

Choose the new server that will help your small business grow

Why to upgrade to a new server powered by Intel instead of a desktop

As the owner of a small business, you're constantly juggling your obligations. From budget to customer service, it's on you to make sure everything runs smoothly. So when it comes to the technology that powers your business, you need something that enables your work without creating new problems. Maybe you have an old server that worked okay a few years ago, but it's slowed way down. Or maybe you're looking for your first server. Either way, you're likely choosing between a desktop and a real server.

We can help. Here at PT, we compared a new server powered by the Intel® Xeon® Processor E3 v5 Product Family to a recently released desktop and an older server. We looked at how each system handled the work that lets your staff look up data and your customers make orders: database work.

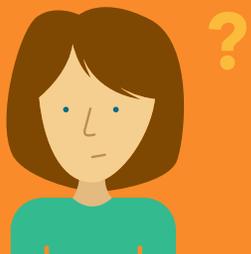
Our hands-on approach proved that a new server could handle more than twice the database work of the older server and 1.8 times the work of the desktop. With that capability—plus a host of other server features we'll explore later—a new server powered by Intel Xeon processor E3 v5 could help your business grow and thrive.

With a new server powered by the Intel Xeon Processor E3 v5 Product Family, you could do...

Up to
2x

...of an older server or recent desktop in the same amount of time.

the database work



Anna's old server is failing, and her staff are losing productivity. Her law office needs an upgrade.



Bill set up a server for his dental practice a few years ago, but it's slowing down. He wants a new solution.

Putting your hardware options to the test

In our office in Research Triangle Park, North Carolina, we set up three possible options for the hardware that holds your databases:

Brand-new server powered by Intel Xeon processors E3 v5:

This new server has the latest features and technologies to help support your databases and your business for several years to come.

Recently released desktop: New hardware is typically faster than older hardware, but a desktop might not have all the features that a real server provides. We'll explore that in this paper.

Five-year-old server: A five-year-old server of the type that many companies might have bought new when it first came out—but never upgraded. You may have one of these in your office today.

For an operating system, the new server and desktop both ran Microsoft® Windows Server® 2016, which offers the latest Windows Server features. The older server ran Windows Server 2012 R2.

After setting them up, we ran the DVD Store 3 tool (DS3) on all three systems. DS3 simulates an online store selling DVDs, measuring how many customer orders the system can handle while maintaining a reasonable response time. We chose DS3 because it's an industry-standard tool for comparing the amount of database work different systems can deal with. In real life, "database work" might translate to:

- A nurse updating a patient's file with a new allergy
- A salesperson pulling information about a customer before sending out a sales email
- A consumer placing orders for your products or services on your website
- An HR assistant entering reimbursements for travel costs
- And many more tasks like these

If a system can do more database work, it means it can do more of those tasks at the same time. That has the potential to improve the experiences of both your customers and staff in a lot of different ways.

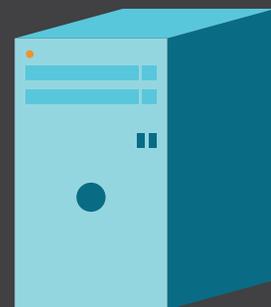
To show how choosing a new server might benefit you, we explored the stories of two hypothetical companies considering an upgrade: a law firm and a dental practice.



What is a server?

A server is basically a computer, but with more powerful components. Those components allow for better multi-tasking and permit many people to access information on the server at the same time. Servers also tend to run different operating systems than normal computers and include several special software and hardware features that allow an entire business—rather than just one person—to use them. Companies use servers for all kinds of things, including running their websites, analyzing data, and storing information of all kinds.

In this report, we talk about the option of using a desktop as a server. If your desktop is powerful enough, it is possible to configure it so it acts like a server. But a "real" server (a system explicitly designed to be a server) may have features that a desktop lacks. We'll explore that more later in the paper.

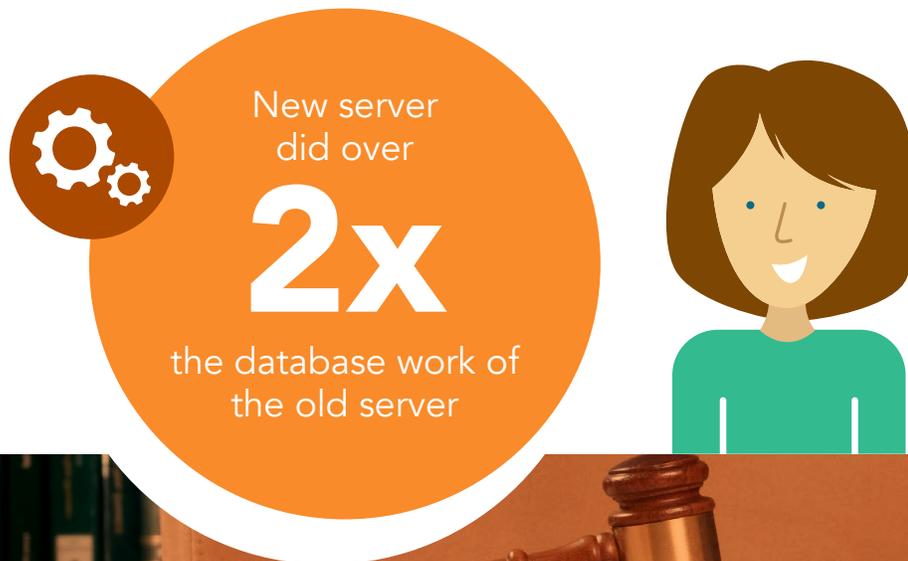


Give your employees faster data access

When Anna started her law firm four years ago, a database was the last thing on her mind. But as she got her business up and running, she realized she needed someplace secure to store her clients' data. She bought a lightly used server and hired an IT company to set it up.

It worked fine for a while, but now it's really starting to slow down. Her associates are complaining about how long it takes them to access or input client data, and it's causing problems for productivity. Anna's business partner thinks they should just tough it out, but Anna's willing to spend the money on something new if it will mitigate those delays.

When we tested a brand-new server powered by Intel Xeon processors E3 v5 against a five-year-old server like Anna's, the new server handled over twice the database work of the old server. (See [Appendix C](#) for our full test results.) With their clients' data stored on this new solution, Anna's associates wouldn't have to wait as long to add data from their meetings or pull client information. They can get more work done without getting frustrated at their computers—time they can use to take on new client work. Choosing this new server just might give Anna's law firm the room to breathe it needs in order to grow.



How servers can make IT management easier

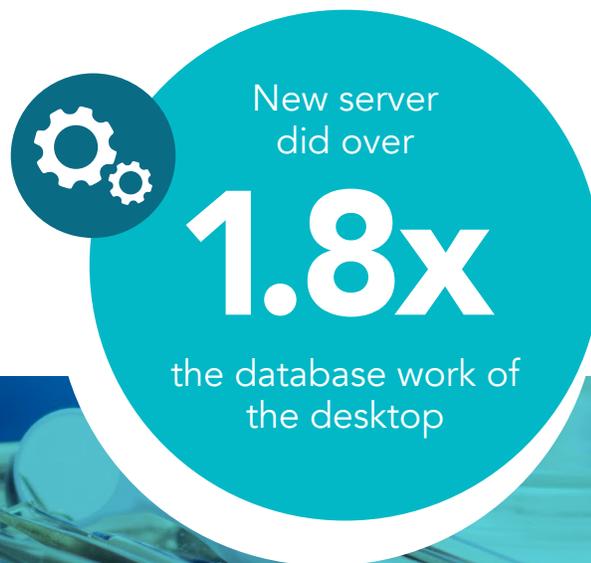
Servers often come with management features that can warn you of technical issues and diagnose them before they cause problems. They can also let you manage the server remotely, like when you're working from home or traveling, and make it easier to update software and run other basic management tasks. You don't have to use these features, and we didn't test them in this report, but having them in your back pocket might be very helpful as your business grows.

Enable your customers to pay their bills faster

Bill relies on his databases to hold all kinds of sensitive data, from his patients' medical records to their bill pay to his own company's HR. His dental practice has used a desktop as a server for four or five years now. But one day last week, none of his dental hygienists could enter updates to patients' medical histories without long delays. And his customers have started complaining about how long it takes to pay their bills on his website. He knows he needs new hardware. Now, he's trying to decide between two options: another desktop or a new server.

Our testing indicates that if he wants his hardware to be able to handle more database work—now and in the future—he should go with the server. It handled 81.6 percent more work than the desktop in the same amount of time. (For full test results, see [Appendix C](#).) If Bill went with this option, more of the assistants could enter updates to patient files at the same time. His customers are less likely to have trouble paying their bills, and he can do the HR work he needs without long wait times.

By choosing this new Intel processor-powered server instead of an equivalent desktop, he would be choosing a solution that gave his practice the quick, easy access that his staff and customers value.



What server virtualization is and how it can help your business

Let's say Bill wants to set up a new data entry system for his hygienists. He's not sure if it'll work, so he'd like to test it separately from the rest of his applications. That way, the new system doesn't mess anything up if it fails.

Bill can do just that with virtualization. When you virtualize, you basically split up the resources of the server so it acts like a lot of independent computers called virtual machines (VMs). Bill can set up a test VM to try the new system, and if it crashes, it's no big deal, because that VM was set apart from the rest of the server. If he had tried it without virtualization, that crash might have brought down his whole office.

You don't have to use virtualization now—or ever—but it can have some helpful benefits. It makes it easier for you to use all the resources in your server more efficiently. It can also help out with things like trying out software updates and recovering quickly if your system goes down.

When we tried virtualizing with the desktop and older server, we could run only two VMs before they ran out of the resources they needed to function. But the new server powered by Intel supported three VMs, each with enough resources to run just fine without conflicting with each other. The ability to support more VMs can give your business more options down the line, even if you aren't virtualizing now.

What the new server offered—that the desktop and older server didn't

When you're choosing new hardware for your company, it's crucial to consider how much database work each option can handle. Our testing proved that the new server with Intel processors did better on that metric than either the desktop or the older server. But there are also a lot of other good reasons to choose the new Intel processor-powered server over a desktop or legacy server. Let's break them down.

The most power-efficient option we tested: Hardware always requires power, but the more power-efficient your system is, the better. We measured "performance per watt," which divides the amount of work the system did by the amount of power it required. The new server powered by Intel gave us up to 96.9 percent greater performance per watt than the competition, putting every watt to its best use. (See [Appendix C](#) for full results.)

Storage that can handle heavy use: The type of storage your system uses can make a big difference in how quickly it runs your applications and how safe it keeps your data. The new server we tested had two 800GB enterprise-class Intel S3610 solid-state drives (SSDs). Compared to hard drives, SSDs are generally faster and more power-efficient, which can help you save on your power bill, and they can contribute to lower wait times for users. For more on Intel SSDs, including how they work together with Intel processors, see <http://www.intel.com/content/www/us/en/solid-state-drives/solid-state-drives-ssd.html>.

Keep your data safe: The new Intel processor-powered server with Intel SSDs also included a hardware RAID controller, which helps protect you from data loss by making multiple copies of your data on different drives. That way, if one drive fails, the other drive keeps your information safe and lets your server keep running. If you need fast storage and can't afford data loss, it's a huge boon. In contrast, the desktop had a single 1TB hard drive and no RAID controller. That's pretty typical for desktops, which often lack these data protection features and the added speed that comes with components designed for business workloads.

More network connections: If you have a ton of traffic on your server—like a flood of customers all trying to buy a product simultaneously, or everyone in your office trying to load a lot of big files at the same time—having more network connections can make all that traffic easier to handle. The new Intel processor-powered server we tested offered four distinct network connections, though the workload we used for testing didn't require all four to function. The older server, on the other hand, had only two, and the desktop only one.

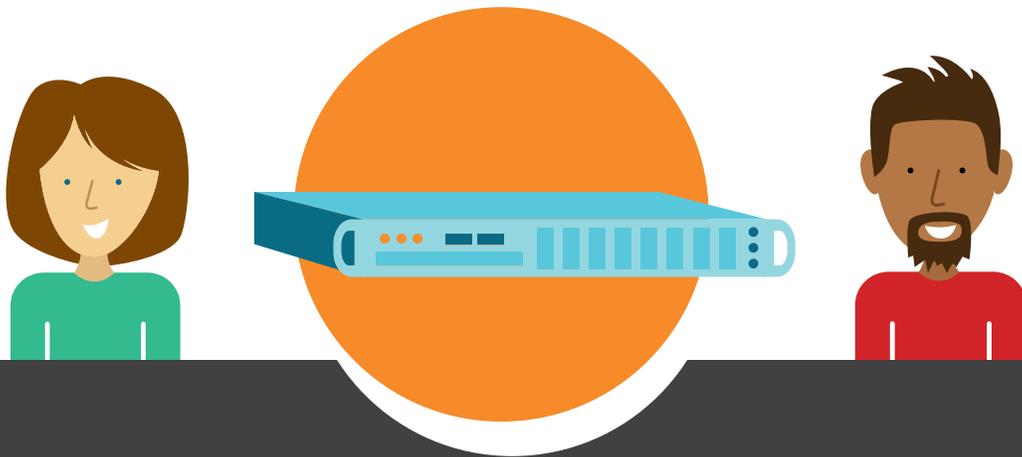


Keep your coworkers and customers happy with a new Intel processor-powered server

Anna and Bill both chose to go with the new server instead of sticking with their old server or trying a desktop as a server. A few months out, they're happy with their choices.

Anna's associates are able to access their client information quickly and easily without keeping the customer waiting on the other end of the phone. The firm also has plenty of room for more clients in their databases, so their tech isn't limiting their growth. In Bill's office, the dental assistants aren't dealing with slow database access, so appointments are moving more quickly. Patients haven't complained about bill pay, either, giving the company a steadier flow of income with higher customer satisfaction.

When we tested all three options available to Anna and Bill, it was clear that the new server was the best choice to help their databases, and therefore their companies, grow. If your business is in a similar situation, consider upgrading your old tech to a new server powered by the Intel Xeon Processor E3 v5 Product Family.



Do more database work with room to grow.



On November 17, 2016, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on November 29, 2016.

Appendix A: What we tested

The following table provides detailed configuration information for the server under test.

System configuration information	Legacy server based on the Intel Xeon processor E3-1280	Recently released desktop based on the Intel Core i5 processor	New server based on the Intel Xeon Processor E3 v5 Product Family
BIOS name and version	American Megatrends Inc 2.2	American Megatrends Inc. A.A0	American Megatrends Inc. 1.0b
Non-default BIOS settings	N/A	N/A	N/A
Operating system name and version/build number	Windows Server 2012 R2	Windows Server 2016	Windows Server 2016
Date of last OS updates/patches applied	11/17/16	11/17/16	11/17/16
Power management policy	Balanced	Balanced	Balanced
Processor			
Number of processors	1	1	1
Vendor and model	Intel Xeon E3-1280	Intel Core™ i5 6600	Intel Xeon E3-1240 v5
Core count (per processor)	4	4	4
Core frequency (GHz)	3.50	3.30	3.50
Stepping	D2	R0	R0
Memory module(s)			
Total memory in system (GB)	32	32	64
Number of memory modules	4	2	4
Vendor and model	Micron MT18JSF1G72AZ	Samsung M391A2K43BB1-CPBQ	Samsung M391A2K43BB1-CPBQ
Size (GB)	8	16	16
Type	PC3-14900E	PC4-17000	PC4-17000
Speed (MHz)	1866	2133	2133
Speed running in the server (MHz)	1333	2133	2133
Storage controller			
Vendor and model	N/A	N/A	Intel RAID Controller RS3DC080
Cache size	N/A	N/A	1GB
Firmware version	N/A	N/A	4.660.00-8102
Driver version	N/A	N/A	6.712.13.0

System configuration information	Legacy server based on the Intel Xeon processor E3-1280	Recently released desktop based on the Intel Core i5 processor	New server based on the Intel Xeon Processor E3 v5 Product Family
Local storage			
Number of drives	1	1	2
Drive vendor and model	Western Digital® VelociRaptor WD1000CHTZ	Western Digital VelociRaptor WD1000CHTZ	Intel S3610 SSDSC2BX800G4
Drive size (GB)	1000	1000	800
Drive information (speed, interface, type)	10K, 6Gb SATA, HDD	10K, 6Gb SATA, HDD	6Gb SATA SSD
Network adapters			
First type of adapter			
Vendor and model	Intel 82574L and 82579LM Gigabit Network Controller	Realtek Gigabit Network Adapter	Intel I210 Gigabit Network Controller
Number and type of ports	1 x 1Gb Ethernet2	1 x 1Gb Ethernet	4 x 1Gb Ethernet4
Driver version	12.6.47.1	9.1.404.2015	12.15.184.0
Second type of adapter			
Vendor and model	Intel 82579LM Gigabit Network Controller	N/A	N/A
Number and type of ports	1 x 1Gb Ethernet	N/A	N/A
Driver version	12.15.31.4	N/A	N/A
Cooling fans			
Vendor and model	Nidec® Ultraflo W40S12BMA5-57	Antec VSK4000E rear exhaust fan	Delta Electronics, Inc. FFB0412UHN
Number of cooling fans	2	1	4
Power supplies			
Vendor and model	3Y Power Technology YM-5201D	Cooler Master RS-400-PSAR-13	Supermicro® PWS-350-1H
Number of power supplies	1	1	1
Wattage of each (W)	200	120	350

Appendix B: How we tested

Configuring the legacy server

We installed the latest updates to all systems on November 17, 2016 and then disabled automatic updates.

Installing Microsoft Windows Server 2012 R2 Standard Edition

1. Insert the Windows Server 2012 R2 installation media into the CD/DVD drive, and restart the server.
2. Press any key when prompted to boot from DVD.
3. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
4. Click Install now.
5. When the installation prompts you, enter the product key.
6. Select Windows Server 2012 R2 Standard (Server with a GUI), and click Next.
7. Check I accept the license terms, and click Next.
8. Click Custom: Install Windows only (advanced).
9. Click New, enter 81920 MB for the size, and click Apply.
10. At the prompt alerting you to Windows creating additional partitions for system files, click OK.
11. Click Next, at which point Windows begins automatically and restarts automatically after completing.
12. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
13. Log in with the password you set up previously.
14. Server Manager will open automatically. Click Tools→Computer Management.
15. Click Disk Management.
16. Right click on the Unallocated space and click New Simple Volume...
17. At the Welcome screen, click Next.
18. At the Specify Volume Size screen, click Next.
19. At the Assign Drive Letter or Path screen, verify that D: is selected and click Next.
20. At the Format Partition screen, click Next.
21. Click Finish.

Installing Microsoft Hyper-V™

1. Open Server Manager, and click Manage→Add Roles and Features.
2. At the Before You Begin screen, click Next.
3. At the Installation Type screen, click Next.
4. At the Server Selection screen, click Next.
5. At the Server Roles screen, check Hyper-V. At the prerequisite pop-up, click Add Features. Click Next.
6. At the Features screen, click Next.
7. At the Hyper-V screen, click Next.
8. At the Virtual Switches screen, click Next.
9. At the Virtual Machine Migration screen, click Next.
10. At the Default Stores screen, change the default location for virtual hard disk files to D:\Virtual Hard Disks and click Next.
11. At the Confirmation screen, check to automatically restart the server after installation, and click Yes at the prompt.
12. Click Install.

Creating the first VM

1. Launch Hyper-V Manager and select the host server in the left pane.
2. In the right pane, click New→Virtual Machine...
3. At the Before You Begin screen, click Next.
4. At the Specify Name and Location screen, give the VM a name, and click Next.
5. At the Specify Generation screen, select Generation 2, and click Next.
6. At the Assign Memory screen, type 12288 MB, and click Next.
7. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.
8. At the Connect Virtual Hard Disk screen, create a new disk, enter 80 GB, and click Next.
9. At the Installation Options screen, click Install an operating system from a bootable image file, and browse to select a Windows Server 2012 R2 Standard installation .iso.

10. Click Next.
11. At the Summary Screen, click Finish.
12. In the Virtual Machines list, right-click the newly created VM, and click Settings.
13. In the VM Settings window, select Processor, and set the Number of virtual processors to be 4.
14. Click Apply.
15. Click OK.

Installing the VM operating system on the first VM

1. Start the VM.
2. Press any key to boot from CD or DVD when prompted.
3. At the Language Selection screen, click Next.
4. Click Install Now.
5. Enter the product key and click Next.
6. Select Windows Server 2012 R2 Standard (Server with a GUI) edition, and click Next.
7. Click I accept the license terms, and click Next.
8. Click Custom.
9. Click Next.
10. At the User's password must be changed before logging on warning screen, click OK.
11. Enter the desired password for the administrator in both fields, and click the arrow to continue.
12. At the Your password has been changed screen, click OK.

Installing Microsoft SQL Server® 2014 on the first VM

1. Prior to installing, add the .NET Framework 3.5 feature to the server.
2. Mount the installation DVD for SQL Server 2014.
3. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2014 DVD, and double-click it.
4. In the left pane, click Installation.
5. Click New SQL Server stand-alone installation or add features to an existing installation.
6. Select the Enter the product key radio button, and enter the product key. Click Next.
7. Click the checkbox to accept the license terms, and click Next.
8. Click Use Microsoft Update to check for updates, and click Next.
9. Click Install to install the setup support files.
10. If there are no failures displayed, click Next.
11. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
12. 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.
13. At the Installation Rules screen, after the check completes, click Next.
14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Server Configuration screen, choose NT Service\SQLSERVERAGENT for SQL Server Agent, and choose NT Service\MSSQLSERVER for SQL Server Database Engine. Change the Startup Type to Automatic. Click Next.
16. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
17. Enter and confirm a password for the system administrator account.
18. Click Add Current user. This may take several seconds.
19. At the Ready to Install screen, click Install.
20. After installation completes, click Close.
21. Close the installation window.
22. Open SQL Server 2014 Configuration Manager, and expand Protocols for MSSQLSERVER.
23. Right-click Named Pipes, and choose Enabled.
24. Click OK, and restart the SQL service.

Creating additional VMs

1. In Hyper-V Manager, make sure the VM to be copied is shut down.
2. In Windows Explorer, navigate to the folder containing the virtual hard disk file for the VM to be copied.
3. Copy and paste the desired virtual hard disk file as many times as necessary to reach the number of additional VMs to be created.
4. For each additional VM to be created, perform the following:
 - a. In Hyper-V Manager, click New→Virtual Machine...
 - b. At the Specify Name and Location screen, give the VM a name, and click Next.
 - c. At the Specify Generation screen, select Generation 2, and click Next.
 - d. At the Assign Memory screen, type 12288 MB, and click Next.
 - e. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.
 - f. At the Connect Virtual Hard Disk screen, select Use an existing virtual hard disk, click Browse..., navigate to and select the desired virtual hard disk, and click Next.
 - g. At the Summary Screen, click Finish.
 - h. In Hyper-V Manager, right-click the new VM and select Settings.
 - i. In the VM Settings window, select Processor, and set the Number of virtual processors to be 4.
 - j. Click Apply.
 - k. Click OK.

Configuring the new server and desktop

Installing Microsoft Windows Server 2016 Standard Edition

1. Provide a datastore with the Windows Server 2016 installation media.
2. Attach the Windows Server 2016 ISO to the virtual machine.
3. Press any key when prompted to boot from DVD.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2016 Standard Edition (Desktop Experience), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Click New, enter 81920 MB for the size, and click Apply.
11. At the prompt alerting you to Windows creating additional partitions for system files, click OK.
12. Click Next, at which point Windows begins automatically and restarts automatically after completing.
13. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
14. Log in with the password you set up previously.
15. Server Manager will open automatically. Click Tools→Computer Management.
16. Click Disk Management.
17. Right click on the Unallocated space and click New Simple Volume...
18. At the Welcome screen, click Next.
19. At the Specify Volume Size screen, click Next.
20. At the Assign Drive Letter or Path screen, verify that D: is selected and click Next.
21. At the Format Partition screen, click Next.
22. Click Finish.

Installing Microsoft Hyper-V

1. Open Server Manager, and click Manage→Add Roles and Features.
2. At the Before You Begin screen, click Next.
3. At the Installation Type screen, click Next.
4. At the Server Selection screen, click Next.
5. At the Server Roles screen, check Hyper-V. At the prerequisite pop-up, click Add Features. Click Next.
6. At the Features screen, click Next.
7. At the Hyper-V screen, click Next.
8. At the Virtual Switches screen, click Next.

9. At the Virtual Machine Migration screen, click Next.
10. At the Default Stores screen, change the default location for virtual hard disk files to D:\Virtual Hard Disks and click Next.
11. At the Confirmation screen, check to automatically restart the server after installation, and click Yes at the prompt.
12. Click Install.

Creating the first VM

1. Launch Hyper-V Manager and select the host server in the left pane.
2. In the right pane, click New→Virtual Machine...
3. At the Before You Begin screen, click Next.
4. At the Specify Name and Location screen, give the VM a name, and click Next.
5. At the Specify Generation screen, select Generation 2, and click Next.
6. At the Assign Memory screen, type 12288 MB, and click Next.
7. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.
8. At the Connect Virtual Hard Disk screen, create a new disk, enter 80 GB, and click Next.
9. At the Installation Options screen, click Install an operating system from a bootable image file, and browse to select a Windows Server 2016 Standard installation .iso.
10. Click Next.
11. At the Summary Screen, click Finish.
12. In the Virtual Machines list, right-click the newly created VM, and click Settings.
13. In the VM Settings window, select Processor, and set the Number of virtual processors to be 4.
14. Click Apply.
15. Click OK.

Installing the VM operating system on the first VM

1. Start the VM.
2. Press any key to boot from CD or DVD when prompted.
3. At the Language Selection screen, click Next.
4. Click Install Now.
5. Enter the product key and click Next.
6. Select Windows Server 2012 R2 Standard (Desktop Experience) edition, and click Next.
7. Click I accept the license terms, and click Next.
8. Click Custom.
9. Click Next.
10. At the User's password must be changed before logging on warning screen, click OK.
11. Enter the desired password for the administrator in both fields, and click the arrow to continue.
12. At the Your password has been changed screen, click OK.

Installing SQL Server 2014 on the first VM

1. Prior to installing, add the .NET Framework 3.5 feature to the server.
2. Mount the installation DVD for SQL Server 2014.
3. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2014 DVD, and double-click it.
4. In the left pane, click Installation.
5. Click New SQL Server stand-alone installation or add features to an existing installation.
6. Select the Enter the product key radio button, and enter the product key. Click Next.
7. Click the checkbox to accept the license terms, and click Next.
8. Click Use Microsoft Update to check for updates, and click Next.
9. Click Install to install the setup support files.
10. If there are no failures displayed, click Next.
11. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
12. 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.
13. At the Installation Rules screen, after the check completes, click Next.
14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Server Configuration screen, choose NT Service\SQLSERVERAGENT for SQL Server Agent, and choose NT Service\MSSQLSERVER for SQL Server Database Engine. Change the Startup Type to Automatic. Click Next.

16. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
17. Enter and confirm a password for the system administrator account.
18. Click Add Current user. This may take several seconds.
19. At the Ready to Install screen, click Install.
20. After installation completes, click Close.
21. Close the installation window.
22. Open SQL Server 2014 Configuration Manager, and expand Protocols for MSSQLSERVER.
23. Right-click Named Pipes, and choose Enabled.
24. Click OK, and restart the SQL service.

Creating additional VMs

1. In Hyper-V Manager, make sure the VM to be copied is shut down.
2. In Windows Explorer, navigate to the folder containing the virtual hard disk file for the VM to be copied.
3. Copy and paste the desired virtual hard disk file as many times as necessary to reach the number of additional VMs to be created.
4. For each additional VM to be created, perform the following:
 - a. In Hyper-V Manager, click New→Virtual Machine...
 - b. At the Before You Begin screen, click Next.
 - c. At the Specify Name and Location screen, give the VM a name, and click Next.
 - d. At the Specify Generation screen, select Generation 2, and click Next.
 - e. At the Assign Memory screen, type 12288 MB, and click Next.
 - f. At the Configure Networking screen, use the drop-down menu to select the virtual switch, and click Next.
 - g. At the Connect Virtual Hard Disk screen, select Use an existing virtual hard disk, click Browse..., navigate to and select the desired virtual hard disk, and click Next.
 - h. At the Summary Screen, click Finish.
 - i. In Hyper-V Manager, right-click the new VM and select Settings.
 - j. In the VM Settings window, select Processor, and set the Number of virtual processors to be 4.
 - k. Click Apply.
 - l. Click OK.

Configuring the database workload client

For our Microsoft SQL Server clients, we used 10 virtual clients hosted in Hyper-V on a separate server. Each client VM had a static IP address, 8 GB of RAM, one vCPU, and was running Windows Server 2012 R2. We also installed the .NET Framework 3.5 feature in each client VM.

Configuring the DVD Store 3 benchmark

We generated the data using the Install_DVDStore.pl script included with DVD Store version 3 (DS3), providing the parameters for our 20GB database size and the Microsoft SQL Server 2014 platform. We ran the Install_DVDStore.pl script on a utility system running Linux®. The Install_DVDStore.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 2014. We built the 10GB database in SQL Server 2014 and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly 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, we created and loaded the database schema 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 DS3 download. We made size modifications specific to our 10GB 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.

- On the SQL Server instance, we created a ds2user SQL Server login using the following Transact-SQL (T-SQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO

EXEC master..sp_addsrvrolemember @loginame = N'ds2user',
    @rolename = N'sysadmin'

USE [DS3]
CREATE USER [ds3DS3user] FOR LOGIN [ds2user]
EXEC sp_addrolemember N'db_owner', N'ds3DS3user'

USE [master]
CREATE USER [ds3masteruser] FOR LOGIN [ds2user]
EXEC sp_addrolemember N'db_owner', N'ds3masteruser'
```

- We set the database recovery model back to full.
- We created the necessary full text index using SQL Server Management Studio.
- We created a database user and mapped this user to the SQL Server login.
- 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.
- The table below shows our initial file size modifications.

Configuring the database workload client

For our testing, we used a virtual client for the Microsoft SQL Server client. To create this client, we installed Windows Server 2008 R2, assigned a static IP address, and installed .NET 3.5.

Logical name	Filegroup	Initial size (MB)
Database files		
primary	PRIMARY	4
cust1	DS_CUST_FG	3,106
cust2	DS_CUST_FG	3,106
ind1	DS_IND_FG	10,240
ind2	DS_IND_FG	10,240
member1	DS_MEMBER_FG	100
member2	DS_MEMBER_FG	100
ds_misc	DS_MISC_FG	200
orders1	DS_ORDERS_FG	1,503
orders2	DS_ORDERS_FG	1,504
review1	DS_REVIEW_FG	1,353
review2	DS_REVIEW_FG	1,353
Log files		
ds_log	Not applicable	10,240

Running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Each complete test cycle consisted of general steps:

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

We used the following DVD Store parameters for testing:

```
ds3sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --n_threads=32 --db_size=10GB --think_time=0.1 --detailed_view=Y --warmup_time=5 --out_filename=<drive path>
```

Measuring workload power

To record each server's power consumption during the workload test, we used an Extech Instruments® (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power cord from the server under test to the Power Analyzer's output load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a 120-volt power outlet.

We used the Power Analyzer's Data Acquisition Software (version 3.0) to capture all recordings. We installed the software on a separate Intel processor-based PC, which we connected to the Power Analyzer via an RS-232 cable.

We captured power consumption at one-second intervals.

To gauge the power usage with no OS activity, we recorded the power usage (in watts) for two minutes while each server was running the operating system but no applications.

We then recorded the power usage (in watts) for each server during the testing at one-second intervals. To compute the average power usage, we averaged the power usage during the time the server was producing its peak performance results. We call this time the average active power.

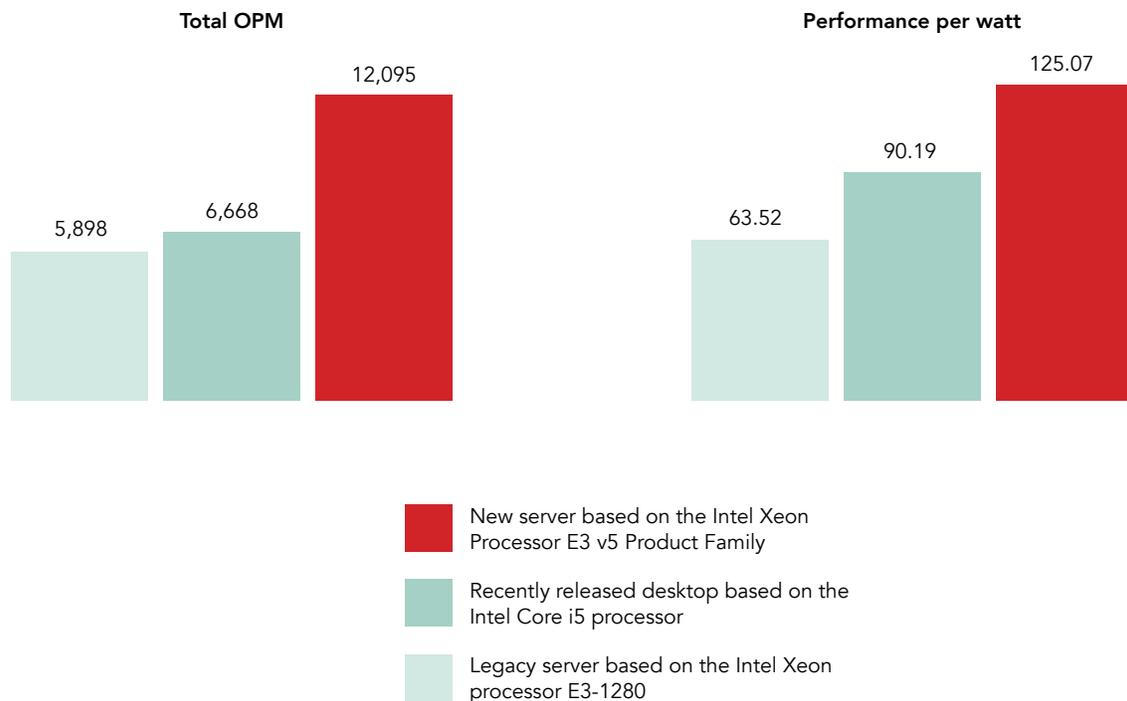
Appendix C: Complete results and explanation of results

The table below shows the median results of three consecutive test runs. We determined the median run based on total OPM results for each system.

We reported the set of power data from the same run.

We calculated total OPM by adding the OPM of all VMs from the median run on each solution. We calculated performance per watt by dividing the total OPM by the average active power from the same run.

	Legacy server based on the Intel Xeon processor E3-1280	Recently released desktop based on the Intel Core i5 processor	New server based on the Intel Xeon Processor E3 v5 Product Family
VMs supported	2	2	3
Database VM 1 OPM	2,890	3,326	4,044
Database VM 2 OPM	3,008	3,342	4,020
Database VM 3 OPM	n/a	n/a	4,031
Total OPM	5,898	6,668	12,095
Total performance improvement by Intel Xeon E3 v5 processor-powered server (%)	105.07%	81.39%	n/a
Average active power (W)	92.85	73.94	96.70
Performance per watt	63.52	90.19	125.07
Total performance per watt improvement by Intel Xeon E3 v5 processor-powered server (%)	96.91%	38.68%	n/a



This project was commissioned by Intel Corp.



Facts matter.®

Principled Technologies is a registered trademark of Principled Technologies, Inc.
All other product names are the trademarks of their respective owners.

DISCLAIMER OF WARRANTIES; LIMITATION OF LIABILITY:

Principled Technologies, Inc. has made reasonable efforts to ensure the accuracy and validity of its testing, however, Principled Technologies, Inc. specifically disclaims any warranty, expressed or implied, relating to the test results and analysis, their accuracy, completeness or quality, including any implied warranty of fitness for any particular purpose. All persons or entities relying on the results of any testing do so at their own risk, and agree that Principled Technologies, Inc., its employees and its subcontractors shall have no liability whatsoever from any claim of loss or damage on account of any alleged error or defect in any testing procedure or result.

In no event shall Principled Technologies, Inc. be liable for indirect, special, incidental, or consequential damages in connection with its testing, even if advised of the possibility of such damages. In no event shall Principled Technologies, Inc.'s liability, including for direct damages, exceed the amounts paid in connection with Principled Technologies, Inc.'s testing. Customer's sole and exclusive remedies are as set forth herein.