

## Dell™ PowerEdge™ PCIe Express Flash SSDs delivered up to **2,592** transactions per second



for a 200GB database.

High-performance 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 large databases, we tested the performance of the Dell PowerEdge R820 server with Dell PowerEdge PCIe Express Flash SSDs running Microsoft SQL Server 2012 with a 200GB database. We found that the Dell PowerEdge R820 using Dell PCIe Express Flash SSDs could handle up to 2,592.5 OLTP transactions per second, without the use of external storage.

To better show the performance of the Dell PCIe Express Flash SSDs, we ran a separate test with a SQL memory cap on the server, forcing increased demand on the SSDs themselves, and found that they performed the same as with the database fully cached in memory.



## BIG PERFORMANCE FOR BIG DATABASES

To assess the performance of Dell PCIe Express Flash SSDs in the Dell PowerEdge R820 server, we created a single 200GB database using SQL Server 2012 Enterprise Edition and configured the server with 128 GB of RAM. To show the performance opportunities that the Dell PowerEdge R820 server with four Dell PCIe Express Flash SSDs could deliver, we first tested the database performance in a normal configuration with the database cached in memory, allowing for less demand on disk drives.

We ran the Benchmark Factory for Databases TPC-E workload on the server; a workload designed to be representative of modern OLTP systems, which manage transaction-oriented applications.

The TPC-E benchmark targets two transactions per second (TPS) for every 1,000 customers. We chose to test our Dell PCIe Express Flash SSD solution with 24,000 customer database rows, which resulted in a 200GB database. Based on the TPC-E requirements, we targeted 48 TPS or more for our testing.

For testing, we used different increments of Benchmark Factory users. Benchmark factory increases stress on a test server by increasing the number of users. Each user simulates the same TPC-E-like workload, so one user performs the workload once, but running with 10 users would run the workload 10 times in parallel. (Note: The number of users is related to Benchmark Factory load and does not correlate to actual users connecting to a database server).

Figure 1 illustrates the transactions per second the Dell PowerEdge R820 with Dell PCIe Express Flash SSDs achieved over the course of the 35-minute test.

The calculated TPS line shows the expected performance at each datapoint. For example, the 10-user datapoint should expect 480 TPS (10 users x 48 TPS per user). For testing, we increased the number of users until the configuration could perform above the expected number of TPS. The last point at which the configuration performed above expected was at 50 Benchmark Factory users.

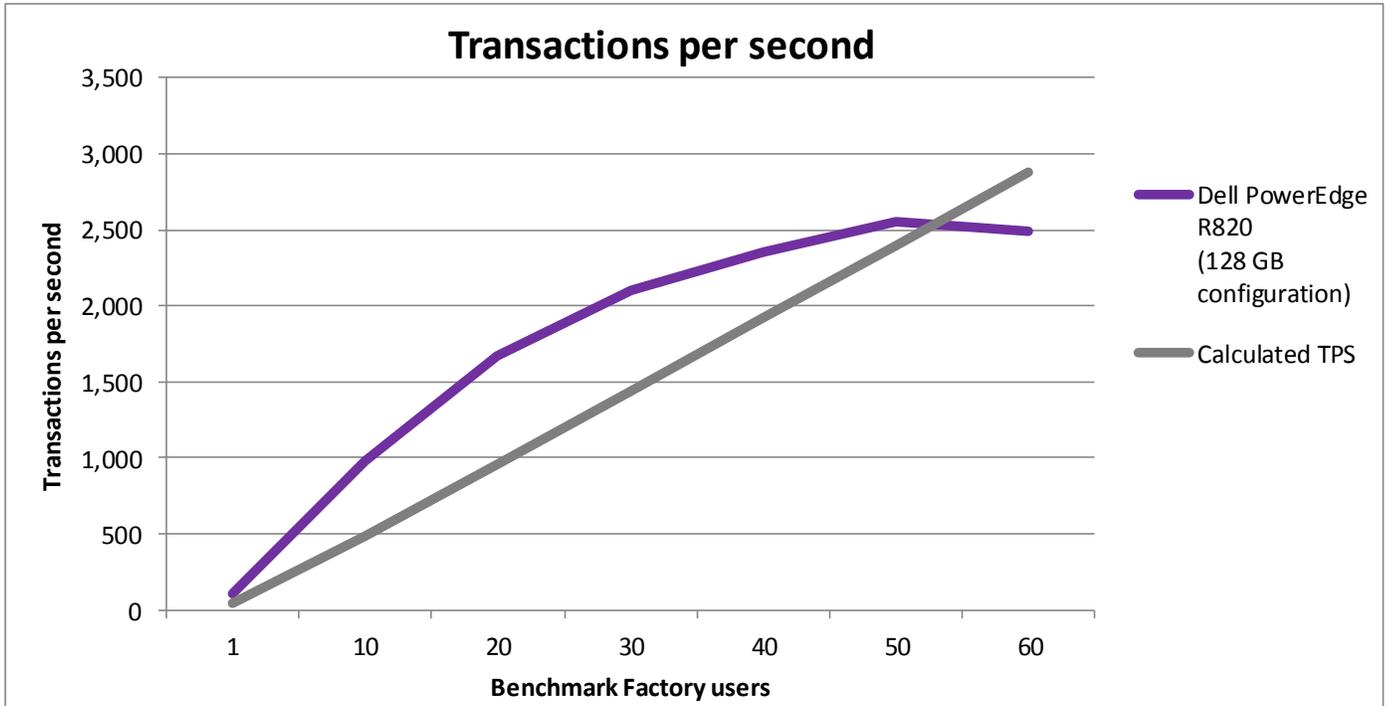


Figure 1: Database performance, in transactions per second, of the server compared to the benchmark's expected performance.

Figure 2 details the results of our testing, in transactions per second, at different user counts throughout the 35-minute test. At up to 50 Benchmark Factory users, the Dell PowerEdge R820 with Dell PCIe Express Flash SSDs exceeded the calculated expected TPS of the benchmark, showing that it provided exceptional database performance.

Number of Benchmark Factory users	Average response time (seconds)	Transactions per second	Calculated expected TPS
1	0.001	111	48
10	0.001	981	480
20	0.001	1,668	960
30	0.002	2,105	1,440
40	0.003	2,355	1,920
50	0.003	2,555	2,400
60	0.004	2,489	2,880

Figure 2: Breakdown of the transactions per second processed at different Benchmark Factory user counts.

Figure 3 shows the disk transfers per second that the server with Dell PCIe Express Flash SSDs handled over the course of the 35-minute test.

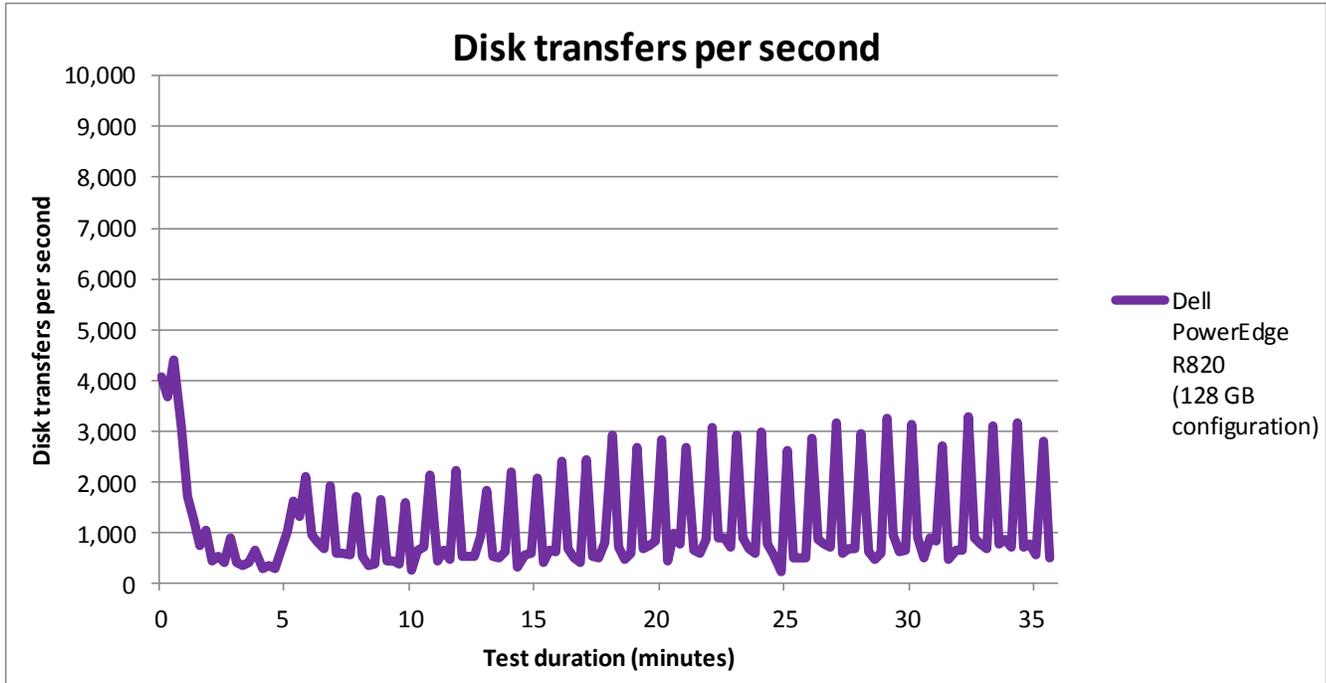


Figure 3: Disk transfers with and without the memory cap.

Figure 4 shows the CPU utilization of the Dell PowerEdge R820 server throughout the test. At no point during testing did CPU utilization reach 50 percent, showing that the server was able to handle to heavy workload with processor resources to spare.

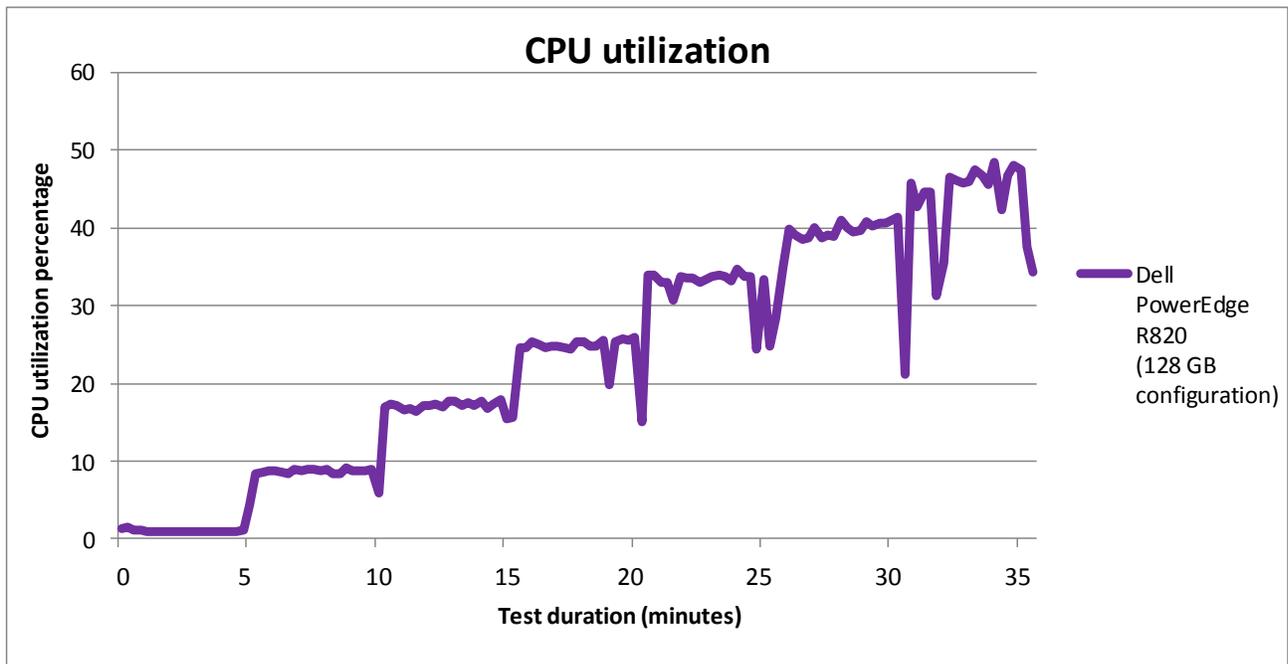


Figure 4: Server CPU utilization percentage for the Dell PowerEdge R820 with 128 GB of RAM

## BIG PERFORMANCE – EVEN WITH RESTRICTED MEMORY

In typical server configurations, RAM drives database performance. To isolate the effect Dell PCIe Express Flash SSDs have on performance, we did an experiment where we placed a SQL memory cap of 8GB on the server, so that it could only use 8 GB of the available 128 GB for database caching, putting more demand on the disks. (Note: This is not a configuration that organization would run, and serves only to increase I/O to the disks to demonstrate the database performance they can provide.)

Figure 5 shows the PowerEdge R820 performance with an 8GB SQL memory cap causing increased disk I/O. The results show the Dell PCIe Express Flash SSDs were able to exceed the calculated TPS up to 50 Benchmark Factory users.

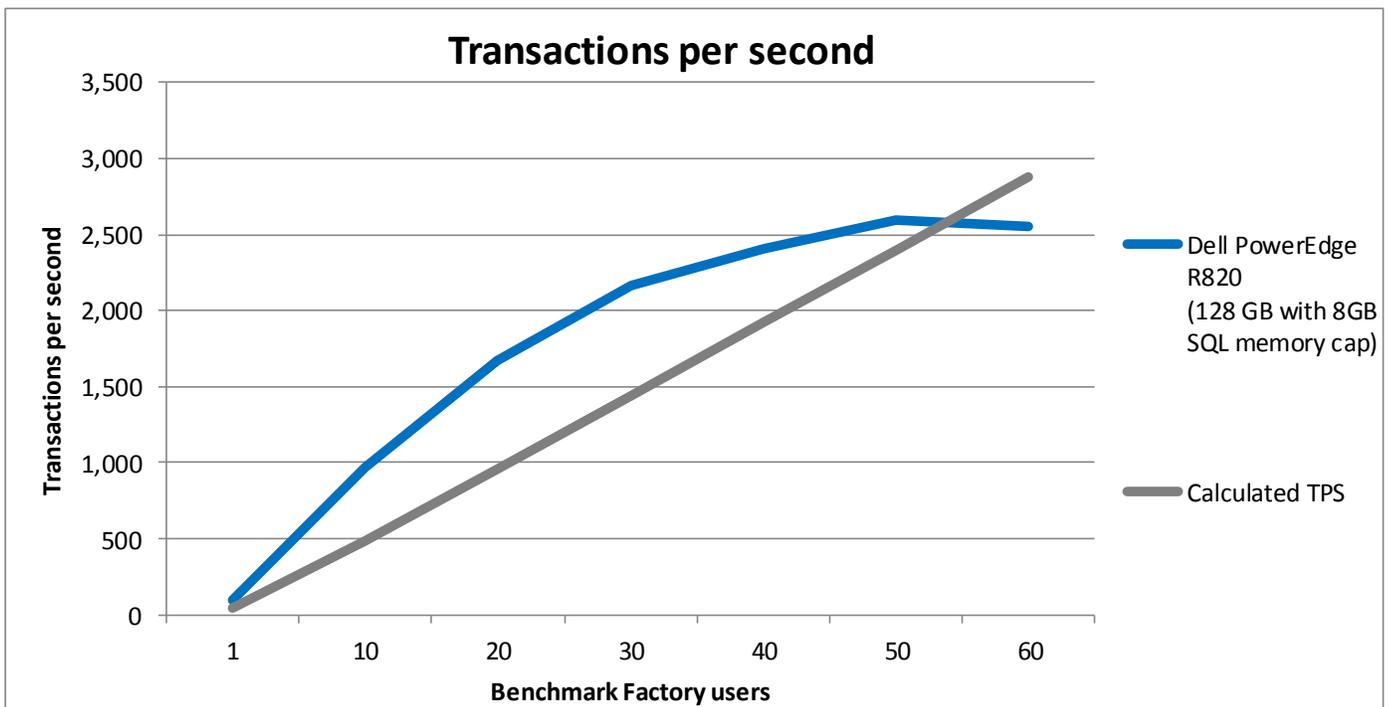


Figure 5: Database performance, in transactions per second, of the server with an 8GB memory cap compared to the benchmark's expected performance.

Figure 6 details the results of our testing, in transactions per second, at different user counts throughout the 35-minute test with the 8GB memory cap. As the results show, the PowerEdge R820 with Dell PCIe Express Flash SSDs were able to drive performance at a higher level than the calculated expected TPS of the benchmark through 50 Benchmark Factory users. This demonstrates that the Dell PCIe Express Flash SSDs are a powerful way to increase database performance without having to simply increase the amount of RAM.

Number of Benchmark Factory users	Average response time (seconds)	Transactions per second	Calculated expected TPS
1	0.002	98	48
10	0.001	965	480
20	0.001	1,676	960
30	0.002	2,160	1,440
40	0.003	2,408	1,920
50	0.003	2,592	2,400
60	0.004	2,551	2,880

Figure 6: Breakdown of the transactions per second processed at different Benchmark Factory user counts with an 8GB memory cap on the server.

We recorded and monitored the disk transfers per second achieved, which is a combination of the disks' reads and writes per second. Higher number of transfers per second means the disks are doing more activity reading and writing data.

Figure 7 shows the disk transfers per second of the Dell PCIe Express Flash SSDs over the course of the test using an 8GB SQL memory cap.

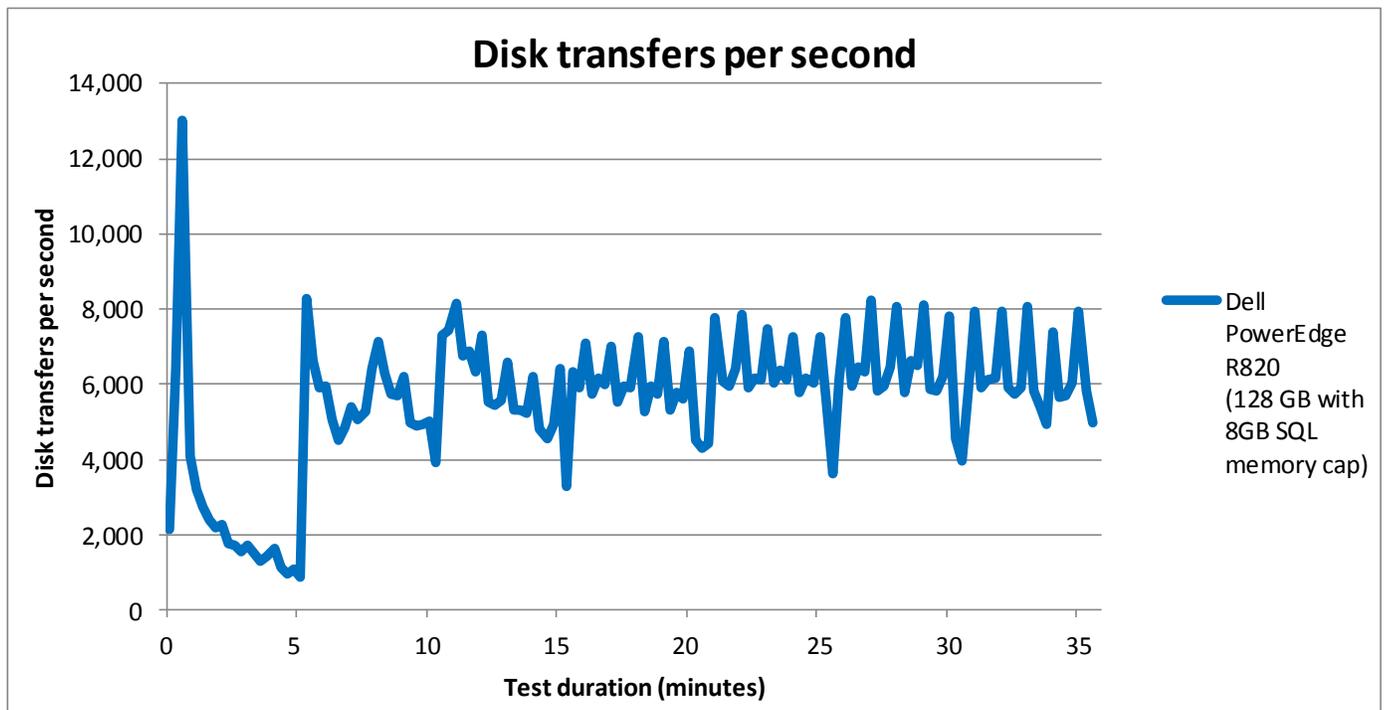


Figure 7: Disk transfers with the 8GB memory cap.

Figure 8 shows the CPU utilization throughout the test. Directing reads and writes to the Dell PCIe Express Flash SSDs had no negative effect on CPU utilization, and in fact generally lowered CPU utilization, especially as the server processed more requests.

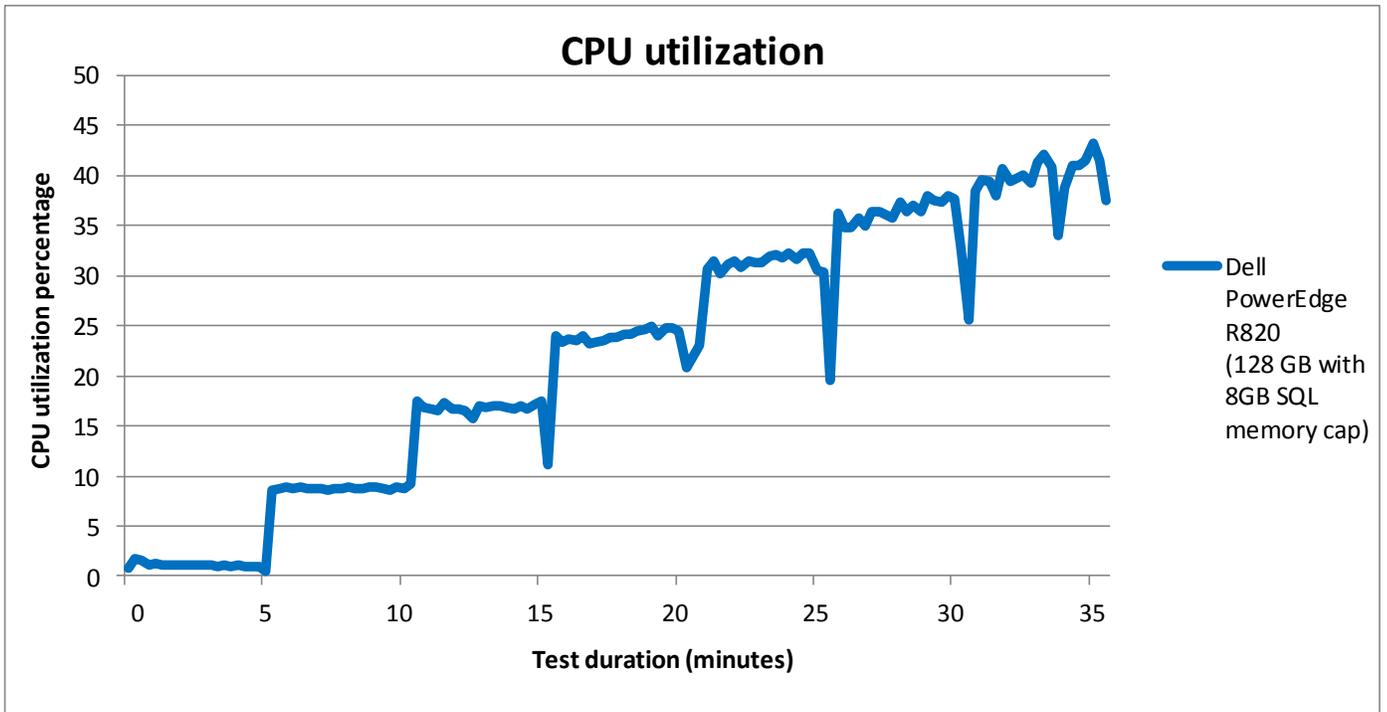


Figure 8: Server CPU utilization percentage with the 8GB memory cap.

## WHAT WE TESTED

To measure database performance, we used the Benchmark Factory for Databases tool, which lets you conduct database workload replay, industry-standard benchmark testing, and scalability testing. It enables you to deploy changes to your database environment with confidence by reducing the risks associated with patches, upgrades, migrations, and adjustments to virtual machine configurations. With this workload replay and scheduling software, you can eliminate slow SQL database performance and dramatically simplify high-performance database management. We used an On-Line Transaction Processing (OLTP) database test in Benchmark Factory to run a TPC-E-like workload.

More information on Benchmark Factory is available at <http://www.quest.com/benchmark-factory/>.

## IN CONCLUSION

With Dell PCIe Express Flash SSDs, you can get powerful performance for your databases from using internal storage. In our tests, the Dell PowerEdge R820 with four Dell PCIe Express Flash SSDs was able to support a maximum of 2,592 TPS, equal to that of a database cached in memory, which performed 2,555 TPS with the same system load.

For critical database applications, the Dell PowerEdge R820 with Dell PCIe Express Flash SSDs can provide you the performance you need without the hassles of external storage with a large number of disks.

## APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 9 provides detailed configuration information for the test system.

System	Dell PowerEdge R820
<b>Power supplies</b>	
Total number	2
Vendor and model number	Dell E1100E-S0
Wattage of each (W)	1,100
<b>Cooling fans</b>	
Total number	6
Vendor and model number	San Ace 60 9GA0612P1J611
Dimensions (h x w) of each	2.5" x 2.5"
Volts	12
Amps	1.50
<b>General</b>	
Number of processor packages	4
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	E5-4650
Stepping	7
Socket type	LGA2011
Core frequency (GHz)	2.70
Bus frequency (GT/s)	8.0
L1 cache (KB)	32
L2 cache (KB)	256
L3 cache (MB)	20
<b>Platform</b>	
Vendor and model number	Dell PowerEdge R820
Motherboard model number	Dell UL94V-0
BIOS name and version	Dell 1.1.5
BIOS settings	Default
<b>Memory module(s)</b>	
Total RAM in system (GB)	128
Vendor and model number	Hynix HMT31GR7BFR4A-H9
Type	PC3L-10600R
Speed (MHz)	1,333
Speed running in the system (MHz)	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-36
Size (GB)	8
Number of RAM module(s)	16

System	Dell PowerEdge R820
Chip organization	Double-sided
Rank	Dual
<b>Operating system</b>	
Name	Windows Server 2008 R2 Enterprise 64-bit
Build number	7601
File system	NTFS
Kernel	SP1
Language	English
<b>Graphics</b>	
Vendor and model number	Matrox® G200eR
Graphics memory (MB)	16
<b>RAID controller</b>	
Vendor and model number	Dell PERC H710P Adapter
Firmware version	21.0.2-0001
Cache size (GB)	1
<b>Dell PCIe Express controller</b>	
Vendor and model number	Dell Express Flash 320H
Driver	6.27.1.8
<b>Hard drive 1 (operating system)</b>	
Vendor and model number	Seagate® ST9300653SS
Number of drives	2
Size (GB)	300
RPM	15,000
Type	SAS
<b>Hard drive 2</b>	
Vendor and model number	Dell RealSSD P320h MTFDGAL350SAH
Number of drives	4
Size (GB)	350
RPM	N/A
Type	PCIe
<b>Ethernet adapter</b>	
Vendor and model number	Intel Gigabit 4P I350-t
Type	Integrated
<b>Optical drive(s)</b>	
Vendor and model number	PLDS DVD+-RW DS-8A5SH
Type	Internal
<b>USB ports</b>	
Number	4 external, 1 internal
Type	2.0

Figure 9: System configuration information for the test system.

## APPENDIX B - HOW WE TESTED

We used a Dell PowerEdge R820 as the system under test. We configured it with two 300GB SAS drives in a RAID 1 for the Windows Server 2008 R2 operating system and installed four Dell PCIe Express Flash SSD drives for all database traffic. We configured the four disks in a software-striped volume inside the Windows Server 2008 R2 OS.

We used a Dell PowerEdge R810 server as the Benchmark Factory client. We configured the R810 with two 73GB SAS hard drives for the operating system. The server had four Intel Xeon processor X7560 2.27GHz processors and 128GB of memory.

The steps below show how we configured the Dell PowerEdge R820 and Dell PowerEdge R810 servers for testing.

### Installing Windows Server 2008 R2 Enterprise Edition

We installed a fresh copy of Windows Server 2008 R2 on both servers. We used the same network setup steps and ran Windows updates on both.

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.

### Installing SQL Server 2012

We used the following steps to install SQL Server 2012 on the Dell PowerEdge R820 server.

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 after 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.

### 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.

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.

### Preparing the Benchmark Factory client

We completed the following steps on the Dell PowerEdge R810 server.

## Installing Client Connectivity Tools/SQL Server Management Studio

1. Insert the SQL Server 2012 disk.
2. If prompted, click OK to enable the .NET Framework Core role.
3. In the left pane, click Installation.
4. Select New SQL Server Stand-alone installation or Add features to existing installation.
5. On the Setup Support Rules screen, click OK.
6. On the Setup Support Files screen, click Next.
7. On the Installation Type screen, click Next.
8. On the Product Key screen, click Next.
9. At the License agreements screen, click Next.
10. On the Feature selection screen, check Management Tools Basic, and click Next.
11. On the Error and Usage Reporting screen, click Next.
12. On the Installation Rules screen, click Next.
13. On the Ready to Install screen, click Install.
14. On the Complete screen, click Close.

## Installing Benchmark Factory 6.7

We used the steps below to configure Benchmark Factory. We made a backup of the database after creation.

We ran five minute iterations for each user amount.

1. Double-click the exe to start the installation.
2. At the Welcome to the installer screen, click Next.
3. At the License Agreement, select I accept the terms, and click Next.
4. On the Destination Screen, select Next.
5. On the Ready to install program screen, select Yes install the default repository database, and click Install.
6. Click Start→All Programs→Quest Software→Benchmark Factory for Databases(64-bit)→Benchmark Factory for Databases.
7. When the Load Scenario Wizard screen pops up, click Next.
8. At the Select Load Scenario screen, select Industry standard benchmarks (TPC-C, TPC-E, TPC-H...), and click Next.
9. At the Select Benchmark screen, select TPC-E, and click Next.
10. At the Select Profile screen, click New.
11. Click Next.
12. At the Driver Selection screen, select Microsoft SQL Server (ODBC) from the drop-down menu, and click Next.
13. At the Connection Information, click Add DSN.
14. Select System Data Source, and click Next.
15. Select SQL Server Native Client 11.0, and click Next.
16. Enter Test for the file data source, and click Next.
17. Click Finish.
18. For Which SQL Server do you want to connect to? enter host name for R820 server and click Next.
19. For How should SQL Server verify the authenticity of the login ID? select With SQL Server authentication using a login ID and password entered by the user, enter sa for the Login ID and Password1 for the password, and click Next.
20. At the next screen, check the Change the default database to checkbox and select Testdb from the drop-down menu. Click Next.
21. Click Finish.
22. Click Test Data Source...
23. Click OK.
24. Click OK.

25. Click Next.
26. Enter Test for the Profile Name.
27. Click Finish.
28. At the Select Profile screen, click Next.
29. At the Benchmark Scale screen, change Benchmark Scale to 24 and click Next.
30. At the Measurement Intervals screen, click Delete All to remove the default selected user loads, enter the different user amounts under Add Single User Load, and click Add. Click Next. (We used the following seven user counts for testing: 1, 10, 20, 30, 40, 50, 60)
31. At the Enter Script Name, select Create a new Benchmark Factory Script file, enter TPC-E, and click Next.
32. At the next screen, uncheck the box beside Do you want the job to be automatically submitted to the jobs Queue? and click Finish.
33. Right-click the newly created job, and click Copy.
34. Right-click TPC-E above the job, and click Paste. You should see identical copies of the newly created job. Rename the first to TPC-E Job – Create, and the second to TPC-E Job – Test
35. On TPC-E Job - Create, right-click TPC-E Transaction Mix, and click Remove. Click Yes to confirm.
36. On TPC-E Job – Test, right-click Create Objects for TPC-E, and click Remove. Click Yes to confirm.
37. Right-click TPC-E Job – Create, and click Submit Job.
38. Click Submit.

### Splitting the Tempdb database

We expanded the tempdb database into 17 files and moved them to the Dell PCIe Express Flash SSD striped volume for testing. We ran the commands below in SQL as a new query to split the database:

```
alter database tempdb modify file(name=tempdev, filename='E:\Temp\tempdb.mdf',
SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB)
```

```
go
```

```
alter database tempdb modify file(name=templog, filename='E:\Temp\templog.ldf',
SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB)
```

```
go
```

```
ALTER DATABASE tempdb ADD LOG FILE
```

```
(NAME=templog2, FILENAME='E:\Temp\templog2.ldf', SIZE=10240MB, FILEGROWTH=10%,
MAXSIZE=25600MB)
```

```
go
```

```
ALTER DATABASE tempdb ADD FILE
```

```
(NAME=tempdev01, FILENAME='E:\Temp\tempdb01.mdf', SIZE=5120MB, FILEGROWTH=10%,
MAXSIZE=25600MB),
```

```
(NAME=tempdev02, FILENAME='E:\Temp\tempdb02.mdf', SIZE=5120MB, FILEGROWTH=10%,
MAXSIZE=25600MB),
```

```
(NAME=tempdev03, FILENAME='E:\Temp\tempdb03.mdf', SIZE=5120MB, FILEGROWTH=10%,
MAXSIZE=25600MB),
```

(NAME=tempdev04, FILENAME='E:\Temp\tempdb04.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev05, FILENAME='E:\Temp\tempdb05.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev06, FILENAME='E:\Temp\tempdb06.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev07, FILENAME='E:\Temp\tempdb07.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev08, FILENAME='E:\Temp\tempdb08.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev09, FILENAME='E:\Temp\tempdb09.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev10, FILENAME='E:\Temp\tempdb10.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev11, FILENAME='E:\Temp\tempdb11.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev12, FILENAME='E:\Temp\tempdb12.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev13, FILENAME='E:\Temp\tempdb13.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev14, FILENAME='E:\Temp\tempdb14.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev15, FILENAME='E:\Temp\tempdb15.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

(NAME=tempdev16, FILENAME='E:\Temp\tempdb16.mdf', SIZE=5120MB, FILEGROWTH=10%, MAXSIZE=25600MB),

go

## ABOUT PRINCIPLED TECHNOLOGIES



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