

SQLskills Immersion Event

IE3: High Availability & Disaster Recovery

Module 2: Consolidation

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Overview

- Consolidation methods
- Choosing a consolidation strategy
- Hardware and software considerations
- Post-consolidation tools



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Reasons For Consolidating

- Reducing the server sprawl caused by adding new servers for each application that is implemented in the environment
- Simplifying manageability and reduce patching requirements
- Improving hardware utilization and reducing power and cooling costs

Complications of Consolidation

- Consolidation eliminates department-level isolation from other departments within the company
- Consolidation reduces performance of Line-Of-Business applications in the environment
- Vendors may not support their databases being run on the same instance of SQL Server with other databases in the environment
- Consolidation increases visibility and risk of impact from hardware failures and downtimes

Overview

- **Consolidation methods**
 - Database-level
 - Instance-level
 - Virtualization
- Choosing a consolidation strategy
- Hardware and software considerations
- Post-consolidation tools

Database-Level Consolidation

- **Methodology**
 - Multiple application databases are moved to a single server that hosts a single SQL Server instance
- **Pros:**
 - Reduces the total number of instances installed in the environment as well as the number of servers
- **Cons:**
 - All server-level objects and resources, such as tempdb, are shared thus increasing the risk of impact a single database can have across the environment
 - Server security is more complex and requires enforcement of least-privilege required which may be difficult for vendor applications

Instance-Level Consolidation

- **Methodology**

- Databases for a single application have a dedicated instance of SQL Server but multiple named instances are installed on a single server

- **Pros:**

- Reduces the number of physical servers in the data center
- Provides security isolation by application, allowing vendor applications that check if their account is in the sysadmin role to function
- Separate tempdb for each application

- **Cons:**

- Increased potential for resource contention
 - Soft NUMA can limit specific instances to specific CPUs
 - Min/Max Server Memory can limit memory contention

Virtualization

- **Methodology**

- Convert consolidation candidates to virtual machines using physical to virtual conversion or P2V
- The entire server is moved into a virtual machine

- **Pros:**

- Reduces the number of physical servers in the data center
- Minimal or no downtime associated with the P2V process
- Maintains the same security isolation at the Windows OS and SQL level as a physical environment

- **Cons:**

- Can be more expensive to implement overall
- Same management and patching requirements as an entirely physical environment

Hybrid Consolidation

- It is possible to have multiple virtual machines running on a hypervisor that hosts multiple instances with one or more databases per instance to build a hybrid-stacked version of all three consolidation methods
 - Be careful that manageability costs don't exceed the hardware or resource savings that a hybrid approach might provide

Database Migration Strategies

Detach, Copy, Attach

- One of the most common ways of moving databases between instances of SQL Server is to detach the database from the source, copy the files to the new server, and attach the database to the new instance
- Incurs the most downtime for the database
 - Downtime proportional to the size of the database files
 - Database files will usually contain free space that has to be copied across the network and can increase the time to copy
- May require file system ACL changes on the database files to be able to attach them to the new instance
 - <http://msdn.microsoft.com/en-us/library/ms189128.aspx>

Database Migration Strategies

Detach, Copy, Attach

- **SAN LUN migration**
 - If the database files are currently hosted on a SAN LUN, the fastest way to move the databases is often to remove the SAN LUN from the original server and present it to the new server
 - SQL Server instance installation must be done separately
 - After the LUN is presented to the new server and brought online, the databases can be attached to SQL Server
- **In consolidations involving virtual machines, the SAN LUN can be mounted as an RDM to the VM allowing access to the database files**

Database Migration Strategies

Database Mirroring/Log Shipping

- **Database mirroring and log shipping can be used to minimize the amount of downtime associated with a database migration by pre-staging a majority of the data on the new server ahead of the final migration**
 - Restore the last FULL backup and all subsequent backups onto the destination server to stage the database
 - Configure database mirroring using High Performance mode initially if available, and then switch to High Availability mode before initiating failover
 - Configure log shipping and perform a tail-log backup immediately prior to migrating to take the database offline, allowing the tail-log to be applied to the new server and the database to be brought online

Database Migration Strategies

Physical-to-Virtual Machine Migration (P2V)

- Third-party and hypervisor-vendor tools exist to migrate a server from physical hardware into a virtual machine with minimal downtime to the end users for the migration
 - Requires a brief downtime for the actual switch from physical server requiring it to be powered off, to the new virtual machine which gets powered on as a direct replacement
- It is generally recommended that the SQL Server services be shut down during the P2V process to prevent data integrity problems

Database Migration Strategies

Virtual Machine to Virtual Machine Migration

- Consolidating databases between virtual machines can sometimes be accomplished in the same way as a LUN migration under the detach, copy, attach methodology
- Virtual machines use virtual hard disk files (VMDKs for VMware and VHDs for Hyper-V) that can be removed from one virtual machine and added to another virtual machine on-the-fly
 - Depending on the version of the hypervisor and the Windows OS, removing the disk may require rebooting the source VM to get it released from Windows
 - Useful in scenarios where you've over consolidated to migrate databases to another VM for balancing load

Overview

- Consolidation methods
- **Choosing a consolidation strategy**
 - Security
 - High availability
 - Resource management
- Hardware and software considerations
- Post-consolidation tools

Cost Considerations of Consolidating

- Consolidating increases hardware utilization regardless of the consolidation method being used, potentially requiring a larger server to handle the combined workloads
- Multiple databases on the same instance cost the same as multiple instances on the same SQL Server
- Windows Server 2008 R2 and SQL Server 2008/2008 R2 licensing are designed for virtualization support, allowing multiple virtual machines on the same physical server to share the license
- SQL Server 2012 licensing has changed though...

Security

- **Security is one of the most overlooked consolidation considerations until it is too late**
- **Data-security requirements need to be evaluated before choosing a consolidation method**
- **Consider:**
 - Application use of fixed server roles (especially sysadmin/securityadmin roles)
 - Common SQL logins with different passwords and levels of access
 - Multiple-instance consolidation separates instance-level access, but server administrators still have high-level access to the data for all consolidated databases

High Availability

- **Increasing the density of databases on a single server through consolidation also increases the level of impact an outage will have across the enterprise**
- **SQL Server high availability**
 - Database mirroring
 - Failover clustering
 - Log shipping
- **Virtualization high availability**
 - VMware DRS and Hyper-V failover clustering
 - VMotion and Live Migration

Resource Management

SQL Server Soft NUMA

- **Soft NUMA can be used to create a custom NUMA configuration independent of hardware NUMA configuration to fix specific instances of SQL Server to specific CPUs**
 - Registry settings control Soft NUMA configuration
 - Allows the ability to mask independent instances as nodes to specific TCP ports for increased performance
 - Soft NUMA CPU masks can only include CPUs from a single hardware node
- **Soft NUMA only subdivides CPUs it does not subdivide memory resources**
 - Does not create additional LazyWriter threads
 - I/O Completion Port (IOCP) is for network I/O, not disk I/O
- **Reference:**
 - <http://sqlskills.com/help/SoftNuma>

Resource Management

SQL Server Min and Max Server Memory

- **Use Min Server Memory to guarantee a minimum amount of memory to the buffer pool after memory ramp up completes**
- **Use Max Server Memory to limit the maximum amount of memory that the buffer pool for a SQL instance can allocate**
 - Only applies to the buffer pool, does not set the total amount of memory used by SQL Server
 - Additional memory for thread stack and multipage allocators
- **(Total system memory) – (memory for thread stack) – (OS memory requirements ~ 2-4GB) – (memory for other applications)**
 - Memory for thread stack = (max worker threads) x (stack size)
 - x86 = 512K; x64 = 2MB; ia64 = 4MB
- **Memory\Available Mbytes > 150-300MB**

Resource Management

VM Reservations vs. VM Limits vs. VM Priority

- VM reservations guarantee a fixed amount of physical resources to a guest VM
- VM Limits guarantee a minimum amount of physical resources to a guest VM
- VM priority guarantees that a VM is prioritized higher in the hypervisor than other VMs of lower priority

Overview

- Consolidation methods
- Choosing a consolidation strategy
- **Hardware and software considerations**
 - Hardware sizing
 - New technologies
 - Bottlenecks
- Post-consolidation tools

Hardware Sizing

- Appropriately sizing the hardware being used for consolidation projects is critical to the success or failure of the project
- Benchmarking and baselining existing hardware configurations is a critical first step in any consolidation effort to allow appropriate sizing and planning of the consolidation effort
 - Reducing the number of physical servers in the datacenter gains you nothing if you also reduce the overall performance at the same time
- Consolidation may save money long term, but it can also cost money short term

Hardware Sizing: CPU Usage

- Each of the workloads being consolidated should be evaluated for its representative CPU usage before actually being migrated to a consolidated server
- Items of importance
 - CPU % utilization
 - Possible to reduce with appropriate tuning of indexes and code
 - Be aware of the impact of backup compression on CPU usage
 - Number of concurrent user connections and the amount of concurrent user activity
 - Thread-pool starvation problems can occur in SQL Server through over consolidation of databases with high numbers of concurrent user connections that also generate large volumes of concurrent user activity
 - Each executing task requires at least 1 worker thread while executing
 - Usage of parallelism
 - Parallel tasks require 1 control thread and 2 worker threads per level of DOP and parallelism operator contained in the execution plan during execution

Hardware Sizing: Memory Usage

- Evaluate each databases usage of the buffer cache by querying the `sys.dm_os_buffer_descriptors` DMV prior to migrating the database
- Evaluate each databases workload plan cache usage
 - Ad hoc workloads will cause excessive cache bloat problems and may impact the cache reuse of non-ad hoc workloads
- Items of importance
 - Current buffer pool memory usage
 - Use Paul's Buffer Pool Summary script to determine current usage trends
 - <http://sqlskills.com/help/BufferPoolSummary>
 - Database workload for ad hoc and single-use plans
 - <http://sqlskills.com/help/AdhocSingleUse>
 - Database usage of multipage allocators like SQLCLR, OLE Automation, Extended Stored Procedures, or Linked Servers

Hardware Sizing: Disk Usage

- Evaluate each databases I/O profile and usage by querying the `sys.dm_io_virtual_file_stats` DMV and monitoring the Physical Disk performance counters
 - Physical Disk: Disk Transfers/Sec
 - Physical Disk: Disk Writes/Sec
 - Physical Disk: Disk Reads/Sec
- Isolating I/O for a single database by segregating the data and log files physically will provide the most accurate sizing for partially consolidated environments
 - This may not be possible without using a intermediate server as a part of the consolidation process that allows each database or applications workload profile to be isolated and understood

Performing the Consolidation

Determining What to Consolidate Together

- Based on the usage analysis and baseline data collected for the existing configuration and ongoing analysis of the consolidation environment
 - Don't rush to consolidate to fast or performance problems will result
 - Ensure that there is sufficient time after moving a database to gauge its total impact to the new environment
 - Ensure that the consolidated workloads continue to have resources available for growth over time
 - Use CNAME records in DNS on a per application basis to allow easier movement of databases if a problem does occur

Handling New Applications/DBs

- Continue to maintain an environment where the impact of a new application or database can be benchmarked to obtain a valid baseline before deciding to consolidate it with other databases
- Ensure that the baseline is created after the application is under its true production load for a few weeks to gauge the actual impact
- Use a CNAME in DNS for the application configuration to allow movement of the databases without reconfiguring the application settings

New Technologies

- **Hardware**

- Intel and AMD have included special virtualization instructions in processors for years, making hardware based virtualization possible
- Newer processors have more cores and multiple memory controllers per socket allowing greater scalability

- **Software**

- SQL Server 2012 AlwaysOn Availability Groups allow for better consolidation by offloading read-only workloads to secondary replicas
- Hypervisor changes increase the scalability and features available to virtual machines
 - VMware ESX 5.0 allows VMs with 32 vCPUs and up to 1TB of RAM

Resource Bottlenecks

- **One of the biggest problems for consolidated workloads is the overall impact of resource bottlenecks to the enterprise when they occur**
- **Consolidation requires proactive monitoring and resource management to prevent performance problems from becoming system outages**
 - Tools are available to assist with monitoring and responding to resource based issues dynamically
 - DRS under VMware can automatically load balance VMs across a cluster
 - Resource Governor can be used to limit SQL Server CPU and Memory usage within a single instance
 - PerfMon or third-party tools can monitor performance for the host and VMs

Overview

- Consolidation methods
- Choosing a consolidation strategy
- Hardware and software considerations
- **Post-consolidation tools**
 - Resource governor
 - Performance monitor

Resource Governor

- Useful when multiple databases have been consolidated into a single instance of SQL Server
- Can be used to prevent or minimize run-away query scenarios
- Can be used to provide predictable concurrent execution of different workloads within the same instance
 - Provide mission critical workloads with a guaranteed minimum set of resources
 - Limit the amount of resources a large workload receives
 - Prioritize workloads in the instance
- **Only controls CPU bandwidth and memory usage**
 - Memory = any request through the Single Page Allocator in the SQLOS
 - Does not limit I/O resources for the server

Performance Monitor

- Provides the ability to collect performance counters to identify resource usage metrics.
- Performance counters exist for physical resources in Windows, .NET, SQL Server, and most modern applications
- Performance Monitor provides a graphical user interface for collecting, viewing and performing limited analysis of performance counter information
- Performance Monitor can be opened from the Administrative Tools, or by running perfmon from the command line
- Leverage PAL SQL Server Template for rapid data collection and workload analysis

Review

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Questions?

