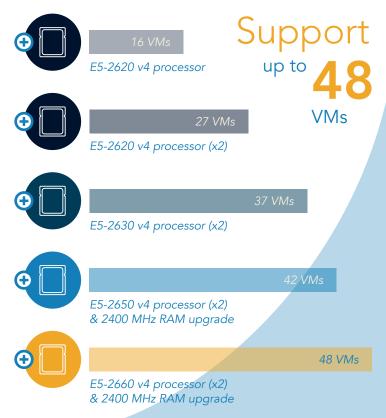# Accelerate your growth potential

Higher-end Intel Xeon processors can help your organization do more work, serve more customers, and save money over time

Whether your company is facing the challenge of harnessing the power of Big Data, capitalizing on faster times to insights, or gaining a more efficient infrastructure, finding the right server configuration for your needs can be a big step in the right direction.

When it comes to server processors, higher-bin processors from Intel can supply enough performance to offset the initial investment by allowing you to do more work with fewer servers, saving your company money over time.

In the Principled Technologies datacenter, we worked hands-on with servers powered by four products in the Intel® Xeon® Processor E5-2600 v4 Product Family: the E5-2620 v4, E5-2630 v4, E5-2650 v4, and E5-2660 v4. We tested each server in the same environment, measuring the number of virtual machines each could handle before VM performance decreased. To determine how well each option fits a variety of budgets, we estimated the total cost of ownership (TCO) for these configurations over five years, taking into account the cost of the hardware, hardware support, energy, facilities, and server administration.

Faster processors are an investment, and we found that each new Intel processor we tested offered a better value for your money than the last.

16 VMs
E5-2620 v4 processor

27 VMs
E5-2620 v4 processor (x2)

37 VMs
E5-2630 v4 processor (x2)

42 VMs
E5-2650 v4 processor (x2) & 2400 MHz RAM upgrade

48 VMs
E5-2660 v4 processor (x2) & 2400 MHz RAM upgrade

Support up to **48** VMs

Take a step—big or small

There are many reasons for upgrading—your long-time competitor has gone belly-up and you want their customers to turn to you in their hour of need. You're expanding your offerings and need more servers to handle the load. When it's time to modernize your datacenter, it can be tempting to cut costs—but doing so could short-change your business in the long run. Your organization deserves a future-conscious solution that can help save money over time.

Whatever your goals, we found that all of the servers we tested can help you do more to achieve them. With each step up on the Intel Xeon processor ladder, you're capable of getting more value and work out of a server. The bigger the step, the bigger the benefit to your organization. In most real-life use cases, this means you can replace older servers with a smaller number of new ones, saving money on both initial and ongoing costs.

We tested a server in five different configurations using four processors from the Intel Xeon processor E5-2600 Product Family. We used a performance benchmark called SPEC VIRT_SC® 2013 to determine how many mixed-workload VMs the servers could handle before the work affected performance. While each of the configurations delivered strong performance, the higher-bin processors consistently delivered better performance than their predecessors.

Do more with less

For companies operating at rack-space capacity, the thought of buying even more servers just to keep up with your work can be frustrating. But upgrading your processors to the latest Intel processors can enable your servers to do more work than before. Dealing with fewer servers could mean your IT staff spends less time on routine updates and upkeep, while spending more time working to optimize and innovate the way you handle tech. Fewer servers could also save your business money in energy costs as well as software licensing costs depending on which software you use, and how it's priced.
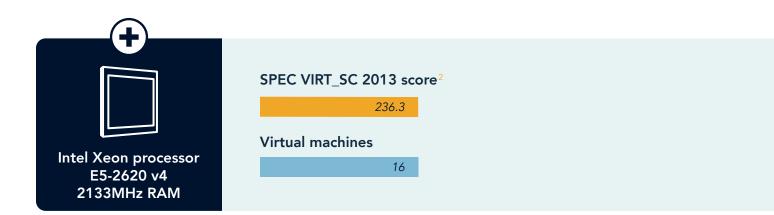
We also gathered data on the capital expense and five-year TCO so you can see for yourself how much value each processor upgrade could bring to your business (for more on our TCO methods, see Appendix C). With the Intel processors we looked at, it's clear that a modest additional investment can go a long way.

Why we used SPEC VIRT_SC 2013 v1.1

SPEC VIRT_SC is a particularly relevant benchmark because of the prevalence of virtualization in modern datacenters. According to the SPEC organization, SPEC VIRT_SC 2013 "measures the end-to-end performance of all system components, including the hardware, the virtualization platform, and the virtualized guest operating system and application software."[1] The SPEC VIRT_SC 2013 benchmarks "match a typical server consolidation scenario of CPU requirements, memory, disk I/O, and network utilization." Each set of SPEC VMs (called a "tile") consists of several servers, including mail, web, batch, infrastructure, and database servers. Note that the test results in this paper are noncompliant SPEC VIRT_SC 2013 test results published under the academic/research use guidelines. As such, they are not comparable to compliant results from the SPEC website.

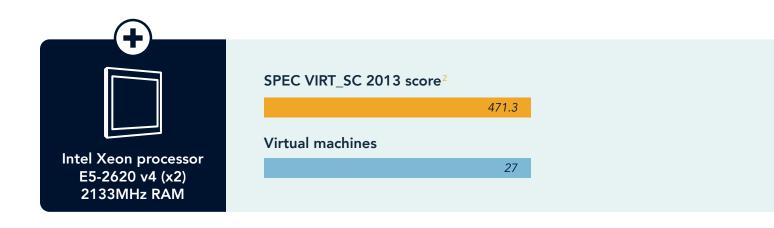# Our baseline: The Intel Xeon processor E5-2620 v4

A server powered by a single Intel Xeon processor E5-2620 v4 (often used for file/print servers or applications that don't require a lot of resources) will cost your organization $34,775.89 over five years. And for all that money, each of these servers will be able to support only 16 VMs total. In the next few sections, we'll see how dual-socket servers equipped with higher-bin Intel Xeon processors can allow your company to do more work while saving money.

Intel Xeon processor E5-2620 v4 2133MHz RAM

SPEC VIRT_SC 2013 score[2]

236.3

Virtual machines

16

One small step up opens up a world of possibilities

Using a dual-socket server can enable your business to run more resource-intensive applications and sort through larger databases. In our datacenter, a server equipped with two Intel Xeon processors E5-2620 v4 ran 27 virtual machines comfortably before our test workload negatively affected overall performance. To get the same amount of work using our single-socket baseline server, you'd need to purchase two servers for every dual-socket configuration, which would cost your organization $69,551.78 over five years.
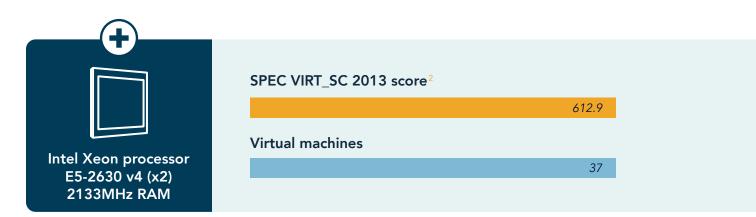
A new dual-socket Dell EMC PowerEdge™ R730xd configured with this processor carries a TCO of $35,876.40—meaning you get 1.6 times the number of VMs our baseline server could support for nearly half the cost.

Intel Xeon processor E5-2620 v4 (x2) 2133MHz RAM

SPEC VIRT_SC 2013 score[2]

471.3

Virtual machines

27

More power with the Intel Xeon processor E5-2630 v4

Customers use your website to pay their bills and view statements, read news stories, or write blog entries. We found that more users can accomplish these tasks concurrently with a server powered by the Intel Xeon processor E5-2630 v4.

A dual-socket server loaded with two Intel Xeon processors E5-2630 v4 was able to support 37 virtual machines, 2.3 times as many as our baseline server. Our TCO analysis revealed this configuration would cost $36,349.04, meaning that for just a $1,573.15 additional investment over five years, you could do more than twice the amount of work and support more users.

Intel Xeon processor E5-2630 v4 (x2) 2133MHz RAM

SPEC VIRT_SC 2013 score[2]

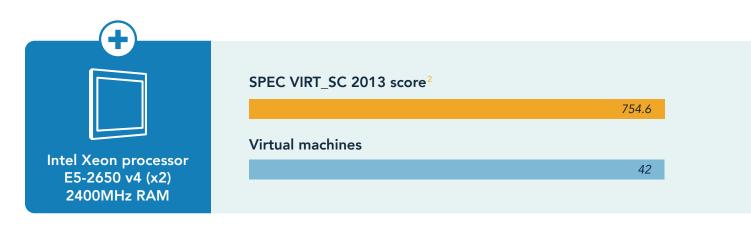612.9

Virtual machines

37

Ever upward with the Intel Xeon processor E5-2650 v4

Peak usage times can challenge underpowered hardware and diminish the customer experience. Upgrading to a server powered by the Intel Xeon processor E5-2650 v4 allows you to support more customers and gives you room for future growth, all without degrading performance.

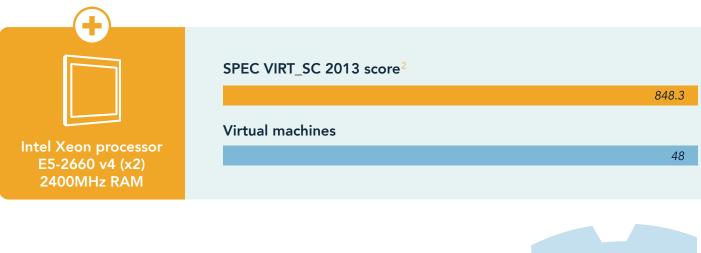## Fully utilize your investment

You can get the most out of your CPUs by choosing appropriate RAM to support them. We upgraded the server above with 2400MHz RAM, and found the server was able to run 42 virtual machines before performance wavered. A server configured with two Intel Xeon processors E5-2650 v4 and 2400MHz RAM would cost your organization $37,915.48 over five years. To get the same amount of performance from the single-socket server we tested, you'd have to purchase three of those servers for $104,327.67 over five years.

Intel Xeon processor E5-2650 v4 (x2) 2400MHz RAM

SPEC VIRT_SC 2013 score[2]
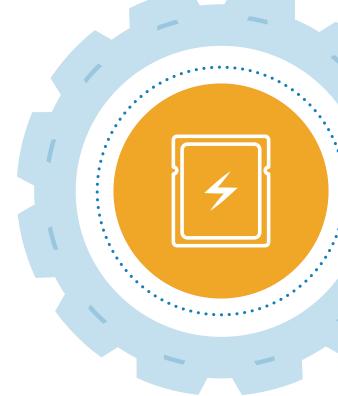
754.6

Virtual machines

42

Take everything to the next level with the Intel Xeon processor E5-2660 v4

Big Data analytics are changing the face of business. Timely insights affect everything from day-to-day operations to customer-facing initiatives, and everything in between. But working with these powerful analytics is extremely resource intensive. So, we loaded our server with two Intel Xeon processors E5-2660 v4 and gave the system an extra boost with the same 2400MHz RAM as before. The resulting solution handled 48 virtual machines before performance decreased. That's three times performance of our baseline configuration.
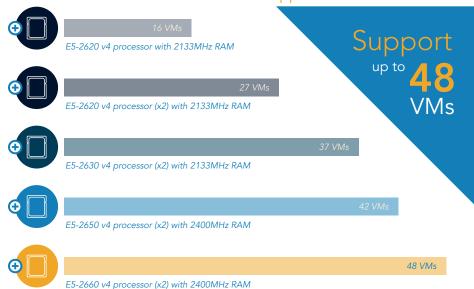
A server using two of these processors with 2400MHz RAM would cost $38,494.21 over five years. To get the same performance using our single-socket baseline, you'd have to purchase three servers for $104,327.67. Choosing a solution with a better value means you may be able to stave off your next upgrade and continue supporting your workloads for the foreseeable future.

Intel Xeon processor E5-2660 v4 (x2) 2400MHz RAM

SPEC VIRT_SC 2013 score[2]

848.3

Virtual machines

48

Conclusion: Choose a solution that makes sound business sense

Each server configuration we tested enabled us to do more work than our baseline without risking performance. Compared to the total cost of a server, the initial cost of a processor upgrade is easily offset by the performance boost each processor drives. Each upfront investment means you'll be able to meet rising customer demands better and, in some cases, gives your business room to grow.

Number of VMs supported

16 VMs
E5-2620 v4 processor with 2133MHz RAM

27 VMs
E5-2620 v4 processor (x2) with 2133MHz RAM

37 VMs
E5-2630 v4 processor (x2) with 2133MHz RAM

42 VMs
E5-2650 v4 processor (x2) with 2400MHz RAM

48 VMs
E5-2660 v4 processor (x2) with 2400MHz RAM

Support up to **48** VMs

Cost to match 24U of E5-2660 v4 processor-powered servers[3]

$1,251,932
36x E5-2620 v4 processors in 36 servers

$789,281
44x E5-2620 v4 processors in 22 servers

$581,585
32x E5-2630 v4 processors in 16 servers

$530,817
28x E5-2650 v4 processors in 14 servers

$461,931
24x E5-2660 v4 processors in 12 servers

Save up to **$790,001** over 5 years

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1 https://www.spec.org/virt_sc2013/

2 The test results in this paper are noncompliant, though our test environment had only minor differences from SPEC guidelines. As such, we believe our results are an accurate measurement of server performance. Review our methodology in Appendix B to learn more about how we tested.

3 Number of servers required at each configuration level to host at least the same number of VMs as 12x E5-2660 v4 servers

On December 8, 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 January 11, 2017.

Appendix A – System configuration information

Server configuration information	Dell EMC PowerEdge R730xd
BIOS name and version	2.3.4
Non-default BIOS settings	Boot Mode = UEFI
Operating system name and version	Red Hat Enterprise Linux Server 7.2 (KVM)
Date of last OS updates/patches applied	12/08/2016
Power management policy	Performance
Processor #1	
Number of processors	1 or 2
Vendor and model	Intel Xeon E5-2620 v4
Core count (per processor)	8
Core frequency (GHz)	2.10
Stepping	R0
Processor #2	
Number of processors	2
Vendor and model	Intel Xeon E5-2630 v4
Core count (per processor)	10
Core frequency (GHz)	2.20
Stepping	R0
Processor #3	
Number of processors	2
Vendor and model	Intel Xeon E5-2650 v4
Core count (per processor)	12
Core frequency (GHz)	2.20
Stepping	M0
Processor #4	
Number of processors	2
Vendor and model	Intel Xeon E5-2660 v4
Core count (per processor)	14
Core frequency (GHz)	2.00
Stepping	M0

Server configuration information	Dell EMC PowerEdge R730xd
Memory module(s) #1	
Total memory in system (GB)	512
Number of memory modules	13 3
Vendor and model	Samsung M393A4K40BB0-CPB0Q Micron MTA36ASF4G72PZ-2G1B1
Size (GB)	32
Type	DDR4
Speed (MHz)	2133
Speed running in the server (MHz)	2133
Memory module(s) #2	
Total memory in system (GB)	512
Number of memory modules	16
Vendor and model	Hynix HMA84GR7MFR4N-UH
Size (GB)	32
Type	DDR4
Speed (MHz)	2400
Speed running in the server (MHz)	2400
Storage controller	
Vendor and model	Dell PERC H730P Mini
Cache size (GB)	2
Firmware version	25.5.0.0018
Driver version	06.904.07.00_el7.2-1
Local storage front	
Number of drives	16
Drive vendor and model	Intel SSDSC2BX40
Drive size (GB)	400
Drive information (speed, interface, type)	6G SATA SSD
Local storage rear	
Number of drives	2
Drive vendor and model	Samsung MZ7LM120HCFD00D3
Drive size (GB)	120
Drive information (speed, interface, type)	SATA SSD
Network adapter	
Vendor and model	1 x Broadcom 5720 QP
Number and type of ports	4 x 1Gb
Driver version	3.137

Server configuration information	Dell EMC PowerEdge R730xd
Network adapter	
Vendor and model	2 x Intel 10G Server Adapter X520-DA2
Number and type of ports	2 x 10Gb
Driver version	4.4.6-1
Power supplies	
Vendor and model	Astec E750E-S1
Number of power supplies	2
Wattage of each (W)	750

Appendix B – How we tested

Setting up the SPEC VIRT_SC 2013 environment

Performing basic setup

1. Install Red Hat Enterprise Linux 7.3 on the R730xd per Red Hat Enterprise Linux best practices.
2. Make sure all hardware and software is up to date with drivers, firmware, updates, etc.
3. Install the E5-2660 v4 CPUs and 2400MHz memory to start.
4. Configure the storage per SPEC VIRT_SC 2013 recommendations:
   a. Appserver: 16GB
   b. Batch: 16GB
   c. DB: 40GB
   d. Infra: 50GB
   e. Mail: 36GB
   f. Web: 16GB
5. Configure network SPEC VIRT_SC 2013 recommendations
   a. One network interface connected to an external network for clients and VM communication

Setting up SPEC VIRT_SC 2013

Setting up the Infraserver VM

1. Install the OS.
2. Install Java 7.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECweb®2005 directory from the harness kit onto the VM.
5. Setup a remote filesystem, create a 32 GB filesystem, and make it accessible by the webserver VM.
6. Configure the back end simulator (BeSim) by taking the following actions:
   a. Configure the system with web server software on port 81.
   b. Build the BeSim code.
   c. Install the code to the BeSim web server.
   d. Start the BeSim web server.
   e. Use the test_besim_support scripts to test the setup.

Setting up the webserver VM

1. Install the OS.
2. Install Java 6 or greater Compatible JRE software.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECweb2005 directory from the harness kit onto the VM.
5. Set localization on the system to US.
6. Install and configure Nginx 1.8.1 with PHP and SSL or TLS support.
7. Set the current working directory to the wafgen directory.
8. Make a document root support/downloads directory a fileserver mount from the infraserver VM by taking the following actions:
   a. Go to the SPECweb2005/wafgen directory and edid the support wafgen files to the TILEINDEX value for the tile you are creating.
   b. Edit /opt/SPECweb2005/wafgen/unix/support_downloads_props.rc and set the parameter TILEINDEX equal to the tile number minus 1.
   c. Edit /opt/SPECweb2005 wafgen/unix/support_image_props.rc and set the parameter TILEINDEX equal to the tile number minus 1.
   d. Build the image files.
   e. Build the support files.

Setting up PHP

1. Copy the contents of the /opt/SPECweb2005/Scripts/PHP/* directory to your document root.
2. Verify the "support" and "Smarty-2.6.26" subdirectories are under the document root, and ensure the web server has read and write access to these directories and subdirectories.

Setting up the mailserver VM

1. Install the OS.
2. Install Java 6 or greater Compatible JRE software.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECimap directory from the harness kit onto a directory on the mailserver virtual machine.
5. Install dovecot 2.2.25.
6. Configure a storage location in your IMAP server than can hold 14 GB of data.
7. Set up 500 users in your IMAP server software.
8. Load the user accounts with data using the SPEC VIRT_SC 2013 IMAP loader before you run the benchmark.
    a. Modify the IMAP config file for the load.
    b. Use the run_load_gen and run_init .sh or .bat files to load the mailstore.

Setting up the database server VM

1. Install the OS.
2. Install Java 6 or greater Compatible JRE software.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECjAppServer2004 files from the harness kit to the database VM.
5. Install and configure DB2 v9.7.
6. Configure a storage location that can hold 20 GB of data.
7. Load the database for a SPECjAppServer2004 injection rate (IR) of 500.
8. Modify the /opt/SPECjAppServer2004/config/run.properties file on the client so the variable txRate=500.
9. Create the database schema using scripts specific to your database
10. After the load finishes, ensure the value of txRate is at the runtime injection rate of 100.
11. Backup the database.

Setting up the application server VM

1. Install the OS.
2. Install Java 6 or greater Compatible JRE software.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECjAppServer2004 directories from the harness kit to the VM
5. Install WebSphere Application Server 8.5.5.
6. Tune the application server to handle a peak injection rate of 200.

Setting up the batchserver VM

1. Install the OS.
2. Install Java 6 or greater Compatible JRE software.
3. Configure the OS to start the pollme.jar listener automatically on boot.
4. Copy the SPECbatch directory from the harness kit onto the VM.
5. Make sure that Java 6 or greater Compatible JDK software is installed.
6. Unpack the cpu2006-virt.tgz workload into the SPEC batch directory.
7. From the cpu2006-virt directory, run install.sh accepting the default options.
8. Build the 401.bzip2 "base" executable.
9. Customize the batch run script.
10. Configure the OS to start the SPECbatch listener automatically on boot.

After all the previous setup steps are complete, clone out as many tiles as you need.

Configuration details

For complete details about the configurations and test methodology for our SPEC VIRT_SC 2013 v1.1 testing, review the output file for the E5-2660 v4 test directly at http://facts.pt/qvAbBk. All CPU configurations were tested with these settings with the total number of VMs being the only difference.

Configuration details	
Web server configuration details	
Web Server Name/Version	Nginx 1.8.1
Script Name/Version	PHP 5.3.3
Other Software	Alternative PHP Cache APC 3.1.9 Smarty Template Engine 2.6.26
App Server Configuration Details	
App. Server Name/Version	GlassFish Server Open Source Edition 3.1.2.2
Emulator Name/Version	Apache Tomcat 7.0.73
Mail Server Configuration Details	
Mail Server Name/Version	Dovecot 2.2.25
Database Configuration Details	
Database Name/Version	PostgreSQL 9.2.19
Infraserver Configuration Details	
Web Server Name/Version	Apache 2.2.15
Script Name/Version	FastCGI 2.4.6-2
Batch Server Configuration Details	
C Compiler Version	gcc 4.4.7-17
Optimization Flags	-O2
Common VM Configuration Details	
JVM Version	OpenJDK Runtime Environment (1.7.0.99-2.6.5.1.el6-x86_64)
Other Software	ixgbevf v3.2.2

Common Configuration Details:

- JVM Version: OpenJDK Runtime Environment (1.7.0.99-2.6.5.1.el6-x86_64)
- Other Software: ixgbevf v3.2.2

Web Server Configuration Details:

- Web Server Name/Version: Nginx 1.8.1
- Script Name/Version: PHP 5.3.3
- Other Software:
    - Alternative PHP Cache APC 3.1.9
    - Smarty Template Engine 2.6.26

App Server Configuration Details:

- App. Server Name/Version: GlassFish Server Open Source Edition 3.1.2.2
- Emulator Name/Version: Apache Tomcat 7.0.73

Mail Server Configuration Details:

- Mail Server Name/Version: Dovecot 2.2.25

Database Configuration Details:

- Database Name/Version: PostgreSQL 9.2.19

Infraserver Configuration Details:

- Web Server Name/Version: Apache 2.2.15
- Script Name/Version: FastCGI 2.4.6-2

Batch Server Configuration Details:

- C Compiler Version: gcc 4.4.7-17
- Optimization Flags: -O2

Appendix C: TCO

About our total cost of ownership (TCO) analysis

We estimated the cost of each server to include hardware purchase, hardware support, energy costs, datacenter space costs, and server administration. We estimated these costs for a server life of five years.

Hardware purchase costs

We priced the Dell PowerEdge R730xd servers on the Dell site. The prices for the five servers we tested vary because of their different processors and memory modules and range from $13,093.66 for the single Intel Xeon processor E5-2620 model to $15,579.55 for the dual-socket server with the Intel Xeon processor E5-2660.[1]

Hardware support costs

We used the price on the Dell EMC website for ProSupport Plus: 5 Year Mission Critical 4-hour Onsite Service of $4,107.36 per server.[2]

Energy costs

We measured power usage on the servers while both actively running the SPEC benchmark and while idle. We estimated energy costs based on the servers being active 50 percent of the time, averaging the active and idle energy usage. We estimated a 10.4-cent cost per Kilowatt hour based on a U.S. Energy Information Administration report of average price per electricity to ultimate commercial customers for year to date ending in October, 2016.[3] We used that information to calculate energy costs to power the server. We estimated the energy overhead of the server at double that to account for cooling, heating, and other data center infrastructure power usage. Datacenters differ in their power usage effectiveness; our 2.0 multiplier is conservative.

Datacenter Space

Servers also have additional overhead costs related to the datacenter space they occupy. We estimated these costs at $1,000 per month per rack. Assuming a 42U rack, the five-year cost for each 2U server is $2,858.

Server administration

We estimate that each server administrator can support an average of 40 servers for hardware and OS management. That number could vary based on automation and other efficiencies. We calculated costs based on salary and benefits of a Systems Administrator II at $106,958.[4] That works out to a five-year administration cost per server of $13,369.75.

Processor	TCO	Processor cost	% of TCO that is processor cost
1x 2620	$34,775.89	$458.65	1.32%
2x 2620	$35,876.40	$917.30	2.56%
2x 2630	$36,349.04	$1,301.92	3.58%
2x 2650	$37,915.48	$2,092.08	5.52%
2x 2660	$38,494.21	$2,536.94	6.59%

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1 http://www.dell.com/us/business/p/poweredge-r730xd/pd
2 http://configure.us.dell.com/dellstore/config.aspx?c=us&cs=04&fb=1&l=en&model_id=poweredge-r730xd&oc=pe_r730x-d_1358_b&s=bsd&vw=classic
3 http://www.eia.gov/electricity/monthly/pdf/epm.pdf, Table 5.3.
4 http://swz.salary.com/SalaryWizard/Systems-Administrator-II-Salary-Details.aspx?hdcbxbonuse=off&isshowpiechart=true&isshowjob-chart=false&isshowsalarydetailcharts=false&isshownextsteps=false&isshowcompanyfct=false&isshowaboutyou=false

This project was commissioned by Intel Corp.