WHITE PAPER

# HPE ProLiant DL380 Gen9 with Lightning Ascend™ SAS SSDs 19TB Data Warehouse Fast Track Reference Architecture

## Based on the SQL Server® 2014 Data Warehouse Fast Track (DWFT) Reference Architecture

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## Executive Summary

This guide details the server, storage, and software configurations for the HPE ProLiant DL380 (Gen9) with Lightning Ascend™ 12Gb/s SAS SSDs (1.6TB) from SanDisk®, which Microsoft has validated for a Fast Track-rated user capacity of 19TB. By installing a single CPU in the two-socket system, this 19TB architecture offers scalable capacity and performance, while keeping SQL Server 2014 licensing costs to a minimum.

This document is for individuals (BI architects, DBAs, report developers, and IT directors) involved in decision making who are looking for guidance when designing enterprise, business-intelligence applications.

The Microsoft SQL Server Data Warehouse Fast Track (DWFT) reference architecture is designed to eliminate the complexity of properly sizing hardware, which helps reduce unnecessary scale-out of storage and servers. The sizing techniques used in the SQL Server DWFT will properly size servers, based on I/O and CPU consumption. This consumption-based approach ensures your data warehouse can fully take advantage of your hardware investment.

## About the HPE ProLiant DL380 Gen9

The HPE ProLiant DL380 Gen9 Server delivers the latest performance and expandability in the HPE 2P rack portfolio. Reliability, serviceability, and near continuous availability, backed by a comprehensive warranty, make it ideal for any server environment.

This server reduces costs and complexity by leveraging Intel's latest E5-2600 v3 processors, with up to 70% performance gain. It also features the latest HPE DDR4 SmartMemory, supporting 1.5TB and up to 14% performance increase. Additional support is available for a 12Gb/s SAS, 40Gb NIC with a broad range of graphics and compute options.

The HPE ProLiant DL380 Gen9 Server has a flexible, redesigned chassis. This includes

- A new HPE Universal Media Bay configuration with options for 8 to 24 SFF drives and 4 or 12 LFF drives, as well as NVMe options
- Additional rear drive support for expandability and investment protection

The server also features HPE Persistent Memory, the first Non-volatile DIMM (NVDIMM) optimized on HPE ProLiant, offering unprecedented levels of performance and data resiliency for databases and analytic workloads.

In conjunction with the embedded SATA HPE Dynamic Smart Array B140i Controller for boot, data, and media needs, the redesigned HPE Flexible Smart Array and HPE Smart SAS HBA Controllers allow you the flexibility to choose the optimal 12 Gb/s solution for your environment. You can select from embedded 4x1GbE, HPE FlexibleLOMs, or PCIe standup 1GbE to 40GbE adapters to provide flexibility in your networking bandwidth and fabric. This in turn helps you adapt and grow to changing business needs. For more information on HPE ProLiant DL380 Gen9 Servers, visit this link: http://www8.hp.com/h20195/v2/getpdf.aspx/c04346247.pdf

## Lightning® Product Family of SAS SSDs from SanDisk

The Lightning Ascend Gen. II 12Gb/s SAS SSD doubles interface speed, providing the highest performance for mission-critical hyperscale, cloud and virtualized data center application workloads. This next-generation Lightning SSD offers a feature-rich, robust design, combined with SanDisk's innovative parallel processing architecture. It delivers full data path protection (T10-DIF support), temperature based power control, SED instant secure erase, an MTBF of 2.5 million hours, and power-fail protection. This SSD is backward-compatible with 6Gb/s SAS and offers a single firmware binary platform for seamless integration and reduced qualification times. For more information, refer to the Lightning Ascend datasheet: https://www.sandisk.com/content/dam/sandisk-main/en_us/assets/resources/enterprise/data-sheets/lightning-ascend-genII-sas-ssd-datasheet.pdf

## New Data Warehouse Features in Microsoft® SQL Server® 2014.

Microsoft added clustered column store indexes (CCI) in SQL Server 2014, which are designed to decrease query response times and deliver deeper levels of data compression. CCI eliminates the need to build summary tables, thus further reducing ETL run times.

- CCI is optimized for query performance. Our solution delivers an order-of-magnitude 7x better query performance when using CCI. It accomplishes this by using a columnar format to compress the data by 10x or more, processing a set of rows in batches, and reading only the columns that are referenced in the query.
- CCI is updateable allowing concurrent insert – both bulk import and trickle – of new data while the query workload is running. This reduces the data latency from the time data is born to when it is available for querying.

## About the Data Warehouse Fast Track Reference Architecture

The SQL Server Data Warehouse Fast Track reference architecture provides a scalable framework based on balancing I/O to achieve maximum performance from SMP-based servers. SQL Server Data Warehouse Fast Track eliminates the complexity of sizing servers with data warehouses by providing a set of data consumption rates that properly balances performance between the disk subsystem, CPU, and memory.

More information on SQL Server DWFT can be found here:

http://www.microsoft.com/en-us/server-cloud/data-warehouse-fast-track.aspx

## Reference Architecture

The following table shows the configuration details for the Data Warehouse Fast Track architecture, for the HPE ProLiant DL380 Gen9 with Lightning Ascend.

| | |
|---|---|
| **Server** | HPE ProLiant DL380 Gen9 |
| **Operating System** | Microsoft Windows Server 2012 R2 Standard Edition |
| **CPU** | Intel® Xeon® E5-2697 v3 @ 2.6 GHz (1S/14C/28T) |
| **PCI-E Slots** | Up to eight PCIe 3.0 slots (two CPU and second riser card) |
| **Drives** | 2 x 1.2TB SAS (OS) |
| **RAM** | 256GB |

## Server UEFI Configuration

- Hyper-Threading was enabled
- Operating mode was changed to "Maximum Performance"
- Fan Offset was set to "Increased Cooling"

## General Settings

### Operating System Settings

The operating system used for this Data Warehouse Fast Track test was Microsoft Windows Server 2012 R2 Standard Edition. Standard installation steps were used to install the operating system with default values, followed by service packs and update patches.

### Windows Configuration – Power Settings

The High Performance plan was chosen to reduce CPU throttling.

### Storage Configuration

The Windows 2012R2 OS was configured on a pair of 10K SAS HDDs (mirror).

The Lightning Ascend SSDs were configured using Storage Spaces. This technology allows Windows Server to virtualize storage by grouping industry-standard disks into storage pools and then creating virtual disks called storage spaces from the available capacity in those storage pools.

Storage Spaces enable cost-effective, highly available, scalable and flexible storage solutions for business-critical deployments.

**Physical Disk Storage Pool**

| Slot | BUS | Physical Disk | Presented Capacity | Storage Pool |
|---|---|---|---|---|
| **8** | SAS | Lightning Ascend | 1.45TB | SQL |
| **6** | SAS | Lightning Ascend | 1.45TB | SQL |
| **5** | SAS | Lightning Ascend | 1.45TB | SQL |
| **7** | SAS | Lightning Ascend | 1.45TB | SQL |
| **3** | SAS | Lightning Ascend | 1.45TB | SQL |
| **4** | SAS | Lightning Ascend | 1.45TB | SQL |

**SQL Storage Pool - Virtual Disks**

| Name | Layout | Provisioning | Capacity | Path |
|---|---|---|---|---|
| **SQL Data** | Parity | Fixed | 6.78TB | C:\DB\DATA |
| **SQL Logs** | Mirror | Fixed | 300GB | C:\DB\LOGS |

## SQL Server Settings

### Database Configuration

A 1TB data warehouse schema was created for benchmarking using the Fast Track toolkit. The schema used a master filegroup with four additional filegroups.

### TempDB Configuration

In total, eight 10GB tempdb files were created and stored on the volume designated for data files. The tempdb transaction log file was stored on the volume designated for log files.

### Memory Allocation

SQL Server was allocated 118GB of the available server memory (256GB). This amount is allocated as part of the Fast Track test criteria to drive backend disk activity during the Row Store query runs.

### Local Security Policy

The SQL Server maintenance account was granted the following privileges:

- Enable Lock Pages in Memory
- Perform Volume Maintenance Tasks

### SQL Server 2014 Configuration Parameters

| Parameter | Setting | Description |
|---|---|---|
| **Memory Allocation** | 118GB | This is the Fast Track-required value for a two-socket, 1TB database. Memory is deliberately constrained to enforce I/O pressure on the subsystem. |
| **Max Degree of Parallelism** | 28 | When SQL Server runs on a computer with more than one microprocessor or CPU, it detects the best degree of parallelism (the number of processors employed to run a single statement). |
| **Resource Governor memory Allocation** | 12% | The default is 25%. This is reduced to 12% for both Row Store and Column Store to reduce the maximum memory consumed per query. |
| **Fast Track Required Start-up Parameters** | -T1117 | This trace flag ensures even growth of all files in a file group in case `autogrow` is enabled. The standard FTDW recommendation for database file growth is to pre-allocate rather than use `autogrow` (with the exception of tempdb). |
| **Optional Startup Parameters** | -T1118 | The startup parameters help alleviate allocation bit map contention in tempdb by switching allocations to full extents (eight physically contiguous pages (64KB)). |
| **Startup Parameters** | -T834 | When set, SQL Server uses Windows large-page memory allocations for the buffer pool. This trace flag can improve throughput rates for many data warehousing workloads. |

## Measured Performance

During Fast Track Database validation, Microsoft's Reference Point tool drives multiple concurrent query workloads designed to identify bottlenecks. The tool establishes the key performance metrics in the table below, for a single-socket configuration.

| Scan Rate Type | Scan rate | Description |
|---|---|---|
| Rated User Capacity | 19TB | Represents the optimal Fast Track-certified data capacity of the configuration.<br><br>Allows for 5:1 compression with 10% recommended free space. 25% capacity is reserved for tempdb, while some memory and throughput based limits are also applied. |
| Row Store Relative Throughput | 98 | Percentage throughput of this configuration in comparison to the FTDW reference configuration. This result almost matched the reference configuration, using only a single socket. The reference architecture is a 25TB dual-socket configuration. |
| Column Store Relative Throughput | 160 | Percentage throughput of this configuration in comparison to the FTDW reference configuration. |
| Maximum User Data Capacity | 22TB | Calculated, based on total disk capacity. Allows 5:1 compression. This factors the recommended free space but ignores the throughput limits applied to the Rated User Capacity. |
| RS Measured Throughput (Q/Hr/TB) | 131 | Number of Row Store combined benchmark queries completed during the measurement interval. This is normalized to the 1TB database. |
| CS Measured Throughput (Q/Hr/TB) | 1040 | Number of Column Store combined benchmark queries completed during the measurement interval. This is normalized to the 1TB database. |

# SQL Server Data Warehouse Fast Track Certification

| DWFT Certification #2014-053 | HP ProLiant DL380Gen9 with Lightning Ascend from SanDisk 19TB Reference Architecture for Microsoft SQL Server 2014 DWFT Reference Architecture | Report Date: 26/04/2016 |
|---|---|---|
| DWFT Rev. 5.4 | | |

| System Provider | System Name | Processor Type | Memory |
|---|---|---|---|
| Hewlett Packard Enterprise | HP ProLiant DL380 (Gen9) | Intel Xeon E5-2697 v3 (1S/14C/28T) | 256 GB |

| Operating System | SQL Server Edition |
|---|---|
| Windows Server 2012 R2 | SQL Server 2014 Enterprise Edition |

| Storage Provider | Storage Information |
|---|---|
| SanDisk | 6 x 1.6TB Lightning Ascend from SanDisk - presented via Storage Spaces<br>6780GB allocated to Data and TempDB (Parity)<br>300GB allocated to LOG (Mirror) |

**Primary Metrics**

| Rated User Data Capacity[1] (TB) | Row Store Relative Throughput[2] | Column Store Relative Throughput[3] | Maximum User Data Capacity[1] (TB) |
|---|---|---|---|
| 19 | 98 | 160 | 22 |

**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.) (%) |
|---|---|---|---|---|---|
| 98 | 131 | 2,493 | 3,273 | 2,883 | 81 |

**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.) (%) |
|---|---|---|---|---|---|
| 160 | 1,040 | 1,133 | 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.

## Summary

Together, Hewlett Packard Enterprise and SanDisk dedicated hundreds of hours of testing to engineer the SQL Server DWFT solution to provide the most optimal reliability and performance. These series of tests pushed the HPE ProLiant DL380 Gen9 to peak performance without hardware failure. The reliability and performance experienced during testing is what can be expected in production environments.

The same configuration meets the need of both Row Store and Column Store configurations, delivering high physical read throughput in the Row Store configuration at 2.5 GB/s, and high query rates in the Column Store configuration at 1,040 Q/Hr/TB.

## Bill of Materials

### HPE ProLiant DL380 Gen9 – Non-High-Availability Option

| Qty | SKU | Description |
|---|---|---|
| 1 | 719064-B21 | HPE ProLiant DL380 Gen9 8SFF CTO Server |
| 1 | 719054-B21 | HPE ProLiant DL380 Gen9 E5-2697v3 Kit |
| 16 | 726719-B21 | HP 16GB 2Rx4 PC4-2133P-R Kit |
| 6 | 846432-B21 | HPE 1.6TB 12G SAS Write Intensive-1 SFF (2.5in) SC 3-year Warranty Solid State Drive |
| 2 | 720484-B21 | HP 800W FS Universal Hot Plug Power Supply Kit |