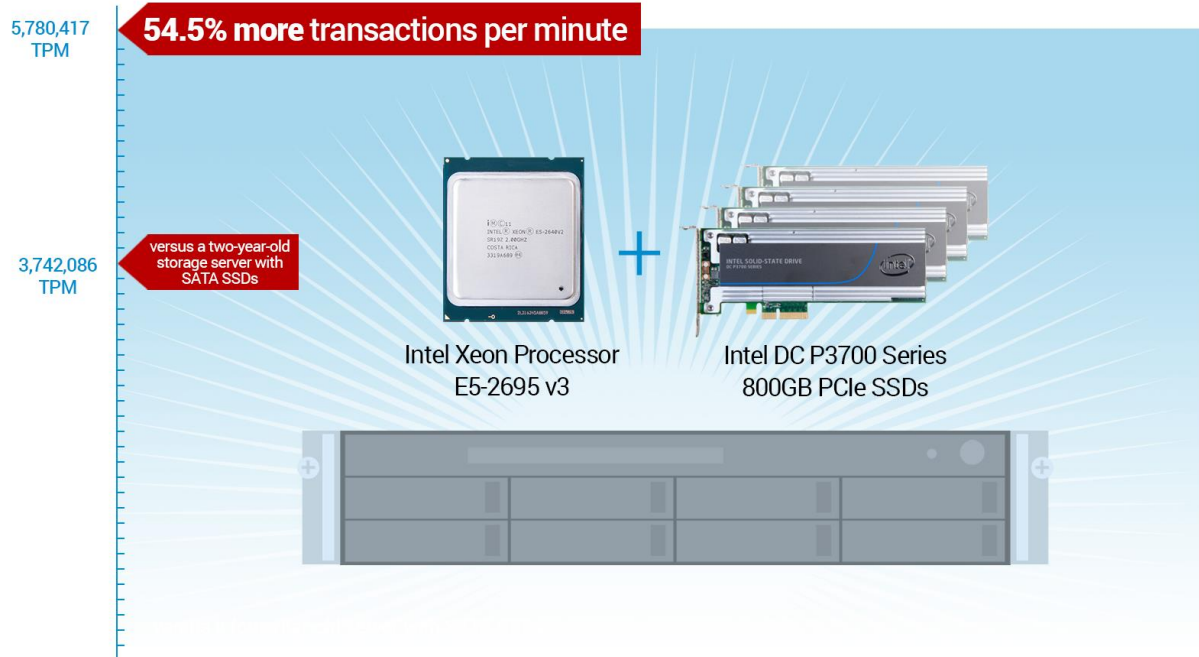


# BOOSTING YOUR STORAGE SERVER PERFORMANCE WITH THE INTEL XEON PROCESSOR E5-2600 V3 PRODUCT FAMILY

## Give your old storage servers a dramatic boost

The Intel® Xeon® Processor E5-2600 v3 Product Family delivered significantly faster performance and lower latency



Storage infrastructure is a key component of any datacenter. Some businesses have taken to using servers as storage arrays due to the flexibility they offer when it comes to management and upgrading hardware. If you are using an older server for your storage infrastructure, you can enjoy serious improvement by upgrading to a new server based on the powerful Intel Xeon Processor E5-2600 v3 product family and other Intel components that boost performance.

In the Principled Technologies labs, we tested an older storage server with SATA solid-state drives (SDDs) against a new PCIe® SSD-based server with the Intel processor E5-2695 v3. The newer server also used four ports on a 10Gb network interface card (NIC), versus a single port on the NIC in the older server. The new storage server delivered 54.5 percent more transactions per minute (TPM), handled 42.4 percent greater I/O, and delivered much quicker response times.

This performance gain shows the power of newer Intel storage and processor technologies and how you could stand to benefit greatly by upgrading your servers with Intel's offerings.



# INTEL COMPONENTS MAKE FOR A HIGH-PERFORMING STORAGE SERVER

The performance gains we saw in our testing are attributable to three primary components of the upgrade. The new storage server had a faster processor, faster storage (PCIe SSDs instead of SATA SSDs), and more 10GbE network connections (four instead of one).

The new storage server we tested uses the Intel Xeon processor E5-2695 v3, part of the Intel Xeon Processor E5-2600 v3 product family. This product family provides one and one-half times the cores and cache than the previous generation of Intel Xeon servers. It also provides faster memory. The PCIe SSD in our storage server is the Intel DC P3700 Series 800GB SSD and the NIC is part of the Intel Ethernet Server Adapter X710 product family.

Together, these components work to deliver strong performance in terms of database TPM, strong I/O performance, and quick response time.

## OUR TEST RESULTS

### Database performance

From a business perspective, you may find your SQL servers with SATA SSDs take too much time to handle tasks, creating bottlenecks. We used the HammerDB benchmark to measure the transactions per minute each server delivered. Figure 1 shows the increase in database TPM the storage server powered by the Intel processor E5-2695 v3 delivered compared to the older storage server.

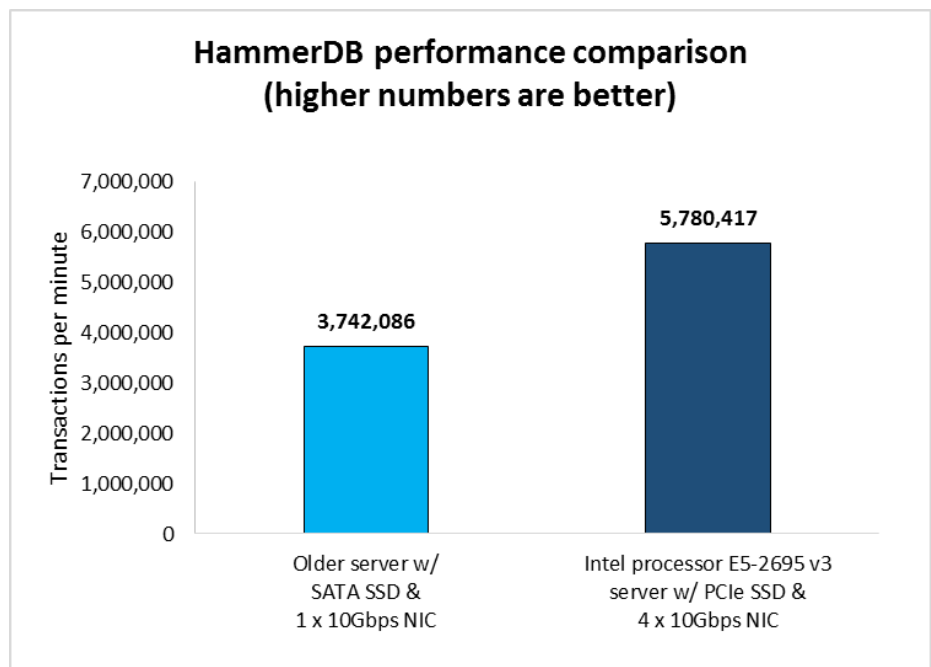


Figure 1: The database performance of the storage server powered by the Intel processor E5-2695 v3 greatly exceeded that of the older storage server.

The storage server powered by the Intel Xeon processor E5-2695 v3 delivered 54.5 percent more TPM, which means SQL servers connected to the upgraded storage server could increase productivity. Our benchmark ran the same workload against the SATA SSD-based storage server and the PCIe SSD-based storage server, and where the SATA SSD server struggled, the PCIe SSD server excelled. Database admins can rest assured that this storage can handle demanding database workloads, regardless of the task.

## I/O performance

Figure 2 shows how replacing SATA SSDs with PCIe SSDs can increase input/output (I/O) load. The storage server powered by the Intel processor E5-2695 v3 handled 42.4 percent greater load than the older storage server did.

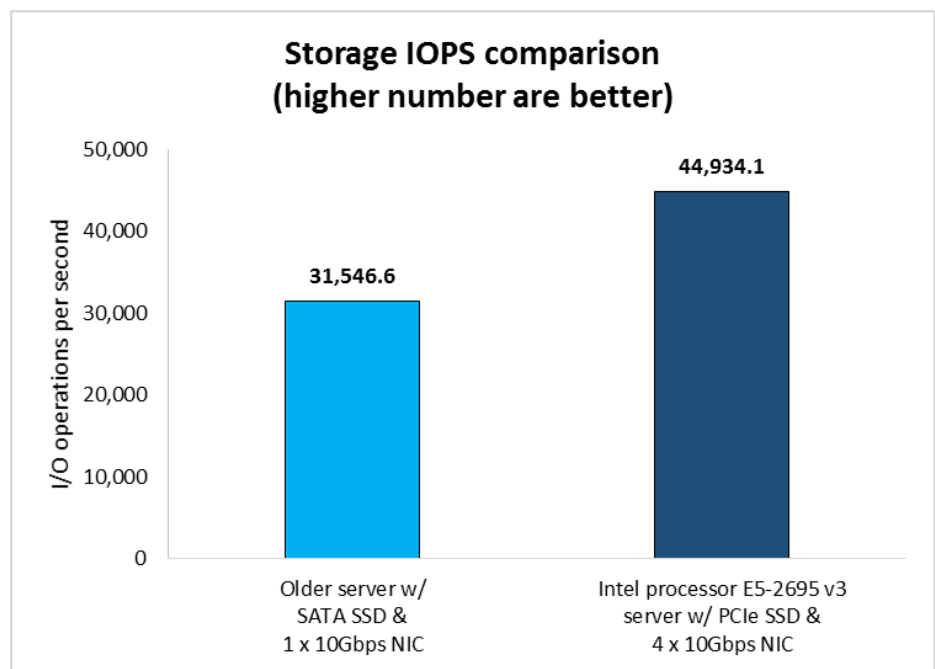


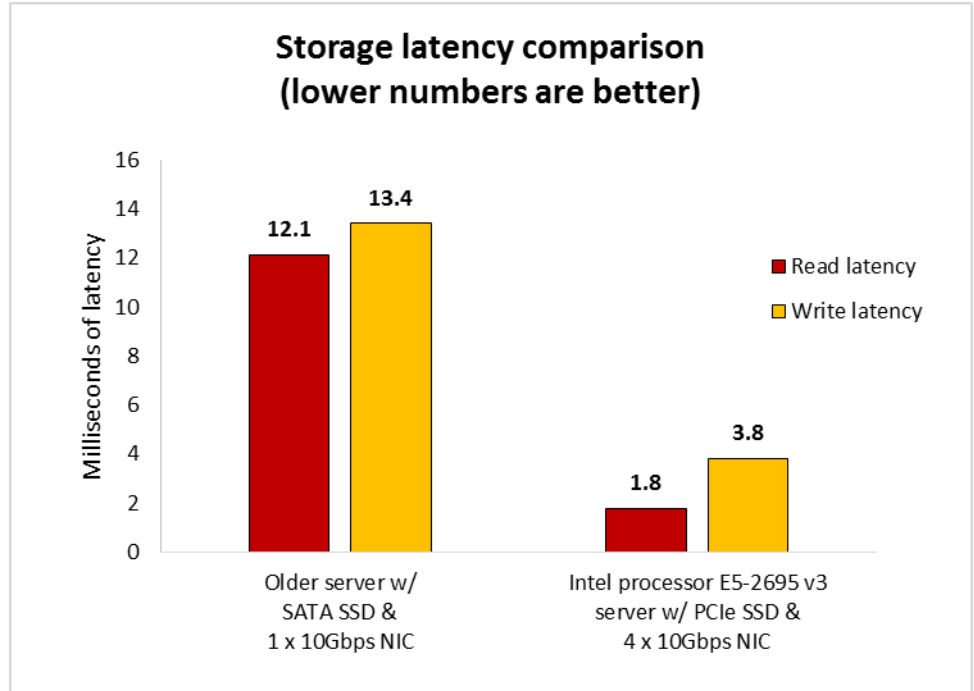
Figure 2: The disk performance of the storage server powered by the Intel processor E5-2695 v3 exceeded that of the older storage server.

The results mirror what we saw with HammerDB and helps explain why the TPM was greater on the upgraded server. SATA SSDs don't excel as much as PCIe SSDs, and workloads can require several times more SATA SSDs to achieve the same results from a smaller number of PCIe SSDs. This can mean wasted valuable datacenter space in addition to unrealized performance potential. PCIe SSDs can allow scaling of databases or workloads to meet the needs of your users.

## Response time

Figure 3 shows the read and write latency of the two tested storage servers from the perspective of the SQL servers. The read latency of the storage server powered by the Intel processor E5-2695 v3 was roughly one-seventh that of the older storage server and the write latency was less than one-third that of the older server.

Figure 3: The response time of the storage server powered by the Intel processor E5-2695 v3 was almost instantaneous compared to that of the older storage server.



With a performance differential so large, there needs to be an explanation for it and the latency shows what was happening. The older system had more difficulty handling the load thrown at it than the storage server powered by the Intel processor E5-2695 v3, which was able to take the load and provide almost instantaneous response time. From a usability perspective, long response times due to a storage bottleneck can be frustrating and slow down application responsiveness.

## CONCLUSION

The performance of your storage server is a critical component of database performance. Upgrading an older SATA SSD-based server with a single 10Gbps NIC to a new server equipped with components from the Intel Xeon Processor E5-2600 v3 product family and the Intel DC P3700 Series of PCIe SSDs can increase performance dramatically.

## APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 4 provides detailed configuration information for the test servers.

System	Intel S2600WTT	Dell PowerEdge R720
<b>Power supplies</b>		
Total number	2	1
Vendor and model number	DPS-750XB A	Dell D750E-S1
Wattage of each (W)	750	750
<b>Cooling fans</b>		
Total number	6	6
Vendor and model number	Nidec UltraFlo V60E12BS1B5	San Ace 60 9GA0612P1K641
Dimensions (h × w) of each	2.5" × 2.5"	2.5" × 2.5"
Volts	12 V	12
Amps	1.50	0.95
<b>General</b>		
Number of processor packages	2	2
Number of cores per processor	14	10
Number of hardware threads per core	2	2
System power management policy	Default	Balanced
<b>CPU</b>		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2695 v3	E5-2680 v2
Stepping	2	M1
Socket type	LGA-2011-3	LGA2011
Core frequency (GHz)	2.30	2.80
Bus frequency	9.6 GT/s QPI	8.0 GT/s
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache (MB)	35	25
<b>Platform</b>		
Vendor and model number	Intel Grantley Server	Dell PowerEdge R720
Motherboard model number	Intel S2600WTT	OM1GCR
BIOS name and version	GRNDSDP1.85B.0030.R03.1405061547	Dell 2.2.3 (05/20/2014)
BIOS settings	Default	Default
<b>Memory module(s)</b>		
Total RAM in system (GB)	64	64
Vendor and model number	Hynix HMA42GR7MFR4N-TF	Samsung M393B1K70BH1-CH9
Type	W2PC4-2133P	PC3-10600R
Speed (MHz)	2133	1333
Speed running in the system (MHz)	2133	1333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	15-15-15-32	9-9-9-24
Size (GB)	16 GB	8 GB

System	Intel S2600WTT	Dell PowerEdge R720
Number of RAM module(s)	8	8
Chip organization	Dual sided	Double Sided
Rank	2	2Rx4
<b>Operating system</b>		
Name	Windows Server 2012 R2 Datacenter 64-bit	Windows Server 2012 R2 Datacenter 64-bit
Build number	9600	9600
File system	EXT3	NTFS
Kernel	5.0.0	ACPI x64-based PC
Language	English	English
<b>Graphics</b>		
Vendor and model number	Matrox G200	Matrox® G200e
Graphics memory (MB)	256 MB	256
<b>Disk controller</b>		
Type	Intel Onboard SAS controller	PERC H310 Mini Mono
Firmware version	GRNDSDP1.85B.0030.R03.1405061547	20.13.0-0007 A08 (05/12/2014)
Cache size	N/A	N/A
<b>Hard drives</b>		
<b>First Disk</b>		
Vendor and model number	Western Digital WD1003FZEX	Dell ST973452SS
Number of drives	1	2
Size (GB)	1 TB	146 GB
RPM	15k	15k
Type	SATA 6.0	SAS 6.0
<b>Second Disk</b>		
Vendor and model number	Intel SSDPEDMD800G4	Intel SSDSC2BA800G
Number of drives	4	4
Size (GB)	800 GB	800 GB
RPM	SSD	SSD
Type	PCIe	SATA 6.0
<b>Ethernet adapters</b>		
<b>First network adapter</b>		
Vendor and model number	Intel Ethernet Controller X540-AT2	Intel Ethernet Controller X540-AT2
Type	Integrated	Integrated
<b>Second network adapter</b>		
Vendor and model number	Intel Ethernet Controller X710	Intel 10G Quad Port NIC D57446-001
Type	PCIe	PCIe

Figure 4: System configuration information for the test systems.

# APPENDIX B – HOW WE TESTED

## OUR TESTBED SETUP

Figures 5 and 6 show our test bed setup.

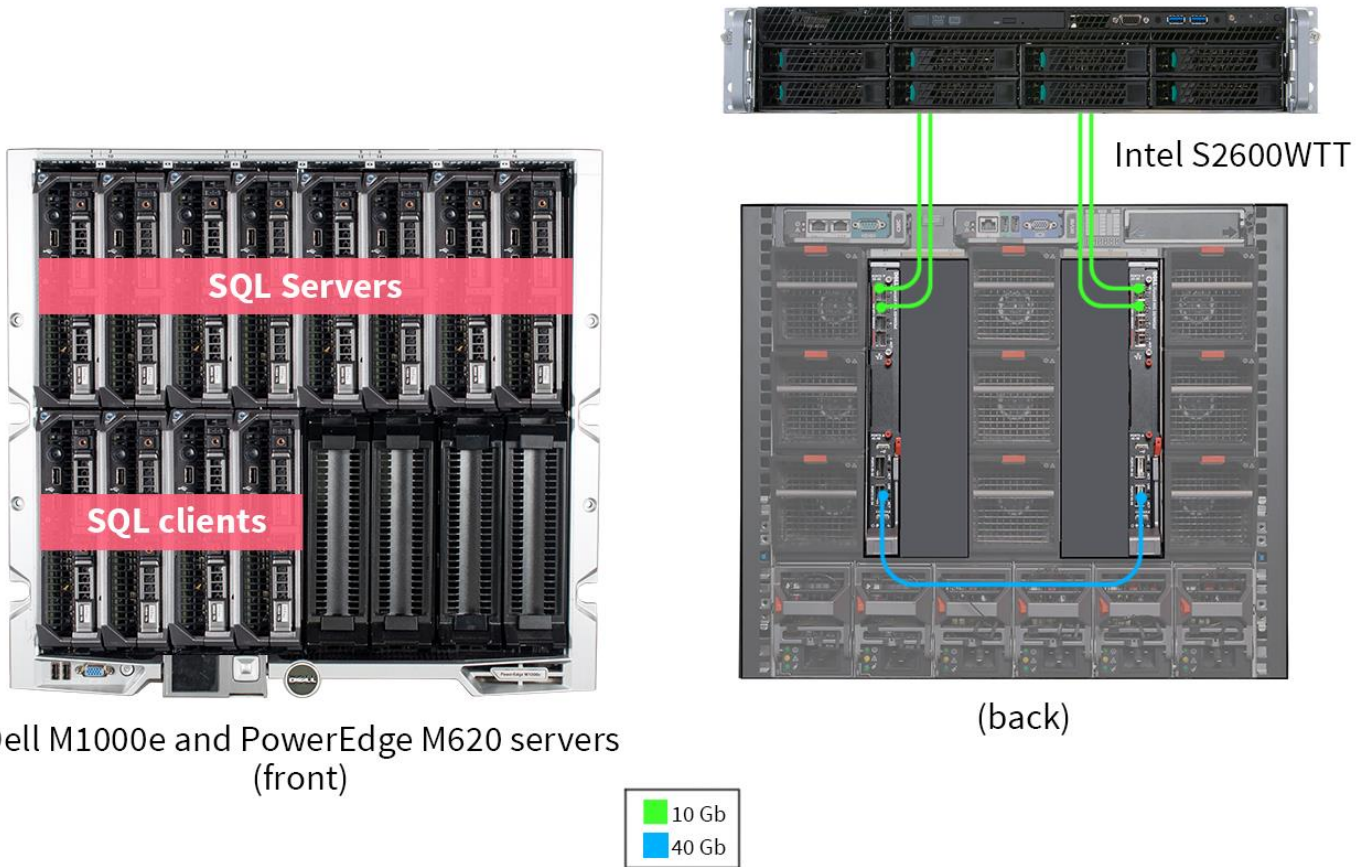


Figure 5: Setup for the newer server powered by the Intel processor E5-2695 v3.

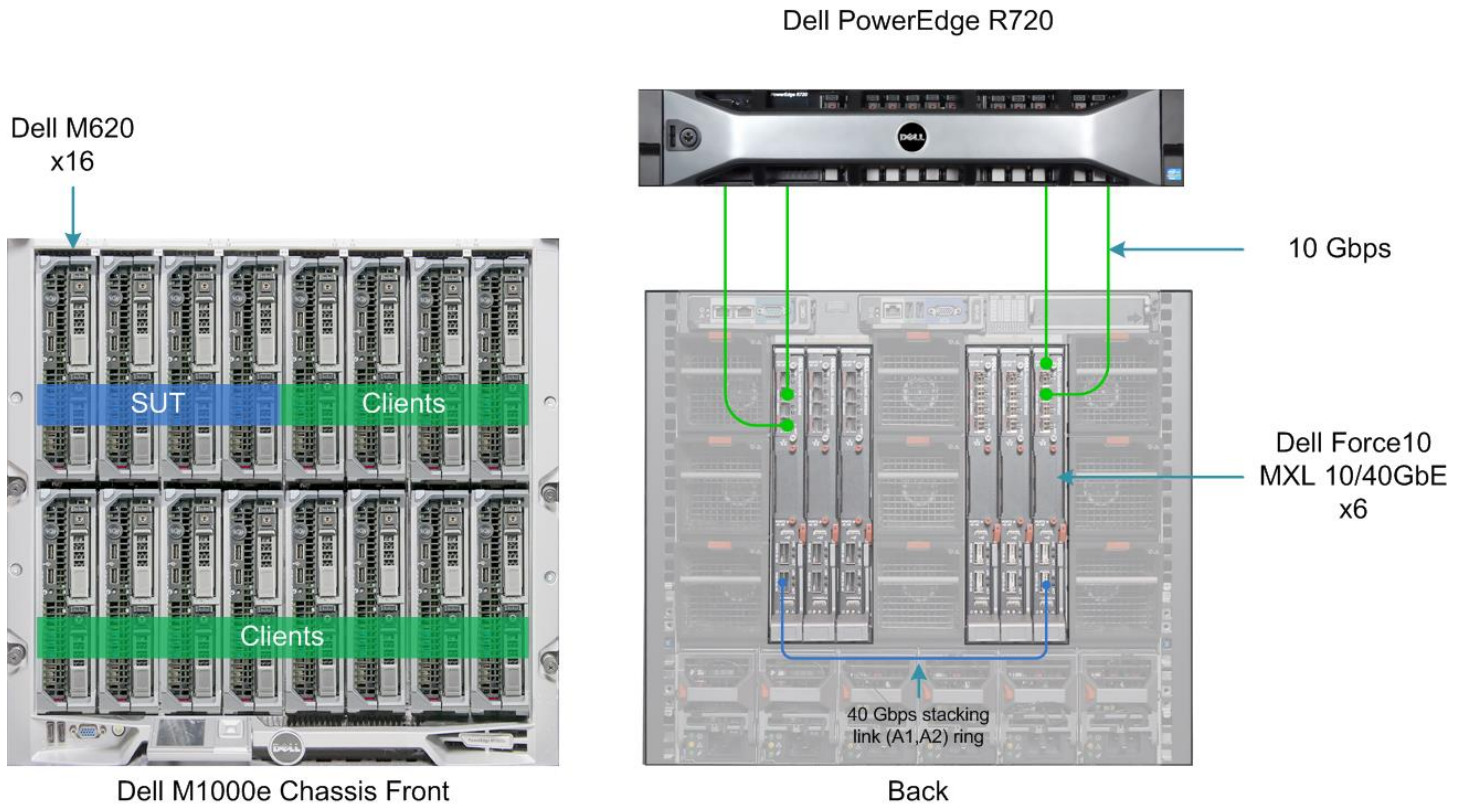


Figure 6: Setup for the older server.

## ABOUT THE BENCHMARK WE USED - HAMMERDB

HammerDB is an open-source benchmark tool that tests the database performance of many databases, including Oracle Database, Microsoft® SQL Server®, PostgreSQL®, MySQL™, and more. The benchmark includes built-in workloads derived from industry-standard benchmarks, such as a transactional (TPC-C-like) workload and a data warehouse (TPC-H-like) workload. For this study, we used the transactional workload. Our tests were not official TPC results and are not comparable in any manner. For more information, visit [hammerora.sourceforge.net](http://hammerora.sourceforge.net).

## INITIAL ISCSI CLIENT INSTALLATION AND CONFIGURATION

1. Install WS2012 R2 Datacenter.
2. Install updates.
3. Enable iSCSI service by pressing the Start button, typing iSCSI, and pressing Enter. When prompted, click Yes to start the iSCSI service and have it start automatically.
4. In the iSCSI Initiator Properties window, click the Configuration tab and record the initiator name displayed there.
5. Repeat steps 1 though 5 for the next three iSCSI clients.



# CONFIGURING THE SYSTEM UNDER TEST

## Initial setup

1. Install Windows Server 2012 R2 Datacenter.
2. Install updates.
3. Reboot the computer.
4. While the computer is booting, press the appropriate shortcut key to enter your RAID BIOS console.
5. In the RAID BIOS console, select the four hard drives to be tested, and disable the RAID controller on those disks.
6. Reboot your computer.

## Installing Storage Spaces and iSCSI Target Server on Windows Server 2012 R2

1. Open the Server Manager, and click Manage → Add Roles and Features.
2. On the Before You Begin screen, click Next.
3. Choose Role-based or feature-based installation, and click Next.
4. Choose the local server, and click Next.
5. Expand File and Storage Services → File and iSCSI services, and check File Server, Storage Services, and iSCSI Target Server. Click Next.
6. Leave default features, and click Next.
7. Review the settings, and click Install.

## Configuring Storage Spaces

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), and choose all the available disks. Click Next.
7. Review your selections, and click Create.
8. Right-click the storage pool you just created, and click New Virtual Disk...
9. On the Before You Begin screen, click Next.
10. Choose the storage pool, and click Next.
11. Name the virtual disk, check the Create storage tiers on this virtual disk box, and click Next.
12. Choose the Mirror storage layout, and click Next.
13. Select the Two-way mirror resiliency option, and click Next.
14. Choose Fixed provisioning, and click Next.
15. Choose Maximum size for both tiers, and click Next.
16. Review your selections, and click Create.
17. The New Volume Wizard will open when the virtual disk finishes creation, click Next on the Before You Begin screen.
18. Choose the server and virtual disk you created, and click Next.
19. Set the volume size to the maximum capacity, and click Next.

20. Assign a drive letter, and click Next.
21. Set the File system to NTFS, the Allocation unit size to Default, and name the Volume. Click Next.
22. Review your selections, and click Create.

## Configuring the iSCSI target server

1. In the Server Manager window, click File and Storage Services in the left pane.
2. Select Tasks → New iSCSI Virtual Disk.
3. In the New iSCSI Virtual Disk Wizard, select your local server and the Storage Spaces disk you created, and click Next.
4. Name the iSCSI virtual disk (we chose server1 for the first disk, server2 for the second disk, and so on), and click Next.
5. Make the iSCSI virtual disk 160 GB, make sure that Fixed size is selected, and click Next.
6. Select New iSCSI target, and click Next.
7. Name your new target (we followed the same scheme as the virtual disk: server1, server2, etc.), and click Next.
8. Click Add to add an iSCSI initiator.
9. Select Enter a value for the selected type, make sure that IQN is selected, and type the appropriate initiator name you recorded when setting up your iSCSI client. Click OK.
10. Click Next.
11. Make sure that CHAP and reverse CHAP is disabled, and click Next.
12. Review your iSCSI disk you created, and click Create.
13. Repeat steps 2 through 12 for the remaining servers.

## FINISHING THE ISCSI CLIENT INSTALLATION AND CONFIGURATION

### Installing MPIO

1. Open the Server Manager, and click Manage → Add Roles and Features.
2. On the Before You Begin screen, click Next.
3. Choose Role-based or feature-based installation, and click Next.
4. Choose the local server, and click Next.
5. Click next on the Server Roles window to move on to features.
6. Select Multipath I/O and click Next.
7. At the confirmation, click Install.
8. When the installation complete, click Close.
9. Open MPIO Properties and go to the Discover Multi-Paths tab.
10. Check Add support for iSCSI devices and click Add.
11. When asked whether to reboot, click Yes.

### Connecting the iSCSI clients to their iSCSI targets

1. Log in to the first iSCSI client.
2. Open iSCSI Initiator.

3. In the Quick Connect text field, type the IP address of the system under test, and click Quick Connect. A confirmation window of the iSCSI target you created for the client should appear. Click Done.
4. If connecting to the newer server, click on the connection you just added and then click Connect.
5. In the Connect To Target window, check Enable multi-path and click Advanced.
6. In the Advanced Settings window, click the Initiator IP and add the second NIC IP on the target server.
7. Repeat steps 5 and 6 two more times for the remaining two NICs.
8. Open the Server Manager, then click File and Storage Services in the left pane.
9. In the left pane, select Disks.
10. In the right pane, right-click the new disk, and select Bring Online.
11. Click Yes to confirm.
12. Right-click the newly online disk, and select New Volume.
13. Click Next to go past the Before you begin window.
14. Select the local server and the new disk, then click Next.
15. Accept the GPT notification by clicking OK.
16. Make sure that the volume size is equal to the available capacity, and click Next.
17. Select your drive letter (the letter does not matter, but make sure it is consistent across all iSCSI clients for ease of use), and click Next.
18. Accept the file system and allocation size, label your volume (we chose HDD for hard drives, and SSD for the solid state drives), and click Next.
19. In the confirmation window, click Next to start the volume creation.
20. In the results window, click Close.

## Installing 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 the I accept the license terms box, 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 the use Microsoft Update to check for updates (recommended) box, 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 the SQL Server Feature Installation radio button, 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 the radio button for Mixed Mode (SQL Server authentication and Windows authentication), and enter a password for the SQL Server system administrator (sa) account.
17. Click the Add Current User button.
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 HAMMERDB CLIENTS

1. Install Windows Server 2012 R2 Datacenter.
2. Install updates.
3. Download the most recent HammerDB release from <http://hammerora.sourceforge.net/download.html>.
4. Run the HammerDB installation file, select your language, and click OK.
5. When prompted, click Yes to install HammerDB.
6. At the Welcome window, click Next.
7. Accept the default install location and click Next.
8. Accept the default setup type and click Next to start the installation.
9. Click Finish to complete the installation.
10. Download Microsoft ODBC Driver 11 for SQL Server from <http://www.microsoft.com/en-us/download/details.aspx?id=36434>.
11. Run the installer you downloaded.
12. In the Welcome window, click Next.
13. Accept the terms of the license agreement and click Next.
14. Accept the default installation options, and click Next.
15. Click Install to begin the installation.
16. When the installation completes, click Finish to close the installer.

## RUNNING THE TEST

We used HammerDB to create a 5,000-warehouse TPC-C database on SQL Server, and then created a .bak file of the database.

Using that backup file and SQL Server's built-in restore options, we were able to create the databases on each SQL server. We pointed HammerDB clients, hosted on the client system, to each database on the SQL servers, and simultaneously ran the TPC-C job.

We captured various performance metrics on the SUTs during the run, such as CPU and RAM utilization, and drive reads and writes. We started all clients simultaneously, and gathered the results when the run finished. Follow these steps to recreate how we ran the test.

### Client 1 pre-test configuration

1. Open HammerDB.
2. Select Options → Benchmark.
3. In the Benchmark Options window, select MSSQL Server, and click OK.
4. In the left pane, expand TPC-C, then Driver Script, and double-click Options.
5. Use the following options for the TPC-C Driver Script:
  - SQL Server: server1 (or your first SQL server hostname)
  - SQL Server Port: 1433 (default)
  - SQL Server ODBC Driver: ODBC Driver 11 for SQL Server
  - Authentication: SQL Server Authentication
  - SQL Server User ID: sa (default)
  - SQL Server User Password: Your password
  - SQL Server Database: tpcc
  - TPC-C Driver Script: Timed Test Driver Script
  - Total Transactions per User: 1000000 (default)
  - Exit on SQL Server Error: unchecked (default)
  - Keying and Thinking Time: unchecked (default)
  - Checkpoint when complete: unchecked (default)
  - Minutes of Rampup Time: 2 (default)
  - Minutes for Test Duration: 20
6. Click OK.
7. In the left pane, double-click Load to load the driver script.
8. Click Options → Mode.
9. In the Mode Options window, select Master Mode, and click OK.
10. Click Yes.
11. Record the Master mode ID, and click OK.

### Additional client pre-test configuration

1. Open another instance of HammerDB.
2. Select Options → Benchmark.

3. In the Benchmark Options window, select MSSQL Server, and click OK.
4. In the left pane, expand TPC-C, then Driver Script, and double-click Options.
5. Use the following options for the TPC-C Driver Script:
  - SQL Server: server2 (or your second SQL server hostname)
  - SQL Server Port: 1433 (default)
  - SQL Server ODBC Driver: ODBC Driver 11 for SQL Server
  - Authentication: SQL Server Authentication
  - SQL Server User ID: sa (default)
  - SQL Server User Password: Your password
  - SQL Server Database: tpcc
  - TPC-C Driver Script: Timed Test Driver Script
  - Total Transactions per User: 1000000 (default)
  - Exit on SQL Server Error: unchecked (default)
  - Keying and Thinking Time: unchecked (default)
  - Checkpoint when complete: unchecked (default)
  - Minutes of Rampup Time: 2 (default)
  - Minutes for Test Duration: 20
6. Click OK.
7. In the left pane, double-click Load to load the driver script.
8. Click Options → Mode.
9. In the Mode Options window, select Slave Mode, enter the Master ID you wrote down previously, and click OK.
10. Repeat steps 1 through 9 for the remaining two servers.

## Running the test

1. Return to the master HammerDB instance, expand Virtual User in the left pane, and double-click Options.
2. Increase the number of virtual users to 128, check all checkboxes in the options window, and click OK.
3. Double-click Create.
4. Click the green arrow button to run the virtual users.
5. At the end of the test, gather your results from the four HammerDB instances.

## ABOUT PRINCIPLED TECHNOLOGIES



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