IMPROVING SQL SERVER PERFORMANCE USING INTEL SSD DC P3600 SERIES NVME SSDS ON THE DELL EMC POWEREDGE R730XD

INCREASE DATABASE THROUGHPUT

with the Dell EMC PowerEdge™ R730xd and Intel® SSD DC P3600 Series NVMe SSDs powered by the Intel Xeon® processor E5 v3 family

Get up to
69%
more orders
per minute and
25%
greater performance
per dollar vs. SATA SSDs

Getting the best performance out of your Microsoft® SQL Server® database virtual machines is a great way to ensure your business is moving at the right speed for employees and customers alike. Anything you can do to optimize your server infrastructure and maximize performance can mean increased productivity, better user experience, and money saved on hardware. If you can get more performance simply by selecting better internal hardware, you can potentially achieve these business benefits while also helping your bottom line.

Upgrading a Dell EMC PowerEdge R730xd server from SATA SSDs to new Intel SSD DC P3600 Series NVMe SSDs can improve database performance by as much as 69.9 percent, according to our hands-on tests. By making the extra investment in drive upgrades at the time of purchase, your new PowerEdge R730xd can deliver better database performance per dollar, approximately 25.9 percent more, and allow customers and employees to complete their requests more quickly.

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A PRINCIPLED TECHNOLOGIES REPORT
Commissioned by Intel Corp.

STORAGE IMPROVEMENTS LET YOU PROCESS MORE ORDERS

If your company hosts database VMs, fast database processing is vital. Whether you are an infrastructure as a service (IaaS) provider on a private or public cloud or you want to consolidate many departmental databases, the more transactions each can handle, the better. It's a good strategy to maximize your resources, which means you can get more performance from each server before you have to expand your infrastructure, a potentially costly endeavor.

Intel NVMe SSDs can deliver increased input/output per second (IOPS) and lower latency compared to legacy storage standards such as SATA SSDs, which are themselves a step forward from traditional HDDs.

To test this, we used an Intel Xeon E5-2690 v3 processor-powered Dell EMC PowerEdge R730xd with either four Intel SATA SSDs or four Intel SSD DC P3600 Series NVMe SSDs, and 20 15K SAS HDDs. We configured 20 VMs running Microsoft Windows Server® 2012 R2 and SQL Server 2014, each with a 40GB database. We stored all OS and log data on the SAS HDDs, and placed the database data volumes on the SATA SSDs or NVMe SSDs for each test. We ran the DVD Store benchmark, representative of an OLTP workload, against each database with no think time to simulate a peak performance scenario. DVD Store reported the results in orders per minute, or OPM.

For more about the components we tested, see Appendix A. To learn more about our system configuration, see Appendix B. See Appendix C for details on how we tested.

WHAT WE FOUND

Every transactional database functions by processing requests, which includes orders, and the more orders your server can process, the more work gets done. While the Dell EMC PowerEdge R730xd configured with SATA SSDs delivered strong database performance, the same configuration with Intel NVMe SSDs provided significantly better performance. As Figure 1 shows, configuring the Dell EMC PowerEdge R730xd with Intel NVMe SSDs increased OLTP database performance on the Dell EMC PowerEdge R730xd by 69.9 percent.

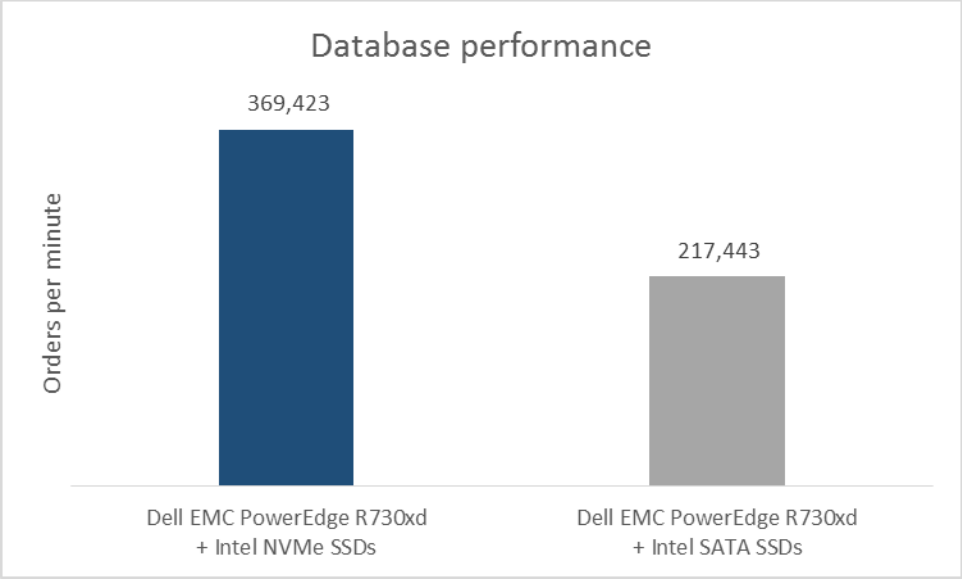

Figure 1: The Dell EMC PowerEdge R730xd with Intel NVMe SSDs outperformed the same server with SATA SSDs.

For users, this can mean quicker access to database results because each VM on the server can process more orders simultaneously. When a fast database lets customers search or complete purchases more quickly, they may be more likely to stay on your site, continue browsing, or even return for additional purchases. Internal users, such as employees who rely on database information when providing customer service, can get more done when the server can handle additional requests more quickly.

For administrators, an upgrade to Intel NVMe SSDs can help them maximize the existing infrastructure to meet performance targets that drive the organization. This can help save space by avoiding having to migrate VMs onto additional servers when they are unable to keep up with performance demands, which can mean less hardware to manage and maintain by configuring fewer servers with more powerful internal hardware.

For businesses, maximizing database performance within each server can mean big savings by avoiding additional server and software license purchases and in datacenter space. We found that performance per dollar using OPM and hardware cost for a new server with four Intel SSD DC P3600 Series NVMe SSDs was better compared to the same server with four SATA SSDs (see Appendix B for configurations). With the additional cost of the drive upgrade, you can get 25.9 percent better performance per dollar from your Dell EMC PowerEdge R730xd. Figure 2 details the OPM results of our testing, prices Dell EMC quoted PT for both configurations, and performance per dollar as of 8/11/2016. These prices do not include tax or shipping.

System	Performance (OPM)	Price (USD)	Performance/dollar
Dell EMC PowerEdge R730xd + Intel NVMe SSDs	369,423	$44,195.45	8.36
Dell EMC PowerEdge R730xd + SATA SSDs	217,443	$32,762.00	6.64

Figure 2: Prices for servers with different drive types, quoted on 8/11/2016.

Ultimately, maximizing server performance can help you utilize resources most efficiently to make sure your organization gets the most out of your datacenter.

CONCLUSION

Which drives are right for your servers? If you want to maximize virtualized SQL Server performance, we found that Intel SSD DC P3600 Series NVMe SSDs could help. In our hands-on tests, upgrading the Dell EMC PowerEdge R730xd with Intel NVMe SSDs in place of SATA SSDs increased database orders by 69.9 percent across our 20 database VMs. Get the most out of every server you have by looking inward before expanding: changing your drives to Intel NVMe SSDs can boost your database performance per dollar by up to 25.9 percent to keep your business moving more cost-efficiently at a rapid pace.

APPENDIX A – ABOUT THE COMPONENTS

About the Dell EMC PowerEdge R730xd

Dell EMC designed the two-socket, 2U Dell EMC PowerEdge R730xd rack server to provide the scale-out storage efficiency needed by big data users, including the option for hybrid internal storage tiering and six distinct storage configurations. The configuration we tested had two 2.5'' rear HDD bays, eight 3.5'' front HDD bays, and 18 1.8'' front SSD bays. Powered by the latest Intel Xeon processors E5-2690 v3, the PowerEdge R730xd has 24 DIMM slots to support up to 1.5 TB of memory.

With redundant power supply units, hot-swappable hardware, and Dual SDTM card for Failsafe Hypervisors, the Dell EMC PowerEdge R730xd supports hardware high availability. The PowerEdge R730xd comes standard with iDRAC8 with Lifecycle Controller and Dell EMC OpenManage™, which all work to streamline management. For more details on the Dell EMC PowerEdge R730xd, visit www.dell.com/us/business/p/poweredge-r730xd/pd.

About the Intel Xeon processor E5-2600 v3 product family

According to Intel, the Intel Xeon processor E5-2600 v3 product family "helps IT address the growing demands placed on infrastructure, from supporting business growth to enabling new services faster, delivering new applications in the enterprise, technical computing, communications, storage, and cloud." It also can deliver benefits in performance, power efficiency, virtualization, and security. The E5-2600 v3 product family has up to 50 percent more cores and cache than processors from the previous generation.

Other features include the following:

- Intel Advanced Vector Extensions 2 (AVX2)
- Intel Quick Path Interconnect link
- Up to 18 cores and 36 threads per socket
- Up to 45 MB of last level cache
- Next-generation DDR4 memory support
- Intel Integrated I/O providing up to 80 PCIe® lanes per two-socket server
- Intel AES-NI data encryption/decryption

The Intel Xeon processor E5-2600 v3 product family also uses Intel Intelligent Power technology and per-core P states to maximize energy efficiency. Learn more at ark.intel.com/products/family/78583/Intel-Xeon-Processor-E5-v3-Family#@All.

About DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 (DS2) benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute that the system could handle, to show what kind of performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment.

For more details about the DS2 tool, see www.delltechcenter.com/page/DVD+Store.

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 3 provides detailed configuration information for the test systems.

System	Dell EMC PowerEdge R730xd
Power supplies	
Total number	2
Vendor and model number	Delta Electronics D705E-S6
Wattage of each (W)	750
General	
Number of processor packages	2
Number of cores per processor	12
Number of hardware threads per core	2
CPU	
Vendor	Intel
Name	Xeon
Model number	E5-2690 v3
Socket type	FCLGA2011-3
Core frequency (GHz)	2.60
Bus frequency	9.6 GT/s
L1 cache	64 KB x 64 KB (per core)
L2 cache	256 KB (per core)
L3 cache	30 MB
Platform	
Vendor and model number	Dell EMC PowerEdge R730xd
Motherboard model number	2GHLV12
BIOS name and version	Dell 2.0.2 (3/15/2016)
BIOS settings	Default
Memory module(s)	
Total RAM in system (GB)	256
Vendor and model number	Hynix® HMA42GR7MFR4N-TF
Type	PC4-17000
Speed (MHz)	2,133
Speed running in the system (MHz)	2,133
Timing/Latency (tCL-tRCD-tRP-tRASmin)	15-15-15-36
Size (GB)	16
Number of RAM module(s)	16
Chip organization	Double-sided
Rank	Dual
Operating system	
Name	Windows Server 2012 R2 Datacenter
Build number	9600
File system	NTFS
Language	English

System	Dell EMC PowerEdge R730xd
RAID controller	
Vendor and model number	Dell EMC PERC H730 Mini
Firmware version	25.3.0.0016
Driver version	6.602.7.0
Cache size (MB)	1,024
Local storage	
SATA solid-state drive	
Vendor and model number	Intel SSDSC2BB800G6R
Number of drives	4
Size (GB)	800
Type	SATA SSD
NVMe PCIe solid-state drive	
Vendor and model number	Intel SSDPE2ME020T4D
Number of drives	4
Size (GB)	2,000
Type	NVMe PCIe SSD
Hard drives	
Vendor and model number	Seagate® ST9300653SS
Number of drives	20
Size (GB)	300
RPM	15K
Type	SAS
Ethernet adapter	
Vendor and model number	Intel 4P X540/I350
Type	Integrated
Number of ports	4

Figure 3: System configuration information for the Dell EMC PowerEdge R730xd.

APPENDIX C – HOW WE TESTED

We installed Windows Server 2012 R2 on the Dell EMC PowerEdge R730xd using a 20-disk RAID10. We configured the server with up-to-date drivers and firmware and Windows updates. We created a RAID10 with the SATA SSDs, and mounted the NVMe SSDs as individual drives. A generic rack server with Hyper-V™ hosted the virtual DVD store clients to drive the workload on the SQL Server VMs.

Installing Microsoft Windows Server 2012 R2

1. Insert the installation media into the CD/DVD drive, and restart the server.
2. Press any key when prompted to boot from DVD.
3. When the installation screen appears, click My language is English (United States).
4. Leave language, time/currency format and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2012 R2 Datacenter (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
12. Log in with the password you set up previously.

Configuring Windows Update

1. In the left pane of the Server Manager window, click Local Server.
2. In the main frame, next to Windows Update, click Not configured.
3. In the Windows Update window, in the main pane, click Let me choose my settings.
4. Under Important updates, select Never check for updates (not recommended), and click OK.
5. In the left pane, click Check for updates, and install all available updates.
6. Close the Windows Update window.

Installing Hyper-V

1. Open Server Manager, and click Manage→Add Roles and Features.
2. At the Before You Begin screen, click Next.
3. At the Installation Type screen, click Next.
4. At the Server Selection screen, select one of the servers in the failover cluster.
5. At the Server Roles screen, check Hyper-V. At the prerequisite pop-up, click Add Features. Click Next.
6. At the Features screen, click Next.
7. At the Hyper-V screen, click Next.
8. At the Virtual Switches screen, click Next.
9. At the Migration screen, click Next.
10. At the Default Stores screen, enter the iSCSI storage location. Click Next.
11. At the Confirmation screen, check to automatically restart the server after installation, and click Install.

Creating the first VM

1. Click Start, type `Hyper-V Manager`, and press Enter.
2. In the right pane, click Virtual Machines→New Virtual Machine.
3. Select a node on which to install the VM, and click OK.
4. At the Before You Begin screen, click Next.
5. At the Specify Name and Location screen, give the VM a name, and click Next.
6. At the Assign Memory screen, type `8 GB`, and click Next.
7. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.
8. At the Connect Virtual Hard Disk screen, create a new disk, enter 50 GB, and click Next.
9. At the Summary screen, click Finish.

Installing the VM operating system on the first VM

1. From the VM console, connect to the ISO image of the installation DVD for Windows Server 2012 R2 Datacenter. If the ISO image is not stored on the host, start the VM, and connect to the ISO image.
2. Start the VM.
3. At the Language Selection Screen, click Next.
4. Click Install Now.
5. Select a full installation of the Datacenter edition, and click Next.
6. Click I accept the license terms, and click Next.
7. Click Custom.
8. Click Next.
9. At the User's password must be changed before logging on warning screen, click OK.
10. Enter the desired password for the administrator in both fields, and click the arrow to continue.
11. At the Your password has been changed screen, click OK.
12. Install the latest Host Integration Tools package on the VM. Restart as necessary.
13. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
14. Enable remote desktop access.
15. Change the hostname, and reboot when prompted.
16. Create a shared folder to store test script files. Set permissions as needed.
17. Set up networking:
    a. Click Start→Control Panel, right-click Network Connections, and choose Open.
    b. Right-click the VM traffic NIC, and choose Properties.
    c. Select TCP/IP (v4), and choose Properties.
    d. Assign the VM a static IP address.

Installing and configuring Microsoft SQL Server 2014

We installed Microsoft SQL Server 2014 on a VM residing on the system under test. We cloned the completed VM to give us 20 VMs total.

Configuring the SQL Server VM

Before cloning, modify the SQL VM to contain the following settings:

- Memory: 4 GB
- Virtual Processors: 1
- Additional virtual disks:
    - 65GB virtual disks for SQL database data (Thick provisioned)
    - 11GB virtual disk for SQL log data (Thick provisioned)

In the VM, configure the VM storage:

1. In the taskbar, click the Server Manager icon.
2. In the left pane, expand Storage, and click Disk Management.
3. Right-click the first volume, and choose Initialize Disk.
4. In the right pane, right-click the volume, and choose New Simple Volume…
5. At the welcome window, click Next.
6. At the Specify Volume Size window, leave the default selection, and click Next.
7. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
8. At the Format Partition window, choose NTFS, and click Next.
9. At the Completing the New Simple Volume Wizard window, click Finish.

Installing .Net Framework 3.5

1. Click Start→Server Manager→Manage→Add Roles and Features.
2. Select Role-based or feature-based installation, and click Next.
3. Select the local server under Server Pool, and click Next twice.
4. Under Features select .NET Framework 3.5 Features, and click Next.
5. Click Install.
6. Click Close upon completion.

Installing Microsoft SQL Server 2014

1. Attach the installation media to the server.
2. Launch setup.exe from the installation media.
3. Choose the Installation section on the left, and click New SQL Server stand-alone installation or add features to an existing installation.
4. At the Product Key screen, enter the product key, and click Next.
5. At the License Terms screen, check I accept the license terms, and click Next.
6. At the Global Rules screen, allow the Global Rules check to finish, and click Next.
7. At the Microsoft Update screen, check Use Microsoft Update to check for updates (recommended), and click Next.
8. Once the updates have been downloaded and installed, click Next.
9. At the Install Setup Files screen, allow the setup files to install, and click Next.
10. At the Install Rules screen, allow the Install Rules check to run, and click Next.
11. At the Setup Role screen, select SQL Server Feature Installation, and click Next.

12. At the Feature Selection screen, select the features required for your installation. We selected Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tool Backwards Compatibility, Management Tools - Basic, and Management Tools - Complete.
13. At the Feature Rules screen, allow the Feature Rules check to run, and click Next.
14. At the Instance Configuration screen, click Next to use the default instance named MSSQLSERVER.
15. At the Server Configuration screen, click Next.
16. At the Database Engine Configuration screen, select Mixed Mode (SQL Server authentication and Windows authentication), and enter a password for the SQL Server system administrator (sa) account.
17. Click Add Current User.
18. In the Data Directories tab, enter the directories to be used for SQL data and logs. We used E:\ and F:\, respectively, to place the data and logs on their appropriate VHDs. Click Next.
19. At the Feature Configuration Rules screen, allow the Feature Configuration Rules check to finish, and click Next.
20. At the Ready to Install screen, click Install.
21. After the installation has completed, close the wizard.

Configuring the database workload client

For our testing, we used a virtual client for the Microsoft SQL Server client. To create this client, we installed Windows Server 2008 R2, assigned a static IP address, and installed .NET 3.5.

Configuring the database

Data generation overview

We generated the data using the Install.pl script included with DS2, providing the parameters for our 40GB database and the database platform on which we ran Microsoft SQL Server. We ran the Install.pl script on a utility system running Linux. The Install.pl script generated the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2014. We built the 40GB database in SQL Server 2014, and then performed a full backup, storing the backup file on the C:\ drive for quick access. We used that backup file to restore the server between test runs.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed the following steps:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 40GB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.

5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
            DEFAULT_DATABASE=[master],
            DEFAULT_LANGUAGE=[us_english],
            CHECK_EXPIRATION=OFF,
            CHECK_POLICY=OFF
GO
```

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.
12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

    Figure 4 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
Database files		
primary	PRIMARY	5
cust1	DS_CUST_FG	6,144
cust2	DS_CUST_FG	6,144
cust3	DS_CUST_FG	6,144
cust4	DS_CUST_FG	6,144
ind1	DS_IND_FG	5,120
ind2	DS_IND_FG	5,120
ind3	DS_IND_FG	5,120
ind4	DS_IND_FG	5,120
ds_misc	DS_MISC_FG	200
orders1	DS_ORDERS	3,072
orders2	DS_ORDERS	3,072
orders3	DS_ORDERS	3,072
orders4	DS_ORDERS	3,072
Log files		
ds_log	Not applicable	28,672

Figure 4: Our initial file size modifications.

Running the test

Test start and run times

We ran all workloads concurrently to start and record all performance counters for this report. The specific testing parameters we used are included in the setup section, and the following section describes specifics for launching the test.

About running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DS2 outputs OPM, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Each complete test cycle consisted of general steps:

1. Clean up prior outputs from the target system and the client driver system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the host and client system.
6. Wait for a ping response from the server under test and the client system.
7. Let the test server idle for 10 minutes.
8. Start the DVD Store driver on the client.

We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --
n_threads=32 --db_size=40GB --think_time=0 --detailed_view=Y --warmup_time=5
--report_rate=1 --csv_output=<drive path>
```

ABOUT PRINCIPLED TECHNOLOGIES

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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

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Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.