



The science behind the report:

Improve database performance by adding Intel Optane DC persistent memory and Intel Optane NVMe SSDs to the Lenovo ThinkSystem SR650

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [Improve database performance by adding Intel Optane DC persistent memory and Intel Optane NVMe SSDs to the Lenovo ThinkSystem SR650](#).

We concluded our hands-on testing on April 18, 2019. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on April 17, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

System configuration information

The table below presents detailed information on the systems we tested.

| Server configuration information | Intel Broadwell processor-based legacy server | Lenovo ThinkSystem SR650 (SATA SSDs) | Lenovo ThinkSystem SR650 (with Intel Optane) |
|--|---|--------------------------------------|--|
| BIOS name and version | PB2TS395 | 2.10 | 2.10 |
| Non-default BIOS settings | N/A | N/A | N/A |
| Operating system name and version/build number | Windows Server 2016 Datacenter | Windows Server 2016 Datacenter | Windows Server 2019 Datacenter |
| Date of last OS updates/patches applied | 4/11/2019 | 4/11/2019 | 4/11/2019 |
| Power management policy | Balanced | Balanced | Balanced |
| Processor | | | |
| Number of processors | 2 | 2 | 2 |
| Vendor and model | Intel Xeon E5-2640 v4 | Intel Xeon Platinum 8268 | Intel Xeon Platinum 8268 |
| Core count (per processor) | 10 | 24 | 24 |
| Core frequency (GHz) | 2.40 | 2.9 | 2.9 |
| Stepping | R0 | 7 | 7 |
| Memory module(s) | | | |
| Total memory in system (GB) | 128 | 192 | 192 |
| Number of memory modules | 8 | 6 | 6 |
| Vendor and model | Hynix HMA42GR7MFR4N-TF | Micron 36ASF4G72PZ-2G6D1 | Micron 36ASF4G72PZ-2G6D1 |
| Size (GB) | 16 | 32 | 32 |
| Type | PC4-2133 | PC4-2666 | PC4-2666 |
| Speed (MHz) | 2,133 | 2,666 | 2,666 |
| Speed running in the server (MHz) | 2,133 | 2,666 | 2,666 |
| Persistent memory module(s) | | | |
| Total memory in system (GB) | N/A | N/A | 768 |
| Number of memory modules | N/A | N/A | 6 |
| Vendor and model | N/A | N/A | Intel NMA1XBD128GQS |
| Size (GB) | N/A | N/A | 128 |
| Type | N/A | N/A | DCPMM |
| Speed (MHz) | N/A | N/A | 2,666 |
| Speed running in the server (MHz) | N/A | N/A | 2,666 |
| Storage controller | | | |
| Vendor and model | Lenovo ThinkServer RAID 110i | Lenovo ThinkSystem RAID 930-8i | Lenovo ThinkSystem RAID 930-8i |
| Cache size (GB) | N/A | 2GB | 2GB |
| Firmware version | PB2TS395 | 50.5.0-1678 | 50.5.0-1678 |
| Driver version | 17.1.2016.216 | 7.707.11.0 | 7.707.11.0 |

| Server configuration information | Intel Broadwell processor-based legacy server | Lenovo ThinkSystem SR650 (SATA SSDs) | Lenovo ThinkSystem SR650 (with Intel Optane) |
|--|---|--------------------------------------|--|
| Local storage (OS) | | | |
| Number of drives | 2 | 2 | 2 |
| Drive vendor and model | Seagate ST3300656SS | Intel S3520 | Intel SSD0L20408 |
| Drive size (GB) | 300 | 960 | 750 |
| Drive information (speed, interface, type) | 15k SAS HDD | SATA SSD | NVMe SSD |
| Local storage (SQL data) | | | |
| Number of drives | 4 | 4 | 1 |
| Drive vendor and model | Seagate ST9600204SS | Intel S3520 | Intel SSD0L20408 |
| Drive size (GB) | 600 | 960 | 750 |
| Drive information (speed, interface, type) | 10k SAS HDD | SATA SSD | NVMe SSD |
| Local storage (SQL logs) | | | |
| Number of drives | 2 | 2 | 1 |
| Drive vendor and model | Seagate ST3300656SS | Intel S3520 | Intel NMA1XBD128GQS |
| Drive size (GB) | 300 | 960 | 128 |
| Drive information (speed, interface, type) | 15k SAS HDD | SATA SSD | DCPMM |
| Network adapter | | | |
| Vendor and model | Intel I350T | Intel X722 | Intel X722 |
| Number and type of ports | 4x 1Gb | 4x 10Gb | 4x 10Gb |
| Driver version | 12.15.22.6 | 1.9.221.0 | 1.9.221.0 |
| Cooling fans | | | |
| Vendor and model | Lenovo 00FC529 | Delta 01KP693 | Delta 01KP693 |
| Number of cooling fans | 6 | 6 | 6 |
| Power supplies | | | |
| Vendor and model | Delta DPS-1100EB | ARTE SP57A03116 | ARTE SP57A03116 |
| Number of power supplies | 2 | 2 | 2 |
| Wattage of each (W) | 1,100 | 750 | 750 |

How we tested

Installing Windows Server

We used the hardware RAID adapters on each server to create a RAID1 from the two OS drives, a RAID10 for the four SQL data drives, and a RAID1 for the SQL log drives. On the Intel Optane-powered configuration, we created a RAID1 for the two OS drives, and used a single Intel Optane NVMe drive for SQL data, and a single Intel Optane DCPMM module for SQL logs.

Intel Optane DCPMMs can be presented to the OS in either Memory Mode, App Direct Mode, or Mixed Memory Mode. With Memory Mode, the Intel DCPMMs are presented to the OS as normal memory. In App Direct Mode, the DCPMMs are presented to the OS as persistent memory devices and can be used for block storage. App Direct Mode can be used in Interleaved Mode (data is striped across all DCPMMs similar to RAID0), or Non-Interleaved Mode (each DCPMM is presented as a separate device). Mixed Mode makes it possible to use some of the DCPMMs in Memory Mode, and others in App Direct Mode. For our testing, we used Non-Interleaved App Direct Mode.

1. Attach the Windows Server 2016 or 2019 installation media to the server.
2. When prompted to boot from DVD, press any key.
3. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
4. Click Install now.
5. When the installation prompts you, enter the product key.
6. Select Windows Server Datacenter Edition (Desktop Experience), and click Next.
7. Check I accept the license terms, and click Next.
8. Click Custom: Install Windows only (advanced).
9. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
10. When the Settings page appears, fill in the Password and Reenter Password fields with the same password. Log in with the password you set up previously.
11. From Server Manager, disable Windows Firewall and enable Remote Desktop.
12. Run Windows Updates.

Creating a partition on the DCPMM

Open a PowerShell window as the Administrator user. Run the following commands to create a partition on the DCPMM:

```
Get-PmemUnusedRegion | New-PmemDisk -AtomicityType BlockTranslatableTable  
Get-Disk -FriendlyName Persistent* | Initialize-Disk  
Get-Disk -FriendlyName Persistent* | New-Partition -UseMaximumSize\  
-AssignDriveLetter | Format-Volume -FileSystem NTFS -IsDax $True
```

Installing SQL Server 2017

1. Attach the installation media ISO for SQL Server 2017 to the server.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2017 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Specify Evaluation as the edition you are installing, and click Next.
6. To accept the license terms, click the checkbox, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.
8. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
9. Click Next.
10. At the Instance configuration screen, leave the default selection of default instance, and click Next.
11. At the Server Configuration screen, accept defaults, and click Next.
12. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
13. Enter and confirm a password for the system administrator account.
14. Click Add Current user. This may take several seconds.
15. In the Directories tab, enter the volumes designated for SQL data and logs into their respective fields.
16. Click Next.
17. At the Ready to Install screen, click Install.

18. Close the installation window.
19. In the SQL Server Installation Center, click on Install SQL Server Management Tools.
20. Click Download SQL Server Management Studio.
21. Click Run.
22. When the Microsoft SQL Server Management Studio screen appears, click Install.
23. When the installation completes, click Close.

Configuring and running the DVD Store 2 benchmark

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 250GB database size and the database platform we used. We ran the Install.pl script on a utility system running Linux® to generate 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 2017. We built the 250GB database in SQL Server, then performed a full backup, storing the backup file remotely for quick access.

We used that backup file to restore the database when necessary.

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. Other than this file size modification, we created and loaded the database in accordance to the DVD Store documentation. Specifically, we followed these steps:

1. Generate the data, and create the database and file structure using database creation scripts in the DS2 download. Make size modifications specific to our 250GB database, and make the appropriate changes to drive letters.
2. Transfer the files from our Linux data generation system to a Windows system running SQL Server.
3. Create database tables, stored procedures, and objects using the provided DVD Store scripts.
4. Set the database recovery model to bulk-logged to prevent excess logging.
5. Load the data we generated into the database. For data loading, use the import wizard in SQL Server Management Studio. Where necessary, retain options from the original scripts, such as Enable Identity Insert.
6. Create indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, create 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. Set the database recovery model back to full.
10. Create the necessary full text index using SQL Server Management Studio.
11. Create a database user, and map this user to the SQL Server login.
12. Perform a full backup of the database. This backup allows you to restore the databases to a pristine state.

Running the DVD Store tests

DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the last OPM that each target reported.

Each complete test cycle consisted of these general steps:

1. Clean up prior outputs from the target system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the target host.
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 clients.

We used the following DVD Store 2 parameters for testing:

```
ds2sqlserverdriver.exe --target=<target _ IP> --ramp_rate=10 --run_time=30 --n_threads=32 --db_size=250GB --think_time=0.00 --detailed_view=Y --warmup_time=5 --csv_output=<drivepath>
```

Read the report at <http://facts.pt/1mgym04> ►

This project was commissioned by Lenovo.



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