PowerEdge Product Group

Direct from Development

PowerEdge R740 SQL Server Performance with NVDIMMs

Tech Note by:
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SUMMARY

Offering low latency, high performance and data persistence, NVDIMMs have become an essential technology for data centers seeking better business outcomes and greater competitive advantage.

In a Dell EMC Engineering study it was found that the new, 14th-generation PowerEdge R740 configured with NVDIMM-Ns running Microsoft SQL Server 2016 OLTP workload, when compared to the same server without NVDIMM-Ns:

- boosted transactions per second (tps) by 42%
- increased Batch Requests per Second by 43%

While the R740 without NVDIMMs delivers impressive high performance, data centers wanting to get the utmost out of their systems should consider implementing NVDIMMs.

Boosting performance with NVDIMMs

Nonvolatile memory has quickly moved from an emerging technology to a powerful industry trend. Non-volatile dual inline memory module (NVDIMM) technology provides the speed of memory along with storage persistence that retains data in the event of power outage. These benefits of low latency, high performance and data preservation make NVDIMM's an essential technology for users driving business-critical applications and workloads in the quest for better business outcomes and greater competitive advantage. Support for NVDIMM technology by hardware platforms and applications thus becomes an important check-box for users considering acquisition and implementation of new servers and database solutions.

The PowerEdge R740 with and without NVDIMMs

To prove out the performance benefits of hardware platforms supporting NVDIMMs, Dell EMC Engineering evaluated a new 14th-generation (14G) PowerEdge R740 configured with NVDIMMs, and compared to the same system without NVDIMMs. NVDIMMs are installed in the R740 and other systems in a regular DIMM slot. The data persistence comes from the fact that NVDIMMs have onboard flash that are used to back up DRAM data, and a battery backup unit (BBU) to provide power in the event of AC power loss. PowerEdge 14G servers use host-managed NVDIMMs with a single energy source to back up multiple NVDIMMs in the server. Each server supports a single BBU that is cable to the planar and shared across all NVDIMMs, as shown in Figure 1 below:

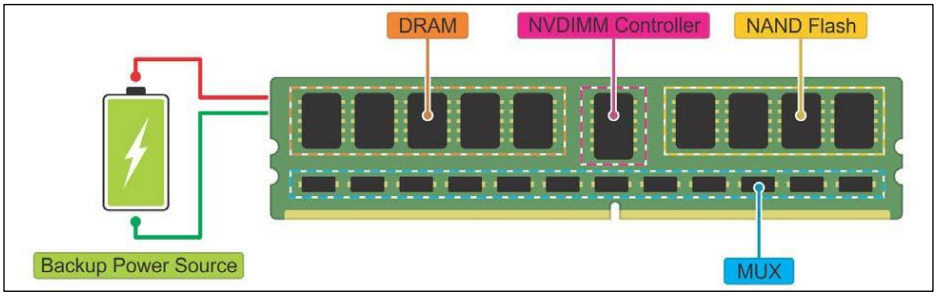

Figure 1: NVDIMM brings storage persistence at the speed of memory by using an attached controller to transfer data from the volatile DRAM to the NAND Flash in the event of an AC power loss. A battery backup unit keeps the NAND Flash powered to preserve data.

There are of course installation guidelines regarding NVDIMMs and other memory modules in the R740. These guidelines can be found in the full-length white paper on this topic shown in the notes section on page 4, or the R740 Technical Guide, also noted on page 4.

SQL Server transaction commit processing

The R740's configuration flexibility allows it to be optimized for a wide range of applications and workloads, including Online Transactions Processing (OLTP) databases such as Microsoft SQL Server. Some database products experience a significant performance bottleneck caused by latency issues when committing to the transaction log. Microsoft SQL Server 2016 SP1 overcomes this bottleneck with a new capability that can accelerate transaction commit times by 2-4 times when using NVDIMMs. This capability, Direct Access (DAX), is a new protocol for storage access and is faster than traditional modes. If the file system is formatted as DAX, the operating system allows byte-level access to the persistent memory.

Figure 2 below illustrates how traditional log processing works compared to logging with DAX. In traditional log processing, each log record is copied in a buffer and is made to wait to be written to a stable media. That is, SQL Server writes transaction log records in a buffer, and flushes them out to durable media during commit processing. SQL Server will not complete the commit until the commit log record is stored on a stable media. This log hardening can delay the processing in systems with a very high transaction rate.

The Windows Server 2016 operating system recognizes NVDIMM modules as a disk device with special characteristics. In conjunction with this, SQL Server 2016 SP1 uses a region of memory that is mapped to a file on a DAX volume. This enables the memory (rather than a disk) to hold the log buffer. The memory hosted by the DAX volume is already persistent. Hence, SQL Server does not need to write the contents of the buffer to disks before executing another commit. As a result, commits are processed as soon as the transaction completes, without waiting for the log cache data to be written to disks. This can result in significant increases in OLTP performance.

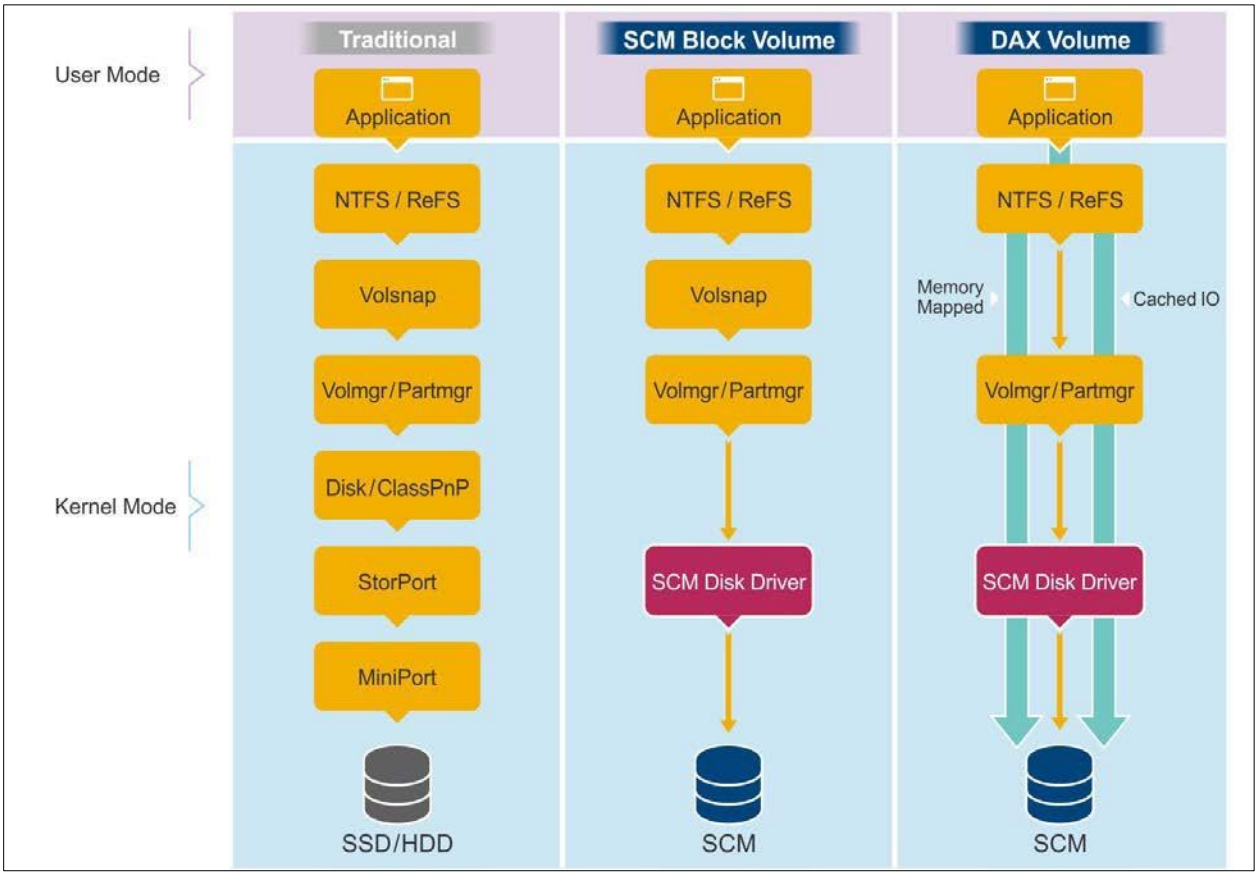

Figure 2 – Comparing traditional log processing with Direct Access (DAX)

Results of the bake-off

A PowerEdge R740 with four NVDIMM modules (4 x 16GB @ 2666MHz) was utilized for testing, with the results compared to performance runs on the same R740 configured without NVDIMMs. Using the TPC-C benchmark, the performance of four OLTP databases of 350GB each was tested. SQL Server databases were deployed on 4 x 350GB SSD drives. SQL server binaries and Temp DB files were deployed on 2 x 350GB SSD drives.

Two different scenarios were explored:

Scenario 1 (without NVDIMM)	Scenario 2 (with NVDIMM)
• Tail of the log for all databases resided in volatile memory RDIMM	• Tail of log for all databases resided in persistent memory NVDIMM. • Tail of the log for the four databases were mapped to four different NVDIMM (DAX mode) modules respectively.

In both scenarios, performance was monitored using the following Windows performance counters for SQL Server:

- SQL statistics - Batch requests per second
- Databases - Transactions per second.

As summarized in Figure 3, the results for Scenario 1 show that the PowerEdge R740 with powerful Intel Xeon Platinum processors delivers a highly impressive 16,800 transactions per second (tps), and just over 32,000 batch requests per second. Implementing NVDIMMs and Direct Access (DAX) mode on the same system drives performance significantly higher however, to 24,000 tps and to 46,000 batch requests per second, respectively. This translates into 42% more transactions per second, and 43% more batch requests per second, attained by implementing NVDIMMs and DAX.

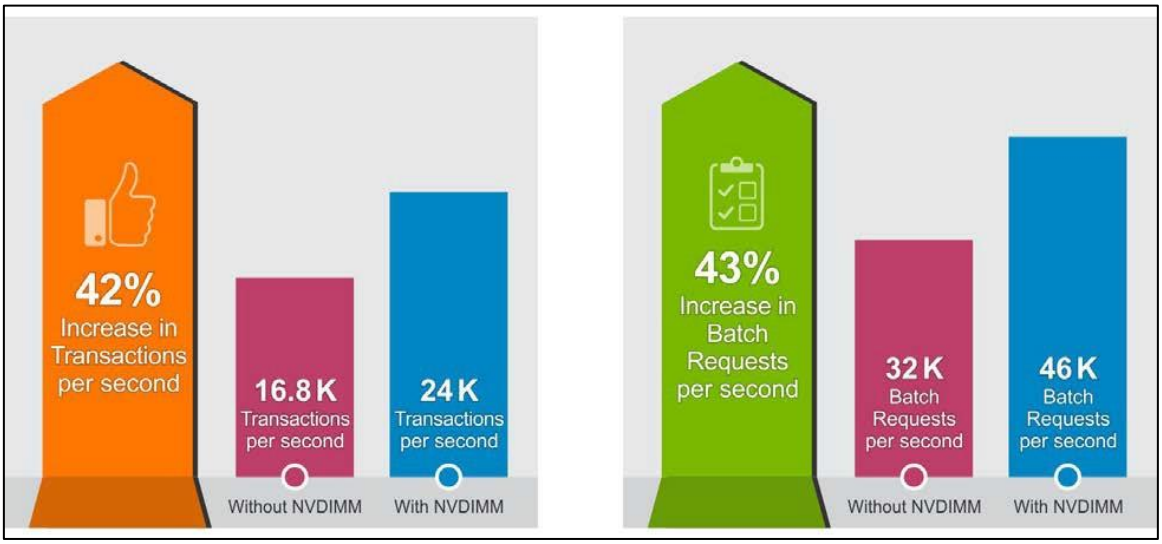

Figure 3: High performance can be driven even higher by implementing NVDIMMs

Conclusion

Data centers driving demanding workloads need to get the utmost out of their systems. This comparative test has shown that the powerful new PowerEdge R740 server with Intel Xeon Platinum processors delivers highly impressive OLTP and batch request performance. Some users will demand even more: Whether it is to achieve higher overall throughput, or to gain faster response times to boost worker productivity, ensure customer satisfaction, and gain competitive advantage, many users want more, faster. These users can attain even higher results by implementing NVDIMMs and Direct Access (DAX), attaining 42% more tps and 43% more batch requests per second, thereby enabling even better business outcomes.

Notes:

- The results reported in this paper are based on a Dell EMC Engineering study conducted in July 2017, using the TPC-C benchmark to test Microsoft SQL Server 2016. Actual performance by other users may vary.
- For further information and details about this performance evaluation, please see the full-length white paper, "***Accelerating Microsoft SQL Server Performance with NVDIMM and Dell EMC PowerEdge R740***" at http://en.community.dell.com/techcenter/enterprise-solutions/m/sql_db_gallery/20444570/
- For guidelines regarding installation of NVDIMMs and other memory modules in the R740, please refer to the **PowerEdge R740/R740xd Technical Guide** at http://www.dell.com/learn/us/en/usbsd1/shared-content~data-sheets~en/documents~poweredge_r740_r740xd_technical_guide.pdf
- For general information about the PowerEdge R740 server, please visit dell.com at: http://www.dell.com/en-us/work/shop/povw/poweredge-r740