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Comparing major cloud-service providers: virtual processor performance

A Cloud Report by Danny Gee, and Kenny Li

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09/03/2014

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1 Executive Summary

Cloud computing continues to play an increasingly important role for IT organizations in 2014. In partnership with Cloud Spectator, Gigaom Research conducted research to determine how three major cloud providers — Amazon EC2, Microsoft Azure and Rackspace Cloud — perform with regards to processor and memory.

The three providers were tested using Geekbench 3 standardized tests over a three-day period of time. Individual test results proved a variability of as much as 25 percent. The complex of variables between cloud providers beyond just processor and memory can contribute heavily to this variability in results. Tests were conducted over a three-day period to normalize the results. With each provider, different configurations of each solution were tested to demonstrate the variability and value between configurations. In addition, the provider's updated hardware configurations were used to ensure currency.

It should be noted that the tests in this research focused on the performance of processor and memory only. There are a number of other variables (network, architecture, etc) that can vary the results for a specific application or service.

Key findings in this report include:

- Rackspace led in performance, though this was offset by a higher variability.
- Microsoft and Amazon showed stable results, but at a lower-performance rate.
- Rackspace demonstrated a 2x value over Amazon and Microsoft. Value is defined as the ratio of cost and performance.
- Amazon's Reserve Instances provide an alternative that brings the cost/performance ratio closer to that of Rackspace. Depending on the specific use case, one solution may be more appropriate than the other.

2 The IaaS industry

Public-cloud infrastructure, often referred to as infrastructure as a service (IaaS), provides pay-as-you-go, on-demand virtual servers with scalability to grow with an organization's IT demands. Unlike in a private cloud, in which businesses use dedicated hardware to create virtual environments, public IaaS users provision virtual machines on shared hardware resources, where different users reside on the same physical server(s).

Amazon EC2, Rackspace Cloud, and Microsoft Azure are three of the largest global public-cloud service providers (CSPs). With cloud-enabled regions around the world and a diverse portfolio of supplementary technology offerings, all three of these CSPs deliver a robust suite of IT services.

Over the past several years, some CSPs and third-party companies have made a collective effort to provide transparency on available features, pricing, and security. But one nebulous issue — performance — is still unaddressed due to its complexity.

Performance variability

In our study we observed two instances of performance variability within a single cloud data center:

Type 1. Different underlying hardware. In our three days of testing across Amazon EC2, our virtual machines provisioned on two different processors: the Intel(R) Xeon(R) CPU E5-2670 v2 @ 2.50GHz and Intel(R) Xeon(R) CPU E5-2680 v2 @ 2.80GHz. The former was continuously seen with the m3.medium instance, and occasionally on the c3.2xlarge instance. The latter processor was reported on every test iteration of the c3.large and c3.xlarge, and occasionally on the c3.2xlarge instance. When the c3.2xlarge instance was provisioned with the Intel(R) Xeon(R) CPU E5-2670 v2 @ 2.50GHz processor, performance dropped by around 7 to 8 percent.

A list of the underlying processor hardware behind the virtual cores tested in this study.

Providers	Amazon EC2	Rackspace Cloud	Microsoft Azure
Processor(s)	Intel(R) Xeon(R) CPU E5-2670 v2 Intel(R) Xeon(R) CPU E5-2680 v2	Intel Xeon E5-2670	AMD Opteron(tm) Processor 4171 HE

Type 2. Different physical servers. On Rackspace Cloud, only one processor was reported on the BIOS from all virtual machine sizes and iterations. Despite this fact, performance ranges varied with

each iteration. Using our extra-large (eight cores) VM size as an example, the second and third iterations of testing on the first day produced a difference of almost 25 percent for processor performance. Significant performance differences can adversely affect the end-user experience and cause a business to unnecessarily scale up resources.

Performance differences can be due to numerous reasons. Larger CSPs find it difficult to frequently perform hardware refreshes to their entire environment, resulting in a mix of older and newer hardware. Performance fluctuation exclusive of hardware variance may be due to noisy neighbors contending for limited physical resources. These reasons and many more are why we believe it is important to conduct testing continuously over a period of time on several different virtual servers. A thorough and accurate testing process for businesses may be a very time-consuming and resource-intensive project.

Purpose of this study

A lack of standardization in the IaaS industry results in a difficult like-for-like comparison across CSPs. By carefully evaluating cloud infrastructure options, businesses can maximize the performance of their applications while minimizing cost. This report was created as a first step for businesses in the process of standardizing and comparing CSPs to make informed purchase decisions.

There are numerous CSPs around the world. And some may perform just as well, if not better, than the CSPs analyzed in this report. We chose Amazon EC2, Rackspace Cloud, and Microsoft Azure due to their size and positions in the IaaS industry.

3 Methodology and limitations

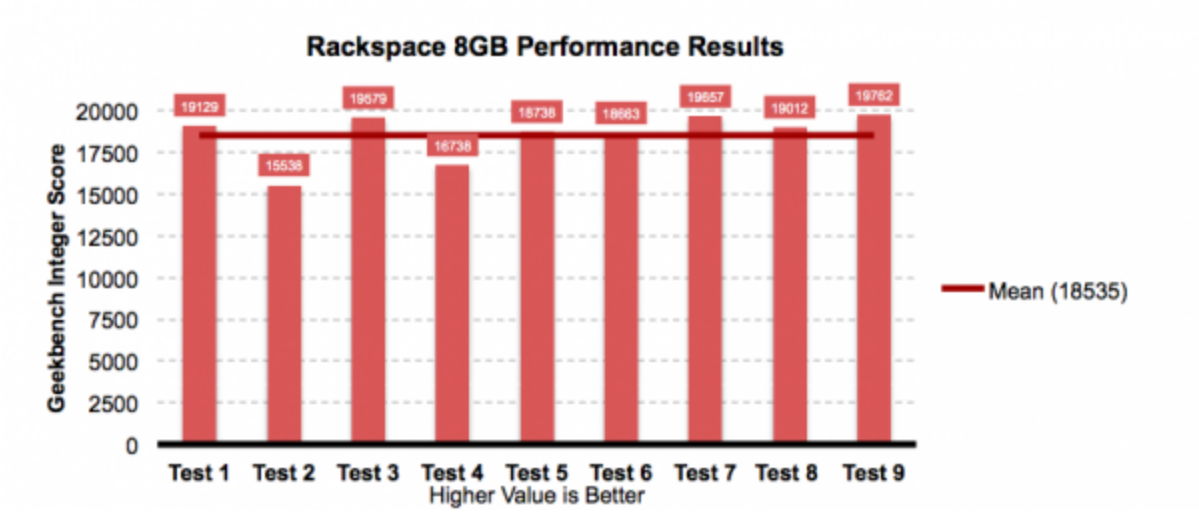
Methodology

The study was conducted by provisioning virtual machines (VMs) on each of the three providers. On each provider, four different virtual machines were provisioned to measure performance as the VMs scaled. Due to variable offerings across providers, an exact configuration for all virtual machines is not possible to achieve, but due to the focus on processor and memory in this report, providers were matched with equivalent amounts of vCPUs. (See Appendix for list of instance types.)

Because Geekbench 3 was designed to service many different markets, it was not designed with one particular workload in mind. Rather, it contains modern workloads that are common tasks for servers and desktops (e.g., compression, decompression, encryption, and dynamic content generation). While Geekbench 3 minimizes the effect of the operating system on the final score there are inevitably variables outside of the control of the program that may affect the performance such as compilers used by different operating systems. Therefore, this study standardized the version of each operating system to Ubuntu 14.04.

The Geekbench 3 suite was installed and run on each of the VMs. Three test iterations were run per day on each instance type for a period of three days. For each iteration a new VM was provisioned, tested, and deleted, rather than starting and stopping the same VMs over the course of the study. Longitudinal data from testing over time helps illustrate the complexity of public cloud resource contention or provider throttling. The graph below shows Rackspace's integer score over the nine iterations of tests run on different virtual machines of the same size (8GB Performance). The mean shows a score of 18535, although on Test 2, the score drops to 15538, a 3,000-point difference—approximately 80 percent of the mean. (See Appendix for notes on provisioning.)

Rackspace Cloud's 8GB Performance VM scores over a three-day period, which included three iterations per day. Results show the performance outliers that can occur below and above average.



Geekbench 3, created by Primate Labs, is designed for processor and memory performance. We selected this as the test in this study for two main reasons. The suite contains a variety of common modern-day use cases handled by the processor and memory, which can apply to a variety of use cases. Many other benchmarks may focus on more synthetic workloads or HPC cases, which are less practical. Also, Geekbench 3's most recent release, version 3.1.5, occurred in March 2014. Many alternative processor and memory benchmark suites have not made updates for years.

Following the benchmark tests, the data was aggregated and analyzed to create this report. The graphs and charts shown later in the report highlight the key takeaways from the data. A value comparison was also conducted to determine the relative costs and benefits of the different offerings.

Limitations

This report examines virtual processor performance and memory bandwidth across various machines on Amazon EC2, Rackspace Cloud, and Microsoft Azure. The information in the performance and value analysis should not be extrapolated to represent other performance behaviors, such as that of disk IO and network bandwidth.

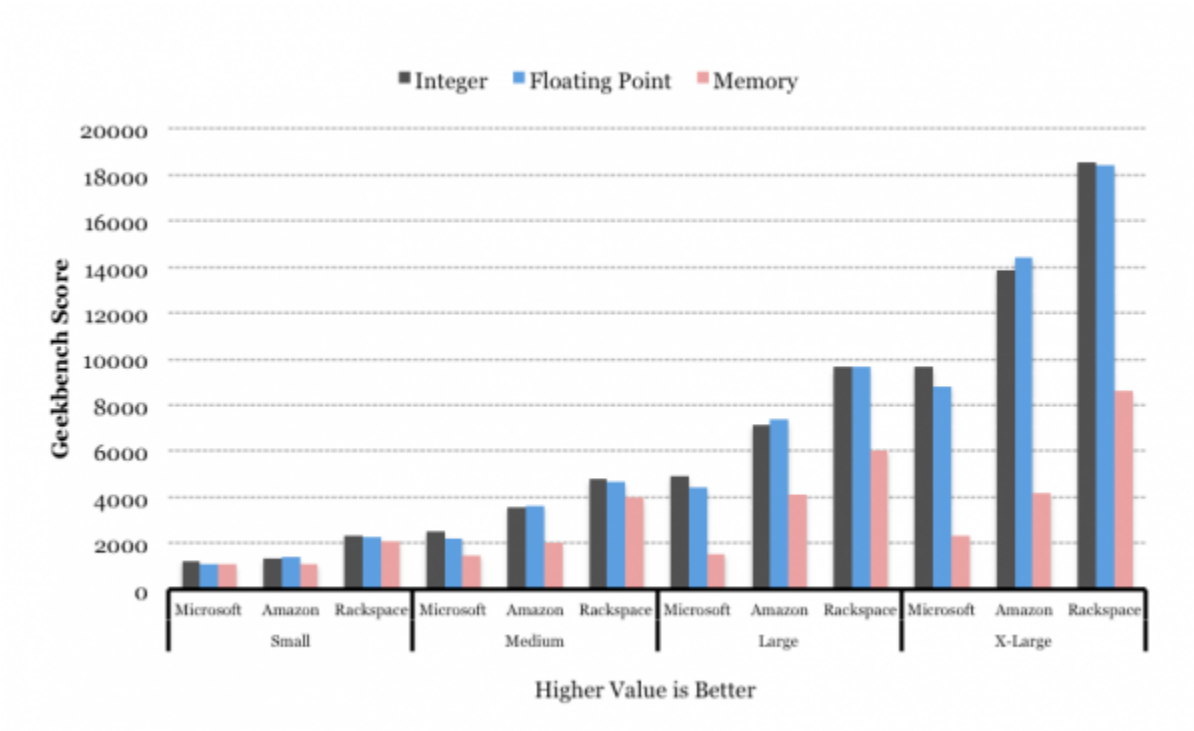
Because of that scope, higher Geekbench 3 scores do not equate to greater performance across the board, which may involve other components such as subsystem IO or internal network. The results in this study are not meant to be representative of overall system performance or overall performance of the provider. Other components will be explored in future reports.

4 Performance findings

The trade-offs between price, performance, and stability can be seen between the three providers. Rackspace's leadership position on vCPU performance throughout this experiment is offset by its variability in performance. On the other hand, Microsoft Azure and Amazon EC2's performance over the duration of this experiment result in a more stable environment, but also lower vCPU performance. Amazon EC2's long-term discounts (referred to as Reserved Instances) give users a great option for price and performance value when committing to their virtual machines for a longer period of time.

Top performers by average

Individual average results over the testing period (three days, three iterations per day) for small, medium, large and extra large servers on Amazon EC2, Microsoft Azure, and Rackspace Cloud.

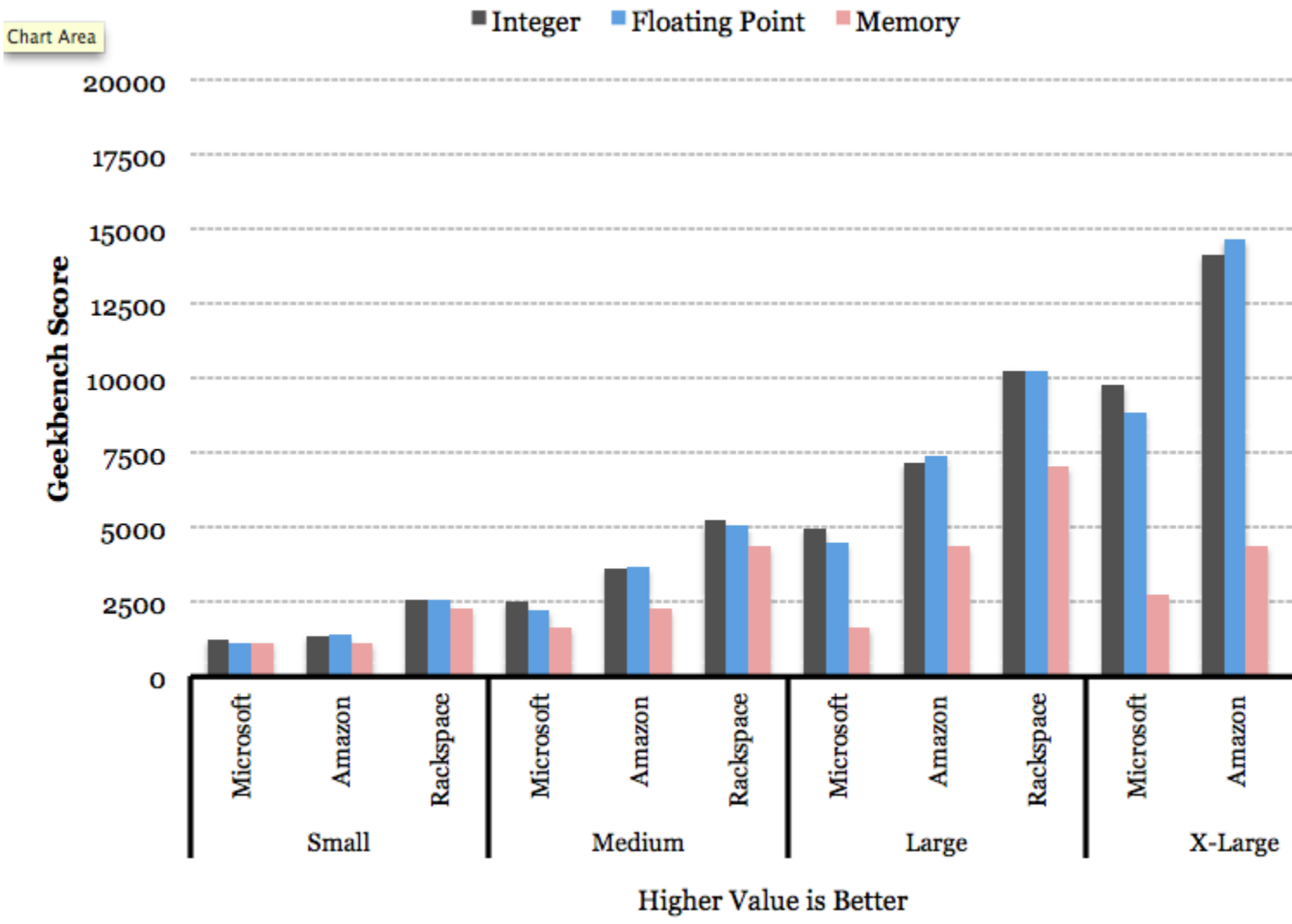


Average results over the course of the testing show that Rackspace maintains processor-performance advantage over Amazon EC2 and Microsoft Azure. The virtual machines on Amazon EC2 and Rackspace Cloud utilize Intel processors, which may explain the better

performance between floating point and integer CPU tests, compared with Microsoft Azure's AMD Opteron processors.

Top performers by high score

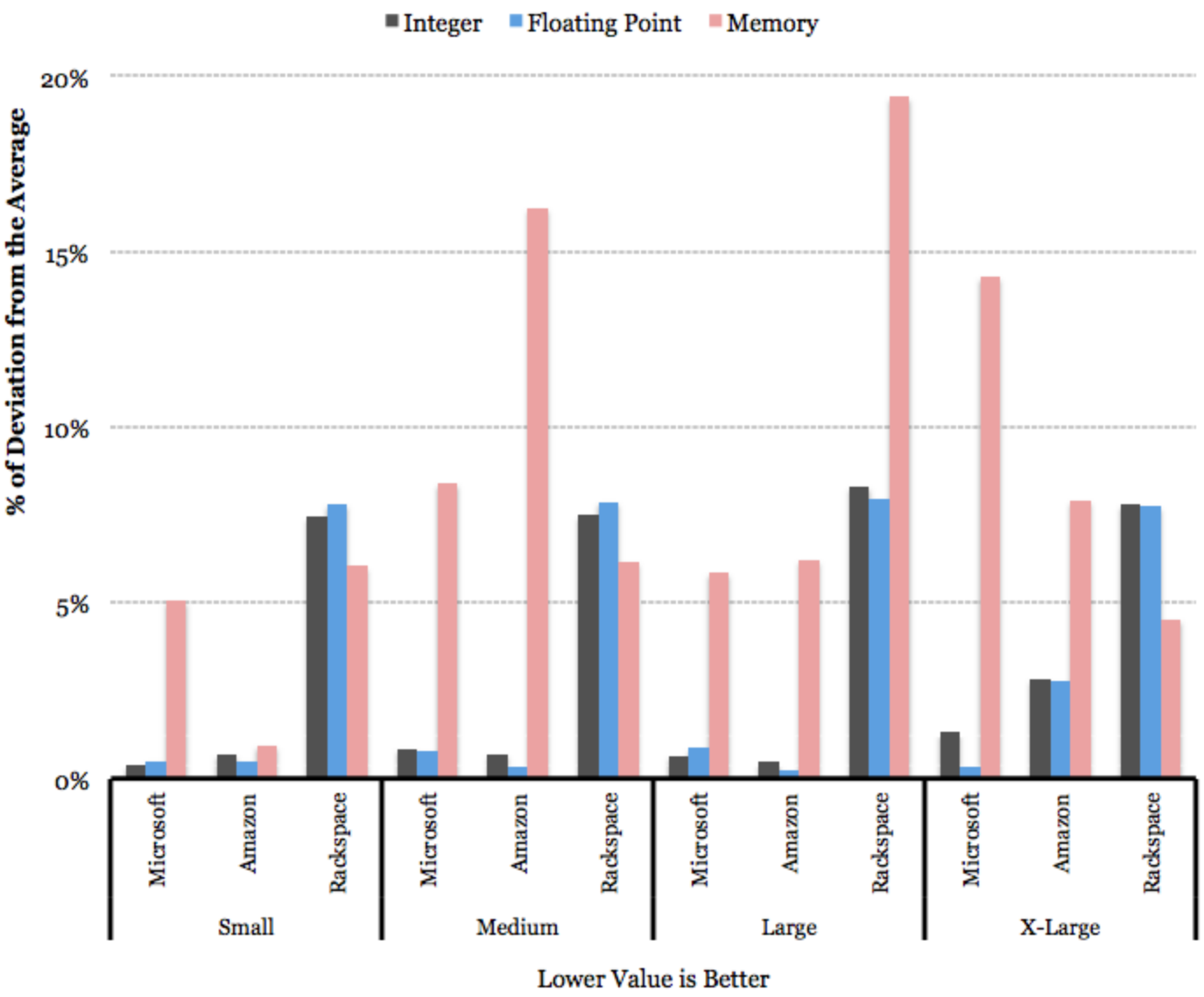
The highest scores achieved over the testing period (three days, three iterations per day) for small, medium, large and extra-large servers on Amazon EC2, Rackspace Cloud, and Microsoft Azure.



Rackspace achieves the highest performance numbers compared with Amazon EC2 and Microsoft Azure in the course of this experiment as well. Rackspace's high scores contribute to the high averages.

Performance stability

The percentage of variability over the testing period (3 days, 3 iterations per day) for small, medium, large and extra large servers on Amazon EC2, Microsoft Azure, and Rackspace Cloud. Variability is calculated by expressing the ratio of standard deviation and mean as a percentage.



Both Amazon EC2 and Microsoft Azure delivered a steadier rate of performance over the testing period than Rackspace Cloud. Memory bandwidth exhibited much less control with spikes in variation from the average on each provider's virtual machine.

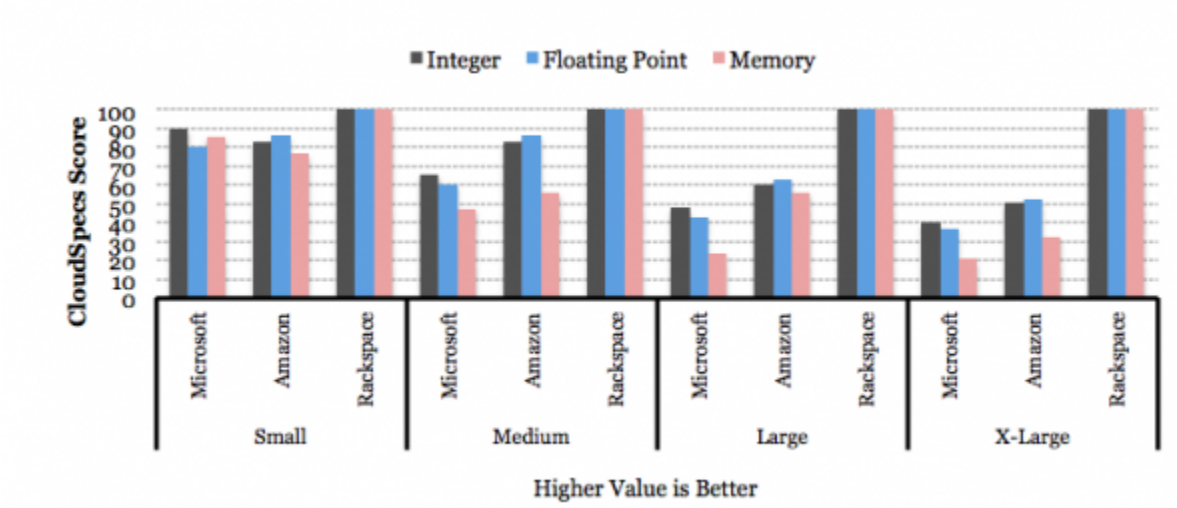
5 Price and performance findings

Value in this study is defined as the ratio between the cost (per hour or per year) and the performance score achieved from the Geekbench 3 tests run on the four virtual machine types with each CSP.

Each provider's score is indexed such that the highest-value CSP receives a score of 100. All other providers are pegged relative to the highest score. For example, if Provider A receives a score of 100 and Provider B receives a score of 50, then Provider A offers 2x more value for, in this case, processor and/or memory performance. This is called the CloudSpecs Score™.

Value for on-demand (hourly) services

The indexed CloudSpecs Score for processor and memory performance on Microsoft, Amazon, and Rackspace's small, medium, large, and extra large servers based on on-demand costs.

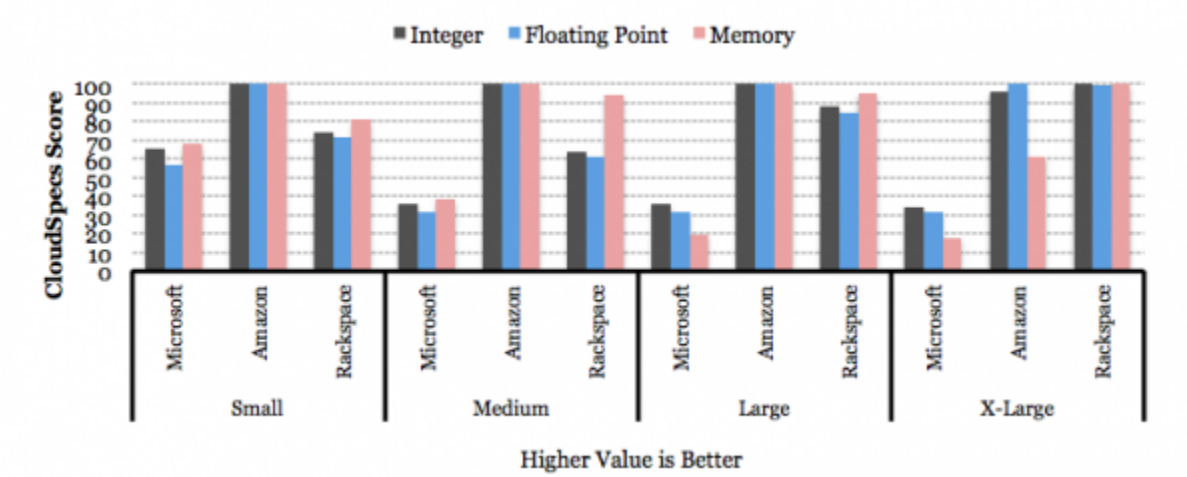


Standard on-demand pricing was used to calculate the ratio for all three providers. For the purpose of this study, which did not require any level of managed services, Rackspace's cost was calculated with its most basic level of managed service support, Managed Infrastructure. The monthly minimum service charge for Rackspace was incorporated into the hourly on-demand rate used in the ratio calculation. All Rackspace virtual servers now come standard with one of three levels of managed services. Cost for support was not included in the total cost per hour on Microsoft and Amazon because it does not come standard.

Due to high-scoring performance and low on-demand costs, Rackspace achieves a much higher value score than its competitors for processor and memory performance for on-demand pricing. While Microsoft's servers are matched closely in price with Amazon, the higher performance results on Amazon gives Amazon an advantage over Microsoft in the CloudSpecs Score™.

Value for annual services

The indexed CloudSpecs Score for processor and memory performance on Microsoft, Amazon, and Rackspace's small, medium, large, and extra large servers based on annual subscriptions.



Amazon's Reserved Instances (Heavy Utilization) is an option for users willing to commit to a long-term contract. Despite the upfront costs, the significantly lower on-demand costs make it an attractive option for long-term use. Rackspace and Microsoft both have long-term discounts, but neither could be applied to this study due to the inability to meet the discount qualifications (e.g., a minimum amount that must be spent per month).

As the virtual machines scale vertically in size, Rackspace slowly increases in value against Amazon. At the extra-large machine, while the annual cost at Rackspace is $2,850 and at Amazon is $2,220, the performance of the Rackspace virtual machine results in Rackspace reclaiming the lead for processor and memory value on the extra-large VM size.

6 Conclusion

CSPs offer varying amounts of value for similarly described products. Providers find ways to justify the price differentials between themselves and their competitors, but on a basic level of price and performance, some machines simply offer more value than others.

As shown above, Rackspace's current generation of servers are offering a higher level of performance compared to its peers. While this comes at a cost of lower stability in performance, the overall increase in performance may be worth it to customers.

Examining the value of the services, Rackspace's performance leadership translates over to price/performance value for on-demand hourly services. However, Amazon's discounts for long-term usage raise it above or to the same level as Rackspace for customers that are able to commit to at least a year of continuous usage.

Amazon continues to dominate the market for IaaS while Microsoft is steadily pushing to catch up. Rackspace meanwhile is focusing on its premium service differentiation and has recently segmented its cloud offering into Managed Operations and Managed Infrastructure. With prices slated to keep dropping and performance expected to rise with newer hardware, it would be wise to keep an eye on the price/performance value CSPs are offering on a frequent basis.

Further studies

Processor and memory performance are only a couple of pieces of the entire puzzle in understanding virtual machine performance and value. Follow up reports in the series of performance studies initiated by this report will feature additional testing applicable to other components of the infrastructure. Further studies may also include a larger scope of server sizes to be tested as well as potential tests of specific applications.

7 Appendix

Server setups

Providers	Amazon EC2	Rackspace Cloud	Microsoft Azure
Small VM (1 core)	**m3.medium**	**1GB Performance**	**A1**
Virtual Cores	1	1	1
Memory (in GB)	3.75	1	1.75
Medium VM (2 cores)	**c3.large**	**2GB Performance**	**A2**
Virtual Cores	2	2	2
Memory (in GB)	3.75	2	3.5
Large VM (4 cores)	**c3.xlarge**	**4GB Performance**	**A3**
Virtual Cores	4	4	4
Memory (in GB)	7.5	4	7
Extra Large VM (8 cores)	**c3.2xlarge**	**8GB Performance**	**A4**
Virtual Cores	8	8	8
Memory (in GB)	15	8	14

Provisioning cloud servers

Providers	Amazon EC2	Rackspace Cloud	Microsoft Azure
Default User	Variable	root	azureuser
Provision through API	Yes	Yes	Yes
Administrator Privileges at Login?	No	Yes	No
SSH Security	Key Pair Only	Password	Key Pair or Password
Operating System	Ubuntu 14.04 (HVM)	Ubuntu 14.04 (PVHVM)	Ubuntu 14.04
Data Center Location	US East (N. Virginia)	Northern Virginia (IAD)	US East (Virginia)

Notes on Provisioning

- All virtual machines were provisioned in availability zones in the Northern Virginia area, as it was the only geographical presence that included all three CSPs included in this experiment.
- After each test iteration, the virtual machines were deleted; every test iteration started with a newly provisioned machine. This was done to enable the possibility of switching physical machines throughout the process of testing, which would increase the likelihood of spotting performance variation and the effectiveness of the sample size.
- Once a new virtual machine was created for each new iteration of testing, "apt-get update" and "apt-get upgrade –yes" commands were issued, followed by a reboot of the system before installing any tests.
- On Amazon EC2 and Microsoft Azure, ICMP ports are closed by default. It was necessary to configure Amazon EC2 security groups and Microsoft Azure's network options to enable ICMP for ping response. Ping response was used to ensure that the virtual machine was back up after a reboot following the system updates and upgrades.
- For Microsoft Azure, a cloud service is provisioned with each new instance, unless a specific cloud service is assigned. By default, a limit of 20 cloud services can be active at once. Cloud services do not get deleted along with the virtual machine, so cloud services had to be manually deleted as well.
- No additional dependencies or applications were installed apart from anything that may be available by default from the CSP.

Global presence for each provider

Providers	Amazon EC2	Rackspace Cloud	Microsoft Azure
Total Global Regions	8	6	11
North America	US East (North Virginia) US West (Oregon) US West (Northern California)	Dallas/Fort Worth (DFW) Chicago (ORD) North Virginia (IAD)	US East (Virginia) US West (California) US North Central (Illinois) US South Central (Texas)
Europe	EU (Ireland)	London (LON)	Europe North (Ireland) Europe West (Netherlands)
Asia Pacific	Asia Pacific (Singapore) Asia Pacific (Tokyo) Asia Pacific (Sydney)	Hong Kong (HKG) Sydney (SYD)	Asia Pacific Southeast (Singapore) Asia Pacific East (Hong Kong) Japan East (Saitama Prefecture) Japan West (Osaka Prefecture)
South America	Sao Paulo		Brazil South (Sao Paulo State)

8 About Cloud Spectator

Cloud Spectator is a cloud analyst agency focused on cloud IaaS performance. The company actively monitors 20+ of the largest IaaS providers in the world, comparing VM performance (i.e., CPU, RAM, disk, internal network, and workloads) and pricing to achieve transparency in the cloud market. The company helps cloud providers understand their market position and helps businesses make intelligent decisions in selecting cloud providers and lowering total cost of ownership. The firm was founded in early 2011 and is located in Boston, MA.

9 About Gigaom Research

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