White Paper

Oracle Sun ZFS Storage Appliance: A Coming of Age Story

By Mark Peters, Senior Analyst and Kerry Dolan, Research Analyst

September 2012

This ESG White Paper was commissioned by Oracle and is distributed under license from ESG.
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Maturity Comes Wisdom and Value</td>
<td>3</td>
</tr>
<tr>
<td>What Is Oracle Sun ZFS Storage Appliance?</td>
<td>3</td>
</tr>
<tr>
<td>ESG Lab Validates Sun ZFS Storage Appliance Performance Results</td>
<td>4</td>
</tr>
<tr>
<td>File Server Throughput and Response Time</td>
<td>4</td>
</tr>
<tr>
<td>Transaction-oriented Database Performance</td>
<td>5</td>
</tr>
<tr>
<td>Throughput Performance</td>
<td>6</td>
</tr>
<tr>
<td>Quantitative Customer Research</td>
<td>8</td>
</tr>
<tr>
<td>Customers Have Their Say</td>
<td>10</td>
</tr>
<tr>
<td>The Bigger Truth</td>
<td>11</td>
</tr>
</tbody>
</table>

All trademark names are property of their respective companies. Information contained in this publication has been obtained by sources The Enterprise Strategy Group (ESG) considers to be reliable but is not warranted by ESG. This publication may contain opinions of ESG, which are subject to change from time to time. This publication is copyrighted by The Enterprise Strategy Group, Inc. Any reproduction or redistribution of this publication, in whole or in part, whether in hard-copy format, electronically, or otherwise to persons not authorized to receive it, without the express consent of The Enterprise Strategy Group, Inc., is in violation of U.S. copyright law and will be subject to an action for civil damages and, if applicable, criminal prosecution. Should you have any questions, please contact ESG Client Relations at 508.482.0188.

© 2012 by The Enterprise Strategy Group, Inc. All Rights Reserved.
With Maturity Comes Wisdom and Value

The Oracle Sun ZFS Storage Appliance has grown so that today it is a proven enterprise storage system with a robust feature set. It was originally brought to market by Sun Microsystems, and thus it became part of the Oracle product line-up when Oracle acquired Sun in the spring of 2009. That change has benefitted the product significantly. Although its “teenage years” were somewhat marred by Sun’s less-than-100% focus on storage in general, Oracle has since put its considerable muscle and commitment behind it, and the Sun ZFS Storage Appliance has experienced a dramatic renaissance of late—taking market share from storage behemoths being installed in large database environments, and supporting significant cloud deployments.

It is a fascinating history and development; clearly, what matters to prospective users is what the product offers today and so ESG has conducted a thorough review. Not only have we looked at the product from a market perspective, but we also tested it by conducting a full ESG Lab Validation to establish an overview of its capabilities in a real-world context. In addition, we reached out to Sun ZFS Storage Appliance customers to find out about their experiences, performing both quantitative research and qualitative telephone interviews. The hard part has been to reduce all the data we collected down to the most relevant details...especially when Oracle has been off proving the product’s capabilities in multiple industry-standard benchmarking tests as well! Everything is summarized in this paper.

What Is Oracle Sun ZFS Storage Appliance?

A good start is an overview of the product. Designed to be an affordable enterprise storage system that offers extreme levels of performance and efficiency, the Sun ZFS Storage Appliance is Oracle’s unified block and file storage array (as well as its preferred NAS offering). It supports NFS, CIFS, HTTP, WebDAV, and FTP for NAS, as well as iSCSI, Fibre Channel, ISER, SRP, and both IP and RDMA over InfiniBand for block.

Its primary performance advantages come from the Hybrid Storage Pool, ZFS file system, and compression architectures. These pools are created using DRAM, flash cache, and hard drives in varying amounts depending on the model. The Oracle Solaris ZFS file system identifies I/O patterns automatically and places data on the optimal storage medium. Low-latency solid-state drives (SSDs) are used to quickly acknowledge writes so that applications can continue operations. These writes are then flushed to traditional HDDs as a background task. Flash is used for read cache to reduce latency, and “hot” data is kept in read cache for quick response. Storage performance and capacity can be scaled with disk shelves, while flash cache and DRAM scale independently. This enables customers to optimize the price/performance balance. (Additional performance information is provided in the discussion of the ESG Lab Validation.)

The Sun ZFS Storage Appliance includes support for Oracle Database Hybrid Columnar Compression. This unique feature reduces storage volumes by 10x to 50x for existing Oracle databases with in-database archives for OLTP, data warehousing, or mixed workloads. Of course, this data compression not only shrinks capacity requirements, but also delivers additional performance improvement. Inline, block-level deduplication also keeps capacity needs to a minimum.

The browser-based user interface makes provisioning and management simple. A key feature is the inclusion of DTrace Analytics software that provides real-time analysis and monitoring, with details delivered in visual forms to speed understanding. These features enable storage administrators to identify and resolve performance issues as well as storage and networking bottlenecks before they affect infrastructure operations. And clearly it works: Among numerous comments from customers about how helpful these analytics were, one customer interviewed for this study put it succinctly: “I love the analytics and my next system will be another [Sun] ZFS [Storage Appliance].”

The comprehensive self-healing provided by the Oracle Fault Management Architecture helps make the Sun ZFS Storage Appliance a high-availability as well as a high-performance solution. In addition, read-only snapshot and local replication functionality are included, while clones and remote replication are separately licensed.
All of these features and more are delivered in an affordable package, which is built using cost-efficient components and designed to reduce both energy and data center floor space requirements. Models that use 7,200 RPM drives and flash offer the greatest cost and space efficiency, but configurations with 15,000 RPM drives are available for applications that need higher I/O. Three models are available (7120, 7320, and 7420), with storage capacities ranging from 3.3TB to 1.7PB and varying amounts of write- and read-optimized flash. All software applications are included in every model, and active-active, dual-node clustering is supported in the 7320 and 7420.

As this brief overview shows, the Oracle Sun ZFS Storage Appliance hits on several characteristics that are vitally important in today’s business environment—high performance, application availability, simple management (one customer stated that while their EMC storage must be managed by the storage team, the Sun ZFS Storage Appliance is handled by the DBA team), and efficiency that delivers both CAPEX and OPEX savings. Customers also found the product to be extremely reliable. A customer in the medical research field calls the Sun ZFS Storage Appliance its “core storage” and stores petabytes of data on it. The operations manager noted, “Reliability was our main driver [for this storage purchase] and [the Sun] ZFS [Storage Appliance] is rock solid—you could take an axe to the system and it would still run.”

**ESG Lab Validates Sun ZFS Storage Appliance Performance Results**

As part of this effort, Oracle took advantage of the ESG Lab team to perform hands-on testing in a real-world environment. The mission of the ESG Lab is to help end-users make buying decisions that will positively impact their businesses as well as to validate vendor claims and capabilities. ESG Lab engineers tested the Oracle Sun ZFS Storage Appliance Model 7420 in the spring of 2012 at Oracle’s facilities in Broomfield, Colorado. The appliance was tested in an active/standby configuration, with a mirrored 5.7TB storage pool using 15K RPM, 300GB drives and a 53TB RAID-Z pool. The ESG Lab team was impressed with the ease of management, availability features, and Hybrid Columnar Compression, but in addition it was able to review and audit the results of performance testing using published benchmarks, including SPECsfs, SPC-1, and SPC-2. These benchmarks compare performance results of multiple vendors.¹

**File Server Throughput and Response Time**

SPECsfs is a client-independent, vendor-neutral measurement of NFS fileserver throughput and response times, and provides a standardized method for comparing the performance of NFS file servers across different vendor platforms. During testing the Oracle Sun ZFS Storage Appliance was able to generate 943 operations per second per disk, while maintaining a high level of throughput (267,928 operations per second). As Figure 1 demonstrates, the Oracle appliance offered higher performance than any of the other platforms—and 85% better performance than the second highest system.

---

¹ We are including comparative information here because it comes from benchmarks that are not only well established and accepted in the industry but also because each reported vendor has willingly conducted and published the tests. Regarding the summary of the ESG Lab, the focus of this White paper is on the performance results, but you can read the complete ESG Lab Validation here.
Figure 1. Oracle Sun ZFS Storage Appliance SPECsfs Comparisons

Operations Per Disk Performance Results
(more is better)


Of equal note is the fact that the Sun ZFS Storage Appliance performed at this high level while using only a fraction of the total number of drives compared to the other configurations, as demonstrated in Table 1 below.

<table>
<thead>
<tr>
<th>System</th>
<th>ops/sec/disk</th>
<th>File Systems</th>
<th>Throughput</th>
<th>ORT (ms)</th>
<th>Total Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun ZFS Storage 7420 Appliance</td>
<td>943.41</td>
<td>32</td>
<td>267,928</td>
<td>1.31</td>
<td>284</td>
</tr>
<tr>
<td>HDS 3090-G2</td>
<td>510.74</td>
<td>4</td>
<td>189,994</td>
<td>2.08</td>
<td>372</td>
</tr>
<tr>
<td>EMC Celerra VG8</td>
<td>434.36</td>
<td>4</td>
<td>135,521</td>
<td>1.92</td>
<td>312</td>
</tr>
<tr>
<td>Isilon S200 (140 Node)</td>
<td>331.16</td>
<td>1</td>
<td>1,112,705</td>
<td>2.54</td>
<td>3,360</td>
</tr>
<tr>
<td>NetApp FAS3270</td>
<td>281.06</td>
<td>2</td>
<td>101,183</td>
<td>1.66</td>
<td>360</td>
</tr>
<tr>
<td>HP BL860 i2</td>
<td>225.39</td>
<td>16</td>
<td>333,574</td>
<td>1.68</td>
<td>1,480</td>
</tr>
</tbody>
</table>

As the ESG Lab team noted, “Such high throughput and low response time from a small number of disks proves out the effectiveness of the unique Hybrid Storage Pool architecture of the Sun ZFS Storage Appliance.” The ESG Lab team also measured overall response time, indicating how quickly a server can respond to operations requests over a range of increasing traffic levels. The Sun ZFS Storage Appliance was 10% to 40% faster in operational response time than the other configurations tested.

Transaction-oriented Database Performance

To measure database performance many organizations use SPC-1, an application-level, industry-standard benchmark suite maintained by the Storage Performance Council. The testing generates a single workload that emulates the typical functions of transaction-oriented, real-world database applications, such as OLTP, database operations, and mail server implementations. Both performance and price/performance metrics are provided to demonstrate the cost of handling storage demands in a typical transaction-oriented application environment. Price/performance is measured in dollars per I/O per second ($/IOPS).
As Figure 2 demonstrates, the Sun ZFS Storage Appliance offers much better price/performance than the others tested, with $2.99 per IOPS, 55% lower than the second-place vendor, coming in at $6.71 per IOPS. In addition, the Sun ZFS Storage Appliance achieved much higher performance: 137,066 IOPS, 53% more than the second-highest vendor that generated 89,491 IOPS. So, not only is the Sun ZFS Storage Appliance the most cost-effective, but it also yielded the best performance of the configurations tested.

Throughput Performance

Large file throughput performance is measured using SPC-2, which consists of three distinct workloads designed to demonstrate how a storage system performs while executing business-critical applications that require large-scale, sequential movement of data. It shows how an array performs with large file processing (such as for scientific computing and financial processing), large database queries (such as scans or joins of large relational tables such as those used for data mining and business intelligence), and video on demand (such as subscriber video downloads from a digital film library). Figure 3 shows the published results for the top five performing systems as measured by SPC-2, with throughput on the left and price/MB/second on the right. The Sun ZFS Storage Appliance ranked second in overall performance, and leads the pack with the best $/MBPS.

---

2 The other arrays tested were the HDS AMS2500, Oracle 6780, NetApp 3270, and IBM V7000.
The Sun ZFS Storage Appliance (with its midmarket entry point) was the second fastest performing system among the top five published SPC-2 results—the other four were all what would typically be described as enterprise solutions. So its results are certainly notable or striking. In addition, it has the best price/performance results among these top five. It should be noted that only one other midmarket solution had any published results at all, and that one didn’t even make the top ten in performance.

One can easily get lost in performance details, and a lack of context can make it difficult to understand exactly what these results mean: the simple “take-away” is that the results are genuinely impressive. It is worth remembering that the comparisons are with certified, published results of industry-standard tests comparing specific vendors—and the Sun ZFS Storage Appliance demonstrated a distinct performance advantage. Here’s why that matters. First and foremost, better performance can translate directly to cost savings—just ask Oracle customers. One telecommunications customer using the Sun ZFS Storage Appliance for database consolidation had this to say:

“The savings are coming through consolidation, which comes from better performance gains on the database machines. We couldn’t have realized those cost benefits without the [Sun] ZFS [Storage] Appliance [for our] unique configuration/situation.”

Also, storage growth and high demands for throughput are causing much strain on storage managers. Users will complain feverishly if application performance suffers because of data growth, so a storage solution that offers efficiency and proven performance in an affordable package is of great value.

ESG Lab testing validated the remarkable performance, availability, and efficiency claims of the Sun ZFS Storage Appliance. Finding enterprise-level capabilities in a cost-effective package that is also easy to use is certainly a compelling story for this maturing product...and a long way from its “upbringings!”
Quantitative Customer Research

Soliciting customer feedback is another way to understand a product and its effects. ESG conducted end-user research in the spring of 2012 with Oracle Sun ZFS Storage Appliance customers. The objective was to discover why customers purchased it, what they were using it for, and how it was meeting expectations.

Some basic demographics on the population surveyed will provide some context. Our survey covered a wide selection of customer types, ranging from organizations with fewer than 100 employees to more than 20,000, across a broad industry spectrum. Total storage capacity ranged from less than 50TB to more than 5PB, including NAS, SAN, DAS, and server-based storage. Almost three-quarters (74%) of respondents indicated that they were currently using server virtualization in their environments.

In terms of the Sun ZFS Storage Appliance specifically, customers had varying lengths of experience: 50% had been using it for a year or less, and 38% for two years or more. The majority of customers (53%) had purchased it for a net-new technology deployment, while 29% were upgrading existing Oracle equipment, and a full 29% bought it specifically to replace another technology. All three models were being used, in both clustered and non-clustered deployments, across all supported connectivity protocols.

So why did customers choose the Sun ZFS Storage Appliance? The research revealed that the number one reason identified by 70% of respondents was the total cost of ownership (TCO), followed by product features (second), with overall performance, consolidation, existing Oracle relationship, and efficient disk utilization all roughly tied for third (see Figure 4). When respondents were asked for the single primary reason for the purchase, TCO and product features remained at the top, while disk efficiency and an existing Oracle relationship were noticeably more emphasized, moving into a clear joint third place.

![Figure 4. Reasons for Purchasing Oracle Sun ZFS](source: Enterprise Strategy Group, 2012.)
To drill deeper on these reasons, the data was cut to discover the motivations of those users that were focused on TCO and disk-space efficiency. Of those who stated that TCO was a reason for purchasing the Sun ZFS Storage Appliance, 38% reported that they have been able to reduce TCO by 30% or more. Similarly, of those stating that disk-space efficiency was a purchasing driver, 45% reported reducing disk-space requirements by 30% or more, and 16% indicated that they reduced disk space by 50% or more. Notable improvements, indeed.

Customers clearly consider the Sun ZFS Storage Appliance a reliable platform, and as such many leverage it for disaster recovery and business continuity (DR/BC). In our survey 55% of respondents either currently use it for DR/BC or have plans to do so. ESG experience with thousands of customers—as well as basic common sense—tells us that organizations only use what they consider to be highly reliable, well-performing storage platforms for DR. When a disaster strikes, the last thing you want is to worry about whether the storage at the DR site will come up!

Our research also revealed how customers compare the Sun ZFS Storage Appliance to other storage deployments they had actually used (see Figure 5). Of particular note is the fact that 72% of respondents reported that storage performance was better or much better than other vendors, and 70% stated that efficiency was better or much better than others. In all areas, a majority of users rated it better or much better than the competition.

**Figure 5. Experience with Oracle Sun ZFS Compared with Other Vendors**

For each of the areas below, please rate your organization’s experience with its Oracle ZFS Storage Appliance(s) relative to other enterprise storage vendors that your organization has utilized. (Percent of respondents)

- 5 (Much better compared to other storage vendors we’ve worked with)
- 4 (Better compared to other storage vendors we’ve worked with)
- 3 (No different from any storage vendor we’ve worked with)
- 2 (Worse compared to other storage vendors we’ve worked with)
- 1 (Much worse compared to other storage vendors we’ve worked with)

<table>
<thead>
<tr>
<th>Area</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>Source: Enterprise Strategy Group, 2012.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance (N=80)</td>
<td>34%</td>
<td>14%</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data protection (N=78)</td>
<td>36%</td>
<td>21%</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of use/manageability (N=81)</td>
<td>30%</td>
<td>30%</td>
<td>26%</td>
<td>6%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Scalability (N=79)</td>
<td>24%</td>
<td>30%</td>
<td>29%</td>
<td>6%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Application integration (N=77)</td>
<td>23%</td>
<td>30%</td>
<td>26%</td>
<td>17%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Efficiency (N=82)</td>
<td>22%</td>
<td>48%</td>
<td>22%</td>
<td>1%</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Interoperability (N=82)</td>
<td></td>
<td>33%</td>
<td>28%</td>
<td></td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Reliability (N=79)</td>
<td></td>
<td>35%</td>
<td>22%</td>
<td></td>
<td>9%</td>
<td></td>
</tr>
</tbody>
</table>
Customers Have Their Say

Finally, ESG conducted telephone interviews with a number of Sun ZFS Storage Appliance customers, ranging from small manufacturers to high-performance computing companies and major telecommunications organizations, with 60% of the interviews from companies in the Americas and 40% in Europe. Their Sun ZFS Storage Appliance deployments ranged from 17TB to 2.1PB of storage, and—not surprisingly—they had a wide range of experience and were using a wide range of applications. The customers were quite frank with us, willing to impart all their good thoughts about the product, as well as one or two “dislikes.”

In general, the customers were pleased with their Sun ZFS Storage Appliance implementations, and particularly impressed with the DTrace analytics—indeed they couldn’t say enough good things about it. For example, one customer working in a research environment with many simultaneous users said:

“...the analytics have allowed us to drill down and find troublesome areas—instead of having to reboot the device and shut things down to find the problem, and then in turn shut down user’s processes.”

This is a clear statement of benefit—the DTrace analytics directly created higher application availability for the end-user. This is not to be taken lightly: with user demands and expectations escalating, the Sun ZFS Storage Appliance offers a great opportunity for IT to show up as the hero in terms of keeping an organization productive. While they are not (yet) universally offered, real-time storage analytics should not be considered a luxury—they are the key to performance and capacity planning. IT simply must know what it has and how it’s working in order to optimize any aspect of the storage deployment, from capacity utilization to performance to cost.

There were many positive comments about system performance, such as one construction company’s IT manager who said:

“The performance and availability are good; why does this matter? Because, if our CAD and/or supply chain systems go down, then we cannot make plans and cannot order supplies. We’d—literally—have to go back to the drawing board and couldn’t build anything.”

In terms of availability, one customer doing high performance computing was able to reduce downtime from three days to 15 minutes using the Sun ZFS Storage Appliance, and told ESG that they had been able to cut their time to problem resolution tenfold. Another has enjoyed dramatic reductions in backup and batch processing, saving time and giving them “much needed breathing room.”

While a few negative comments were made,3 the users that were interviewed were still quite happy with the product. One customer commented that the product quality was indeed much improved over a few years ago—his organization now considers the Sun ZFS Storage Appliance its tier-1 storage and uses it to support all their virtual machines:

“Although we experienced a number of issues and early experiences with the product weren’t so good, the [Sun] ZFS [Storage Appliance] has improved and gone on to exceed our needs and our hopes in terms of performance and reliability.”

Any vendor should be pleased to hear that type of comment from a customer. Despite whatever pretty marketing face vendors put on, everyone knows that no product is without its challenges! So to hear that a customer who began the relationship less-than-fully-happy is now not only very happy, but also finds the product exceeding expectations, is a true measure of vendor responsiveness and product quality.

For many customers, the fact that the product did what they needed was enough. Who ever said there was something wrong with not having to pay attention to your storage because it just works?

---

3 While failover time was noted as a weak point, that metric is affected by OS versions and Sun ZFS Storage Appliance models. Oracle has recently made some improvements that put failover time on a par with other vendors, and better than some.
The Bigger Truth

As was the case in both 2010 and 2011, ESG’s 2012 IT Spending Intentions Survey revealed that the top IT priorities for organizations today are to drive the increased use of server virtualization and manage data growth. IT organizations want to expand their virtual server trials and development to production deployments because of the clear benefits of consolidation: reduced capital expenditure, increased management simplicity, and reduced operational expenses. Recognizing the value of pulling pieces together to be centrally managed, organizations are also appreciative of the benefits of unified storage—if you want to reduce complexity and expense, by all means stop running separate SAN and NAS environments. What has stopped many organizations, however, is the fear that consolidating workloads will throw a monkey wrench into application performance due to storage bottlenecks. Still, it does look as if most organizations will eventually succumb to the call of cost reduction and management ease, and find a way to consolidate both servers and storage. And data growth? It’s a constant, especially with the massive increase of unstructured/file data, and can itself also be a driver of unified storage—even expanding SAN and NAS silos can continue to create cost and management challenges.

Viewed in this (or any) context, the Oracle Sun ZFS Storage Appliance is certainly noteworthy in the market. While it may have experienced early challenges, it appears to be a “late bloomer.” It offers unified block and file storage with a midmarket price point, but with serious high-end features: consolidated storage pools with automated tiering; flexible, scalable performance and capacity using disk shelves, flash cache, and DRAM; built-in compression and deduplication; and advanced storage analytics, to name a few. Taken together, these features provide a storage solution that can be tailored and managed to optimize performance and capacity and minimize costs. It’s a compelling value proposition—and one that has proven itself in performance tests and with customers.

ESG put this product through its paces and it showed very well. Benchmark test results demonstrated not just better performance than other (high-end) arrays for NFS, database, and large files, but also better price/performance. With business managers struggling with tight budgets and IT administrators dealing with storage growth and end-user performance and availability demands, this is an impressive—and desirable—combination. Customers have also put it through its paces, and rate it highly in TCO and efficiency—especially in comparison to other storage arrays they have used. Their glowing comments about analytics, performance, efficiency, availability, and reliability can be summed up with a final quote from a European customer:

“I like it—it’s like the Swiss Army Knife of storage.”

Coming of age can be a beautiful thing—and the Oracle Sun ZFS Storage Appliance could well be the perfect storage example of a slightly “perfection-challenged’” duckling that has grown up to be a very attractive swan!