Rackspace Cloud Servers Analysis

A comparison of cloud servers across Generations of Rackspace Cloud Offerings

By Cloud Spectator
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Section | Page Number

Introduction

Since 2011, Cloud Spectator has monitored Rackspace server performance by setting up accounts as a normal user would, and installing the CloudSpecs application on its servers. Since that time, Rackspace has made strategic (price changes) and technical decisions (shifting to OpenStack), altering its position in the market. Most recently, Rackspace has shifted again with its new Performance Offering, which is supplied with 1GB to 120GB of RAM, powered by Intel Xeon E5 processors (for a list of processors tested from each generation, please see Appendix).

Rackspace has three main categories of IaaS offerings still available in all or select data centers. All three categories of servers are tested in this document to compare within and across generations of Rackspace servers:

First Generation
This is Rackspace's IaaS offering prior to its shift to OpenStack in late 2012. The machines on this generation range from 256MB RAM to 30GB RAM. All machines share 4 vCPUs except the 30GB RAM machine, which has 8 vCPUs (see Appendix for more information). Currently, users are limited to one First Generation data center per account. Those data centers include DFW, ORD, and LON.

Next Generation
Rackspace's late-2012 IaaS offering introduced an OpenStack-powered cloud to users. These OpenStack-powered servers do not offer a 256MB RAM size, but still scale up to 30GB RAM. vCPU allocation scales as well, giving larger servers an increased vCPU amount (see Appendix for more information). All Rackspace data centers have the Next Generation servers available.

Performance Servers
These servers are Rackspace's most recent offering, introduced in November 2013. Separated into 2 subcategories, the Performance 1 servers range from 1-8GB RAM, and the Performance 2 servers start at 15GB RAM and go up to 120GB RAM. vCPU allocation also scales. Currently, both subcategories of Performance Serves are only available in the North Virginia (IAD) data center.

This report is a collective document providing the results of CPU and memory experiments on Rackspace's servers across generations. The 256MB, 512MB, and 1GB servers from the First Generation are not tested; the 512MB and 1GB servers from the Second Generation are not tested; and the 1GB server from the Performance Servers is not tested.

Beginning with its First Generation offering all the way to its new Performance Servers (released November 5, 2013), this report covers aspects of the general system performance and includes lower-level analysis on CPU (single and multi-core) and RAM performance. This document also examines the performance of the new 60, 90, and 120GB virtual machines available through Rackspace. It does not include performance on server offerings less than 2GB of RAM.

Key Findings

- **Performance Servers CPU scaling:** users running CPU-intensive workloads may consider the 4GB Performance 1 offering over the 15GB Performance 2, or the 8GB Performance 1 over the 30GB Performance 2. This is due to the vCPU allocation, which is equivalent between the 4GB and 15GB, and the 8GB and 30GB. Tests show similar CPU performance in those sets. Users can save up to $9,000 per year with this decision.
- **Single core performance:** a Performance Server's core outperforms both a First Generation and Next Generation core by 60% (with the exception of the 2GB Next Generation server – see "To Consider").
- **Data Center Performance Variability**: The Next Generation Servers were provisioned on different physical machines; the more modern 2GB RAM dual core scored 25% higher in CPU tests than the less modern dual core 4GB RAM offering. This may not be the case for the new Performance offerings, which all seem to run on Intel E5s within the North Virginia data center for more predictable VM performance.
- **Performance Servers RAM Bandwidth**: Memory bandwidth of the Performance Servers increase by around 2.5x compared to the memory speeds of the Next Generation servers, creating a more suitable environment for databases running from memory.

To Consider

- The Rackspace Next Generation 2GB virtual machine was provisioned on an AMD Opteron 4332 HE, a more modern processor than other Next Generation machines. This explains the increased single-core and multi-core performance of the 2GB machine.
- While the same general pattern of performance emerges from each generation, the Unixbench test suite gives slightly different results from the Geekbench test suite because the Unixbench test suite considers performance of disk with its File Copy tests.
- To view breakdowns of the Rackspace results from Geekbench tests, please visit the links in the Appendix.
- This experiment was conducted during the initial release of the Rackspace Performance offering. Thus, the benchmark scores and measurements may not be reflective of fully user-saturated physical machines.
- While the offerings are tiered in accordance to RAM amount, vCPUs vary among generations of the same-tiered offering. Costs remain similar, despite the difference in vCPU allocation. More information on server sizes can be found in the Appendix.

The Test Setup

Data Center
First Generation Next Generation: DFW Data Center
Performance Servers: IAD Data Center

Operating System
All virtual machines ran Rackspace's default Ubuntu 12.04 LTS (Precise Pangolin) image.

Tests Used
Below lists the tests presented in this document for the purpose of analyzing performance under each category. More test results and information can be found in the Appendix. All data is accurate as of November 5, 2013.

System Performance Measurement

Geekbench 3
Geekbench 3, developed by Primate Labs (http://www.primatelabs.com/), runs single core and multi core tests to measure processor performance. Running a variety of CPU-intensive and RAM-intensive tasks, the suite considers integer performance, floating point performance, and memory performance as three categories to measure, each with single core and multi core results. The results are then indexed and a score is produced relative to the performance of an Intel Core i5-2520 M (2.50 GHz).

Byte-Unixbench
The purpose of UnixBench is to provide a basic indicator of the performance of a Unix-like system; hence, multiple tests are used to test various aspects of the system's performance. These test results are then compared to the scores from a baseline system to produce an index value, which is generally easier to handle than the raw scores. The entire set of index values is then combined to make an overall index for the system.

vCPU Single Core Performance Measurement

Geekbench 3 Integer Single Core
The Geekbench 3 Integer test runs basic CPU tasks such as encryption, compression, decompression, and simple mathematical problems. The Integer workloads consist of 10 separate tests. For more information on each test and the results of each separately, please see Appendix.

LAME MP3 Audio Encoding
Downloaded as a test within the Phoronix Test Suite, this audio encoding test times how long it takes to encode a WAV file to MP3 format using LAME MP3, an MP3 encoder. The less time it takes to encode, the better the CPU performance.

vCPU Multi Core Performance Measurement

Geekbench 3 Integer Multi Core

The Geekbench 3 Integer test runs basic CPU tasks such as encryption, compression, decompression, and simple mathematical problems. The Integer workloads consist of 10 separate tests. For more information on each test and the results of each separately, please see Appendix.

X264 Video Encoding

Downloaded as a test within the Phoronix Test Suite, this test measures CPU performance when encoding video. Results are provided in frames per second (FPS). The higher the FPS, the better the CPU performance. The input file on this test is YUV4MPEG2 and the output file once converted is H.264/MPEG-4 AVC.

Memory Performance Measurement

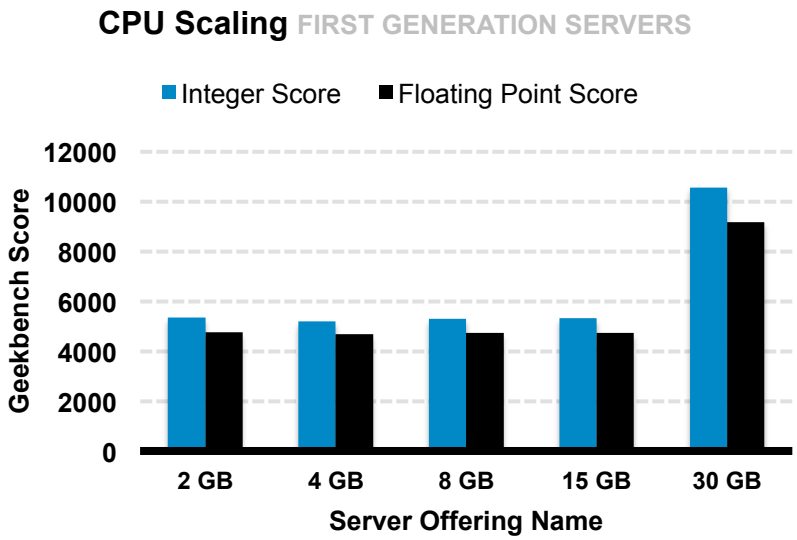
Geekbench 3 Memory Multi Core (STREAM)

Geekbench's memory performance tests are a combination of STREAM tests converted into an indexed score that is meaningful for the Geekbench score. STREAM runs basic commands to test RAM performance. For more information, see Appendix.

RAMspeed/SMP

RAMspeed is a suite of memory tests similar to STREAM, which run copy, scale, add, and triad (a combination of add and scale) to test the RAM performance in mb/s. The SMP version is multi core capable.

A Look Under the Hood



Geekbench Results	Integer Scores		Floating Point Scores	
Offering	Single Core	Multi Core	Single Core	Multi Core
2 GB	1380	5343	1227	4746
4 GB	1364	5195	1220	4682
8 GB	1382	5305	1228	4740
15 GB	1381	5321	1226	4727
30 GB	1379	10567	1226	9174

First Gen	vCPUs	Processor
2 GB	4	AMD Opteron 2374 HE (2.20 GHz)
4 GB	4	AMD Opteron 2374 HE (2.20 GHz)
8 GB	4	AMD Opteron 2374 HE (2.20 GHz)
15 GB	4	AMD Opteron 2374 HE (2.20 GHz)
30 GB	8	AMD Opteron 2374 HE (2.20 GHz)

The First Generation Servers

The First Generation Servers, Rackspace's preliminary IaaS offering, are currently available in DFW, ORD, and LON data centers. Before August 2012, all Rackspace users provisioned servers from this generation. Afterwards, users had a choice to provision on the First Generation or OpenStack-powered Next Generation servers, which are analyzed in the next section.

The Scaling of the vCPU

Users on the First Generation Servers may not experience scaling performance of the CPU when selecting a larger VM offering. That is because every virtual machine is allocated 4 vCPUs until a user purchases the 30GB RAM offering, which comes with 8 vCPUs.

The scores in the chart on the left illustrate the steady performance of the CPU until the 30GB offering; at that point, multi-core performance increases. The results in the table are gathered from running the Geekbench 3 benchmark suite's processor tests. A final score is given after the tests are all run and aggregated (for more information on the tests run within each category and individual scores, see Appendix).

Users running CPU-intensive workloads on the First Generation servers may not see a significant performance increase until they scale up to the 30GB offering—at that point, CPU performance doubles.

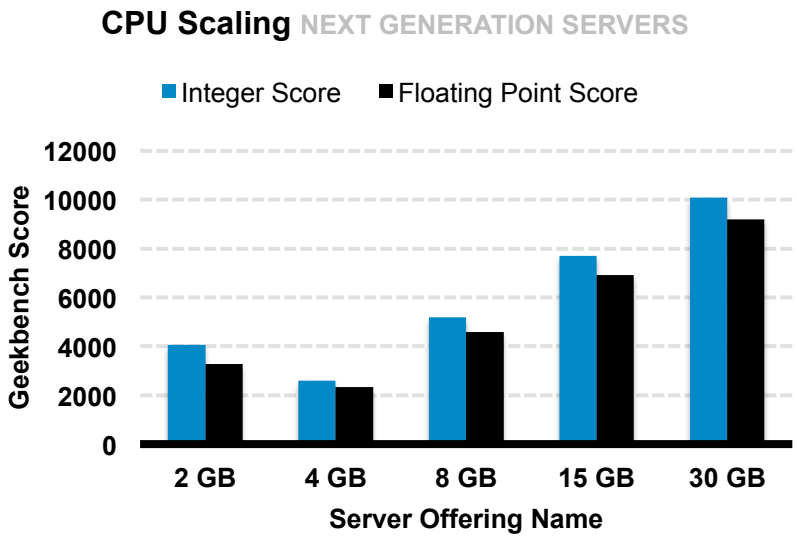
For a detailed breakdown of the Geekbench results, please see the Appendix.

The Next Generation Servers

Rackspace introduced the Next Generation Servers, powered by OpenStack, in late 2012. Since that time, the offering has become available in all Rackspace data centers in the United States. From the list of available servers, the 256MB RAM VM was removed, and the remaining VMs introduced a new level of processor scalability as different sizes offered different allocations of vCPU.

The Scaling of the vCPU

Unlike its predecessor, the Next Generation servers have vCPU resources allocated in a more scalable configuration; as servers increase in RAM, the number of vCPUs in the system increase as well. The result is a linear pattern of CPU performance scaling as the vCPUs increase by 2 from the 4GB RAM up to the 30GB RAM offering.



Geekbench Results	Integer Scores		Floating Point Scores	
Offering	Single Core	Multi Core	Single Core	Multi Core
2 GB	2074	4059	1676	3272
4 GB	1325	2591	1166	2321
8 GB	1328	5181	1178	4597
15 GB	1325	7708	1177	6912
30 GB	1327	10090	1177	9195

Next Gen	vCPUs	Processor
2 GB	2	AMD Opteron 4332 HE (3.00 GHz)
4 GB	2	AMD Opteron 4170 HE (2.10 GHz)
8 GB	4	AMD Opteron 4170 HE (2.10 GHz)
15 GB	6	AMD Opteron 4170 HE (2.10 GHz)
30 GB	8	AMD Opteron 4170 HE (2.10 GHz)

One interesting pattern is observed in the performance degradation between the 2GB and 4GB system. This is due to the generational gap between the AMD processors. The servers were ordered through the Rackspace Cloud Control Panel as a normal user, and the 2GB RAM server provisioned on an AMD Opteron 4332 HE, a 3 GHz processor introduced in early December 2012. The other servers were provisioned on AMD Opteron 4170 HE, an older 2.1 GHz processor introduced in late June 2010. The dual core on the 4GB receives a Geekbench score expected for the scaling pattern (approximately 2,500 points in integer performance per 2 vCPUs). The 2GB offering, which also has 2 vCPUs like the 4GB offering, does not match the expected scaling pattern due to the difference in AMD Opteron processor generations.

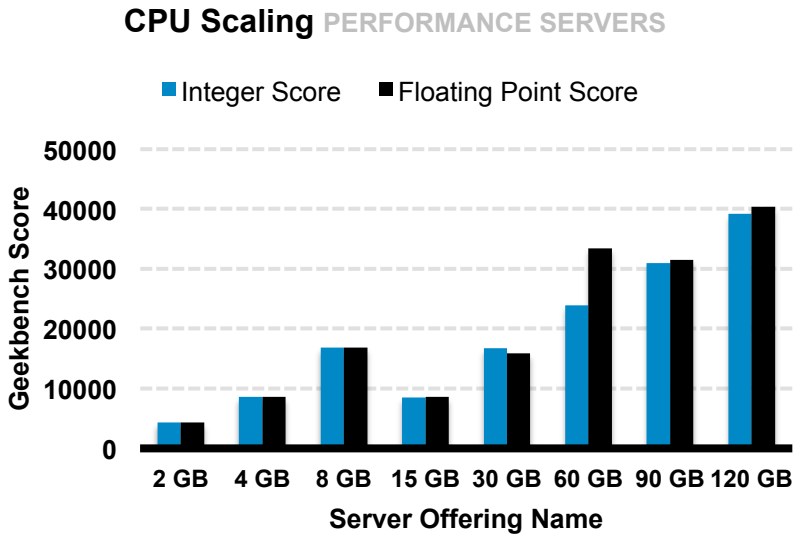
The difference of dual core performance between the two processors running the same IaaS environment highlights the variability of performance in cloud environments, emphasizing the importance of testing VMs for tuning performance. Following the same performance pattern with CPU scaling of the Opteron 4170 HE, a user would see a 60% increase in performance of the 30GB virtual machine on an Opteron 4332 HE powered physical server. In this case, a less expensive 2GB VM provides a user more CPU power than a more expensive 4GB VM.

For a detailed breakdown of the Geekbench results, please see the Appendix.

The Performance Servers

The Performance Servers offering removes the 512GB cloud VM offering available in the previous Next Generation offering. It introduces 3 new sizes as well, the 60GB, 90GB, and 120GB offerings, each including a generous amount of vCPUs to pair. Please remember that this test was conducted during the initial launch of the Rackspace Performance Servers, and results may change once servers become saturated with more users.

Prior to the new Performance offering, Rackspace powered its cloud VMs with older-generation AMD Opteron processors (see Appendix for more information). One exception was the AMD Opteron 4332 HE found in the Next Generation 2GB offering during the test, which is a more recent processor than the Intel Xeons running inside the Performance Servers. The Intel Xeon 2GB scored higher on single-core and multi-core CPU tests.



Geekbench Results	Integer Scores		Floating Point Scores	
Offering	Single Core	Multi Core	Single Core	Multi Core
2 GB	2192	4332	2165	4318
4 GB	2193	8581	2167	8601
8 GB	2186	16807	2169	16881
15 GB	2180	8538	2156	8564
30 GB	2169	16749	2142	15895
60 GB	2163	23859	2161	33405
90 GB	2178	30944	2159	31507
120 GB	2160	39154	2141	40344

Performance	vCPUs	Processor
2 GB	2	Intel Xeon E5-2670 0 (2.60 GHz)
4 GB	4	Intel Xeon E5-2670 0 (2.60 GHz)
8 GB	8	Intel Xeon E5-2670 0 (2.60 GHz)
15 GB	4	Intel Xeon E5-2670 0 (2.60 GHz)
30 GB	8	Intel Xeon E5-2670 0 (2.60 GHz)
60GB	16	Intel Xeon E5-2670 0 (2.60 GHz)
90GB	24	Intel Xeon E5-2670 0 (2.60 GHz)
120GB	32	Intel Xeon E5-2670 0 (2.60 GHz)

The Scaling of the vCPU

VCPU performance scales in a linear pattern for the Performance 1 servers. The dip in performance marks the gap between the Performance 1 and Performance 2 offerings.

At 15GB (the smallest Performance 2 offering), the number of vCPUs is reduced back to 4, the same amount as the 4GB Performance 1 offering, and increases again as the server tiers increase. Thus, the vCPU performance of the 15GB and 30GB are similar to that of the 4GB and 8GB, respectively.

The Performance 2 servers, which begin with the 15GB offering until the largest offering, 120GB, scales at the same rate as the Performance 1 servers first, and begins to decrease after the 60GB offering. The Geekbench CPU scores from the 90GB to 120GB increase by 27%, while the scores from the 15GB to 30GB increase by almost 100%.

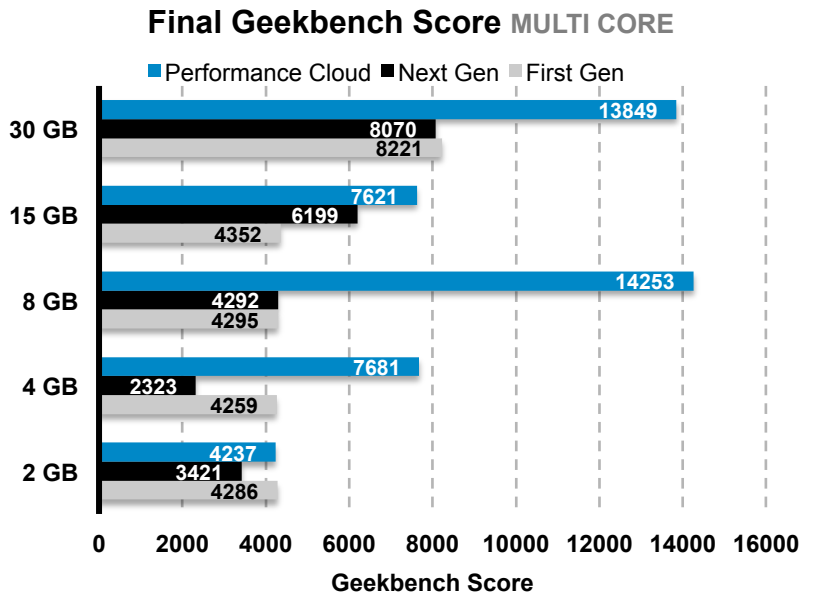
For a detailed breakdown of the Geekbench results, please see the Appendix.

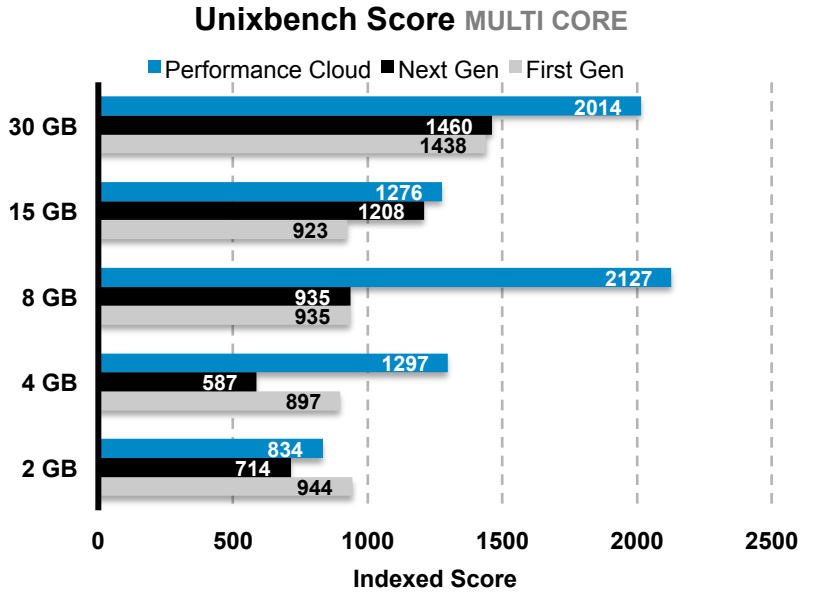
Virtual Machine Performance Comparison Across Rackspace Generations

This section compares processor and memory performance of virtual machines across the First Generation, Next Generation, and Performance Servers. The 2GB, 4GB, 8GB, 15GB, and 30GB virtual machines are tested. The virtual machines that are excluded from this comparison are:

- First Generation: 256MB, 512MB, 1GB
- Next Generation: 512MB, 1GB
- Performance Servers: 1GB, 60GB, 90GB, 120GB

Each section contains two tests to cross-compare results. While the metrics may not correspond, a similar pattern of performance scaling and the relativity of performance differences are exhibited in both sets of tests.





show a 1.3x increase in system performance.

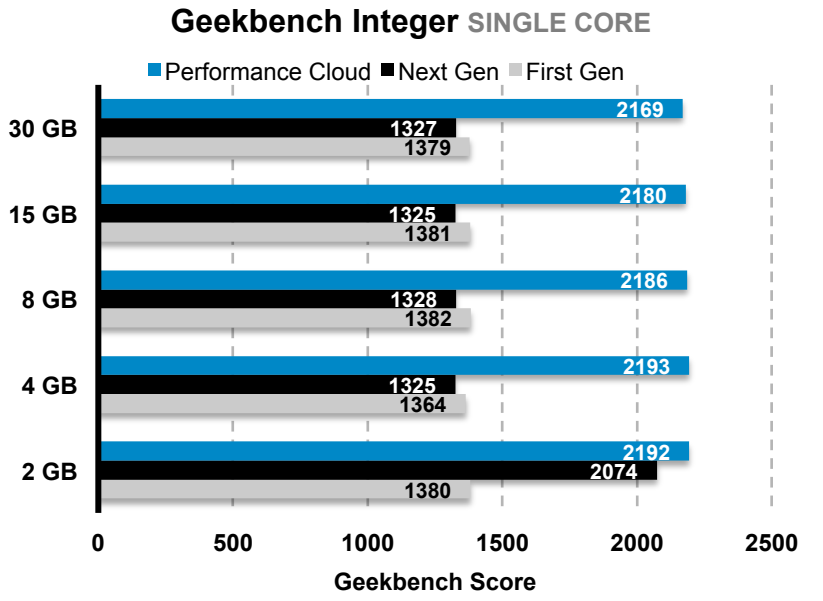
Please note that these comparisons are made on Linux Ubuntu 12.04 LTS machines. Performance results may vary on Windows or different Linux machines. Also, Rackspace is providing specific image types for its Performance VMs, which are supposed to optimize performance for users. Ubuntu 12.04 has not been optimized, although Ubuntu 13.04 is expected to be as well as Fedora 19. Those images are not ready for production use at this time, as noted in a Rackspace blog (results from Performance-optimized VMs are available in this post as well): http://developer.rackspace.com/blog/welcome-to-performance-cloud-servers-have-some-benchmarks.html

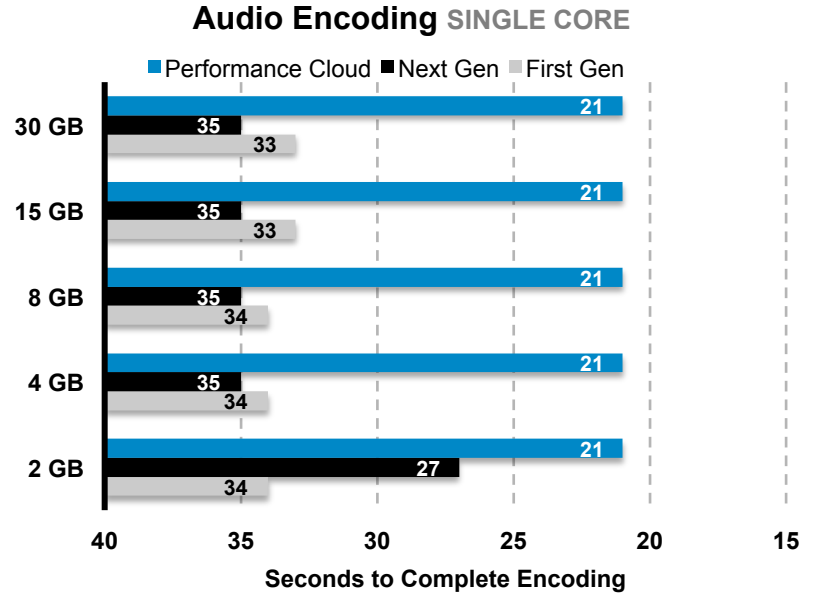
System Performance Across Rackspace Generations

For this experiment, system performance is measured with Geekbench and Unixbench. Both are suites of individual benchmarks testing various aspects of the machine. Geekbench tests run to measure processor and memory performance, while Unixbench runs tests to measure processor, memory, and disk performance. Both suites aggregate the results of each benchmark and index the score to conveniently compare machines. Specific scores can be viewed in the Appendix.

First Generation servers outperformed Next Generation servers on 2GB and 4GB virtual machines because the First Generation VMs have 4 vCPUs, while Next Generation VMs have only 2 vCPUs. At 8GB, the Next Generation offering matches the First Generation in performance, and surpasses it at 15GB. At 30GB, both generations are matched again, as the number of vCPUs is both scaled to 8. Though the generations ran on different processors, the processor performance did not increase significantly. The 15GB Next Generation server provides the most value to customers, as results

The Performance Servers begin evenly matched for the 2GB systems, though slightly higher in performance than the 2GB Next Generation. As the servers are scaled, though, the Performance Servers increase quickly to surpass performance of the First Generation and Next Generation servers.





CPU Performance Across Rackspace Generations: Multi Core

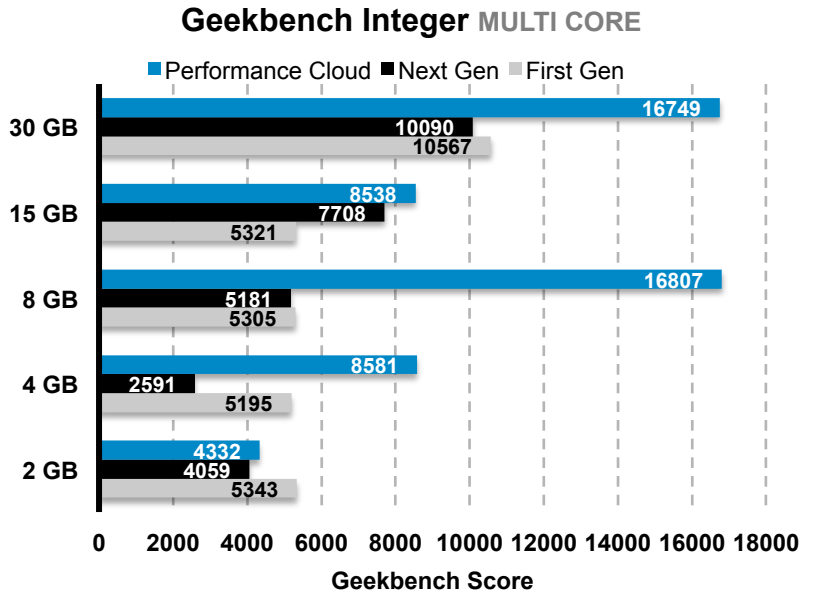
From the power of the aggregate vCPUs, a pattern of scaling emerges unique in each generation. The Geekbench integer sub-suite is used with multi-core scores, and a multi-core video encoding test using the x264 video encoder is also run. Geekbench's Integer sub-suite is a category within the Geekbench suite. It runs various single-core and multi-core tests to gauge processor performance. Tests include compression, decompression and encryption. The x264 converts video from YUV4MPEG2 to H.264/MPEG-4 AVC format. A measurement of the frames per second that are encoded provides a metric to interpret the efficiency of the vCPUs.

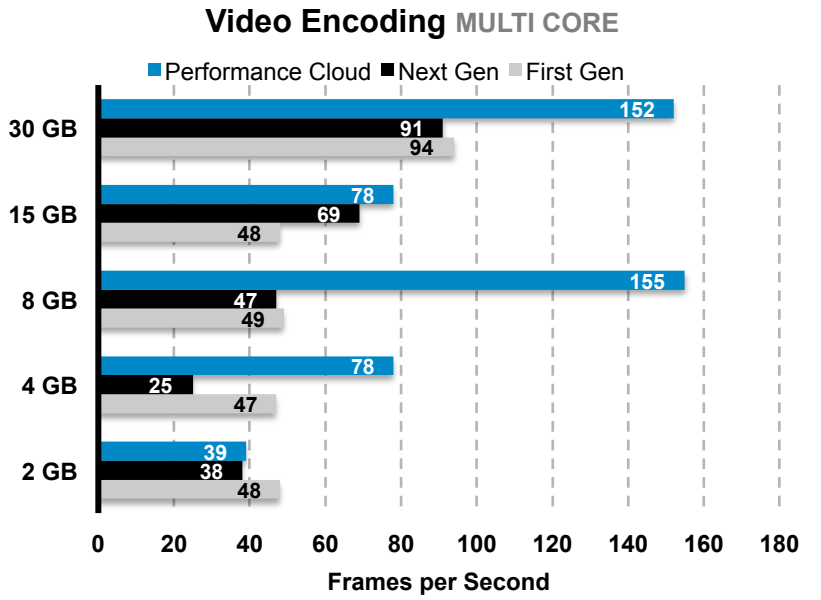
CPU Performance Across Rackspace Generations: Single Core

The results of the Geekbench Integer sub-suite of tests and LAME MP3 Audio Encoding tests are illustrated in the left-hand charts. Geekbench's Integer sub-suite is a category within the Geekbench suite. It runs various single-core and multi-core tests to gauge processor performance. Tests include compression, decompression and encryption. The audio encoding test uses LAME MP3 and tracks the time (in seconds) it takes to complete an encoding from WAV to MP3; thus, the smaller the result, the better the performance. Results shown on the left reflect the performance of a single core.

Due to the provisioning that Cloud Spectator could not control, the 2GB Next Generation machine ended up on a more modern processor. As a result, the 2GB Next Generation machine completed encoding the audio files, on average, in 77% of the time it took of other servers in the Next Generation offering.

The Performance Servers run modern Intel Xeon E5 processors, and the results of the experiment show a significant increase in performance per core. One exception is the 2GB Next Generation server, which was provisioned on a modern AMD Opteron (see Appendix for more information). Otherwise, users can expect a 60% increase in performance per core. For audio encoding, it decreased the time to complete by 14 seconds, a performance enhancement interesting for multimedia-sharing websites and online communities. Details on encryption, compression, and decompression from Geekbench can be found in the Appendix.





The Performance Servers outperform the First Generation and Next Generation servers in multi-core tests for all server sizes except the 2GB server. In the case of the 2GB server, the First Generation performs better due to the amount of vCPUs allocated to the machine: 4, compared to the Performance Server 2GB's 2 vCPU allocation. The Next Generation's 2GB server has 2 vCPUs, making it evenly matched for resources. It does not score higher, on average, than the Performance Servers, although only slightly behind, due to its modern Opteron processor, which was released months after the release of the Intel Xeon E5 running on the Performance Servers.

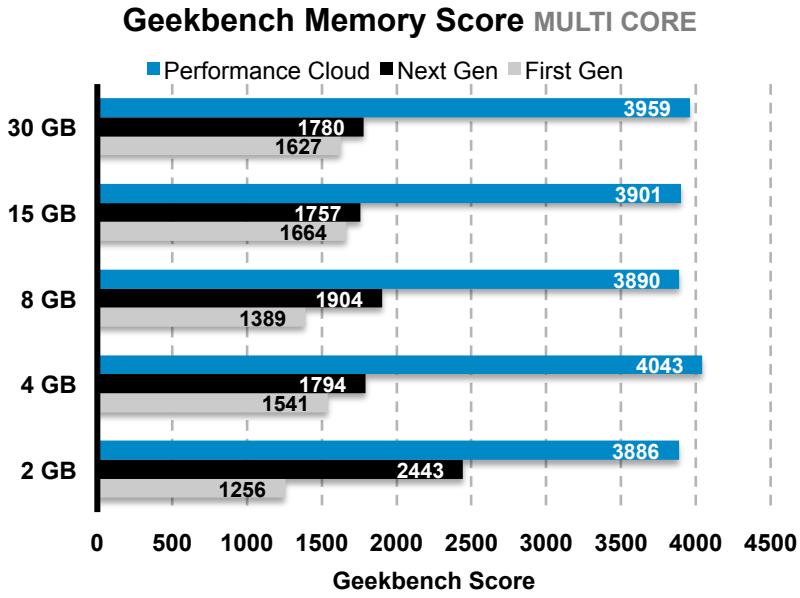
The First Generation servers produce very limited scalability on cores as servers are scaled. This is because each offering is allocated 4 vCPUs until a user provisions the 30GB server, which has 8 vCPUs. Thus, a user sees the same performance for video encoding until the 30GB server, where the FPS doubles. A similar pattern is displayed in the Geekbench results.

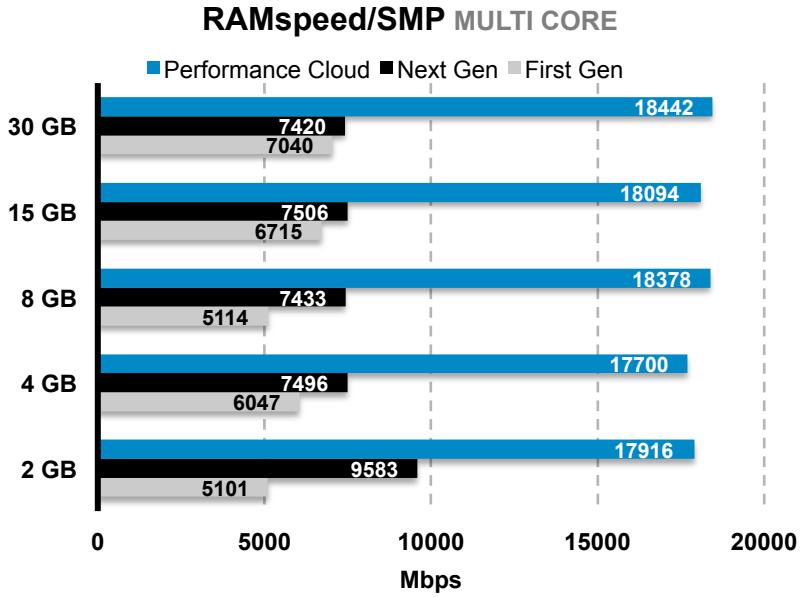
The Next Generation servers produce a strong linear pattern of scalability as the servers scale from 4GB to 30GB. Each jump to the next large server increases the video encoding results by 22 frames per second (FPS)—almost doubling the performance from the jump between 4GB and 8GB. Every 2 vCPUs seem to enhance the performance by the ratio seen in the video encoding test. One exception to this pattern is the 2GB server. While it has the same amount of vCPUs as the 4GB, it does not fall into the pattern as the underlying processor is different from the other servers in the same generation. Because the Next Generation servers are the most widespread offering at Rackspace, available in all data centers, users may expect to see this behavior. Different VMs may be provisioned on different hardware, leading to performance discrepancies between VMs of the same size, although users are paying the same amount. Thus, it is important to run tests to gauge the performance of these servers before moving or cloning servers.

The Performance Servers are categorized into 2 subcategories: Performance 1 and Performance 2. Performance 1 servers include the 2GB, 4GB, and 8GB servers. The multi-core performance of these systems scale much more than their First Generation and Next Generation counterparts. With more vCPUs in both the 4GB and 8GB offering compared to the Next Generation, the video encoding performance jumps by 4x from the 2GB server to the 8GB server. A similar pattern of performance behavior is seen in the Geekbench multi-core tests.

The 15GB and 30GB servers in the Performance category are part of the Performance 2 subcategory. These machines scale back in multi-core performance to the equivalent of the 4GB and 8GB machines, respectively, due to the amount of vCPUs present in these machines—the same as the 4GB and 8GB machines. The same scaling pattern is seen from the 15GB to 30GB servers in Performance 2 as from the 4GB to 8GB servers in Performance 1.

Because all of the Performance servers run on Intel Xeon E-5 processors, performance variability across VMs of the same size should not be expected. The increased vCPUs in each virtual machine offering also gives users a better performance experience compared to previous generations.





Memory Performance Comparison Among Rackspace Generations

Most programs that are CPU-intensive require the high performance in RAM, as the resources are closely bound. RAM bandwidth is tested with the Geekbench suite's Memory category (using multi-core results) and RAMspeed/SMP, a multi-core version of RAMspeed. Geekbench's memory suite runs STREAM, a memory benchmark, to test bandwidth using a series of add, scale, copy, and triad commands, similar to RAMspeed/SMP. More information on these commands can be found in the Appendix.

The Performance Servers offer more bandwidth for RAM—almost 2.5x more than the First Generation and Next Generation. The increased bandwidth for the memory reduces the memory bottleneck in high-performance computing and for database applications residing in memory. Because of the dependence of memory for the CPU, the bandwidth contributes to the performance of the Performance Server vCPUs.

Conclusion and Further Thoughts

This document presents a concise analysis on the performance of Rackspace Cloud's virtual processors and RAM across generations. It does not, however, include information on disk and internal network performance, which will be covered in a subsequent report. Rackspace's Performance Servers are upgraded with SSDs and larger network connections; thus, it is a reasonable assumption that the disk IO and internal network performance has increased, but the next report explores by how much.

Rackspace Performance Servers deliver a new generation of hardware for improved processor performance and memory bandwidth. By contrast, the previous First Generation and Next Generation offerings are fairly matched in most tests. That, in combination with the SSDs and improved network connection, is a major overhaul to the previous offerings. Benchmarks run on these systems are a good indicator for system capabilities, but this should not be a final indicator of performance for every application; specific use-cases should be experimented to give more information relevant to a business's projects.

About Cloud Spectator

Cloud Spectator is the premier international cloud analyst group focused on infrastructure pricing and server performance. Since 2011, Cloud Spectator has monitored the cloud Infrastructure industry on a global scale and continues to produce research reports for businesses to make informed purchase decisions by leveraging its CloudSpecs utility, an application that automates live server performance tests 3 times a day, 365 days a year with use of open source benchmark tests. Currently, the CloudSpecs system actively tracks 20 of the top IaaS providers around the world.

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Appendix

Only information on servers tested in this document is provided. Rackspace offers other services, features, and virtual machine sizes that are not listed in this Appendix.

Geekbench Tests Descriptions

Original Article http://support.primatelabs.com/kb/geekbench/geekbench-3-benchmarks

Integer Workloads

AES:
The AES workload encrypts a generated text string using the advanced encryption standard (AES). AES is used in security tools such as SSL, IPsec, and GPG. Geekbench uses the AES-NI instructions when they are available. When the AES-NI instructions are not available, Geekbench uses its own software AES implementation.

Twofish:
The Twofish workload also encrypts a text string, but it uses the Twofish algorithm. Twofish is from the family of encryption algorithms known as "Feistel ciphers." It is included in the OpenPGP standard.

SHA1:
SHA1 is a cryptographic hash algorithm: given a binary input it generates a "hash" or "digest" of the input. SHA1 is designed so that the hash may be computed quickly, but it is difficult to find a string that generates a given hash. SHA1 may be used, for example, to encrypt passwords by storing the hash instead of the password text. The SHA1 workload uses a text string as input.

SHA2:
SHA2 solves the same problem as SHA1, but is more secure: SHA1 has a known vulnerability to "collision attacks." Although these attacks are still impractical and SHA1 is still widely used, it is being gradually replaced by SHA2.

BZip2 compression and decompression:
BZip2 is a compression algorithm. The BZip2 workloads compress and decompress an ebook formatted using HTML. Geekbench 3 uses bzlib version 1.0.6 in the BZip2 workloads.

JPEG compression and decompression:
The JPEG workloads compress and decompress one digital image using lossy JPEG format. The workloads use libjpeg version 6b.

PNG compression and decompression:
The PNG workloads also compress and decompress a digital image, but they do so using the PNG format. The workloads use libpng 1.6.2.

Sobel:
The "Sobel operator" is used in image processing for finding edges in images. The Sobel workload uses the same input image as the JPEG and PNG workloads.

Lua:
Lua is lightweight scripting language. The Lua workload is similar to the code used to display Geekbench results in the Geekbench Browser.

Dijkstra:
The Dijkstra workload computes driving directions between a sequence of destinations. Similar techniques are used by AIs to compute paths in games and by network routers to route computer network traffic.

Floating Point Workloads

Black-Scholes:
The Black-Scholes equation is used to model option prices on financial markets. The Black-Scholes workload computes the Black-Scholes formula: a special case solution of the Black-Scholes equation for European call and put options.

Mandelbrot:
The Mandelbrot set is a fractal. It is a useful floating point workload because it has a low memory bandwidth requirement.

Sharpen image:
The sharpen image workload uses a standard image sharpening technique similar to those found in Photoshop or Gimp. The sharpened image computed by the workload is:

Blur image:
Image blurring is also found in tools such as Photoshop. In Geekbench 3, the blur image workload is more computationally demanding than the sharpen workload.

SGEMM and DGEMM:
GEMM is "general matrix multiplication." Matrix multiplication is a fundamental mathematical operation. It is used in physical simulations, signal processing, graphics processing, and many other areas.

SFFT and DFFT:
The fast Fourier transform (FFT) workloads simulate the frequency analysis used to compute the spectrum view in an audio processing application such as Pro Tools.

N-Body:
This workload computes a physical simulation similar to that required for a physics game placed in outer space.

Ray trace:
The ray trace workload renders a 3D scene from a geometric description.

Memory Workloads

STREAM copy:
The stream copy workload tests how fast your computer can copy large amounts of data in memory. It executes a value-by-value copy of a large list of floating point numbers.

STREAM scale:
This workload is similar to stream copy, but each value is multiplied by a constant during the copy.

STREAM add:
The stream add workload reads two large lists of floating point numbers value-by-value, adds corresponding values, and stores the result in a third list.

STREAM triad:
This workload combines stream add and stream scale. It reads two lists of floating point numbers value-by-value, multiplies one of the numbers by a constant, adds the result to the other number, and writes that result to a third list.

Unixbench Tests and Descriptions
Original Article https://code.google.com/p/byte-unixbench/

Dhrystone
Developed by Reinhold Weicker in 1984. This benchmark is used to measure and compare the performance of computers. The test focuses on string handling, as there are no floating point operations. It is heavily influenced by hardware and software design, compiler and linker options, code optimization, cache memory, wait states, and integer data types.

Whetstone
This test measures the speed and efficiency of floating-point operations. This test contains several modules that are meant to represent a mix of operations typically performed in scientific applications. A wide variety of C functions including sin, cos, sqrt, exp, and log are used as well as integer and floating-point math operations, array accesses, conditional branches, and procedure calls. This test measure both integer and floating-point arithmetic.

Execl Throughput
This test measures the number of execl calls that can be performed per second. Execl is part of the exec family of functions that replaces the current process image with a new process image. It and many other similar commands are front ends for the function execve().

File Copy
This measures the rate at which data can be transferred from one file to another, using various buffer sizes. The file read, write and copy tests capture the number of characters that can be written, read and copied in a specified time (default is 10 seconds).

Pipe Throughput
A pipe is the simplest form of communication between processes. Pipe throughput is the number of times (per second) a process can write 512 bytes to a pipe and read them back. The pipe throughput test has no real counterpart in real-world programming.

Pipe-based Context Switching
This test measures the number of times two processes can exchange an increasing integer through a pipe. The pipe-based context switching test is more like a real-world application. The test program spawns a child process with which it carries on a bi-directional pipe conversation.

Process Creation
This test measure the number of times a process can fork and reap a child that immediately exits. Process creation refers to actually creating process control blocks and memory allocations for new processes, so this applies directly to memory bandwidth. Typically, this benchmark would be used to compare various implementations of operating system process creation calls.

Shell Scripts
The shells scripts test measures the number of times per minute a process can start and reap a set of one, two, four and eight concurrent copies of a shell scripts where the shell script applies a series of transofrmation to a data file.

System Call Overhead
This estimates the cost of entering and leaving the operating system kernel, i.e. the overhead for performing a system call. It consists of a simple program repeatedly calling the getpid (which returns the process id of the calling process) system call.

The time to execute such calls is used to estimate the cost of entering and exiting the kernel.

Geekbench Results Table for Servers Tested

Test Cores	Integer Single	Integer Multi	Floating Point Single	Floating Point Multi	Memory Single	Memory Multi	Geekbench Score Single	Geekbench Score Multi
First Gen	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**
2 GB	1380	5343	1227	4746	956	1256	1234	4286
4 GB	1364	5195	1220	4682	1005	1541	1234	4259
8 GB	1382	5305	1228	4740	1103	1389	1264	4295
15 GB	1381	5321	1226	4727	1051	1664	1253	4352
30 GB	1379	10567	1226	9174	1057	1627	1253	8221
Next Gen	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**
2 GB	2074	4059	1676	3272	1571	2443	1814	3421
4 GB	1325	2591	1166	2321	1128	1794	1222	2323
8 GB	1328	5181	1178	4597	1133	1904	1229	4292
15 GB	1325	7708	1177	6912	1002	1757	1201	6199
30 GB	1327	10090	1177	9195	1072	1780	1216	8070
Performance	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**
2 GB	2192	4332	2165	4318	2162	3886	2175	4237
4 GB	2193	8581	2167	8601	2097	4043	2163	7681
8 GB	2186	16807	2169	16881	2136	3890	2169	14253
15 GB	2180	8538	2156	8564	2130	3901	2160	7621
30 GB	2169	16749	2142	15895	2094	3959	2143	13849
60 GB	2163	23859	2161	33405	2106	3974	2150	23700
90 GB	2178	30944	2159	31507	2130	3961	2160	25772
120 GB	2160	39154	2141	40344	2106	3963	2141	32591

Geekbench Uploaded Results for Servers Tested

The links below lead to uploaded results of the tests, where individual test results are recorded and can be viewed by users publicly.

First Gen	More Test Results Information Link
2 GB	http://browser.primatelabs.com/geekbench3/180383
4 GB	http://browser.primatelabs.com/geekbench3/180384
8 GB	http://browser.primatelabs.com/geekbench3/180385
15 GB	http://browser.primatelabs.com/geekbench3/180386
30 GB	http://browser.primatelabs.com/geekbench3/180388
Next Gen	**More Test Results Information Link**
2 GB	http://browser.primatelabs.com/geekbench3/180416
4 GB	http://browser.primatelabs.com/geekbench3/180418
8 GB	http://browser.primatelabs.com/geekbench3/180419
15 GB	http://browser.primatelabs.com/geekbench3/180420
30 GB	http://browser.primatelabs.com/geekbench3/180421
Performance	**More Test Results Information Link**
2 GB	http://browser.primatelabs.com/geekbench3/180431
4 GB	http://browser.primatelabs.com/geekbench3/180433
8 GB	http://browser.primatelabs.com/geekbench3/180432
15 GB	http://browser.primatelabs.com/geekbench3/180434
30 GB	http://browser.primatelabs.com/geekbench3/180435
60 GB	http://browser.primatelabs.com/geekbench3/180817
90 GB	http://browser.primatelabs.com/geekbench3/180818
120 GB	http://browser.primatelabs.com/geekbench3/180819

Unixbench Results Table for Servers Tested

Test	Dhrystone 2	Double-Precision Whetstone	Execl Throughput	Pipe-based Context Switching
First Gen	**Loops/Sec**	**MIPS**	**Mbps**	**Loops/Sec**
2 GB	77631838	10395	2673	157675
4 GB	76660064	10279	2565	148278
8 GB	77841676	10431	2644	150273
15 GB	77711717	10411	2597	149598
30 GB	155285803	20680	4280	299320
Next Gen	**Loops/Sec**	**MIPS**	**Mbps**	**Loops/Sec**
2 GB	46525102	6162	1769	103943
4 GB	37274192	4979	1459	82741
8 GB	74446862	9950	2615	166525
15 GB	111658136	14905	3572	244410
30 GB	148865229	19855	4455	329211
Performance	**Loops/Sec**	**MIPS**	**Mbps**	**Loops/Sec**
2 GB	59514863	6547	2092	111327
4 GB	119048725	13084	3758	222626
8 GB	237860754	26145	6648	464595
15 GB	118965541	13085	3760	244410
30 GB	237663295	26149	6500	329211
60 GB	438215887	51302	9070	219675
90 GB	484983902	72150	8617	443615
120 GB	497202339	90834	7245	682827

Unixbench Results Continued

Tests	Pipe Throughput	Process Creation	Shell Scripts (1 Concurrent)	Shell Scripts (8 Concurrent)	System Call Overhead
First Gen	**Loops/Sec**	**Loops/Sec**	**Loops/Minute**	**Loops/Minute**	**Loops/Minute**
2 GB	1018138	5573	6515	874	1018894
4 GB	963280	5297	6269	842	961950
8 GB	965011	5477	6491	871	977765
15 GB	964911	5363	6367	855	967210
30 GB	1948428	8121	10769	1440	1850344
Next Gen	**Loops/Sec**	**Loops/Sec**	**Loops/Minute**	**Loops/Minute**	**Loops/Minute**
2 GB	706803	3767	4269	578	542823
4 GB	503627	3044	3521	475	486933
8 GB	996066	5387	6384	862	955093
15 GB	1479229	7191	8770	1176	1394917
30 GB	1990250	8631	11008	1479	1797273
Performance	**Loops/Sec**	**Loops/Sec**	**Loops/Minute**	**Loops/Minute**	**Loops/Minute**
2 GB	679713	4444	4994	673	729988
4 GB	1386882	7789	9104	1229	1432173
8 GB	3103963	12524	16503	2229	2637179
15 GB	1372317	7597	9145	1232	1406417
30 GB	2897098	12222	16086	2166	2609260
60 GB	5049182	14800	24013	3203	3091338
90 GB	8323099	12676	25529	3434	3760608
120 GB	7753373	10739	21661	2917	4303301

Unixbench Results Continued

File Copy Tests	256 Bufsize 500 maxblocks	1024 Bufsize 2000 maxblocks	4096 Bufsize 8000 maxblocks
First Gen	**Kb/s**	**Kb/s**	**Kb/s**
2 GB	68210	256675	655047
4 GB	65232	241609	649767
8 GB	66313	247591	639208
15 GB	6671	249843	642395
30 GB	62989	239639	649777
Next Gen	**Kb/s**	**Kb/s**	**Kb/s**
2 GB	88253	314446	907650
4 GB	72549	265352	765986
8 GB	71232	260219	666384
15 GB	66855	247692	659430
30 GB	65478	240570	654803
Performance	**Kb/s**	**Kb/s**	**Kb/s**
2 GB	95158	366714	1173104
4 GB	79772	280125	940042
8 GB	84152	297217	967832
15 GB	78249	282958	910097
30 GB	77335	288296	894819
60 GB	71586	265425	883665
90 GB	90258	332691	1027296
120 GB	74079	263073	906446

Rackspace Server Information for Servers Tested

First Gen	Cost (Hour)	vCPUs	Processor
2 GB	$0.12*	4	AMD Opteron 2374 HE (2.20 GHz)
4 GB	$0.24*	4	AMD Opteron 2374 HE (2.20 GHz)
8 GB	$0.48*	4	AMD Opteron 2374 HE (2.20 GHz)
15 GB	$0.96*	4	AMD Opteron 2374 HE (2.20 GHz)
30 GB	$1.80*	8	AMD Opteron 2374 HE (2.20 GHz)
Next Gen	**Cost (Hour)**	**vCPUs**	**Processor**
2 GB	$0.12*	2	AMD Opteron 4332 HE (3.00 GHz)
4 GB	$0.24*	2	AMD Opteron 4170 HE (2.10 GHz)
8 GB	$0.48*	4	AMD Opteron 4170 HE (2.10 GHz)
15 GB	$0.90*	6	AMD Opteron 4170 HE (2.10 GHz)
30 GB	$1.20*	8	AMD Opteron 4170 HE (2.10 GHz)
Performance	**Cost (Hour)**	**vCPUs**	**Processor**
2 GB	$0.08	2	Intel Xeon E5-2670 0 (2.60 GHz)
4 GB	$0.16	4	Intel Xeon E5-2670 0 (2.60 GHz)
8 GB	$0.32	8	Intel Xeon E5-2670 0 (2.60 GHz)
15 GB	$0.68	4	Intel Xeon E5-2670 0 (2.60 GHz)
30 GB	$1.36	8	Intel Xeon E5-2670 0 (2.60 GHz)
60GB	$2.72	16	Intel Xeon E5-2670 0 (2.60 GHz)
90GB	$4.08	24	Intel Xeon E5-2670 0 (2.60 GHz)
120GB	$5.44	32	Intel Xeon E5-2670 0 (2.60 GHz)

*Cost of the virtual machine prior to the introduction of the Performance Servers on November 5, 2013. Prices may have changed since that time.