Dell Reference Configuration for Microsoft® SQL Server® 2008 R2 Fast Track Data Warehouse using PowerVault MD3620i

Dell | Database Solutions Engineering

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Introduction

Data Warehousing is used for storing, normalizing, and analyzing data, trend analysis, business intelligence, etc. With today’s never ending data growth, it is becoming a tedious job for the customers to balance capacity and performance of the warehousing system. As data grows larger, response times of the warehousing systems are increasing day-by-day. Many solution providers and IT executives are looking for solutions that ease maintenance and administration, and improve the performance of the entire warehousing stack.

There are many challenges in designing a database configuration for OLAP workloads. The most vital factor is to design an optimally balanced database configuration for data warehouse applications. This design enables each of the components of the entire database stack to provide sufficient throughput to match the database capabilities of the specific setup.

Dell and Microsoft jointly provided guidelines and design principles to assist customers in designing and implementing a balanced configuration specifically for Microsoft SQL Server data warehouse workloads to achieve “out-of-box” scalable performance.

The theme of this white paper is to describe the architectural design principles and guidelines to achieve an optimally balanced SQL Server Data Warehouse solution according to the Microsoft Fast Track Data Warehouse guidelines.

Audience and Scope

The target audience of this white paper consists of customers, architects, database administrators, storage administrators and business intelligence (BI) users who are evaluating, planning, and deploying optimally balanced warehouse solutions. The scope of this white paper is limited to data warehouse (OLAP) environments. It does not include other implementations that utilize data warehouses as a source of data, such as SSAS, SSIS, and SSRS.

Microsoft SQL Server Fast Track Data Warehouse

In order to overcome the limitations of traditional warehouse systems, Microsoft created a cost effective solution that optimally balances the hardware and software capabilities of the system. It provides an easy to deploy data warehouse infrastructure by mainly focusing on the storage tuning and database layout. Fast Track Data Warehouse (FTDW) follows a different way of implementing data warehouse solutions. Because most of the data warehousing queries scan large volumes of data, FTDW designs are optimized for sequential scans/reads. When you apply these proven methodologies, the performance gain from such systems is much better than the traditional warehousing systems. Based on this fact, Dell made a deep study on the FTDW architecture and then created a reference guide that helps customers implement FTDW on Dell hardware.

Dell Fast Track Data Warehouse Reference Architecture

This white paper describes the implementation of the Fast Track Data Warehouse solution based on the Microsoft SQL Server Fast Track Data Warehouse Reference Guide 3.0 by using Dell PowerEdge R610 servers and PowerVault MD3620i iSCSI storage.
In order to obtain the best performance out of all the components in the database stack, the proper tuning of each layer is important. The following sections explain the tuning of the selected hardware and software components, in order to build an optimally balanced system.

**Hardware Component Architecture**

Dell conducted redundant and robust tests on Dell’s PowerEdge servers and PowerVault storage to determine the best practices and guidelines to build a balanced FTDW system.

Figure 1 shows the pictorial representation of the proposed reference architecture.

**Figure 1. Dell Fast Track Reference Architecture**

The above reference configuration includes one PowerEdge R610 Server, two MD3620i iSCSI storage arrays, two Dual Port Broadcom 57711 10Gb NICs and two 8024 10GbE switches for high availability.

Note: Dell also tested the configuration with a single 8024 fabric and verified that there is no compromise on performance for this specific configuration. Based on the high availability requirements, you may decide to have single or dual switches for the configuration.

Additionally, the availability of the configuration may be further enhanced by configuring database clustering using multiple servers.

Table 1 shows the configuration details, tested by Dell, as part of this white paper exercise.
Table 1. Dell Fast Track Reference Architecture Component Details

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution ID</td>
<td>1912847</td>
</tr>
<tr>
<td>Server</td>
<td>PowerEdge R610 (BIOS: 3.0.0)</td>
</tr>
<tr>
<td>CPU</td>
<td>Intel® Xeon® CPU X5687 @3.60GHz (HT Enabled)</td>
</tr>
<tr>
<td>Number of cores per socket</td>
<td>4</td>
</tr>
<tr>
<td>Total Number of CPU Cores</td>
<td>8</td>
</tr>
<tr>
<td>Memory</td>
<td>96GB RAM (12 * 8 DDR3 DIMMs @1333MHz)</td>
</tr>
<tr>
<td>Network Adapters</td>
<td>2 * Broadcom BCM57711 NetXtreme II 10GbE Dual Port Adapter (Firmware: 6.2.16)</td>
</tr>
<tr>
<td>Network Switch</td>
<td>2 * PowerConnect™ 8024 (Firmware: 3.1.4.5)</td>
</tr>
<tr>
<td>Storage</td>
<td>2 * MD3620i (Firmware: 07.75.14.61)</td>
</tr>
<tr>
<td></td>
<td>48 * 146GB 15k RPM 6Gbps SAS Disks; No additional storage Premium features are used</td>
</tr>
<tr>
<td>Operating System</td>
<td>Microsoft Windows® 2008 R2 SP1 Enterprise Edition</td>
</tr>
<tr>
<td>MultiPathing Software</td>
<td>Microsoft MPIO</td>
</tr>
<tr>
<td>iSCSI Software Initiator</td>
<td>Microsoft iSCSI Initiator (Driver Version: 6.1.7601.17514)</td>
</tr>
<tr>
<td>Database Software</td>
<td>Microsoft SQL Server 2008 R2 Standard Edition</td>
</tr>
</tbody>
</table>

**Dell PowerEdge R610 Server**

The Dell™ PowerEdge™ R610 is a 2-socket 1U rack server that offers simplified management, purposeful design, and energy efficiency with support of Intel 5500 and 5600 series processors and ECC DDR3 RDIMMs @1333MHz with a maximum capacity of 192GB Memory. PowerEdge R610 comes with two x8 Gen2 slots. For more technical specifications of R610 Server, refer to the Power Edge R610 Technical Guide link located in the References section of this document.

**Processors**

In the FTDW architecture, the selection of the processor is critical because the complete FTDW architecture depends on the processing capabilities of the hosted application. In this configuration, Dell used (2) Intel® Xeon® X5687 Quad core Westmere processors each operating at 3.6GHz speed.

**Memory**

For FTDW architecture, Microsoft provides a general recommendation of 8GB of memory per processor core. By having enough memory installed on the system, the large-scale queries involving Hash joins and sorting operations benefit because the SQL Server offloads the operations from the Tempdb to Memory. Selection of Memory DIMMS also plays a critical role in the performance of the entire stack. Dell configured the database server with 96GB of RAM, running at 1333 MHz speed. Refer to the Microsoft Fast Track 3.0 Reference Guide for the detailed recommendations on system memory configuration.

**iSCSI SAN**

Microsoft Fast Track guidelines are intended to arrive at a maximal performing balanced configuration. Therefore, it mandates that you have a high performing SAN configured with the recommended best practices.
Dell Reference Configuration for Microsoft® SQL Server® 2008 R2 Fast Track Data Warehouse using PowerVault MD3620i for the specific configuration. The sections below detail the SAN configuration settings used for the proposed reference configuration.

**Broadcom 57711 10GbE Network Adapter**
In this configuration, Dell used two Dual port Broadcom 57711 10Gb NIC cards. Enable ISOE (iSCSI Off Load Engine) feature on Broadcom NICs to off load the iSCSI workload from the processors to the NICs. Figure 2 shows a screenshot of the UI when using the Broadcom Advanced Suite to enable ISOE on the NICs. See the References section of this document for detailed instructions on enabling the ISOE feature.

![Figure 2. iSCSI Offload Engine setting on Broadcom NIC](image)

For the recommended Fast Track configuration, enable jumbo frames on all the NICs and set the MTU (Maximum Transferrable Unit) to the maximum possible value of 9300 as shown in Figure 3.

![Figure 3. Maximum Transferable Unit setting on Broadcom NIC](image)

**PowerConnect 8024 Ethernet Switch**
Dell PowerConnect 8024 is a 1U rack mountable 10Gb Ethernet switch with 24x 10GBASE-T (10Gb/1Gb/100Mb) and 4x Combo Ports of SFP+ (10Gb/1Gb) or 10GBASE-T ports. For the specific Fast Track reference
configuration, enable jumbo frames on all switch ports and set the MTU (Maximum Transferrable Unit) to 9216 Bytes. Keep all other switch settings as default. For more details, refer to the Dell PowerConnect 8024/8024F Manuals given in the References section of this document.

**MultiPathing using Microsoft MPIO**
Dell PowerVault MD3620i storage comes with its own Device Specific Module (DSM) software, included in the MD3620i’s Resource DVD, which is fully integrated with Microsoft MPIO and helps you configure the multipath solutions. Dell recommends that you use all the default MultiPathing settings for the configuration.

Figure 4 shows the MPIO policy settings of the storage LUN at the host side. Note that the default MPIO policy used is “Least Queue Depth”.

**Figure 4. MPIO settings**

![Figure 4](image)

**MD3620i iSCSI Storage Enclosures**
Dell introduced the 10Gb MD3620i storage controllers with the support of 2.5 inches 6Gbps SAS disks because the demand for iSCSI technology based products is rapidly growing. MD3620i comes with two controllers. Each controller has two iSCSI 10Gbps Ethernet host side ports and one SAS out port, which is used to connect to any additional storage enclosures. On each controller, there is an iSCSI management port for Out-of-Band Management and serial console port for In-Band Management. Each RAID controller module contains 2GB of cache that is mirrored with the other controller's cache for high availability and is protected by a battery-powered cache offload mechanism.

The following sections explain some of the important features of MD3620i that you must tune to achieve optimal performance from the storage array for a high performing Fast Track Data Warehouse.

**Jumbo Frames on Storage iSCSI Ports:**
In the proposed configuration, you should configure all the storage iSCSI ports to use the MTU value as maximum limit of 9000 bytes/frame.

Figure 5 shows the snapshot of the iSCSI port configuration to enable jumbo frames on the storage side.
Cache settings

For the Fast Track configuration, Dell recommends that you set the controller cache block size to 32KB for maximum array throughput.

Figure 6 shows the storage management window to modify the cache settings.

Figure 5. Jumbo Frame Configuration

![Jumbo Frame Configuration](image)

![Cache Settings](image)
**Dell Reference Configuration for Microsoft® SQL Server® 2008 R2 Fast Track Data Warehouse using PowerVault MD3620i**

**Segment size Settings**

By default MD3620i creates Virtual disks with I/O characteristics suitable for File Systems with default segment size of 128KB. During the Fast Tract exercise, Dell observed that a segment size of 256KB is the most beneficial for sequential workloads.

Figure 7 shows the storage option to modify the virtual disk segment size.

**Figure 7. Segment Size Settings**

![Segment Size Settings Figure]

**RAID Configuration**

One of the most critical decisions that you have to make when deploying a new storage solution is what RAID type(s) to use because it heavily impacts the performance of the application. In order to attain the better balance between the controllers and to achieve the efficient use of the storage hard drives, Dell configured the proposed Fast Track configuration using RAID 5(4+1) disk groups for Database data files and RAID1 for Database Log files. Four RAID 5(4+1) data disk groups and one RAID 1 log disk group were created on a single storage enclosure. You should assign two RAID 5 disk groups to a controller and the other two to the other controller, to balance the controllers expeditiously. The log disk group may be assigned to either of the controllers.

Figure 8 shows the proposed RAID configuration for a single enclosure.

**Figure 8. RAID Configuration**

![RAID Configuration Figure]
Application Configuration

The sections below explain the settings applied for the operating system and database layers.

Windows Server 2008 R2 SP1
Dell used the default settings for the Windows 2008 R2 SP1 operating system.

SQL Server Configuration
Dell added the following startup options to the SQL Server Startup options:

- E: This parameter increases the number of contiguous extends in each file that are allocated to a database table as it grows. This is beneficial to improve sequential access.
- T1117: This trace flag ensures the even growth of all files in a file group when auto growth is enabled. It may be noted that the Fast Track reference guidelines recommend to pre allocate the data file space rather than to auto grow.

Storage System
The Fast Track Reference Architecture guidelines define three primary layers of storage configuration:

- Physical disk array (RAID Groups for Data and Logs)
- Operating system volume assignment (LUN)
- Databases: User, System Temp, Log

For each Storage array:

- Four RAID 5 Disk Groups were created, each consisting of 5 disks. These RAID groups were dedicated for the primary user data.
- The primary disk groups were evenly distributed among the storage controllers. Each storage controller was assigned two of the primary disk groups.
- One RAID 1 disk group was created of 2 disks. This RAID group was dedicated to host the database transaction log files.
- The remaining 2 disks were assigned as the storage hot spares.

For the entire storage setup involving two storage enclosures, there were eight disk groups dedicated to hold the primary user data and a total of two disk groups to hold the database log files.

For Fast Track architectures, Dell recommends that you use mount points for the storage access rather than using drive letters. It is also important to assign the appropriate LUN/Volume and mount point names to the configuration in order to make the troubleshooting and performance analysis much simpler. Assign the mount point names in such a way that the logical file system reflects the underlying physical storage enclosure mapping. Table 2 shows the LUN and mount point names used for the specific reference configuration and the appropriate storage layer mapping. All the logical volumes were mounted to the “C:\FT” folder.
## Table 2. Mount Point Naming and the Storage Enclosure Mapping

<table>
<thead>
<tr>
<th>Storage Enclosure</th>
<th>Storage Processor</th>
<th>Disk Group</th>
<th>Logical LUN (volume)</th>
<th>Logical Volume Label</th>
<th>Logical Array Label</th>
<th>Full Volume Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>SE1-SP1-DG1-v1</td>
<td>PRI</td>
<td>C:\FT\PRI\SE1-SP1-DG1-v1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>SE1-SP1-DG2-v2</td>
<td>PRI</td>
<td>C:\FT\PRI\SE1-SP1-DG2-v2</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>SE1-SP2-DG3-v3</td>
<td>PRI</td>
<td>C:\FT\PRI\SE1-SP2-DG3-v3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>SE1-SP2-DG4-v4</td>
<td>PRI</td>
<td>C:\FT\PRI\SE1-SP2-DG4-v4</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>SE1-SP2-DG5-v5</td>
<td>LOG</td>
<td>C:\FT\LOG\SE1-SP2-DG5-v5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>SE2-SP1-DG6-v6</td>
<td>PRI</td>
<td>C:\FT\PRI\SE2-SP1-DG6-v6</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>SE2-SP1-DG7-v7</td>
<td>PRI</td>
<td>C:\FT\PRI\SE2-SP1-DG7-v7</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>SE2-SP2-DG8-v8</td>
<td>PRI</td>
<td>C:\FT\PRI\SE2-SP2-DG8-v8</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>9</td>
<td>9</td>
<td>SE2-SP2-DG9-v9</td>
<td>PRI</td>
<td>C:\FT\PRI\SE2-SP2-DG9-v9</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>SE2-SP2-DG10-v10</td>
<td>LOG</td>
<td>C:\FT\LOG\SE2-SP2-DG10-v10</td>
</tr>
</tbody>
</table>

**Notes:**
- SE: Storage Engine, SP: Storage Processors, DG: Disk Group & V: Volume

Figure 9 represents the storage system configuration for the proposed Fast Track reference using MD3620i iSCSI storage.

### Figure 9. Storage system Components
Dell deployed the production, staging, and system temp databases per the recommendations given in the Microsoft Fast Track Data Warehouse 3.0 Reference Guide.

**Performance Benchmarking**

Microsoft Fast Track guidelines help you achieve optimized database architecture with balanced CPU and storage bandwidth. The sections below describe the performance characterization activities carried out for the proposed Dell Microsoft Fast Track reference architecture.

**Baseline Hardware Characterization using Synthetic I/O**

The storage hardware needs to be analyzed thoroughly to make sure that the storage backend is capable of delivering the maximum possible throughput. This analysis ensures that the performance of the system is not bottlenecked in any of the intermediate layers.

Dell used the disk characterization tool, SQLIO, to validate the configuration. For detailed guidelines, refer to the Fast Track Reference Guide link located in the References section of this document. Figure 10 shows the baseline performance numbers achieved for the proposed reference architecture.

**Figure 10. Baseline Hardware Characterization using SQLIO**
Fast Track Workload Evaluation

The performance of a Fast Track database configuration is measured using two core metrics: Maximum CPU Consumption Rate (MCR) and Benchmark Consumption Rate (BCR).

Calculating MCR

MCR indicates the per core I/O throughput in MB or GB per second. MCR is measured by executing a pre-defined query against the data in the buffer cache and then measuring the time taken to execute the query against the amount of data processed in MB or GB. The MCR value provides a baseline peak rate for performance comparison and design purposes.

For the proposed configuration with two Intel X5687 quad core processors, the system aggregate MCR is 2368 MB/s. The realized MCR value per core is 296 MB/s.

Calculating BCR

BCR is calculated in terms of total read bandwidth from the disks and not from the buffered cache. BCR is measured by running a set of standard queries specific to the data warehouse workload, directly serviced from disk.

For the proposed Fast Track configuration, the aggregate BCR is 2080 MB/s. More details on the BCR calculation and the bandwidth achieved by the component layers are shown in Figure 11.

Figure 11. Maximum Benchmark Consumption Rate (BCR)
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During the evaluation cycle, the system configuration was analyzed for multiple query variants (simple, average, and complex) with multiple sessions and different degrees of parallelism (MAXDOP) options to arrive at the optimal configuration. Each of the evaluation results at each step were validated and verified jointly by Dell and Microsoft. The performance benchmark results are summarized in the table below.

<table>
<thead>
<tr>
<th>Physical Throughput (MB/s)</th>
<th>Logical Throughput (MB/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td><strong>Peak</strong></td>
</tr>
<tr>
<td>1280.5</td>
<td>1512</td>
</tr>
</tbody>
</table>

The session based results of the performance characterization benchmarks are in the Appendix section.

**Conclusion**

Microsoft Fast Track Data Warehouse architecture provides a unique data warehouse implementation solution. By following the best practices at all the layers of the stack, you can achieve a balanced data warehouse environment with a greater performance benefit than the traditional data warehouse systems.

The Dell Microsoft Fast Track Architecture 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 the 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.
References

Dell SQL Server Solutions
www.dell.com\sql

Dell Services
www.dell.com\services

Dell Support
www.dell.com\support

OLTP and OLAP
http://datawarehouse4u.info/OLTP-vs-OLAP.html

Microsoft Fast Track Data Warehouse and Configuration Guide Information
www.microsoft.com/fasttrack
http://download.microsoft.com/download/B/E/1/BE1AABB3-6ED8-4C3C-AF91-448AB733B1AF/Fast_Track_Configuration_Guide.docx

An Introduction to Fast Track Data Warehouse Architectures

Power Edge R610 Technical Guide

Broadcom NetXtreme II Network Adapter User Guide

Dell PowerConnect 8024/8024F Manuals

Dell PowerVault MD3620 Storage Array Documentation
Table 4. **Reference Architecture Performance Characterization Results**

<table>
<thead>
<tr>
<th>Query Sessions</th>
<th>Total Physical IO Throughput(MB/s)</th>
<th>Total Logical IO Throughput(MB/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple Workload, MAXDOP:0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Session</td>
<td>1426</td>
<td>1726</td>
</tr>
<tr>
<td>10 Session</td>
<td>1485</td>
<td>1823</td>
</tr>
<tr>
<td>20 Session</td>
<td>1512</td>
<td>2274</td>
</tr>
<tr>
<td>40 Session</td>
<td>1418</td>
<td>2078</td>
</tr>
<tr>
<td><strong>Complex Workload, MAXDOP:0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Session</td>
<td>1103</td>
<td>1478</td>
</tr>
<tr>
<td>10 Session</td>
<td>1077</td>
<td>1477</td>
</tr>
<tr>
<td>20 Session</td>
<td>1049</td>
<td>1439</td>
</tr>
<tr>
<td>40 Session</td>
<td>1075</td>
<td>1523</td>
</tr>
</tbody>
</table>