Technical Report

Microsoft SQL Server 2017 on NetApp ONTAP

Solution Delivery Guide

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Abstract

This purpose of this report is to enable storage administrators and database administrators to successfully deploy Microsoft SQL Server on NetApp® storage.

NetApp®

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1 Introduction

SQL Server 2017 represents a major step towards making SQL Server 2017 a platform that gives you choices of development languages, data types, on-premises or cloud, and operating systems by bringing the power of SQL Server to Linux, Linux-based Docker containers, and Windows.[1] Equally important, SQL Server 2017 is engineered to handle the fast-evolving needs of modern data developers and administrators.

Microsoft SQL Server 2017 powers your entire data estate by supporting structured and unstructured data sources. It builds on previous versions of SQL Server, which have been industry leading for four years in a row and a leader in TPCE. It scales to petabytes of data and allows customers to process big data through PolyBase using T-SQL over any data[2]. SQL Server 2017 has also been the least vulnerable database during the last seven years. SQL Server 2017 brings data insights with business intelligence capabilities that provide analytics at a fraction of the cost on any device—along with advanced analytics with support for R and Python.

Application developers can build their applications using any language, including Node.JS, .NET, Java, and PHP, and deploy their solutions on platforms such as Windows, Linux, and Docker containers—all in a private cloud (on-premises), Microsoft Azure, third-party clouds, or a hybrid environment.

1.1 Purpose and Scope

NetApp Solution for Microsoft SQL Database

Accelerate your success with solutions for Microsoft SQL Server, in the data center or in the cloud.

Get predictable performance and the flexibility to run a variety of Microsoft SQL Server workloads. NetApp solutions combine simplicity of management, scalability and data protection. The biggest benefit would be the storage efficiency by using NetApp ONTAP® data management software. You are also able to use something called a Flex Clone during test and development, so you can clone your database which won't take up any capacity until you change the clone. The scope, scale, and complexity of today's data-driven world create new demands for agility in the data center.

NetApp SnapCenter® Plug-in for Microsoft SQL Server is tightly integrated with Microsoft technology to help SnapCenter Plug-in to streamline database storage management while simplifying storage layout planning, backup, and restore operations. NetApp's agile storage infrastructure can save you time, help you consolidate storage, and simplify management across a SQL Server environment. With SnapCenter Plugin, you can dramatically reduce SQL Server data recovery times from hours to minutes. You can also use SnapCenter Plug-in to automate critical processes such as data backup, restore, and cloning, thus freeing your IT staff to focus on other value-added activities. With SnapCenter Plug-in, you get an industry-leading combination of high availability and seamless scalability for SQL Server environments.

The NetApp solutions for SQL Server offer the following advantages:

- **Reduce costs[3]**

  Reduce your TCO by consolidating your SQL Server databases onto NetApp storage systems. Our support for FC, FCoE, iSCSI SAN, and SMB (CIFS) means you can use your existing infrastructure to cut storage outlay. Our unified architecture helps you increase storage and server utilization while simplifying data management. Particularly, NetApp's built-in support for SMB 3.0 greatly simplifies the provisioning of database clones to use in test/dev/test.

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[1] SQL Server Documentation. What's new in SQL Server 2017. October 2017.

[2] Microsoft SQL Server 2019 Technical White Paper. September 2018.

[3] NetApp Solutions for Microsoft SQL Server

- **Optimize database performance**

  NetApp AFF systems address enterprise storage requirements with high performance, superior flexibility, and best-in-class data management. Built on ONTAP data management software, AFF systems speed up your business without compromising on the efficiency, reliability, or flexibility of your IT operations. With enterprise-grade all-flash arrays, AFF systems accelerate, manage, and protect your business-critical data and enable an easy and risk-free transition to flash media for your data center.

  Designed specifically for flash, the AFF series all-flash systems deliver industry-leading performance, capacity, density, scalability, security, and network connectivity in a dense form factor. With the addition of a new entry-level system, the new AFF series family extends enterprise-grade flash to midsize businesses. At up to 7 million IOPS per cluster with sub millisecond latency, the AFF series is the fastest family of all-flash arrays built on a true unified scale-out architecture.

- **Provide SnapCenter advantages**

  NetApp SnapCenter software delivers a unified, scalable platform and plug-in suite for application-consistent data protection and clone management. IT infrastructure admins can empower application and database administrators to self-manage their own copies and data protection. They retain centralized control through powerful policies and reporting capabilities—across the data. For more information about SQL Server Plug-in for SnapCenter, see TR-4714: Best Practice Guide for SQL Server Using NetApp SnapCenter.

  With SnapCenter, data protection and clone management tasks become:

  - **Simple:** A centralized GUI supports monitoring, notification, logging, reporting, and scheduling for all application and database plug-ins, including custom plug-ins.
  - **Scalable:** You can add SnapCenter servers with transparency for high availability and load balancing, supporting thousands of applications.
  - **Empowering:** Role-based access control (RBAC) provides self-service for application admins; SnapCenter infrastructure administrators retain oversight.

- **Speed backup and increase data protection**

  With NetApp integrated data protection solutions, you get quick, space-efficient backups, and a comprehensive set of Windows PowerShell cmdlets for easy scripting of backup/restore workflows. With federated backup, you can add multiple SQL Server instances and databases to the same federated group and take a NetApp Snapshot™ copy to back up all databases in that group at the same time. You have the ability to restore to a marker, so you can tie recovery to a business event, which is particularly useful for applications that span multiple databases across multiple SQL Server instances. You also can enable NetApp thin replication technology to protect your critical SQL Server database data, including SQL Server Availability Groups, against disasters.

- **Optimize disaster recovery and business continuity**

  To help you meet or exceed your stringent SLA, NetApp storage solutions enable rapid recovery of SQL Server databases—in minutes. With NetApp ONTAP software you can maintain SQL Server uptime during storage infrastructure (hardware and software) maintenance and upgrades through a highly available storage back end. Additionally, with built-in support for Always On Availability Groups (AGs) in SQL Server combined with the latest release of SnapCenter for Microsoft SQL Server. SnapCenter can accelerate AG setup, rapidly backup and restore all databases in AGs, create space-efficient clones of databases in AGs using NetApp FlexClone® technology, and quickly resynchronize databases within the AG using the SMSQL Reseed wizard. In addition, AGs can be mirrored to remote locations using NetApp SnapMirror technology.

- **Provide multitenancy and QoS**

  Customers can use functionality that ONTAP offers to provide data compartmentalization for all tenants, with each granted access only to its designated storage container. Rich support based on Windows PowerShell for both ONTAP and NetApp integrated backup empowers administrators to develop appropriate workflows that support the needs of your multitenant environment. In addition, ONTAP provides storage QoS workload management using policies that specify a throughput limit,

defined in terms of IOPS or MBps. This makes sure that SQL Server performance can be optimized consistently without being affected by other application workloads or tenants.

- **Achieve intelligent management**

  NetApp integrated backup helps you streamline administrative tasks such as backup, restore, cloning, and disaster recovery so that administrators can focus on more strategic tasks and business initiatives. With SnapManager federated backups you can simplify data protection of SQL Server applications where data is distributed across multiple SQL Server instances and databases. In addition, the combination of ONTAP and Windows PowerShell scripting enables DBAs to automate management of LUNs and volumes.

- **Improve manual, slow, and space-inefficient test and development processes**

  Accelerate the release and improve the quality of new applications based on SQL Server with NetApp FlexClone technology. With FlexClone, you can create space-efficient copies of SQL Server data for development, testing, reporting, and disaster recovery testing in seconds. You can also perform clone lifecycle management and on-demand, periodic, and customized staging and user-acceptance testing services. You can do this quickly through a policy-based clone automation framework and without causing errors to other DBAs and end users.

- **Speed deployment of business-critical applications with converged infrastructure**

  FlexPod validated solutions combine storage, networking, and server components into a single, flexible architecture for business workloads such as SQL Server. FlexPod solutions speed the deployment of infrastructure and business-critical applications while reducing costs, complexity, and risk. With a validated design and centralized management, you can quickly and easily deploy and host multiple instances of SQL Server, all with cooperative support from Microsoft, Cisco, and NetApp.

- **Respond quickly to data growth**

  With seamless scaling, you can quickly and easily scale NetApp solutions to meet your changing business needs. With thin provisioning provided by NetApp FlexVol technology, you can cost-effectively expand and reallocate storage while increasing efficiency through deduplication of active data—all without interfering with your business operations. ONTAP allows you to nondisruptively move your data within your storage cluster to meet the needs of SQL Server data growth and increased and changing SQL Server application workloads.

1.2 Intended Audience

This technical document is intended for NetApp customers, partners, employees, and field personnel who are responsible for deploying a SQL Server database solution in a customer environment. NetApp assumes that the reader is familiar with the various components of the listed solution previously

2 Technology Requirements

2.1 Hardware Requirements

Table 1 lists the ONTAP 9.X version requirements. For additional information, see the AFF A-Series All Flash Arrays product page.

Table 1) ONTAP 9.X version requirements.

Storage Controller Model	Minimum ONTAP Version	Maximum ONTAP Version
FAS2600 Series	9.1RC1	9.4.x
FAS2700 Series	9.4RC1	9.4.x
FAS8200	9.1RC1	9.4.x

Storage Controller Model	Minimum ONTAP Version	Maximum ONTAP Version
FAS9000	9.1RC1	9.4.x
AFF A200	9.1RC1	9.4.x
AFF A220	9.1RC1	9.4.x
AFF A300	9.1RC1	9.4.x
AFF A700	9.1RC1	9.4.x
AFF A700s	9.1RC1	9.4.x
AFF A800	9.1RC1	9.4.x

2.2 Processor, Memory, and Operating System Requirements

Table 2 lists the operating system requirements for MS SQL Server.

Table 2) Operating system requirements for MS SQL Server.

Component	Requirement
Memory	• Minimum: – Express Editions: 512MB – All other editions: 1GB • Recommended: – Express Editions: 1GB • All other editions: At least 4GB and should be increased as database size increases to ensure optimal performance.
Processor speed	Minimum: x64 processor, 1.4 GHz Recommended: 2.0 GHz or faster
Processor type	x64 processor: AMD Opteron, AMD Athlon 64, Intel Xeon with Intel EM64T support, Intel Pentium IV with EM64T support

Note: Installation of SQL Server is supported on x64 processors only. It is no longer supported on x86 processors.

SQL Server 2017 is also supported on Red Hat Enterprise Linux, SUSE Linux Enterprise Server, and Ubuntu. It is also supported as a Docker image, which can run on Docker Engine on Linux or Docker for Windows/Mac. For additional information, see Installation Guidance for SQL Server on Linux on the Microsoft SQL Docs web site.

2.3 Software Versions or Configurations

ONTAP 9.1, 9.2, 9.3, 9.4 are general availability releases in the ONTAP 9 release family. You can run ONTAP 9.1, 9.2, 9.3, 9.4 on all NetApp FAS systems, NetApp AFF systems, and NetApp FlexArray® Virtualization systems that are supported with this release.

2.4 Licenses

Table 3) SQL Server 2017 editions availability by licensing model.

SQL Server 2017 Editions	Licensing Options	
	Server + CAL	Per Core
Enterprise		
Standard		
Developer	Free edition	
Express	Free edition	

The SQL Server 2017 editions align with how customers deploy applications and solutions:

- Enterprise Edition is for applications that require mission critical in-memory performance, security, and high availability
- Standard Edition delivers fully featured database capabilities for mid-tier applications and data marts

SQL Server 2017 is also available in free Developer and Express editions. Web Edition is offered in the Services Provider License Agreement (SPLA) program only.

3 Storage

Database storage was configured to adhere to All Flash Business Processing (AFBP) specifications for a NetApp AFF8080 system. A single aggregate was created on each of the two AFF8080 controllers as follows:

- 63 x 400GB SSDs using three RAID groups
- Total aggregate size of 12.07TB

By using this configured storage, a set of volumes was provisioned (each volume contained one FC LUN). The LUNs were used as components of a MS-SQL database. The following LUNs were created on each of the AFF8080 nodes:

- 8 x 3TB LUNs used for MS-SQL database portion
- 8 x 500GB LUNs used for MS-SQL log portion
- 8 x 500GB LUNs used for MS-SQL temp database

Figure 1) Storage layout of SQL Server.

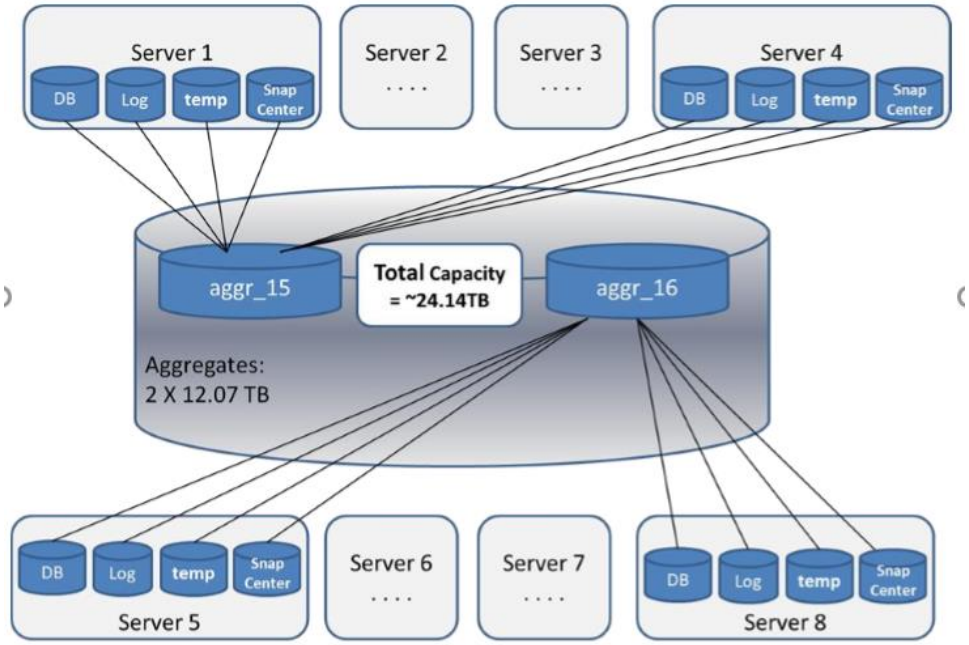


Figure 1 shows the storage layout for SQL Server. It shows aggregates aggr_15 and aggr_16, one on each storage node, each using 42 SSDs, leaving one spare SSD per node. With a RAID group size of 21, the configuration yielded 12.07TB of usable storage space per storage node, for a total of 24.14TB of usable space across both nodes.

Eight MS-SQL databases in all are hosted on this cluster, four on each node. The database was created by using the TPC-E tool. This configuration resulted in the TPC-E test workloads being evenly spread across both storage nodes.

4 Networking

Figure 2 shows the architecture of the validation test configuration. This configuration uses a two-node NetApp AFF8080 cluster with four shelves containing 96 SSDs of 400GB. Eight MS SQL servers were used. Figure 2 shows dual paths between the RAC nodes and a 10GbE network between the database servers, serving as a cluster interconnect.

Figure 2) Network connections.

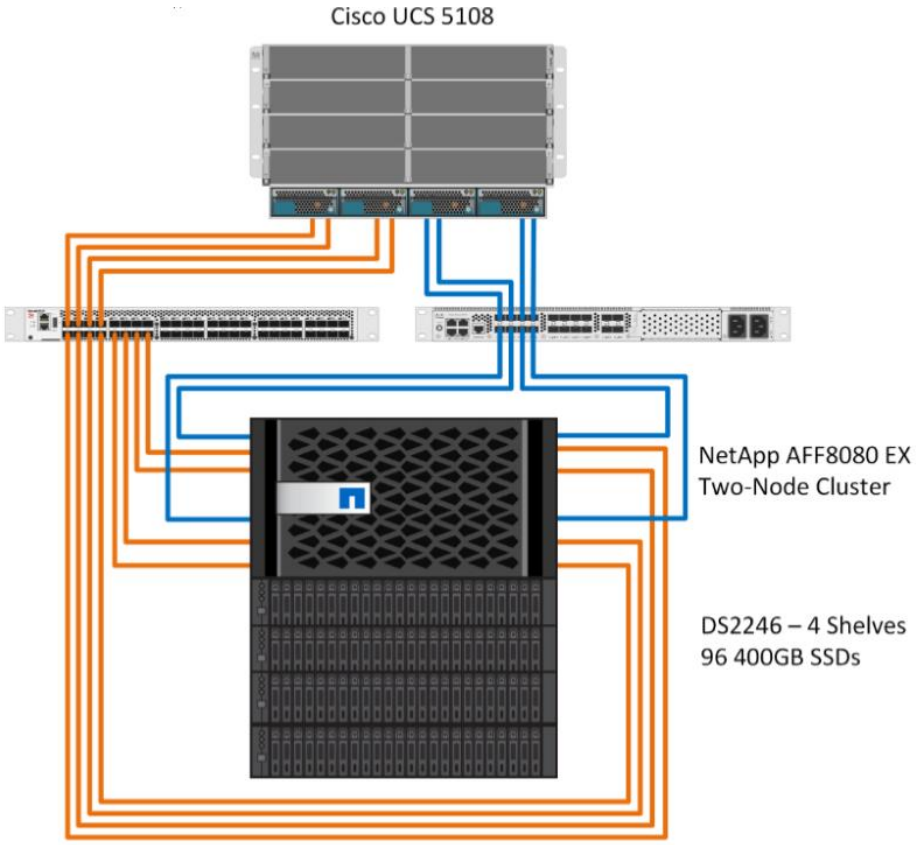


Table 4 through Table 6 list the SQL Server and NetApp hardware and software components that were used for testing. The storage was configured for compliance with the AFBP guidelines.

Table 4) SQL Server hardware and software test components.

Component	Details
SQL Server database servers	Cisco UCS 5108 with 4 x B200 M4 blades (2 x SQL Servers per blade)
Server operating system	Windows Server 2012 R2 Datacenter Edition hosted on VMware ESX 5.5.0
SQL Server database	MS SQL Server Enterprise Edition
Processors/server	2 x socket, 14 cores per server
Physical memory/server	32GB

Table 5) Network components.

Component	Details
FC network	16Gb FC with multipathing
FC HBA	QLogic QLE2672 dual-port PCIe FC HBA
Network connections	4 x Intel 82599ES 10Gbps SFI/SFP+ network connections
16Gb FC switch	Brocade 6510 24-port
10GbE switch	Cisco Nexus 5596

Table 6) NetApp storage hardware and software test components.

Component	Details
Storage controller	AFF8080 EX configured as an HA active-active pair
ONTAP software	v9.0
Number/size of SSDs	96 x 400GB (48 SSDs per cluster node)
FC target ports	8 x 16Gb (4 per node)
Ethernet ports	4 x 10Gb (2 per node)
Storage virtual machines (SVMs)	1 x across both node aggregates
Management LIFs (Ethernet)	4 x 1GbE data (1 per node connected to separate private VLANs)
FC LIFs	8 x 16Gb data

5 Architecture

NetApp ONTAP is designed to simplify a storage environment regardless of the storage structure employed.

Microsoft S SQL is a relational database management system that has huge data storage demands. Use ONTAP to make more efficient use of your storage environment allowing SQL Server to scale by accessing more storage.

SnapCenter provides application consistent data protection for ONTAP systems. SnapCenter allows taking Snapshot copies of applications, databases, file systems, and virtual machines. Use SnapCenter to back up to a secondary storage system within the same data center or to a storage system located in a different data center.

5.1 Data Storage Design

This section contains a few examples of SQL Server designs for NetApp storage and considerations for environments that use SnapManager for SQL Server and SnapCenter.

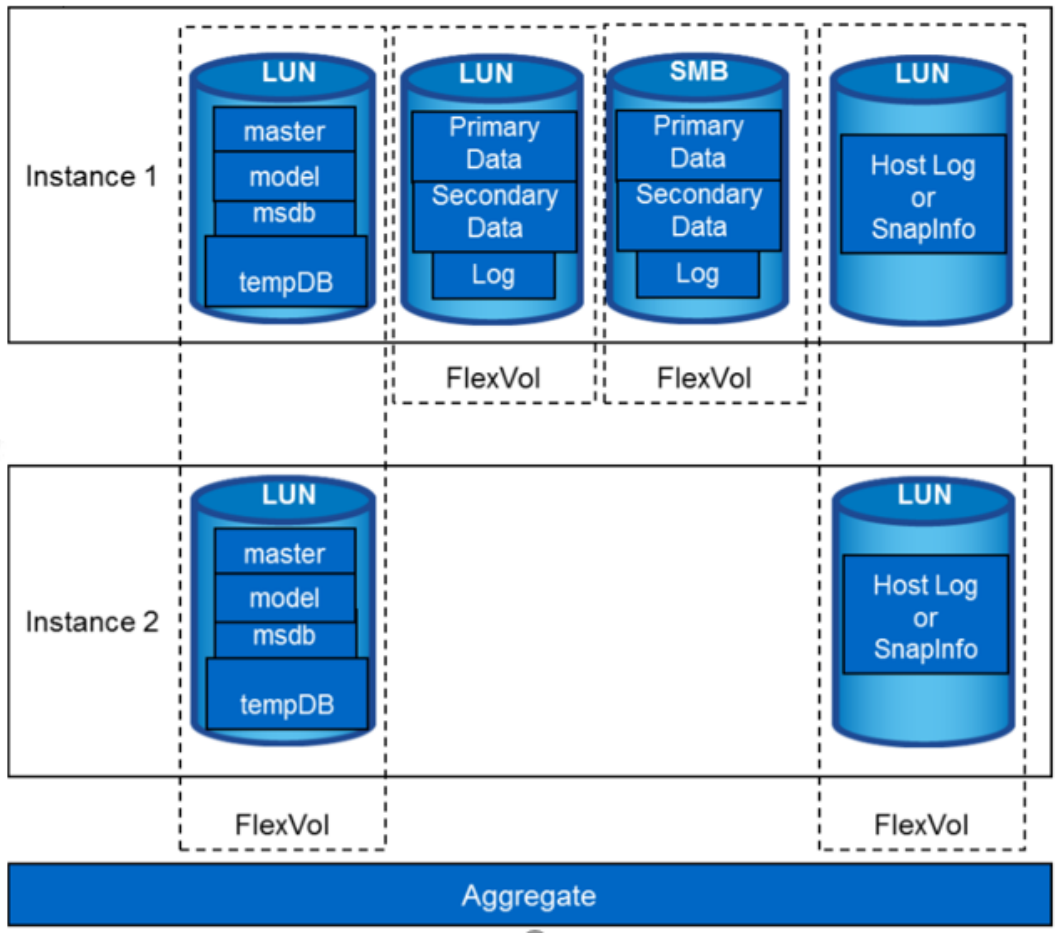
Design Example 1

This configuration can be used for SQL Server instances that require basic performance and contain multiple small databases. The database storage design has the following characteristics:

- Contains one aggregate for SQL Server instances.

- Uses a dedicated volume and LUN for the SQL Server system databases, including the tempdb database.
- Uses a dedicated LUN for each database.
- Uses a single volume for both data and log.
- Uses dedicated SMB shares for both data and log (if using SMSQL for backup).

Figure 3) Basic SQL Server database design for NetApp storage for SMSQL or SnapCenter.



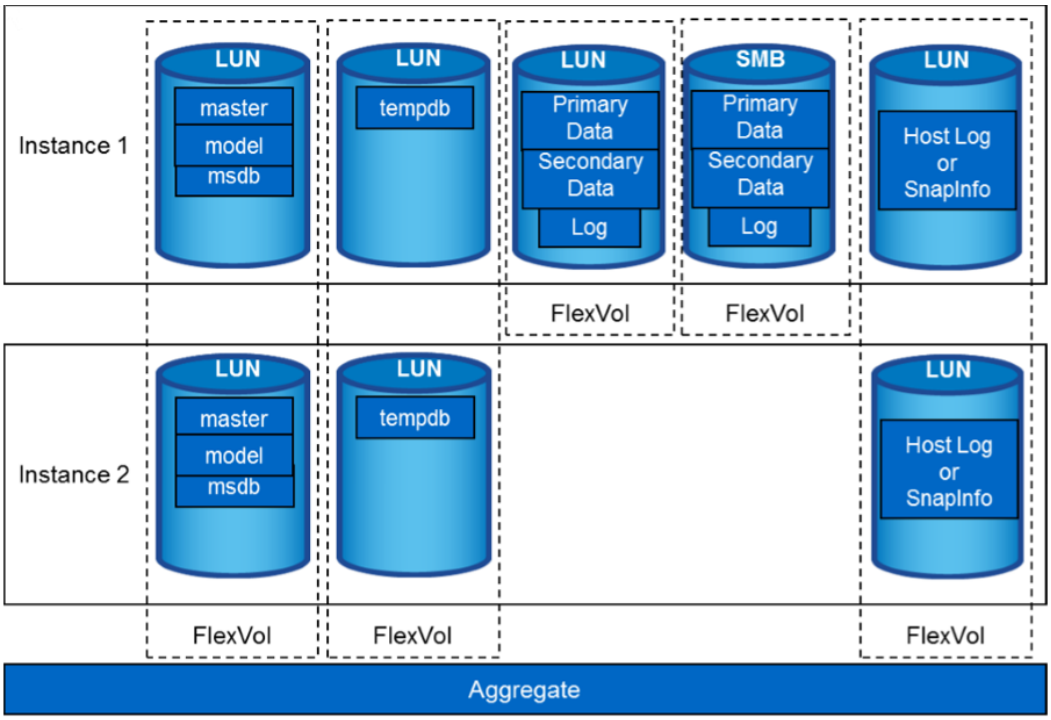
Because system databases, including tempdb databases, reside in the same volume, the database backup is performed by using native SQL Server but not SMSQL or SnapCenter.

Design Example 2

This configuration is designed to be used for SQL Server instances that require basic performance and contain multiple databases that are backed up using either SMSQL or SnapCenter. The database storage design has the following characteristics:

- Contains one aggregate for SQL Server instances.
- Uses a dedicated volume and LUN for the SQL Server system databases.
- Uses a dedicated volume and LUN for tempdb database.
- Uses a dedicated LUN for each database.
- Uses a single volume for both data and log.
- Uses dedicated SMB shares for both data and log (if using SMSQL for backup).

Figure 4) SQL Server database design for NetApp storage using SMSQL or SnapCenter.

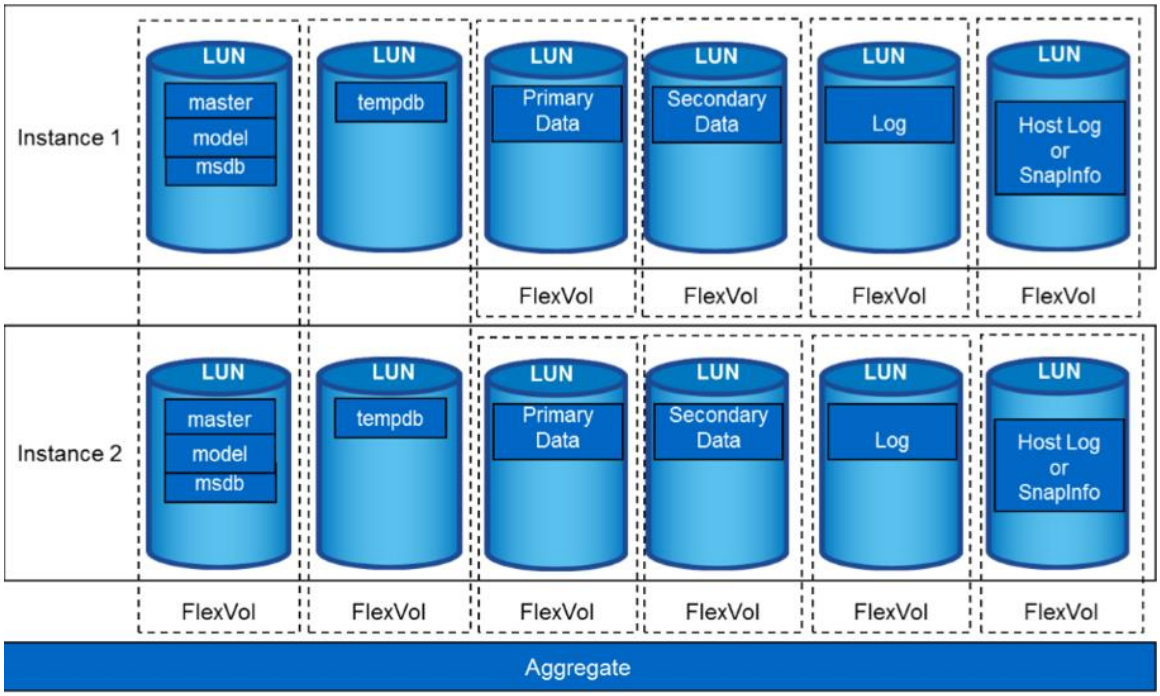


Design Example 3

This configuration is designed to be used for SQL Server instances that require high performance and contain a few databases that are backed up using either SMSQL or SnapCenter. The database storage design has the following characteristics:

- Contains one aggregate for SQL Server instances.
- Uses a dedicated volume and LUN for the SQL Server system databases.
- Uses a dedicated volume and LUN for tempdb database.
- Uses a dedicated LUN for each user database.
- Uses dedicated volumes for primary and secondary data and log files.

Figure 5) Server database design for NetApp storage using SMSQL or SnapCenter.



5.2 Shared Instance Versus Dedicated Instance

If an application has many schemas/stored procedures, this could potentially affect other apps that share the same SQL Server instance. Instance resources could potentially become divided/locked, which in turn causes performance issues for any other apps with databases hosted on the shared SQL Server instance.

Troubleshooting performance issues can be complicated because you must figure out which instance is the root cause. This question is usually weighed against the costs of operating system and SQL Server licenses. If application performance is paramount, then a dedicated instance is highly recommended.

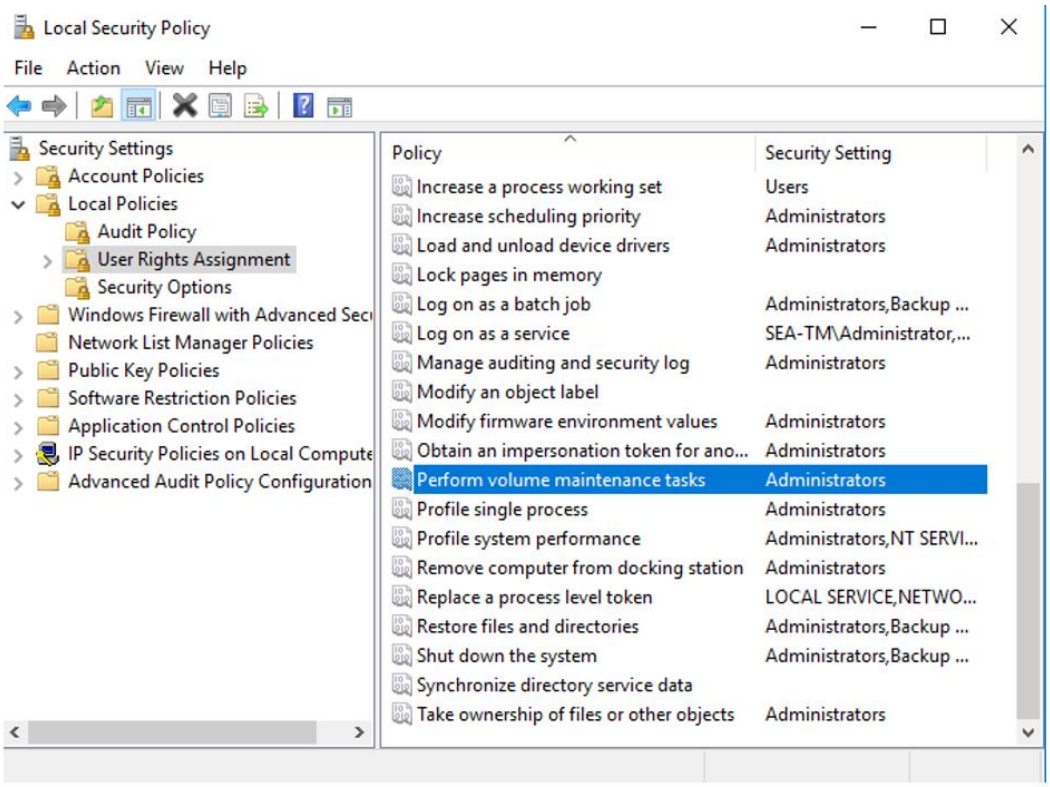
Microsoft licenses SQL Server at the server level per core and not per instance. For this reason, database administrators are tempted to install as many SQL Server instances as the server can handle, to save on licensing costs, which can lead to major performance issues later.

NetApp recommends choosing dedicated SQL Server instances whenever possible to get high performance.

6 Grant Perform Volume Maintenance

You can enable instant file initialization by adding the SA_MANAGE_VOLUME_NAME permission, also known as perform volume maintenance task, to the SQL Server startup account. You can add this permission under the local security policy management application (secpol.msc), as shown in Figure 6. You need to open properties for “perform volume maintenance task” permission and add the SQL Server startup account to the list of users there.

Figure 6) Local security policy management application.



To verify whether a permission is enabled, use the code shown in the example in Figure 7. This code sets two trace flags that force SQL Server to write additional information to the error log, create a small database, and read the content of the log.

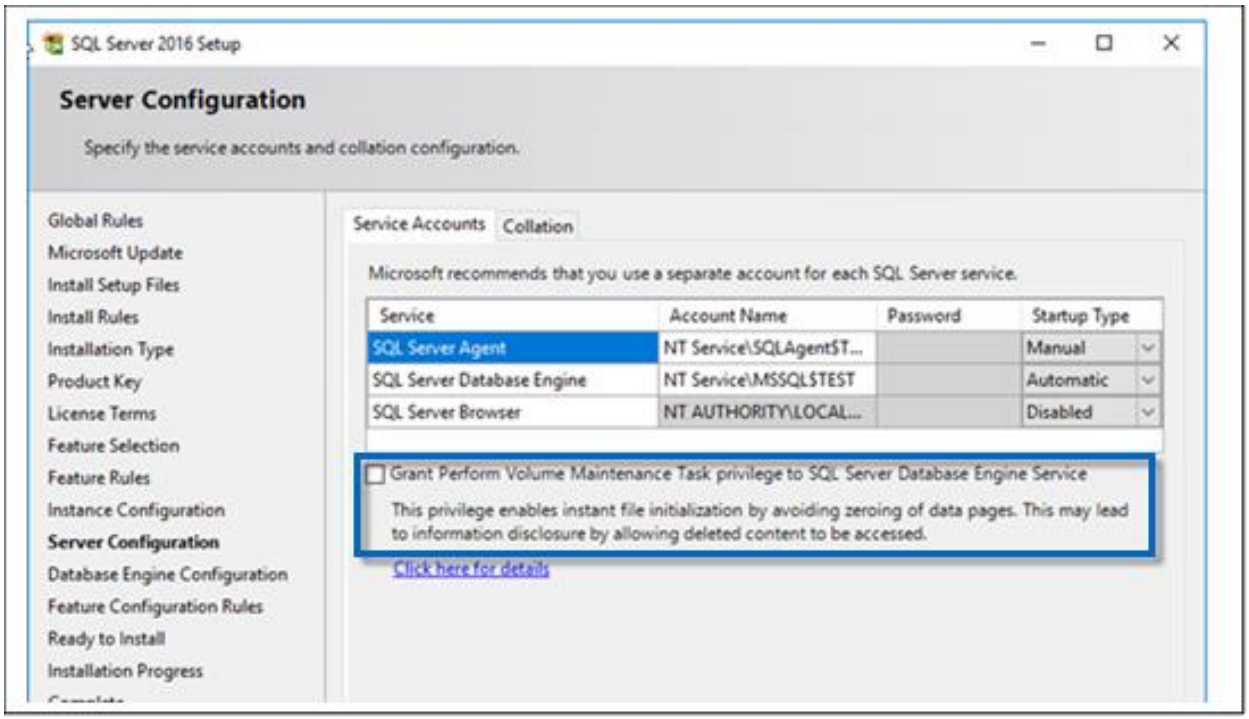
If the instant file initialization isn't enabled, the SQL Server error log shows that SQL Server is zeroing the mdf data file in addition to zeroing the ldf log file, as shown in Figure 7. When instant file initialization is enabled, the log displays only zeroing of the log file.

Figure 7) SQL Server zeroing the log file.

	LogDate	ProcessInfo	Text
365	2017-02-09 08:10:07.660	spid53	Ckpt dbid 3 flush delta counts.
366	2017-02-09 08:10:07.660	spid53	Ckpt dbid 3 logging active xact info.
367	2017-02-09 08:10:07.750	spid53	Ckpt dbid 3 phase 1 ended (8)
368	2017-02-09 08:10:07.750	spid53	About to log Checkpoint end.
369	2017-02-09 08:10:07.880	spid53	Ckpt dbid 3 complete
370	2017-02-09 08:10:08.130	spid53	Starting up database 'DelMe'.
371	2017-02-09 08:10:08.150	spid53	FixupLogTail(progress) zeroing C:\Program Files\Micros
372	2017-02-09 08:10:08.160	spid53	Zeroing C:\Program Files\Microsoft SQL Server\MSSQL
373	2017-02-09 08:10:08.170	spid53	Zeroing completed on C:\Program Files\Microsoft SQL
374	2017-02-09 08:10:08.710	spid53	Ckpt dbid 6 started
375	2017-02-09 08:10:08.710	spid53	About to log Checkpoint begin.

The perform volume maintenance task is simplified in SQL Server 2016 and later as an option is provided during the installation process. The following figure displays the option to grant the SQL Server database engine service the privilege to perform the volume maintenance task.

Figure 8) GPVM privilege option.



Another important database option that controls the database file sizes is autoshrink. When this option is enabled, SQL Server regularly shrinks the database files, reduces their size, and releases space to the operating system. This operation is very resource intensive and rarely useful because the database files grow again after some time when new data comes into the system. Autoshrink must never be enabled on the database

7 Extensibility

NetApp Cloud Volumes ONTAP software is deployed using OnCommand Cloud Manager to deliver secure, proven NFS, CIFS, and iSCSI data management for cloud storage. A software-only storage service running the ONTAP software, Cloud Volumes ONTAP combines data control with enterprise-class storage features—such as data deduplication and compression—to minimize your storage footprint. Create Snapshot copies of your data without requiring additional storage or impacting your application's performance. Cloud Volumes ONTAP can tie your cloud storage to your data center using the leading NetApp replication protocol, SnapMirror technology. OnCommand Cloud Manager handles deployment and management of Cloud Volumes ONTAP, giving you a simple point-and-click environment to manage your storage and ease control of your data.

7.1 Cloud Volumes ONTAP (Formerly ONTAP Cloud)

Cloud Volumes ONTAP runs in a hyperscaler cloud environment, bringing intelligence and Data Fabric connectivity to hyperscaler storage volumes. The overall best practices for running SQL Server on Cloud Volumes ONTAP are generally the same as for SQL Server on ONTAP. The primary considerations specific to SQL Server on Cloud Volumes ONTAP surround performance and, to a lesser extent, cost.

Cloud Volumes ONTAP is partially limited by the performance of the underlying volumes managed by the cloud provider. The result is more manageable storage, and, in some cases, the caching capability of Cloud Volumes ONTAP offers a performance improvement. However, there are always some limitations in terms of IOPS and latency due to the reliance on public cloud provider storage.

The prime use cases for Cloud Volumes ONTAP are currently disaster recovery (DR) and development and testing work, but some customers have used Cloud Volumes ONTAP for production activity as well.

7.2 Benefit of Cloud Volumes ONTAP With SQL Server

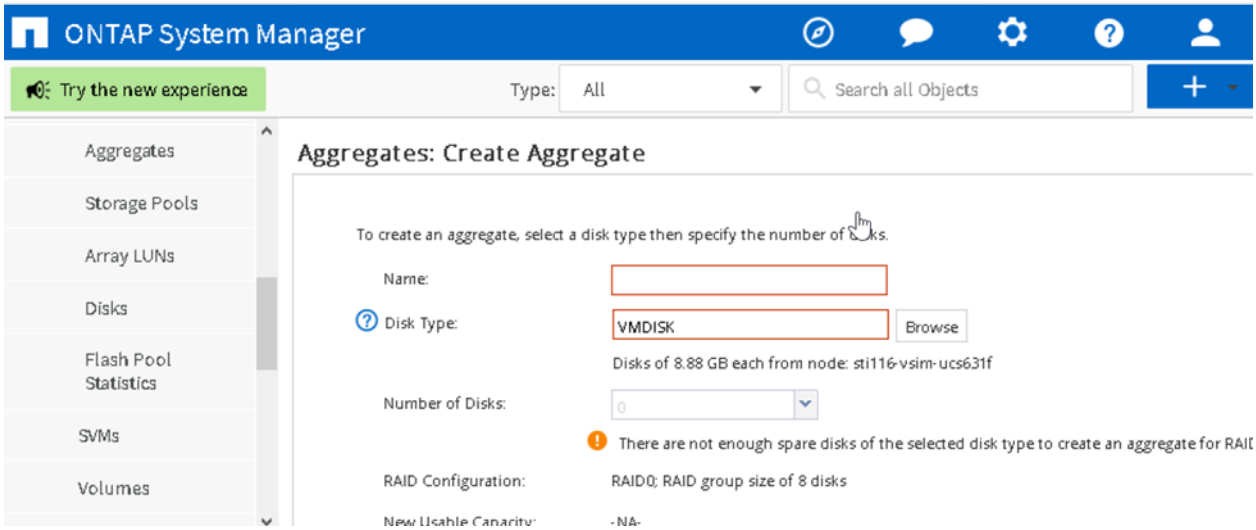
With Cloud Volumes ONTAP, you get advanced data management that enhances service levels, saves time for IT and DevOps, and reduces storage management and associated costs. The following are benefits of using Cloud Volumes ONTAP with SQL Server:

- **Cost savings with storage efficiencies**. Cloud Volumes ONTAP can save up to 90% on storage capacity with space efficient technologies: data deduplication, compression, thin-cloning, and Snapshot copies that don't affect storage footprint.
- **High availability**. Achieve high availability with a two-node solution that supports multiple Availability Zones and enables business continuity for your critical production workloads and databases with no data loss (RPO=0) and short recovery times (RTO < 60 secs).
- **Data protection and disaster recovery**. Recover from data corruption or loss with efficient data Snapshot copies and disaster recovery copies which are easily configured, cost effective, and support seamless failover, failback, restore, and recovery processes that meet minute-level SLAs.
- **Hybrid and multicloud environments**. Save time and money by using the same storage and advanced NetApp ONTAP data management software across hybrid and multicloud environments, including DR, HA, Dev/Test and DevOps, sandbox, reporting, data tiering, workload hosting, and training.
- **Data mobility**. Migrate, replicate and synchronize your data securely, using efficient data Snapshot copies to transfer only incremental changes and recover from any point in time using NetApp's SnapMirror.
- **Cloning technology for developers**. Increase DevOps agility by cloning writable volumes from Snapshot copies so data can be shared simultaneously across organizations and regions with zero capacity and performance penalties using NetApp FlexClone.
- **Interoperability**. Use multi-protocol support (iSCSI and SMB) for your data and file shares and meet the demands of SQL Server workloads.
- **Flexible licensing**. There are multiple Cloud Volumes ONTAP solutions from hourly priced options to longer-term subscriptions and Bring Your Own License (BYOL) options.
- **Enhanced security**. In addition to security and privacy features offered by the hyperscaler, it can provide NetApp managed encryption which gives you the ability to manage encryption keys on your own premises.

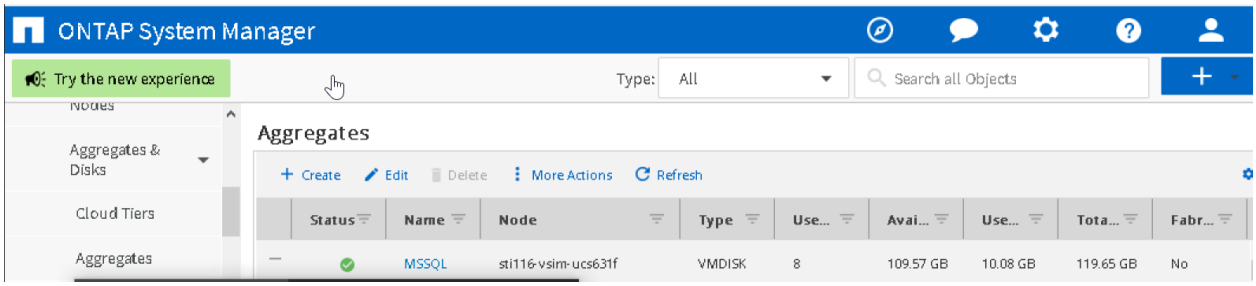
7.3 Deploy SQL Server Database Data Files

To deploy SQL Server database files by spreading the workload to several volumes, complete the following steps:

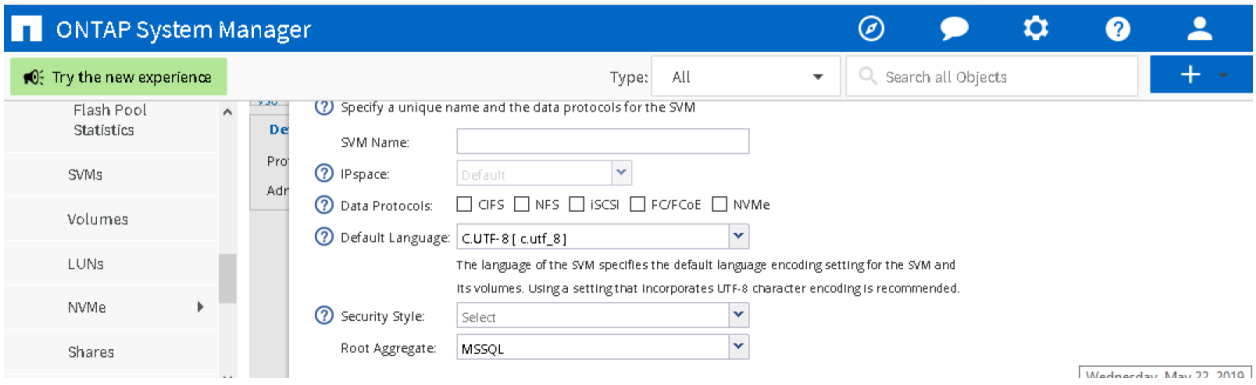
1. Log in to OnCommand System Manager browser and create an aggregate:
    a. Click Aggregate.
    b. Enter a name for the aggregate.
    c. Browse out to select the disk type then enter the number of disk.
    d. Click Submit.



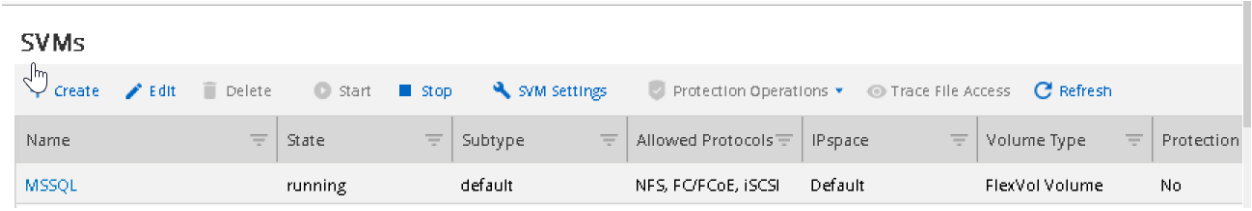
2. After the aggregate is created, it should be displayed in the aggregate list.



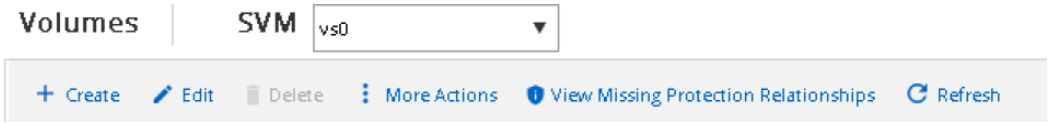
3. Create a storage virtual machines (SVM):
   a. Click SVM and then click Create.
   b. Enter the SVM name, data protocols (CIFS, NFS, iSCSI, and FC), and root aggregate.
   c. Click Submit.



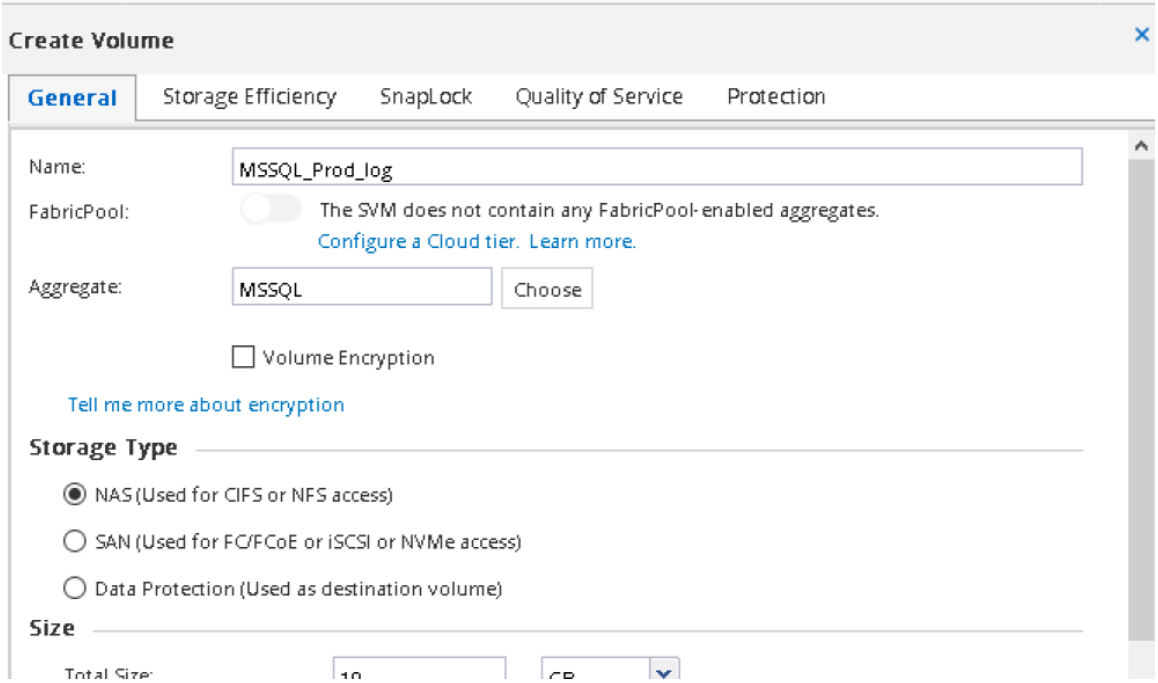
In this example, an SVM MSSQL was created.



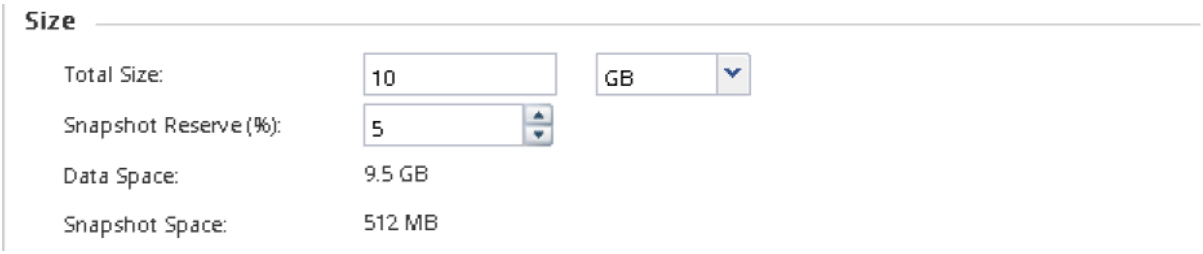
4. Create the volumes to spread out the workloads:
   a. Click on Volumes.
   b. Click Create.
   c. Click Create FlexVolume.



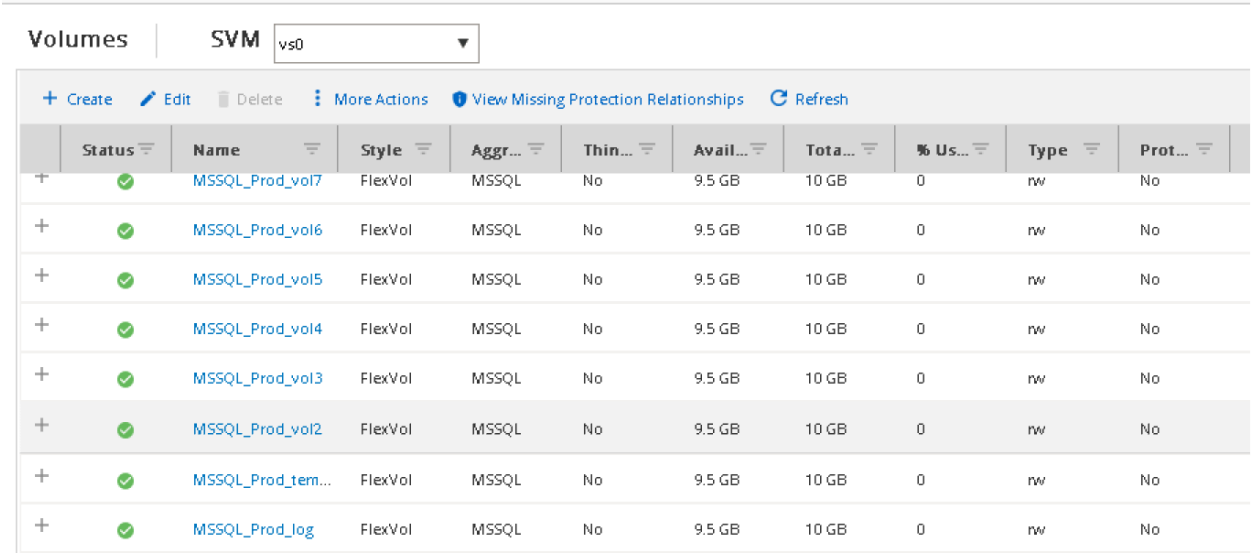
5. Create several volumes to distribute the workloads:
   a. Enter the name of the volume you want to create.
   b. Select the aggregate where you would like the volume placed.
   c. Select the storage type (NAS or SAN are preferred).



6. Enter the size of the volume and then click Create.



7. in this example, seven volumes and a log and temp volume were created. Each volume was named toward the workload name to spread out the workload for each database. Notice each volume has approximately 10GB available. ONTAP System Manager allows you choose to divide up the workload to however many volumes that are specified for the database, temp, and log volumes.



Status	Name	Style	Aggr...	Thin...	Avail...	Tota...	% Us...	Type	Prot...
	MSSQL_Prod_vol7	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_vol6	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_vol5	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_vol4	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_vol3	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_vol2	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_tem...	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No
	MSSQL_Prod_log	FlexVol	MSSQL	No	9.5 GB	10 GB	0	rw	No

8. Go to disk management on the windows server, it shows you all the unmapped and uninitialized disks. Click Initialize, select the desired disk, and then click OK. After initialization, you can fill the disk with new simple volumes and assign a mount path with the `C:\MSSQL` directory.

8 Best Practices

8.1 Before Installing SQL Server

Follow these best practices when you set up the server environment:[4]

- Enhance physical security
- Use firewalls
- Isolate services
- Configure a secure file system
- Disable NetBIOS and server message block

[4] SQL Server Documentation. Security Considerations for a SQL Server Installation. August 2017.

- Install SQL Server on a domain controller

Enhance Physical Security

Physical and logical isolation make up the foundation of SQL Server security. To enhance the physical security of the SQL Server installation, do the following tasks:

- Place the server in a room accessible only to authorized persons.
- Place computers that host a database in a physically protected location, ideally a locked computer room with monitored flood detection and fire detection or suppression systems.
- Install databases in the secure zone of the corporate intranet and do not connect your SQL Servers directly to the Internet.
- Back up all data regularly and secure the backups in an off-site location.

Use Firewalls

Firewalls are important to help secure the SQL Server installation. Firewalls will be most effective if you follow these guidelines:

- Put a firewall between the server and the Internet. Enable your firewall. If your firewall is turned off, turn it on. If your firewall is turned on, do not turn it off.
- Divide the network into security zones separated by firewalls. Block all traffic, and then selectively admit only what is required.
- In a multi-tier environment, use multiple firewalls to create screened subnets.
- When you are installing the server inside a Windows domain, configure interior firewalls to allow Windows Authentication.
- If your application uses distributed transactions, you might have to configure the firewall to allow Microsoft Distributed Transaction Coordinator (MS DTC) traffic to flow between separate MS DTC instances. You will also have to configure the firewall to allow traffic to flow between the MS DTC and resource managers such as SQL Server.

Isolate Services

Isolating services reduces the risk that one compromised service could be used to compromise others. To isolate services, consider the following guideline:

- Run separate SQL Server services under separate Windows accounts. Whenever possible, use separate, low-rights Windows or Local user accounts for each SQL Server service.

Configure a Secure File System

Using the correct file system increases security. For SQL Server installations, you should do the following tasks:

- Use NTFS. NTFS is the preferred file system for installations of SQL Server because it is more stable and recoverable than FAT file systems. NTFS also enables security options like file and directory access control lists (ACLs) and Encrypting File System (EFS) file encryption. During installation, SQL Server will set appropriate ACLs on registry keys and files if it detects NTFS. These permissions should not be changed. Future releases of SQL Server might not support installation on computers with FAT file systems.

  Note: If you use EFS, database files will be encrypted under the identity of the account running SQL Server. Only this account will be able to decrypt the files. If you must change the account that runs SQL Server, you should first decrypt the files under the old account and then re-encrypt them under the new account.

- Use a redundant array of independent disks (RAID) for critical data files.

Disable NetBIOS and Server Message Block

Servers in the perimeter network should have all unnecessary protocols disabled, including NetBIOS and server message block (SMB).

NetBIOS uses the following ports:

- UDP/137 (NetBIOS name service)
- UDP/138 (NetBIOS datagram service)
- TCP/139 (NetBIOS session service)

SMB uses the following ports:

- TCP/139
- TCP/445

Web servers and DNS servers do not require NetBIOS or SMB. On these servers, disable both protocols to reduce the threat of user enumeration.

Install SQL Server on a Domain Controller

For security reasons, we recommend that you do not install SQL Server on a domain controller. SQL Server Setup will not block installation on a computer that is a domain controller, but the following limitations apply:

- You cannot run SQL Server services on a domain controller under a local service account.
- After SQL Server is installed on a computer, you cannot change the computer from a domain member to a domain controller. You must uninstall SQL Server before you change the host computer to a domain controller.
- After SQL Server is installed on a computer, you cannot change the computer from a domain controller to a domain member. You must uninstall SQL Server before you change the host computer to a domain member.
- SQL Server failover cluster instances are not supported where cluster nodes are domain controllers.
- SQL Server Setup cannot create security groups or provision SQL Server service accounts on a read-only domain controller. In this scenario, setup will fail.

8.2 During or After Installation of SQL Server

After installation, you can enhance the security of the SQL Server installation by following these best practices regarding accounts and authentication modes:

- Service accounts:
  - Run SQL Server services by using the lowest possible permissions.
  - Associate SQL Server services with low privileged Windows local user accounts, or domain user accounts.
- Authentication mode:
  - Require Windows authentication for connections to SQL Server.
  - Use Kerberos authentication.
- Strong passwords:
  - Always assign a strong password to the sa account.
  - Always enable password policy checking for password strength and expiration.
  - Always use strong passwords for all SQL Server logins.

Important

During the setup of SQL Server Express, a login is added for the BUILTIN\Users group. This allows all authenticated users of the computer to access the instance of SQL Server Express as a member of the public role. The BUILTIN\Users login can be safely removed to restrict Database Engine access to computer users who have individual logins or are members of other Windows groups with logins.

9 Conclusion

SQL Server users typically face a series of significant challenges in their effort to increase the return on their SQL Server investments and optimize their infrastructure to support business and IT requirements. They must:

- Accelerate new database implementations or migrations and lower the risk of these operations.
- Make sure that the underlying storage infrastructure is fully optimized to support SLAs, including performance, scalability, and availability.
- Consolidate existing databases and infrastructure to lower costs.
- Reduce complexity and simplify IT infrastructure.
- Increase the productivity of IT personnel.

To handle these challenges, the architects, sysadmins, or DBAs are looking to deploy their databases and storage infrastructure based on proven best practices and technology.

This document covers the NetApp's recommendations for designing, optimizing, and scaling Microsoft SQL Server deployments, which can vary greatly between implementations. Options such as cluster awareness and virtualization introduce further variables. The right solution depends on both the technical details of the implementation and the business requirements driving the project.

Where to Find Additional Information

To learn more about the information that is described in this document, review the following documents and/or websites:

- TR-4369: Best Practices Guide for Microsoft SQL Server and SnapManager 7.2 for SQL Server with Clustered Data ONTAP
  https://www.netapp.com/us/media/tr-4369.pdf
- TR-4714: Best Practice Guide for SQL Server Using NetApp SnapCenter
  https://www.netapp.com/us/media/tr-4714.pdf
- Azure SQL Database Documentation
  https://docs.microsoft.com/en-us/azure/sql-database/
- SQL Server Documentation
  https://docs.microsoft.com/en-us/sql/sql-server/sql-server-technical-documentation?toc=..%2ftoc%2ftoc.json&view=sql-server-2017

Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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