

Report

Cloud Storage Performance Analysis

Prepared for IONOS Cloud by Cloud Spectator



IONOS

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Executive Summary

Cloud Spectator was approached by IONOS to assess the performance of their latest Compute Engine cloud storage offerings. Cloud Spectator performed storage benchmarks on multiple IONOS Cloud Compute Engine VMs and storage options as well as other popular cloud providers to see how these offerings stand up in terms of price, performance, and value (the performance you get per dollar spent).

This analysis includes the following providers: IONOS, Amazon AWS, Microsoft Azure, and Google Compute Engine.

Upon final analysis of the results produced from this benchmarking effort Cloud Spectator identified more than a few interesting trends and results that show the performance and value of the latest generation of IONOS Cloud Compute Engine. The headlines from this analysis include the following:

IONOS Cloud offers excellent storage performance compared to the larger cloud providers tested in this study. IONOS Cloud also offers truly supreme value when it comes to the storage performance you get per dollar spent.

Furthermore, the storage benchmark results revealed additional insights, as summarized below:

- IONOS Cloud offers the best overall random read and random write performance.
- IONOS Cloud leads the pack in both “standard” and “premium” storage categories.
- IONOS Cloud also offers incredible value for storage performance, meaning that you get more storage performance per dollar spent on storage.

The remainder of this report will present the selection and testing methodology, along with results of the benchmarking effort.

Introduction

Cloud computing continues to be one of the fastest growing segments in the Information Technology (IT) market. While much of the focus has been on the “dominant” forces in the industry, such as Amazon AWS, Google Compute Engine, and Microsoft Azure, we are seeing many other cloud providers introducing new offerings that may turn some heads.

This report examines the latest storage offerings from [IONOS Cloud Compute Engine](#), specifically their newly released Standard and Premium SSD storage options. This report focuses on how these new offerings stack up against the largest and most well-known cloud providers when viewed from multiple angles.

Cloud Spectator performed synthetic benchmark testing on two types of storage classes between IONOS, AWS, GCE, and Azure to assess storage performance and value. FIO was used as the benchmark for this report and random read and write testing was executed on multiple VMs over many iterations to provide an accurate view of how each offering performs under stressful storage workloads.

The VM specifications and selection methodology are described in detail below.

VM Specs, Pricing, and Selection Methodology

The goal of testing two storage tiers is to better understand performance differences between each provider's storage options, specifically the "low end" or standard option, along with the high end / fastest storage offering.

For this analysis Cloud Spectator provisioned VMs with four vCPUs with at least 8 GB of RAM and attached two different tiers of SSD storage to each VM (with the exception of GCE, which only has one type of detachable SSD storage).

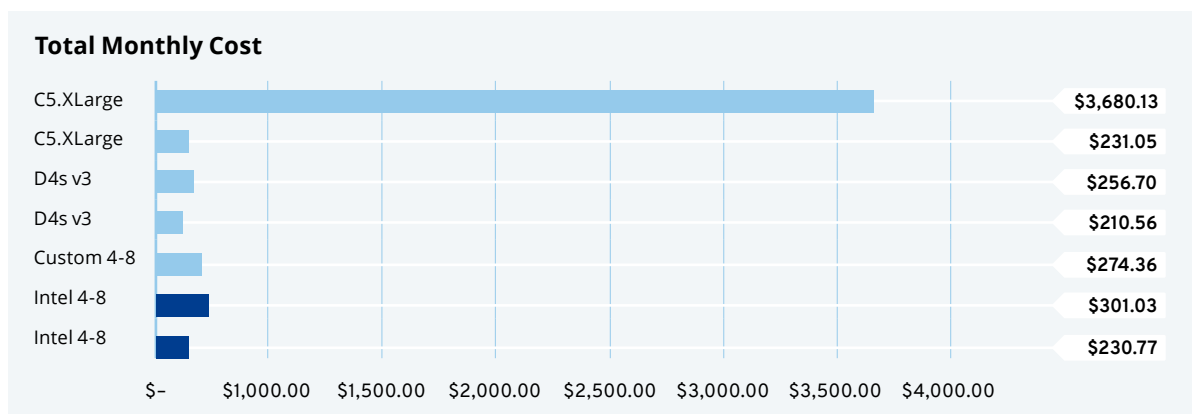
All VMs were provisioned in the same data center location and created with the latest version of Ubuntu LTS offered (Ubuntu 20.04 LTS). All storage offerings tested were attached as a secondary disk on each VM.

The EXT4 filesystem was used to format the entire disk.

All VMs in this report have similar specs and pricing, however the storage pricing varied wildly in some cases as you will see with AWS's Provisioned IOPS storage. All pricing is in USD.

Provider	VM	vCPU	RAM (GB)	Disk (GB)	Storage Type	VM Monthly Cost	Storage Monthly Cost	Total Monthly Cost
IONOS	Intel 4-8	4	8	600	Standard SSD	\$167.54	\$63.23	\$230.77
IONOS	Intel 4-8	4	8	600	Premium SSD	\$167.54	\$133.49	\$301.03
GCE	Custom 4-8	4	8	600	Provisioned SSD	\$152.59	\$121.78	\$274.36
Azure	D4s v3	4	16	512	Standard SSD	\$168.57	\$41.99	\$210.56
Azure	D4s v3	4	16	512	Premium SSD	\$168.57	\$88.14	\$256.70
AWS	C5.XLarge	4	8	600	General Purpose EBS	\$146.77	\$84.29	\$231.05
AWS	C5.XLarge	4	8	900	Provisioned IOPS EBS (45K IOPS)	\$146.77	\$3,533.36	\$3,680.13

As you can see below all of the offerings are similarly priced with the exception of AWS, which offers an extremely expensive Provisioned IOPS storage volume.



Cloud Spectator's Selection Methodology involves comparing IaaS Provider VMs with the same vCPU count and similar storage offerings against each other. This provides a more detailed and accurate view into each provider's cloud storage performance. For this study, Cloud Spectator looked at the following:

- **Four cloud providers**
 - IONOS Cloud Compute Engine
 - Amazon Web Services EC2
 - Microsoft Azure
 - Google Compute Engine
- **One VM size group**
 - VMs with four vCPUs and at least 8GB of RAM
- **Two SSD storage tiers**
 - Standard
 - Premium / high end

Benchmarking Methodology

All VMs went through the exact same setup process, which involved updating all packages then rebooting, followed by entire disk partitioning. Each VM was left alone for one hour after mounting each storage device to allow the operating system to initialize the filesystem (via ext4lazyinit). Each VM was tested as is with no kernel or operating system tweaks or optimizations applied.

Test Design Considerations

Infrastructure performance testing was conducted on specific VM and Storage types for each provider. Provider VM configurations may yield different results based on underlying infrastructure, time of day, number of tenants running other workloads on the same hardware, virtualization technology and settings (e. g. shared resources), and other technology factors.

Furthermore, issues such as user contention or physical hardware malfunctions can also cause suboptimal performance. The VMs and Storage volumes selected for this engagement were generally available with specified offerings from the various providers.

Infrastructure Testing: Storage

Storage results were obtained using FIO (Flexible I/O tester) using 4 KB block size and a total job/thread count that matches each VMs vCPU count, in this case each VM had four vCPUs. Multiple 300-second iterations were conducted to compensate for the high variability often seen when stressing storage volumes. Results were gathered and represented in IOPS (input / output operations per second). The results displayed in this report are derived from the average IOP value recorded during each test.

Performance Summary

The values displayed in this section are the averages of many test iteration results, from multiple VMs, providing an accurate, overall performance average for each offering. All testing was performed between July and August 2020.

The section below focuses on overall SSD storage performance, specifically random read and random write, using the smallest block size possible, 4 KB. Applications that are reliant on a database often see many small random reads and writes. This type of disk I/O can be extremely demanding which is why we focused on testing each provider using these parameters. Stark differences can usually be detected better than testing sequential performance, where many storage offerings tend to look similar.

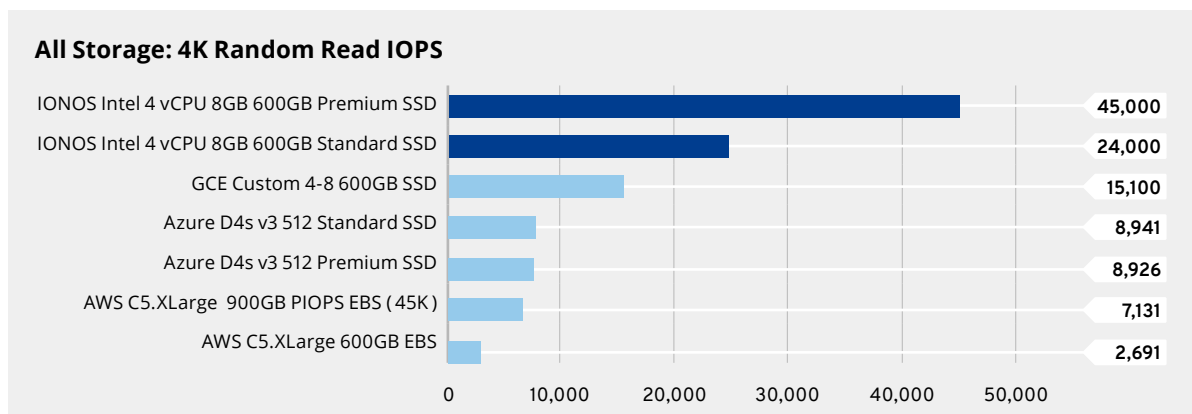
Please note that not all providers offer similar read and write performance. Just because a VM scores well for reads does not mean the same will hold true for writes. Local or included storage volumes were not tested for this report – only detachable SSD block storage was tested.

Overall SSD Storage Performance – Read

Both IONOS Cloud storage offerings outperformed all other offerings in this study when it comes to random read performance.

IONOS Premium SSD Storage **outperformed every option tested, beating the closest competitor (Google Compute Engine) by almost three times over.**

Again, the results below were obtained by running FIO's random read test with 4 KB block size and four total jobs.



IONOS Cloud storage even beat AWS's Provisioned IOPS EBS storage offering, which was not able to achieve 45,000 IOPS even though it was configured to provide 45,000 IOPS.

AWS's Provisioned IOPS EBS volume performance was a bit of a surprise. Even though the volume was provisioned to achieve 45,000 IOPS it never reached this level of performance. After reviewing the results and diving deeper into the documentation for EBS it appears that the benchmark results are valid, at least for the C5.Xlarge VM. It turns out that others have noticed some AWS Provisioned IOPS performance discrepancies as well.

While the C5 VM family appears to be part of the "Nitro System" compatible VMs, there seem to be EBS IOPS limits based on the VM size. It appears that in order to achieve more than 40,000 IOPS you need to provision a c5.18xlarge or larger. This larger VM was not tested because this report focuses on smaller sized VMs with four CPUs and 8 GB of RAM.

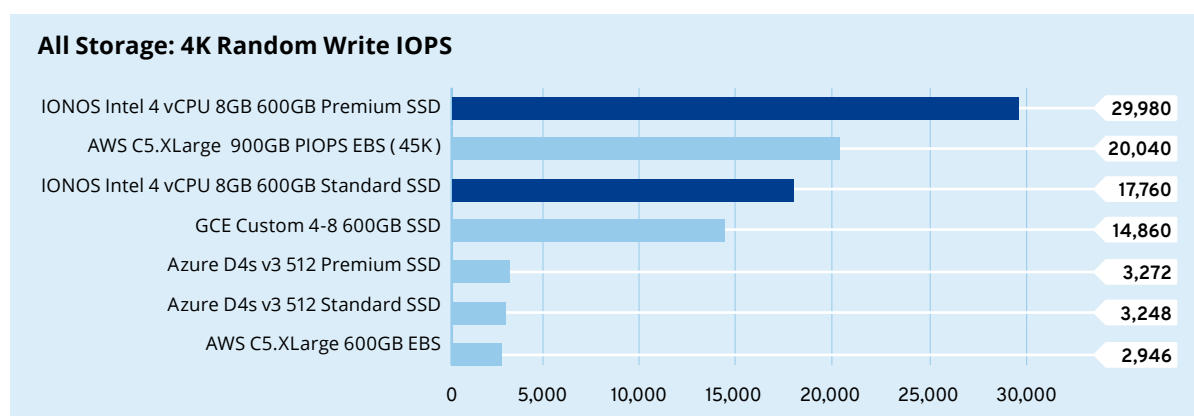
This is one of the reasons why benchmarking cloud performance is still relevant today. Even if you pay for a certain amount of IOPS, you may not be able to reach maximum performance across all VM types and sizes.

Not all providers handle storage in this way. IONOS Cloud Compute Engine takes a much simpler approach by scaling storage performance based on volume size. This means that you can achieve excellent storage performance with much smaller VMs, giving you a lot more choice and flexibility in terms of VM configuration.

Needless to say, this also means that you can get great performance for a lot less, at least with IONOS Cloud.

Overall SSD Storage Performance – Write

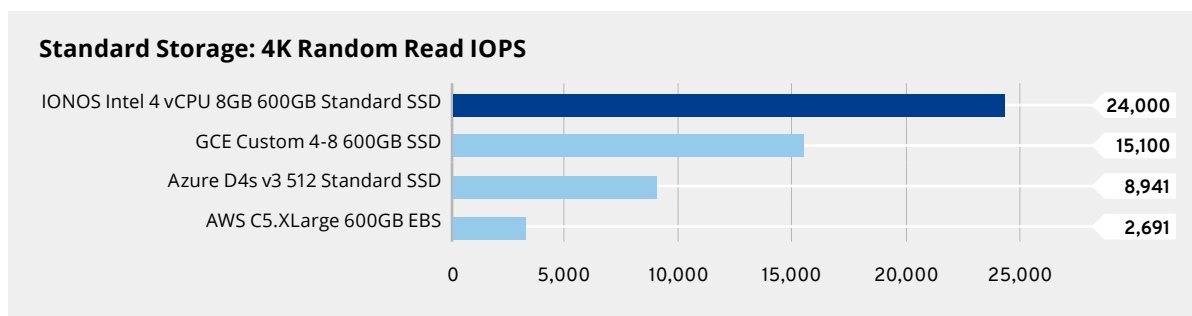
IONOS Cloud Compute Engine Premium SSD Storage also leads the pack for random write performance, beating AWS's higher priced Provisioned IOPS volume by nearly 1.5 times. Random write workloads can be the most demanding type of I/O as writes must eventually be committed to the underlying disk, caching can help improve performance but ultimately every write needs to be placed on non-ephemeral storage.



IONOS Cloud Compute Engine storage offerings provide truly stellar read and write performance compared to the largest and most prominent cloud providers. In the sections below we will elaborate on these results and take a look at the price-performance (value) that each provider offers for both storage tiers.

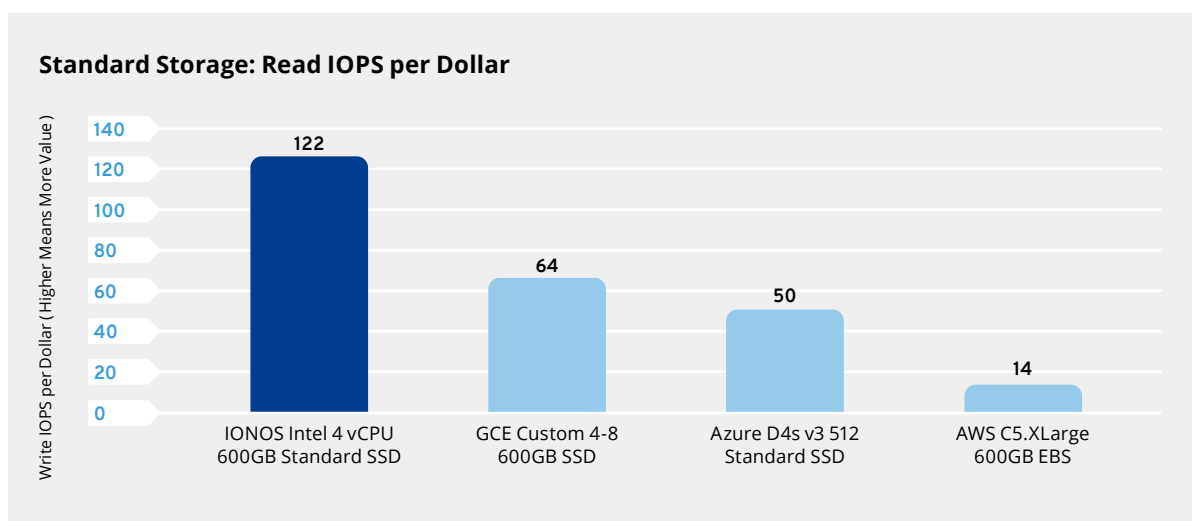
Standard SSD Storage Performance

The standard storage tier includes the least expensive SSD block storage offering from each provider. IONOS Cloud offers exceptional random read performance at this tier, outperforming GCE's provisioned SSD storage by 1.6 times. **IONOS Cloud Standard SSD storage beats Azure and AWS four times over.**



While IONOS Cloud offers excellent read performance they offer even more amazing value, which Cloud Spectator defines as the performance you receive per dollar spent. By combining the overall performance along with the price, we can see which provider offers the best bang for your buck. Everyone may want the best and fastest option out there, but at what cost?

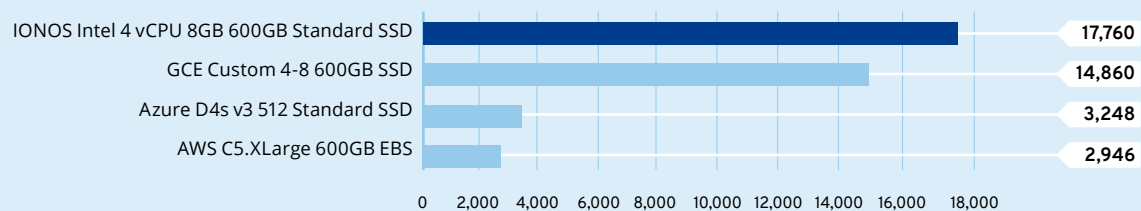
The chart below shows that IONOS Cloud offers nearly twice the value of GCE's provisioned SSD storage, which is the runner up. Even more impressive, **IONOS Cloud Standard SSD storage offers 8.7 times the value of AWS's standard EBS storage.**



The values above were generated by dividing the average IOPS observed by the total cost of the VM and Storage offering. Just because a storage offering is extremely fast does not necessarily mean it is the best option to use. The same is true for storage offerings that do not appear to perform well compared to other offerings. If the price is low enough the offering may be a great option for those looking to efficiently spend their money.

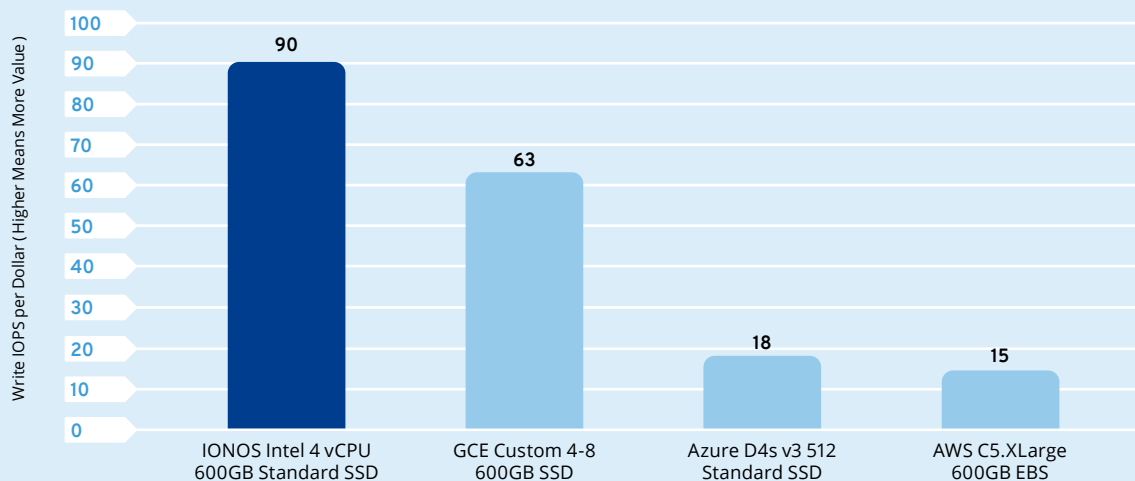
IONOS Standard SSD storage also beats the competition when it comes to random write performance. Although the performance difference is a bit less dramatic in this case, IONOS Cloud storage still outperforms the runner-up (GCE) by 1.2 times and **outperforms Azure and AWS by at least 5.4 times.**

Standard Storage: 4K Random Write IOPS



When you factor in the price of each offering, IONOS Cloud continues to lead the pack when it comes to value. **Offering 1.4 times more storage write value than GCE and at least five times more value than Azure and AWS.** Anyone running a very write intensive application should take note of this as writes tend to be the most expensive I/O activity.

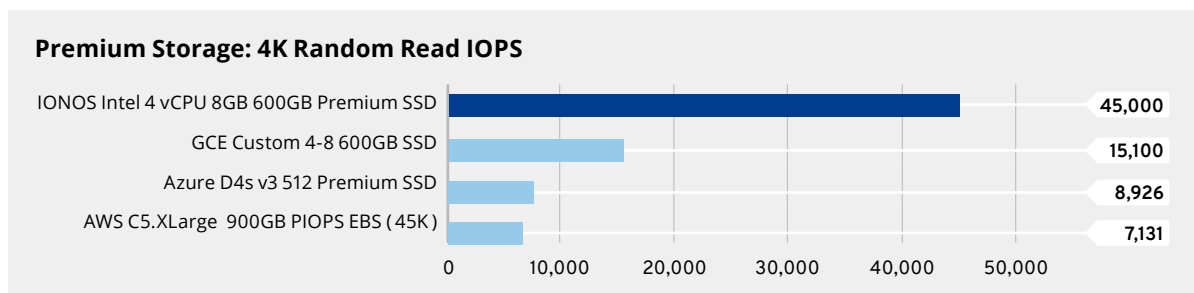
Standard Storage: Write IOPS per Dollar



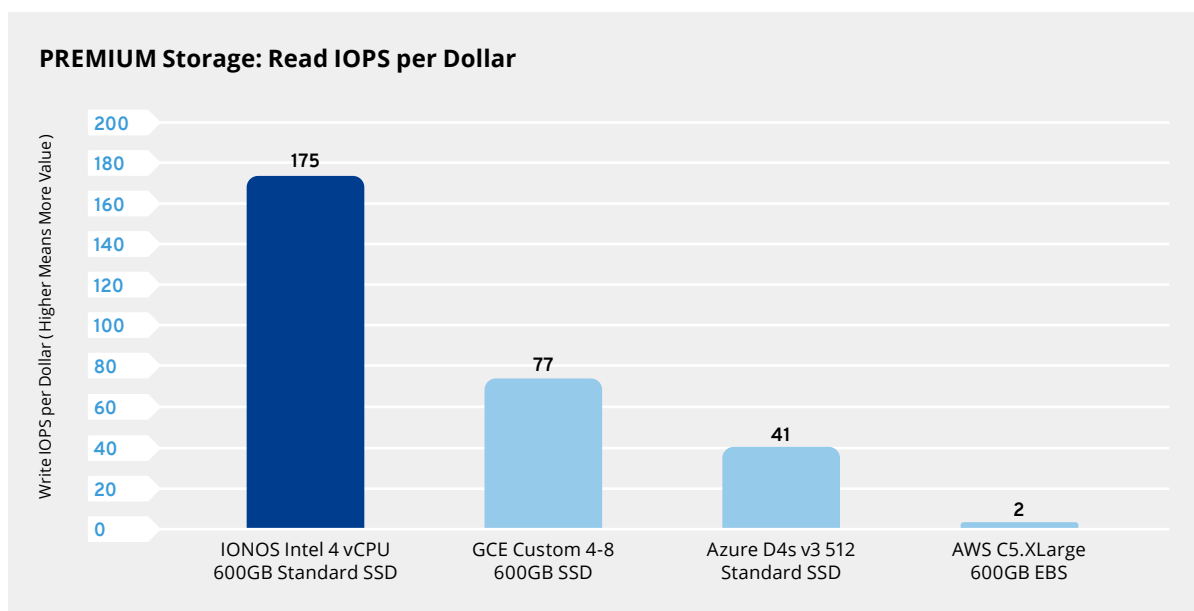
Premium SSD Storage Performance

In this section, we look at the high-end premium storage offerings from each provider. These offerings are the most expensive and should provide the highest level of storage performance. Anyone who needs the fastest I/O should pay special attention to these results.

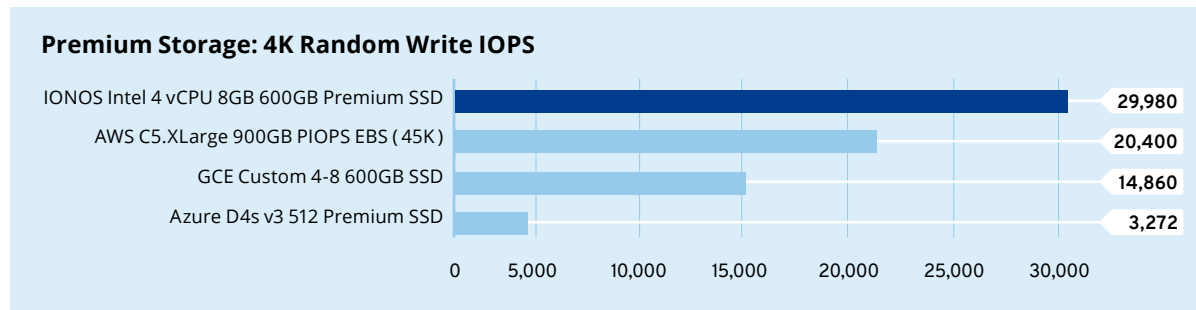
IONOS Premium SSD storage dominates the other providers at least three times over, beating out AWS provisioned IOPS EBS more than six fold when it comes to random read. Again, the results displayed are not from a single test. They are the average of multiple test iterations.



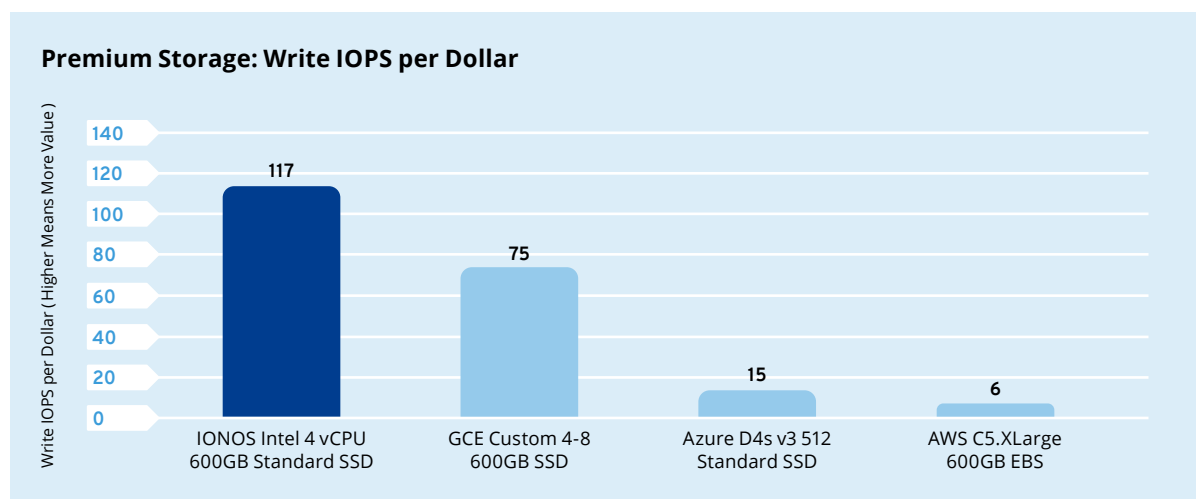
Again, we see that IONOS Premium SSD storage is ahead when it comes to value, or performance per dollar spent, **offering between two and 87 times better value than the most well-known cloud providers!** AWS lags behind significantly in this case due to the extremely high cost of Provisioned IOPS EBS storage volumes and less than stellar I/O performance observed.



Looking at random write performance for the premium storage tier we see that IONOS once again takes the top spot. AWS's Provisioned IOPS volume comes close, but in terms of random write performance **IONOS Premium SSD Storage still beats AWS's Provisioned IOPS volume 1.5 times over.**



By now, it should not be a surprise to see IONOS Cloud continue to lead the pack in value. Looking at how many random write IOPS you get per dollar spent, IONOS Cloud offers over 1.5 times the value compared to the runner-up, in this case Google. **Again, we see a huge difference in value between IONOS Cloud and AWS storage offerings. In this case, IONOS Cloud offers 19.5 times the value of AWS.**



Conclusion

[IONOS Cloud Compute Engine](#) consistently offers the best performance and value when it comes to SSD based storage. Whether you look at the low-end options or the high-end flagship options, IONOS Cloud is the clear leader, even when compared to significantly higher priced options.

IONOS Cloud is able to achieve these impressive results by simply offering excellent and predictable performance at a low cost, at least compared to the other providers covered in this report. It is worth noting that IONOS storage is not limited by per VM type restrictions, like AWS and Azure. If you want to have extremely fast storage performance even on a tiny VM, you can do so with IONOS Cloud. You can provision a tiny VM to use an expensive Provisioned IOPS volume with AWS, but you will not achieve the performance you actually pay for.

While AWS, GCE, and Azure tend to be the most high profile providers, this report shows that there are many good reasons to consider other cloud providers. Check out the latest [IONOS Cloud Compute Engine](#) offering if you require consistent, high performance that won't break the bank!

Appendix

FIO Commands used to test all VM storage

```
fio --time_based --name=benchmark --size=8G --runtime=300 --filename=rand
--ioengine=libaio --randrepeat=0 --iodepth=32 -direct=1 --invalidate=1 --verify=0
--verify_fatal=0 --numjobs=4 --rw=randwrite --blocksize=4k --group_reporting
```

```
fio --time_based --name=benchmark --size=8G --runtime=300 --filename=rand
--ioengine=libaio --randrepeat=0 --iodepth=32 -direct=1 --invalidate=1 --verify=0
--verify_fatal=0 --numjobs=4 --rw=randread --blocksize=4k --group_reporting
```

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