



## SanDisk Fusion ioMemory application accelerators take your Dell EMC PowerEdge server to the next level

### The PowerEdge R930 did more work with Fusion ioMemory SX350 application accelerators

Enterprises are constantly searching for ways to maximize server performance. While flash-based solid-state storage has dramatically improved CPU and memory utilization, the newest approach is moving data even closer to compute through Peripheral Component Interconnect Express, or PCIe. Unlike earlier types of SSDs that require controllers that can slow data transfer, PCIe cards such as SanDisk® Fusion ioMemory™ SX350 application accelerators connect directly to the server's PCIe bus, which translates to extreme processing speed.

In the Principled Technologies datacenter, we configured a Dell EMC™ PowerEdge™ R930 server two ways—with eight SATA SSDs and with two SanDisk Fusion ioMemory SX350-3200 PCIe application accelerator cards. We set up Microsoft® SQL Server® 2016 virtual machines and slammed them with a heavy workload to see how the different storage options affected performance.

The R930 with two SanDisk Fusion ioMemory cards in a software-mirrored configuration outperformed the R930 with eight SATA SSDs, processing 43 percent more database orders per minute while also reducing latency by as much as 84 percent. These results show that the SanDisk configuration is far better equipped to handle periods of peak database load, which means your customers and your business benefit.



Serve more customers simultaneously and faster

*43% more orders per minute*

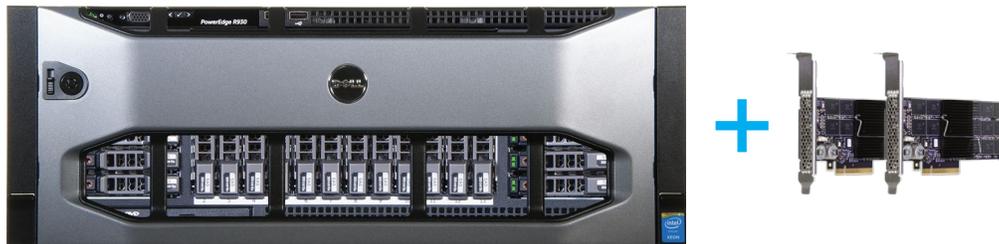


Reduce latency for a better customer experience

*up to 84% lower latency*

## Quantifying the SanDisk Fusion ioMemory advantage

To learn how these two storage options affected the performance of our Dell EMC PowerEdge R930 test server, we set up a Microsoft Windows Server® 2016 Hyper-V® environment and then used the DVD Store 2.1 benchmark to generate an online transaction processing (OLTP) workload. We tested the R930 with the SanDisk application accelerators in a Windows® Storage Spaces RAID1 pool, for maximum data protection. We added SQL Server 2016 virtual machines until aggregate performance across all VMs, measured in orders per minute (OPM), levelled off. In this way, we learned that the SanDisk configuration could support 23 SQL Server 2016 VMs running in parallel.



We then configured the R930 with eight SATA SSDs in a RAID10 volume and measured performance using the identical workload, 23 simultaneous SQL Server 2016 VMs.

### Storage, a primer

For many years, servers and other computers have used spinning hard disk drives (HDDs) to store operating systems, applications, and data. Like old-fashioned record players, hard disks include reading arms that hover above the disk as it spins.

Solid state technology uses flash memory chips that function like HDDs but are much faster. They don't spin or fragment data the way that HDDs do, so retrieving data from them is much quicker. There are several different types of solid state drives, each with its own type of interface.

Serial ATA (SATA) SSDs are prevalent in today's datacenters. They can process data at around 600 MB per second, a great deal faster than the fastest

HDDs at 120 MB per second. Serial Attached SCSI (SAS) SSDs roughly double the rate of SATA SSDs, to 1,200 MB per second.

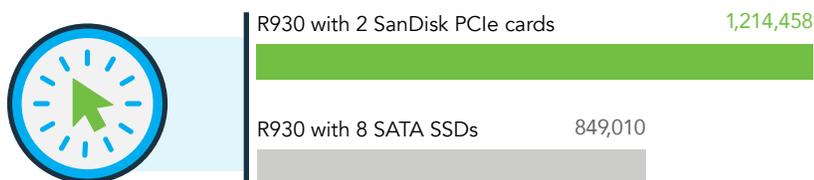
Peripheral Component Interconnect Express is the newest approach to solid state storage. Unlike SATA and SAS drives, which require controllers that can slow down data transfer, PCIe storage connects directly to the PCIe bus of the server, which greatly increases processing speed. The SanDisk Fusion ioMemory SX350 application accelerators we used in our testing, the SX350-3200 model, are rated at 2.8 GB per second, equal to 2,867 MB per second.<sup>1</sup>

<sup>1</sup> [https://www.sandisk.com/business/datacenter/resources/data-sheets/fusion-iomemory-sx350\\_datasheet](https://www.sandisk.com/business/datacenter/resources/data-sheets/fusion-iomemory-sx350_datasheet)

## More transactions

As the chart below shows, the Dell EMC PowerEdge R930, when outfitted with two SanDisk Fusion ioMemory SX350 application accelerator cards, processed 43 percent more OPM across the 23 virtual machines than it did when configured with eight SATA SSDs.

### Orders per minute

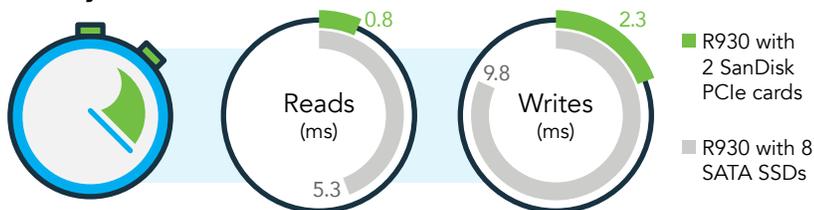


## Latency and user experience

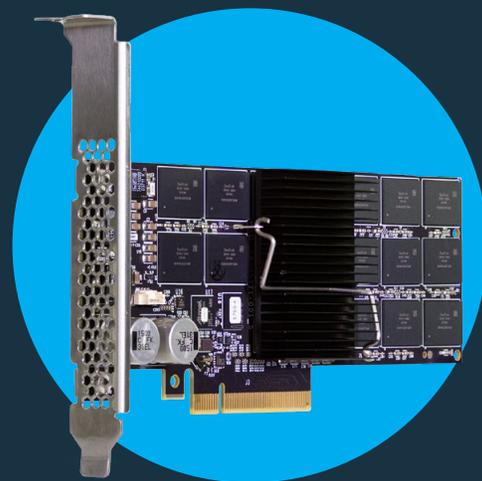
In database applications, latency is a measure of how long hardware and software take to respond to a request. Requests can involve either retrieving or saving data, which translate to read and write operations respectively. When storage keeps up with the pace of requests, latency is low and users enjoy speedy response times. During periods of heavy activity, bottlenecks can occur, creating a queue of outstanding requests. Latency increases and users experience delays; the more time-sensitive the transactions are, the more damaging these delays become.

Because SanDisk Fusion ioMemory SX350 application accelerators connect directly to the system bus, they eliminate additional paths that data would need to traverse with traditional solid-state storage. These paths have an inherent latency penalty and avoiding them helps the SanDisk PCIe cards deliver the much faster response times we observed in our testing.

### Latency



The chart above shows how average latency for reads and writes across the test period was dramatically lower on the SanDisk PCIe configuration than on the SATA SSD configuration. The SanDisk configuration took 84 percent less time for reads and 76 percent less time for writes. This lower latency provides users with quicker response times and a better experience.



## The value of proximity

Imagine that server storage is like the supply warehouse for a small retail shop. To keep the shelves stocked, workers must retrieve products from a storage location.

HDDs would be like using a hand truck to transport items from a warehouse down the road—doable but slow. SATA or SAS SSDs would be like using a car to retrieve the same goods—the process would be much faster but the distance would be the same.

With SanDisk Fusion ioMemory PCIe application accelerators, the storage area is on site in a back room. Data is stored much closer to where the computing happens, so applications retrieve it much more quickly.

## A window into performance

The Dell Performance Analysis Collection Kit (DPAK) measures key performance attributes and gives datacenter administrators insight into each layer of the storage subsystem between an application and the physical storage. This knowledge helps them understand at a granular level why read or write operations may be slow.

We used DPAK during our testing to learn about latency. You can use DPAK to compare your results to those in this report.

## Conclusion

Those who run enterprise datacenters face the perennial challenge of increasing IO so that they can reap the many benefits of accomplishing greater workloads with fewer servers. As our testing demonstrated, the already strong performance of a Dell EMC PowerEdge R930 improved dramatically when we replaced eight SATA solid-state drives with two SanDisk Fusion ioMemory SX350 application accelerators.

The SanDisk configuration delivered 43 percent more OLTP database work, which means that two of these servers could process almost as many transactions as three SATA SSD-equipped R930 servers could. Not only did the SanDisk storage allow the server to do more work, it also lowered latency by as much as 84 percent, which can translate to a smoother and speedier experience for your users.

When you're investing in powerful enterprise-class servers such as the Dell EMC PowerEdge R930, attack the IO challenge by choosing SanDisk Fusion ioMemory application accelerators—and do more work more quickly.



On February 8, 2017, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on February 16, 2017.

## Appendix A – About the hardware and software we tested

### About the SanDisk Fusion ioMemory SX350 PCIe application accelerator

SanDisk Fusion ioMemory PCIe application accelerators, with up to 6.4 terabytes of Flash memory per card, are designed to accelerate the flow of data between servers and other assets. This has the potential to improve virtualization, databases, business intelligence, and real-time financial data processing, as well as read-intensive workloads, such as web hosting, data mining, seismic data, content caching, 3D animation, and CAD/CAM.

Learn more at <https://www.sandisk.com/business/datacenter/products/flash-devices/pcie-flash/sx350>

### About the Dell EMC PowerEdge R930

The Dell EMC PowerEdge R930 is a 4U, four-socket server that features the Intel® Xeon® processor E7 series. It is a versatile system designed to handle demanding workloads such as large-scale virtualization and massive databases—workloads that are becoming increasingly important for the day-to-day operations of enterprise organizations.

Under the hood, the R930 boasts a bevy of high-class specifications that make it a powerful tool for the modern datacenter. These specifications include:

- 96 DIMM slots — The ample number of slots help leverage cost with performance and capacity needs. It accommodates a larger memory footprint which can be configured with smaller-capacity DIMMs for potential cost-efficiency, or can support up to 6 TB for more memory-intensive use cases.
- 24 drive bays, configurable with a mix of SAS/SATA HDDs and SSDs as well as optional NVMe PCIe® SSDs for expanded storage capabilities. Two chassis configurations—one with 24 HDD/SSD drive bays, and one with 16 HDD/SSD drive bays and 8 PCIe SSD drive bays—allow you to configure the PowerEdge R930 however your business needs.

Learn more at <http://www.dell.com/us/business/p/poweredge-r930/pd>

### About Microsoft SQL Server 2016

SQL Server 2016 delivers performance and security features built-in for mission-critical transactional systems and data warehouses, along with an integrated business intelligence and advanced analytics solution for building data analytics applications. High-performance features are key to ensuring your applications can deliver a smooth transactional experience and also potentially support demanding real-time operational analytics.

Learn more at <https://www.microsoft.com/en-us/sql-server/sql-server-2016>

## Appendix B – System configuration information

Server configuration information	Dell EMC PowerEdge R930
BIOS name and version	Dell 2.0.1
Non-default BIOS settings	Intel Turbo Boost enabled, Virtualization enabled
Operating system name and version/build number	Microsoft Windows Server 2016 – 10.10.14393
Date of last OS updates/patches applied	2/12/2017
Power management policy	Performance
<b>Processor</b>	
Number of processors	4
Vendor and model	Intel Xeon E7-8890 v3
Core count (per processor)	18
Core frequency (GHz)	2.50
Stepping	E0
<b>Memory module(s)</b>	
Total memory in system (GB)	256
Number of memory modules	16
Vendor and model	Hynix® HMA42GR7MFR4N-TFT1
Size (GB)	16
Type	PC4-17000
Speed (MHz)	2,133
Speed running in the server (MHz)	1,600
<b>Storage controller</b>	
Vendor and model	Dell PERC H730p
Cache size (GB)	2
Firmware version	25.4.0.0017
Driver version	6.603.6.0
<b>Local storage #1</b>	
Number of drives	8
Drive vendor and model	Intel SSDSC2BX80
Drive size (GB)	800
Drive information (speed, interface, type)	SATA SSD
<b>Local storage #2</b>	
Number of drives	2
Drive vendor and model	SanDisk Fusion ioMemory SX350 application accelerator
Drive size (TB)	3.2

<b>Server configuration information</b>	<b>Dell EMC PowerEdge R930</b>
Drive information (speed, interface, type)	PCIe x8 SSD
Network adapter	
Vendor and model	Broadcom® 5720 quad-port 1Gb NDC
Number and type of ports	4 x 1GbE
Driver version	17.2.1.0
Cooling fans	
Vendor	Dell
Number of cooling fans	6
Power supplies	
Vendor	Lite-On®
Number of power supplies	4
Wattage of each (W)	1,100

## Appendix C – How we tested

### About our test tool, DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 benchmarking tool, or DS2. 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.

Learn more at <http://en.community.dell.com/techcenter/extras/w/wiki/dvd-store>

### Configuring the SATA SSDs and SanDisk Fusion ioMemory SX350 cards

Before installing the host operating system, we created a RAID10 virtual disk using the eight SATA SSDs. For the SATA SSD configuration, we used this virtual disk for all virtual hard drives (VHDs). For the SanDisk configuration, we used Microsoft Storage Spaces to create a software RAID1 virtual disk using the two SanDisk cards, and used that virtual disk for all VHDs.

### Installing Microsoft Windows Server 2016 Datacenter Edition

1. When prompted to boot from DVD, press any key.
2. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
3. Click Install now.
4. When the installation prompts you, enter the product key.
5. Select Windows Server 2016 Datacenter Edition (Desktop Experience), and click Next.
6. Check I accept the license terms, and click Next.
7. Click Custom: Install Windows only (advanced).
8. Select Drive 0 Unallocated Space, and click Next, at which point Windows begins automatically, and restarts automatically after completing.
9. When the Settings page appears, complete the Password and Reenter Password fields using the same password.
10. Log in with the password you set up previously.

Note: After completing the installation, we disabled the firewall, enabled Remote Desktop, ran Windows Updates, and enabled the Hyper-V role.

### Configuring Windows Storage Spaces (SanDisk configuration only)

1. In the Server Manager window, click File and Storage Services in the left pane.
2. Click Storage Pools.
3. Right-click the Primordial storage pool, and click New Storage Pool...
4. On the Before You Begin screen, click Next.
5. Enter a name for the new Pool, choose the group of disks, and click Next.
6. Check that all the disks have the correct Media Type (SSD or HDD), choose all the available disks, and click Next.
7. Review your selections, and click Create.
8. Using PowerShell, run the following command to create a RAID1 set with no write caching:  

```
New-VirtualDisk -FriendlyName PCIeFlash -ResiliencySettingName "Mirror" -WriteCacheSize 0 -UseMaximumSize
```
9. Open Disk Management and format the drive.
10. Assign a drive letter, and click Next.
11. Set the File system to NTFS, the Allocation unit size to 4096, and name the Volume. Click Next.
12. Review your selections, and click Create.

### Creating the workload virtual machines

We created 23 VMs with Windows Server 2016 Datacenter Edition and SQL Server 2016 to run our test workload. We assigned four vCPUs and 4 GB of RAM to each VM. We created three VHDs for each VM: a 40GB VHD for the operating system, a 60GB VHD for SQL Server data, and a 30GB VHD for SQL Server logs. After creating the base VM, we installed Windows Server 2016 Datacenter Edition onto the VM using the steps in the Installing Microsoft Windows Server 2016 Datacenter Edition section above.

### Installing Microsoft SQL Server 2016

1. Attach the installation media ISO for SQL Server 2016 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2016 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. To accept the license terms, click the checkbox, and click Next.
6. Click Use Microsoft Update to check for updates, and click Next.
7. To install the setup support files, click Install.
8. If no failures are displayed, click Next.
9. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
10. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
11. Click Next.
12. At the Instance Configuration screen, leave the default selection of default instance, and click Next.
13. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
14. Enter and confirm a password for the system administrator account.
15. Click Add Current user. This may take several seconds.
16. Click Next.
17. At the Error and usage reporting screen, click Next.
18. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
19. At the Ready to Install screen, click Install.
20. Close the installation window.

## Configuring the database workload client

We used a Dell EMC PowerEdge R730 server with Microsoft Windows Server 2016 Datacenter Edition and the Hyper-V role. We created a virtual client for each SQL Server 2016 virtual machine on the system under test, and assigned two vCPUs and 4 GB of RAM to each virtual client. We also assigned a static IP address to each virtual client.

## Configuring the database

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 40GB database size and the database platform on which we ran, Microsoft SQL Server 2016. We ran the Install.pl script on a utility system running Linux®. The database schema was also generated by the Install.pl script.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2016. We built the database in SQL Server 2014 and performed a full backup, storing the backup file on the network for all guest VMs to access. We used that backup file to restore the databases between test runs.

The only modifications we made to the schema creation scripts were in the specified file sizes for our database. We deliberately 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 schema according to the DVD Store documentation. Specifically, we performed the following steps:

1. Generate the data and create the database and file structure using database creation scripts in the DS2 download. (We made size modifications specific to our database and 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 you 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 mapped this user to the SQL Server login.
12. Performed a full backup of the database. This backup allows you to restore the databases to a pristine state relatively quickly between tests.

## Running the DVD Store 2.1 test

We ran the workload with one client per target database. The specific testing parameters we used for the benchmark appear below.

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the aggregate OPM reported by the clients. We ran the test three times and report results from the median run.

Each complete test cycle consisted of the steps listed below.

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

We used the following DVD Store parameters for testing:

```
--target=<target_IP> --ramp_rate=10 --run_time=90 --n_threads=32 --db_size=40GB  
--think_time=0.00 --detailed_view=Y --warmup_time=5 --csv_output=<drive path>
```

## Appendix D: Test results

We ran the test three times. Below, we report the results from the median run.

	<b>R930 with 8 SATA SSDs</b>	<b>R930 with 2 SanDisk PCIe cards</b>
VM 1	35,433	51,844
VM 2	36,137	49,748
VM 3	36,426	49,950
VM 4	38,850	57,793
VM 5	36,620	52,332
VM 6	37,010	51,006
VM 7	37,301	52,305
VM 8	39,838	59,021
VM 9	36,585	52,309
VM 10	36,858	50,603
VM 11	37,138	52,399
VM 12	39,592	59,524
VM 13	36,153	51,236
VM 14	36,328	50,532
VM 15	32,591	51,710
VM 16	39,037	57,302
VM 17	35,579	52,098
VM 18	35,552	49,815
VM 19	36,036	50,349
VM 20	38,060	56,173
VM 21	36,759	53,926
VM 22	37,626	50,914
VM 23	37,501	51,569
<b>Total orders per minute</b>	<b>849,010</b>	<b>1,214,458</b>
<b>Average OPM per VM</b>	<b>36,913</b>	<b>52,803</b>

This project was commissioned by Dell Technologies.



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