Head-to-Head Product Report

February 2014

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MAKING THE RIGHT HYBRID STORAGE ARRAY BUYING DECISION:

ORACLE ZS3 SERIES STANDS OUT AS A HYBRID ENTERPRISE STORAGE SOLUTION

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HEAD-TO-HEAD PRODUCT REPORT

Making the Right Hybrid Storage Array Buying Decision: Oracle ZS3 Series Stands Out as a Hybrid Enterprise Storage Solution

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Executive Summary

Don't look now but storage hardware and software costs have become the biggest line item by percentage in many enterprise data centers. Driven by new data center forces such as Big Data, consolidation and server virtualization, enterprises are buying a more diversified set of storage array types to keep up with their ever changing capacity, performance, and budgetary requirements. Yet enterprises often feel compelled to continue purchasing from the same few storage providers that they have in the past.

This is a mistake. Fundamental changes in how storage arrays are architected to maximize capacity, performance, and total cost of ownership (TCO) have occurred over the past few years and the traditional storage providers are not always the ones doing the best job of delivering on the promises of these next generation solutions.

Nowhere is the evidence of these changes more visible than in hybrid storage arrays. Designed with a *"flash first"* mentality, these arrays are architected to deliver the performance of flash while still offering the high levels of storage capacity and cost effectiveness that are normally associated with conventional storage arrays.

The key for enterprises is to identify a storage provider that delivers the best of what these next generation hybrid storage arrays have to offer. However, this storage provider also has to meet financial stability and long-term viability requirements, in addition to the expected enterprise-class technical service and support.

Enter Oracle. A long time player in the enterprise space, it now offers a full portfolio of enterprise storage solutions led by its newest flagship ZFS Storage Appliance ZS3 Series. Designed from the ground up as hybrid storage arrays, the ZS3 Series storage offers a robust set of hardware features that enterprises may fully capitalize by leveraging the sophisticated software included on the arrays.

Early users of ZS3 Series storage already report that they have experienced up to 50x improvements in capacity utilization and up to 7x increases in performance in their Oracle Database environments. Further, through Oracle's integration with hypervisors such as VMware vSphere, ZS3 Series storage offers similar capacity and performance improvements to highly virtualized environments.

By architecting the ZS3 Series storage as a *"flash first"* hybrid storage array, Oracle offers enterprises the cost-effective capacity and high performance they seek in a single array from a recognized enterprise solution provider that may be relatively *"new"* to storage but is certainly accustomed to meeting and exceeding enterprise expectations.

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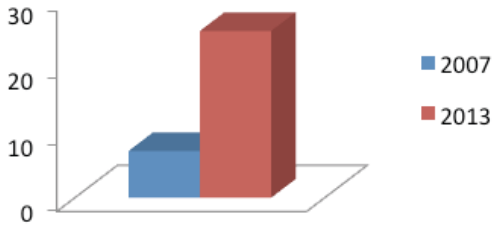
Making the Right Hybrid Storage Array Buying Decision: Oracle ZS3 Series Stands Out as a Hybrid Enterprise Storage Solution

The Insatiable Enterprise Appetite for Storage

Anyone responsible for corporate IT knows that buying behaviors have evolved over the years—nowhere more evident than in the areas of data storage hardware and software.

In 2007 companies allocated about 7% of their IT budget to storage.[1] Just six years later this percentage has increased dramatically. Driven by new forces such as data center consolidation, desktop/server virtualization, Big Data initiatives, private/public storage clouds, and growing archival/backup data stores, organizations may spend as much as 25% of their IT budget on data storage hardware and software.[2]

Change in Data Storage as a Percentage of IT Budget



This growing corporate appetite for storage has resulted in significant changes in how providers develop and configure their storage arrays. Storage arrays are now available in seven distinct classifications to satisfy the varying enterprise requirements *(see Callout #1)*. However, among these different storage array types enterprises find *"hybrid storage"* particularly attractive.

A "Flash First" Mentality Drives Throughput

Hybrid storage arrays often lead the list of array types that enterprises are most interested in purchasing. Like many of their midrange predecessors, these storage arrays incorporate flash memory as a cache or a high performance storage tier. The difference is that hybrid storage arrays take a "*flash first*" approach to managing data.

1. Forrester Research. "What Percentage of Your IT Budget Is Spent on the Following?" Processor.com. Sandhills Publishing Company, Inc, May 2007. Web. 25 Nov. 2013. http://www.processor.com/articles//P3001/30p01/30p01chart.pdf?guid=.
2. Henderson, Nicole. "Enterprises Spend 25 Percent of IT Budgets on Data Storage: NaviSite Study." Web Host Industry Review. iNet Interactive, 2 May 2013. Web. 25 Nov. 2013. http://www.thewhir.com/web-hosting-news/enterprises-spend-25-percent-of-it-budgets-on-data-storage-navisite-study.

CALL-OUT #1

The Seven Storage Array Classifications

The large number of storage arrays on the market today would almost seem to suggest that there are too many. While there may be some truth to that statement, storage arrays have been forced to evolve and transform to meet the distinctive needs of today's organizations. This has resulted in the emergence of multiple storage array types that fall under the following classifications.

- **Enterprise midrange arrays.** These storage arrays spawned many if not all of the array types that follow. Used as general purpose arrays to host a wide variety of applications, the primary attributes of these arrays are high availability, high levels of reliability and stability, moderate to high amounts of storage capacity and performance, and mature and proven code. They are typified by dual, redundant controllers and are optimized for block level traffic (FC & iSCSI).
- **Enterprise high-end arrays.** These storage arrays typically deliver the highest levels of availability, capacity, performance and reliability. Their ability to concurrently connect to any server OS including mainframes, network protocol support that includes FICON and support for non-disruptive upgrades typically distinguishes these storage arrays from all others. These storage arrays also come with similarly high price tags that could easily run into the millions of dollars.
- **All-flash memory storage arrays.** These are the new speed demons of storage arrays. Populated entirely with flash memory, many of these arrays can achieve performance of 500,000 to 1 million IOPS with latency at under a millisecond. They distinguish themselves from other arrays by their ability to manage flash's idiosyncrasies *(garbage collection, wear leveling, etc.)*
- **Hybrid storage arrays.** Hybrid storage arrays offer both flash memory and HDDs. They take a *"flash first"* approach and attempt to place data on the most appropriate tier of storage at the best time. They use sophisticated caching algorithms as well as compression and deduplication to improve storage efficiencies and lower the effective price per GB of the array.
- **Private cloud storage arrays.** Private cloud storage arrays support the dynamic addition or removal of capacity, performance or both to an existing array configuration. These arrays are intended for use behind corporate firewalls.
- **Public cloud storage gateway arrays.** These arrays connect to public storage clouds. Data is stored on a local disk cache before it is moved out to the public storage cloud on some schedule based upon either default or user-defined policies.
- **Unified storage arrays.** These arrays support both block (FC, iSCSI, FCoE) and file (NFS, CIFS) protocols from a single array. In almost every other respect they are similar to midrange arrays in terms of the capabilities they offer.

Using this "*flash first*" design, hybrid storage arrays provide a combination of DRAM cache, flash memory and SAS or SATA hard disk drives. To control the cost of flash while delivering on its higher performance characteristics, hybrid storage arrays combine caching, storage tiering software and capacity optimization algorithms to most effectively use the available DRAM, flash and hard drive capacity. Combining these features maximizes the I/O throughput that a hybrid storage array can deliver while minimizing capacity and costs.

Hybrid storage arrays leverage the latest generations of hardware such as multi-core CPUs, denser DRAM, and SLC and MLC flash. This makes it possible for vendors to offer high levels of performance as well as data optimization methods such as in-line data deduplication and compression.

This aggregated set of technologies and sophisticated data tiering algorithms have resulted in hybrid storage arrays achieving documented speeds in the range of hundreds of thousands of IOPS—2–10X higher than their conventional midrange array counterparts, often at comparable or lower price points.

These metrics are prompting enterprise IT storage architects and buyers to turn their attention to hybrid storage arrays. While hybrid storage arrays may solve pressing performance needs in enterprise data centers, IT managers also need to evaluate the vendors to ensure that they have the financial stability, long-term viability, and ability to deliver high levels of technical service and support, often on a global basis.

CALL-OUT #2

Identifying the "Best" Hybrid Storage Array

The key way a hybrid storage array differentiates itself from a standard storage array is its ability to *dynamically place data in a storage pool that consists of DRAM, flash memory and HDDs.* Some storage providers refer to this as *"automated storage tiering"* or *"dynamic storage tiering."* Other providers also talk in terms of sophisticated caching and data placement algorithms. This dynamic data placement may be based on preset system policies/algorithms, user-defined policies, user-defined performance targets, or some combination of the three.

The arrays that do the best job of dynamically placing data on the appropriate performance/capacity tier should deliver the best price/performance ratio by offering both the performance and the capacity that businesses need from a storage system.

Identifying the best hybrid storage array for one's environment depends on selecting one that does continuous intelligent monitoring of the storage and possesses an understanding of the application data. This enables a *"set it and forget it"* approach that ***prevents*** *application performance problems* rather than correcting them after a problem already exists.

It Takes One to Know One

An unwritten but commonly understood rule exists in enterprise IT organizations. When it comes to hosting their business- and mission-critical applications, enterprises prefer to buy and use storage systems from established storage providers.

This mindset is both understandable and justifiable. Established providers offer the technical expertise and multiple levels of support that IT often calls upon to resolve the thorny and time-sensitive issues that may arise when running mission-critical applications on their storage arrays. These storage providers are also generally financially stable giving enterprises a high degree of confidence that these services will be available for the long term.

Not surprisingly, this approach leads many enterprises to acquire storage arrays from one of the three leading vendors: EMC, NetApp and IBM. It also explains why enterprises are generally unwilling to *"bet the farm"* on a storage startup no matter how compelling its storage offering may be.

Not All Hybrid Storage Arrays Are Created Equal

As organizations restrict their search to these established providers, they need to take a close look at their hybrid storage arrays. For the most part, they took their legacy storage arrays, added new hardware and/or software and re-positioned them as *"hybrid storage arrays"* without fundamentally changing the underlying architecture. It may work but is that really the best way to design a hybrid storage array?

Hybrid storage arrays need to manage capacity and performance much more efficiently than previous generations of storage arrays. This raises questions as to whether these *"new"* systems from the established providers can fully deliver on the range of capacity and performance features that hybrid storage arrays can and should offer. The uncertainty that comes when new parts are

strapped on an old architecture makes it necessary for enterprises to look beyond the traditional storage providers. Instead, they should identify hybrid storage arrays from ***enterprise-capable*** competitors who offer substantial differentiation.

Oracle Epitomizes the Enterprise

Enterprises will likely dismiss hybrid storage array offerings from smaller storage providers such as Nimble Storage, Tintri, Dot Hill, Tegile, and X-IO. While they offer storage arrays classified as hybrids, these providers fail to meet the standards for financial stability, long-term viability, and capability to provide the high level (and often global) service and support that enterprises expect.

It is nearly impossible for enterprises to so easily dismiss a storage provider like Oracle. Unlike smaller providers, Oracle's position in the enterprise coupled with its ability to support and deliver on enterprise requirements is nearly indisputable. Consider:

- Oracle is a ***$37 billion*** company with over ***120,000 employees around the globe,*** and some ***400,000 customers worldwide***[3]
- ***Over 60,000 people*** attended Oracle OpenWorld in fall 2013[4]
- ***97%*** of Global Fortune 500 companies use Oracle software[5]
- ***Over 50,000 IT professionals*** become certified in Oracle software each year[6]

While arguably best known for its database software and business applications, Oracle has also emerged as an enterprise storage player having acquired several storage companies since 2010, including:

- ZFS Storage Appliance *(part of Sun Microsystems acquisition)*
- Pillar Data Systems
- StorageTek tape storage solutions *(part of the Sun Microsystems acquisition)*

Of these three acquisitions, Sun is particularly noteworthy from a storage perspective. While Sun may be best known for the Java programming language, Sun SPARC workstations and servers running the advanced Solaris operating system, Sun also owned the StorageTek portfolio of tape solutions, a line of mid-range storage systems, and intellectual rights to the ZFS file system.

ZFS has become the hidden gem in Oracle's acquisition of Sun. It possesses specific characteristics that made it ideal as one of the foundational component of hybrid storage arrays. Sun also pioneered the use of Hybrid Storage Pools in 2008 with its ZFS Storage Appliance, whose unique architectural design enables it to service 70%–90% of IOs in DRAM, de-stage the data to flash and subsequently hard disk drives (HDDs) based on usage patterns. The optimization of Solaris, the ZFS Appliance Kit and the underlying DRAM-centric architecture *(up to 2TB)* makes the ZFS Storage Appliance stand out as a hybrid storage array for its throughput and price/performance, as demonstrated in industry standard benchmarks.

Oracle ZS3 Series Storage Competitive Edge

Oracle's development and marketing of the ZFS Storage Appliance continued after it acquired from Sun, culminating in the current ZS3 Series of hybrid storage arrays. Though Sun already had 1,000 customers using its ZFS Storage Appliance by 2009, the number of ZFS Storage Appliance customers under Oracle's oversight swelled to 3,000 by 2011. By 2013 Oracle had installed its 10,000th ZFS Storage Appliance.

Oracle's customer base and name recognition certainly helped to drive some of the ZFS Storage Appliance sales to enterprises. However, the technical features and functionality of the ZFS Storage Appliance play an equally influential role in the selection of these hybrid storage arrays by enterprises over competitive offerings.

File System and LUN Capacity

As more enterprises centralize file stores and consolidate their available storage capacity, they want assurances

3. Oracle Fact Sheet.
4. Ibid.
5. Ibid.
6. Ibid.

Table 1. File System and LUN Capacity

	ORACLE ZS3-2	ORACLE ZS3-4	EMC VNX5400	EMC VNX8000	EMC ISILON S200	NETAPP FAS3250	NETAPP FAS6250	IBM V7000U
File System Size (Max TB)	***1 Billion***	***1 Billion***	16	16	20,000	20,000	20,000	Not Published
LUNs (Max)	16,384	16,384	1,000	4,000	Not Applicable	4,096	4,096	2,048

that their hybrid storage array's file system will scale to handle petabytes of data. As shown in Table 1, the ZFS file system scales to hold zettabytes of data which is up to ***50,000X more data*** than what these competitive solutions currently support.

In this respect, it could be said that the Oracle ZS3 Series is the ***only*** hybrid storage array that can handle a nearly infinite amount of data, alleviating concerns that enterprises may have in managing petabytes of data. For example, to store 10 petabytes of data a NetApp filer requires 100 file systems or more whereas a ZFS Storage Appliance requires just one.[7] The resulting filer sprawl increases upfront costs, complexity and ongoing management expenses. Similarly the Oracle ZS3 Series easily surpasses competitive offerings in terms of LUN capacity.

A Speed Demon

Providing high levels of capacity is only relevant if a storage array can also deliver high levels of performance. The number of CPU cores, the amount of DRAM and the size of the flash cache are the key hardware components that most heavily influence the performance of a hybrid storage array.

The Oracle ZS3 Series ZS3-2 and ZS3-4 storage controllers scale to support substantially more of these three key performance engines than any of their competitors offer (See Table 2). However, superior hardware by itself does not guarantee superior performance—a sophisticated operating system and caching algorithms are necessary to extract maximum performance from the hardware.

Oracle ZS3 Series storage leverages a multi-threaded, Symmetric Multi-Processing (SMP) operating system and Hybrid Storage Pools intelligent data caching architecture and algorithm to ensure that up to 90% of *"hot"* IO is processed in DRAM—up to 2TB per system. Frequently accessed data is cached in flash—up to 22TB per system—and less frequently accessed data is read from disk when needed. The efficacy of the ZFS Appliance's hardware/software combination is that it delivers performance that far exceeds its traditional competitors as demonstrated in industry benchmarks.

Table 2: Key Storage Controller Components

	ORACLE ZS3-2	ORACLE ZS3-4	EMC VNX5400	EMC VNX8000	EMC ISILON S200	NETAPP FAS3250	NETAPP FAS6250	IBM V7000U (4 Node)
Max Raw Capacity (TBs)	***768***	***3,500***	750	3,000	3,110	2,880	5,760	1,920
CPU Cores	32	80	8	32	8	16	16	32
DRAM (GB)	512	2,048	32	256	96	40	144	64
Flash Cache (TB)	16	22	1	4.2	13.8	2	8	Not Published

7. NetApp. "FAS6200 Series Technical Specifications." http://www.netapp.com/us/products/storage-systems/fas6200/fas6200-tech-specs.aspx. NetApp, Web. 28 Jan. 2014.

As shown in Table 3, both Oracle ZS3 Series storage systems easily beat NetApp FAS3250 filer (the only other comparable two-node system) in performance. In contrast, the EMC VNX 8000 is a seven node system and the Isilon 200 is a 56-node system cost significantly more and, even in those two cases, the ZS3-4 delivers lower latency than they do.

The EMC VNX5400 is probably the most ill-equipped of these arrays to meet enterprise performance demands short and long term. It combines the DART operating system from CLARiiON and the FLARE operating system from Celerra in one physical storage array. In it, each one remains a separate, distinct operating system that is converged under a virtual hypervisor. This architectural approach adds latency to storage processing and complexity to storage management.

Taken together these SPC-2 and SPECsfs results show that the ZS3 Series storage excels at a range of workloads from high-throughput streaming performance applications, such as data warehousing and business intelligence to latency sensitive applications such as databases.[8]

However, this level of performance that the Oracle ZS3 Series can deliver is relevant only if enterprises need it. In Oracle's case, Oracle Database users have always sought higher I/O and throughput to drive their applications.

In Oracle's customer base the ZS3 Series storage will prove meaningful as it removes existing throughput and I/O bottlenecks and accelerates the performance of Oracle Database and applications. In addition, through Oracle's hardware and software co-engineering development, there are a number of unique integration points between the Oracle ZS3 Series storage and Oracle Database (covered below) that further drive performance, efficiency, and lower TCO. The Oracle ZS3 Series storage also helps resolve other data center performance issues, especially highly virtualized environments.

Designed to Thrive in Highly Virtualized Environments

The Oracle ZFS Storage Appliances are optimized and tuned for running Oracle Database in the most efficient and fastest ways currently available. However the Oracle ZS3 Series storage architecture also lays the foundation for these storage appliances to handle a much broader set of application workloads in an equally impressive manner.

For instance, Oracle can take some of the same techniques it used in delivering capacity and performance optimizations for Oracle Database and apply them to other even more widely adopted applications or operating systems deployed by enterprises. Any application with a performance bottleneck would benefit from an injection of ZS3 storage. Offering sub-millisecond response times, ZS3 can eradicate bottlenecks that organizations with SQL databases, Windows environments and, most notably, highly virtualized environments face.

In the latter case, Oracle's own Cloud Services Group internally tested a ZFS Storage Appliance model 7420 in a VMware environment and achieved over 2,200 virtual machines (VMs) per single system—with only 33% CPU utilization. The new ZS3 Series is expected to deliver at least 4x times the VM density of the ZFS 7420 appliance. In contrast, Oracle also internally tested NAS filers from a competitor and was only able to achieve 250 VMs per system before hitting 100% CPU utilization.

To support the same 2,200 VMs, more of the competitive filers had to be installed to support the increasing number of VMs, inevitably leading to filer sprawl. Using the Oracle ZFS Storage Appliance, organizations could potentially achieve up to a 9:1 consolidation ratio of VMs per single system. Further, they can expect this ratio to increase

Table 3: Published Performance Metrics

	ORACLE ZS3-2	ORACLE ZS3-4	EMC VNX5400	EMC VNX8000	EMC ISILON S200	NETAPP FAS3250	NETAPP FAS6250	IBM V7000U (2 Node)
SPC-2 MBPS	+	***17,224***	+	+	+	+	+	3,133
SPECsfs IOPS (NFS)	210535	450702	+	580796	*456223*	100922	+	+
SPECsfs Latency	1.12ms	700µs	+	780µs	*3.27ms*	1.76ms	+	+

+ No third party performance benchmark information publicly available

8. Oracle's Storage Systems Benchmarks. http://www.oracle.com/us/solutions/performance-scalability/sun-storage-gateway-160373.html.

significantly with the advances made in the new ZS3 Series. By leveraging its Symmetric Multi-Processing OS, the ZS3 Series can process thousands of threads concurrently where as conventional hybrid NAS filer can process only a fraction of that amount.

The other factor that makes this performance possible is that ZS3 has ***50x the DRAM*** of typical NAS filers. This facilitates the caching of a significant number VMs on media with the fastest response times possible. Then to further accelerate VM response times in the future, Oracle has already announced that it has licensed the VMware vSphere APIs for its storage arrays which should result in it producing some interesting VMware-centric solutions in the near future.[9]

Right now ZFS Storage Appliances are the only arrays from the enterprise storage vendors to offer in-line deduplication at block, file and VM levels, perform in-line data deduplication in DRAM cache and scale DRAM cache to much higher levels than any of its competitors. It is not a huge leap to think that the ZS3 Series will make a high-performance, capacity efficient storage solution for VMware vSphere deployments, especially since VMs are known to deduplicate very well.

Removing the Network Bottleneck

Due to their robust DRAM and flash memory configurations coupled with their Oracle Database integration, there is a high probability that an Oracle Database write I/O will hit or that a read I/O will request data residing in one of these two locations on the array. This results in the ZFS Storage Appliance potentially achieving ***nanosecond*** *(one millionth of a second)* response times. While array response times of this magnitude are highly desirable, the storage network between the server and storage emerges as a potential bottleneck.

The Oracle Database and ZS3 Series storage overcome this bottleneck by each taking steps to optimize the I/O traffic between them by varying packet size. Rather than forcing Oracle Database to transmit data in the same size packets (4K, 8K, etc.) as other storage arrays require, the ZS3 Series storage gives the Oracle Database the flexibility to send data in packets that are optimal for the transmission of application data. This increases the amount of data sent while minimizing the amount of overhead required to package data on the server and then unwrap it on the storage array.

On the receiving end, the ZFS Storage Appliances recognize the packets it receives. Since they know these packets originate from an Oracle Database, they can interpret the metadata inside of the packets and process the data inside them correctly. Equally important, they can optimize the length of the data packet sent back to the Oracle Database. With these features, organizations using Oracle Databases minimizes the network bottleneck and accelerates application performance.

Running System Services

The performance delivered by the ZS3 Series storage provides fast Oracle database access while having sufficient overhead to simultaneously run critical system services to maintain operations. These include Hybrid Storage Pools, data and networking protocols, deduplication and compression, single, double, and triple-parity RAID, mirroring, end-to-end data integrity check summing, protection against silent data corruption, snapshots and a complete set of management functions.

All of these software functions are included in the base price of the ZS3 Series storage (cloning, replication and Snap Management Utility are licensed and priced separately). Two of these services are worth pointing out for their competitive differentiation: Deduplication and DTrace Analytics.

Data Deduplication

Although all of the providers examined in this report offer data deduplication, it is telling how they implement data deduplication. In every case except for Oracle, they elect to do post-process as opposed to in-line data deduplication (See Table 4).

Table 4: In-line vs. Post-Process Data Deduplication

	ORACLE ZS3-2	ORACLE ZS3-4	EMC VNX5400	EMC VNX8000	EMC ISILON S200	NETAPP FAS3250	NETAPP FAS6250	IBM V7000U
In-line Data Deduplication	✓	✓	✗	✗	✗	✗	✗	✗
Post-Process Data Deduplication	✗	✗	✓	✓	✓	✓	✓	✗

9. Oracle Corp. *Oracle Licenses VMware VSphere® Storage APIs for Oracle Storage.* Oracle Corp, 23 Oct. 2013. Web. 02 Dec. 2013.

By first storing the data in its native format and then deduplicating it at a later time, additional storage space is consumed. Deduplicating data as it is written to the system (in-line), as the Oracle ZS3 Series storage does, eliminates the extra storage capacity needed to first store the data before it is later deduplicated. Using in-line data deduplication positions the ZS3 Series to handle the data deduplication requirements of more performance-intensive production workloads in the future.

DTrace Analytics

DTrace Analytics provides a comprehensive and intuitive analytics environment for ZS3 Series storage. As with in-line deduplication, DT Trace Analytics is included in the base price of the ZS3 Series storage. Graphical displays of performance and utilization statistics can be used to pinpoint bottlenecks and optimize storage performance in real time—all while systems continue running in production.

DTrace Analytics provides a granular view into the I/O stream such that in virtualized environments system administrators can quickly find why a particular VM is slow, or which VM is making the other VMs slow.

DTrace Analytics can prevent an organization from having 1–2 VM users corrupt an entire 1,200 VM system by tracing the issue back to a particular user on a specific VM, for example user #43 on VM #948. This kind of visibility into a virtualized environment saves time and money while mitigating performance bottlenecks and potential downtime.

Features without the Licensing Fees

While Oracle includes most of the ZS3 Series storage features in the system's base price, competitive vendors may charge separately for each one. For example, some like NetApp only includes one protocol of an organization's choice in its base configuration and then separately licenses each additional protocol. Further, organizations may also need to separately license versions of its SnapManager software as well as its storage management utility.

ZS3 Series Co-engineering with Oracle Database Delivers Unique Capabilities

Oracle's *"hardware and software engineered to work together"* philosophy comes to life in three unique points of integration between the Oracle Database and the Oracle ZS3 Series storage: Oracle's ***Hybrid Columnar Compression (HCC), Advanced Data Optimization (ADO***) and ***Oracle Intelligent Storage Protocol (OISP),*** which are available only to Oracle storage. HCC and OISP are components of the Oracle Database so there is no additional cost to organizations for these two features.

Hybrid Columnar Compression

Hybrid Columnar Compression (HCC) was introduced with Oracle Database 11gr2. HCC combines both row and columnar methods for storing data to achieve the compression benefits of columnar storage, while avoiding the performance shortfalls of a pure columnar format. Storing column data together, with the same data type and similar characteristics, significantly improves the storage efficiencies achieved with compression. Using this technology has resulted in 10x to 50x compression rates.

In addition, compressed tables stored on the ZS3 Series storage can be cloned without decompression overhead, and can then be immediately available for use in the compressed format for development, test, quality assurance, reporting, etc. HCC technology also accelerates the performance of Oracle Database stored on ZS3 Series storage in the following two ways:

- First, when a compressed Oracle Database is modified, the ZS3 Series storage does ***NOT*** need to decompress the data before modifying it. As a result, the ZS3 Series storage is not bogged down with decompressing, modifying and then again compressing modified data in Oracle databases as would occur on other storage arrays that do not integrate with HCC.
- Second, when an Oracle database performs a query, the ZS3 Series storage sends ***compressed*** data results back to the database server. This accelerates Oracle Databases reads since less data is sent over the network plus they offload the task of decompressing data to the database server.

Advanced Data Optimization

Advanced Data Optimization (ADO), a separately purchased add-on to Oracle Database 12c, automates HCC compression throughout the data life cycle. ADO leverages real-time heat maps of data usage to determine which level of HCC compression to apply to which data based on policies set by the user.

For example, hot data (very actively used data with a lot of reads/writes against it—typically 5% of the data) may be left uncompressed. As data usage cools (mostly query), a low-level of HCC compression may be applied, yielding perhaps 10x compression, and when data is rarely

accessed and ready for archive maximum compression is applied, yielding up to 50x compression.

Oracle Intelligent Storage Protocol

Oracle Intelligent Storage Protocol (OISP), available with Oracle Database 12c, opens a direct line of communication between Oracle Database and ZS3 Series storage so that critical metadata is passed to the storage with information about the incoming database data. With this information, the storage can dynamically setup and tune itself, optimizing itself for the precise parameters of the incoming data. Using OISP, organizations can substantially reduce the amount of time associated with manual configuration and tuning as well as reduce ongoing operational costs.

Taken together, these three Oracle-specific technologies, HCC, ADO, and OISP, combine to reduce capital expenditures by reducing capacity requirements, minimizing or even avoiding future purchases of additional hardware or software, and lowering operational costs by eliminating the need to hire and train staff and by automating previously manual processes.

Oracle Raising Its Storage Sights

Capacity and performance features like these are why Oracle is raising its storage sights. Oracle could arguably be satisfied just selling its ZS3 Series storage into the vast number of enterprises that already use its Oracle Database where unique points of integration with Oracle Database are clear differentiators, and persuade them to now host their Oracle Database instances on Oracle storage. Simply servicing these opportunities could lead to Oracle capturing a double digit percentage of the addressable storage market.

However, the architecture of the ZS3 Series storage coupled with Oracle's enterprise presence puts Oracle in a position to serve a much larger number of enterprise needs beyond Oracle Database users. These hybrid storage arrays include all of the next-generation storage features that make them appealing to enterprises for use with multiple applications and workloads, such as highly virtualized environments.

Couple this functionality with the fact that these arrays are already mature *(having been available since 2008)* and achieve extremely high SPECsfs and SPC-2 performance benchmarks and it becomes clear that the Oracle ZS3 Series storage has already passed hybrid storage arrays from their competitors when it comes to *"flash first"* architecture design and unquestionably have a significant leg up in Oracle Database environments. Once Oracle completes its additional integration with hypervisor providers such as VMware and others, it is then positioned to take on a broader set of enterprise workloads in general and VMware vSphere deployments in particular as vSphere is very well suited for running on hybrid storage arrays.

Oracle ZS3 Series: Hybrid Storage Without Compromise

Enterprises recognize that a change in storage array technology is underway with hybrid storage arrays emerging as the preferred platform to meet the competing high capacity and high performance demands of today's production applications. However, unlike small and midsize organizations, enterprises prefer to buy from storage providers who have proven service and support capabilities, financial stability, and long-term viability. While this approach historically provided enterprises with a sufficient number of storage choices, hybrid storage arrays represent a next generation of storage technology that the traditional storage providers still vary greatly in delivering on its promise.

The Oracle ZFS Storage Appliance ZS3 Series stand out in stark contrast to other offerings from enterprise storage providers. It gives enterprise organizations the features they need in a hybrid storage array without having to compromise.

Oracle architected the ZS3 Series storage to ensure that enterprises can get both the cost-effective capacity and high performance they seek in a single array that is designed from the ground up with a *"flash first"* mentality. The ZS3 Series provides the most robust stack of hardware and software features when compared to competitive hybrid storage arrays.

Further, when it comes to Oracle Database environments, the ZS3 Series has unique integration points (unavailable to third-party storage vendors), such as HCC, ADO and OISP, that give it a clear advantage in these environment. Equally important, organizations obtain this advanced storage from an acknowledged enterprise-class solution provider that may be relatively *"new"* to storage but is certainly not new to meeting and exceeding enterprise expectations.

APPENDICES

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HEAD-TO-HEAD PRODUCT REPORT

Making the Right Hybrid Storage Array Buying Decision: Oracle ZS3 Series Stands Out as a Hybrid Enterprise Storage Solution

Appendix A: Head-to-Head Comparison of Features on Leading Enterprise Hybrid Storage Arrays

HARDWARE

	Oracle		EMC			NetApp		IBM	
	ZS3-2	ZS3-4	VNX5400	VNX8000	ISILON S200	FAS3250	FAS6250	V7000U (2 NODE)	V7000U (4 NODE)
Max Raw Capacity (TBs)	768	3,500	450	300	3,110	2,880	5,760	960	1,920
Max CPU Cores	32	80	8	32	8	16	16	16	32
File System Size (Max TBs)	1 Billion	1 Billion	16	16	20,000	20,000	20,000	+	+
Flash Cache (Max TBs)	16	22	1	4.2	13.8	2	8	+	+
DRAM (Max GBs)	512	2,000	32	256	96	40	144	32	64
LUNs (Max #)	16,384	16,384	1,000	4,000	*	4,096	4,096	2,048	2,048
RAID (Any)	✓	✓	✓	✓	*	✓	✓	✓	✓
RAID 1	✓	✓	✓	✓	*	✗	✗	✓	✓
RAID 5	✓	✓	✓	✓	*	✗	✗	✓	✓
RAID 6	✓	✓	✓	✓	*	✓	✓	✓	✓
RAID 10	✓	✓	✓	✓	*	✗	✗	✓	✓
RAID 50	✓	✓	✗	✗	*	✗	✗	✗	✗
RAID 60	✓	✓	✗	✗	*	✗	✗	✗	✗
Triple Parity	✓	✓	✗	✗	*	✗	✗	✗	✗

STORAGE NETWORKING INTERFACES

1 Gb Ethernet	✓	✓	✓	✓	✓	✓	✓	✓	✓
10 Gb Ethernet	✓	✓	✓	✓	✓	✗	✗	✓	✓
8 Gb FC	✓	✓	✗	✗	✗	✗	✗	✗	✗
16 Gb FC	✓	✓	✓	✓	✗	✓	✓	✓	✓
Infiniband	✓	✓	✗	✗	✗	✗	✗	✗	✗

** Not applicable* *+ Not published and/or publicly available*

Appendix A: Head-to-Head Comparison of Features on Leading Enterprise Hybrid Storage Arrays (continued)

STORAGE NETWORKING PROTOCOLS AND SECURITY

	Oracle		EMC			NetApp		IBM	
	ZS3-2	ZS3-4	VNX5400	VNX8000	ISILON S200	FAS3250	FAS6250	V7000U (2 NODE)	V7000U (4 NODE)
Active Directory	✓	✓	✓	✓	✓	✓	✓	✓	✓
CIFS/SMB	✓	✓	✓	✓	✓	✓	✓	✓	✓
dNFS	✓	✓	✓	✗	✗	✓	✓	✓	✓
FC	✓	✓	✓	✓	✗	✓	✓	✓	✓
FCoE	✗	✗	✓	✓	✗	✓	✓	✓	✓
FTP	✓	✓	✓	✓	✓	✓	✓	✓	✓
FTPS	✓	✓	✓	✓	✗	✗	✗	✗	✗
HTTP	✓	✓	+	+	✓	✓	✓	✓	✓
Infiniband	✓	✓	✗	✗	✗	✗	✗	✗	✗
iSCSI	✓	✓	✓	✓	✓	✓	✓	✓	✓
LDAP	✓	✓	✓	✓	✓	✓	✓	✓	✓
NDMP	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFS v2	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFS v3	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFS v4	✓	✓	✓	✓	✓	✓	✓	✗	✗
pNFS	✗	✗	✓	✓	✗	✓	✓	✗	✗
SFTP	✓	✓	✓	✓	✗	✗	✗	✓	✓
SNMP	✓	✓	✓	✓	✓	✓	✓	✓	✓
WebDAV	✓	✓	✗	✗	✓	✗	✗	✗	✗
Incl w/Base Price	✓	✓	✓	✓	✓	✗	✗	✓	✓

\+ *Not published and/or publicly available*

PUBLISHED PERFORMANCE METRICS

SPC-2 MBPS	+	17,224	+	+	+	+	+	3,133	+
SPECsfs IOPS (NFS)	210535	450702	+	580796	456223	100922	+	+	+
SPECsfs Latency	1.12ms	700µs	+	780µs	3.27ms	1.76ms	+	+	+

\+ *No third party performance benchmark information publicly available*

Appendix A: Head-to-Head Comparison of Features on Leading Enterprise Hybrid Storage Arrays (continued)

SOFTWARE

	Oracle		EMC			NetApp		IBM	
	ZS3-2	ZS3-4	VNX5400	VNX8000	ISILON S200	FAS3250	FAS6250	V7000U (2 NODE)	V7000U (4 NODE)
Application Analytics	✓	✓	+	+	+	+	+	+	+
· License Included	✓	✓	+	+	+	+	+	+	+
Auto Multi-Level Data Caching	✓	✓	✓	✓	✓	✓	✓	✓	✓
· License Included	✓	✓	✗	✗	✗	✗	✗	✓	✓
Data Compression	✓	✓	✓	✓	✗	✓	✓	✓	✓
Data Migration Utility	✓	✓	✓	✓	✗	✗	✗	✓	✓
DB Analytics	✓	✓	+	+	✗	+	+	+	+
· License Included	✓	✓	+	+	✗	+	+	+	+
Deduplication	✓	✓	✓	✓	✓	✓	✓	✗	✗
· In-line	✓	✓	✗	✗	✗	✗	✗	✗	✗
· Post-Process	✗	✗	✓	✓	✓	✓	✓	✗	✗
Oracle DB Integration	✓	✓	✗	✗	✗	✗	✗	✗	✗
· ADO w/HCC	✓	✓	✗	✗	✗	✗	✗	✗	✗
· HCC	✓	✓	✗	✗	✗	✗	✗	✗	✗
· OISP	✓	✓	✗	✗	✗	✗	✗	✗	✗
Replication (Any)	✓	✓	✓	✓	✓	✓	✓	✓	✓
· Async; Continuous	✓	✓	✓	✓	✓	✓	✓	✓	✓
· Async; Periodic	✓	✓	✓	✓	✓	✓	✓	✓	✓
· Synchronous	✗	✗	✓	✓	✓	✓	✓	✓	✓
· License Included	✗	✗	✗	✗	✗	✓	✓	✗	✗
SMP OS*	✓	✓	✓	✓	✗	✗	✗	✗	✗
Snapshots	✓	✓	✓	✓	✓	✓	✓	✓	✓
· Cloning	✓	✓	✓	✓	✗	✓	✓	✓	✓
· AoW	✓	✓	✓	✓	✓	✓	✓	✗	✗
· Copy-on-Write	✓	✓	✓	✓	✓	✗	✗	✓	✓
· Split Mirror	✗	✗	✓	✓	✗	✗	✗	✓	✓
· License Included	✓	✓	✗	✗	✗	✓	✓	✓	✓
Thin Provisioning	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unified Storage	✓	✓	✓	✓	✓	✓	✓	✓	✓
· Single OS	✓	✓	✗	✗	✓	✓	✓	✗	✗

** Symmetric multiprocessing OS* *+ Not published and/or publicly available*

DCIG

HEAD-TO-HEAD PRODUCT REPORT

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Appendix B: DCIG Disclosures

Over the last few years the general trend in the US has been for both large and boutique analyst firms to receive some or all of their revenue from vendors.

DCIG is no different in that respect as it also receives payment for the different services it performs for vendors. The services that DCIG provides include blogging, Customer Validations, Executive White Papers, Special Reports and Head-to-Head Product Reports.

A number of the vendors included in DCIG Buyer's Guides and Head-to-Head Product Reports are or have been DCIG clients though they were given preferential treatment in a Buyer's Guide. All it meant was that DCIG had more knowledge of their products and that DCIG would *consider* their product(s) for inclusion in a particular Buyer's Guide.

In that vein, there are a number of important facts to keep in mind when considering the information contained in this Head-to-Head Product Report.

- No vendor paid DCIG any fee to develop a Buyer's Guide (some of the information found in previously published DCIG Buyer's Guides is used in this report.)
- DCIG did not guarantee any vendor that its product would be included in a Buyer's Guide.
- Each vendor was given the opportunity to review information about its product and respond to it before the information was published in either a Buyer's Guide or this report.
- All research was based upon one or more of the following: publicly available information, information provided by the vendor and/or the expertise of those evaluating the information.
- Because of the number of features analyzed, how these features were weighted and then how these products were scored and then ranked, there was no way for DCIG to predict at the outset how individual products would end up scoring or ranking.

DCIG wants to emphasize that no vendor was privy to how DCIG did the scoring and ranking of the products included in a Buyer's Guide. In every case a vendor only found out the scores and rankings of its product(s) after the analysis was complete.