21 TB Data Warehouse Fast Track Reference Architecture for Microsoft SQL Server 2014 using PowerEdge R730xd Server

Dell Configuration and Performance Results

Dell Database Solutions Engineering
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A Dell Reference Architecture

Revisions

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Executive summary

The performance and stability of a data warehouse depends on the integration between hardware platform and solution design. Microsoft Data Warehouse Fast Track (DWFT) program enables customers to select standard and proven system architectures optimized for a range of enterprise Data Warehousing requirements. Dell and Microsoft together provide guidelines to design and implement a balanced configuration for Microsoft SQL Server data warehouse workloads to achieve "out-of-the-box" scalable performance on Dell enterprise products.

This Dell technical white paper provides practices to achieve a compact, balanced, optimized 21 TB configuration for SQl Server 2014 data warehouse using Dell PowerEdge R730xd servers and Microsoft Data Warehouse Fast Track (DWFT) principles.

1 Introduction to Data Warehouse Fast Track Reference Architectures for SQL Server 2014

The key focus of the Microsoft Data Warehouse Fast Track(DWFT) program is to find a minimal, yet optimal configuration, tuned at the hardware and software level which can satisfy the storage and performance requirements of a data warehouse workload. The DWFT Reference Architectures for SQL Server 2014 are proven system architectures for data warehouse conforming SQL Server workloads.

Each DWFT reference architecture is defined by a workload and a set of configuration, validation, and database best practices guidelines. The following are tangible benefits of implementing these recommended configuration best practices and guidelines:

- Accelerated data warehouse projects with pre-validated hardware and SQL Server configurations.
- Reduced hardware and maintenance costs by purchasing the right-balanced hardware solution and optimizing it for a data warehouse workload.
- Reduced planning and setup costs by leveraging the Certified Reference Architecture configurations.
- Predictable performance by configuring the system correctly and taking advantage of the tuning directions.

Dell and Microsoft together developed guidelines and design principles to assist customers in designing and implementing a balanced configuration specifically for Microsoft SQL Server data warehouse workloads to achieve scalable performance on Dell hardware.

This Dell technical white paper describes the reference architectures and design principles required to achieve a balanced configuration with Dell PowerEdge R730xd server by using the Microsoft DWFT for SQL Server 2014 guidelines.

1.1 Dell and Microsoft DWFT reference architectures for SQL Server 2014

With the advent of Dell PowerEdge 13th generation servers and Microsoft SQL Server 2014 customers have a variety of solutions to choose, on the basis of data warehouse capacity and scan rate requirements.

Dell PowerEdge 13G 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 (PCIe) slots on the new PowerEdge platforms ensure faster database throughput.

Microsoft SQL Server 2014 Enterprise Edition comes with several exciting features which directly benefit data warehouse environments. One of these features is Columnstore Indexes. This enables storing data in columnar method, in contrast to the traditional row-based approach. This technology enables better compression rates within the database, which is very beneficial for data warehouses because of the large amount of data being handled. Columnstore Indexes also benefit common data warehousing queries such as filtering, aggregating, grouping, and star-join queries. Microsoft DWFT for SQL Server 2014 guidelines incorporate the benefit of Columnstore Indexes for improved query performance.

The Dell configurations for Microsoft DWFT reference architectures for SQL 2014 are developed by Dell and Microsoft. The hardware and software optimizations are tested by Dell and the performance results are verified by Microsoft Data Warehouse Fast Track Engineering team. Microsoft then certifies the optimized reference configuration. This approach presents "Faster time-to-value" by using integrated, balanced, and verified architectures.

2 Recommended reference architecture

Dell recommends a DWFT reference architecture comprising of SQL Server 2014 Enterprise Edition(EE) and PowerEdge R730xd servers for 21 TB rated capacity and scan rate of about 1700 MBps.

Table 1 Recommended reference architecture with solution ID

Reference Architecture	Solution ID
Single server reference architecture	5338974

Deployment Guide: 21 TB Data Warehouse Fast Track for Microsoft SQL Server 2014 using PowerEdge R730xd Server provides step-by-step instructions on how to implement this solution.

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

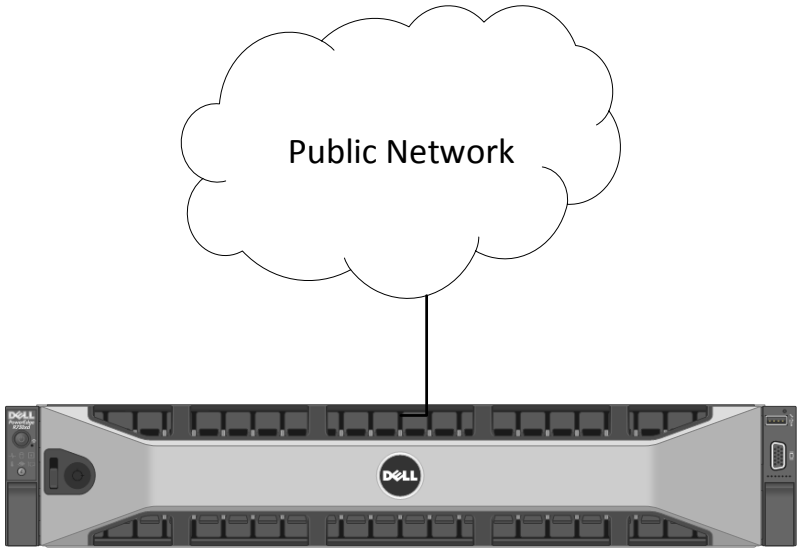

Figure 1 Single server reference architecture

Table 2 Single server reference architecture details

Server component	Description
Server	Dell PowerEdge R730xd 2.5-inch Chassis
Processors	1 × Intel Xeon E5-2650v3 (2.3 Ghz, 10 cores, 20 threads)
Total cores	10
Total logical processors	20 (Hyper-Threading enabled)
Total memory	192 GB (12 × 16 GB DDR4 DIMMs @2133 MHz)
Network adapters	Minimum of one network adapter (1 Gbps or 10 Gbps based on requirements) to connect to public network Recommended to have more than one network adapter with load balancing configured.
Operating system	Windows Server 2012 R2 Standard Edition

Database software	SQL Server 2014 Enterprise Edition
Internal RAID Controller	PERC9 H730P mini
Disk drives	24 × 1.2 TB 10K SAS 2.5" + 2 × 146 GB 15K SAS 2.5" rear hard disk drives

3 Hardware components

This section describes the hardware components used in the reference configuration.

3.1 Dell PowerEdge R730xd server

Dell PowerEdge R730xd, part of the new 13G of Dell servers, maximizes server-based storage performance and flexibility, offers simplified management along with energy efficiency. PowerEdge R730xd is a 2-socket, 2U rack server that supports latest Intel Xeon E5 series Haswell processors and DDR4 RAM. PowerEdge R730xd supports DDR4 RAM with 24 DIMM slots, maximizing the system memory up to 768 GB. It also contains multi-mode RAID controllers with twice the storage bandwidth as compared to the earlier generations.

PowerEdge R730xd systems are provided in different chassis configurations with optional in-server hybrid storage configuration that supports tiering and capacity for up to 28 drives, including up to 18 × 4.5cm (1.8) SATA SSDs. The reference architecture leverages the twenty-four plus two-hard drive system with up to twenty-four, 2.5-inch hard drives, and 2.5-inch back accessible hard drives.

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

3.2 Processors

PowerEdge R730xd supports the latest Intel Xeon E5 2600 V3 processors with a maximum of 36 cores per server (18 cores per socket). In order to balance the internal storage and the memory on the PowerEdge R730xd, a single socket with a 10-core Intel Xeon E5 2650 V3 processor operating at 2.3 GHz is used. The remaining socket can be populated with similar processor model for future scalability of the solution.

3.3 Memory

Dell PowerEdge R730xd server supports DDR4 RAM (RDIMMs and LRDIMMs) with a maximum of up to 768 GB system RAM 192 GB (12, 16 GB DIMMs) of memory operating at 2133 MHz was used in the certification. Because the reference architecture uses a single socket configuration, it is important to populate the memory DIMM slots allocated for processor 1. DIMMs in slots A1–A12 are assigned to processor 1, and DIMMs in slots B1–B12 are assigned to processor 2. For future scalability of the solution, additional DIMMs can be populated on the second processor.

To achieve 192 GB of memory, install all the 12 DIMMs in slots A1–A12.

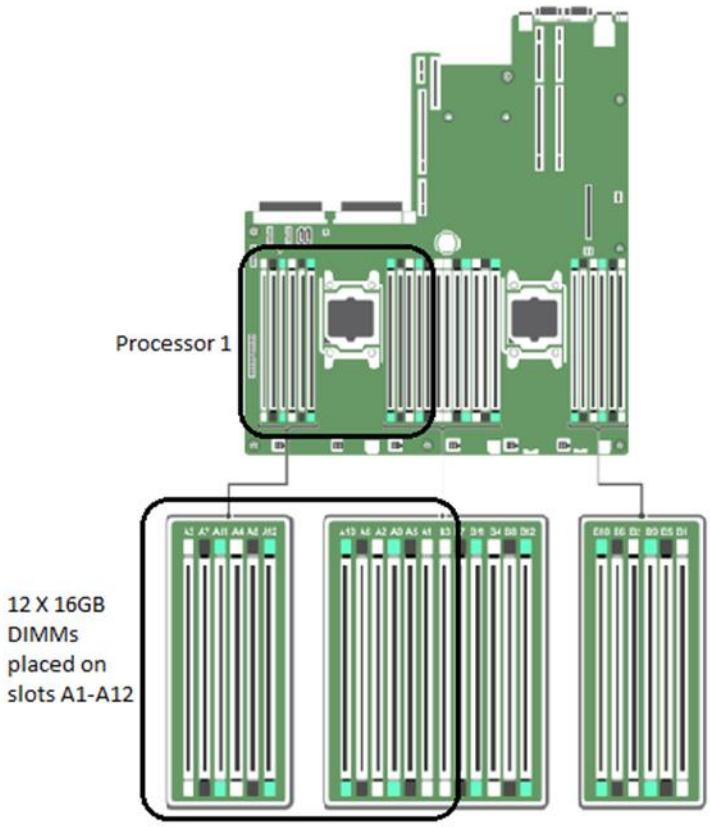

Figure 2 Memory configuration

4 Configuring internal storage-PERC9 H730P Mini

The Dell PERC (PowerEdge RAID Controller) family of enterprise class controllers is designed for enhanced performance, increased reliability, fault-tolerance, and simplified management – thereby creating a robust infrastructure and helping maximize server uptime.

The reference architecture uses the PERC H730P mini card which brings out significant performance gains on the HDD-based R730xd server. With eight internal ports, H730P mini delivers two PowerPC processor cores and a 72-bit DDR3 interface that drives 2 GB non-volatile cache memory.

For more information about the H730P Mini PERC, go to:

http://i.dell.com/sites/doccontent/shared-content/data-sheets/en/Documents/Dell-PowerEdge-RAID-Controller-H730P.pdf

The PERC H730P Mini management console can be accessed by using the BIOS utility. Following configurations are made in the internal RAID controller.

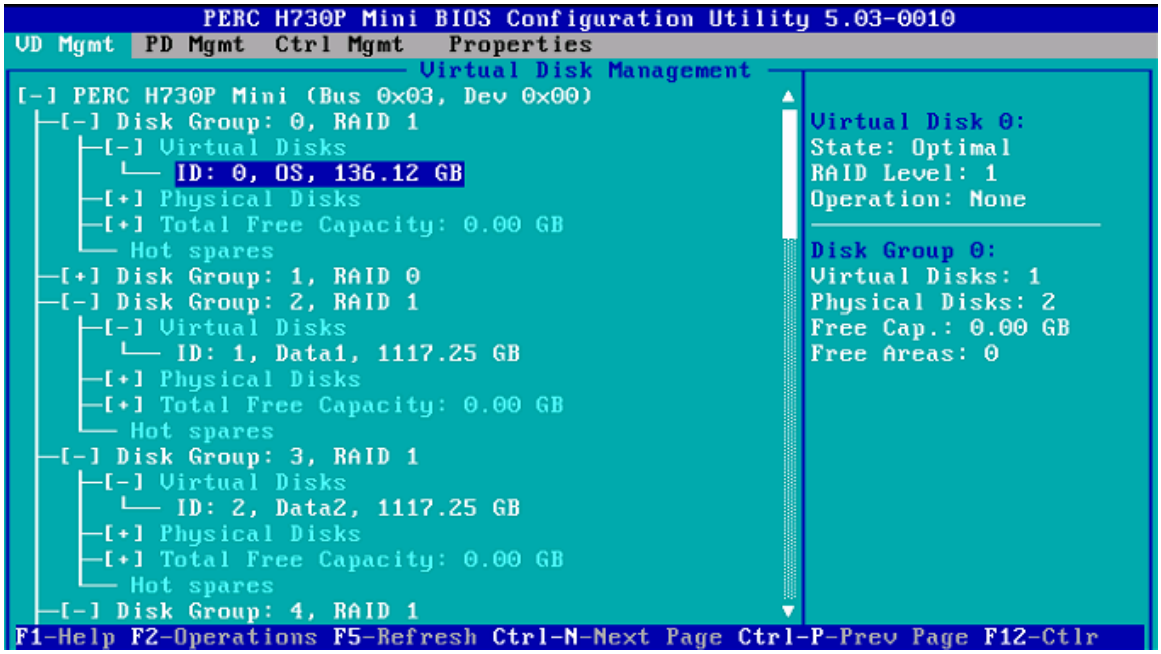

Figure 3 Virtual disk management

4.1 Stripe size

By default, the PERC H730P creates virtual disks (VDs) with a segment size of 64 KB. However, for the reference configuration, a higher stripe element size of 512 KB was selected to support the data warehouse workload pattern.

4.2 Read policy and write policy

The PERC H730P read policy setting comes with two options— Read Ahead and No Read Ahead. For the write policy, the options for Write-Back and Write-Through are available. The configuration was tested with Read-Ahead read policy and the Write-Back write policy. Disk cache policy is also enabled (or unchanged) for testing.

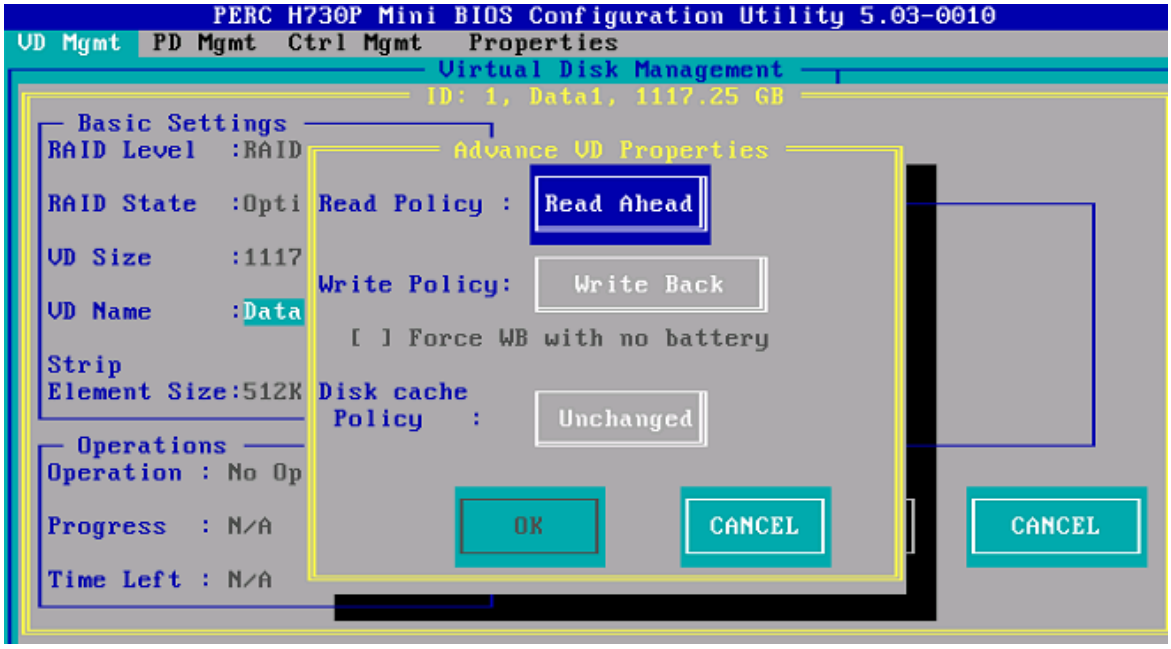

Figure 4 Read and write policy settings on the H730P

4.3 Configuring RAID

Selecting the correct RAID level while configuring storage is a key task in getting the maximum application performance. The reference configuration uses RAID1 disk groups for database data and log files. Nine RAID1 disk groups with one VD each was created to host the database data files. One RAID1 disk group with one VD was created for the database log files. Also, two hard drives in a RAID0 disk group configuration were used for staging. Remaining two hard drives are assigned as hot-spare in the solution for providing availability when the disk fails.

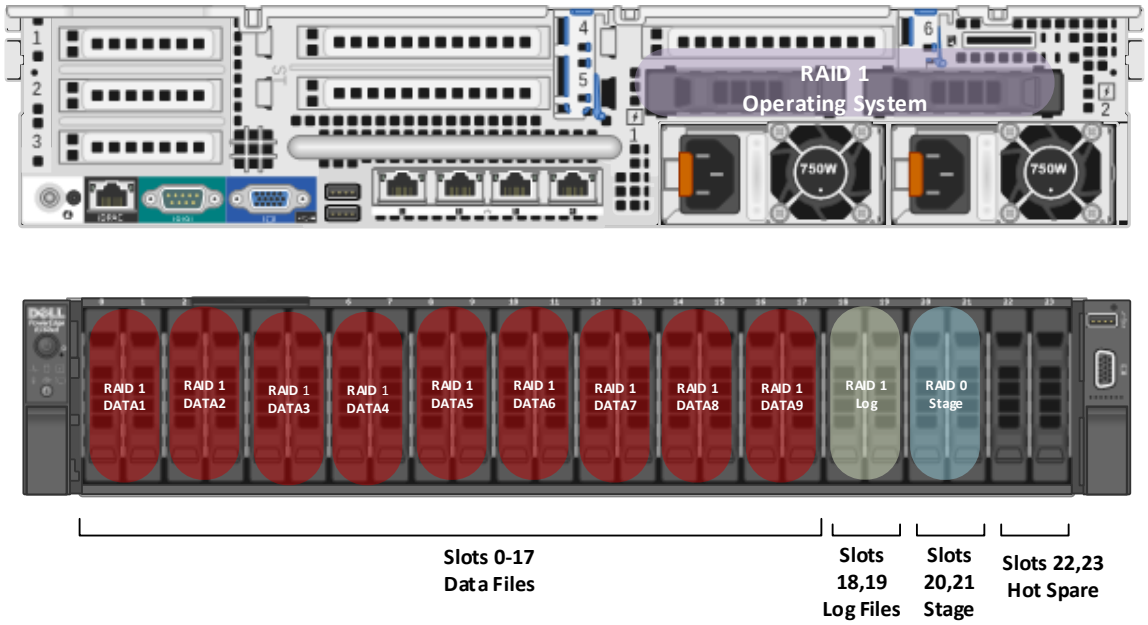

Figure 5 RAID configuration

5 Configuring R730xd server

The system BIOS profile is set to Performance. Logical Processor option is set to the default property–enabled, to leverage 20 logical processors for the reference configuration.

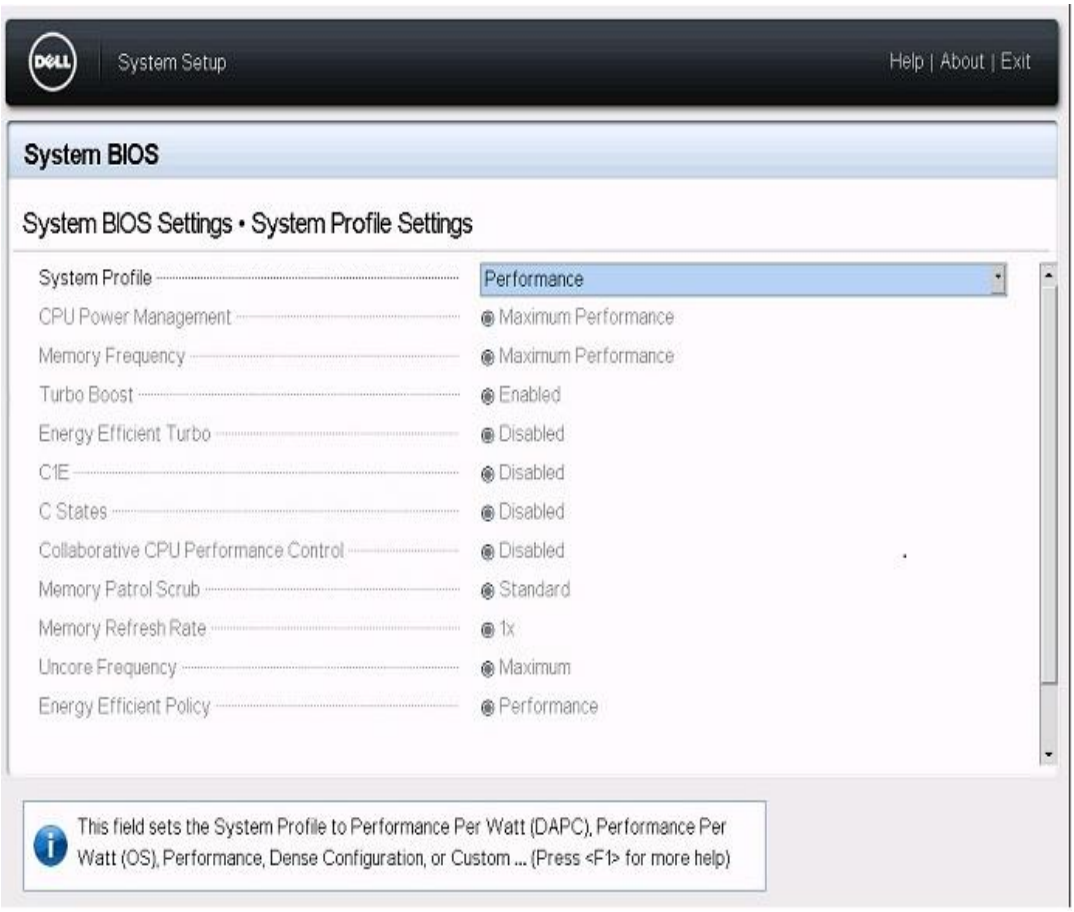

Figure 6 Server configuration

6 Configuring Windows Server 2012 R2

This section describes the fine-tuning of the Windows Server 2012 R2 operating system (OS) on the database server.

6.1 Windows volumes

One volume is created per VD discovered in the OS. All the volumes are formatted with NTFS and use the default allocation unit of 64 KB.

For the DWFT reference architectures, it is recommended to use mount-points for the volumes rather than using drive letters for storage access. It is also important to assign appropriate volume labels and mount-point names to simplify troubleshooting and performance analysis. Mount-point names must be assigned in such a way that the logical file system reflects the underlying physical storage enclosure mapping.

The table 3 shows the VD and mount-point names used for the configuration and its mapping to the storage layer. All logical volumes are mounted to the **C:\FT** folder.

Table 3 Mount-point naming and physical enclosure mapping

Disk Group	Virtual Disk	Virtual Disk Label	Logical Label	Full Volume Path	Capacity (GB)
1	1	Cage1-Card1-vData1	Data1	C:\FT\Cage1-Card1-vData1	1117.25
2	2	Cage1-Card1-vData2	Data2	C:\FT\Cage1-Card1-vData2	1117.25
3	3	Cage1-Card1-vData3	Data3	C:\FT\Cage1-Card1-vData3	1117.25
4	4	Cage1-Card1-vData4	Data4	C:\FT\Cage1-Card1-vData4	1117.25
5	5	Cage1-Card1-vData5	Data5	C:\FT\Cage1-Card1-vData5	1117.25
6	6	Cage1-Card1-vData6	Data6	C:\FT\Cage1-Card1-vData6	1117.25
7	7	Cage1-Card1-vData7	Data7	C:\FT\Cage1-Card1-vData7	1117.25
8	8	Cage1-Card1-vData8	Data8	C:\FT\Cage1-Card1-vData8	1117.25
9	9	Cage1-Card1-vData9	Data9	C:\FT\Cage1-Card1-vData9	1117.25
10	10	Cage1-Card1-vLog	Log	C:\FT\Cage1-Card1-vLog	1117.25
11	11	Cage1-Card1-vStage	Stage	C:\FT\Cage1-Card1-vStage	2234.5

6.2 Power plan

For the reference configuration, the "Balanced" power plan was selected to automatically balance performance and energy consumption.

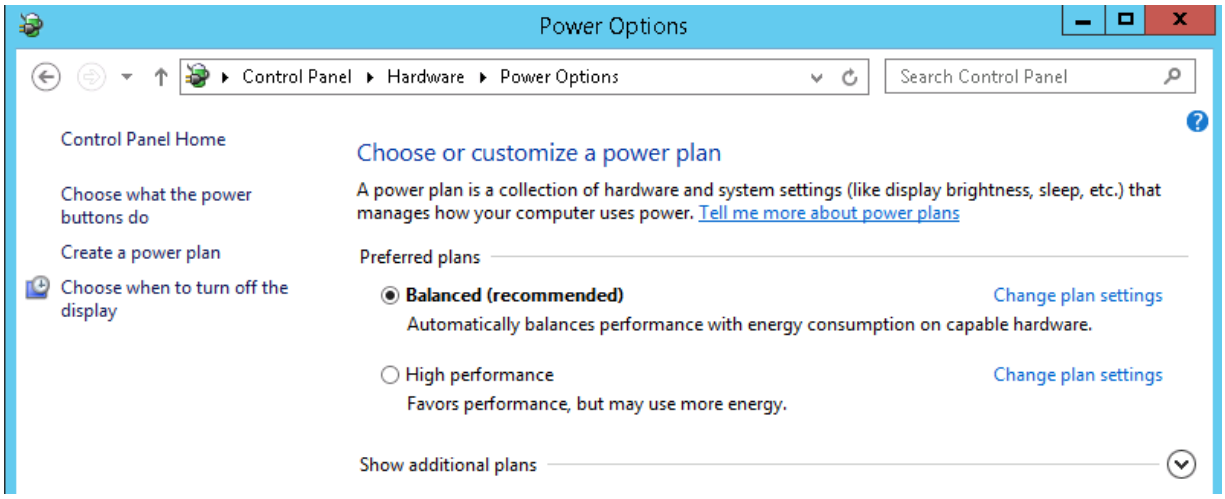

Figure 7 Power plan

6.3 Enabling lock pages in memory

Enable lock pages in memory to prevent the system from paging memory to hard disk drive. The SQL Server service account is added to lock pages in memory setting.

For more information about configuring this option, go to:

https://msdn.microsoft.com/en-IN/library/ms190730.aspx

7 Configuring SQL Server 2014 EE

This section describes the tunings applied to the SQL Server application for the certification.

7.1 SQL Server startup options

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

- **-E**: This parameter helps improve sequential access by increasing the number of contiguous extends that are allocated to a database table in each file.
- **T1117**: This trace flag ensures the even growth of all files in a file group when auto growth is enabled. Note that it is recommended to pre-allocate the data file disk space rather than to depend on auto grow.

For more information about trace flags, go to:

http://support.microsoft.com/kb/920093

7.2 SQL Server maximum memory

For the reference architecture, 92 percent of the system RAM (that is 176 GB) is allocated to the SQL Server. If additional applications share the server then the RAM left to the OS requires to be adjusted accordingly.

7.3 Resource governor

Resource governor enables to specify limits on the maximum memory consumed per query. While it can be beneficial for many data warehouse workloads to limit the amount of system resources available to individual session, this is best measured after analysing current queries. The configuration was tested with 12 percent and 25 percent memory grant and the 12 percent setting was found to provide optimal results for the row store and column store test environments.

For more information about the resource governor, go to:

https://msdn.microsoft.com/en-us/library/bb933866.aspxp

7.4 Maximum Degree of Parallelism (MAXDOP)

The SQL Server max degree of parallelism option is used to limit the number of processors used in parallel execution of a query. For the certification, MAXDOP setting of 0 (that is 20 logical processors) and 8 was tested and MAXDOP setting of 8 provided the best results.

For more information about max degree of parallelism, go to:

https://msdn.microsoft.com/en-us/library/ms189094.aspx#Recommendations

7.5 Configuring system temp database

For the tested configuration nine equal sized `tempdb` data files are hosted on the nine data volumes . Disk space was pre-allocated to all the `tempdb` files. The `tempdb` log file was created on the log volume with auto grow enabled.

8 DWFT for SQL Server 2014 certification

DWFT Certification #2014-021	Dell R730xd with Internal Disk - 21 TB DWFT Reference Architecture		Report Date: 2/5/2015
DWFT Rev. 5.4			
System Provider	**System Name**	**Processor Type**	**Memory**
DELL	Dell PowerEdge R730xd	Intel Xeon E5-2650v3 2.3 GHz (1S/10C/20T)	192 GB
Operating System		**SQL Server Edition**	
Windows Server 2012 R2		SQL Server 2014 Enterprise Edition	
Storage Provider	**Storage Information**		
DELL	18 x 1.2TB 10K SAS for data and tempdb (RAID 1) 2 x 146GB 15K SAS for OS (RAID 1) 2 x 1.2TB 10K SAS each for log (RAID 1), staging (RAID 0) and hot spare		

Primary Metrics			
Rated User Data Capacity[1] (TB)	Row Store Relative Throughput[2]	Column Store Relative Throughput[3]	Maximum User Data Capacity[1] (TB)
21	57	117	38

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.) (%)
57	75	1,337	1,995	1,666	78

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.) (%)
117	763	1,185	N/A	N/A	100

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 8 Dell PowerEdge R730xd DWFT for SQL 2014 certification

9 Summary

Dell, in partnership with Microsoft, enables customers to deploy tested and validated data warehouse systems by 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 database best practices and recommendations enable the customer to achieve enhanced Return on Investment (ROI) with a balanced data warehouse environment with greater performance than traditional data warehouse systems.

The Dell and Microsoft DWFT reference architectures for SQL Server 2014 provides the following benefits to customers:

- Delivers a tested and validated configuration with proven methodology and performance behavior.
- Achieves a balanced and optimized system at all the levels of the stack by following the best practices of hardware and software components.
- Avoids over-provisioning of hardware resources.
- Offers high-availability at all levels of setup (host, switches, and storage).
- 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 Dell technical white paper demonstrated a reference configuration by using R730xd server with internal storage and implementing DWFT design principles to achieve a data warehouse requirement of up to 21 TB capacity and scan rate of around 1700 MBps.

10 Additional resources

- Dell SQL Server Solutions
  www.dell.com\sql
- Dell Services
  www.dell.com\services
- Dell Support
  www.dell.com\support
- Dell Data Warehouse Fast Track for SQL Server Advisor
  http://www.dell.com/solutions/advisors/us/en/g_5/SQLFastTrack/4/Start?s=biz" \l "212418
- Deployment guide for 21 TB Data Warehouse Solution with PowerEdge R730xd internal storage
  Deployment Guide: 21 TB Data Warehouse Fast Track for Microsoft SQL Server 2014 using PowerEdge R730xd Server

11 Acknowledgements

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