Cloud CPU Benchmark Report

AMAZON (AWS), ALIBABA CLOUD, DIGITALOCEAN, GOOGLE CLOUD PLATFORM (GCP), LINODE, MICROSOFT AZURE

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Introduction

"The [COVID-19] pandemic validated cloud's value proposition. The ability to use on-demand, scalable cloud models to achieve cost efficiency and business continuity is providing the impetus for organizations to rapidly accelerate their digital business transformation plans. The increased use of public cloud services has reinforced cloud adoption to be the 'new normal' now more than ever."

– **SID NAG**, RESEARCH VICE PRESIDENT, GARTNER

Gartner

Businesses, including essential service providers, are relying on scalable infrastructure to deliver reliability and customer satisfaction. In an economy that's seeing a faster pivot to the cloud, it's critical to make sure that developers and business owners understand all their options in the current market, and how alternative cloud providers can provide performance that can exceed hyperscalers in both overall performance and value per dollar.

The cloud experience starts at the hardware level. The central processing unit (CPU) is a significant factor in how fast a website or application will process and complete transactions, load important information, and actions like converting and downloading a file.

Not all CPU needs are created equal, and that's why there are so many plans available from different cloud providers: shared CPU, dedicated (optimized) instances, high memory, high clock speed, and more. But what happens when you compare identical plan specifications on different providers?

Key Findings

Cloud Spectator performed CPU, disk, and database benchmarks on multiple Linodes running the latest generation of AMD 7542 processors, including both Shared and Dedicated plans. Cloud Spectator tested how these offerings stand up in terms of price, performance, and value, or the performance per dollar spent.

This analysis includes the following providers: Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Alibaba, and DigitalOcean. All testing was performed in a US East data center.

Final analysis of the benchmarking results highlights more than a few interesting trends that show the performance and value of the latest generation of Linode VMs (Virtual Machines) for synthetic testing as well as real-life database testing.

The headlines from this analysis include the following:

Linode's latest AMD-based cloud VMs offer excellent CPU, storage, and database performance compared to the larger cloud providers tested in this study. Linode also offers truly supreme value when it comes to the performance you get per dollar spent. Whether you need high performance or a budget-friendly cloud, Linode delivers much more than the larger cloud providers.

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

- Linode offers excellent **random read and random write storage performance compared to the larger hyperscale providers.**

- Linode offers the **best overall Multi-Core CPU performance.**

- Linode also offers **incredible value** when it comes to CPU, storage, and database performance, meaning that you get more performance per dollar spent.
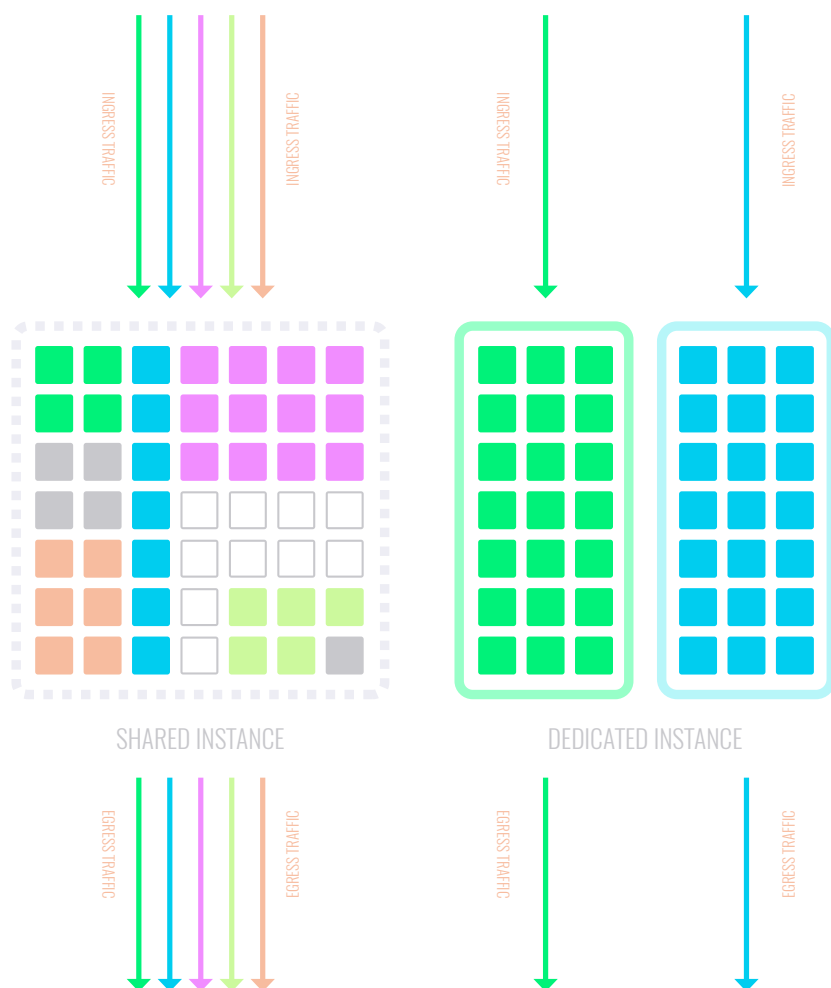
The remainder of this report will present the selection and testing methodology and the benchmarking effort results.

VM Selection Methodology

This report contains the performance results from two groups of VMs (Virtual Machines).

The first group consists of 1-CPU VMs running in a shared CPU environment. VMs running in a shared environment can be impacted by noisy neighbors and can show reduced or improved performance depending on the time of day. Shared plans have their own pros and cons: performance for Shared plans cannot be guaranteed, but generally these types of VMs are priced much lower than "optimized" or dedicated VMs for this reason.

The second group consists of 4-CPU VMs that have dedicated CPU cores, which are focused on optimized CPU performance. These VMs generally have more consistent CPU performance due to lower host densities and stricter CPU allocation for guest VMs. Generally speaking, anyone using a Dedicated or optimized CPU VM will have to worry less about sporadic CPU performance that can be caused by **noisy neighbors** or **overloaded host servers**.

INGRESS TRAFFIC   INGRESS TRAFFIC   INGRESS TRAFFIC   INGRESS TRAFFIC

SHARED INSTANCE   DEDICATED INSTANCE

EGRESS TRAFFIC   EGRESS TRAFFIC   EGRESS TRAFFIC   EGRESS TRAFFIC

Figure: Shared instances (left) are perhaps best compared to multi-tenancy buildings, such as apartment complexes. The entire building shares access, resources, and space. Noisy neighbors can interrupt others.

Dedicated instances (right) contain CPU cores which are not used by other customers, perhaps best compared to a detached single dwelling home, where access, resources, and space are utilized by only one custmer.

VM Selection Methodology

1 CPU Shared VMs

Provider	Alibaba	AWS	Azure	DigitalOcean	GCP	Linode
VM Type	ecs.n4.small	T2.small	B1ms	1 CPU 2GB	n1-custom 1 CPU 2GB	AMD 1 CPU 2GB
Infrastructure Type	Shared	Shared	Shared	Shared	Shared	Shared
CPU Model	Intel(R) Xeon(R) Platinum 8163	Intel(R) Xeon(R) CPU E5-2676 v3	Intel(R) Xeon(R) CPU E5-2673 v4	Intel(R) Xeon(R) Gold 6140	Intel(R) Xeon(R) CPU @ 2.20GHz	AMD EPYC 7542
Location	US East	US East (Ohio)	US East 2	US East	US East	US East (NJ)
CPU Count	1	1	1	1	1	1
RAM (GB)	2	2	2	2	2	2
Storage Type	block	ebs	premium ssd	local	standard	local
Storage (GB)	100	128	50	50	50	50

1 CPU VMs: Total Monthly Price
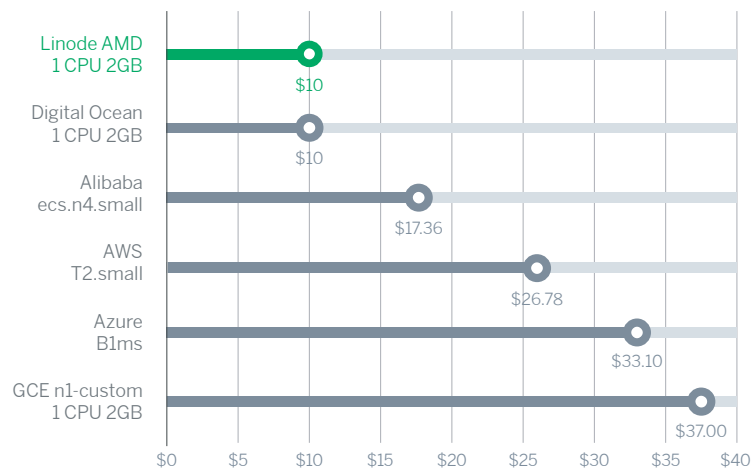
VM Selection Methodology

4 CPU Dedicated / Optimized VMs

Provider	Alibaba	AWS	Azure	DigitalOcean	GCP	Linode
VM Type	ecs.c5.xlarge	c5.xlarge	F4s v2	CPU Optimized 4 CPU 8GB	n2-custom 4 CPU 8GB	Dedicated CPU 8GB
Infrastructure Type	CPU Optimized	CPU Optimized	CPU Optimized	CPU Optimized	Standard	CPU Optimized
CPU Model	Intel(R) Xeon(R) Platinum 8163	Intel(R) Xeon(R) Platinum 8124M	Intel(R) Xeon(R) Platinum 8168	Intel(R) Xeon(R) Gold 6140	Intel(R) Xeon(R) CPU	AMD EPYC 7542
Location	US East	US East (Ohio)	US East 2	US East	US East	US East (NJ)
CPU Count	4	4	4	4	4	4
RAM (GB)	8	8	8	8	8	8
Storage Type	block	ebs	premium ssd	local	standard	local
Storage (GB)	500	500	512	50	500	160

$ 4 CPU VMs: Total Monthly Price
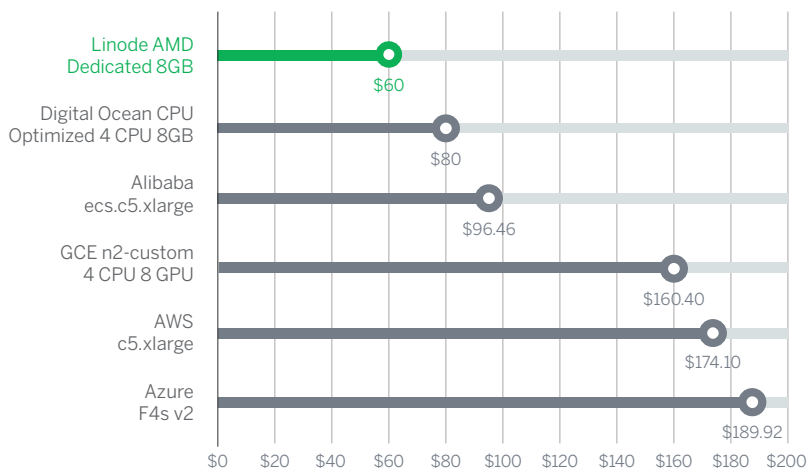
	Price
Linode AMD Dedicated 8GB	$60
Digital Ocean CPU Optimized 4 CPU 8GB	$80
Alibaba ecs.c5.xlarge	$96.46
GCE n2-custom 4 CPU 8 GPU	$160.40
AWS c5.xlarge	$174.10
Azure F4s v2	$189.92

Testing Methodology

All VMs went through the exact same setup process, which involved updating all packages then rebooting, followed by entire disk partitioning (if needed). 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 can 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: CPU
   Compute results were obtained using the GeekBench5 benchmarks. GeekBench5 was performed with standard/default testing options.

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.

Infrastructure Testing: Database
   Database results were obtained using Sysbench OLTP read/write database test. A single database with over 1 million rows was generated on each VM. The latest version of MySQL was installed on each server and the main configuration file was replaced on all VMs to ensure the exact same configuration settings were used.

Shared VM Performance

The results in the section below are focused on the 1 CPU Shared VMs.

CPU Performance

Linode's AMD 7542 based 2GB VM takes the top spot when it comes to GeekBench5 multi core CPU performance, beating the next closest competitor (Alibaba) by almost 1.4x. Linode's Shared 2GB VM is using one of the latest AMD EPYC 7542 CPU while the other providers use various Intel CPUs.

☆ 1 CPU VMs: Average Multi Core Score

VM	GeekBench5 Average Multi Core
Linode AMD Shared 2GB	1,007
Alibaba ecs.n4.small	702
GCE n1-custom 1 CPU 2GB	694
Digital Ocean 1 CPU 2GB	549
AWS T2.small	426
Azure B1ms	351

GeekBench5 Average Multi Core *(Higher is better)*
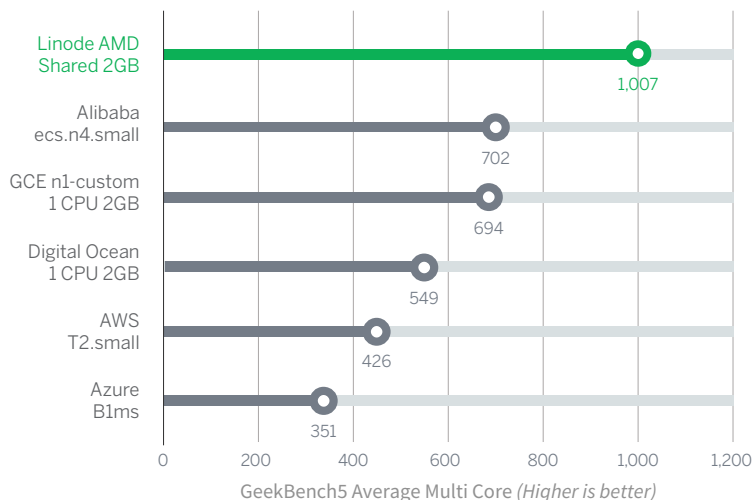
Shared VM Performance

Linode also offers significantly more value or "bang for your buck" than all other providers for 1 CPU VMs. In this case, Linode's Shared 2GB offers close to **2x the value** of the other cloud providers.

1 CPU Shared VMs: Multi Core Performance Per Dollar

Provider	Value
Linode AMD Shared 2GB	101
Digital Ocean 1 CPU 2GB	55
Alibaba ecs.n4.small	40
GCE n1-custom 1 CPU 2GB	19
AWS T2.small	16
Azure B1ms	11

GeekBench5 Multi Core Per Dollar Spent *(Higher means more value)*

1 CPU VMs: Multi Core Standard Deviation

Provider	Value
Linode AMD Shared 2GB	9
GCE n1-custom 1 CPU 2GB	12
Alibaba ecs.n4.small	12
Digital Ocean 1 CPU 2GB	60
AWS T2.small	197
Azure B1ms	252

GeekBench5 Multi Core StDev *(Lower means more consistency)*

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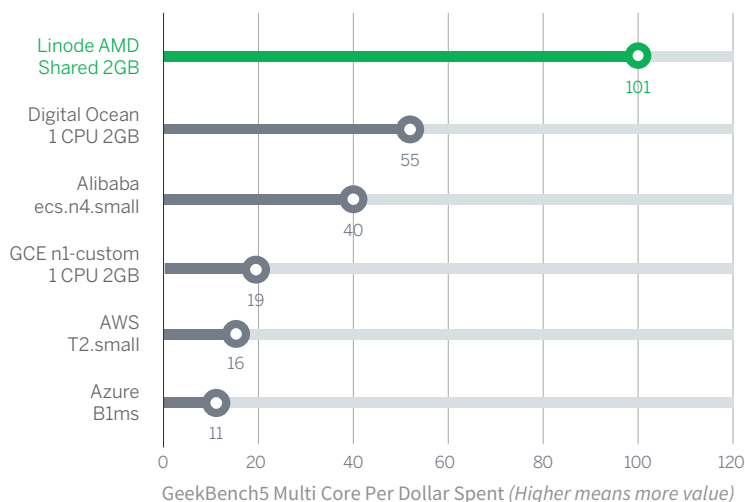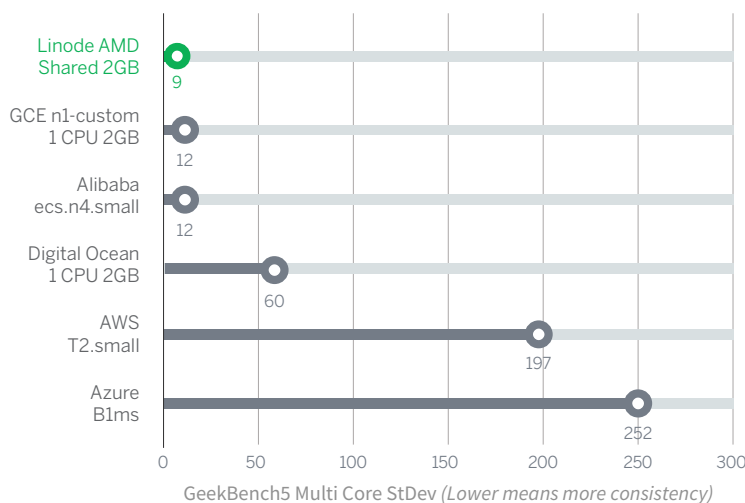
linode

Shared VM Performance

Storage Performance

Alternative cloud providers, Linode and DigitalOcean are miles ahead of the larger hyperscale providers when it comes to random read performance, offering almost 6x the read IOPs.

⭐ 1 CPU Shared VMs: FIO - 4K - AVG READ IOPS

Linode AMD Shared 2GB	34,850
Digital Ocean 1 CPU 2GB	34,297
Alibaba ecs.n4.small	6,236
Azure B1ms	5,443
GCE n1-custom 1 CPU 2GB	1,436
AWS T2.small	931

FIO 4KB Average Read IOPS *(Higher is better)*

⭐ 1 CPU Shared VMs: FIO - 4K READ - StdDev

Linode AMD Shared 2GB	1,209
Digital Ocean 1 CPU 2GB	415
Azure B1ms	103
GCE n1-custom 1 CPU 2GB	24
Alibaba ecs.n4.small	18
AWS T2.small	8

FIO 4KB StDev of Read IOPS *(Lower is better)*
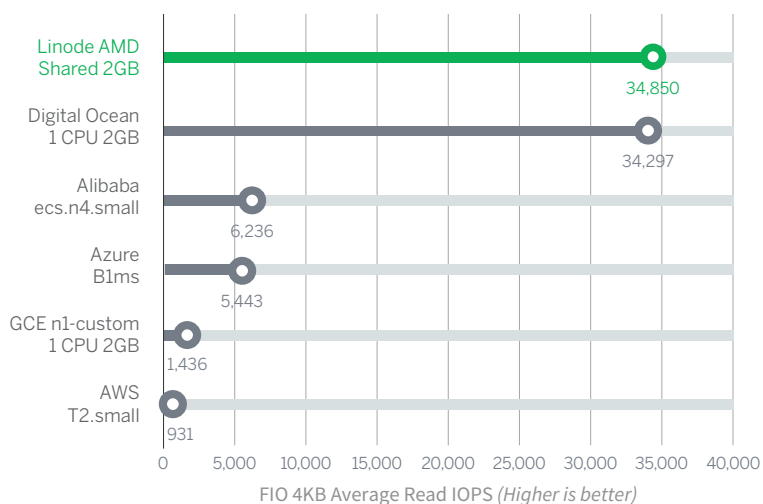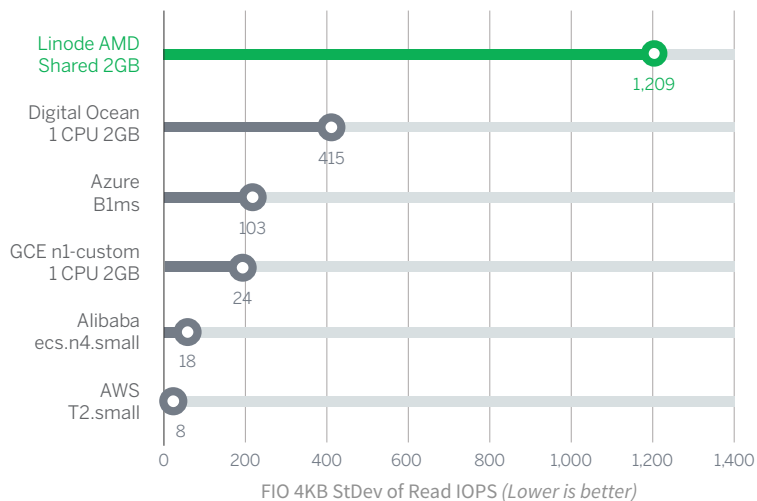
Shared VM Performance

DigitalOcean and Linode beat the larger hyperscale providers, including AWS's EBS, when it comes to average write IOPs.

☆ **1 CPU Shared VMs: FIO - 4K - Write IOPS**

Digital Ocean 1 CPU 2GB	24,516
Linode AMD Shared 2GB	9,584
Alibaba ecs.n4.small	2,373
AWS T2.small	1,840
Azure B1ms	552
GCE n1-custom 1 CPU 2GB	305

FIO 4KB Average Write IOPS *(Higher is better)*

☆ **1 CPU Shared VMs: FIO - 4K - Write Standard Deviation**

Digital Ocean 1 CPU 2GB	5,694
AWS T2.small	1,381
Linode AMD Shared 2GB	504
Alibaba ecs.n4.small	108
Azure B1ms	61
GCE n1-custom 1 CPU 2GB	59

FIO 4KB StDev of Write IOPS *(Lower is better)*
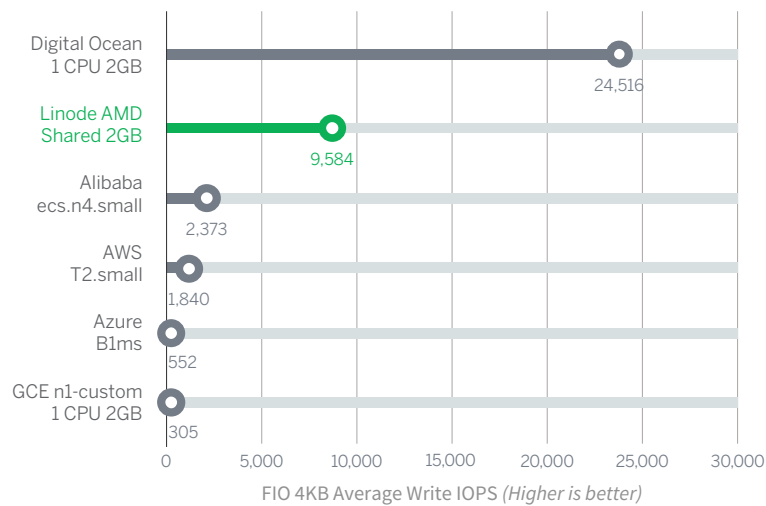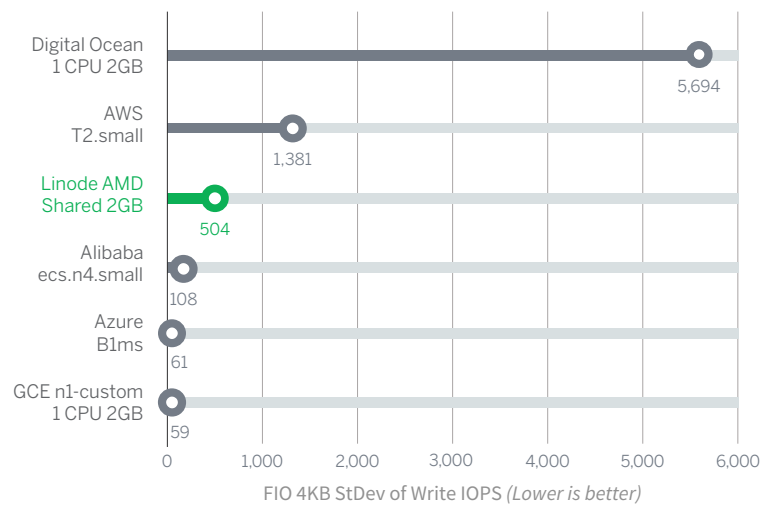
Shared VM Performance

Looking at the IOPs per dollar spent, Linode offers the best random read value compared to all other providers. **Linode offers over 9x more value** for random read IOPs than the larger hyperscale providers such as AWS and Azure. Linode also offers over 17x better random write value compared to the larger cloud providers.

💲 ### 1 CPU Shared VMs: FIO - 4K - READ IOPS Per Dollar
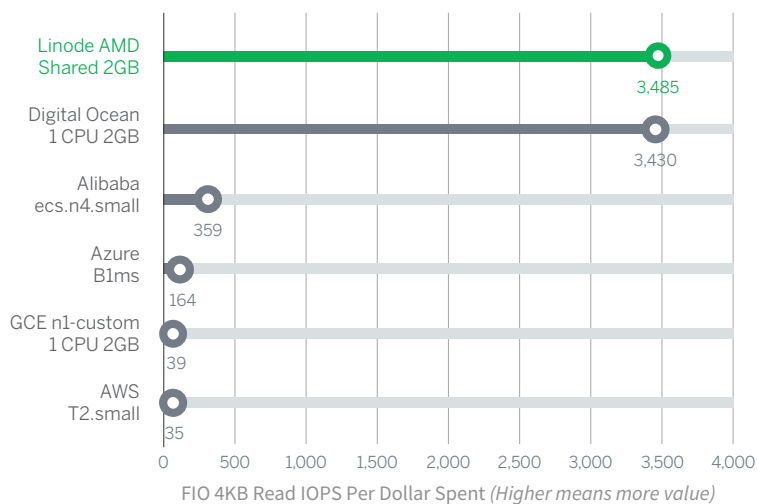
Provider	Value
Linode AMD Shared 2GB	3,485
Digital Ocean 1 CPU 2GB	3,430
Alibaba ecs.n4.small	359
Azure B1ms	164
GCE n1-custom 1 CPU 2GB	39
AWS T2.small	35

FIO 4KB Read IOPS Per Dollar Spent *(Higher means more value)*

💲 ### 1 CPU Shared VMs: FIO - 4K - Write Per Dollar

Provider	Value
Digital Ocean 1 CPU 2GB	2,452
Linode AMD Shared 2GB	958
Alibaba ecs.n4.small	137
AWS T2.small	69
Azure B1ms	17
GCE n1-custom 1 CPU 2GB	8

FIO 4KB Write IOPS Per Dollar Spent *(Higher is better)*

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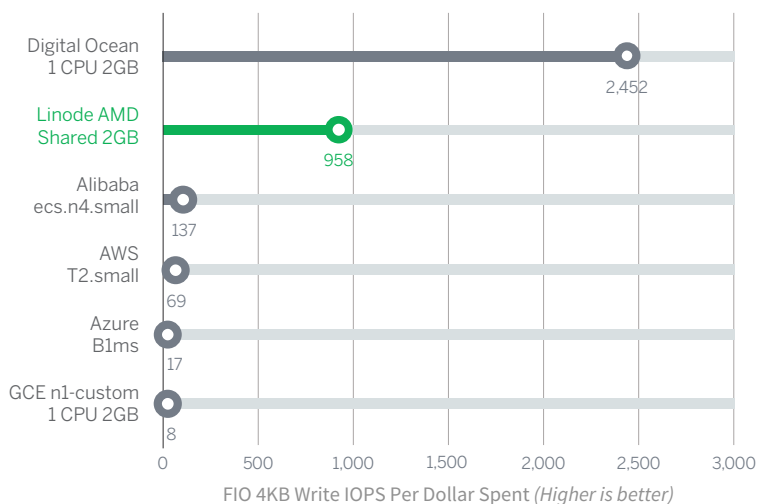
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Shared VM Performance

Database Performance

Linode leads the pack when it comes to database performance, offering the highest queries per second compared to all other 1 CPU Shared VMs.

☆ 1 CPU Shared VMs: OLTP - Avg Queries Per Second

VM	Queries Per Second
Linode AMD Shared 2GB	7,029
Digital Ocean 1 CPU 2GB	6,352
Alibaba ecs.n4.small	6,253
AWS T2.small	5,790
GCE n1-custom 1 CPU 2GB	5,453
Azure B1ms	2,782

2 Thread Sysbench OLTP Read/Write Queries Per Second *(Higher is better)*

☆ 1 CPU Shared VMs: OLTP - Avg Queries Per Second StDev

VM	StDev
Linode AMD Shared 2GB	127
Azure B1ms	145
GCE n1-custom 1 CPU 2GB	148
Digital Ocean 1 CPU 2GB	274
Alibaba ecs.n4.small	309
AWS T2.small	430

2 Thread Sysbench OLTP Read/Write Queries Per Second StDev *(Lower is better)*

Shared VM Performance

1 CPU Shared VMs: OLTP - Avg Queries per Second per Dollar

Provider	Value
Linode AMD Shared 2GB	703
Digital Ocean 1 CPU 2GB	635
Alibaba ecs.n4.small	360
AWS T2.small	216
GCE n1-custom 1 CPU 2GB	147
Azure B1ms	84

Queries Per Second Per Dollar Spent *(Higher means more value)*
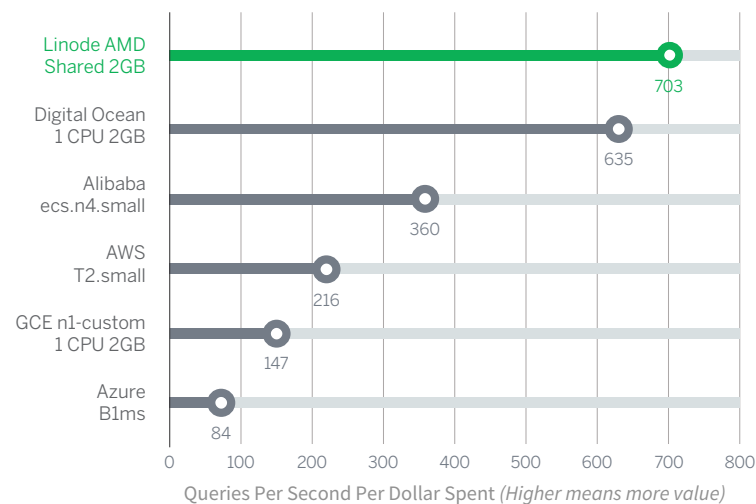
Dedicated VM Performance

The results in the section below are focused on the 4 CPU, Dedicated or Optimized VMs.

CPU Performance

Linode's latest Dedicated AMD VM takes the top spot for outright CPU performance in the 4 CPU VM group. Linode also offers very consistent CPU performance compared to the other providers.

4 CPU Dedicated VMs: Average Multi Core Score

Provider	Score
Linode AMD Dedicated 8GB	2,509
Azure F4s v2	2,227
AWS c5.xlarge	2,187
GCE n2-custom Optimized 4 CPU 8GB	2,171
Digital Ocean CPU Optimized 4 CPU 8GB	2,131
Alibaba ecs.c5.xlarge	1,733

GeekBench5 Average Multi Core Score *(Higher is better)*
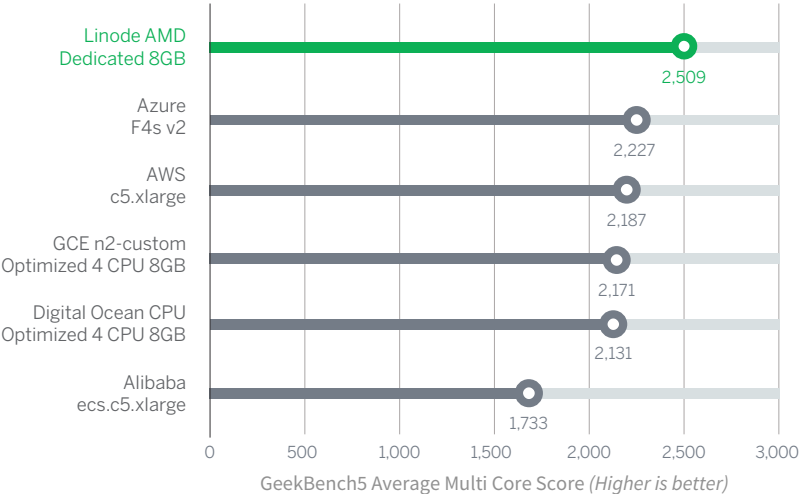
Dedicated VM Performance

Factoring in the price per month for each VM and the performance you get, we see once again **that Linode offers stellar CPU performance per dollar spent, beating Digital Ocean by over 1.5x.**

4 CPU Dedicated VMs: Multi Core Score Performance Per Dollar

VM	Score
Linode AMD Dedicated 8GB	42
Digital Ocean CPU Optimized 4 CPU 8GB	27
Alibaba ecs.c5.xlarge	18
GCE n2-custom Optimized 4 CPU 8GB	14
AWS c5.xlarge	13
Alibaba ecs.c5.xlarge	12

GeekBench5 Multi Core Score Per Dollar Spent *(Higher means more value)*

4 CPU Dedicated VMs: Multi Core Standard Deviation

VM	StDev
Alibaba ecs.c5.xlarge	3.43
Linode AMD Dedicated 8GB	4.31
GCE n2-custom Optimized 4 CPU 8GB	5.77
AWS c5.xlarge	13.04
Digital Ocean CPU Optimized 4 CPU 8GB	15.79
Azure F4s v2	20.98

GeekBench5 Multi Core Score StDev *(Lower means more consistency)*

Dedicated VM Performance

Storage Performance

Linode's AMD-based Dedicated 4 CPU VM offers dramatically better random read performance than the larger hyperscale providers like Azure and AWS.

⭐ 4 CPU Dedicated VMs: FIO - 4K - AVG READ IOPS

Digital Ocean CPU Optimized 4 CPU 8GB	104,459
Linode AMD Dedicated 8GB	73,244
Alibaba ecs.c5.xlarge	7,702
Azure F4s v2	6,883
AWS c5.xlarge	4,293
GCE n2-custom Optimized 4 CPU 8GB	2,177

FIO 4KB Average Read IOPS *(Higher is better)*

⭐ 4 CPU Dedicated VMs: FIO - 4K READ - StdDev

Linode AMD Dedicated 8GB	2,208
AWS c5.xlarge	1,172
Digital Ocean CPU Optimized 4 CPU 8GB	1,001
Azure F4s v2	694
GCE n2-custom Optimized 4 CPU 8GB	17
Alibaba ecs.c5.xlarge	12

FIO 4KB StDev of Read IOPS *(Lower is better)*
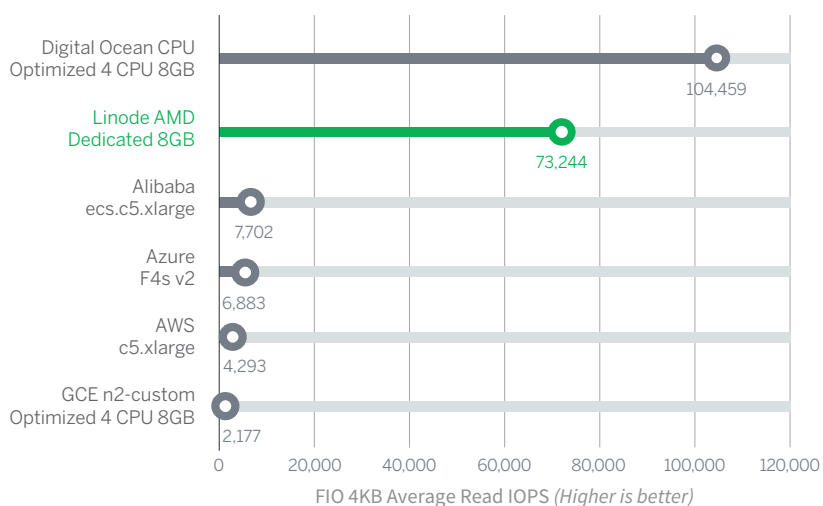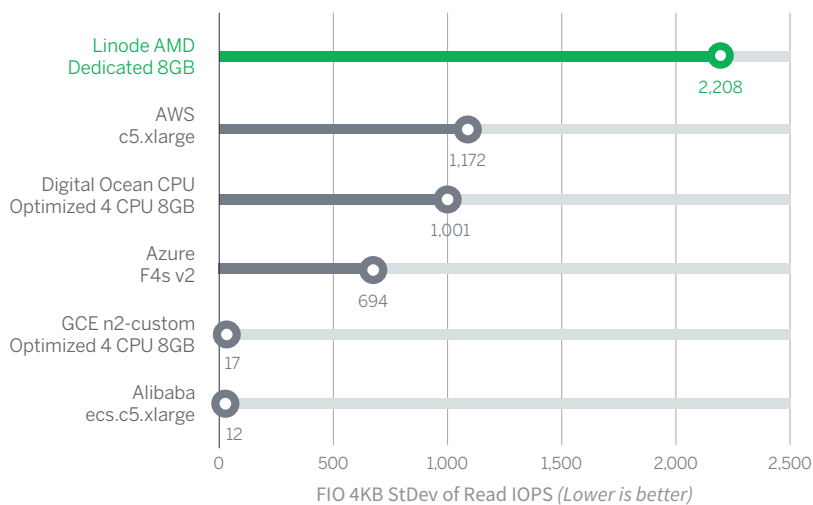
Dedicated VM Performance

DigitalOcean and Linode offered excellent random write performance, **beating AWS by over 8-10x.**

⭐ 4 CPU Dedicated VMs: FIO - 4K - Write IOPS

Digital Ocean CPU Optimized 4 CPU 8GB	31,696
Linode AMD Dedicated 8GB	24,567
Alibaba ecs.c5.xlarge	4,626
AWS c5.xlarge	2,978
Azure F4s v2	2,797
GCE n2-custom Optimized 4 CPU 8GB	984

FIO 4KB Average Write IOPS *(Higher is better)*

⭐ 4 CPU Dedicated VMs: FIO - 4K - Write Standard Deviation

Digital Ocean CPU Optimized 4 CPU 8GB	1,508
Linode AMD Dedicated 8GB	1,329
Azure F4s v2	367
GCE n2-custom Optimized 4 CPU 8GB	251
Alibaba ecs.c5.xlarge	121
AWS c5.xlarge	106

FIO 4KB StDev of Write IOPS *(Lower is better)*

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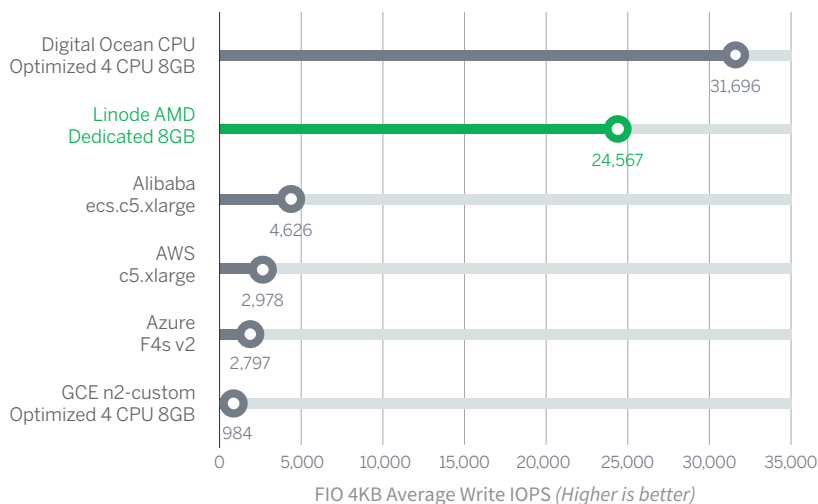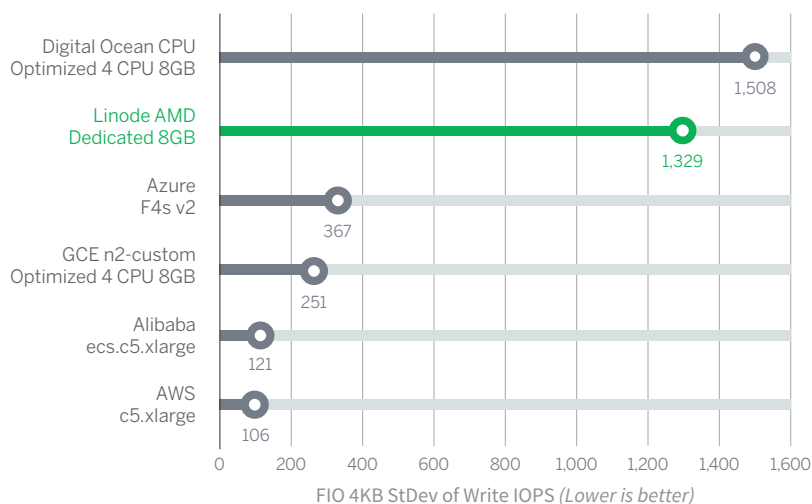
linode

Dedicated VM Performance

Linode's Dedicated 8GB VM offered over 15x more random read IOPS per dollar spent than the larger hyperscale providers such as Alibaba. Linode offered the **best overall random write IOPs per dollar** spent compared to all other providers.

4 CPU Dedicated VMs: FIO - 4K - READ IOPS Per Dollar

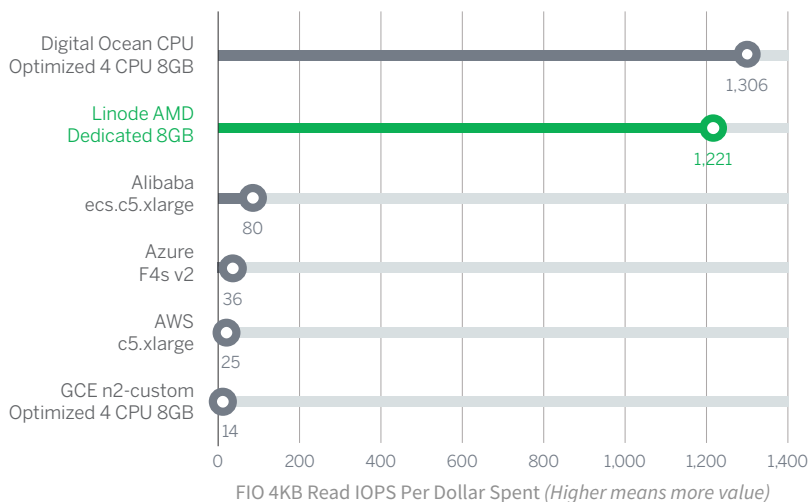| Provider	Value
Digital Ocean CPU Optimized 4 CPU 8GB	1,306
Linode AMD Dedicated 8GB	1,221
Alibaba ecs.c5.xlarge	80
Azure F4s v2	36
AWS c5.xlarge	25
GCE n2-custom Optimized 4 CPU 8GB	14

FIO 4KB Read IOPS Per Dollar Spent *(Higher means more value)*

4 CPU Dedicated VMs: FIO - 4K - Write Per Dollar

Provider	Value
Digital Ocean CPU Optimized 4 CPU 8GB	409
Linode AMD Dedicated 8GB	396
Alibaba ecs.c5.xlarge	48
AWS c5.xlarge	17
Azure F4s v2	15
GCE n2-custom Optimized 4 CPU 8GB	6

FIO 4KB Write IOPS Per Dollar Spent *(Higher means more value)*

CLOUD SPECTATOR

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Dedicated VM Performance

Database Performance

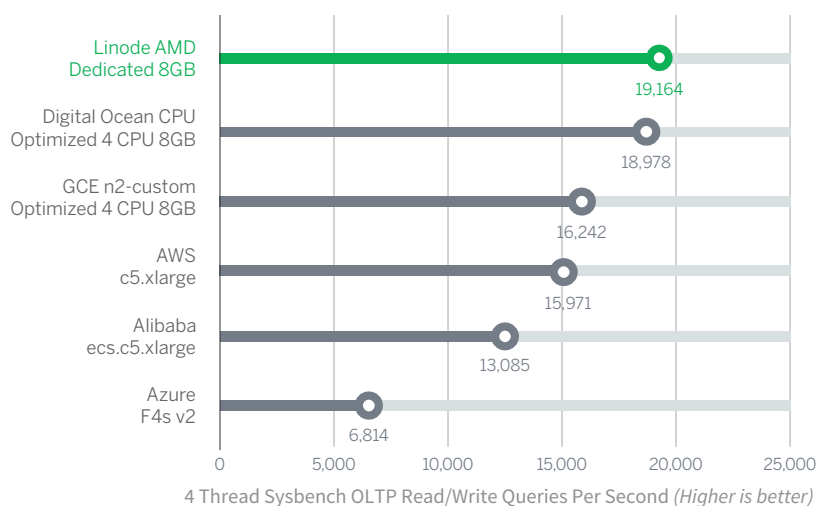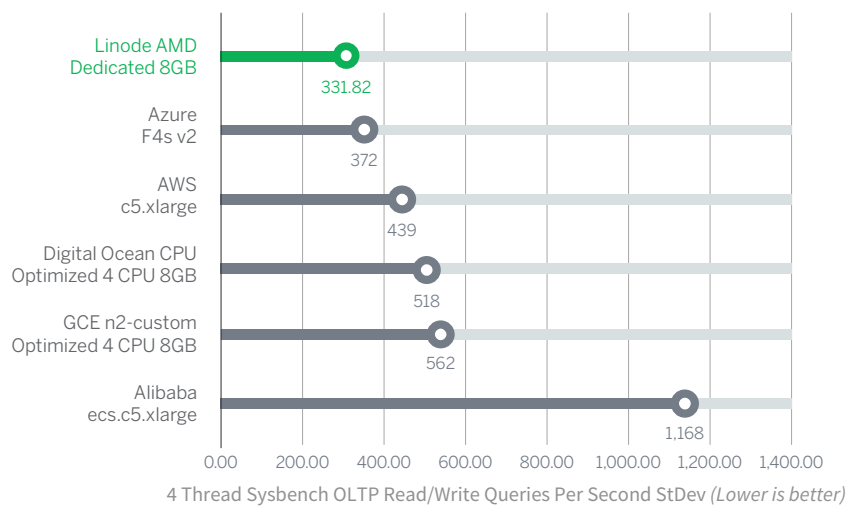Linode's AMD 7542 based Dedicated VM offered the highest outright database performance in the 4 CPU VM group, with DigitalOcean's CPU Optimized VM close behind.

4 CPU Dedicated VMs: OLTP - Avg Queries Per Second

	Value
Linode AMD Dedicated 8GB	19,164
Digital Ocean CPU Optimized 4 CPU 8GB	18,978
GCE n2-custom Optimized 4 CPU 8GB	16,242
AWS c5.xlarge	15,971
Alibaba ecs.c5.xlarge	13,085
Azure F4s v2	6,814

4 Thread Sysbench OLTP Read/Write Queries Per Second *(Higher is better)*

4 CPU Dedicated VMs: OLTP - Avg Queries Per Second StDev

	Value
Linode AMD Dedicated 8GB	331.82
Azure F4s v2	372
AWS c5.xlarge	439
Digital Ocean CPU Optimized 4 CPU 8GB	518
GCE n2-custom Optimized 4 CPU 8GB	562
Alibaba ecs.c5.xlarge	1,168

4 Thread Sysbench OLTP Read/Write Queries Per Second StDev *(Lower is better)*

Dedicated VM Performance

4 CPU Dedicated VMs: Queries Per Dollar Spent

Provider	Value
Linode AMD Dedicated 8GB	319
Digital Ocean CPU Optimized 4 CPU 8GB	237
Alibaba ecs.c5.xlarge	136
GCE n2-custom Optimized 4 CPU 8GB	101
AWS c5.xlarge	92
Azure F4s v2	36

Queries Per Second Per Dollar Spent *(Higher means more value)*
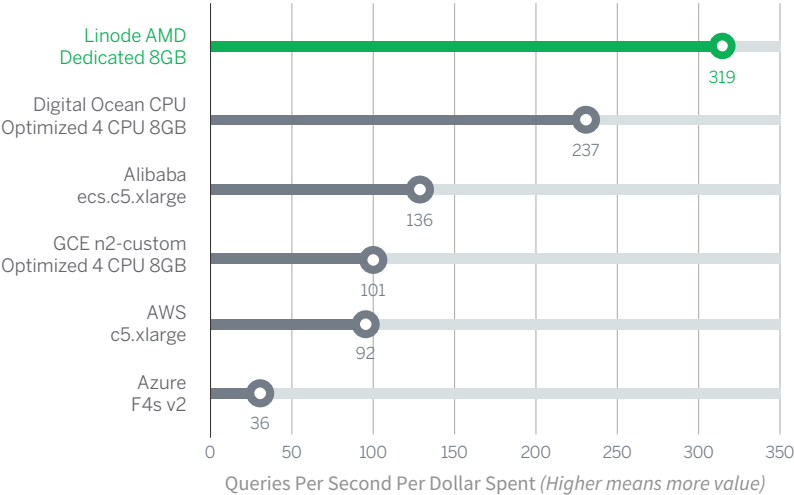
Conclusion

Linode's latest AMD-based VMs offer excellent CPU, storage, and database performance compared against similar-sized VMs from various providers. Linode also offers **extremely high-performance** consistency while also offering much more value or bang for your buck than the other providers. Regardless of whether you need high performance, consistent performance, or high performance at a low cost, Linode is a stellar provider to look at for all kinds of workloads.

About Linode

Our mission is to accelerate innovation by making cloud computing simple, affordable, and accessible to all.

Founded in 2003, Linode helped pioneer the cloud computing industry and is today the largest independent cloud provider in the world. Headquartered in Philadelphia's Old City, the company empowers more than a million developers, startups, and businesses across its global network of 11 data centers.

About Cloud Spectator

Cloud Spectator is a cloud benchmarking and consulting firm focused on the performance of IaaS and applications in the Cloud.

Cloud Spectator provides a full spectrum of cloud consulting services, including strategy and planning, architecture and technology selection, deployment and implementation, as well as Cloud migration services. Cloud Spectator also helps cloud providers understand their market position and helps businesses make intelligent decisions related to cloud strategy, cloud readiness, cost reduction, and vendor analysis.