BACKING IT UP FAST, RESTORING IT EVEN FASTER
Oracle ZFS Backup Appliance – ZS5 Series

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We can all see that vast amounts of new data are being generated and processed in a competitive arms race to squeeze as much value as possible out of any available data source. It’s no surprise then that deploying the right storage solution is still one of the big keys to overall IT success. No matter how big data grows (and how elastic and agile computing becomes) overseeing data persistence and data protection – at its simplest taking backups and ensuring restorability – will always remain an important IT responsibility.

It’s also not surprising then to hear that Oracle, the leading enterprise database vendor, excels at data-driven storage as well. It turns out that Oracle’s infrastructure offerings aren’t just designed for specialized vertical use cases, but also include broadly applicable solutions like their ZFS Storage Appliance that delivers cost-effective and highly performant enterprise file storage for a wide variety of workloads found in the corporate data center. In fact, Oracle even uses their own ZFS Storage internally to power the 600PB+ Oracle Public Cloud – this is serious storage that scales!

But what might really surprise some folks is that the ZFS Backup Appliance (ZBA), a version of the ZFS ZS5 Series tuned for backup and restore use cases, handily beats Dell EMC’s Data Domain in both backup and restore performance – and in resulting TCO for a wide variety of workloads found in the corporate data center. And as the ZBA is based on Oracle’s core ZFS Storage, it still offers all the impressive ZFS Storage services, supporting additional use cases that leverage backup data sets such as dev/test, QA, and analytics.

In this report we will look at the latest ZS5 Series of the ZFS Storage technology, its architecture, and in particular the ZBA version, to examine how it delivers such impressive backup and restore performance not only for Oracle workloads, but the more general mission-critical workloads of all types. We’ll explore some of the key features engineered into the appliance that provide unmatched support for Oracle Database capabilities like Automatic Data Optimization (ADO) with Hybrid Columnar Compression (HCC). We’ll also review some of the key benchmark results and provide an indication of the TCO factors driving its market leading price/performance on data protection requirements.

PROTECTING IMPORTANT DATA - AND IT’S ALL IMPORTANT

IT organizations today are challenged to protect all the important data in the enterprise, which is quickly growing to encompass not just mission-critical data stores, but the fast growing, wider range of data that business users, partners and online customers are coming to depend on globally at all hours. Collectively, their expectations, if not requirements, for better IT availability are tightening RPOs and RTOs, even as important data volumes explode.

Fundamentally solid data protection first requires efficient backup copies be made, which is becoming quite the challenge in today’s fast growing data storage environment. And traditional backup windows are actually shrinking due to the global nature of many of today’s applications. It’s clear that optimized storage backup “targets” are required to support massive scale data protection...
efforts, and minimize the disk capacities needed. At a minimum, good backup targets can’t just dedupe slowly on the backend, they now must provide increasingly greater throughput rates leveraging all possible avenues for acceleration.

As mentioned above, today’s on-demand storage clients are expecting ever smaller RPOs, even as data and scale grow. But even more critical to the always-on business is providing for smaller RTOs when something does require recovery. IT has to keep in mind that actual recovery is key – all the backups in the world are worthless if they can't be used to recover important data quickly and reliably.

An additional challenge in today’s datacenter is the wider variety of workloads that demand rock solid data protection. Certainly we’ve always needed to protect “tier1” mission-critical, high performance, high availability database data. But today, with interactive, global and mobile users and applications, there are many more “tier2” applications that require data protection and demand acceptable recovery RPO/RTOs. These still include important database data, but also now virtual machine/application/appliance images and virtual disks, key files and filesystems, big data sets and far more. In fact, much of today’s datacenter is likely to be run as a private cloud, if not with actual cloud clusters at least with a service provider posture when it comes to guaranteeing SLAs, multi-tenancy, dynamic operations and the mixed workload sharing of infrastructure.

When it comes to tier1 Oracle database powered applications, Oracle does offer the world-class Zero Data Loss Recovery Appliance (ZDLRA). The ZDLRA is unbeatable for its express use case, but as just discussed, the data protection challenge is bigger than just tier1 databases. The ZFS Backup Appliance serves as a mixed workload data protection storage target capable of supporting any backup software to protect any file system, database, VM or application. To address the broader data protection requirement for the whole data center, Oracle claims its customers can deploy both ZDLRA and ZBA with a lower complete TCO than competitor solutions.

The Oracle ZFS Backup Appliance (ZBA) has been successfully moving into more and more data centers as the DBA-selected best option for “database backup” specific storage. But the truth is that Oracle continues aggressive development of the ZS series for broader convergence and consolidation of mixed workloads in general. The latest ZS5 Series ZBA can impressively sustain 50 TB/s backup and 60 TB/s recovery across a wide variety of workloads. Note again that recovery is key, and with this outstanding recovery rate the ZBA ensures tight RTO SLAs can be met.

In fact, the ZBA can protect full application stacks (from the database through the VM and/or supporting filesystems), across multiple users (multi-tenancy), protocols and use cases. And as we will see, it can easily beat the aging competition in performance, efficiency, and ultimately price.

**Oracle Engineered Storage**

Under the hood, Oracle has continued evolving the ZS Series as a full-blown enterprise solution, able to compete and win against incumbent primary storage vendors on price and performance across a wide variety of workloads. But it also provides a significant database workload advantage through “co-engineering” with Oracle Database. In plain language, this is enterprise-wide storage that when coupled with Oracle Database 12c, greatly accelerates database-powered applications with unique storage-side design features that are both aware of the database and directly leveraged by the database.

The ZS5 Series has several deeply engineered facilities for accelerating and optimizing Oracle Database 12c performance, including backup and restore in the ZBA version. We will examine several of these later in the report, but together they provide tuning, troubleshooting, and performance optimizations that lead to application owners, DBAs, and the lines of business readily choosing ZS5 Series arrays as both a storage platform and a data protection target. Since Oracle is a large trusted IT
vendor with proven support and management, IT has little cause in business-driven designs to look elsewhere. The interesting development is that once the first ZS5 Series appliance is up and running in a data center for any use case, IT generally finds that it can better support and protect many other business-critical workloads.

**Broad Application**

As an enterprise platform, the core ZFS Storage Appliance offers one of the widest multiprotocol selections available including 10Gb Ethernet, 16Gb Fibre Channel, and 40Gb InfiniBand. Because it has built-in dedupe, compression, thin provisioning and other enterprise features, and can naturally deliver high transactional style IO performance, it’s easy to “slide” business critical workloads onto the ZS5 Series. What IT folks discover is that the ZS5 Series is rock-solid mid-range to enterprise storage that scales performance at a lower footprint and price than traditional dual-controller arrays and other popular scale-out storage solutions.

In particular, we note the available option of InfiniBand as a front-end interface. There are several places in the “next gen” datacenter where InfiniBand networking can provide significant advantage – backing up Oracle Exadata to be sure, but also to support massively dense VM hypervisor clusters, large-scale VDI implementations, and HPC-like computing. Reaching from 10GbE to 40Gb InfiniBand, the ZS5 can become a valuable enterprise-wide storage platform and data protection target for all kinds of mixed workloads, from business-critical databases to home directories to highly virtualized environments with massive VM farms and content serving at scale.

**ZS5 SERIES ZBA**

The newest ZS5 Series ZBA is available in two basic models, an entry-level design, and the enterprise performance version, each of which is available in single or HA dual-controller configurations.

- **ZS5-4** – The ZS5-4 supports 144 cores, 3.0TB DRAM, 38.4TB write cache, up to 243TB read flash cache, 7.3PB of raw uncompressed capacity per cluster
- **ZS5-2** – The ZS5-2 supports 72 cores, 1.5TB DRAM, 12.8TB write cache, up to 102TB read flash cache, 3PB of raw uncompressed capacity per cluster

The server platforms here are not small cheap Linux or Windows boxes, but are some of the world’s fastest computers with high-end Intel multi-core processors (running Solaris, a highly threaded symmetric multi-processing operating system that performs extremely well in VM environments). This operating system enables the ZS5 Series to process thousands of threads concurrently in contrast to traditional NAS filers which can become saturated at only a few hundred VMs each causing filer sprawl.

**Performance**

The first thing we note about the core ZS5 Series is its blazing fast performance on critical, high-write, mixed workloads in addition to the engineered performance for Oracle databases. The ZS5 Series derives its performance numbers from three main sources:

- **Massive Multi-level Caching** – The appliance can host a massive amount of DRAM, which unarguably makes the fastest cache. With its intelligent caching algorithms, the ZS5 Series can serve 70-90% of IO requests from DRAM depending on workload (and we note that DRAM is still much faster than flash cache). But then there is also a huge amount of MLC flash configurable for read cache in the controllers, and SLC flash for write cache in the drive bays. Intelligent caching pre-fetches pages, drains DRAM writes asynchronously, and recognizes large incoming synchronous writes to send directly to write flash or large streaming writes to send directly to the disk drive pool.
- **Intelligent Tiering** – Oracle’s Hybrid Storage Pool (HSP) architecture, which holistically includes the above caching scheme, provides for the dynamic migration of data between DRAM, flash, and across
multiple classes of SAS disk, including SAS-3. In HSP, flash isn’t just something tacked on the side, but is treated as an integral part of the fundamental design. HSP’s Adaptive Replacement Caching (ARC) uses in-memory de-duplication and parallel access sequencing to further leverage the massive cache resources.

- **Symmetric Multi-processing (SMP) Operating System** – A highly-threaded SMP operating system that fully leverages the architecture’s massive cache and multi-core CPUs to enable the ZS5 Series to process thousands of threads concurrently helping prevent wasteful filer sprawl (traditional NAS filers and backup systems can become saturated at only a few hundred).

### ZFS For the Enterprise

Obviously a big strength of the ZFS Storage Appliance is the ZFS file system. ZFS was designed as an incredibly scalable file system with massive potential capacity (128-bit addressing), and with matching built-in data protection features to ensure large-scale storage. Based on taking dynamic advantage of storage pooling rather than pre-allocations of volumes, ZFS has no need for external volume management, eliminating much storage management overhead. ZFS was also designed from the ground up with a distinct focus on data integrity, for example maintaining three copies of metadata (compared to just one copy in NetApp WAFL). In addition, ZFS validates the entire I/O path and can rapidly recover from bit rot, ghost writes, misdirected reads and writes, alpha particle hits, memory cell degradation, DMA parity errors, accidental overwrites and flash failures.

### Oracle Acceleration

In addition to overall enterprise capabilities, the ZS5 Series has specific features to accelerate Oracle Database backup and restore. As these features are only available on Oracle products, other storage vendors will have a difficult time competing head-to-head with the ZBA on Oracle Database 12c workloads.

These features include:

- **Hybrid Columnar Compression (HCC)** – On top of database-managed, row-level compression, the system-wide HCC facility organizes data into “compression units” that add column orientations over sets of rows for enhanced results of both compression ratios and query performance. HCC provides four advancing levels of “columnar” compression intended for different levels of data usage (low/high que-
ry, low/high archive). Data stays in HCC compressed format during all stages of transfer, storage, networking, query processing, and backup (with RMAN), optimizing every downstream operation. It’s notable that the ZBA makes use of HCC for backing up Oracle databases, which is far more efficient than any possible “application blind” storage-side dedupe capability. And such HCC data need not be unencrypted or uncompressed before handing it off to the ZBA storage target – a big benefit that reduces the backup window and network load, while improving throughput rates. Still the ZBA’s native dedupe is highly competitive and can deliver 5—10x reduction ratios on mixed workload backups. When compared to traditional backup solutions, the ZBA in this mode can more than double the leverage of its media capacity.

- **Automatic Data Optimization (ADO)** – ADO tracks database data as it ages and becomes less referenced transactionally and/or increasingly static (see Heat Maps figure). As data “cools”, ADO applies various HCC compression levels to balance current access needs with optimal space savings. Not only does this result in 5-50x reduced storage capacity for any given chunk of data, but data subsequently referenced analytically can actually increase in performance under this scheme through both less disk IO and columnar organization.

- **Oracle Intelligent Storage Protocol (OISP)** – OISP enables the Oracle Database to directly configure allocated storage in the ZFS Storage Appliance. By automating the steps of setting parameters for low level database/storage alignment (e.g. record sizes, log biases, etc.), manual database tuning time is more than halved and misconfiguration potential is completely eliminated. Think of this as a speed dial offered from the Oracle Database directly to the ZFS Series.

![Figure 1 - Oracle Heat Map Tiering](image)

Overall, these capabilities on top of the ZS5 Series enterprise storage features lead to best-in-class Oracle Database performance with optimal capacity usage. Less silo-oriented resources are needed for operations and fewer mistakes can be made—all adding up to unmatched database hosting efficiency. The ZS5 Series is essentially designed to help customers accelerate time to insight, mitigate risk with highly granular data center analytics and run database queries faster.

**Engineered for Management**

Oracle’s own use of the ZFS Storage Appliance in the Oracle Cloud shows that it’s been designed for serious scale. It features complete open APIs that externalize all storage capabilities – same as what’s available in its own CLI/GUI – for ease of integration into any management framework, but also comes with OpenStack drivers including Cinder and Manila native, Swift by proxy.
ZS Series appliances can be fully managed through Oracle Enterprise Manager, providing a unified view from on-premises to Oracle’s Public Cloud. In fact, we note that only Oracle delivers exactly the same identical storage (including services, user experience, and actual infrastructure) to customers that deploy the ZFS Storage Appliance on-premises and make use of the Oracle Cloud. This enables enterprises to seriously entertain deeper cloud adoption of reliable hybrid or DR scenarios for mission-critical applications that absolutely depend on complete storage alignment.

Application-specific capabilities, such as Oracle Database 12c, result from uniquely being able to engineer across both the application and the storage infrastructure. This engineering is intentionally designed from both sides to work intimately in concert, but is loosely coupled in operation—other Oracle solutions like Exadata and SuperCluster also support HCC. We think this is the best kind of convergence, and in important ways, represents what other solution vendors are still striving to achieve with analogous application-aware designs.

When multiple facets of IT are designed together as a complete system, the resulting co-engineered solution can provide much faster troubleshooting and direct application-level storage visibility. The ZS5 Series comes with Oracle’s DTrace Analytics for integrated visual-based problem solving across multiple layers of storage and database components, including Oracle Database 12c pluggable databases. In more siloed systems, storage misalignment, contention, and errors can disrupt business critical applications, sometimes degrading their performance over long periods of time without obvious connection.

**TOP PERFORMANCE TODAY, BRIGHTER FUTURE AHEAD**

The ZS5 Series is designed for high performance backup/restore, cloud building, highly virtualized data centers, and for direct attach to high-speed, high-throughput compute clusters. Any environment that is write-intensive with demanding requirements for concurrent throughput, latency and IOPs is an ideal fit for its DRAM-fueled performance. Consequently, the ZS5 ZBA provides peak performance when backing up, and, more importantly, performing restores for Oracle’s Engineered Systems but also for any database, application, VM or file system in the datacenter.

Unlike many other storage specific vendors, Oracle appreciates that infrastructure is only truly productive when used in production by important applications – and is willing to publicly prove it. To that end, Oracle has implemented a deliberate program to fully test out its storage solutions at large scale first in its own massive production operations (Oracle Cloud & Oracle IT) before going to customers.
The underlying performance and capacity optimizations lead to great savings on backup/restore processes—space, time, utility and % success—and smaller footprint, power and cooling requirements for the ZFS Backup Appliance.

**TANEJA GROUP OPINION**

The ZFS Backup Appliance initially faces off in the hotly contested data protection market with Dell EMC’s Data Domain, and according to Oracle, easily displaces it when a prospect runs into the issues with backing up at scale (space and throughput limits), actionable recovery (RTO), and ultimately overall TCO. Oracle reports that the ZBA has consistently demonstrated superior backup/restore performance over Data Domain in customer conducted trials—from 6X to as much as 66X, delivering 6X performance or more at half the competing price. Oracle has shown that the ZBA restores data at 60TB/hour whereas Dell EMC Data Domain doesn’t even disclose restore rates (anecdotally, production restores with older generation solutions can take as long as 25 days). You can back up all of your data all week long, but that’s all pointless if you can’t restore it in a rapid manner – and if you can’t restore, your business is really at far more risk than it would knowingly accept.

The ZS5 Series threatens the traditional enterprise NAS market. While traditional vendors like NetApp are perceived as falling behind the technology curve when it comes to massive scale and performance, Oracle here is continuing to innovate. In fact, Oracle claims a 4:1 consolidation when replacing NetApp filers, and offers 2X-6X performance gains to boot. Against other well-known competitors, the ZS5 Series brings stiff competition on performance, price and TCO, and significantly, competing solutions will all lack specific Oracle Database 12c acceleration and capacity optimization capabilities, giving the ZS5 Series a wide open door to almost every account with an Oracle Database driven application.

Now in its fifth generation, the Oracle ZFS Storage Appliance continues to gather impressive steam. Adoption is already significant just as an optimizing storage solution just for Oracle Database environments, but IT on a broader scale is taking notice that the ZS5 Series is a great value for a wider class of enterprise needs. As its broader usefulness becomes known, we expect Oracle to show up on the short list of an increasing number of enterprise storage infrastructures in general.

The ZS5 Series ZBA represents a great value for customers looking for a comprehensive, highly performant storage backup/restore target to protect any and all important data in the data center – any app, any database, any VM or file, from any backup application or source. And you can probably justify it just on Oracle Database protection requirements – and expand its use once proven there. And as a last word, don’t forget this all works brilliantly with the fully compatible Storage Cloud Services in the Oracle Public Cloud for tier3 and colder data and DR copies.

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