hypervisors is measured at the hypervisor layer instead of aggregating the performance in the guest virtual machines. There are known discrepancies with such aggregate methods that have been well documented by both VMware and Microsoft.

This section shows data obtained at the limit of the system scalability. This is not a recommended region for planning a consolidation strategy. When planning for a more sustainable load level on the consolidation server, all consolidation methods showed a decline in throughput of less than 10 percent.
Conclusion

Summary

A flexible server consolidation solution enables organizations to reduce costs by centralizing database services on fewer servers. By providing a centralized data services management interface and policy-based management, SQL Server makes it easy for organizations with multiple data stores to reduce management overhead. The industry-leading features and performance of SQL Server 2008 Enterprise and its ability to explicitly control server resources enables you to consolidate your data services while providing the scalability and performance your applications require.

The various consolidation methods presented in this paper have specific differences in terms of cost, ease of consolidation, ease of administration, and performance as summarized in the following table:

<table>
<thead>
<tr>
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<td>Similar across all methods</td>
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<tr>
<td>Data security</td>
<td>Server-level and database-level administrators are shared across all instances</td>
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<tr>
<td>Data availability</td>
<td>Network identity and connection string changes</td>
<td>Network identity and connection string changes</td>
<td>No changes required</td>
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<tr>
<td>Ongoing management and administration</td>
<td>Security concerns need to be managed across the life of the system.</td>
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</tr>
<tr>
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<td>Scales easily as consolidation workloads are added.</td>
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</tbody>
</table>

For every database consolidation project, evaluate each of these categories independently and determine which method is best for the specific environment. Database environments are complex, and can vary significantly.
from each other; there is no single solution that is best in all cases for all environments. The good news is that EMC Proven Solutions can help you create, back up, and protect database storage solutions for any environment.

References

Related documents

For more information, refer to the following document available on the EMC Powerlink® website:

- **EMC Virtual Infrastructure for Microsoft SQL Server 2008 Enabled by EMC Celerra, EMC Replication Manager, and VMware vSphere 4 — Reference Architecture**

Additional information

Refer to the following websites for additional information:

- Microsoft SQL Server license
- Microsoft Window server license
- VMware ESX Server
- Technical Case Study on virtualization
  [http://download.microsoft.com/download/9/F/F/9FF596C1-B83C-44A6-8BB8-32332FF264F7/0558IdentifyingVirtualServersTCS.doc](http://download.microsoft.com/download/9/F/F/9FF596C1-B83C-44A6-8BB8-32332FF264F7/0558IdentifyingVirtualServersTCS.doc)