

## Dell™ PowerEdge™ PCIe Express Flash SSDs delivered up to **328,774** orders per minute



for eight 20GB databases.

Virtualized database applications depend on powerful server and storage solutions to deliver the performance you need. Traditionally, large external storage arrays have been necessary to power such applications, but they're expensive and take up premium data center space. With new PCIe SSD technologies, it's possible to reduce the expense and hassle of external storage and increase the performance of your server using internal drives. PCIe SSDs speed up performance by eliminating the moving parts in traditional hard drives, and improve performance by residing on the PCIe bus closer to the CPU and memory.

To investigate the performance such a solution can provide for a number of virtualized production databases, we tested the Dell PowerEdge R720 server with Dell PowerEdge PCIe Express Flash SSDs running Microsoft® SQL Server® 2012 with eight 20GB databases in Microsoft® Windows Server® 2008 R2 Hyper-V™ virtual machines (VMs). We found that the Dell PowerEdge R720 with 128 GB of RAM using Dell PCIe Express Flash SSDs could handle up to 328,774 orders per minute, without the use of external storage and limited activity on the SSD drives.

As a separate test, we forced more of the database onto the storage to see how well it handled the increased load. The result? In both configurations, the Dell PowerEdge R720 with PCIe Express Flash SSDs delivered excellent database performance.

## BIG PERFORMANCE FOR VIRTUALIZED DATABASES

To assess the performance of four Dell PCIe Express Flash SSDs in the Dell PowerEdge R720 server, we created eight 20GB databases using SQL Server 2012 Enterprise Edition, each in its own Hyper-V VM, and configured the server with 128 GB of RAM.

To run our heavy database workload on the server, we used the DVD Store Version 2.1 (DS2) benchmark, which measures performance in orders per minute (OPM). The workload was designed to be representative of modern OLTP systems, which manage transaction-oriented applications. For more information about the server we tested, see [Appendix A](#). For our detailed test methodology, see [Appendix C](#).

In our tests, the Dell PowerEdge R720 with PCIe Express Flash SSDs was able to handle 328,774 orders per minute. In a previous test in the Principled Technologies labs, a six VMs on a Dell PowerEdge R720 using hard drives in external storage achieved 286,861 OPM.<sup>1</sup> Please note that these results are not directly comparable, as the configurations differ, but may give an indication of the performance Dell PCIe Express Flash SSDs provide.

## BIG PERFORMANCE, EVEN WITH LESS MEMORY

Traditionally, because server memory, or RAM, processes data so quickly, it stores most data and is the driving force behind database performance. To show the performance opportunities that the Dell PCIe Express Flash SSDs deliver, we scaled down the memory to show their impact on performance. We tested 64GB and 32GB RAM configurations to show that even with dramatically less memory, the Dell PCIe Express Flash SSDs drive performance in place of memory and deliver comparable high performance.

Figure 1 illustrates the OPM the Dell PowerEdge R720 with Dell PCIe Express Flash SSDs achieved using the different memory configurations. All three configurations achieved comparable data performance.

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<sup>1</sup> [http://www.principledtechnologies.com/clients/reports/Dell/R720\\_vs%20R710\\_0312.pdf](http://www.principledtechnologies.com/clients/reports/Dell/R720_vs%20R710_0312.pdf)

**Figure 1: Database performance, in orders per minute, the server achieved with different memory configurations.**

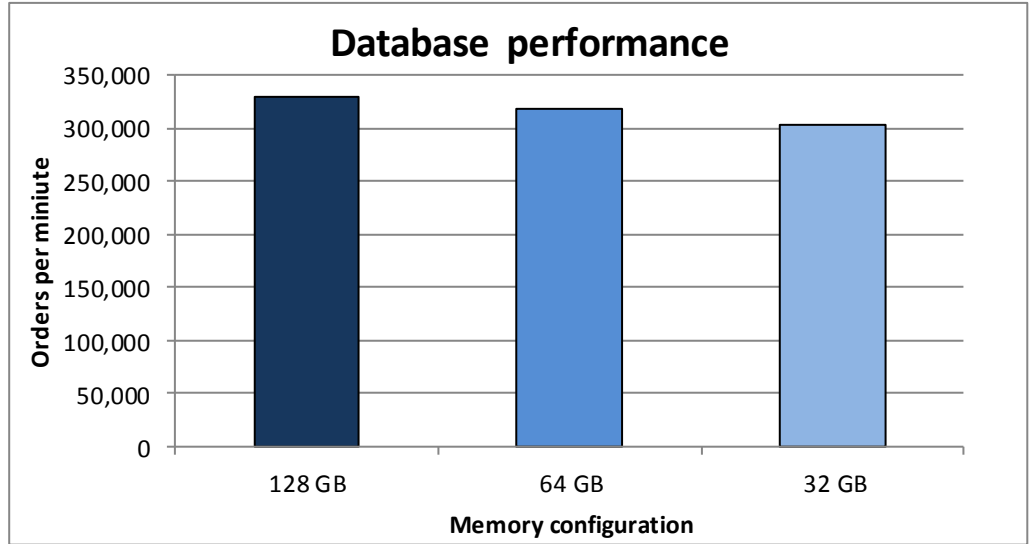


Figure 2 shows the disk transfers per second, reads per second, and writes per second the Dell PCIe Express Flash SSDs achieved over the course of the tests. While performance (OPM) decreased slightly with the reduced memory, transfers, reads, and writes per second increased dramatically. This shows that the Dell PCIe Express Flash SSDs could handle the heavy workload placed on them when the server was unable to rely on large memory amounts to power the virtualized databases. The Dell PCIe Express Flash SSDs handled more than three times the number of disk transfers in the 32GB memory configuration as in the 128GB configuration, while overall performance decreased slightly.

It is worth noting that with a typical storage system using SAS hard drive, performance would decrease drastically with this type of I/O increase. For detailed test results, see [Appendix B](#).

Memory amount	OPM	Transfers/second	Reads/second	Writes/second	CPU utilization
128 GB	328,774	9,177.0	4,212.8	4,964.2	85.4%
64 GB	317,081	23,608.0	14,017.7	9,590.3	87.4%
32 GB	302,999	35,346.0	21,580.2	13,765.9	88.8%

**Figure 2: Total disk transfers , reads and writes, and CPU utilization at the various memory configurations.**

## WHAT WE TESTED

### 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 information about the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

## IN CONCLUSION

Being able to do without expensive and cumbersome external storage arrays can only benefit your organization. With Dell PCIe Express Flash SSDs, you can get powerful virtualized database performance for all your production databases from within your server.

In our tests, the Dell PowerEdge R720 with Dell PCIe Express Flash SSDs was able to support up to 328,774 orders per minute. Comparing these results to previously published test results for a differently configured R720 server shows that the PowerEdge R720 with Dell PCIe Express Flash SSDs delivered exceptional virtualized database performance.

When we ran a separate test routing the reads and writes to disk by using significantly less RAM, the PowerEdge R720 with PCIe Express Flash SSDs delivered similar high performance levels. Testing with these reduced amounts of memory demonstrated the ability of Dell PCIe Express Flash SSDs to successfully drive database performance without relying solely on memory for performance.

For database applications in a virtualized infrastructure, the Dell PowerEdge R720 with Dell PCIe Express Flash SSDs can provide you the performance you need without the costs and hassles of external storage with a large number of disks.

## APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 3 provides detailed configuration information for the test system. This table shows the 128GB memory configuration. For the 64GB and 32GB configurations, we used the same memory and simply removed the appropriate amount for those tests. We used eight 8GB memory sticks for the 64GB configuration and four 8GB sticks for the 32GB configuration.

System	Dell PowerEdge R720
<b>Power supplies</b>	
Total number	2
Vendor and model number	Dell D750E-S1
Wattage of each (W)	750
<b>Cooling fans</b>	
Total number	6
Vendor and model number	AVC DBTC0638B2V
Dimensions (h x w) of each	2.5" x 2.5"
Volts	12
Amps	1.2
<b>General</b>	
Number of processor packages	2
Number of cores per processor	8
Number of hardware threads per core	2
System power management policy	Balanced
<b>CPU</b>	
Vendor	Intel
Name	Xeon
Model number	E5-2680
Stepping	D
Socket type	LGA2011
Core frequency (GHz)	2.70
Bus frequency	8.0
L1 cache	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)
L3 cache	20 MB
<b>Platform</b>	
Vendor and model number	Dell PowerEdge R720
Motherboard model number	0M1GCR
BIOS name and version	Dell 1.2.6
BIOS settings	Default
<b>Memory module(s)</b>	
Total RAM in system (GB)	128
Vendor and model number	Hynix HMT31GR7BFR4A-H9
Type	PC3-10600R
Speed (MHz)	1,333
Speed running in the system (MHz)	1,333

<b>System</b>	<b>Dell PowerEdge R720</b>
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-36
Size (GB)	8
Number of RAM module(s)	16
Chip organization	Double-sided
Rank	Dual
<b>Operating system</b>	
Name	Windows Server 2008 R2 Enterprise SP1
Build number	7601
File system	NTFS
Kernel	APCI x64-based PC
Language	English
<b>Graphics</b>	
Vendor and model number	Matrox® G200e
Graphics memory (MB)	8
<b>RAID controller</b>	
Vendor and model number	PERC H710P Mini
Firmware version	21.0.1-0132
Cache size	1 GB
<b>Hard drive # 1</b>	
Vendor and model number	Seagate® ST9300653SS
Number of disks in system	6
Size (GB)	300
RPM	15,000
Type	SAS
<b>Hard drive # 2</b>	
Vendor and model number	Micron Technology, Inc. MTFDGL350SAH-1NBABES
Number of disks in system	4
Size (GB)	350
RPM	N/A
Type	PCIe2/SSD
<b>Ethernet adapters</b>	
Vendor and model number	Intel Gigabit 4P I350-T RNDC
Type	Integrated
<b>Optical drive(s)</b>	
Vendor and model number	TEAC DV-28SW
Type	DVD-ROM
<b>USB ports</b>	
Number	4 external, 1 internal
Type	2.0

Figure 3: System configuration information for the test system.

## APPENDIX B – DETAILED TEST RESULTS

Figure 4 shows the orders per minute, by client, the server achieved with the varying memory configurations we tested.

	128 GB	64 GB	32 GB
<b>Orders per minute</b>			
Client 8	44,199	42,187	40,171
Client 7	42,172	40,947	39,196
Client 6	39,038	37,571	36,185
Client 5	36,210	37,430	35,490
Client 4	41,554	39,572	37,635
Client 3	44,395	41,343	39,340
Client 2	39,262	38,171	36,789
Client 1	41,944	39,860	38,193
<b>Total OPM</b>	<b>328,774</b>	<b>317,081</b>	<b>302,999</b>

Figure 4: Orders per minute, by client, the Dell PowerEdge R720 achieved in our test.

Figure 5 shows the total disk transfers per second, reads per second, and writes per second the Dell PCIe Express Flash SSDs handled with the varying memory configurations we tested. We configured the four Dell PCIe Express Flash SSDs in a striped volume inside Windows Server 2008 R2. The table below shows activity for each of the disks and total of all four. Note that the total disk transfers per second are the sum of the reads and writes per second.

	128 GB	64 GB	32 GB
<b>Total disk transfers/sec</b>			
Drive 1	2,290.7	5,893.9	8,825.2
Drive 2	2,298.0	5,913.1	8,850.8
Drive 3	2,292.4	5,896.0	8,832.1
Drive 4	2,296.0	5,905.0	8,838.0
<b>Total</b>	<b>9,177.0</b>	<b>23,608.0</b>	<b>35,346.0</b>
<b>Reads /sec</b>			
Drive 1	1,048.8	3,496.6	5,383.7
Drive 2	1,058.1	3,514.4	5,407.5
Drive 3	1,051.3	3,500.0	5,393.4
Drive 4	1,054.6	3,506.7	5,395.5
<b>Total</b>	<b>4,212.8</b>	<b>14,017.7</b>	<b>21,580.2</b>
<b>Writes /sec</b>			
Drive 1	1,241.9	2,397.3	3,441.5
Drive 2	1,239.9	2,398.8	3,443.3
Drive 3	1,241.1	2,395.9	3,438.7
Drive 4	1,241.3	2,398.3	3,442.5
<b>Total</b>	<b>4,964.2</b>	<b>9,590.3</b>	<b>13,765.9</b>

Figure 5: Total disk transfers per second, reads per second, and writes per second in our test.

Figure 6 shows the total disk bytes per second, reads bytes per second, and writes bytes per second the Dell PCIe Express Flash SSDs handled with the varying memory configurations we tested. Note that the total disk transfers bytes per second are the sum of the reads and writes bytes per second.

	128 GB	64 GB	32 GB
<b>Disk bytes/sec</b>			
Drive 1	29,129,239	57,173,781	79,729,302
Drive 2	29,287,374	57,331,922	79,950,404
Drive 3	29,181,041	57,191,395	79,800,401
Drive 4	29,222,610	57,252,344	79,832,847
<b>Total</b>	<b>116,820,264</b>	<b>228,949,443</b>	<b>319,312,953</b>
<b>Disk reads bytes/sec</b>			
Drive 1	17,782,642	32,487,987	45,111,038
Drive 2	17,936,639	32,642,594	45,311,810
Drive 3	17,827,174	32,516,460	45,184,738
Drive 4	17,869,587	32,571,092	45,216,592
<b>Total</b>	<b>71,416,042</b>	<b>130,218,133</b>	<b>180,824,178</b>
<b>Disk writes bytes/sec</b>			
Drive 1	11,346,597	24,685,794	34,618,264
Drive 2	11,350,736	24,689,328	34,638,594
Drive 3	11,353,868	24,674,935	34,615,662
Drive 4	11,353,023	24,681,253	34,616,254
<b>Total</b>	<b>45,404,222</b>	<b>98,731,310</b>	<b>138,488,775</b>

Figure 6: Bytes/second statistics for the total disk transfers, reads, and writes in our test.



## APPENDIX C - HOW WE TESTED

### Installing Windows Server 2008 R2 Enterprise Edition

1. Boot the server, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
5. Click the I accept the license terms check box, and click Next.
6. Click Custom.
7. At the Where to Install Windows screen, click Drive options (advanced).
8. Ensure you select the proper drive, and click New.
9. Enter the partition size, and click Apply. (We used the entire disk.)
10. At the pop-up informing you Windows will create additional partitions, click OK.
11. At the Where to Install Windows screen, click Next.
12. At the User's password must be changed before logging on warning screen, click OK.
13. Enter a password as the new password in both fields, and click the arrow to continue.
14. At the Your password has been changed screen, click OK.

### Setting up the network configuration on the server

1. Click Start→Control Panel→Network and Internet→Network and Sharing Center, and click Change Adapter Settings.
2. Right-click on the network adapter, and select Properties from the drop-down menu.
3. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
4. At the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
5. Enter a valid static IP address, subnet mask, and default gateway.
6. Click OK to close the window.
7. At the Local Area Connection Properties window, click Close.
8. Close the Network Connection window.

### Installing system updates in Windows Server 2008 R2

We installed all critical updates on the server using the Windows Update feature.

### Setting up the storage on the server

We used the steps below to configure the four Dell PCIe Express Flash SSDs drives in a striped volume. We configured eight database virtual hard disks (VHDs) and eight separate log VHDs on the striped volume and attached to each server VM. This placed all database and log activity on the Dell PCIe Express Flash SSDs drives.

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 Striped 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 64K allocation unit size, and click Next.
9. At the Completing the New Striped Volume Wizard window, click Finish.

### Adding the Hyper-V R2 SP1 role

1. Open Server Manager, and click Roles.

2. Click Add Roles.
3. On the Before You Begin page, check the Skip this page by default box, and click Next.
4. Select Hyper-V, and click Next.
5. On the Hyper-V Introduction page, click Next.
6. On the Create Virtual Networks page, click Next.
7. Confirm installation selections, and click Install.
8. Once the installation is complete, click Close.
9. When the system prompts a restart, click Yes.
10. Allow the system to fully reboot, and log in using the administrator credentials.
11. Once the desktop loads, the Hyper-V Installation Results window will finish the installation.
12. Click Close. The Hyper-V role will now be available in Server Manager under Roles.

## Configuring Virtual Network Manager

1. At the Hyper-V Manager screen, in the right pane, click Virtual Network Manager.
2. At the Virtual Network Manager screen, select Internal, and click Add.
3. At the Virtual Network Manager screen, click Apply, and click OK.

## Configuring the VMs

We provide steps below for installing the operating system, Microsoft SQL Server, and configurations of the VMs.

### Installing the VM operating system on the first VM

1. Connect to the ISO image of the installation DVD for Windows Server 2008 R2 SP1 Enterprise from the VM console. If the ISO image is not stored on the host, start the VM first and then connect to the ISO image.
2. Start the VM.
3. At the Language Selection screen, click Next.
4. Click Install Now.
5. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
6. Click the I accept the license terms check box, 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. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
13. Enable remote desktop access.
14. Change the hostname, and reboot when prompted.
15. Create a shared folder to store test script files. Set permissions as needed.
16. 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. Set the IP address, subnet, gateway, and DNS server for the virtual NIC, which will handle outgoing server traffic. Click OK, and click Close.
17. In the VM, configure the VM storage:
  - a. Click the Server Manager icon in the taskbar.
  - b. In the left pane, expand Storage, and click Disk Management.
  - c. Right-click the first volume, and choose Initialize Disk.
  - d. In the right pane, right-click the volume, and choose New Simple Volume...

- e. At the welcome window, click Next.
  - f. At the Specify Volume Size window, leave the default selection, and click Next.
  - g. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
  - h. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
  - i. At the Completing the New Simple Volume Wizard window, click Finish.
  - j. Repeat steps c through i for the remaining VM volumes.
18. Copy the pre-created DVD Store backup file to the backup virtual disk inside the first VM.

## Installing SQL Server 2012

1. Insert the installation DVD.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2012 DVD, and double-click.
3. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
4. In the left pane, click Installation.
5. Click New SQL Server stand-alone installation or add features to an existing installation.
6. At the Setup Support Rules screen, wait for the rule check to complete. If there are no failures or relevant warnings, click OK.
7. Select the Specify a free edition and select Evaluation from the drop-down menu. Click Next.
8. Click the checkbox to accept the license terms, and click Next.
9. If no failures are displayed after the setup support files are installed, click Next.
10. At the Setup Role screen, choose SQL Server Feature Installation.
11. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
12. At the Installation Rules screen, click Next once the check completes.
13. At the Instance configuration screen, choose a named instance, specify an instance name, and click Next.
14. At the Disk Space Requirements screen, click Next.
15. At the Server Configuration screen, choose system accounts, such as NT Service\MSSQLSERVER, for SQL Server services. Click Next.
16. At the next error-checking screen, click Next.
17. At the Database Engine Configuration screen, select Mixed Mode.
18. Enter and confirm a password for the system administrator account.
19. Click Add Current user. This may take several seconds.
20. Click Next.
21. At the Error-and usage-reporting screen, click Next.
22. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
23. At the Ready to Install screen, click Install.
24. After installation completes, click Close.
25. Repeat steps 5-24 to install second SQL Server instance using MSSQLSERVER2 as the instance name.
26. Close the installation window.

## Configuring additional VMs on Hyper-V

1. In Hyper-V, ensure VM1 is powered down.
2. Navigate to where the VHD is stored, and duplicate the file 7 times.
3. In Hyper-V, right-click the server → New virtual machine, enter VM2 for the name, and click Next.
4. On the Assign Memory screen, select 15,360, and click Next.
5. On the Configure networking screen, select the network you set up, and click Next.

6. At the connect Virtual Hard Disk screen, select Use an Existing, and browse to where you duplicated the original VM's main VHD.
7. Repeat these steps for the remaining VMs.
8. Ensure in each VM that the necessary virtual disks are all online and the IP addressing is properly assigned.
9. Modify the hostname of each VM.

## Installing and configuring the database clients

For the DS2 scripts, we used a Dell PowerEdge R810 server for virtual clients to simulate a number of users putting a load on the server. We installed Windows Server 2008 R2 with Hyper-V on the Dell PowerEdge R810 server as outlined in the steps above. We installed Windows Server 2008 R2 Enterprise Edition inside the eight VMs we used for virtual clients. Each virtual machine had four virtual processors and one virtual network adapter. We adjusted the memory per VM based on the amount of system memory. For the 128GB memory test, we used 15GB per VM, for the 64GB memory test, we used 7GB per VM, and for the 32GB memory test we used 3GB per VM. We installed the .NET 3.5 SP1 framework on each VM, as the DS2 test executable requires at least .NET2.0. After the installation, we created a folder on each VM to store the DS2 executable. We followed this process for each installation:

1. Install Microsoft Windows Server 2008 R2 Enterprise Edition on VM client.
2. Assign a computer name of `Clientx` for the database client, where x is the client number.
3. For the licensing mode, use the default setting of five concurrent connections.
4. Enter a password for the administrator logon.
5. Select Eastern Time Zone.
6. Use typical settings for the Network installation.
7. Type `Workgroup` for the workgroup.
8. Install Windows Updates, .NET 3.5 SP1 framework, and copy the DVD Store client executable into the folder.

## Creating scripts on the database clients

To simplify testing, we created batch files named `test.bat` on all eight virtual clients to start the DVD Store executable with the correct parameters. We put the batch files in a folder on the clients in the following directory: `c:\clientshare`. The batch files contained the following text:

```
c:\clientshare\ds2sqlserverdriver.exe --target=192.168.0.100 --ramp_rate=10
--run_time=30 --n_threads=16 --db_size=20GB --think_time=0 --
database_name=ds2 --detailed_view=Y --warmup_time=1 --pct_newcustomers=5 --
output_path=c:\clientshare\opmoutds2.txt
```

## Setting up DVD Store version 2.1

### Data generation overview

We generated the data using the `Install.pl` script included with DVD Store version 2.1, providing the parameters for our 20GB database size and the database platform on which we ran - Microsoft SQL Server 2012. We ran the `Install.pl` script on a utility system running Linux. The `Install.pl` script also 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 2012. We built the 20GB database in SQL Server 2012, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore on the server between test runs.

The only modification we made to the schema creation scripts were 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. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed the steps below:

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 20GB 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 7 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
<b>Database files</b>		
primary	PRIMARY	4
cust1	DS_CUST_FG	2,168
cust2	DS_CUST_FG	2,168
cust3	DS_CUST_FG	2,168
cust4	DS_CUST_FG	2,168
cust5	DS_CUST_FG	2,168
cust6	DS_CUST_FG	2,168
cust7	DS_CUST_FG	2,168
cust8	DS_CUST_FG	2,168
ind1	DS_IND_FG	1,280
ind2	DS_IND_FG	1,280

Logical name	Filegroup	Initial size (MB)
ind3	DS_IND_FG	1,280
ind4	DS_IND_FG	1,280
ind5	DS_IND_FG	1,280
ind6	DS_IND_FG	1,280
ind7	DS_IND_FG	1,280
ind8	DS_IND_FG	1,280
ds_misc1	DS_MISC_FG	2,560
ds_misc2	DS_MISC_FG	2,560
ds_misc3	DS_MISC_FG	256
ds_misc4	DS_MISC_FG	256
ds_misc5	DS_MISC_FG	256
ds_misc6	DS_MISC_FG	256
ds_misc7	DS_MISC_FG	256
ds_misc8	DS_MISC_FG	256
orders1	DS_ORDERS	1,536
orders2	DS_ORDERS	1,536
orders3	DS_ORDERS	1,536
orders4	DS_ORDERS	1,536
orders5	DS_ORDERS	1,536
orders6	DS_ORDERS	1,536
orders7	DS_ORDERS	1,536
orders8	DS_ORDERS	1,536
<b>Log files</b>		
ds_log	Not Applicable	20,480

Figure 7: Our initial file size modifications.

### Editing the workload script – ds2xdriver.cs module

A new feature of DVD Store version 2.1 is the ability to target multiple targets from one source client. We used this functionality. In order to record the orders per minute output from each specific database target, we modified the ds2xdriver to output this information to log files on each client system. To do this, we used the StreamWriter method to create a new text file on the client system, and the WriteLine and Flush methods to write the relevant outputs to the files during the tests. We also added the capabilities to target differently named databases.

After making these changes, we recompiled the ds2xdriver.cs and ds2sqlserverfns.cs module in Windows by following the instructions in the DVD Store documentation. Because the DS2 instructions were for compiling from the command line, we used the following steps on a system with Visual Studio installed:

1. Open a command prompt.
2. Use the `cd` command to change to the directory containing our sources.
3. Execute the following command:

```
csc /out:ds2sqlserverdriver.exe ds2xdriver.cs ds2sqlserverfns.cs
/d:USE_WIN32_TIMER /d:GEN_PERF_CTRS
```

## ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.  
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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.

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