Performance Analysis: Benchmarking Public Clouds

Performance comparison of web server and database VMs on Internap AgileCLOUD and Amazon Web Services

By Cloud Spectator
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ABSTRACT

Selecting an Infrastructure-as-a-Service (IaaS) provider can be a complex exercise that involves an array of considerations including business needs, budget, and application requirements. Buyers frequently respond to this complexity by filtering vendors based on variables that are more easily comparable, usually product features, location, and price. By contrast, performance, which is a critical factor to ensuring fit with business needs and ultimately satisfaction with the service, is often ignored. Virtual machine (VM) performance can be challenging to assess because it can vary drastically across vendors, instance sizes and prices, as well as in terms of a particular application's unique requirements.

Internap commissioned this benchmarking analysis to examine the relative performance of major VM components including virtual cores, memory, block storage, and internal network for Internap AgileCLOUD and Amazon Web Services (AWS) EC2/EBS. Specifically, the study examines raw performance and price-indexed performance for two common workloads: web servers and databases. Findings from the study show that Internap AgileCLOUD provides better raw performance and price-indexed performance than AWS.

INTRODUCTION

The rise of public cloud as a robust infrastructure choice over the past several years has led organizations to aggressively outsource their compute, memory, and storage needs to a growing number of IaaS providers. With increasing cloud adoption, more vendors have decided to enter this fast-growing market. Cloud Spectator maintains a provider database containing 241 public cloud providers selling IaaS services across the world. With pricing, feature set and performance options varying across every one of these providers, the number of variables at play is enormous. This diversity, while enhancing choice and market competition, has led to confusion among infrastructure buyers as to how to best assess cloud providers when making purchase decisions. Like-to-like performance assessments are particularly difficult when considering price and specific application use cases. To assess relative value for IaaS buyers, Cloud Spectator conducted a normalized comparison of two cloud providers' services, AWS EC2 and Internap AgileCLOUD. This analysis considers each providers' IaaS functionality, price, and performance in the context typical cloud-hosted workloads. The tested scenarios include:

(1) Web Servers

a. Static Web Servers
b. Read/Write Web Servers
c. High-traffic Web Servers

(2) Databases

a. Single-node Databases
b. Clustered Database Environments

METHODOLOGY

Cloud Spectator tested virtual machines from AWS and Internap for a period of five days between December 31, 2014 and January 4, 2015. An iteration of the test suite was run once per day. Each iteration of the test suite captured performance data on virtual processors, memory bandwidth, block storage IOPS, and internal network throughput. Tests within the suite are categorized below.

Test	Resources Measured	Description
Geekbench 3	Processor & Memory	Geekbench 3 is a licensable product designed by Primate Labs. It is a collection of tests designed to simulate real-world scenarios, providing an indication of processor and memory performance. Tests results are broken out between processor (integer & floating point) and memory scores.
Fio	Block Storage	Fio is an open source tool designed to stress IO. Cloud Spectator configured Fio to run sequential read, sequential write, random read, and random write tests to gather performance data on block storage IOPS.
Iperf	Network Throughput	Iperf is an open source tool used to measure network throughput between client and server. By default, Iperf connects between the machines and measures throughput performance using a TCP protocol. Cloud Spectator used the default TCP protocol and transferred data bi-directionally.

Table 1: The tests listed in this table were used to collect quantitative data on performance across the selected VMs (see Table 2) on Internap AgileCLOUD and AWS.

In an effort to standardize VM sizes between Internap AgileCLOUD and AWS, comparable virtual machines were chosen based on equivalent amounts of virtual cores reported by the provider. Block storage was matched by comparing a 50GB volume using the best available options from both providers (e.g., Provisioned IOPS and SSD-backed EBS technology from AWS). A separate, equivalently sized virtual machine was provisioned within the same region/availability zone to act as a server for internal network testing. All virtual machines ran using Ubuntu 14.04 (on AWS, the HVM image was used). Table 2 provides details of VMs used for each provider.

2 vCPU Machines	vCPUs	Memory	Block Storage
Internap AgileCLOUD B Series 2vCPU	2	8 GB	50 GB
Amazon AWS m3.large	2	7.5 GB	50 GB

4 vCPU Machines	vCPUs	Memory	Block Storage
Internap AgileCLOUD B Series 4vCPU	4	15 GB	50 GB
Amazon AWS m3.xlarge	4	15 GB	50 GB

16 vCPU Machines	vCPUs	Memory	Block Storage
Internap AgileCLOUD B Series 16vCPU	16	60 GB	50 GB
Amazon AWS r3.4xlarge	16	122 GB	50 GB

Table 2: illustrates the VMs that were used in the comparison standardized by vCPU cores. Only 50GB volumes were examined in this study. Provider storage performance may scale with volume size. AWS's r3.4xlarge was closest to match with Internap's B Series 16 vCPU machine.

The CloudSpecs Score, which is an indexed score for price-performance value, was calculated by taking the hourly price of each provider and performance results of the components, expressed as a singular number. That number was then pegged to the highest result, which gets a score of 100; thus, value numbers are relative. For example, if Provider A scores 100 and Provider B scores 50, then Provider A shows 2x more price-performance value than Provider B. Please see the formula below to calculate the CloudSpecs Score.

1. provider_value = {provider performance score} / {provider cost}
2. best_provider_value = max{provider_values}
3. Provider's CloudSpecs Score = 100*provider_value / best_provider_value

Provider	Data Center	2 vCPU	4 vCPU	16 vCPU	Block Storage (Monthly)
Internap AgileCLOUD		$0.16	$0.32	$1.28	$15
Amazon AWS		$0.14	$0.28	$1.40	$103.75

Table 3: The table above shows the price of the VMs used on Internap AgileCLOUD and Amazon AWS. The block storage on Amazon AWS costs significantly more per month due to Provisioned IOPS storage and SSD-backed EBS.

A CloudSpecs score was produced for each of the following components on Internap AgileCLOUD and AWS: vCPU, memory, read/write IOPS, and internal network (see Table 4). The separate scores were aggregated based on the components examined in each category to produce a VM CloudSpecs Score. The VM CloudSpecs scores were then averaged to produce the Category's CloudSpecs Score. For example, on the Static Web Server:

1. VM CloudSpecs Score = ({vcpu_cloudspecs_score} + {read_iops_cloudspecs_score})/2
2. Static Web Server CloudSpecs Score = ({2vcpu_VM_CloudSpecs_Score} + {4vcpu_VM_CloudSpecs_Score})/2

Multi-core vCPU | CloudSpecs Scores	2 vCPU	4 vCPU	16 vCPU
Internap AgileCLOUD	100	100	100
Amazon AWS	79	76	87

Memory Bandwidth | CloudSpecs Scores	2 vCPU	4 vCPU	16 vCPU
Internap AgileCLOUD	100	100	100
Amazon AWS	60	84	45

Internal Network Throughput | CloudSpecs Scores	2 vCPU	4 vCPU	16 vCPU
Internap AgileCLOUD	100	100	100
Amazon AWS	21	21	35

Block Storage IOPS | CloudSpecs Scores	2 vCPU	4 vCPU	16 vCPU
Internap AgileCLOUD	100	100	100
Amazon AWS*	9	9	9

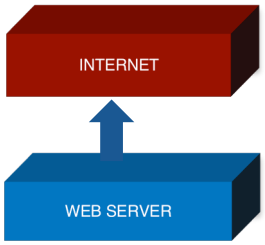
Table 4: A table listing the CloudSpecs scores received by Internap AgileCLOUD VMs and their AWS counterparts.
*AWS's block storage IOPS CloudSpecs score accounts for SSD-based block storage and provisioned IOPS pricing for 1500 IOPS. IOPS for block storage did not scale with the size of the VM on Internap AgileCLOUD or AWS.

WEB SERVERS COMPARISON

Due to the variety of possible web server configurations, Internap's web server performance was examined in three categories: (1) static web server, which includes small websites; (2) read/write web server, which covers a majority of websites that can download and upload content; and (3) high-traffic web server, which encompasses large web architectures to sustain high amounts of traffic and transactions.

Both 2 vCPU and 4 vCPU virtual machines were used for the performance comparison of the web servers (see Methodology for more information). Internap AgileCLOUD VMs exhibited higher performance than their AWS counterparts on tests conducted for processor performance, disk IOPS, and internal network throughput, resulting in superior price-performance value for the web servers, as seen in the value charts below.

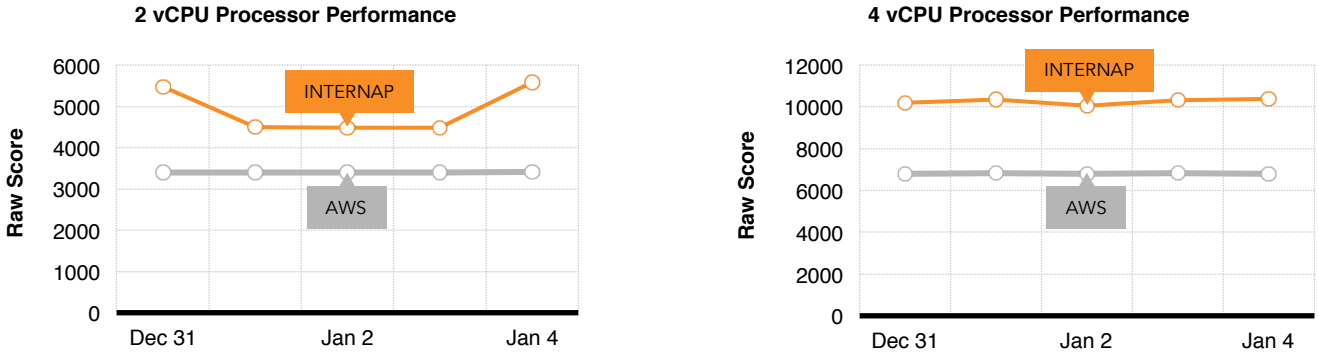
STATIC WEB SERVER RESULTS



A static web server primarily serves content to viewers. Writes to the disk are commonly limited to any edits to the website made by the site administrator. Examples include personal webpages, online portfolios, and image galleries. The following performance metrics are considered for the static web server:

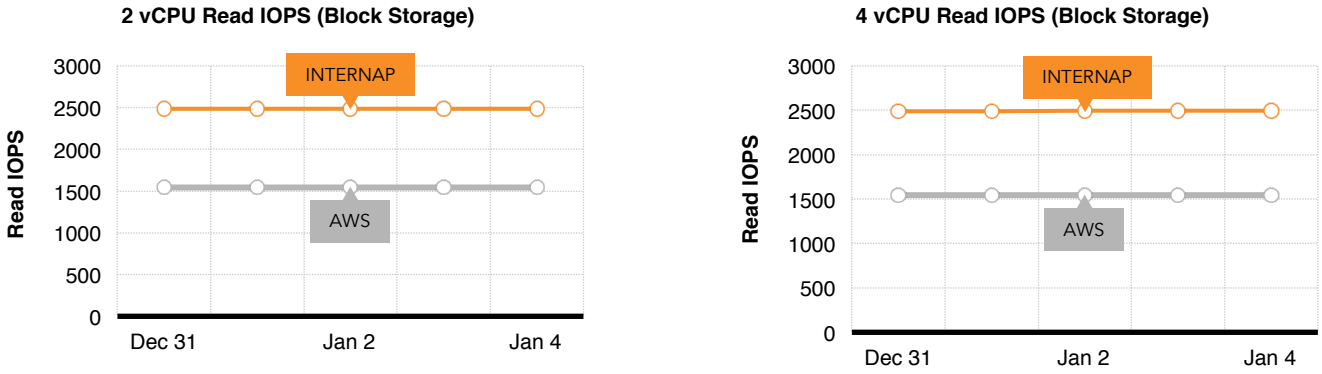
VIRTUAL PROCESSORS | READ IOPS

Processor performance, critical for web servers in general and specific CPU-bound tasks such as data encryption and image compression/decompression, was examined by running Geekbench 3 tests. On average, Internap AgileCLOUD's virtual processors scored approximately 50% higher on performance than its AWS counterparts for the 2 vCPU and 4 vCPU servers (see Graph 1 for more details).



Graph 1: The processor performance over five days of the study (illustrated in the graphs) shows Internap AgileCLOUD's processor performance continuously scoring higher than its AWS counterparts.

Read IOPS, another common performance measurement relevant to static web servers, was also examined. All-else-equal, higher read IOPS translates into a faster, more consistent experience for users of static web applications. For the duration of the study, Internap AgileCLOUD's disk reads from a 50GB block storage device sustained approximately 2,490 IOPS, while Amazon AWS's Provisioned IOPS 50GB block storage device sustained an average of 1,542 read IOPS (See Graph 2). The IOPS numbers applied to an even distribution of sequential and random reads.



Graph 2: Read performance examined in this study is comprised of 50% sequential reads and 50% random reads on a single 50GB volume. On Internap and AWS, sequential and random performance exhibited the same output; thus, the final results are reflective of both types of read operations. To sustain the 1,500 IOPS on AWS, Provisioned IOPS were purchased for the study. The 2,500 IOPS achieved by Internap AgileCLOUD did not require any additional purchase other than the 50GB block storage. It should be noted that Provisioned IOPS on AWS increases with larger storage volume sizes.

Chart 1 illustrates the overall value for static web server performance between 2- and 4-vCPU VM offerings on Internap. For the static web server assessment, superior processor performance as well much lower cost per read transaction (due to faster read speeds and lower cost for block storage) resulted in a 2x higher price/performance score for Internap AgileCLOUD relative to AWS.

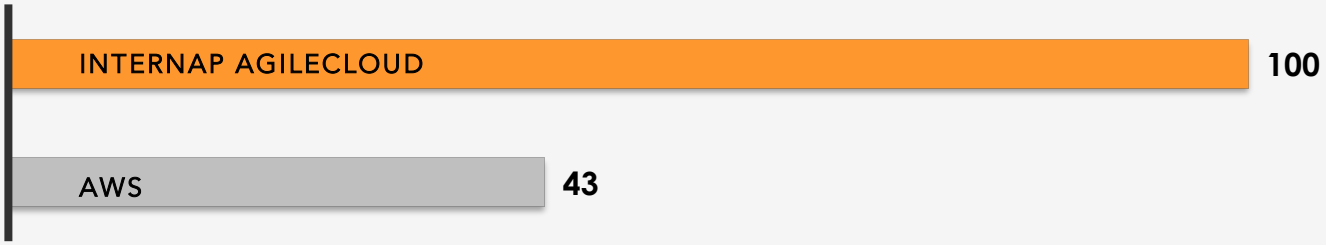
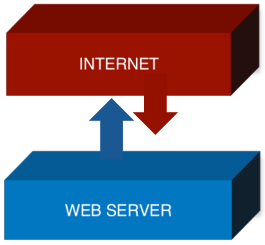


Chart 1: When examining virtual processor and block storage read performance in conjunction with cost to produce a value score, Internap demonstrated more than twice the value on its VMs as compared with its AWS counterparts.

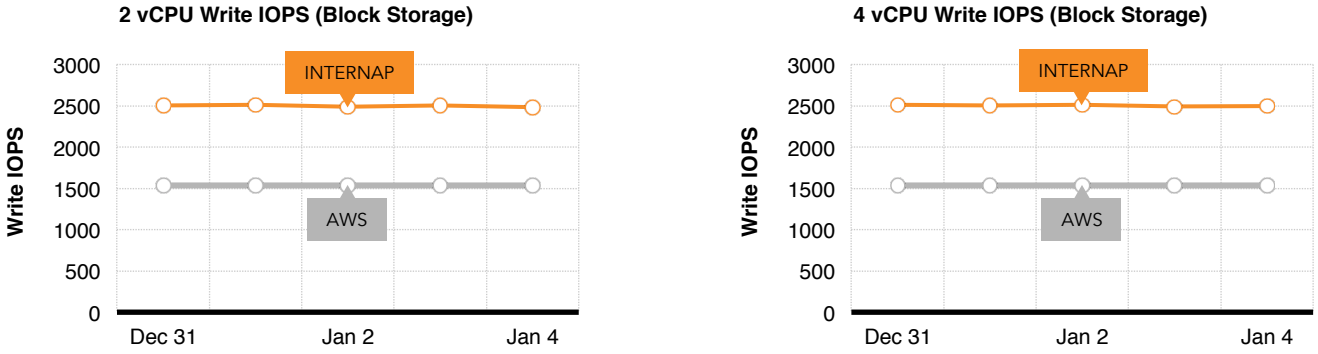
READ-WRITE WEB SERVER



Read/write web servers frequently serve content to viewers and write/update data (such as user subscriptions and user preferences) in databases and/or upload files (such as video or image sharing sites). Examples include blogs, media sharing websites, and social media. The following performance metrics are considered for the read/write web server:

- VIRTUAL PROCESSORS
- READ IOPS
- WRITE IOPS

Similar to the read performance examined in the static web server results, write performance from block storage sustained on average 2,500 IOPS and 1,542 IOPS on Internap and AWS respectively. Internap AgileCLOUD's higher IOPS and corresponding lower cost for block storage resulted in a lower cost per write transaction. For applications with more frequent data update requirements, this superior IOPS performance can directly benefit cost and improve capital efficiency.



Graph 3: Internap AgileCLOUD and AWS exhibited similar performance with the write IOPS as compared to read IOPS (see Graph 2). The write IOPS results above are comprised of 50% sequential writes and 50% random writes.

Chart 2 illustrates the difference in value between Internap AgileCLOUD's tested VMs and their AWS counterparts. The difference, greater than 3x higher value score for Internap VMs compared with AWS, was due to AgileCLOUD's higher IOPS and lower cost per transaction for disk write performance metrics in the context of read/write web servers.

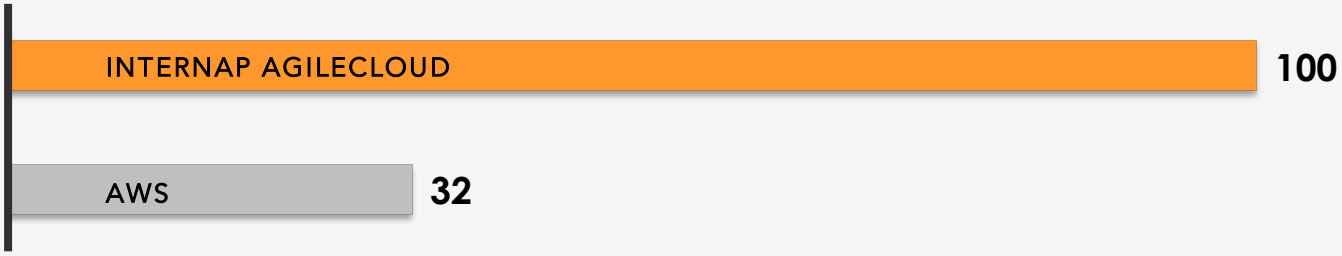
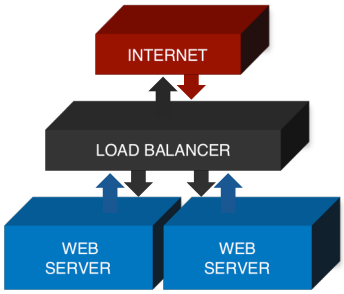


Chart 2: Read/Write web server value analysis included all of the considerations examined in a static web server and included an additional layer of disk write performance. Internap AgileCLOUD VMs scored more than 3x higher than their AWS counterparts in price-performance value.

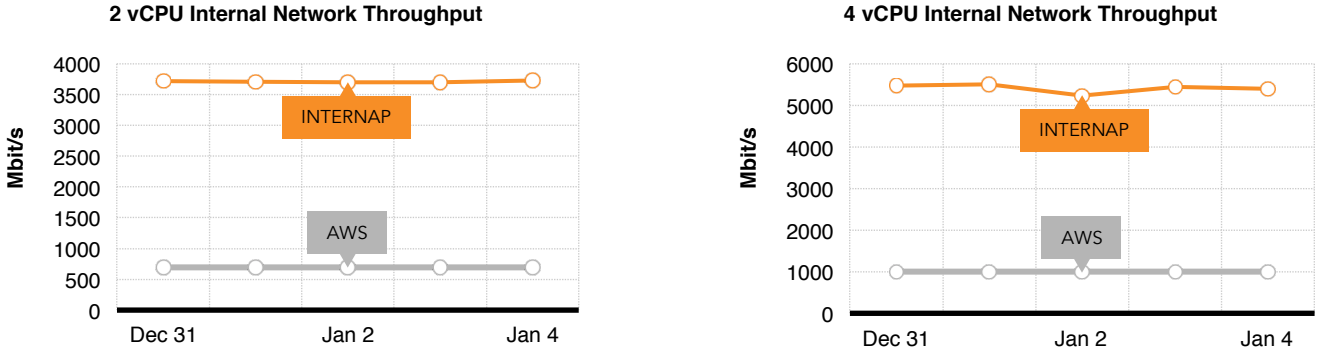
HIGH-TRAFFIC WEB SERVER



High-traffic web servers can be any kind of web server cluster distributed across multiple VMs. By doing so, the web server(s) leverage horizontal scalability and can serve requests concurrently on a large scale. Examples include large news outlets, travel websites, and e-commerce shops. The following performance metrics are considered for the high-traffic web server:

- VIRTUAL PROCESSORS
- READ IOPS
- WRITE IOPS
- NETWORK THROUGHPUT

Load-balanced web server environments scale by cloning virtual machines to sustain higher traffic and user load. The load balancer(s) then distributes requests among multiple servers in the environment. Because of the need to distribute traffic across servers, internal network throughput across a VM cluster can play a major role in the performance of the supported application. Internap AgileCLOUD provided substantially more network throughput than the tested AWS VMs.



Graph 4: Internal network performance results in this study show Internap AgileCLOUD's advantage over AWS in 2 vCPU and 4 vCPU machines. While AWS throughput scales with size of the VM, at the 4 vCPU size, it still only sustained less than 1/5 of Internap AgileCLOUD's throughput.

As illustrated in Chart 3, adding internal network throughput as a critical performance factor increases the value differential with Internap AgileCLOUD's again providing more than 3x the value of Amazon AWS.

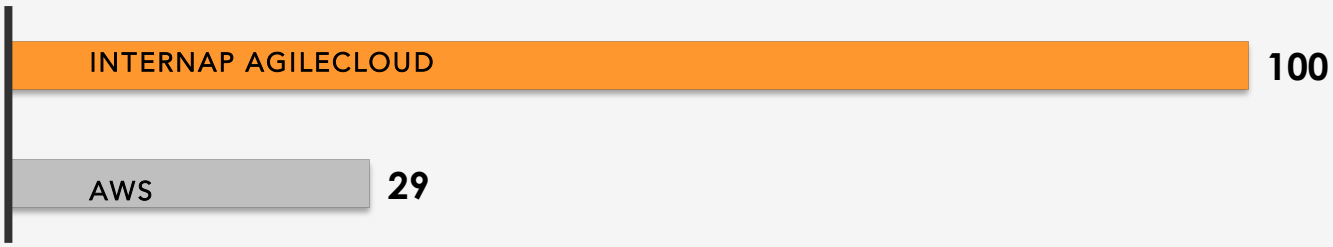


Chart 3: A larger difference in value emerged when examining a scale-out web server environment in the High-traffic Web Server use case. Internap AgileCLOUD VMs scored better than their AWS counterparts in price/performance value in this case due to factors discussed in the Read/Write Web Server as well as their higher internal network throughput.

DATABASES COMPARISON

Apart from the different database applications available, such as MySQL, PostgreSQL, Microsoft SQL, and Oracle (as well as many others), the applicable virtual machine sizes for database environments and numerous use cases can make benchmarking a particular database a very complex process. Cloud Spectator's examined server-side factors that affect database performance, namely the processor, memory, disk, and—in the case of large, distributed databases—internal network.

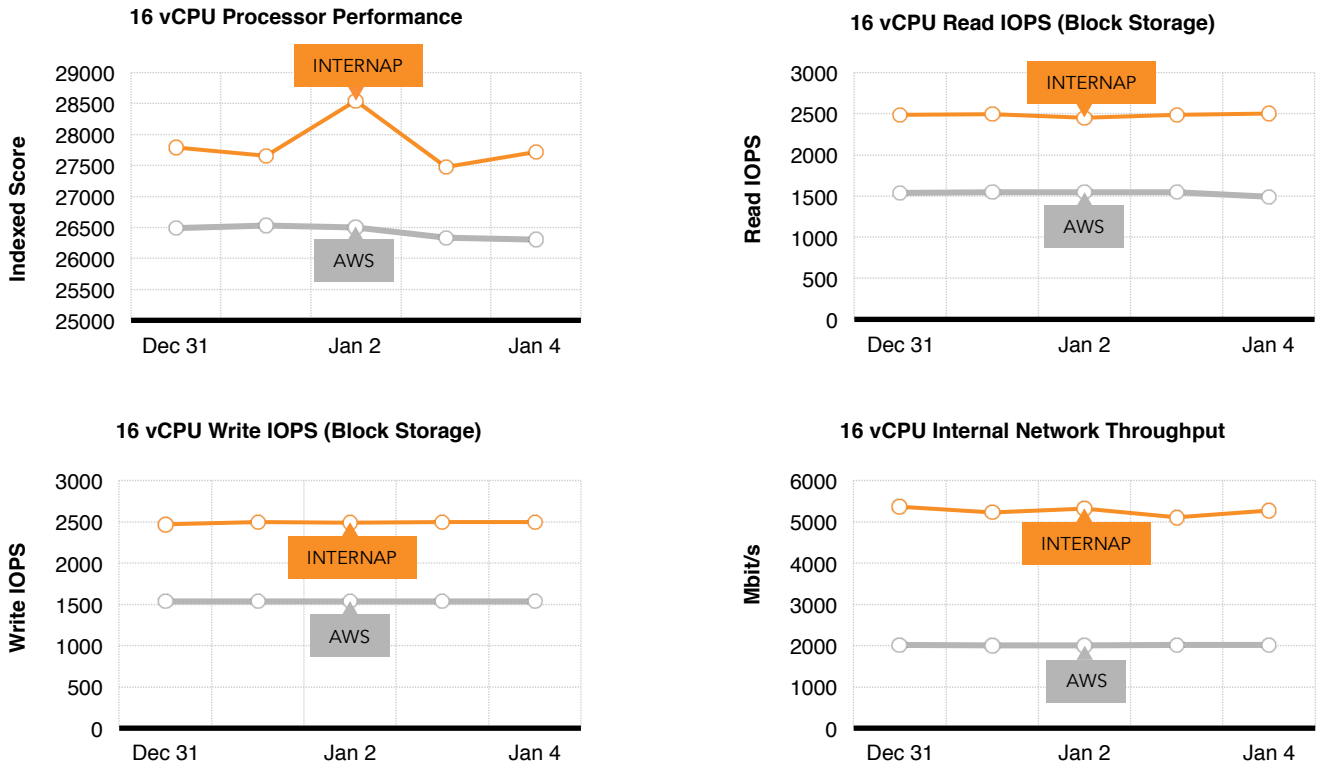
Similar to the web servers, 2 vCPU and 4 vCPU VMs were used in the comparison. For a database, however, it is not uncommon to find large, distributed cluster environments, so a 16 vCPU machine was studied as well. Results of the study were separated into two categories: (1) Single-node Databases and (2) Clustered Database Environments. In both categories, block storage was used for disk testing due to its higher resiliency than local storage.

SINGLE-NODE DATABASE

Single-node databases are small database environments that handle all processing within a single virtual machine. Usually, these types of databases are a piece of a more complex application or environment, such as a LAMP stack for web servers. The following performance metrics are considered for the single-node database:

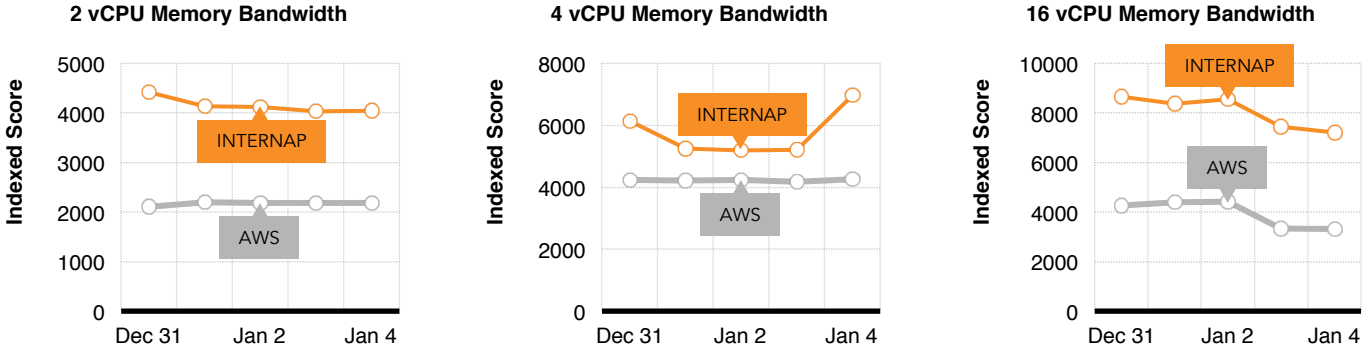
- VIRTUAL PROCESSORS
- MEMORY BANDWIDTH
- READ IOPS
- WRITE IOPS

The single-node database tests, which account for a variety of server components including the virtual processor, memory, and block storage, examined 2 vCPU, 4 vCPU, and 16 vCPU VMs on Internap AgileCLOUD and AWS. The 16 vCPU VM performance results for Internap AgileCLOUD and AWS were similar to the 4 vCPU and 2 vCPU VMs test results which are shown in the web server section of this study (see Graphs 1 through 4). As seen in Graph 5, in processor performance, IOPS tests, and network throughput, AgileCLOUD VMs with 16 vCPUs outpaced similarly-sized AWS instances.



Graph 5: The graphs above show the performance of the 16 vCPU VMs on Internap AgileCLOUD and AWS. On both providers' 16 vCPU VMs, block storage results were consistent with the block storage results of the 2 vCPU and 4 vCPU VMs (see Graph 1). The processor scores however scaled with the number of virtual processors on the 16 vCPU machine. While internal network throughput increased for AWS, Internap's internal network throughput remained roughly the same as with the 4 vCPU VM (see Graph 4).

With respect to memory bandwidth, Internap AgileCLOUD VMs sustained around a 2x more bandwidth on the 2 vCPU and 16 vCPU machines than their AWS counterparts, and a 36% more bandwidth than AWS on the 4 vCPU machines. With greater memory bandwidth, applications are able to read to and write from memory faster, meaning more work can take place in any specified period of time.



Graph 6: While memory bandwidth increased between the 2 vCPU and 4 vCPU VMs on both providers, there was little noticeable increase in bandwidth when scaling from the 4 vCPU to the 16 vCPU VMs for Internap AgileCLOUD or AWS. While on the 2 vCPU and 16 vCPU VMs, Internap AgileCLOUD scored 2x higher than AWS on memory bandwidth tests, on the 4 vCPU, the bandwidth differential was less.

Factoring in price and performance measures for single-node database use cases revealed that the Internap AgileCLOUD virtual machines used in this study provided 2.5x more value than AWS.

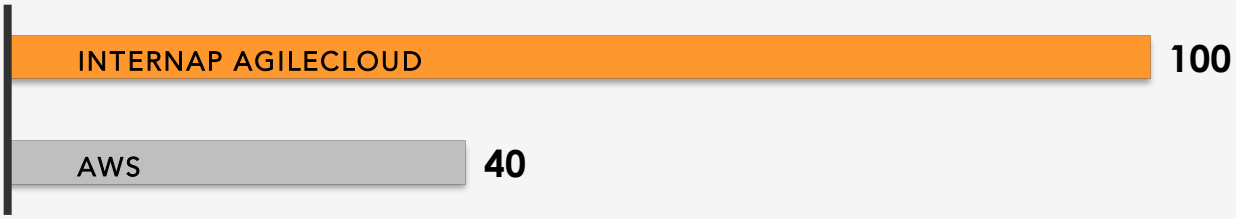


Chart 4: Single-node database performance considers the performance and price-performance value of virtual processors, memory, read and write IOPS. As a collective assessment across 2 vCPU, 4 vCPU, and 16 vCPU VMs, Internap produced approximately 2.5x more value in performance.

CLUSTERED DATABASE ENVIRONMENTS

A clustered database environment combines single-node databases into a system acting as a single entity, or cluster. Clustered databases can improve performance and boost resiliency to avoid a single point-of-failure. While the resources that affect single-node database performance translate over to a clustered database environment, another factor, internal network, plays a major role in affecting the cluster's performance as well. The following performance metrics are considered for the clustered database environment:

- VIRTUAL PROCESSORS
- MEMORY BANDWIDTH
- READ IOPS
- WRITE IOPS
- NETWORK THROUGHPUT

When considering the internal network throughput requirements of clustered database environments, Internap AgileCLOUD scored 2.7x higher for price-performance value than AWS. Internap AgileCLOUD's internal network throughput, which was maximized around 5 Gbit/s on both the 4 vCPU and 16 vCPU VMs, outperformed AWS by more than 5x and 2x respectively (See Graphs 4 and 5). It should be noted that AWS's internal network throughput marginally scaled with the size of the tested VM. The combination of a strong network topology on Internap AgileCLOUD as well as a higher overall performance across CPU, memory, and block storage resulted in better price-performance value (as shown in Chart 5) when assessing a clustered database environment.

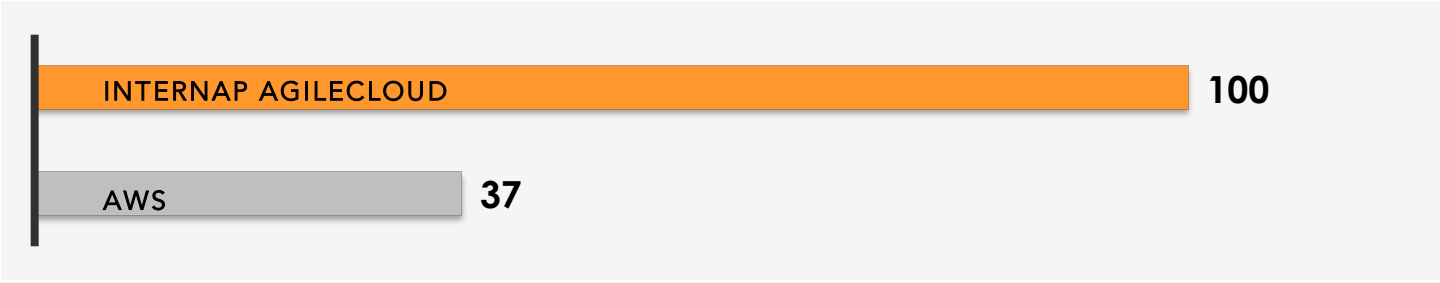


Chart 5: Clustered Database Environments account for performance of all components mentioned and examined in the single-node database environment, but also include internal network performance components. In these tests, Internap AgileCLOUD scored 2.7x higher than AWS for price-performance value.

CONCLUSION

Comparing public cloud offerings on price or features alone does not allow organizations to make fully-informed purchase decisions. Organizations should instead quantitatively assess performance and its relationship with price and related features to make smart procurement decisions.

In this study, a normalized comparison of major VM components including virtual cores, memory, block storage, and internal network show that Internap AgileCLOUD provides better raw performance and price-indexed performance than AWS for two common applications – webservers and databases.

Specifically, when comparing 2 vCPU and 4 vCPU and 16 vCPU virtual machines from Internap and AWS, Internap VMs demonstrated performance measurements superior to AWS. In addition, Internap AgileCLOUD scored higher than AWS EC2 when performance was controlled for price, suggesting AgileCLOUD's greater value for buyers of cloud infrastructure.

CONSIDERATIONS & FURTHER STUDY

While this report examines performance relative to web servers and databases, Internap AgileCLOUD's superior scores for virtual processors, memory, block storage and internal network can translate into better performance for many other applications not examined in this study.

Similarly, as only 2 vCPU, 4 vCPU, and (in the case of databases) 16 vCPU VMs were tested, results should not be assumed to reflect the performance of all virtual cloud or physical servers beyond the scope of this study. In the case of AWS, instances within the M3 Family were used for the 2 vCPU and 4 vCPU comparisons, and instances in the R3 Family were used for the 16 vCPU comparisons.

For this study, only 50 GB block storage volumes were used to conduct disk performance tests on read and write IOPS. With providers such as AWS, block storage performance scales with the size of the volume (in the case for AWS, up to

4,000 IOPS per volume for purchasable Provisioned IOPS). For the 16 vCPU comparison, the R3 Family's r3.4xlarge was used, as it was the closest-matched virtual machine to the Internap AgileCLOUD B Series VM, despite the r3.4xlarge's higher amount of memory. The results in this study do not represent performance of other Families within AWS, or VMs within the compared Families that reside outside of the scope of this study.

About Cloud Spectator

Cloud Spectator leads the industry in performance and pricing analysis for the IaaS marketplace. Since 2011, Cloud Spectator has provided consulting and benchmarking services for enterprise clients, consultancies and providers. Our data-driven approach standardizes and simplifies the IaaS market to inform and guide decision-makers in a complex industry.

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