

Cloud Compute and Storage Performance Analysis - London

Prepared for IONOS cloud by Cloud Spectator

IONOS CLOUD

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Executive Summary

Cloud Spectator was approached by 1&1 IONOS SE to assess the performance of their cloud Compute Engine offerings. Cloud Spectator performed compute and storage benchmarks on multiple IONOS cloud Compute Engine VMs 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 Euro or Dollar spent).

This analysis includes the following providers: IONOS cloud, Amazon AWS, Microsoft Azure, and Google Compute Engine, all of which have datacenters located in London UK.

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

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

- IONOS cloud offers the **best overall random read and random write storage performance.**
- IONOS cloud offers the **best overall Multi Core CPU performance.**
- IONOS cloud also offers **incredible value** for compute storage performance, meaning that you get more performance per EURO (or Dollar) spent for both storage and compute.

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 offerings from [IONOS cloud Compute Engine](#), specifically 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 to measure CPU, Memory and Storage (two types of storage classes) between IONOS, AWS, GCE, and Azure to assess performance and value. GeekBench, SysBench, and FIO were used as the benchmarks for this report. All benchmarks were executed on multiple VMs over many iterations to provide an accurate view how each offering performs under stressful workloads.

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

VM Specs, Pricing, and Selection Methodology

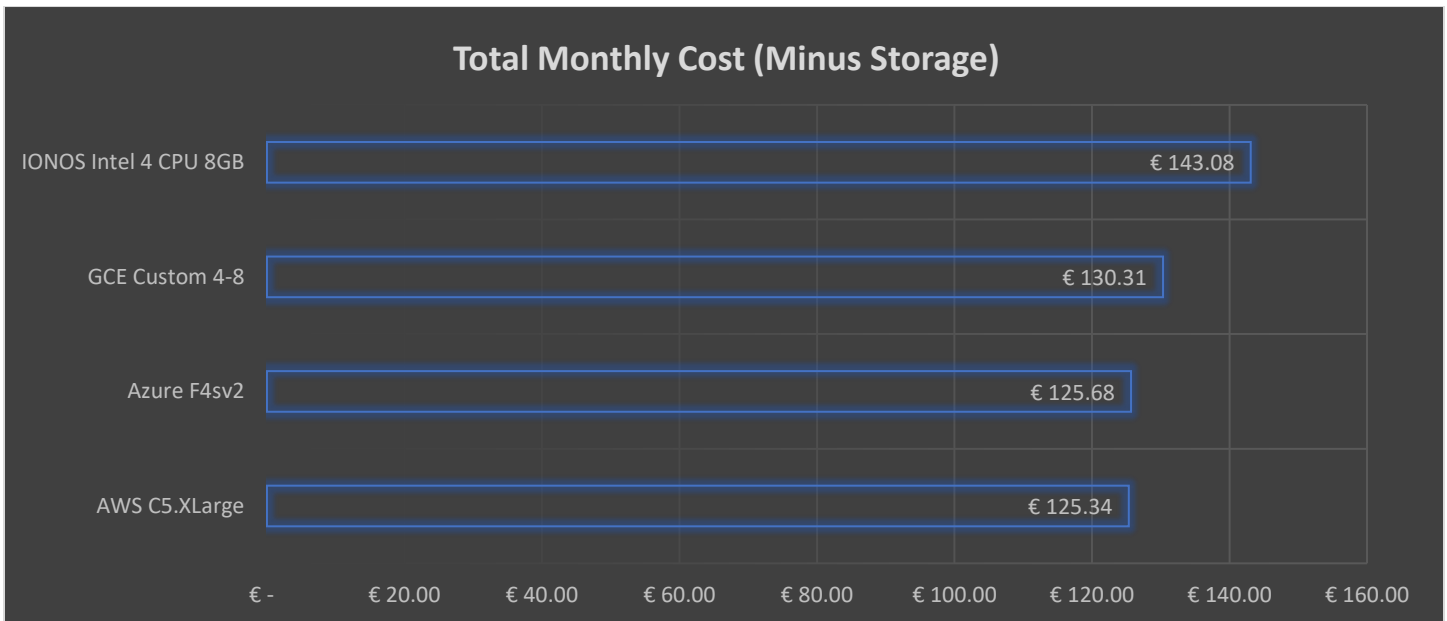
This report is split into two main sections. The first section focuses on compute performance (CPU and Memory), the second section focuses on storage performance. While the VMs are similar in both sections the pricing differs slightly due to storage differences. The two sections below list the VMs tested along with their monthly pricing in EURO.

Compute (CPU & Memory) Benchmarks

Cloud Spectator tested VMs with 4 CPUs and 8GB RAM for the compute benchmarks. **Storage was not factored into the final VM cost for these benchmarks as the focus is only on CPU and Memory performance.** The table below shows the VMs tested, along with their monthly cost (in EURO).

All VMs were provisioned in a London based data center and were created with the latest version of Ubuntu LTS offered (Ubuntu 20.04 LTS).

| Provider | VM | CPUs | RAM (GB) | Location | VM Monthly Cost |
|----------|------------|------|----------|----------|-----------------|
| IONOS | Intel 4-8 | 4 | 8 | London | € 143.08 |
| GCE | Custom 4-8 | 4 | 8 | London | € 130.31 |
| Azure | F4s v2 | 4 | 8 | London | € 125.68 |
| AWS | C5.XLarge | 4 | 8 | London | € 125.34 |



Storage Benchmarks

For the storage analysis Cloud Spectator provisioned VMs with 4 CPUs with at least 8GB 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 a London based data center and were 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 EURO, if a provider did not supply EURO pricing the USD pricing was converted into EURO at the time of this report.

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.

| Provider | VM | CPUs | RAM (GB) | Disk (GB) | Storage Type | Location | VM Monthly Cost | Storage Monthly Cost | Total Month Cost |
|----------|------------|------|----------|-----------|---------------------------------|----------|-----------------|----------------------|------------------|
| IONOS | Intel 4-8 | 4 | 8 | 600 | Standard SSD | London | € 143.08 | € 54.00 | € 197.08 |
| IONOS | Intel 4-8 | 4 | 8 | 600 | Premium SSD | London | € 143.08 | € 114.00 | € 257.08 |
| GCE | Custom 4-8 | 4 | 8 | 600 | Provisioned SSD | London | € 130.31 | € 104.00 | € 234.30 |
| Azure | D4s v3 | 4 | 16 | 512 | Standard SSD | London | € 143.96 | € 35.86 | € 179.82 |
| Azure | D4s v3 | 4 | 16 | 512 | Premium SSD | London | € 143.96 | € 75.27 | € 219.22 |
| AWS | C5.XLarge | 4 | 8 | 600 | General Purpose EBS | London | € 125.34 | € 71.98 | € 197.32 |
| AWS | C5.XLarge | 4 | 8 | 900 | Provisioned IOPS EBS (45K iops) | London | € 125.34 | € 3,017.49 | € 3,142.83 |

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.



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 specified offerings from the various providers.

Infrastructure Testing: Compute

Compute results were obtained using GeekBench5, SysBench CPU, and SysBench RAM benchmarks. GeekBench5 was performed with default / standard testing options. SysBench CPU and RAM benchmarks were run with total thread counts equaling the vCPU count of the VM.

Infrastructure Testing: Storage

Storage results were obtained using FIO (Flexible I/O tester) using 4KB block size and a total job / thread count that matches each VMs vCPU count. 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.

Compute Performance Summary

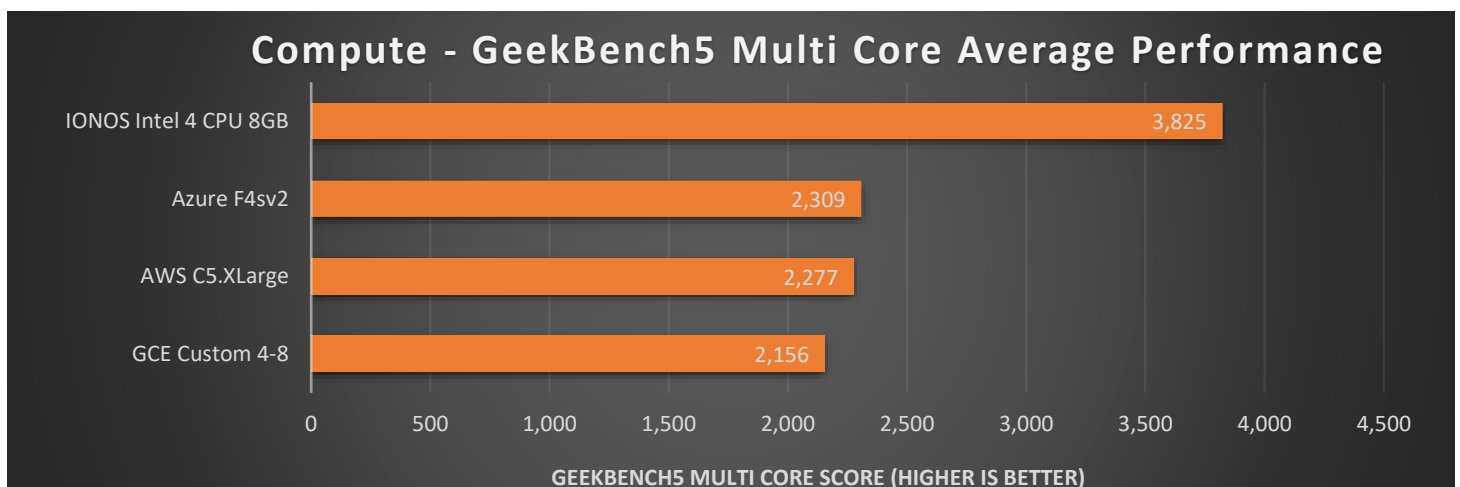
The values displayed in this section are the averages of many test iteration results, from multiple VMs, providing an accurate, overall performance average for each offering. All testing was performed between August and September 2020. Two different CPU benchmarks were used to measure multi core CPU performance to ensure that performance trends are consistent between different tests. All CPU test results shown in this section were executed using all available vCPUs.

The section below focuses on CPU and Memory performance. Please note that the VM pricing in this section is lower than the storage section as the storage cost was factored out to better isolate compute performance per Euro spent.

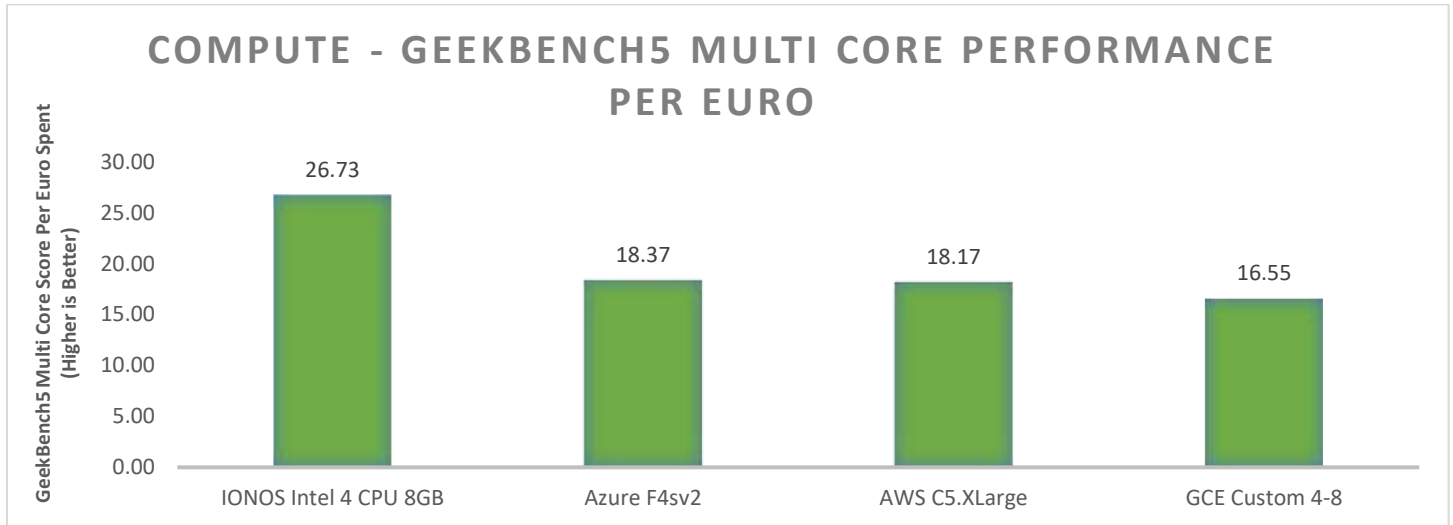
GeekBench5 Multi Core Performance

IONOS cloud takes the top spot when it comes to GeekBench5 multi core CPU performance, **beating the next closest competitor (Azure) by almost 65%**. The other three providers offered similar performance for this test.

It was surprising to see the 4 CPU IONOS VM perform so much better than the other providers, given that each provider lists each VM as having four CPUs. **Upon further inspection it appears that IONOS cloud Intel VMs actually come with two hyper threads per CPU core, which means you essentially get double the number of usable vCPUs as the other providers.** Talk about a great surprise bonus!



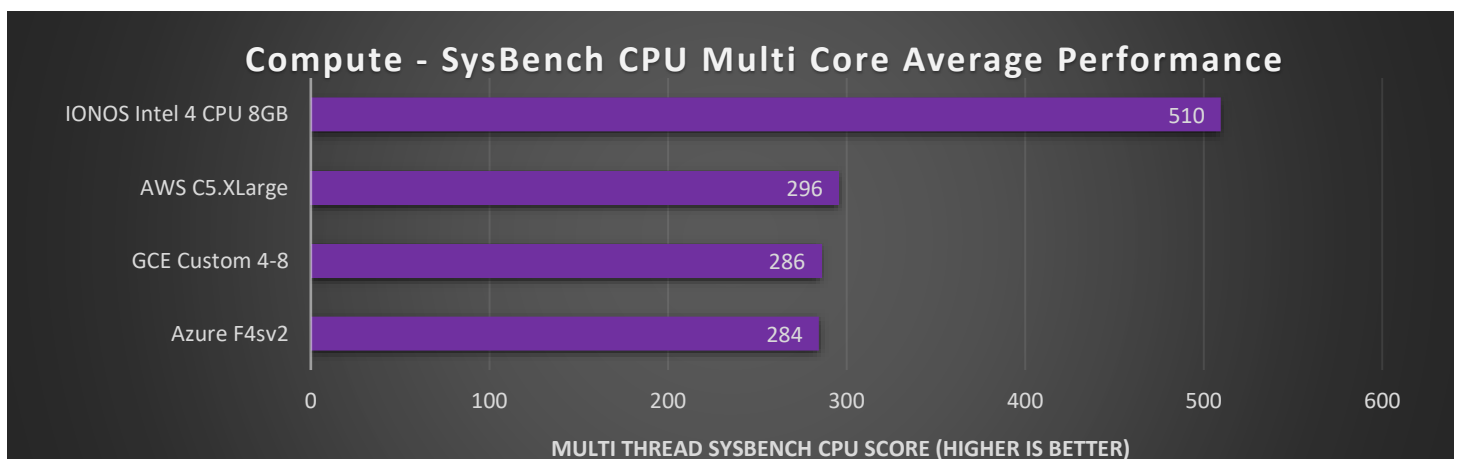
When you factor in the cost of each VM (without storage) IONOS cloud also offers the most value (CPU performance per Euro spent) compared to the other providers. In this case **IONOS cloud offers 45% more value for CPU performance** compared to the next closest provider (Azure).



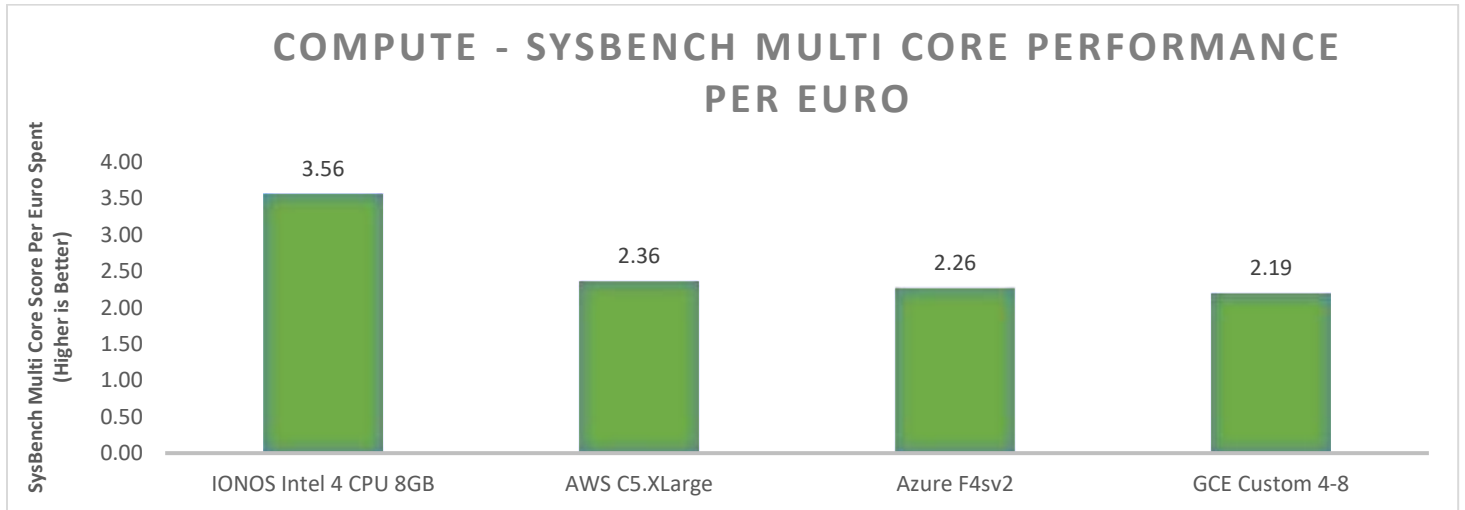
SysBench CPU Multi Core Performance

Cloud Spectator performed a second CPU benchmark to see if the performance trend would remain consistent. For this test SysBench CPU was executed using 4 threads, which is similar to the GeekBench5 multi core test. As you can see in the chart below both benchmarks show similar performance trends.

IONOS cloud continues to lead the pack when it comes to CPU performance, this time **beating the next closest competitor (AWS) by 72%**. These results are quite consistent with GeekBench findings.



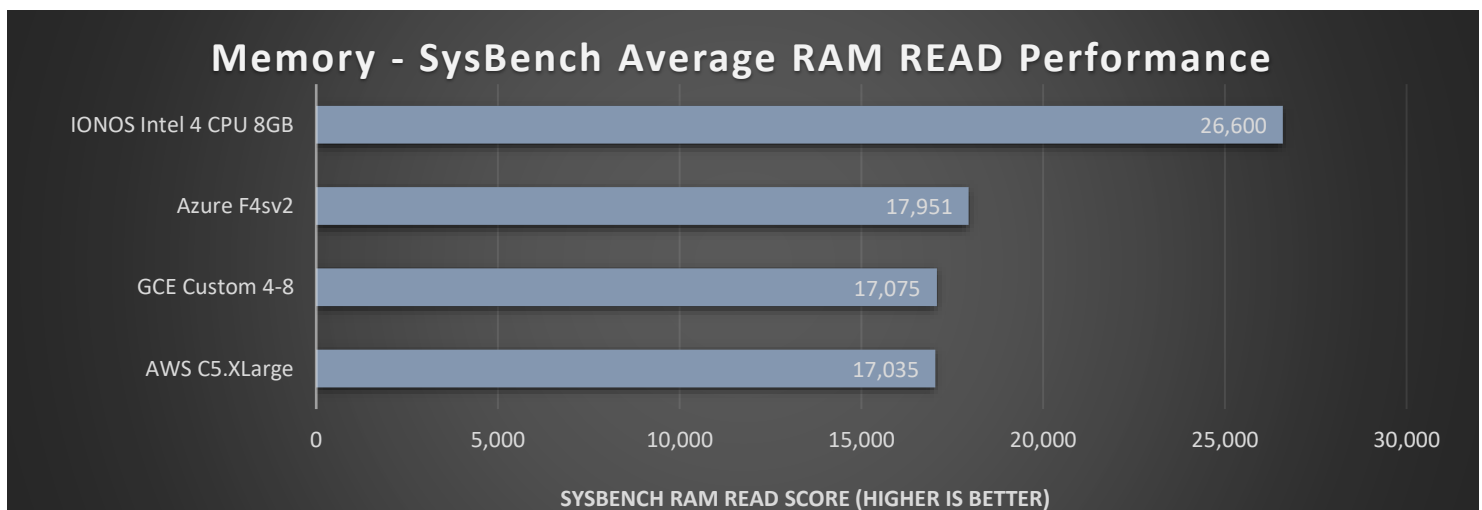
As expected, IONOS cloud also offers great value when you factor in VM monthly cost and the performance score. **IONOS offers 50% more value when it comes to CPU performance per Euro Spent** when using SysBench.



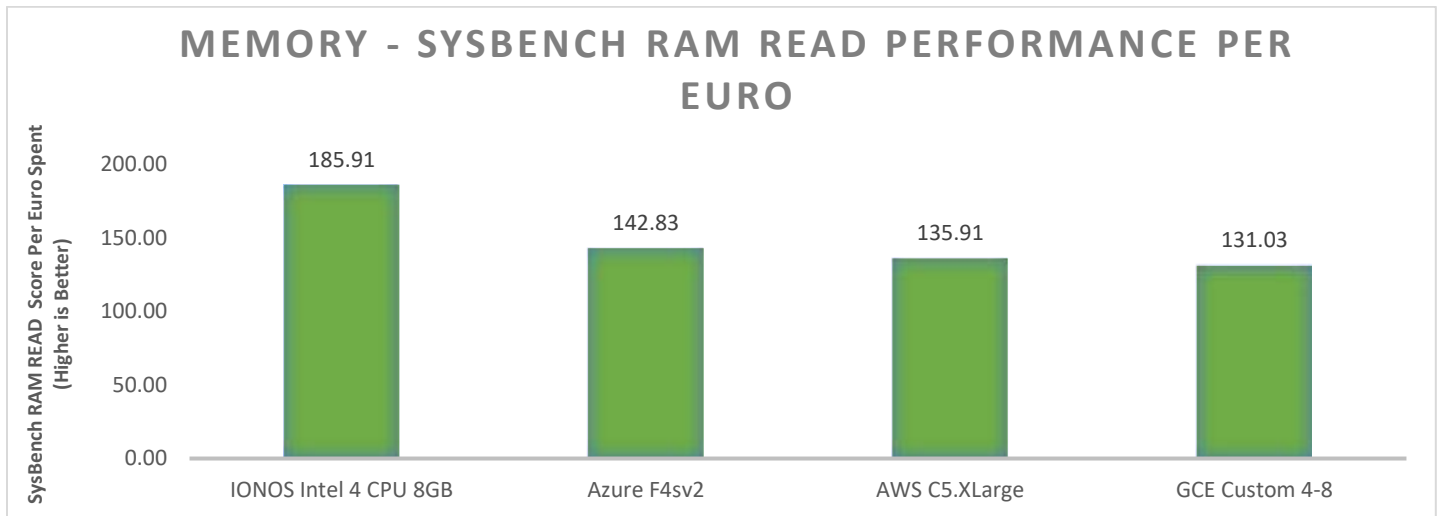
SysBench Memory Read and Write Performance

Cloud Spectator used SysBench’s Memory benchmark to focus on RAM Read and Write performance. Higher values in this section mean better Memory performance.

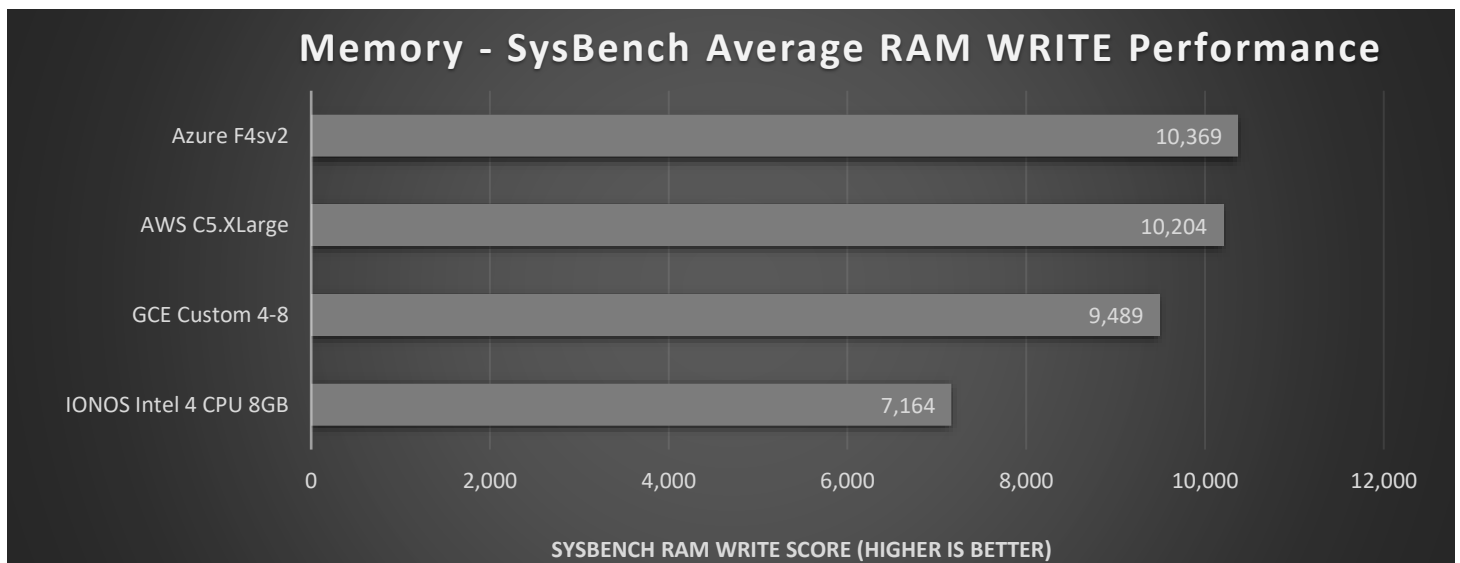
When it comes to RAM Read performance, we see that **IONOS cloud once again takes the top spot, beating the next closest provider by 48%**. The other three providers offered similar performance to each other.



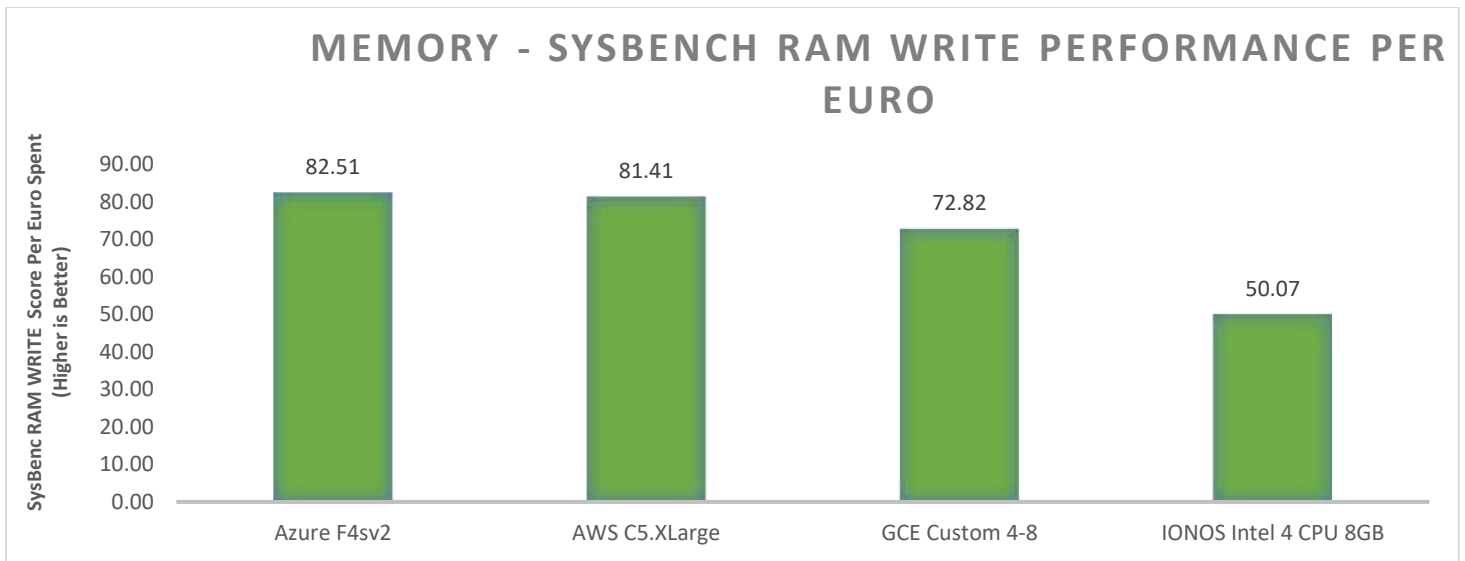
When it comes to RAM Read performance per Euro spent, we see that **IONOS cloud once again takes the top spot, beating the next closest provider by 30%**. The other three providers offered similar value to each other.



When it comes to Memory Write performance IONOS cloud actually falls behind the pack a bit. In this case Azure takes the top spot, followed by AWS and GCE.



When it comes to Memory Write performance per Euro spent, we see that IONOS also falls behind the other providers.



Storage 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 August and September 2020.

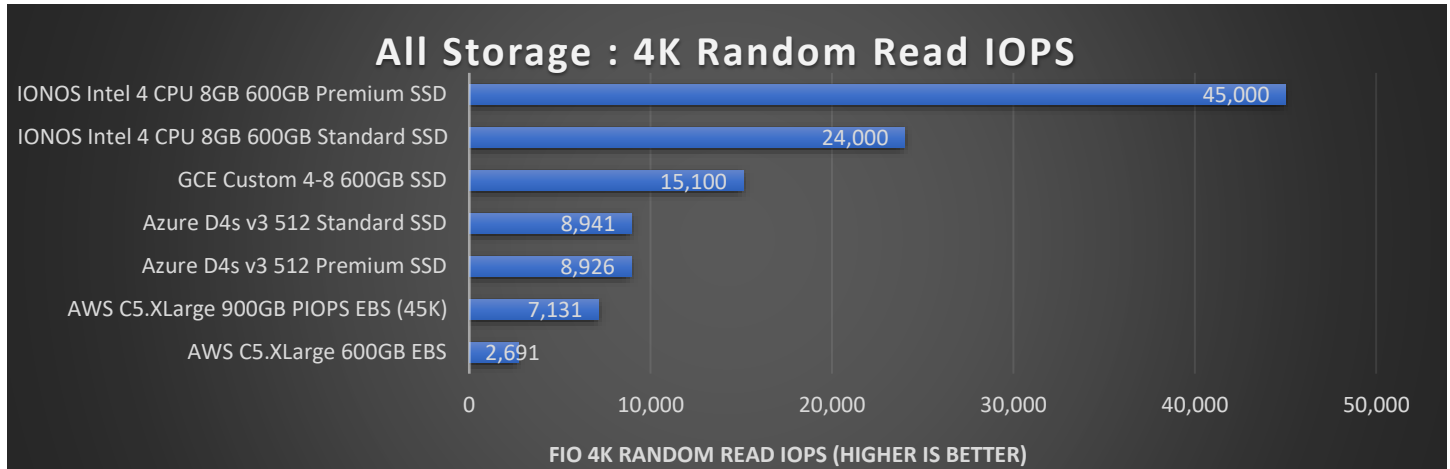
The section below focuses on overall SSD storage performance, specifically random read and random write, using the smallest block size possible, 4KB. Applications that are reliant on a Database often see many small random reads and writes. This type of disk I/O can be extremely demanding which is why we are focused on testing each provider using these parameters, as 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 / 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 next closest provider (Google Compute Engine) by almost 3x.** Again, the results below were obtained by running FIO's random read test with 4KB block size and 4 total jobs.



IONOS cloud SSD 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 appears 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 4 CPUs and 8GB of RAM.

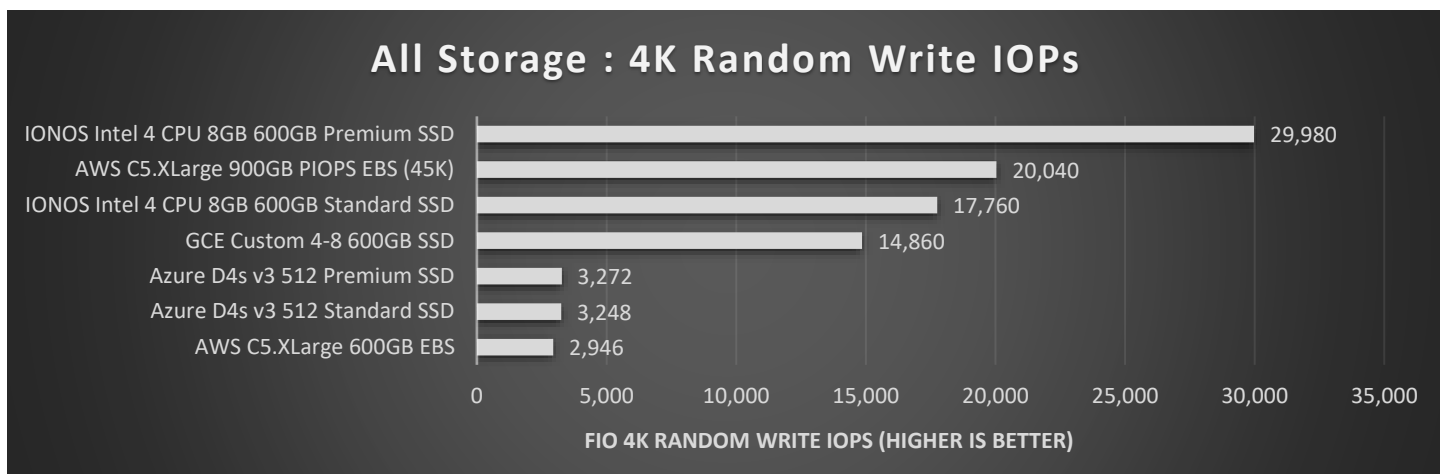
This is one of the reasons why benchmarking cloud performance is still relevant today. Even if you pay for a certain amount of IOPS you may not be able to reach maximum performance with all VM types and sizes.

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 Premium SSD Storage also leads the pack for random write performance, **beating AWS’s higher priced Provisioned IOPS volume by nearly 1.5x**. 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.

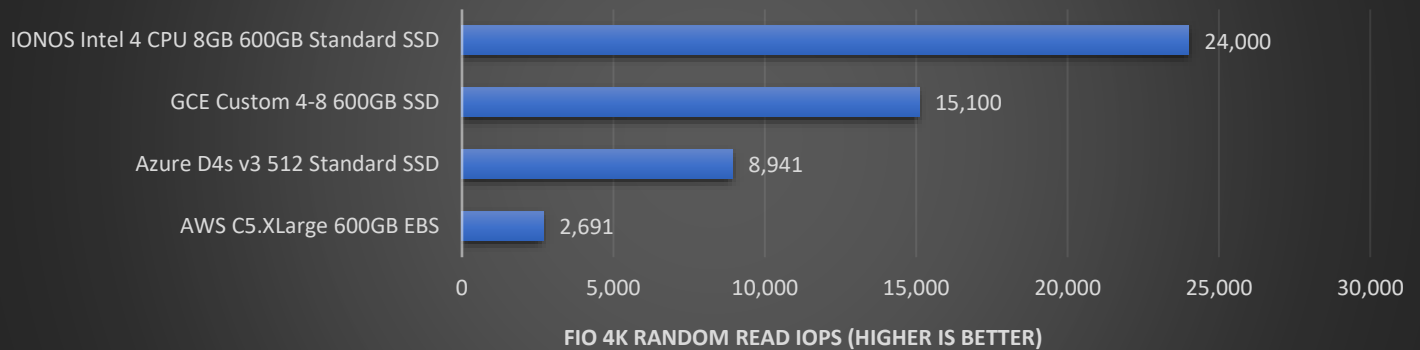


IONOS cloud SSD storage offerings provide truly stellar read and write performance compared to the largest and most prominent cloud providers. In the sections below we will break out these results and take a look at the price-performance (value) that each provider offers for both storage tiers.

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 in this tier, outperforming GCE’s provisioned SSD storage by 1.6x. **IONOS cloud Standard SSD storage beats Azure and AWS by over 4x.**

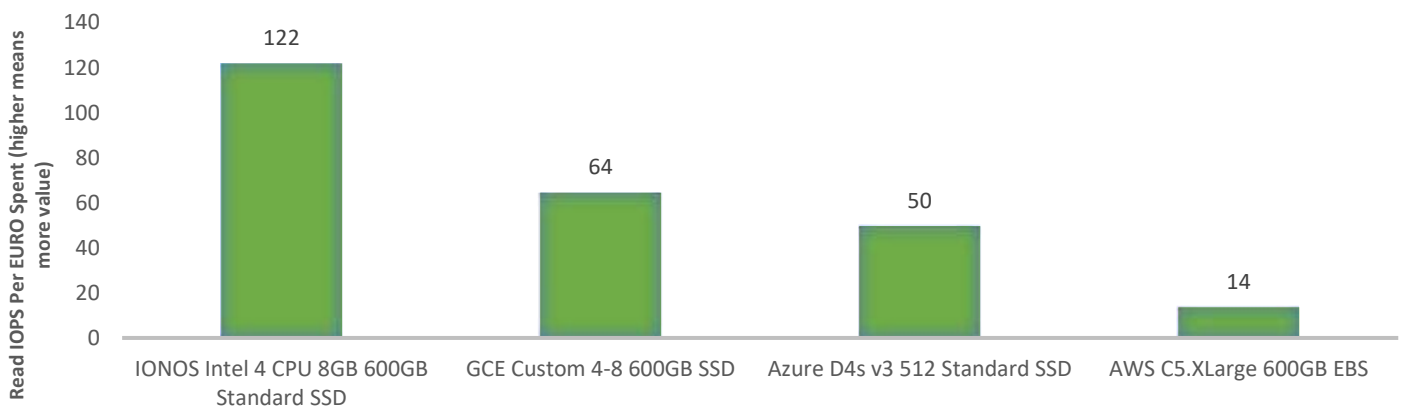
Standard Storage : 4K Random Read IOPs



While IONOS cloud offers excellent read performance they offer even more amazing value, which Cloud Spectator defines as the performance you receive per Dollar or Euro 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 2x the value GCE’s provisioned SSD storage, which is the runner up. Even more impressive, **IONOS cloud Standard SSD storage offers 8.7x the value of AWS’s standard EBS storage.**

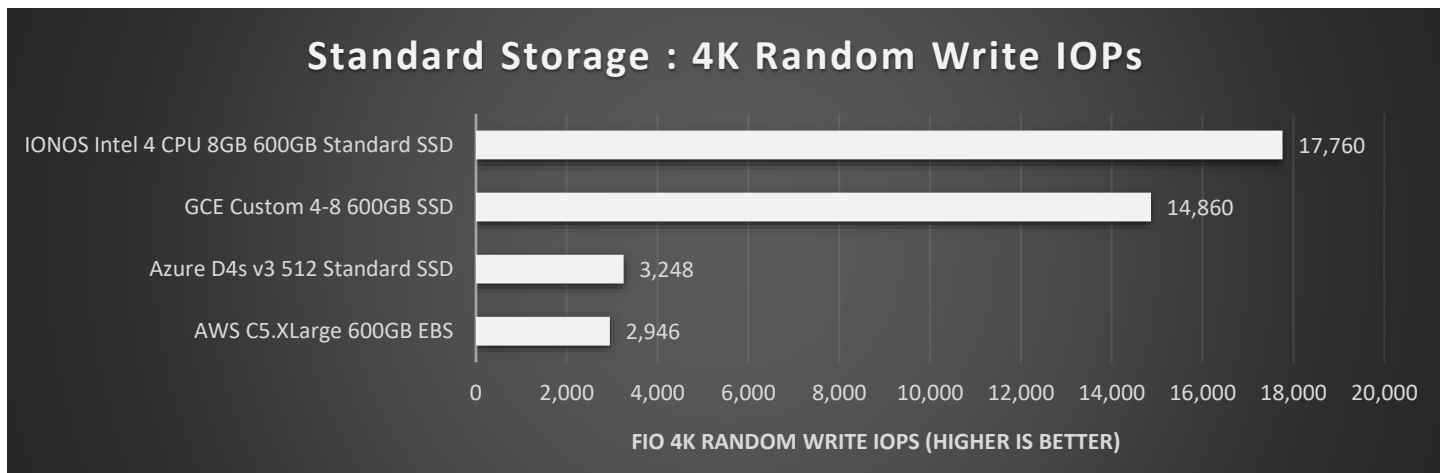
STANDARD STORAGE: READ IOPS PER EURO SPENT



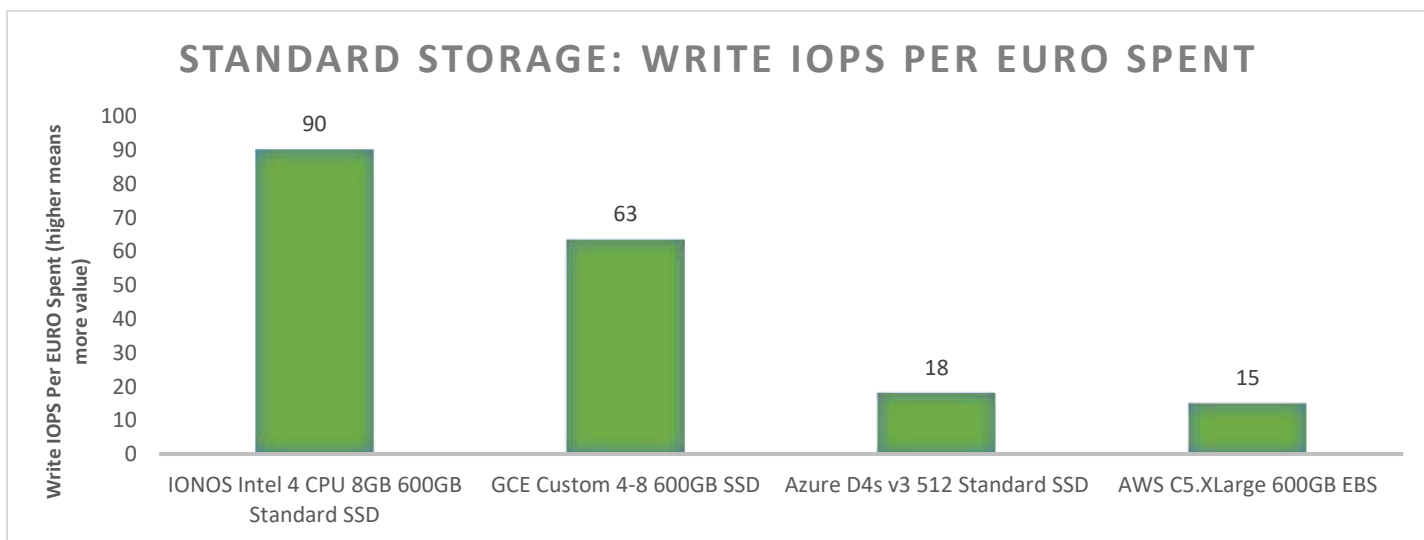
The values above were generated by dividing the average IOPs observed by the total cost of the VM and Storage offering. Just because a storage offering is extremely fast does not necessarily mean it is the best option to use. The same is true for storage offerings that do not appear to perform well compared 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 1.2x and **outperforms Azure and AWS by at least 5.4x.**



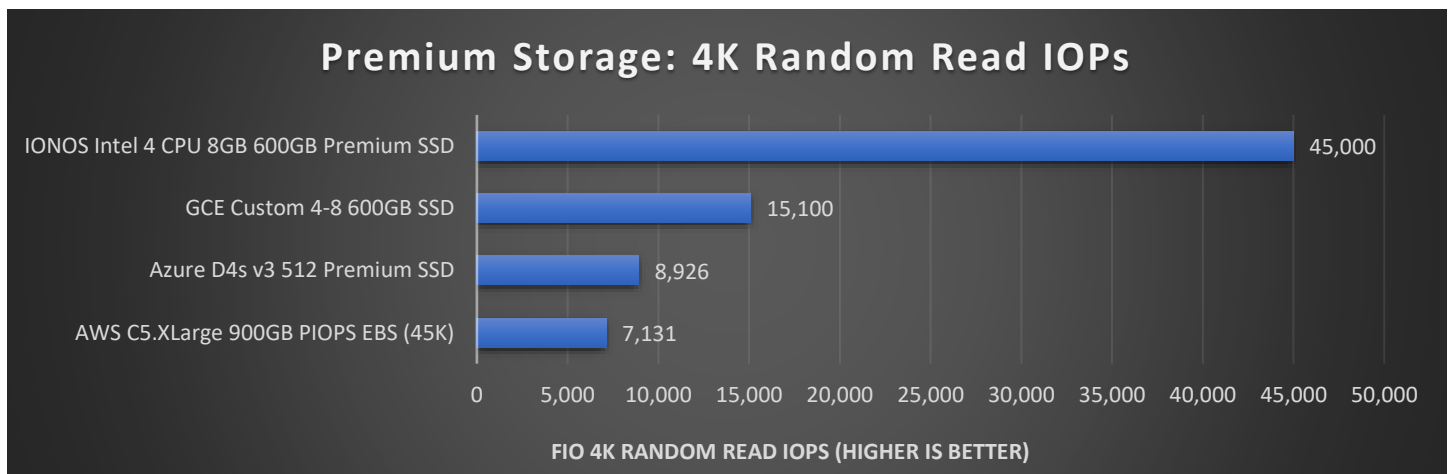
When you factor in the price of each offering, IONOS cloud continues to lead the pack when it comes to value. **Offering 1.4x more storage write value than GCE and at least 5x more value than Azure and AWS.** Anyone running a very write intensive application should take note of this as writes tend to be the most expensive I/O activity.



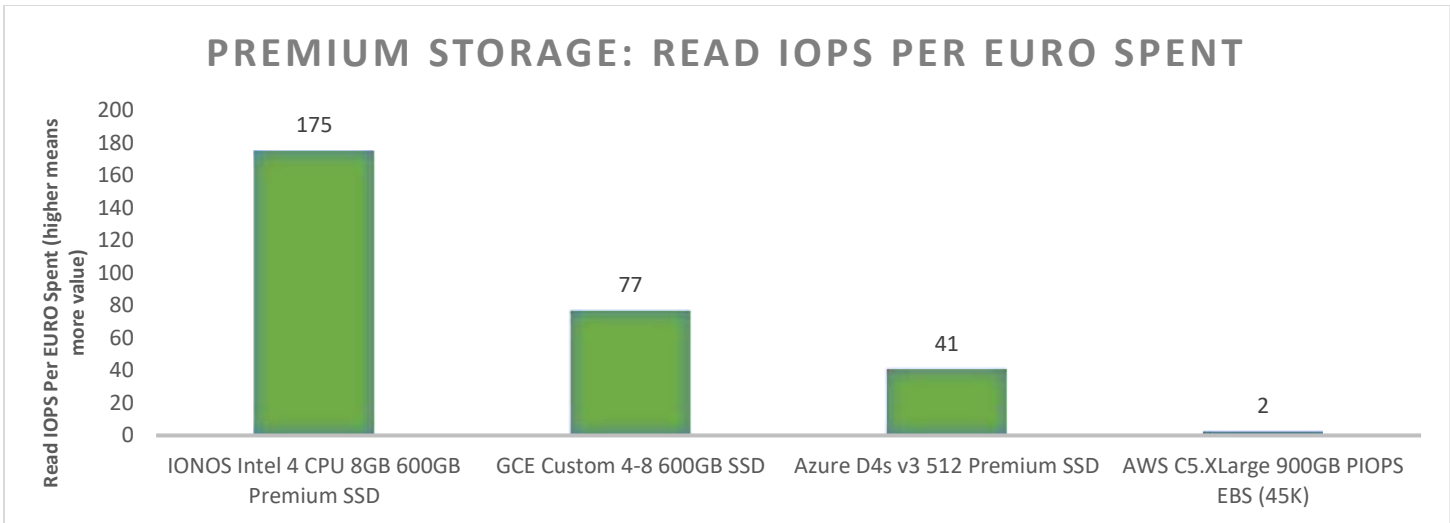
Premium SSD Storage Performance

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.

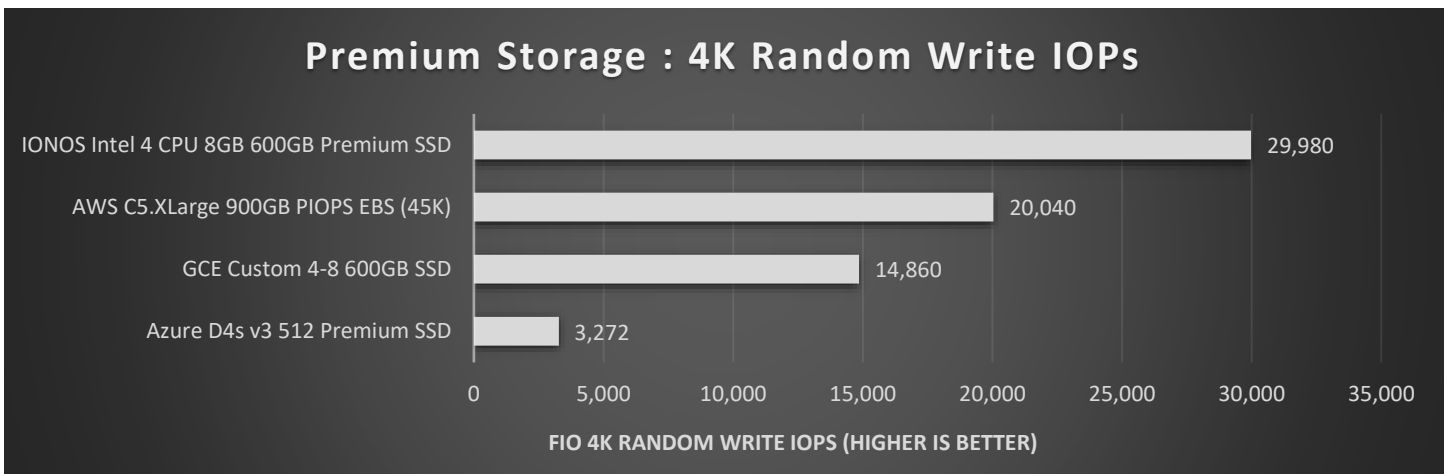
IONOS Premium SSD storage dominates the other providers by at least 3x, beating out AWS provisioned IOPS EBS by over 6x when it comes to random read. Again, the results displayed are not from a single test, they are the average of multiple test iterations.



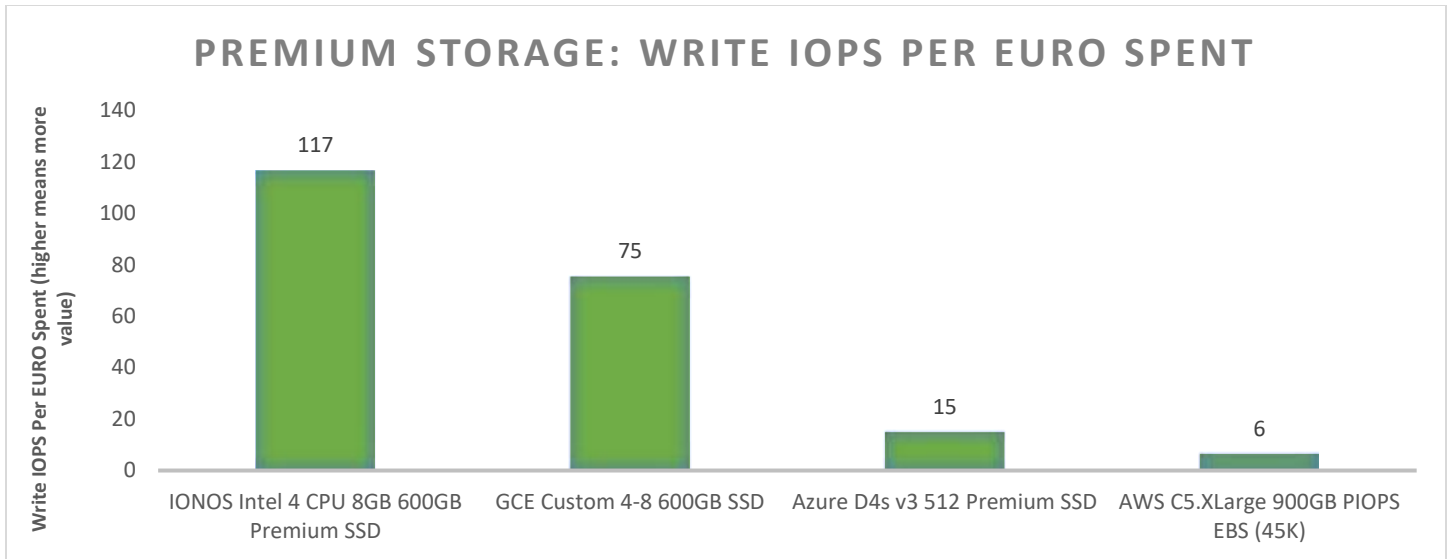
Again, we see that IONOS Premium SSD storage leads the pack when it comes to value, or performance per Dollar or Euro spent, **offering between 2x and 87x better value than the most well-known cloud providers!** AWS lags behind significantly in this case due to the extremely high cost of Provisioned IOPS EBS storage volumes and less than stellar I/O performance observed.



Looking at random write performance for the premium storage tier we see IONOS cloud once again takes the top spot, this time AWS's Provisioned IOPS volume starts to come close but **IONOS Premium SSD Storage still beats AWS's Provisioned IOPS volume by 1.5x for random write performance.**



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 EURO spent, IONOS cloud offers over 1.5x 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 19.5x the value of AWS.**



Conclusion

IONOS cloud Compute Engine offers excellent compute and storage performance when compared against similar sized VMs from Azure, Google, and Amazon. IONOS cloud also offers the most value when it comes to CPU and Storage performance per Euro spent.

IONOS cloud Compute Engine consistently offers the best performance and value when it comes to SSD based storage. It does not matter if you look at the “low” end options or the high end “flagship” options, IONOS cloud is the clear leader in any case, even when compared against 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 at IONOS cloud. You can provision a tiny VM to use an expensive Provisioned IOPS volume at AWS, but you will not achieve the performance you actually pay for.

While AWS, GCE, and Azure tend to have most of the spotlight in the Cloud, this report shows that there are many good reasons to consider other Clouds. Consider checking out the latest IONOS cloud Compute Engine offering if you require consistent, high performance that will not break the bank!

Appendix

SysBench command options

```
sysbench --test=cpu --cpu-max-prime=200000 --num-threads=4 run
```

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
```

