Intel + VMware delivered

Intel® Xeon® processor E7-4870 + VMware® vSphere™ 5.0 with 200GB databases, 1TB system RAM
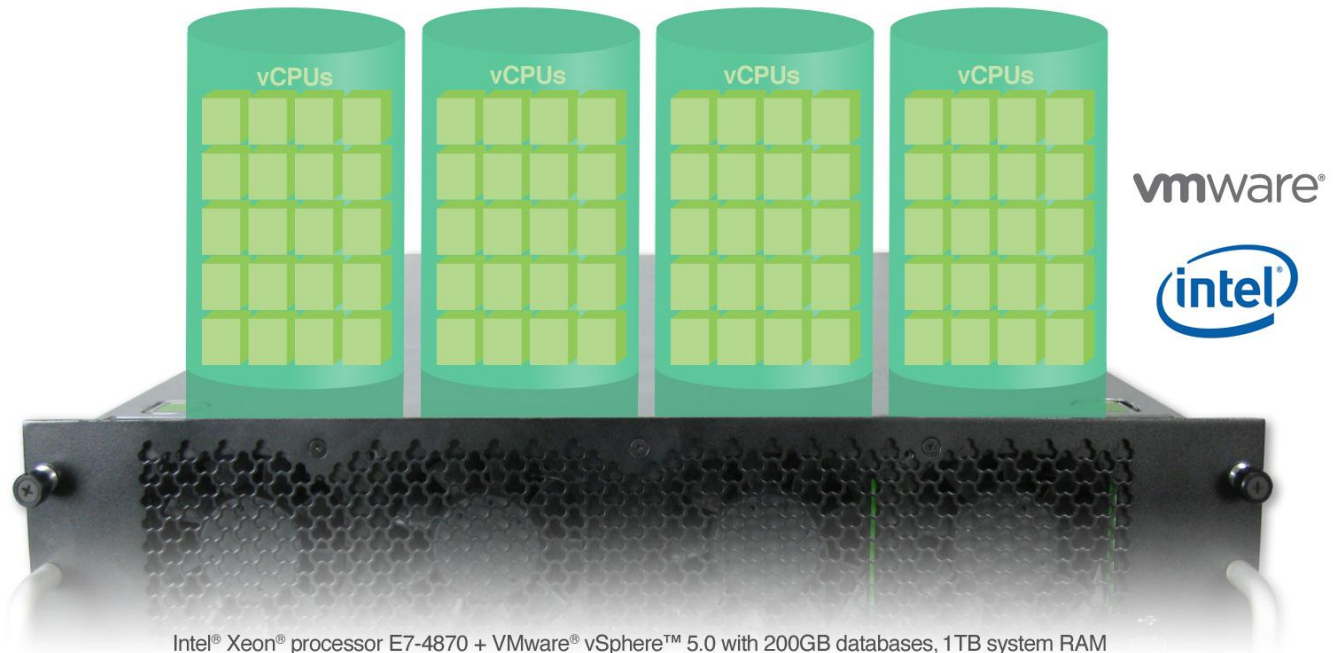
4 virtualized business-critical database applications

If your organization runs large business-critical database applications on expensive UNIX RISC systems, you may have felt stuck. Even as the percentage of enterprise workloads running on virtualized servers has exploded, you have faced a key question: Could industry-standard Intel® architecture-based servers deliver the performance you'd need to consolidate your applications via virtualization?

This study proves that the answer is yes.

On a single four-socket server with the newest Intel® Xeon® processor E7-4870 and VMware® vSphere™ 5.0, we ran four large database applications simultaneously, each with a 200GB database and in its own virtual machine. All delivered strong and consistent performance—and the server had plenty of capacity for future growth.

VIRTUALIZATION ROBUST ENOUGH TO SCALE WITH YOUR LARGE APPLICATIONS

Harnessing the power of the Intel® Xeon® processor E7 family

VMware vSphere 5.0 makes use of the power of the Intel® Xeon® processor E7 family. Among its notable features are the following:

- Full support for RAS features for reliability, availability, and serviceability, including Machine Check Architecture recovery (MCA-r)
- Intel® Trusted Execution Technology (Intel® TXT)
- Support for up to 2TB of system memory
- Full utilization of the 10-core, 20-thread processor, allowing 80 threads per four-socket server

The argument for migrating from a UNIX/RISC platform to industry-standard Intel-architecture servers running virtual machines (VMs) is straightforward enough: Reduce your capital and operational expenses while maintaining the same or better service levels. What's not to like? And what enterprise would opt out of lowering hardware, power consumption, and maintenance costs? Possibly yours, if your databases are both large and business critical.

Studies abound quantifying the dramatic "consolidation ratios" UNIX/RISC-to-Intel migrations make possible and the associated cost savings. However, because they feature small workloads, they don't reflect the scenario you're hoping to achieve—reliably running multiple large database applications, each in its own VM. VMware's most recent version of vSphere has stepped up to take full advantage of the Intel Xeon processor E7-4870's enormous potential, making such a proposition possible.

To learn just how well the Intel/VMware solution supports multiple large database applications, we ran Benchmark Factory's TPC-H-like workload against four virtual machines using 200GB databases. By fully utilizing the Intel Xeon processor E7-4870-based server's massive core count, this solution comfortably supported four 200GB databases. It did so without overcommitting resources, allowing all VMs to run in parallel with solid performance.

Our research suggests that a large UNIX/RISC-based, business-critical database application that was handling peaks of approximately 10,000 queries per hour was delivering good performance. For instance, in a concurrency and workload management study by the WinterCorp consulting group, researchers state that Nationwide Financial Services completes around 2,500 queries per hour, with a maximum of 10,000 queries per hour, using a TwinFin™ data warehouse appliance from Netezza®, an IBM® Company.[1] In our testing, each of the database applications in the four VMs far exceeded that many queries per hour, so each could replace an existing server running such a large business-critical database application.

These results show how your enterprise can maintain or even improve upon the performance of the UNIX/RISC platform while cutting your costs considerably.

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[1] http://www.netezza.com/documents/whitepapers/Concurrency-and-Workload-Management-WP.pdf

HOW MANY 200GB DATABASE APPS CAN THIS PLATFORM HANDLE WITH EASE?

We used Quest Software® Benchmark Factory® as our test engine, using its custom load scenario feature to create a TPC-H-like business-intelligence database workload. (While Benchmark Factory's workload is similar to the more widely known Transaction Processing Performance Council [TPC] benchmarks, the results are not directly comparable. In addition, benchmark results on different database sizes are not comparable.) We used Benchmark Factory's workload because it focuses on decision support systems, which run complex queries, examine large data volumes, and provide answers to important business questions. The Intel Xeon processor E7-4870-based server with VMware vSphere 5.0 ran four virtual machines with updated operating systems and database software as well as a 200GB Benchmark Factory-created database. We conducted three test runs and report the median run.

As Figure 1 shows, the four VMs achieved comparable Benchmark Factory TPC-H scores. All four VMs ran Benchmark Factory's TPC-H-like workload concurrently and completed their tasks in about the same time. Given that the scores are all over 10,000 queries per hour, each VM should be able to replace an existing business intelligence database server. The Intel Xeon processor E7-4870-based server was near 80 percent processor utilization for all three runs.

VM	Benchmark Factory QphH score	Run time (seconds)
VM 1	23,829	890
VM 2	24,528	872
VM 3	24,638	866
VM 4	24,806	870
Total/Average	**97,801**	**875**

Figure 1. The processing power and other capabilities of the Intel® Xeon® processor E7-4870-based server allowed all four VMs to run with consistent performance.

We provide server configuration information in Appendix A, our detailed test results in Appendix B, and our detailed test methodology in Appendix C.

SUMMARY

These results show the consistently strong performance you can expect using virtualization on an Intel Xeon processor E7-4870-based server running VMware vSphere 5.0 to run very large business-critical database applications. The implications for your enterprise are significant: You can enjoy the same reliable performance you have had with the UNIX/RISC platform while lowering hardware, power consumption, and maintenance costs.

APPENDIX A – SERVER AND STORAGE CONFIGURATION INFORMATION

Figure 2 provides detailed configuration information about the test server.

System	Intel® Xeon® processor E7-4870-based server
Power supplies	
Total number	4
Vendor and model number	Delta DPS-850FB
Wattage of each (W)	850
Cooling fans	
Total number	8
Vendor and model number	Delta PFB0812DHE
Dimensions (h x w) of each	3.50" x 3.50"
Volts	12
Amps	3.3
General	
Number of processor packages	4
Number of cores per processor	10
Number of hardware threads per core	2
CPU	
Vendor	Intel
Name	Xeon
Model number	E7-4870
Stepping	F2
Socket type	Socket 1567
Core frequency (GHz)	2.40
Bus frequency (GT/s)	6.4
L1 cache	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)
L3 cache (MB)	30
Platform	
Vendor and model number	Quanta QCI QSSC-S4R
Motherboard model number	31S4RMB00A0
Motherboard chipset	Intel® 7500 chipset
BIOS name and version	Intel QSSC-S4RQCI.01.00.S012.031420111618 (03/14/2011)
BIOS settings	Intel® Virtualization Technology Enabled
Memory module(s)	
Total RAM in system (GB)	1,024
Vendor and model number	Samsung M393B2K70CM0-CF8
Type	DDR3 PC3-8500
Speed (MHz)	1,066
Speed running in the system (MHz)	1,066
Timing/Latency (tCL-tRCD-tRP-tRASmin)	7-7-7-20
Size (GB)	16

System	Intel® Xeon® processor E7-4870-based server
Number of RAM module(s)	64
Chip organization	Double-sided
Rank	Quad
Hard disk	
Vendor and model number	Seagate ST9146803SS
Number of disks in system	2
Size (GB)	146
Buffer size (MB)	16
RPM	10,000
Type	SAS
Operating system	
Name	VMware ESXi 5.0.0
File system	EXT3
Kernel	5.0.0
Build	441354
Language	English
Ethernet	
Vendor and model number	Intel 82576NS Gigabit Ethernet Controller
Type	Integrated
Optical drive(s)	
Vendor and model number	Sony Optiarc AD-7580S
Type	DVD-RW
USB ports	
Number	5
Type	USB 2.0

Figure 2. Server configuration information.

APPENDIX B – DETAILED TEST RESULTS

Figure 3 presents our results from all three test runs.

VM	Benchmark Factory TPC-H score	Run time (seconds)	CPU utilization
Run 1			
VM 1	24,486	867	
VM 2	24,478	875	
VM 3	24,286	888	
VM 4	24,816	867	
Total/Average	**98,066**	**874**	**84%**
Run 2			
VM 1	23,829	890	
VM 2	24,528	872	
VM 3	24,638	866	
VM 4	24,806	870	
Total/Average	**97,801**	**875**	**83%**
Run 3			
VM 1	24,495	873	
VM 2	24,254	876	
VM 3	24,587	870	
VM 4	24,382	880	
Total/Average	**97,718**	**875**	**83%**

Figure 3. Results from all three test runs.

APPENDIX C – DETAILED TEST METHODOLOGY

In this appendix, we present the steps we followed as we conducted our testing. 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. Benchmark Factory is a more flexible, simpler, and less expensive alternative to Oracle Real Application Testing. With this workload replay and scheduling software, you can eliminate slow SQL database performance and dramatically simplify high performance database management. More information on Benchmark Factory is available at http://www.quest.com/benchmark-factory/

Setting up and configuring the EMC storage

We used an EMC® CLARiiON® Fibre Channel connected SAN for this testing. The CX3-40 has two storage processors SP-A and SP-B. We used three QLogic® QLE2462 dual-port host bus adapters (HBA) in our server for testing. We cabled six HBA ports to each SP (A and B) on the SAN to balance the load between SPs. We used seven enclosures of disks on the SAN; with one exception, each enclosure had 15 disks. One of the trays only had 13 disks.

We ran one SQL Server 2008 R2 instance per VM. We created six RAID groups for our test server, two for VM operating systems and four for VM databases/logs. Each of the six RAID groups was composed of 16 disks, and set up as a RAID 0. We then created six 1,066GB LUNs, one on each RAID group.

Installing VMware vSphere 5.0

1. Turn on the server, and insert the vSphere CD.
2. Once the server boots from the CD, it should go into an automatic setup process. This should take about 45 minutes.
3. Once the setup completes, VMware vSphere boots and is ready for use.

Installing vSphere client on a management workstation

1. Configure your management workstation to be on the same subnet as your vSphere server. In Internet Explorer, navigate to the IP address of your vSphere server.
2. Accept certificate warnings by clicking Continue to this website (not recommended), and continue.
3. Click Download vSphere Client to download the vSphere client.
4. Choose Run to Install.
5. Choose your language, and click OK.
6. At the Welcome screen, click Next.
7. Read the End-User Patent Agreement, and click Next.
8. Accept the license terms, and click Next.
9. Enter user and organization details, and click Next.
10. At the Destination folder screen, click Change if you wish to change your install destination; otherwise click Next.
11. Click Install.
12. To complete the installation, click Finish.

Creating a virtual machine with vSphere

1. Click Start→All Programs→VMware→VMware vSphere client.
2. Enter the IP address or hostname, user name, and password, and click Login.
3. Right-click on the host, and choose New Virtual Machine.
4. Choose Custom, and click Next.
5. Assign a name to the virtual machine, and click Next.
6. Select a datastore for the virtual machine files, and click Next.
7. Choose Virtual Machine Version: 8, and click Next.
8. Choose Microsoft Windows, then Microsoft Windows Server 2008 R2 (64-bit). Click Next.
9. Select the number of virtual processors and cores per virtual processor you want to allocate (20 virtual processors and one core per virtual processor in our case), and click Next.
10. Select the amount of RAM you want to allocate (245 GB in our case), and click Next.
11. Select 1 as the number of NICs, select your network, and select your desired network adapter. Click Next.
12. Choose LSI Logic SAS as the SCSI controller, and click Next.
13. Select Create a new virtual disk, and click Next.
14. Choose disk size, store location, select Flat Disk, and click Next.
15. Select the appropriate virtual device node, and click Next.
16. Click Finish.

Installing Windows Server 2008 R2 Datacenter Edition on the hosts

1. Insert the installation DVD for Windows Server 2008 R2 x64 into the drive.
2. In vSphere, right-click the virtual machine, and choose Edit Settings.
3. Click CD/DVD drive 1, click the Host Device radio button, and choose the appropriate drive.
4. Click OK.
5. Right-click the machine, and choose Power→Power On.
6. Right-click the machine, and choose Open console.
7. At the Language Selection Screen, click Next.
8. Click Install Now.
9. Select Windows Server 2008 R2 Datacenter (Full Installation), and click Next.
10. Click the I accept the license terms check box, and click Next.
11. Click Custom.
12. Click Drive options (advanced).
13. Ensure you select the proper drive, and click New.
14. Click Apply.
15. Click Next.
16. At the User's password must be changed before logging on warning screen, click OK.
17. Set the Administrator password, and click the arrow to continue.
18. At the Your password has been changed screen, click OK.

Installing VMware tools on the Virtual machine

1. Right-click the virtual machine, select Guest→Install/Upgrade VMware tools.
2. Click OK to close the VMware Tools warning.
3. Right-click the VM, and choose Open Console.
4. Double-click Run setup.exe
5. At the Welcome screen, click Next.
6. Select Typical Installation, and click Next.
7. Click Install.
8. After installation is complete, click Finish, and restart the virtual machine.

How to create additional virtual disks

1. Right-click the virtual machine, and select Edit Settings.
2. Click Add…
3. Select Hard Disk, and click Next.
4. Select Create a new virtual disk, and click Next.
5. Change the size of your virtual disk to 300 GB, select your database datastore, and click Next.
6. Change your virtual device node to SCSI (1:0), and click Next.
7. To complete the creation of your virtual disk, click Finish.
8. Click SCSI Controller 1.
9. Under SCSI Controller Type, click Change.
10. Select VMware Paravirtual, and click Next.
11. Repeat steps 1 through 7 to create an additional 10 GB virtual disk to store tempdb.

Enabling Large Pages

1. Click Start→Administrative Tools→Local Security Policy.
2. Click Local Policies→User Rights Assignment.
3. Right-click Lock Pages in Memory, and select Properties.
4. Click Add User or Group…
5. Type Administrator, and click Check Names.
6. Click OK.
7. Click OK.

Setting up network configuration on the server

1. Click Start→Control Panel.
2. Click Network and Internet.
3. Click View network status and tasks.
4. Click the Local Area Connection assigned to client/server network traffic.
5. Click Properties.
6. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
7. In the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
8. Enter a valid static IP address, subnet mask, and default gateway.
9. Click OK, and click Close to exit.

Tuning the virtual machine

1. Click Start→All Programs→VMware→VMware vSphere client.
2. Right-click your virtual machine, and click Edit Settings.
3. Click the Resource tab.
4. Click Advanced CPU.
5. Fill in the appropriate CPU binding (0-19, 20-39, 40-59, 60-79).
6. Click Advanced Memory.
7. Click use memory from nodes, and select the appropriate NUMA node (0, 1, 2, 3).
8. Click the Options tab.
9. Click General.
10. Click Configuration.
11. Click Add Row.
12. Type `numa.vcpu.maxPerVirtualNode` in the first column and `32` in the second.
13. Click Add Row.
14. Type `numa.vcpu.preferHT` in the first column and `true` in the second.
15. Click OK.

Installing system updates in Windows Server 2008 R2

We installed all the following updates available on April 13, 2011 on each virtual machine:

- Security Update for Windows Server 2008 R2 x64 Edition (KB2503658)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2506223)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2425227)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2511455)
- Update for Windows Server 2008 R2 x64 Edition (KB2505438)
- Update for Windows Server 2008 R2 x64 Edition (KB2511250)
- Update for Windows Server 2008 R2 x64 Edition (KB2506014)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2497640)
- Windows Internet Explorer 9 for Windows Server 2008 R2 for x64-based Systems
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB2508272)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2507618)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2510531)
- Update for Windows Server 2008 R2 x64 Edition (KB2484033)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2509553)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2506212)
- Security Update for .NET Framework 3.5.1 on Windows 7 and Windows Server 2008 R2 SP1 for x64-based Systems (KB2446710)
- Update for Windows Server 2008 R2 x64 Edition (KB2524375)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2508429)

Installing SQL Server 2008 R2 on the VM

1. Insert the DVD into the physical DVD drive.
2. Right-click the VM, and choose Power→Power On.
3. Right-click the VM, and choose Open Console.
4. Click the connect CD/DVD button. Choose CD\DVD Drive 1, Connect to host device.
5. On the Autoplay menu, click Run SETUP.EXE.
6. If the application prompts you to install the .NET Framework, click OK to install.
7. At the SQL Server Installation Center screen, select Installation.
8. Click New Installation or add features to existing installation.
9. At the Setup Support Rules page, click OK.
10. Enter the product key, and click Next.
11. At the License Terms screen, accept the license terms, and click Next.
12. At the Support Files screen, select Install.
13. At the Setup Support Rules screen, click Next.
14. At the Setup Role screen, select SQL Server Feature Installation, and click Next.
15. At the Feature Selection screen, choose Database Engine Services, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete, and click Next.
16. At the Installation Rules screen, click Next.
17. At the Instance Configuration screen, click Next.
18. At the Disk Space Requirements screen, click Next.
19. At the Server Configuration screen, type `Administrator` as the account name and `Password1` as the password for the SQL Server Agent and the SQL Server Database Engine services, and click Next.
20. At the Database Engine Configuration screen, select Mixed Mode as the authentication mode, enter your password for the (sa) account, and click Add Current User to add the Administrator to the SQL server administrator's account. Click Next.
21. At the Error Reporting screen, click Next.

22. At the Installation Configuration Rules screen, click Next.
23. At the Ready to Install screen, click Install.
24. At the Complete screen, click Close.

Configuring SQL Server to run Benchmark Factory 6.5

1. Click Start→All Programs→Microsoft SQL Server 2008 R2→SQL Server Management Studio.
2. Select SQL Server Authentication, type `sa` and `Password1` as your login and password respectively, and click Connect.
3. Right-click Databases, and select New Database.
4. Set your initial size for your database and log files. This will pre-grow the database and logs to the size you wish to create.
5. Click in the Path Column, set a path for the database and logs to your appropriately sized virtual hard disk, and click OK.

Moving and splitting tempdb

1. Click Start→All Programs→Microsoft SQL Server 2008 R2→SQL Server Management Studio.
2. Click New Query.
3. Type and run the following query to move tempdb:

```
use master;
GO
ALTER DATABASE tempdb
MODIFY FILE ( NAME = tempdev , FILENAME = 'F:\TempDB\tempdb.mdf' )
GO
ALTER DATABASE tempdb
MODIFY FILE ( NAME = templog , FILENAME = 'F:\TempDB\tempdb.ldf' )
GO
```

4. Expand Databases→System Databases, and right-click tempdb.
5. Click Properties.
6. Click Files.
7. Click Add three times.
8. Set the Initial Size, Path, and File Name for your three new tempdb files, and click OK.

Setting up the client

We used a Supermicro 6026T-NTR+ as a host server to virtualize clients. We installed a fresh copy of Windows 7

Professional Edition on each client machine.

Installing Benchmark Factory on the client

1. Right-click BenchmarkFactory_6_5_0_332.msi and select Install.
2. At the Welcome Screen, click Next.
3. Accept the License Terms, and click Next.
4. At the Destination Folder screen, click Next.
5. At the Ready to Install the Program screen, select Yes, install the default repository database, and click Install.
6. At the Installation Wizard Completed screen, click Finish.
7. Click Start→All Programs→Quest Software→Benchmark Factory for Databases.
8. At the Benchmark Factory repository tables prompt, click OK.
9. At the Load Scenario Wizard, click Cancel.
10. Click Help, and select Licensing.
11. Select Modify→Edit Key, and enter Benchmark factory Authorization Key and Site Message.

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12. Click OK, and click Close. Restart Benchmark Factory.

Configuring Benchmark Factory

1. Click Start→All Programs→Quest Software→Benchmark Factory for Databases.
2. At the Welcome to the Load Scenario Wizard screen, click Next.
3. At the Select Load Scenario screen, select Industry standard benchmarks (TPC-C, TPC-E, TPC-H…), and click Next.
4. At the Select Benchmark screen, select TPC-H, and click Next.
5. At the Select Profile screen, click New.
6. At the Welcome to the Profile Creation wizard, click Next.
7. Choose Microsoft SQL Server (Obsolete), and click Next.
8. At the Connection Information screen, enter the server name, select SQL Server Authentication as the Authentication mode, and enter login credentials.
9. Select the TCPH database, and click Next.
10. At the Profile Name screen, enter a name for the newly created profile, and click Next.
11. Click Finish.
12. At the Select Profile screen, select the newly created profile, and click Next.
13. At the Benchmark Scale screen, enter the appropriate benchmark scale, and click Next.
14. Select Create a new Benchmark Factory Script file, and click Next.
15. Uncheck Do you want the job to be automatically submitted to the jobs Queue?, and click Finish.

Executing the benchmark

We completed the following steps each time we executed a full run in order to best simulate a business intelligence scenario. We performed three runs on each server to ensure that our results were valid representations of server performance. We ran steps 7 and 8 on only the first run.

Starting the run

1. Turn on all four virtual machines one at a time to best allocate server resources to the VMs.
2. Run the following script to start SQL Server on the VMs under test:

```
cd "c:\Program Files\Microsoft SQL Server\MSSQL10_50.MSSQLSERVER\MSSQL\Binn"
sqlservr.exe -c -x -E
```

3. Open Benchmark Factory on all four clients.
4. Wait 10 minutes.
5. Queue up the Power task.
6. Wait until Benchmark Factory finishes.
7. Run the following SQL script to disable SQL statistics:

```
USE [master]
GO
ALTER DATABASE [tpch150s] SET AUTO_CREATE_STATISTICS OFF
GO
ALTER DATABASE [tpch150s] SET AUTO_UPDATE_STATISTICS OFF
GO
ALTER DATABASE [tpch150s] SET DATE_CORRELATION_OPTIMIZATION ON
GO
```

8. Restart all four virtual machines.
9. Wait 10 minutes.

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10. Queue up the Power task. This run is meant to be used as a tuning run to load the database into memory.
11. Wait 10 minutes.
12. Queue up the Power task.

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

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.