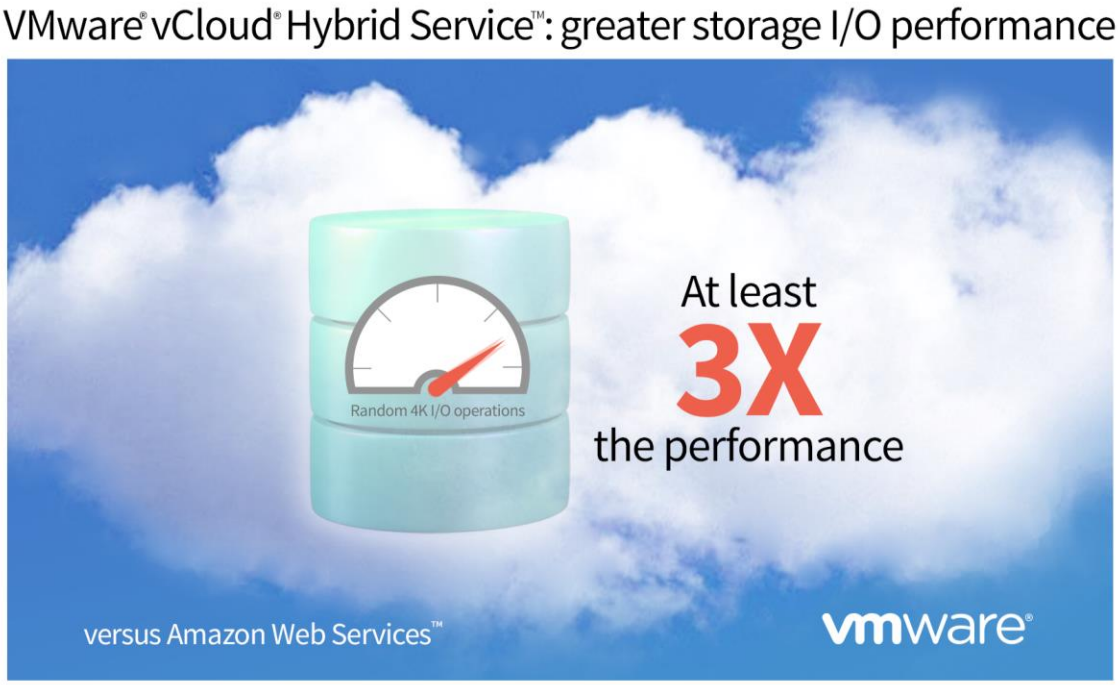
I/O PERFORMANCE COMPARISON OF VMWARE VCLOUD HYBRID SERVICE AND AMAZON WEB SERVICES



Businesses are rapidly transitioning to the public cloud to take advantage of on-demand resources and potential cost savings. Compared to the traditional data center model, where a business purchases and maintains its own physical servers on site, running your virtualized applications off-premises and on Infrastructure-as-a-Service (IaaS) platforms offers enormous flexibility, enhances disaster recover planning, and can save companies in a variety of ways, including management and capital expenditures.

Many public cloud services are available and the I/O throughput that each delivers can vary considerably. From the Principled Technologies labs, we tested the disk I/O performance of two public cloud solutions: VMware vCloud Hybrid Service (vCHS)[1] and a Amazon Web Services (AWS).

Across four different virtual machine sizes and four different block sizes, we found that the I/O performance of our vCHS instances was dramatically greater than that of our AWS instances with Elastic Block Storage (EBS) General Purpose (SSD) volumes and EBS Provisioned IOPS (SSD) volumes; the VMware solution delivered at least 3 times better performance across all scenarios. This advantage translates to much greater throughput for your disk-intensive applications, which can in turn lead to cost savings in your public cloud architecture.

[1] In September 2014, VMware rebranded vCloud Hybrid Service (vCHS) as vCloud® Air™.

JULY 2014 (Revised)
A PRINCIPLED TECHNOLOGIES REPORT
Prepared for VMware

THE POWER OF THE CLOUD

As discussed, businesses moving to the cloud gain efficiency, cut up-front expenses, and enjoy a number of other advantages. It is the rare business in which computing needs remain constant—demand on servers can fluctuate seasonally, as companies grow, in response to special events, and due to countless other factors. Regardless of the reason, IaaS allows a company to immediately expand and contract their compute and storage resources to meet the needs of that particular moment. This responsiveness means that the company saves money by expanding server resources only when demand requires, not weeks or months or years before. More importantly, this responsiveness means employees, customers, and other users are taken care of right away. The company is able to respond to business needs more quickly and deliver resources more nimbly.

Changing from a data center model where companies must budget for capital expenditures to one where virtual machines are a service also means a transition to operating expenses. Because the cloud service provider performs physical server and storage maintenance, including software and security updates, the companies that use them can allocate their IT resources to more productive endeavors.

Cloud-based computing has additional benefits—the fact that data centers are located around the world and accessible from anywhere with an Internet connection aids in collaboration and the ability for workers and customers to connect from anywhere. Unfortunately, not all cloud providers offer the same level of storage performance to their customers.

BETTER I/O PERFORMANCE

In simple terms, I/O performance is the rate at which a virtual machine transfers data back and forth from storage. As data and the storage that houses data are key components of most applications, disk I/O is typically the most important performance bottleneck. Most "slow" applications can be traced back to poor storage performance. In the case of IaaS cloud services, we measured the I/O performance using the Flexible I/O (Fio) benchmark on a test file over a few different virtual machines. We chose the Fio benchmark to test storage performance without the potential overhead caused by the application and database layers.

We used Fio to compare the I/O performance of a 140GB storage device in the two cloud services we tested, VMware vCloud Hybrid Service using the SSD-Accelerated storage tier and Amazon Web Services with both EBS General Purpose (SSD) volumes and EBS Provisioned IOPS (SSD) volumes. To do so, we subscribed to the two services and then set up comparable configurations. To make sure we were comparing apples to apples, we selected specific instance types in the AWS solution and then used the

VMware solution to create customized instances with the same vCPU counts and similar memory. For detailed system configuration information and test methodology, see Appendix A.

TESTING I/O WITH THE FLEXIBLE I/O (FIO) BENCHMARK

To evaluate the solutions, we looked at both random and sequential I/O performance. Because random I/O is generally small, we chose 4K, the smallest block size you typically see in workloads such as database-OLTP and mail servers and 64K to represent average workloads. Sequential I/O is generally large, so we selected the 1M block size, which is typical of file servers, data backup, and database-OLAP workloads and 128K to represent average workloads.

Random I/O

As Figure 1 shows, on the Fio benchmark, the I/O throughput of the vCHS solution far exceeded that of AWS on the random 4K IOPS tests we conducted – against both standard SSD-based storage and the Fixed-IOPS storage. Comparing AWS m3.xlarge instance with four vCPUs and 7 GB RAM to vCHS, vCHS produced an average of nearly 7 times the IOPS of AWS. Storage I/O for vCHS was blazingly fast compared to what we saw with the Amazon solution.

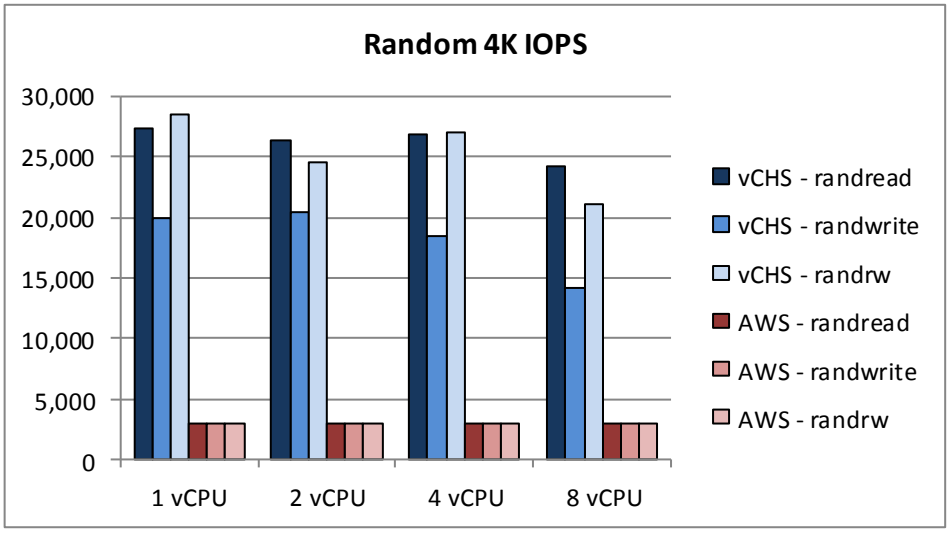


Figure 1: In the Random 4K IOPS tests, the vCHS solution delivered Fio performance far superior to that of the AWS solution.

The results for the 64K block size were similar. As Figure 2 show, the storage I/O for vCHS consistently outperformed the comparable AWS instances across all different random I/O patterns.

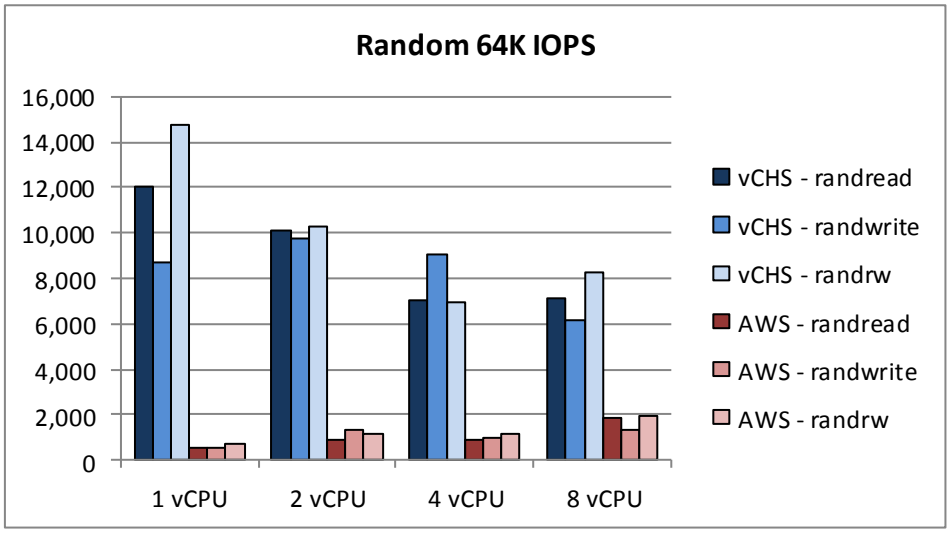


Figure 2: In the Random 64K IOPS tests, the vCHS solution delivered Fio performance far superior to that of the AWS solution.

Sequential I/O

Backup and restore applications and mail servers tend to require large blocks of sequential I/O operations. As Figure 3 shows, on the Fio benchmark, the I/O throughput of the vCHS solution far exceeded that of the AWS solution on the Sequential 1M IOPS tests we conducted. When comparing an AWS m3.xlarge to a 4 vCPU, 7GB RAM virtual machine on vCHS, the I/O throughput was at least 7 times greater with vCHS.

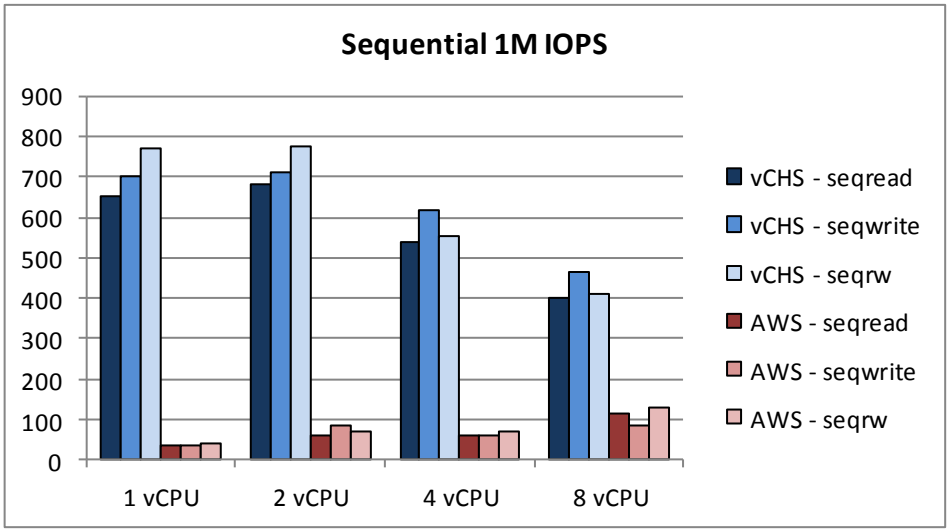


Figure 3: In the Sequential 1M IOPS tests, the vCHS solution delivered Fio performance far superior to that of the AWS solution.

The results for the 128K block size were similar. As Figure 4 shows, vCHS disk I/O consistently outperformed the comparable AWS instances across all different sequential I/O patterns.

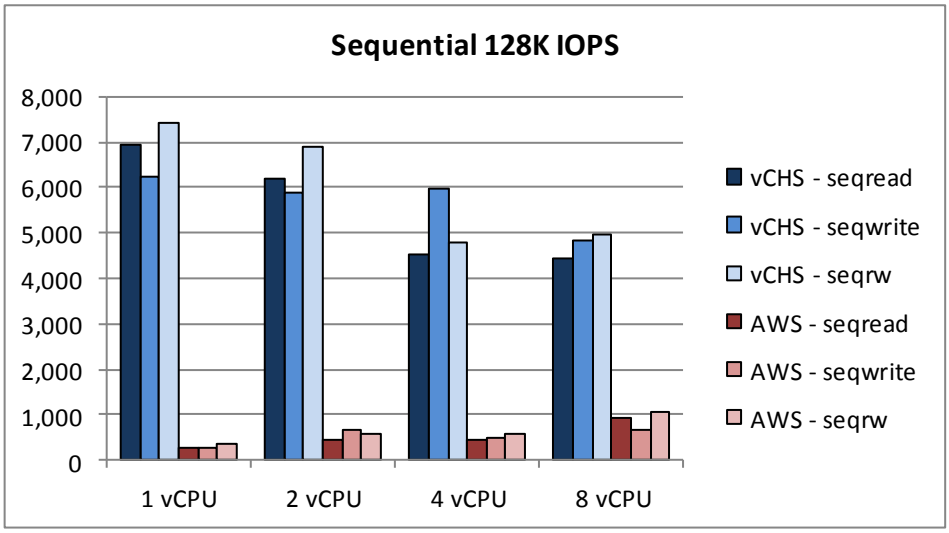


Figure 4: In the Sequential 128K IOPS tests, the vCHS solution delivered Fio performance far superior to that of the AWS solution.

WHAT WE TESTED

About vCloud Air (formerly VMware vCloud Hybrid Service)

In September 2014, VMware rebranded vCloud Hybrid Service (vCHS) as vCloud Air. According to VMware, this service, which is built on VMware vSphere®, "quickly and seamlessly extends your data center into the cloud using the tools and processes you already have." It is available in three service offerings: Disaster Recovery, Dedicated Cloud, and the Virtual Private Cloud. (We tested the Dedicated Cloud offering with resource reservations found in the Virtual Private Cloud offering.)

For more information about VMware vCloud Air, see www.vmware.com/products/vcloud-hybrid-service/.

About Amazon Web Services

According to Amazon, "Amazon Web Services provides a variety of cloud-based computing services including a wide selection of compute instances which can scale up and down automatically to meet the needs of your application, a managed load balancing service as well as fully managed desktops in the cloud."

AWS offers persistent block-level storage through EBS. There are actually three different configurations for EBS – EBS General Purpose (SSD) volumes, EBS Provisioned IOPS (SSD) volumes, and EBS magnetic volumes. We conducted testing against the EBS General Purpose (SSD) volumes across four virtual machine sizes while we conducted additional testing against Provisioned IOPS volumes against the two larger virtual

machine sizes that offered "EBS-Optimized" instances. On the Provisioned IOPS volumes, the virtual machines were set up with 140GB storage volumes to achieve the maximum 4,000 IOPS allowable with this class of storage.

For more information about Amazon Web Services, see aws.amazon.com.

About our test tool, Flexible I/O (Fio) 2.1.7

Fio is a freely available I/O tool used to stress hardware and reports results in IOPS (input/output operations per second). We downloaded and used Fio version 2.1.7 for testing (pkgs.repoforge.org/fio/fio-2.1.7-1.el6.rf.x86_64.rpm).

IN CONCLUSION

Business computing is making its way to the cloud in a dramatic fashion. Selecting the right cloud service provider is a pivotal decision that could have a significant effect on how much your company benefits from this move.

Throughout our I/O tests, we found that VMware vCloud Hybrid Service instances performed dramatically better than the AWS instances, earning consistently higher Fio scores. On a 4K random workload, vCHS delivered performance that averaged 7 times that of the AWS solution, and on a 1M sequential workload, it delivered on average 9 times times the performance of AWS. Across all scenarios, vCHS delivered at least 3 times greater performance than AWS.

By choosing a cloud service that can deliver greater throughput, you can boost the performance of your disk-intensive applications, which can help you make the most of your investment in the cloud platform.

APPENDIX A – DETAILED TEST METHODOLOGY

For testing, we selected four of the default instances from AWS and then configured similar instances with the same virtual processors and memory from VMware vCloud Hybrid Service. For both AWS and vCHS, we used a 60GB root virtual disk and connected a second 140GB virtual disk against which to run FIO. For AWS, we used an SSD-based virtual disk for testing. We used one-, two-, four-, and eight-vCPU configurations for the AWS standard comparison and then four- and eight-vCPU configurations for the the provisioned AWS comparison. We enabled optimized storage on all AWS instances that supported it. Figure 5 shows the configurations we used from AWS.

Compute instance	Virtual CPU	Memory (GB)	Attached storage (GB)
Medium	1	1.75	140 SSD-based IOPS
Large	2	3.50	140 SSD-based IOPS
Xlarge (EBS-Optimized)	4	7.00	140 SSD-based IOPS
2xlarge (EBS-Optimized)	8	14.00	140 SSD-based IOPS
Xlarge (EBS-Optimized)	4	7.00	140 SSD-based Fixed IOPS
2xlarge (EBS-Optimized)	8	14.00	140 SSD-based Fixed IOPS

Figure 5: AWS instance configurations.

Figure 6 shows the similar configurations we used from VMware vCloud Hybrid Service.

Compute instance	Virtual CPU	Memory (GB)	Attached storage (GB)
Medium	1	1.75	140 SSD-accelerated
Large	2	3.50	140 SSD-accelerated
Xlarge	4	7.00	140 SSD-accelerated
2xlarge	8	14.00	140 SSD-accelerated

Figure 6: vCHS instance configurations.

We configured the instances using as close an OS comparison as possible. For AWS, we used Red Hat 6.5 HVM with the latest updates. vCHS does not offer a Red Hat template, so we used CentOS 6.4 and installed the latest updates and kernel. For testing, we used kernel version 2.6.32-431.11.2.el6.x86_64.

We installed Fio version 2.1.7 on all instances. We set rampup time to five minutes and runtime to five minutes as well. We set the I/O depth at 64 for sequential tests and 128 for random tests. We ran fio 9 times for every test and used the median to calculate the result. We completely shut down and powered back on the VM between each run.

FIO example command used:

```
fio --minimal --direct=1 --ioengine=libaio --randrepeat=0 --norandommap --ramp_time=300 --runtime=300 --time_based --numjobs=1 --rwmixread=80 --bs=1024k --rw=write --iodepth=64 --filename=/dev/sdb --name=fio_vmware_4vCPU_1024k-write --output=fio_vmware_4vCPU/fio_vmware_4vCPU_1024k-write_1403141465.txt
```

APPENDIX B – DETAILED TEST RESULTS

Random I/O

4K IOPS	Random Read	Random Write	Random R/W
1 vCPU			
vCHS	27,310	19,949	28,439
AWS	3,058	3,058	3,038
2 vCPU			
vCHS	26,410	20,361	24,508
AWS	3,058	3,058	3,034
4 vCPU			
vCHS	26,794	18,508	27,037
AWS	3,058	3,058	3,058
AWS-provisioned	4,078	4,078	4,078
8 vCPU			
vCHS	24,240	14,137	21,141
AWS	3,058	3,058	3,037
AWS-provisioned	4,078	4,078	4,077

Figure 7: Random I/O results at 4K IOPS.

64K IOPS	Random Read	Random Write	Random R/W
1 vCPU			
vCHS	12,058	8,686	14,797
AWS	551	565	682
2 vCPU			
vCHS	10,062	9,718	10,237
AWS	920	1,290	1,137
4 vCPU			
vCHS	6,995	9,025	6,978
AWS	920	942	1,134
AWS-provisioned	919	942	1,137
8 vCPU			
vCHS	7,121	6,127	8,240
AWS	1,831	1,304	1,966
AWS-provisioned	1,834	1,491	2,087

Figure 8: Random I/O results at 64K IOPS.

Sequential I/O

1M IOPS	Sequential Read	Sequential Write	Sequential R/W
1 vCPU			
vCHS	653	700	773
AWS	34	35	42
2 vCPU			
vCHS	683	711	777
AWS	58	82	71
4 vCPU			
vCHS	538	618	554
AWS	58	58	71
AWS-provisioned	58	58	71
8 vCPU			
vCHS	398	464	409
AWS	114	83	129
AWS-provisioned	115	93	130

Figure 10: Sequential I/O results at 1M IOPS.

128K IOPS	Sequential Read	Sequential Write	Sequential R/W
1 vCPU			
vCHS	6,958	6,236	7,419
AWS	277	282	343
2 vCPU			
vCHS	6,178	5,891	6,901
AWS	464	660	574
4 vCPU			
vCHS	4,540	5,988	4,774
AWS	464	471	573
AWS-provisioned	463	471	573
8 vCPU			
vCHS	4,444	4,850	4,984
AWS	919	680	1,043
AWS-provisioned	925	748	1,043

Figure 9: Sequential I/O results at 128K IOPS.

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.