Dell EMC Ready Bundle for Microsoft SQL

Design Guide for implementing Microsoft SQL Server 2016 with Dell EMC 13th Generation of Servers and Dell EMC Storage

Dell Engineering
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1 Introduction

Microsoft SQL Server 2016 brings a new set of technologies, features and services to SQL Server. It is a relational database platform designed for mission critical applications such as analytics, In-Memory databases, Business Intelligence (BI) and OLTP.

The Dell EMC enterprise portfolio is evolving to incorporate better performing, more energy efficient and more highly available products. With Dell EMC's 13th generation of PowerEdge servers, Dell EMC Storage and Dell EMC Networking product lines, customers have an opportunity to improve their business by virtualizing, consolidating and migrating distributed legacy environments.

The Dell EMC Enterprise Solution team has developed a pre-architected and validated solution for implementing a virtualized infrastructure for SQL Server 2016. This end-to-end solution based on best practices recommended by Microsoft and Dell EMC, provides exceptional performance and scalability, delivers faster time to value and increases return on investment.

1.1 Scope

The scope of this guide is as follows:

- Implementing and validating a virtualized Microsoft SQL server 2016 solution
- Best practices for designing and implementing Microsoft SQL Server 2016

1.2 Audience

The audiences for this document are database administrators, system administrators, storage administrators and architects who design and maintain database infrastructures. Readers should have some knowledge with Microsoft Windows Server, Microsoft SQL Server, Dell EMC PowerEdge servers, Dell EMC Storage and Dell EMC Networking products.

2   Solution components

The components used in this Dell EMC Ready Bundle for Microsoft SQL Server can be categorized into:

- Dell EMC hardware components
- Other vendor components (Brocade)
- Microsoft software components

2.1   Dell EMC hardware components

Dell EMC offers a wide range of enterprise products and solutions, including servers, storage, networking, software and services. The products and solutions are designed with reliability and scalability. They are engineered to handle the most demanding business applications and workloads such as ERP, database, BI, HPC and collaboration.

2.1.1   Dell EMC PowerEdge R730 and R830

The Dell EMC PowerEdge R730 server is a two-socket, 2U rack server designed for a wide variety of workloads for midsized and large enterprises. The R730 server:

- Supports Intel Xeon processor E5-2600 v4 product family with up to 22 cores
- Supports up to 1.5 TB memory in 24 DIMM slots, with DDR4 memory running at a speed of up to 2400 MT/s
- Provides up to 64 TB of internal storage with 3.5" hard drives, ideal for database and BI solutions

The Dell EMC PowerEdge R830 server is a high-performance, four-socket, 2U rack server optimized for database applications on a virtualized environment. The R830 server offers a balance between dense memory and compute capacity, making it an ideal platform for medium or large sized enterprises. The PowerEdge R830 server:

- Supports Intel Xeon processor E5-4600 v4 product family with up to 22 cores
- Supports up to 3 TB memory in 48 DIMM slots, with DDR4 memory running at a speed of up to 2400 MT/s
- Supports up to 16 SSDs or traditional HDDs, well suited for data-intensive workloads

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The following table shows the technical specifications of Dell EMC PowerEdge R730 and Dell EMC PowerEdge R830 in detail:

Table 1   Dell EMC PowerEdge server technical specifications

Server	R730	R830
Form factor	2U	2U
Processor	Intel Xeon processor E5-2600 v4 product family	Intel Xeon processor E5-4600 v4 product family
Processor sockets	2	4
Chipset	Intel C610 series chipset	Intel C612 series chipset
Memory	Up to 1.5 TB (24 DIMM slots): 4 GB/8 GB/16 GB/32 GB/64 GB DDR4 up to 2400 MT/s	Up to 3 TB (48 DIMM slots): 8 GB/16 GB/32 GB/64 GB DDR4 up to 2400 MT/s
I/O Slots	7 PCIe slots and 1 dedicated PERC slot: • 3 x8 half-length, low-profile • 1 x16 full-length, full-height • 3 x8 full-length, full-height	7 PCIe slots: • 2 x16 half-length, full-height • 1 x8 half-length, full-height • 3 x8 half-length, half-height • 1 x8 half-length, full-height for the RAID controller
RAID Controller	• Internal controllers: PERC S130 (SW RAID), PERC H330, PERC H730, PERC H730P • External HBAs (RAID): PERC H830 • External HBAs (non-RAID): 12 Gbps SAS HBA	• Internal controllers: • PERC H330, PERC H730, PERC H730P • External HBAs (RAID): PERC H830 • External HBAs (non-RAID): 12 Gbps SAS HBA
Network Interface	1 x QLogic 57800 2x10 Gb DA/SFP+ + 2 x 1 Gb BT Network Daughter Card (NDC)	1x QLogic 5720 quad port Network Daughter Card (NDC)
	1 x QLogic 57810 Dual Port 10 Gb DA/SFP+ Converged Network Adapter	1x QLogic NetXtreme 10 GbE SFP+ dual port card

2.1.2   Dell EMC storage

Dell EMC Storage is ideal for large-scale systems, high-end workload performance and distributed enterprise environments. It is designed and optimized for using flash storage. It supports multiple SSD tiers to optimize write-intensive and read-intensive SSDs as well as HDDs.

Dell EMC Storage supports the following features:

- Automated intelligent data tiering that dynamically places hot data on high-performance drives and cold data on high-capacity drives
- Data progression that enables performance-optimized flash at the price of a hard disk solution
- Intelligent deduplication and compression
- Enhanced virtualization and encryption
- Space-efficient snapshots and remote synchronous/asynchronous replication

Ready Bundle for Microsoft SQL Server consists of the following Dell EMC Storage options:

- Dell EMC Storage SC9000
- Dell EMC Storage SC4020

The following table contains the technical specifications of Dell EMC Storage in detail:

Table 2   Dell EMC Storage technical specifications

Dell EMC Storage	SC9000	SC4020
Controllers Per Array	2 (active/active)	
Operating System	Dell EMC Storage Center OS (SCOS) 6.7 or higher	
Maximum Drives supported	1024 per array	192 (24 internal, plus 168 external)
Maximum Raw Capacity	3 PB per array (SSD or HDD)	1 PB per array (SSD or HDD)
Storage Media	SAS and NL-SAS drives; different drive types, transfer rates and rotational speeds can be mixed in the same system • SSDs: write-intensive, read-intensive • HDDs: 15K, 10K, 7.2K RPM	
Expansion Enclosures	Mix and match from the following options • SC420 (24 2.5" drive slots, 12 Gb SAS) • SC400 (12 3.5" drive slots, 12 Gb SAS) • SC200 (12 3.5" drive slots, 6 Gb SAS) • SC220 (24 2.5" drive slots, 6 Gb SAS) • SC280 (84 3.5" drive slots, 6 Gb SAS)	Mix and match from the following options • SC200 (12 3.5" drive slots, 6 Gb SAS) • SC220 (24 2.5" drive slots, 6 Gb SAS) • SC280 (84 3.5" drive slots, 6 Gb SAS)
Front-End Network Protocols	FC, iSCSI, FCoE (supports simultaneous multiprotocol)	FC, iSCSI(supports simultaneous multiprotocol)

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2.1.3 Dell EMC networking S4048-ON

Dell EMC Networking S4048-ON 10/40 GbE is a top-of-rack, high-density 1U switch with forty eight 10 GbE uplinks. It offers ultra-low latency and line rate performance that is optimized for data centers.

2.2 Brocade 6505

Brocade 6505 is a flexible, easy-to-use, enterprise-class Storage Area Network (SAN) switch that enables storage connectivity. It supports a maximum of 24 ports and operates at a maximum speed of 16 Gbps, all in a 1U footprint. It comes with Gen 5 Fibre Channel and Brocade Fabric Vision technology.

2.3 Microsoft software components

The validated solution discussed in this guide uses Microsoft's latest software offerings including Windows Server 2016 and SQL Server 2016.

2.3.1 Windows Server 2016

Windows Server 2016 is Microsoft's new cloud-ready operating system that provides enhanced security, built-in containers and support for new software defined capabilities for modern data centers. The following table lists some of the key features of Windows Server 2016:

Table 3   Windows Server 2016 key features

Feature	What's new
Storage Spaces Direct	Enables easy creation and management of redundant and flexible disk storage
ReFS (Resilient File System)	Enables faster placement of VMs on the file system
Software defined networking	Includes enhanced policies to control both physical and virtual networks
Hyper-V	Supports nested virtualization

For a complete list of new features of Windows Server 2016, refer to Microsoft article What's New in Windows Server 2016

2.3.2   Microsoft Hyper-V

In Windows Server, the Hyper-V server role allows the creation of a virtualized server computing environment. Within this environment, users can create and manage VMs. Different VMs can run different operating systems on the same physical computer and these VMs are isolated from each other. Some of the new features in the Hyper-V server role in Windows Server 2016 are listed below:

Table 4   Hyper-V 2016 key features

Feature	What's new
Discrete device assignment	Provides VMs with direct and exclusive access to some PCIe hardware devices
Host resource protection	Prevents a VM from using more than its share of resources
Hot addition/removal of resources	Allows addition/removal of network adapters and adjustments to the amount of memory while the VM is running
Increased amount of resources per VM	Support for up to 12 TB of memory and 240 vCPUs for Generation 2 VMs

2.3.3   SQL Server 2016

SQL Server 2016 brings industry leading OLTP capabilities, new encryption features, greater support for In-Memory databases and an all new end-to-end BI solution. The following are some of the key features of SQL Server 2016:

For further details regarding Microsoft SQL Server 2016 and its complete list of features, see Microsoft article, What's New in SQL Server 2016

Table 5   SQL Server 2016 key features

Feature	What's new
Memory optimized tables	Provides enhanced compute resource utilization, optimized query plans, and extended functionality for In-Memory OLAP tables
Mobile BI platform	Captures insights from online or offline data
MAXDOP, Parameter Sniffing, Hotfixes	These settings can now be configured at a database level
R services	This feature can now be integrated directly into the SQL Server database
Temporal tables	Provides historical view of tables and their values
Query Store	Provides comparison of different queries over time

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3 Solution architecture

The following sections describe the design principles of Dell EMC Ready Bundle for Microsoft SQL Server 2016, and explain how the infrastructure sub-systems are architected. To illustrate the design principles, two implementation examples for medium and large databases are given in section 7.

3.1 Server architecture

In a database environment, it is important to consolidate multiple components to reduce data center footprint and cost. Server virtualization enables optimal resource utilization. This solution uses server virtualization to consolidate different SQL Server roles. To balance performance and resource utilization, processor, memory, and network bandwidth need to be properly assigned.

3.2 Network architecture

Dell EMC ready bundle for SQL Server 2016 provides end-to-end IO connectivity by using multiple port channels and VLT configurations for LAN. Dell EMC Networking S4048-ON switches provide 10 GbE network connectivity between the compute cluster and the rest of the data center.

According to SQL Server 2016 best practices and Dell EMC infrastructure design principles, each application network is deployed as a separate workload VLAN that is defined in the data center core network. All the workload VLANs are created as virtual network adapters on the converged virtual switch across four network connections. The QLogic QLE2662 FC adapters are used for FC connectivity in the host operating system, and virtual FC adapters are used for the VMs that require in-guest FC connectivity. To provide HA for network connections, multiple network cards in the server are connected to redundant network switches.
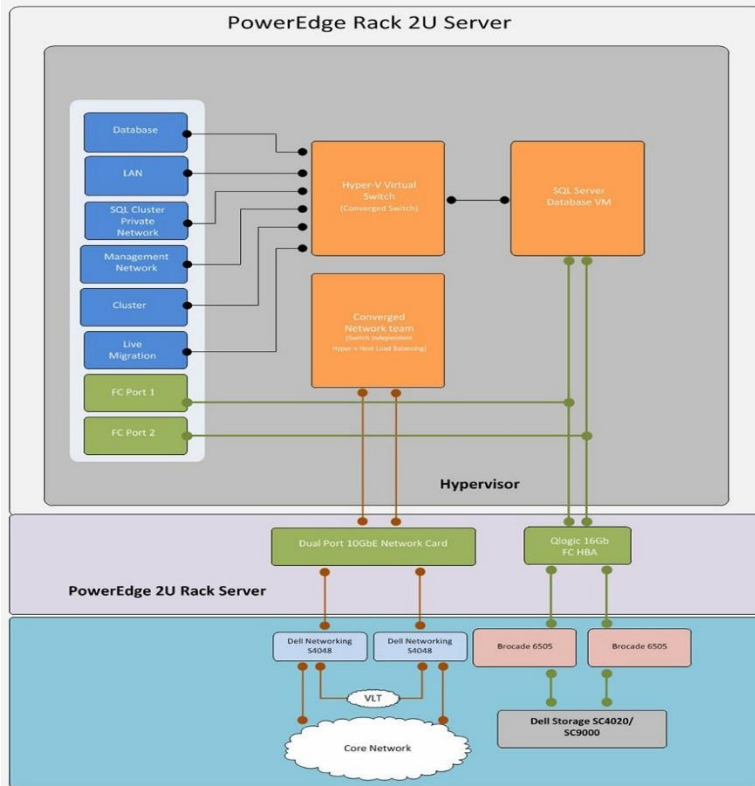
3.3 Storage architecture

Dell EMC Storage offers modular expansion to over 3PB raw SAN capacity with read and write flash SSD drives. Storage center is used to carve out independent volumes for SQL Server database and transaction logs. The SC series has inbuilt intelligence to perform auto tiering of data and assigning RAID for both Read and Write drives. These drives are used for appropriate placement of data.

Dell EMC Storage has the following storage profile options:

- Flash Only with Progression (Tier 1 to Tier 2)
- Write Intensive (Tier 1)
- Low Priority (Tier 3)
- Custom

The solutions described in this guide were designed with Flash Only Progression profile.

4   Design principles

Databases are mission critical. When designing an OLTP database solution, high availability (HA) and Service Level Agreement (SLA) are essential. Customers today also demand fast response time and optimized hardware resource utilization.

4.1   High availability

Dell EMC Ready Bundle for SQL Server 2016 has HA through failover clustering. This provides HA and Disaster Recovery (DR) capabilities. The design is based on the cluster failover concept, where solution components are stacked as Primary and Secondary.

4.2   Infrastructure-level high availability

In a solution infrastructure, servers, network paths, switches and storage should be highly available. RAID for storage drives, dual controllers, and multiple paths provide storage HA. Multiple FC HBAs and FC switches connecting to the SQL Server infrastructure and the storage network build resiliency in network connectivity.

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5 Solution design

Dell Ready Bundle for SQL Server 2016 offers a pre-architected and validated solution for a given size and use case. The configurations supported as part of this solution offering are:

- Dell EMC PowerEdge R730, Dell EMC Storage SC4020, Dell EMC Networking, Brocade 6505
- Dell EMC PowerEdge R830, Dell EMC Storage SC9000, Dell EMC Networking, Brocade 6505
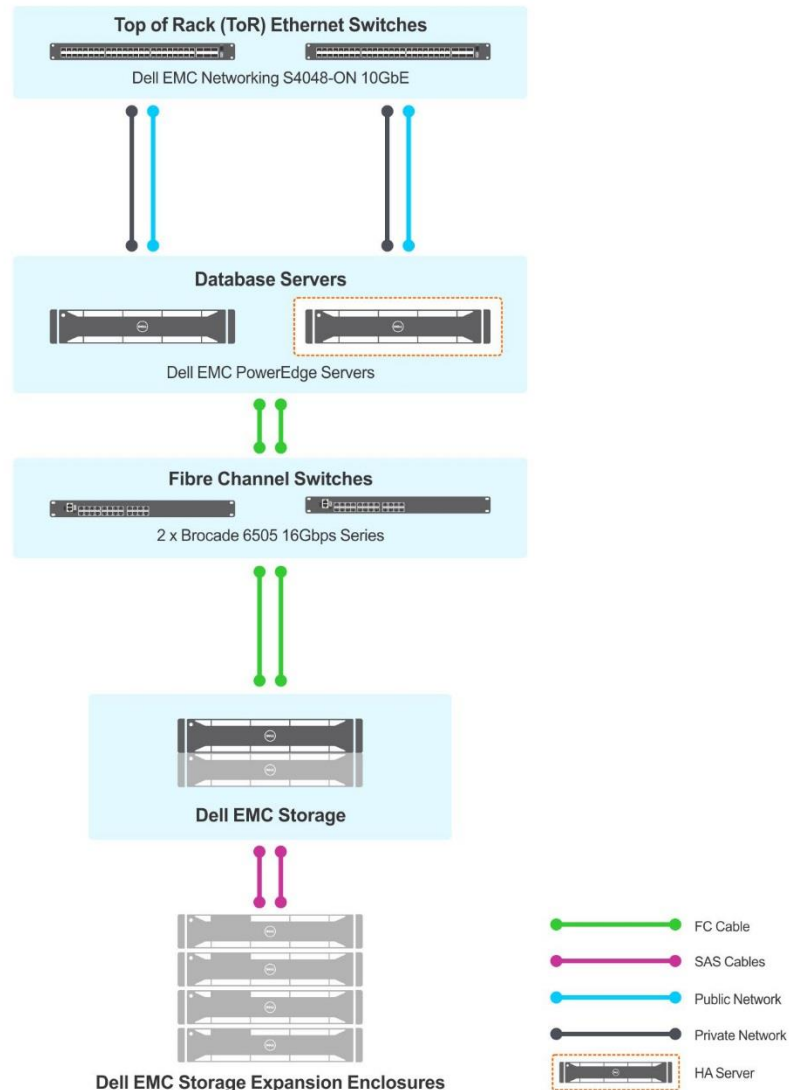
The following diagram illustrates the solution design.

Figure 1　　Solution Design

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6 Solution configuration and best practices

This section covers the solution configuration as well as DELL EMC recommended best practices.

6.1 Server configuration

The following outlines the Dell EMC recommended practices for configuring the servers:

- Use the latest BIOS and firmware for Dell EMC PowerEdge servers.
- Use the latest vendor subscribed HBA drivers.
- Enable hyper threading. This feature doubles the number of available cores. This enables SQL Server to make best use of compute resources and deliver better performance. To enable hyper threading:
  - Go to **System Setup → System BIOS → Processor Settings → Logical Processor** and select **Enabled**.
- Configure the power plan as follows:
  - In BIOS:
    i. Go to **System Setup → System BIOS → System Profile Setting** and select **Performance Per Watt (DAPC)** from the drop-down list.
    ii. Go to **System Setup → System BIOS → System Profile setting → Dell Controlled Turbo** and select **Enabled**.
  - In OS:
    i. Go to **Control Panel → Power Plans Scheme** and select **High Performance Plan**.

6.2 Network configuration

This section outlines the best practices for configuring the network in Dell EMC Ready Bundle for SQL Server.

- Configure HA for all of the following:
  - Network Interface Card (NIC) port
  - NIC
  - Network switch
  - Fibre Channel (FC) port
  - FC card
  - FC switch

6.2.1 Local area network (LAN)

The following outlines the best practices for configuring LAN:

- Use two 10 GbE S4048-ON network switches for end-to-end client traffic to prevent single point of failure.
- Use VLAN tagging to sustain switch failure and NIC teaming to provide multi-tier network HA.
- Use NIC teaming to provide HA at NIC port level.
- Use NIC teaming for virtual and physical network connections.
- Use a minimum of two network cards to provide HA and prevent single point of failure. Two QLogic 10GbE cards were used to enable connectivity between SQL Server host and external network.

6.2.2 Storage area network (SAN)

The following outlines the best practices for designing SAN:

- Use redundant Brocade 6505 switches to prevent single point of failure.
- Use two QLogic 2662 model cards for HA.
- Make crisscross cable connections between redundant FC HBA cards and redundant FC switches to enable HA.
- Use name zoning of end devices (FC HBAs) and SC virtual ports while creating zones. It provides better flexibility because it is not tied to specific physical ports on either the switch or the storage array.

6.3 Storage configuration

When designing a Dell EMC Storage Center, a number of factors have to be taken into consideration. These factors include: customer's performance and capacity needs, desired type of server connectivity, performance in terms of IO/sec and MB/sec and future growth needs for both performance and capacity. The following sub-sections provide guidance and best practices to accomplish this task.

6.3.1 Drive selection

Dell EMC Storage offerings leverage multiple types of drives, with varying capacities and performance levels, and attempt to match data with the optimal drive type based on storage profiles. Typically, mission critical data is stored on high performance drives, while less critical data is moved to high capacity drives.

While every environment is unique, an Online Transaction Processing (OLTP) workload generally consists of small, random reads and writes. A storage system that services an OLTP workload is primarily sized based on the required number of IOPS. Different drive types have different performance capabilities. Faster spinning drives are able to provide more IOPS with lower latency than slower spinning drives. For best performance, Dell EMC recommends SSD drives for OLTP workloads.

The following factors impact drive selections:

- Type of the workload
- Expected IOPS, latency and throughput
- Database size

> **Note:** Calculate the number of disks for capacity by using the following formula:
> Number of disks = (Required Capacity / Capacity per disk)

> **Note:** Calculate the number of disks for performance by using the following formula:
> Number of disks = (Read IOPS + (Write IOPS X RAID performance overhead)) / IOPS per disk

6.3.2 Sizing Dell EMC Storage tiers

Dell EMC Storage can be configured with multiple tiers to balance performance and cost. There are multiple ways to configure and size these tiers based on application requirements. This section provides guidance for sizing these tiers.

6.3.3 Hybrid or HDD storage array sizing

When sizing an SC Series array with two tiers:
- Size tier 1 to support 100% of required IOPS and 30% of required capacity.
- Size tier 2 and 3 to support 30% of IOPS and 100% of required capacity.
- Use the automated tiering feature of SC Series array that automatically moves infrequently accessed data to slower, cheaper storage (tier 3), reducing the storage costs without impacting performance.

6.3.4 Flash optimized storage array sizing

When sizing a flash optimized configuration, use sufficient number of write-intensive drives to handle the volume of writes and sufficient number of read-intensive drives to provide the required capacity.

- Size tier 1 to support 100% of write IOPS and enough bandwidth to accommodate the large block reads that will occur when On Demand Data Progression runs.
- Size tier 1 to support enough capacity that depends on the rate that data is written into the tier and the frequency of replays.
- Size tier 2 to support 100% of read IOPS and enough bandwidth to accommodate the large block reads that will occur when On Demand Data Progression runs.

> **Note:** Using read-intensive drives makes it cost effective to provide a large amount of capacity. However, additional write or read-intensive drives may be needed for the configuration to keep from exceeding the throughput limit of the drives.

6.3.5 Setting I/O paths

FC zoning allows partitioning the FC fabric into multiple subsets called zones. A zone includes FC initiators and targets and enables communication between the initiators and targets.

The following outlines the best practices for setting the I/O paths:

- **Single Initiator Multiple Target Zoning** creates each FC zone with a single initiator (HBA port) and multiple targets (SC Series front-end ports). Therefore, each HBA port requires a separate FC zone with SC front-end ports. Independent zones should be created for each HBA installed in the host.
- **WWN Zoning** contains only the host HBA port and the SC front-end primary ports. In most cases, it is not necessary to include the SC front-end reserve ports because they are not used for volume mapping. Dell EMC recommends creating zones by using a single initiator host port and multiple Storage Center ports.
- **Multipathing** designates how many of the Dell EMC Storage front-end ports that the system will allow the volume to be mapped through. Dell EMC recommends that this option is set to **OS Default**.

6.3.6 Volume provisioning and mapping

Create a server cluster for HA and map the volumes to the server cluster. Map the volumes by using Storage Center Console or Enterprise Manager Console.

For optimal performance, Dell EMC recommends that you:

- Place Tempdb, database, and log files on separate LUNs.
- Leave room for data growth and avoid exceeding 80 percent capacity of the LUNs for database files.
- Carve LUNs for data files on SSD drives.
- Use the latest storage array firmware.
- Configure end-to-end multipathing for availability/redundancy and throughput optimization.
- Use multiples of 64k size as allocation unit for SQL Server volumes.
- Ensure that I/O is distributed across both controllers. For best results, use the same number of volumes on each controller.

6.3.7 Hyper-V storage design

Dell EMC recommends that you:

- Provision a Cluster Shared Volume (CSV) store and Quorum disk on Dell EMC Storage. Map Quorum disk and CSV volumes to the cluster nodes to enable faster failover of the SQL Server VM without the need for dismounting the drive, changing ownership or remounting the volume.
- Create a virtual SAN by grouping WWNs of virtual FC adapters hosted in Dell EMC PowerEdge Server and Dell EMC Storage. Configure the VMs hosting SQL servers with direct access to the storage LUNs.

6.4 Windows Server, Hyper-V and SQL Server configuration

This section outlines the best practices for Windows Server 2016, Hyper-V and SQL Server 2016.

6.4.1 Windows OS configuration

The following outlines the best practices for configuring the OS:

- Use an **allocation unit size** of 64KB to format the volume that stores the database files.
- Set the **MPIO** policy to **Round Robin** for all database volumes. It allows all paths to be used, enabling higher throughput between the server and the storage array.

  Note: For database servers with a large number of I/O ports, the overhead of the Round Robin MPIO policy can reduce the maximum throughput to the storage array. To maximize throughput, provision a volume for each port on the server and use the Fail Over Only MPIO policy to define a unique active path for each volume. All other paths should be defined as standby paths.

- Enable Windows LPIM policy by adding an account with privileges to run sqlservr.exe. The **Lock Pages in Memory (LPIM)** policy option determines which accounts can use a process to keep data in

physical memory. This prevents the Windows operating system from paging out a significant amount of data from physical memory to virtual memory on disk.

6.4.2   Microsoft Hyper-V 2016

The following outlines the best practices for configuring the Hyper-V host and deploying VMs:

- **Do not over commit resources** – Hyper-V allows overcommitting resources like CPU and Network. However overcommitting leads to performance degradation once the resource usage exceeds the available resources.
- **Provision memory** – Memory provisioning can be either static or dynamic. Memory configuration and provisioning is explained in detail in section 6.4.3.
- **Provision compute resource** – A virtual CPU (vCPU) is a representation of the physical core of a processor or threads/logical processors in the core. Hyper-V allows adjusting the relative weights and reserves for a particular VM in **Processor → Settings**. If CPU resources are overcommitted, setting the weights and reserves optimizes the way these resources are used. You can prioritize or deprioritize specific VMs based on your needs.
- **Use fixed-size virtual hard disks** – Dell EMC recommends using fixed virtual hard disk (VHD/VHDX) for production workloads. Using dynamic virtual hard disks can result in occasional pauses when the dynamic disks need to be resized. Use dynamic disks for non-critical test environments or non-production environments.
- **Use separate VHDs/VHDXs for your OS, data and log files** – To rule out disk contention, Dell EMC recommends using separate VHDs/VHDXs. For best performance, create distinct VHDs/VHDXs for operating system, SQL Server data files and SQL Server log files.

6.4.3   Microsoft SQL Server 2016

This section provides guidelines and best practices to optimize a virtualized SQL Server environment.

- **Memory settings:**
  For SQL Server 2016, memory can be assigned for a VM either dynamically or statically. To decide whether memory for a VM should be assigned dynamically or statically, consider the following factors:
    - > How frequently you monitor your database
    - > The VM size (size of the processors, memory and other resources) as compared to the size of a single NUMA node on the host's physical architecture
    - > Preference between performance and levels of scalability

  In general, dynamic memory is preferred when VMs are unmonitored, are relatively smaller and scalability is preferred over performance. On the other hand, for larger production VMs that are reasonably monitored, static memory is preferred for better and more consistent performance.

  For dynamically assigned memory, refer to Microsoft article <u>Running SQL Server with Hyper-V Dynamic Memory</u>.

The best practices for dynamic memory are outlined below:

> Determine and implement the VM **Startup RAM** and minimum memory based on your needs. Microsoft recommends that **max server memory** be left at its default setting, which allows SQL Server to manage memory dynamically. However, if it is a VM on which you are running multiple applications, and/or you can reasonably ascertain the maximum amount of memory that you want to assign to SQL Server, Dell EMC recommends that you change this value as per your needs.

> Set **min server memory** (default value is zero) based on usage and performance considerations because dynamic memory is enabled for the VM.

> When using dynamic memory, Dell EMC recommends set reserves for this VM by using the **Memory Buffer** option. The amount of memory reserved should be based on the **min server memory** set for SQL Server, memory required for any other applications and the OS.

The recommendations for static memory allocation are outlined below:

> To maximize performance, Dell EMC recommends that you assign a particular amount of memory to a VM based on its virtual and physical NUMA architecture.

> To ensure optimal performance, disable the **NUMA Spanning** option for the Hyper-V host, so that each virtual NUMA node is backed by a single NUMA node.

> **Note:** Use this option with caution as Hyper-V will not start, restore or accept a live migration for a VM if the hypervisor is unable to map each virtual NUMA node to a physical NUMA node.

> Dell EMC recommends that you set **max server memory** and **min server memory** values based on the amount of memory you want to reserve for the OS, typical requirements of your SQL Server and other performance considerations. To learn more, please refer to the article, [Blitz Result: Memory Dangerously Low or Max Memory Too High](#).

- **Parallelism settings:**
  - **Max Degree of Parallelism:** The SQL Server configuration option **max degree of parallelism** controls the number of processors used for the parallel execution of a query. If the SQL Server VM in question migrates from hosts with different core configurations, leave this setting at 0. However, if that is not the case, use a better value. To learn more, please refer to the article [MAXDOP of Confusion.](#)
  - **Cost threshold for parallelism:** This is the SQL Server configuration option that specifies a threshold at which query plans run in parallel. Dell EMC recommends that you change the value of this setting from its default value of 5 to 50. You can adjust this number further. To learn more, please refer to the article, [MAXDOP of Confusion.](#)

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7 Solution sizing

Each SQL Server environment has distinct system requirements and must be sized according to the instance-specific demands and the workload deployed. Workload characteristics in a SQL Server deployment include the nature of transactions, the expected user load, the required number of transactions per second and the permissible levels of latency per transaction. SQL Server is a storage-intensive workload and requires HA. Therefore, Dell EMC recommends shared storage option such as Storage Area Network (SAN) over internal storage for deploying SQL Server. The two significant sizing considerations are server and storage.

Server sizing considerations include:

- Determining the type of processor that is best suited for handling the SQL Server workload requirements
- Deciding the size of memory required and allocating the DIMMs to the processor memory channels to take advantage of full memory bandwidth
- Selecting the right host network adapters

Storage sizing and disk selection requirements are elaborated in section 6.3.

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8   Sample implementations

This guide provides two sample solutions. The first solution is built for a medium workload and the second solution is built for a large workload. The architectural design, sizing and configurations for both samples are outlined in the subsections below.

8.1   Medium workload solution

This section outlines a SQL Server solution for a medium size OLTP workload supporting up to 5,000 transactions on a database size of up to 20 TB. The figure below provides an overview of this solution:
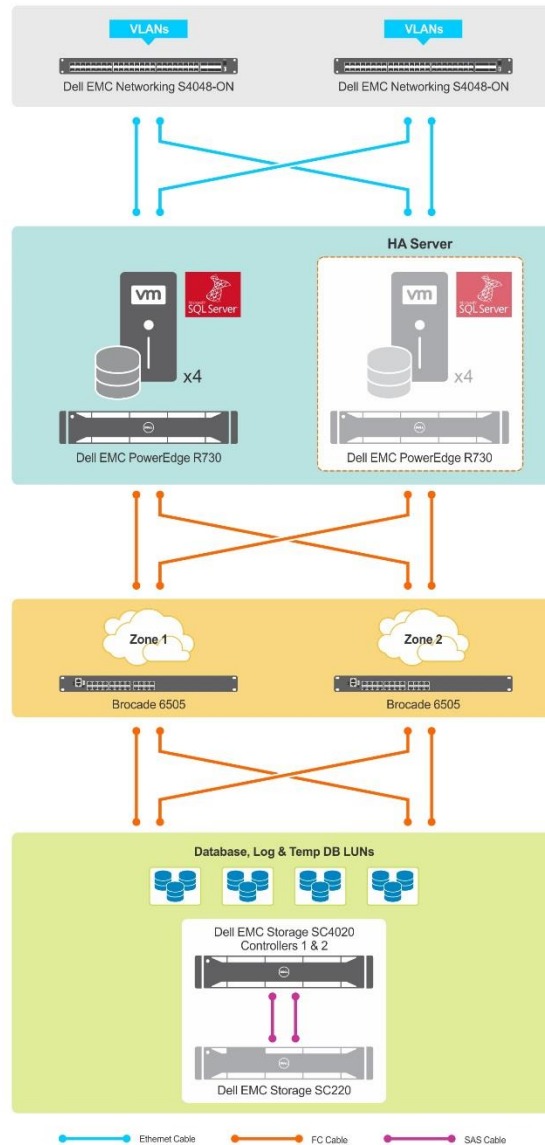

Figure 2   Medium workload solution architecture

The components for this solution are listed in the below table:

Table 6   Medium workload solution configuration

Component	Detail
Server	2 x Dell EMC PowerEdge R730 Server
Network Switches	2 x Dell EMC Networking S4048-ON
FC Switches	2 x Brocade 6505
External Storage	1 x Dell EMC Storage SC4020 (13 X 1.6 TB WI SSD Drives)
Components Per Server	
Processor	2 x Intel Xeon E5-2680 v4 2.4 GHz, 14 cores
Memory (RAM)	1 TB (16 x 64 GB 2400 MT/s DIMM)
Network Interface	1 x QLogic 57800 2x10Gb DA/SFP+ + 2 x 1 Gb BT Network Daughter Card
	1 x QLogic 57810 Dual Port 10Gb DA/SFP+ Converged Network Adapter
FC HBA	2 x QLogic QLE2662 16 Gb Dual Port FC HBA

The implementation details for this solution are listed in the table below:

Table 7   Medium workload implementation details

Component	Detail
Number of VMs	4
Number of Database LUNs	4
Number of Log LUNs	4
Number of TempDB LUNs	4
Maximum storage IOPS	50,000
Maximum Database Transaction rate per second	5,000
Per VM Configuration	
vCPUs	12
Memory	192 GB
Memory for DB	128 GB
Size of database LUN	6 TB
Size of Log LUN	500 GB
Size of TempDB LUN	50 GB

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8.2 Large workload solution

This section outlines a SQL Server solution for a large size OLTP workload supporting up to 10,000 transactions on a database size of up to 40 TB. The following figure provides an overview of this solution:
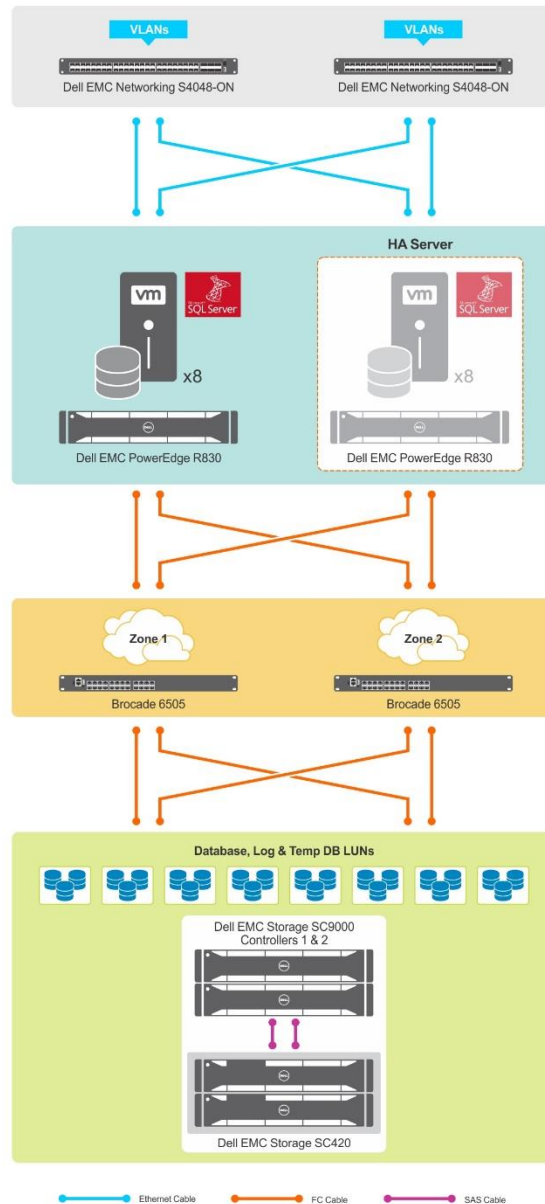

Figure 3   Large workload solution architecture

The components for this solution are listed in the below table:

Table 8   Large workload solution configuration

Component	Detail
Server	2 x Dell EMC PowerEdge R830 Server
Network Switches	2 x Dell EMC Networking S4048-ON
FC Switches	2 x Brocade 6505
External Storage	1 x Dell EMC Storage SC9000 + 2 x Dell EMC Storage SC420 (27 x 1.6 TB WI SSD Drives)
Components Per Server	
Processor	2 x Intel Xeon E5-4669 v4 2.2 GHz, 22 cores
Memory (RAM)	3 TB (48 x 64 GB 2400 MT/s DIMM)
Network Interface	1 x QLogic 57800 2x10 Gb DA/SFP+ + 2 x 1 Gb BT Network Daughter Card
	1 x QLogic 57810 Dual Port 10 Gb DA/SFP+ Converged Network Adapter
FC HBA	2 x QLogic QLE2662 16 Gb Dual Port FC HBA

The implementation details for this solution are listed in the table below:

Table 9   Large workload implementation details

Component	Detail
Number of VMs	8
Number of Database LUNs	8
Number of Log LUNs	8
Number of TempDB LUNs	8
Maximum storage IOPS	150,000
Maximum Database Transaction rate per second	10,000
Per VM Configuration	
vCPUs	20
Memory	320 GB
Memory for DB	256 GB
Size of database LUN	6 TB

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Size of Log LUN	500 GB

9 References

- [What's new in SQL Server 2016](#)
- [What's new in Windows Server 2016](#)
- [Monitoring Performance By Using the Query Store](#)
- [Brent Ozar's article on SQL Server 2016: The Death of the Trace Flag](#)