

17TB Data Warehouse Fast Track Reference Architecture for Microsoft SQL Server 2014 using PowerEdge R730 and Dell Storage PS6210S

Dell configuration and performance results

Dell Storage Engineering
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A Dell Reference Architecture

Revisions

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Executive summary

Dell and Microsoft collaborate to provide guidelines and principles that assist customers in designing and implementing balanced configurations for Microsoft® SQL Server® Data Warehouse workloads to achieve out-of-the-box scalable performance. These database reference architectures enable each of the components in a database stack to provide optimal throughput to match the capabilities of the specific setup. Innovative 13th generation Dell servers, along with robust and cutting edge Dell Storage PS6210 arrays, form efficient candidates for a high performing data warehouse solution.

This reference architecture describes architectural design principles and guidelines to achieve an optimally balanced 26 TB Data Warehouse Fast Track reference architecture for Microsoft SQL Server 2014 using PowerEdge™ R730 servers and Dell PS6210S iSCSI SAN storage. The configuration used to achieve the performance numbers for the reference configuration is discussed in detail.

The target audience for this paper is database administrators, business intelligence architects, storage administrators, IT directors and data warehousing users seeking sizing and design guidance for their enterprise, business intelligence solutions with Microsoft SQL Server 2014.

1 Introduction to Data Warehouse Fast Track reference architectures for SQL Server 2014

Data Warehouse Fast Track (DWFT) reference architectures provide tested and validated configurations and associated resources to help customers identify the right environment for their data warehouse solutions. Tangible benefits of following these recommended configuration best practices and guidelines are:

- Accelerate data warehouse projects with pretested hardware and SQL Server configurations
- Reduce hardware and maintenance costs by purchasing a balanced hardware solution and optimizing it for a data warehouse workload
- Reduce planning and setup costs by leveraging the certified reference architecture configurations
- Ensure predictable performance by configuring the system correctly and taking advantage of the tuning directions

The DWFT reference architectures provide a balanced server, memory, network, and storage hardware configuration and avoid the risk of improperly designed and configured hardware systems. These guidelines ensure that the capability and throughput for the entire system is maximally utilized. Configurations are designed specifically for the data warehouse or Business Intelligence (BI) systems.

1.1 Dell Data Warehouse Fast Track reference architectures for SQL Server 2014

Dell and Microsoft have refreshed the DWFT reference architecture offerings with the latest technology advancements in database, server, and storage technology. Dell PowerEdge 13th generation servers, Dell Storage PS6210S arrays, and Microsoft SQL Server 2014 are the latest additions to the list of reference architecture components.

The Dell 13th generation server platforms, featuring enhanced onboard memory, storage, and processor speeds, have advanced features that boost data warehouse performance. The latest Intel Xeon E5 series processors, larger memory capacities, higher memory speed, and third generation PCI Express slots on the newer PowerEdge platforms ensure faster database throughput.

Dell Storage PS Series arrays offer enterprise-class performance and reliability, intelligent automation, and seamless virtualization of storage with simplified storage management. The Dell Storage PS Series offers exceptional performance for both sequential and transactional applications, with linear scalability as arrays are added. It delivers a modular and cost-effective solution that can be deployed in appropriate increments for small and medium businesses.

Microsoft SQL Server 2014 Enterprise Edition comes with several exciting features that directly benefit data warehouse environments. One of these features is column store indexes. Introduced in SQL Server 2012, column store indexes enable storing data in columnar fashion, providing better query performance and better compression rates. This is very beneficial for data warehouse environments as they typically handle large amounts of data. In SQL Server 2014, columns tore indexes were enhanced to allow clustering and

updating, making them even easier to incorporate. For more information on column store indexes, visit msdn.microsoft.com/en-us/library/gg492088.aspx. Microsoft DWFT for SQL Server 2014 guidelines incorporate the benefit of column store indexes for improved query performance.

The Dell DWFT reference architectures for SQL Server 2014 are engineered jointly by Dell and Microsoft. The hardware and software optimizations are tested by Dell and the performance results are crosschecked by Microsoft. This approach presents a faster time-to-value using integrated, balanced, and verified architectures.

2 Recommended reference architectures

Two different DWFT reference architectures for SQL Server 2014 are comprised of PowerEdge R730 servers and Dell Storage PS6210 arrays. Each reference architecture is assigned a Solution ID, which can be used during the purchase process to identify the hardware components needed to implement the solution.

Table 1 Recommended reference architectures with Solution IDs

Reference Architecture	Solution ID
Single Server Reference Architecture	5413508
Highly Available Reference Architecture	5413509

2.1 Single server reference architecture

Figure 1 illustrates the single server reference architecture with the major elements and Table 2 lists the configuration details.

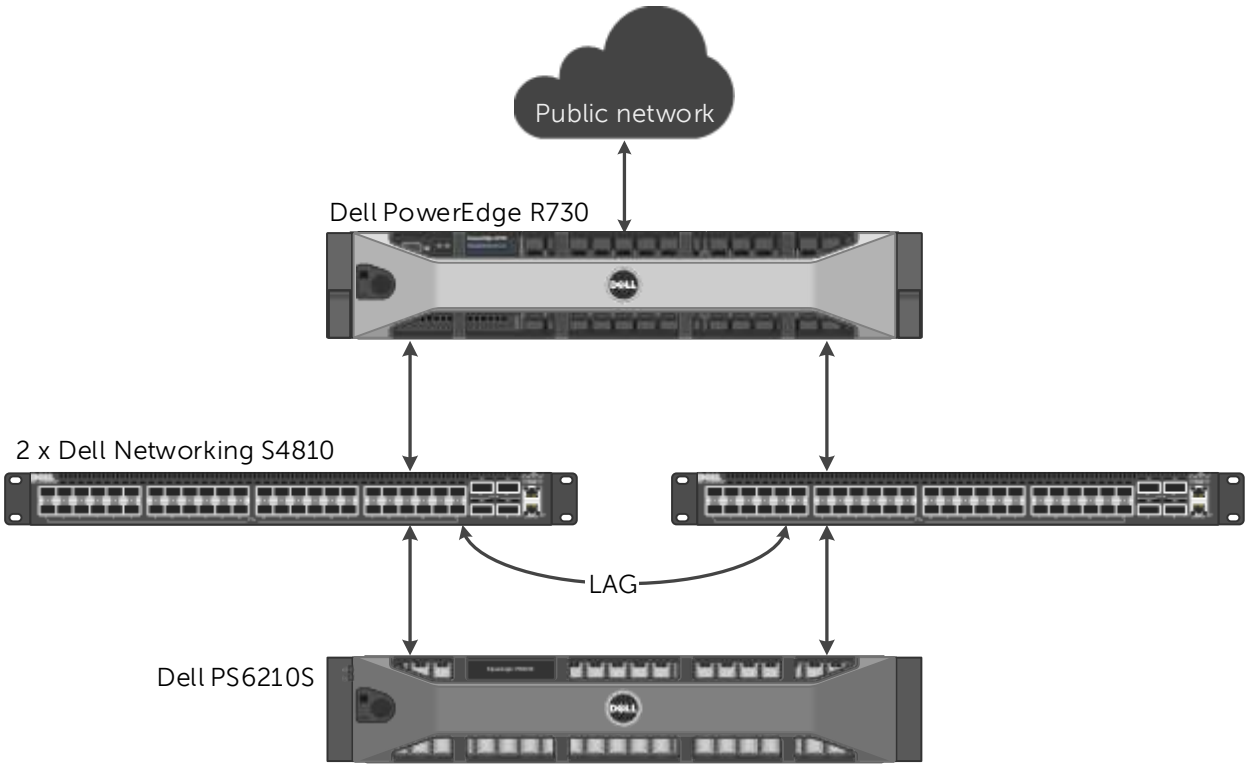


Figure 1 Single server reference architecture

Table 2 Single server reference architecture details

Component	Description	
Server	PowerEdge R730	
	Processors	2 x Intel Xeon E5-2643 v3 (3.40Ghz 6 cores, 12 threads)
	Total cores	12
	Total logical processors	24 (Hyper-Threading enabled)
	Total memory	192GB
	Network adapters (LAN)	Minimum of one network adapter (1 Gbps or 10 Gbps based on requirements) Recommended to have more than one network adapter with load balancing configured
	iSCSI Network Adapters	1 x Intel Ethernet 10G 2P X520 Adapter 1 x Intel Ethernet 10G 4P X520 Embedded
	Internal Disks	2 x 300GB 15K Raid 1
Software	Operating system	Windows 2012 R2 Standard Edition
	Database software	SQL Server 2014 Enterprise Edition
Storage	Storage array	1 x Dell Storage PS6210S
	Disk drives	24 x 400GB SLC SSD drives Raid 50 (Including 2 hot spare drives)
	SAN switches (iSCSI)	2 x Dell Networking S4810 switches (10GbE)

2.2 Highly-available reference architecture

For achieving high availability for the database, Microsoft Windows failover clustering is recommended. Using Microsoft clustering services, one database server is configured as the primary (active) server and the second server is configured as the secondary (passive) server. The secondary server should have exactly the same configuration as the primary server. Since the database is only active on a single server at any point of time, the performance of the database on the primary server (active) is comparable to the single server configuration (discussed earlier).

Figure 2 depicts the highly available reference architecture with the major elements, and Table 3 lists the configuration details.

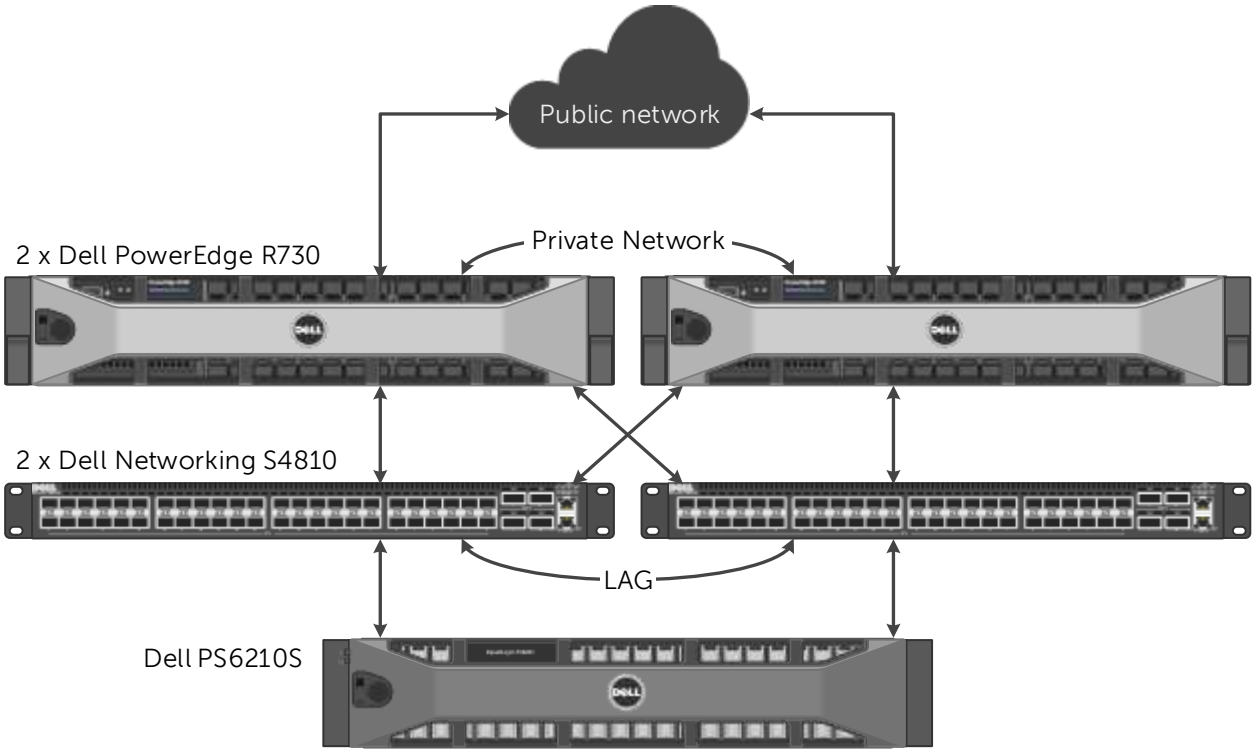


Figure 2 Highly-available reference architecture

Table 3 Highly-available reference architecture details

Component	Description	
Server	2 x PowerEdge R730	
	Processors	2 x Intel Xeon E5-2643 v3 (3.40Ghz 6 cores, 12 threads)
	Total cores	12
	Total logical processors	24 (Hyper-Threading enabled)
	Total memory	192GB
	Network adapters (LAN and Heartbeat)	Public Network: Minimum of two network adapters (1 Gbps or 10 Gbps based requirements) per server with load balancing configured Private Network (Cluster): Minimum of one network adapter with 1 Gbps (or more) connectivity per server
	iSCSI Network Adapters	1 x Intel Ethernet 10G 2P X520 Adapter 1 x Intel Ethernet 10G 4P X520 Embedded
	Internal Disks	2 x 300GB 15K Raid 1
Software	Operating system	Windows 2012 R2 Standard Edition with Windows Failover Clustering
	Database software	SQL Server 2014 Enterprise Edition configured as a Failover Cluster Instance
Storage	Storage array	1 x Dell Storage PS6210S
	Disk drives	24 x 400GB SLC SSD drives Raid 50 (Including 2 hot spare drives)
	SAN switches (iSCSI)	2 x Dell Networking S4810 switches (10GbE)

3 Hardware Components

3.1 Dell PowerEdge R730 server

The PowerEdge R730 is a highly versatile, two-socket 2U rack server with impressive processor performance, a large memory footprint, extensive I/O options and a choice of dense, high performance storage or low-cost, high-capacity storage. The R730 offers simplified management, purposeful design, and energy efficiency with support for Intel E5 series Haswell processors and ECC DDR4 memory with a maximum memory capacity of 768 GB. PowerEdge R730 provides up to seven Gen3 PCIe slots.

For more information on PowerEdge R730 Servers, visit http://www.dell.com/us/business/p/poweredge-r730/pd.

3.2 Intel Ethernet 10G 2P X520 server adapter

The proposed reference architecture uses four active 10 GbE ports. Two are from the embedded Intel Ethernet 10G 4P X520 adapter, and two from an Intel Ethernet 10G 2P X520 card. These adapters have RJ-45 copper interfaces, and are available in both low-profile and full- height interfaces.

For more information on Intel Ethernet 10G 2P X520 server adapters, visit http://www.intel.com/content/www/us/en/network-adapters/gigabit-network-adapters/ethernet-server-adapters.html

3.3 Dell Networking S4810 Ethernet switch

The Dell Networking S4810 switch is a 1U rack-mountable 10GbE Ethernet switch with 48 ports. It features a 1.28Tbps (full-duplex) non-blocking switching fabric designed to deliver line-rate performance under full load with low application latency.

For more information on the Dell Networking S4810 switch, visit http://www.dell.com/us/business/p/force10-s-series/pd

3.4 Dell Storage PS6210S

Dell Storage PS6210S arrays support 2.5 inch, 6 Gbps SAS disks that enable high back-end performance. Each PS6210 array supports up to two controllers in active-passive failover, and each controller has dual 10GbE switch-side ports. Each controller module contains 16GB of cache that mirrors the other controller's cache for high availability and is protected by a battery-powered cache offload mechanism. Dell Storage PS Series arrays provide virtualized storage—host volumes are carved out of storage pools consisting of one to eight arrays. Four storage pools may be configured in a Dell Storage PS Series Group. Automatic optimization mechanisms ensure high performance and availability by distributing volume pages within and across arrays. All Dell Storage PS Series software is included with the array.

For more information on Dell Storage PS6210S arrays, visit http://www.dell.com/us/business/p/dell-EqualLogic-PS6210S/pd.

4 Storage Configuration

4.1 Cabling

The hardware components were connected using Dell Storage best practices. High availability and optimum performance may be achieved by alternating connectivity between the host and the switches as well as the switches to the PS6210S.

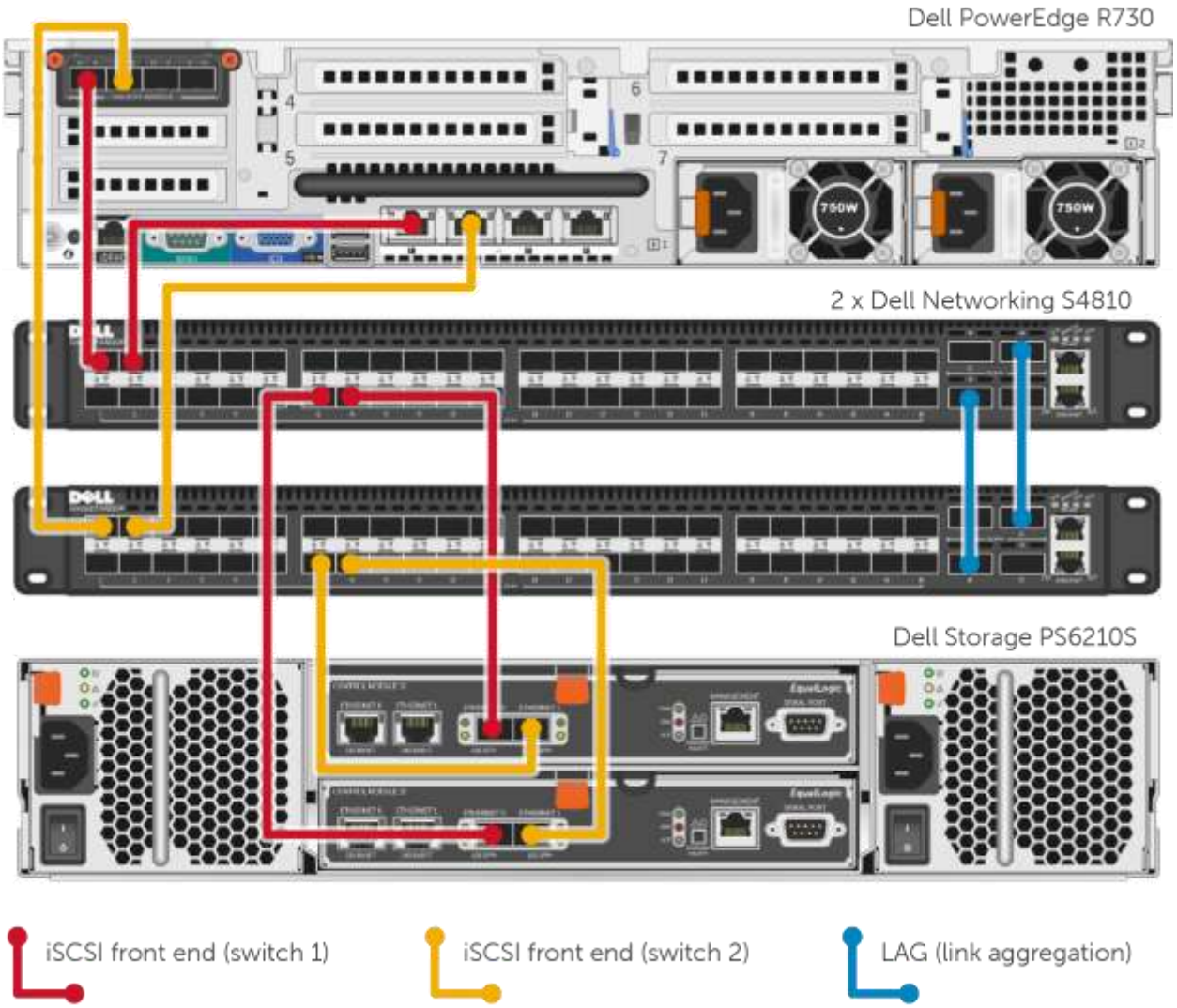


Figure 3 Cabling diagram for single-server configuration

Visit http://www.dell.com/us/business/p/equallogic-ps6210-series/pd for more information on Dell Storage PS6210S arrays.

4.2 iSCSI ports

Dell Storage PS Series arrays are self-optimizing which allows for maximum throughput without changing the default options. The storage arrays automatically detects and adapts to configuration choices made on the host and switch. For this reason, best practices recommend the following:

- Jumbo frames supported on all storage iSCSI host ports
- Install the Host Integration Tool for Microsoft (HIT/Microsoft) and exclude the public IP addresses from the MPIO ranges as indicated:

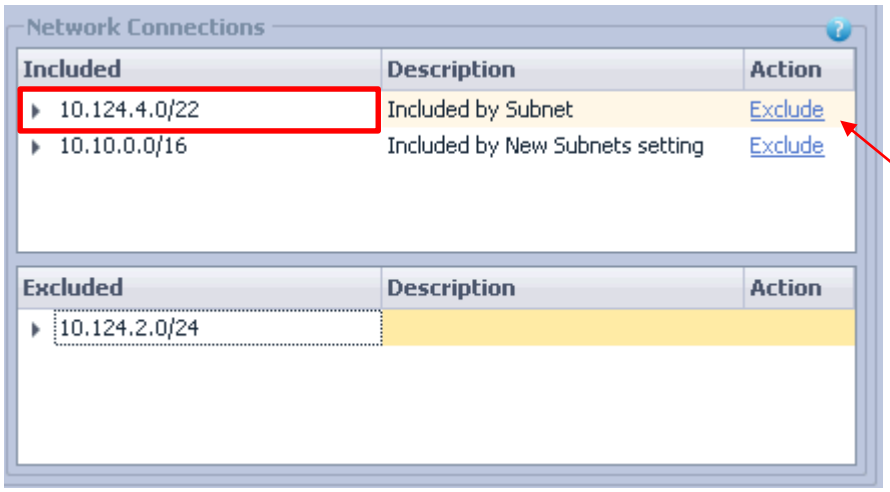


Figure 4 MPIO settings to exclude public LAN IP ranges.

4.3 Storage Disk Protection

For the purpose of the Microsoft Data Warehouse Fast Track reference architectures for SQL 2014 the Raid 50 RAID policy was configured for the PS6210S. Raid 50 provides high availability as well as excellent performance suitable for this application.

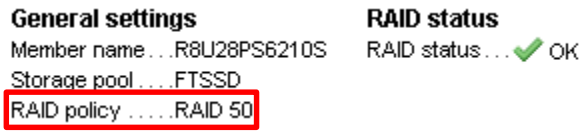


Figure 5 Raid Policy configuration for the PS6210S disk protection

4.4 Dell Networking S4810 Switch Tuning

The following settings are recommended on all participating iSCSI ports of the configuration:

- Set all ports to 10Gb-per-second Ethernet
- Enable switchport mode
- Enable receive and transmit flow control
- Enable jumbo frames
- Set all ports as edge ports

Please refer to the Dell Networking S4810 Switch configuration Guide for Dell Storage PS Series for full instructions. http://en.community.dell.com/dell-groups/dtcmedia/m/mediagallery/20220824

4.5 Dell Storage PS Series volumes

The Dell Storage PS Series arrays allow for high availability and protection through advanced software features such as Snapshots, Asynchronous or Synchronous Replication. These features although available were not enabled to follow the Microsoft guidelines for Fast Track Reference Architectures.

For the DWFT reference architectures, one PS6210S array makes up the group and provides a single storage pool. This array is configured with RAID 50, and the volumes are created from the storage pool. The volumes span all the disks in the array.

- For the primary user and database data files, six 520GB volumes (LUNs) were created.
- For the tempdb data files, four 100GB volumes (LUNs) were created from the storage pool. Each volume has two tempdb files.
- For the primary user and system temp database transaction logs, one 200GB volume (LUN) was created.

By default, two of the disks per Dell Storage PS Series array are dedicated as hot spares. Therefore, 22 disks are used for the database configuration.

Table 4 Dell Storage PS Series volumes created for the reference architecture

Dell Storage PS Series Volume name	Volume purpose
FT2MPRoot	Mount point
FT2SQLSystem-CFFTDW5R8	SQL Server system databases and files
FT2SQLLog-CFFTDW5R8	Transaction log files for tempdb and the data warehouse
FT2SQLData01-CFFTDW5R8	Data files for the data warehouse
FT2SQLData02-CFFTDW5R8	Data files for the data warehouse

Dell Storage PS Series Volume name	Volume purpose
FT2SQLData03-CFFTDW5R8	Data files for the data warehouse
FT2SQLData04-CFFTDW5R8	Data files for the data warehouse
FT2SQLData05-CFFTDW5R8	Data files for the data warehouse
FT2SQLData06-CFFTDW5R8	Data files for the data warehouse
FT2TempData01-CFFTDW5R8	Data files for tempdb
FT2TempData02-CFFTDW5R8	Data files for tempdb
FT2TempData03-CFFTDW5R8	Data files for tempdb
FT2TempData04-CFFTDW5R8	Data files for tempdb

5 Server Configuration

5.1 System BIOS

The system profile is set to **Performance**. All other options, outside of iDRAC configuration, were left at their factory default settings. The logical processor option, under processor settings, is left at its default setting of **Enabled**. This enables hyper-threading, which maximizes the number of logical processors available to SQL Server.

5.2 Network Interface Cards (NICs)

Jumbo packets are enabled on all NIC ports and set to a packet size of 9014 bytes. Jumbo packet settings can be changed on the "Advanced" tab of the Adapter Properties window (Figure 5).

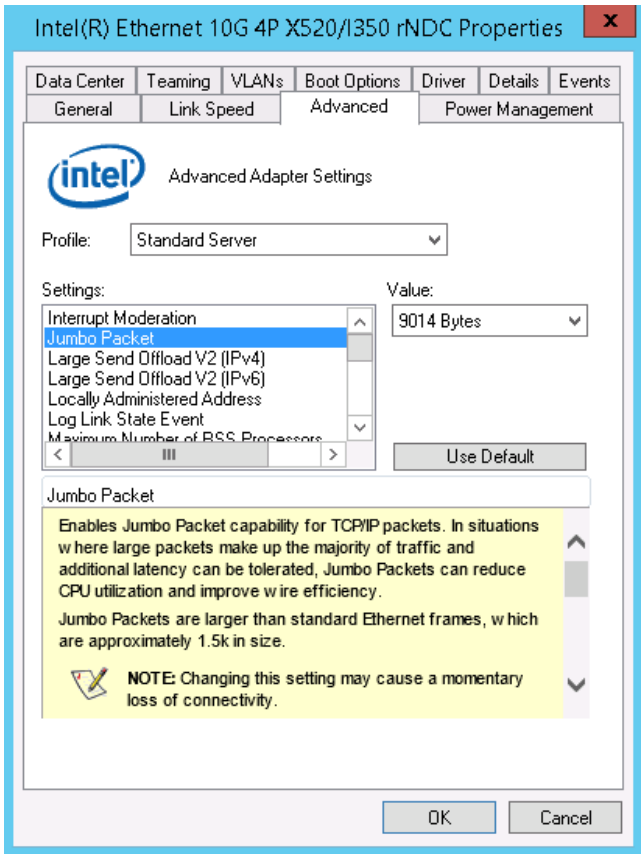


Figure 6 Enabling jumbo packets on network adapter ports

In addition, on the **Advanced** tab of the **Adapter Properties** window, under **Performance Options Properties**, the number of receive and transmit buffers are increased to the maximums of 4096 and 16384, respectively.

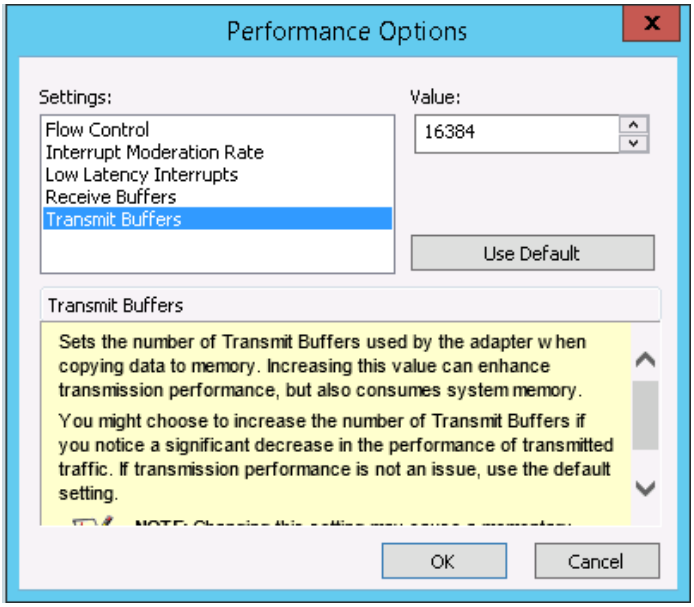


Figure 7 Increasing **Transmit Buffers** on network adapter ports

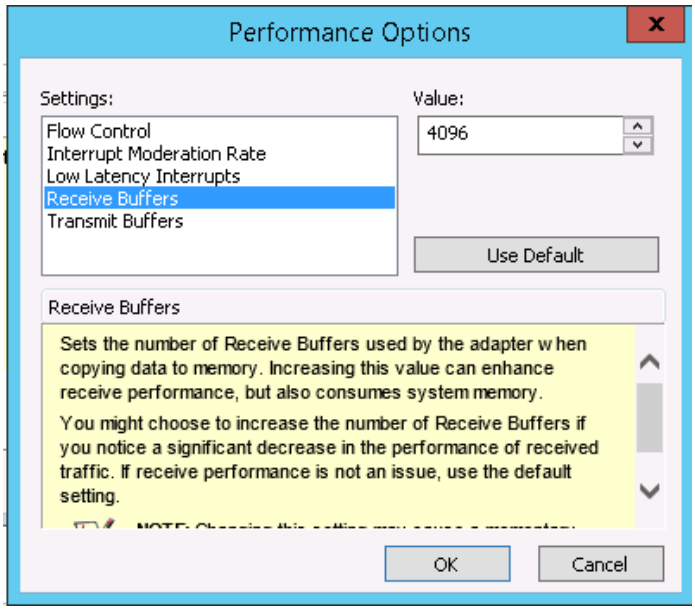


Figure 8 Increasing **Receive Buffers** on network adapter ports

6 Windows 2012 R2 Configuration

6.1 Power plan

To maximize performance, the server was configured to use the **High performance** power plan as shown in Figure 9.

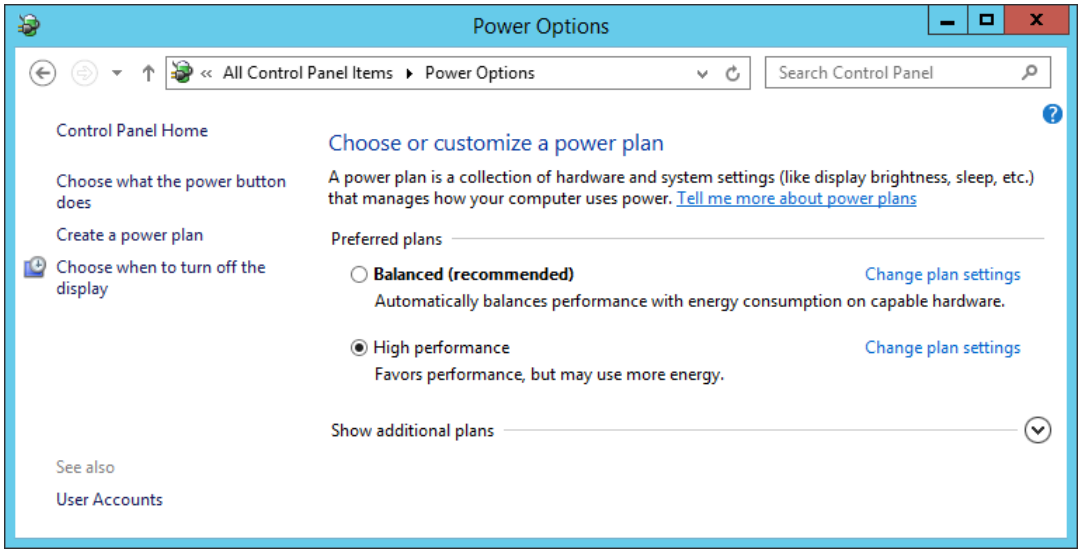


Figure 9 Windows power plan

6.2 Lock pages in memory

To prevent Windows from paging SQL Server memory to disk, the Lock pages in memory option was enabled for the SQL Server service account.

For information on enabling this option, visit https://msdn.microsoft.com/en-IN/library/ms190730.aspx.

6.3 Windows volumes

A single Windows volume was created on each Dell Storage PS Series array volume. All volumes were formatted with the NTFS file system. The mount point host volume used the default allocation unit. All other volumes used an allocation unit of 64KB.

For DWFT reference architectures, Dell recommends using mount points for the volumes instead of drive letters. It is highly recommended to assign appropriate volume and mount point names in order to simplify troubleshooting and performance analysis. Ideally, the mount point names should be assigned in such a way that makes it easy to identify the PS Series volume for a given Windows volume.

For this reference architecture, all logical volumes are mounted to the N:\MPSSD folder.

Table 5 shows the volume labels and access paths used for the reference configuration.

Table 5 Windows volume details

Dell Storage PS Series volume name	Windows volume label	Access path
FT2MPRoot	MPRoot	N:\MPSSD
FT2SQLSystem-CFFTDW5R8	SQLSystem	N:\MPSSD\SQL2System
FT2SQLData01-CFFTDW5R8	SQLData01	N:\MPSSD\SQL2Data01
FT2SQLData02-CFFTDW5R8	SQLData02	N:\MPSSD\SQL2Data02
FT2SQLData03-CFFTDW5R8	SQLData03	N:\MPSSD\SQL2Data03
FT2SQLData04-CFFTDW5R8	SQLData04	N:\MPSSD\SQL2Data04
FT2SQLData05-CFFTDW5R8	SQLData05	N:\MPSSD\SQL2Data05
FT2SQLData06-CFFTDW5R8	SQLData06	N:\MPSSD\SQL2Data06
FT2TempData01-CFFTDW5R8	TempdbData01	N:\MPSSD\FTTMPDB1
FT2TempData02-CFFTDW5R8	TempdbData02	N:\MPSSD\FTTMPDB2
FT2TempData03-CFFTDW5R8	TempdbData03	N:\MPSSD\FTTMPDB3
FT2TempData04-CFFTDW5R8	TempdbData04	N:\MPSSD\FTTMPDB4

6.4 MPIO

To improve throughput, each SQL Server data volume on the server is configured using the Dell Storage PS Series Host Integration Tool kit for Microsoft®. The HIT/Microsoft includes its own Device Specific Module (DSM) software, which is fully integrated with Microsoft MPIO to help configure multipath solutions. MPIO is setup according to best practices for Dell Storage PS Series which is **Least Queue Depth**. The Dell Storage PS Series software comes with no additional charge and included with the MPIO Device Specific Module is Auto-Snapshot Manager for Microsoft which offers protection for SQL, Exchange, SharePoint and Hyper-V by providing consistent copies of the data for backup and restore.

Figure 10 shows the MPIO settings from the Auto-Snapshot Manager GUI.

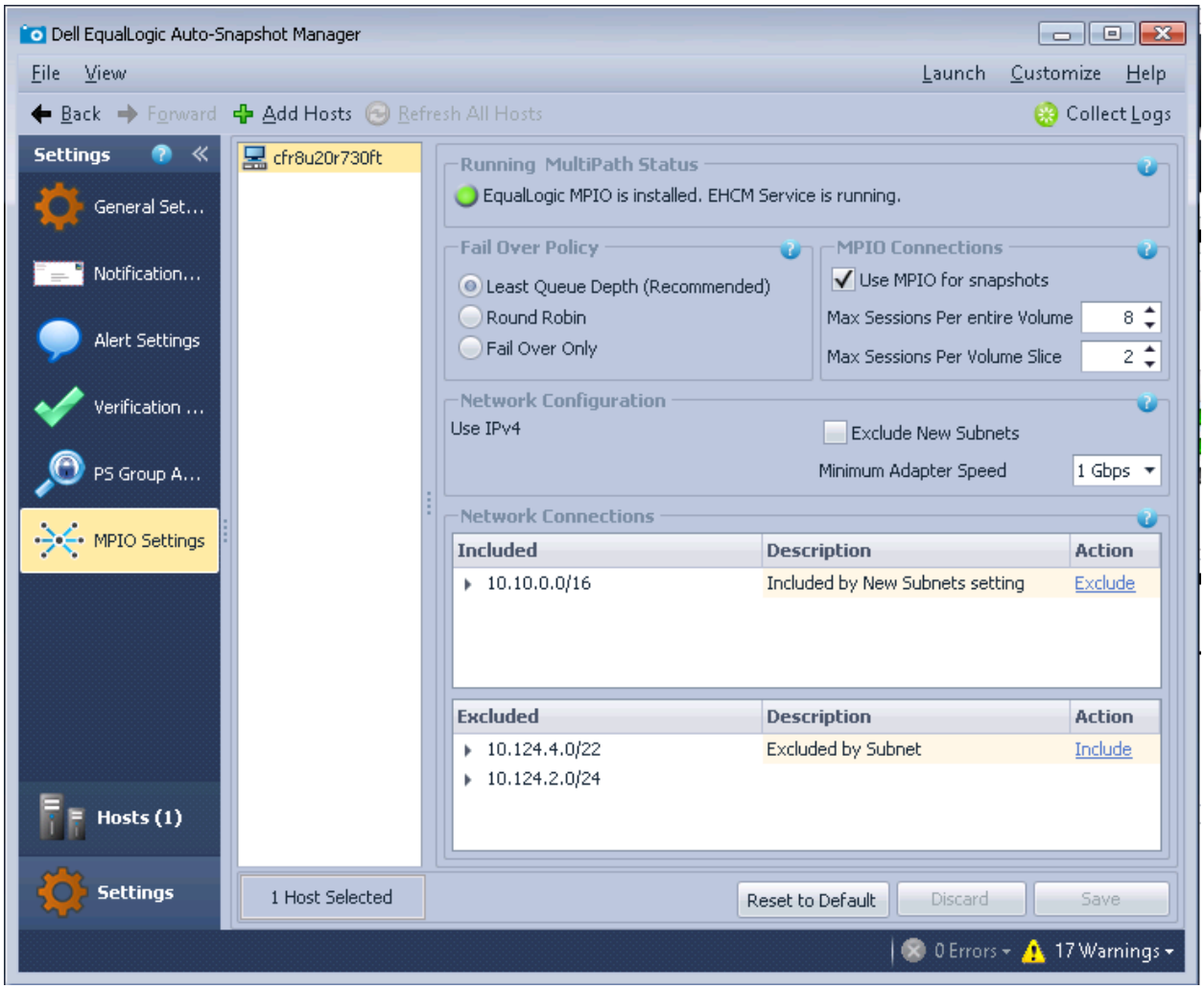


Figure 10 MPIO settings from Dell EqualLogic Auto-Snapshot Manger.

7 SQL Server 2014 Configuration

7.1 Startup parameters

The following options were added to the SQL Server startup parameters:

-E
This parameter increases the number of contiguous extents in each file that are allocated to a database table as it grows. This option is beneficial because it improves sequential access.

-T1117
This trace flag ensures the even growth of all files in a file group when auto growth is enabled. Note that it is recommend to expand the data files to their appropriate size rather than to depend on auto grow.

7.2 SQL Server maximum memory

SQL Server was configured to use 92% of the memory on the server. Maximum server memory for this reference architecture was set to 177 GB. If additional applications share the server, adjust the amount of memory left available to the operating system accordingly.

7.3 Max degree of parallelism (MAXDOP)

The max degree of parallelism was set to 12 for the row store tests and 24 for the column store tests.

For information on configuring the max degree of parallelism, visit https://msdn.microsoft.com/en-us/library/ms189094.aspx.

7.4 Resource Governor

The resource governor was used to limit the maximum memory grant to 12 percent for the row store and column store tests.

For information about the Resource Governor, visit https://msdn.microsoft.com/en-us/library/bb933866.aspx.

7.5 Tempdb configuration

The tempdb database was configured to use eight data files of equal size. The data files were evenly distributed across the four tempdb data volumes, with two files stored on each volume. The tempdb transaction log file was placed on the log volume. All files were expanded to the appropriate size and **auto grow** was enabled.

8 Additional considerations for the Highly Available (HA) DWFT reference architecture

The HA reference architecture leverages Windows Failover Clustering to achieve high availability. When configuring a Windows failover cluster, there are additional storage considerations:

- The recommended quorum model is **Node majority with witness (disk or file share)** using a disk witness. An additional volume needs to be created and configured as the disk witness. Dell recommends using a 2 GB volume for the disk witness. For more information on quorum configurations in a failover cluster, visit https://technet.microsoft.com/en-us/library/jj612870.aspx.
- All volumes need to be mapped to each node of the cluster. In the EqualLogic Group Manager GUI it is recommended to select "Yes" for "Do you want simultaneous access from more than one iSCSI initiator" for each PS Series volume.
- All volumes need to be configured as a cluster resource and added to the SQL Server cluster resource group.

9 DWFT for SQL Server 2014 certification

DWFT Certification #2014-018	Dell R730 with PS6210S - 17 TB DWFT Reference Architecture		Report Date: 1/21/2015
DWFT Rev. 5.4			
System Provider	**System Name**	**Processor Type**	**Memory**
DELL	Dell PowerEdge R730	Intel Xeon E5-2643v3 3.4 GHz (2S/12C/24T)	192 GB
Operating System		**SQL Server Edition**	
Windows Server 2012 R2		SQL Server 2014 Enterprise Edition	
Storage Provider	**Storage Information**		
DELL	Dell EqualLogic PS6210S 24 x 400GB SSD for data, log and tempdb (RAID 50) 2 x 300GB 15K SAS for OS (internal, RAID 1)		

Primary Metrics

Rated User Data Capacity[1] (TB)	Row Store Relative Throughput[2]	Column Store Relative Throughput[3]	Maximum User Data Capacity[1] (TB)
17	65	131	20

Row Store

Relative Throughput[2]	Measured Throughput (Queries/Hr/TB)	Measured Scan Rate Physical (MB/Sec)	Measured Scan Rate Logical (MB/Sec)	Measured I/O Throughput (MB/Sec)	Measured CPU (Avg.) (%)
65	82	1,627	2,205	1,916	69

Column Store

Relative Throughput[2]	Measured Throughput (Queries/Hr/TB)	Measured Scan Rate Physical (MB/Sec)	Measured Scan Rate Logical (MB/Sec)	Measured I/O Throughput (MB/Sec)	Measured CPU (Avg.) (%)
131	851	993	N/A	N/A	99

The reference configuration is a 2 socket system rated for 25TB using the DWFT V4 methodology

[1] Assumes a data compression ratio of 5:1

[2] Percent ratio of the throughput to the row store throughput of the reference configuration.

[3] Percent ratio of the throughput to the column store throughput of the reference configuration.

Reported metrics are based on the qualification configuration which specifies database size and SQL Server memory.

Figure 11 Microsoft DWFT Certification for 17TB with Dell R730 and Dell Storage PS6210S

10 Summary

Dell, in partnership with Microsoft, enables customers to deploy tested and validated data warehouse solutions using Data Warehouse Fast Track reference architectures for SQL Server 2014. These uniquely designed architectures ensure optimal Business Intelligence (BI) solutions. The end-to-end best practices and recommendations enable the customer to achieve enhanced return-on-investment (ROI) and faster time-to-value with an optimally configured data warehouse environment.

The Dell Microsoft DWFT reference architecture provides the following benefits to customers:

- Delivers a tested and validated configuration with proven methodology and performance behavior
- Delivers outstanding performance on the Dell 13G server platform with blazing processor speeds and leading edge flash-based Dell storage arrays
- Achieves a balanced and optimized solution at all the levels of the stack by following the best practices for both hardware and software components, achieving faster time-to-value and lower total-cost-of-ownership (TCO)
- Avoids over-provisioning of hardware resources
- Offers high availability at all levels of setup (host, switches, and storage)
- Offers single point of contact/accountability for purchases, services, and support; SQL Server is available to purchase from Dell worldwide
- Helps customers avoid the pitfalls of an improperly designed and configured system
- Reduces future support costs by limiting solution re-architect efforts because of scalability challenges

This paper describes a reference architecture using an R730 server with a PS6210S (400GB SSD) storage array. By implementing Data Warehouse Fast Track for SQL Server 2014 design principles, this configuration achieved a 17TB rating.

A Additional Resources

Dell Products:

http://www.dell.com

Dell Services:

http://www.dell.com/services

Dell Support:

http://www.dell.com/support

Dell SQL Server Solutions:

http://www.dell.com/sql

Dell Data Warehouse Fast Track for SQL Server Advisor:

http://www.dell.com/solutions/advisors/us/en/g_5/SQLFastTrack/4/Start?s=biz#212418

Dell Storage technical content on Dell TechCenter:

http://en.community.dell.com/techcenter/storage/w/wiki/2631.storage-infrastructure-and-solutions-team