An Oracle White Paper
March 2014

Integrated High-Performance Disk-to-Disk Backup with the Oracle ZFS Storage ZS3-BA
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Executive Overview

Databases are critical to business operations and are continuing to grow in size, making the job of protecting enterprise data ever more challenging. Of utmost importance is the ability to recover quickly in the event that a database gets logically or physically corrupted. For Oracle Database and Oracle engineered systems customers, the Oracle ZFS Storage ZS3-BA offers a cost-effective and flexible way to meet stringent recovery time objectives (RTOs) and data retention needs. The Oracle ZFS Storage ZS3-BA has been optimized to work with Oracle Exadata and Oracle SuperCluster systems to speed up the database backup and recovery process. Some key statistics about how the Oracle ZFS Storage ZS3-BA compares to other leading platforms include:

- 17 TB/hr restore throughput—**4x faster** than that of an EMC Data Domain 880 system

- 26 TB/hr backup throughput—**up to 7x faster** than that of comparable EMC Data Domain 880 system

With native InfiniBand connectivity and included data services, the Oracle ZFS Storage ZS3-BA also makes it simple, easy, and cost effective to implement a fast disk-to-disk backup solution for Oracle engineered systems. In addition to disk-to-disk backups, the architecture also supports archival to tape, enabling organizations to maintain their existing data protection policies.

Introduction

Large-scale databases such as those provisioned on Oracle Exadata or Oracle SuperCluster systems often have very challenging data protection requirements. In addition to their significant size, these databases often support 24/7 operations and have stringent service level agreements (SLAs) and RTOs. With backup and recovery windows shrinking and databases getting larger, disk-to-disk backup and recovery solutions are becoming increasingly necessary.

The Oracle ZFS Storage ZS3-BA is an easy-to-deploy unified storage system that supports Oracle engineered systems backup and recovery using Oracle Recovery Manager (Oracle RMAN). It provides an integrated backup solution for Oracle engineered systems that offers much faster backup and recovery than traditional NAS storage systems as well as purpose-
built backup solutions and provides an easy path for archival to tape. Oracle ZFS Storage ZS3-BAs offer the following advantages for protecting data in engineered systems:

**Simplicity**—This all-Oracle backup solution is tested, validated, and supported together, enabling rapid deployment with direct-connect InfiniBand. The appliance supports both full and incremental backups to disk as well as the option to archive to tape, enabling organizations to continue with their existing backup and recovery best practices.

**Speed**—With backup and restore throughput rates of 26 TB/hr and 17 TB/hr respectively for Oracle Exadata, and 14 TB/hr and 7 TB/hr respectively for Oracle SuperCluster, the Oracle ZFS Storage ZS3-BA offers much shorter backup recovery times than comparably priced NetApp filers and EMC Data Domain systems. The Oracle ZFS Storage ZS3-BA’s InfiniBand-based direct-connect architecture enables organizations to take advantage of additional Oracle RMAN features that speed restore procedures.

**Savings**—The appliance offers greater throughput at a lower price than competitive systems, and the Oracle ZFS Storage ZS3-BA’s direct-connect architecture with InfiniBand technology is lower cost than 10 Gigabit Ethernet (GbE). This architecture eliminates the need for a media server and the associated licenses and support costs. Simplified administration and data services that are included in the cost of the appliance are two more factors that help reduce TCO.

**Reduced Risk**—The appliance is available only in high-availability dual-controller configurations with active-active clustering for failover, ensuring that data can be backed up and restored during maintenance operations or the unlikely event of a complete head failure. The Oracle ZFS Storage ZS3-BA also provides data integrity features that reduce risk of lost data or silent data corruption. In addition, Remote replication is available at an extra charge to facilitate disaster recovery processes.
Oracle Exadata Backup and Recovery Solution Overview

The Oracle ZFS Storage ZS3-BA provides a flexible approach to backup and recovery for Oracle engineered systems, offering both disk-to-disk (D2D) and disk-to-disk-to-tape (D2D2T) options. In this backup solution architecture, the Oracle ZFS Storage ZS3-BA is connected directly to the Oracle Exadata or Oracle SuperCluster system via high-speed InfiniBand network fabric. The appliance is established as a target for Oracle RMAN backups, enabling it to take advantage of Oracle RMAN features that speed up data backup and recovery processes.

An optional tape backup environment consists of a StorageTek tape library system from Oracle, such as the StorageTek SL8500 modular library system shown in Figure 1. The Oracle ZFS Storage ZS3-BA maintains a complete backup on disk for fast restore times, and additional copies can be archived to tape, enabling organizations to continue their existing practices for incremental backups and increased protection through offsite archival. Tape backups are initiated from Oracle RMAN and use the most recent backup file stored in the Oracle ZFS Storage ZS3-BA to create a copy for the tape library. This approach enables tape backups to be executed with minimal performance impact on the Oracle Exadata or Oracle SuperCluster system.

![Oracle Exadata, Oracle ZFS Storage ZS3-BA, Oracle's StorageTek Tape Library](image)

**Figure 1.** The Oracle ZFS Storage ZS3-BA backup and recovery solution provides both disk-to-disk (D2D) and disk-to-disk-to-tape (D2D2T) options.

Backups are accomplished using Oracle RMAN to copy the database files to the established target on the Oracle ZFS Storage ZS3-BA. The architecture of the Oracle ZFS Storage ZS3-BA also supports backups for multiple different databases. For each database instance running on the server, a separate
backup target is defined on the Oracle ZFS Storage ZS3-BA. The appliance is designed to handle multiple workloads, making it a good fit for backing up multiple databases on Oracle Exadata or Oracle SuperCluster systems.

Oracle Recovery Manager

The Oracle RMAN backup and recovery utility is the preferred method for efficiently backing up and recovering the Oracle Database. Oracle RMAN is tightly integrated with the database server and helps reduce risk of data loss by providing block-level corruption detection during backup and restore procedures. Performance and space consumption also are optimized during backup procedures using the Oracle RMAN file multiplexing and compression features. Only database blocks that have changed since the previous backup are copied, resulting in less need for backup storage space and up to an order of magnitude reduction in backup times. Because Oracle RMAN is already built into the Oracle Database, and the Oracle ZFS Storage ZS3-BA is directly connected to Oracle Exadata or Oracle SuperCluster via InfiniBand, there are no extra software licenses to buy and no third-party technology to purchase and manage. For more information about Oracle RMAN, visit http://www.oracle.com/technetwork/database/features/availability/rman-overview-096633.html.

Oracle ZFS Storage ZS3-BA

The Oracle ZFS Storage ZS3-BA provides all the benefits of unified storage in an easy-to-use appliance package, enabling organizations to dramatically simplify their storage deployment and management while also reducing costs. This appliance provides unmatched simplicity and ease-of-use through an intuitive and powerful browser user interface (BUI). Revolutionary storage analytics functionality allows administrators to quickly diagnose and resolve performance issues across the storage environment. The Oracle ZFS Storage ZS3-BA delivers breakthrough performance with exceptional economics powered by high-performance, industry-standard servers, a highly-threaded symmetric multi-processing (SMP) operating system that fully leverages the architecture’s massive cache (DRAM and flash) and multi-core CPUs, along with densely packaged high-capacity disk drives. Leveraging an industry-standard server in place of an expensive, proprietary disk controller reduces both cost and risk because standard components offer economies of scale. These components are integrated in an appliance framework that greatly simplifies deployment and includes an integrated data services software stack. The rich set of data services includes compression, mirroring, snapshot, error correction, and system management features that help simplify ongoing data management. The following sections of the paper highlight the business benefits of using the Oracle ZFS Storage ZS3-BA for backup and recovery of an Oracle Exadata system. For additional information about the Oracle ZFS Storage ZS3-BA, visit Oracle.com.

Simplicity

The Oracle ZFS Storage ZS3-BA offers a simple and straightforward way to implement backup and recovery for an Oracle Exadata or Oracle SuperCluster system. Oracle RMAN can back up the data files as image copies from an Oracle Database to a target area in the Oracle ZFS Storage ZS3-BA. After the initial backup copy is created, subsequent backups with Oracle RMAN will copy only those blocks that have changed since the last backup. Using the incrementally updated backups feature,
Oracle RMAN will merge these changed blocks into the original image backup to create a new image of the Oracle data files. This results in much faster backup times, yet still enables a full restore without the need to merge incremental backups into a full backup as part of the restore operation. In addition, backup and recovery applications such as Oracle Secure Backup can be used to move backup data to tape, making it easy for organizations to continue their existing backup and recovery practices within the data center.

No-Hassle Protection

The Oracle ZFS Storage ZS3-BA software works with Oracle RMAN to help protect against data corruption. Oracle RMAN ensures transaction integrity and manages all information required for database recovery at any point in time. While Oracle RMAN helps ensure that backups are generated free of errors, the Oracle ZFS Storage ZS3-BA helps ensure that they remain free of errors over time. Oracle ZFS Storage ZS3-BA software provides end-to-end checksum and data integrity checking to help reduce the risk that files will be corrupted when restoring old backups. Disaster recovery also can be simplified utilizing replicated copies of the Oracle RMAN backups. Replication is available on the Oracle ZFS Storage ZS3-BA, simplifying replication for disaster recovery.

Oracle’s recommendation for disaster recovery of the Oracle Database is Data Guard, which is a feature of the Oracle Database, Enterprise Edition. In a Data Guard configuration, one or more standby databases are connected to the production or primary database over a network. Data Guard keeps the standby databases synchronized with the primary database, such that in the event of an unforeseen outage at the primary data center, the processing can be easily and quickly switched to one of the standby databases. Data Guard can be configured such that no data is lost in this process and failover can be automatic if desired. Oracle Active Data Guard (licensed separately) enables the standby database to be active, supporting resource-intensive user activities such as reporting and backups, thus helping to offload the production database so it can deliver improved performance.

High Availability and End-to-end Data Integrity

Leading vendors offer single-controller backup appliances. In the event of a hardware failure, data stored in that node is unavailable until the part is replaced, and possibly some data will be lost. In either case, if a restore is needed, the data on that node is clearly not restorable. In contrast, the Oracle ZS3-BA systems are only available in dual-controller configurations with active-active clustering for failover. If one controller fails, the other is can continue the backup operation and the data is available if a restore is needed.

Oracle ZS3-BA systems, like all of the Oracle ZFS Storage Appliance ZS3 Series, is based on the Oracle Solaris operating system, which is designed to provide end-to-end checksum for all data to verify data integrity. The software constantly reads and checks data to help ensure that it is correct, protecting against costly and time-consuming data loss—even previously undetectable silent data corruption. This level of data protection helps to ensure that the data is available when restores are needed, not leaving it to chance.

Simplified Deployment and Management
Integrated High-Performance Disk-to-Disk Backup with the Oracle ZFS Storage ZS3-BA

The Oracle ZFS Storage ZS3-BA can be deployed in less time than traditional backup solutions, and it offers simplified administration and management. The full backup solution has already been tested and validated, and it’s supported by the same vendor that delivers Oracle Exadata. The Oracle ZFS Storage ZS3-BA can be up and running quickly because it’s a preconfigured appliance. In addition, the Oracle Exadata’s internal InfiniBand network has been tested to work with the Oracle ZFS Storage ZS3-BA, saving valuable time during the initial deployment.

The appliance is managed through a BUI, and it provides high-level functions as well as aggregated management of resources, resulting in fewer, simpler steps to accomplish many administrative tasks.

Because this single-vendor solution for backup and recovery has been tested and validated by Oracle, it offers operational efficiencies that cannot be achieved when integrating multiple hardware and software components from different vendors. IT organizations also can save on administration and training costs because IT staff can focus on learning only Oracle tools versus tools from multiple vendors.

Speed

The Oracle ZFS Storage ZS3-BA is designed to address the sweet spot of price/performance where large databases can be backed up and restored very quickly, yet total cost of ownership (TCO) is relatively low.

For instantaneous recovery without downtime, the only way to protect an Oracle Exadata or Oracle SuperCluster system is to deploy a second system that can be continuously updated using Oracle Active Data Guard so that the data is already available in the event of a problem on the first system.

For environments with less stringent RTOs, the most cost-effective option is tape backup with the Oracle Optimized Solution for Oracle Secure Backup. With this low-cost solution, backups are performed with Oracle RMAN handing backup data to the Oracle Secure Backup software on a media server, which then writes it to locally attached tape devices or a remote tape device. For more information about backup and recovery options using Oracle Secure Backup software, please review the Oracle Optimized Solution for Backup and Recovery at http://www.oracle.com/us/solutions/oos/oracle-backup-and-recovery/overview/index.html.

High Sustained I/O Throughput for Fast Backup and Restore Performance

Using the Oracle ZFS Storage ZS3-BA as an Oracle RMAN backup target delivers much faster backup and recovery, enabling organizations to achieve shorter recovery time objectives and shrink backup windows compared to competitive backup solutions. The Oracle ZFS Storage ZS3-BA delivers high sustained read and write I/O performance, further enhanced by high-throughput InfiniBand network fabric connection to the Oracle Exadata or Oracle SuperCluster system.

As the only unified storage vendor to support InfiniBand as a storage network for backup and restore operations, Oracle is leading the way with native high-bandwidth interconnects. The InfiniBand network provides 40 Gb of bandwidth per port between the database servers, storage cells, and the
Integrated High-Performance Disk-to-Disk Backup with the Oracle ZFS Storage ZS3-BA

Oracle ZFS Storage ZS3-BA. Backup and restore operations can be automatically parallelized across all database nodes, storage cells, Oracle ZFS Storage ZS3-BA channels, and controllers.

These technologies, coupled with the data placement optimization capabilities in the Oracle ZFS Storage ZS3-BA software, enable the Oracle ZFS Storage ZS3-BA to deliver unmatched backup and recovery performance for its class of network attached storage (NAS) devices. Tests performed by Oracle have shown that the Oracle ZFS Storage ZS3-BA can achieve sustained transfer rates of 26 TB/hr for backups and up to 17 TB/hr for restore operations for Oracle Exadata. The Oracle ZFS Storage ZS3-BA can achieve sustained transfer rates of 14 TB/hr for backups and 7 TB/hr for restore operations for Oracle SuperCluster. From a competitive comparison standpoint, the tested Oracle ZFS Storage ZS3-BA provides:

- 7x the backup throughput and 4x the restore throughput of an EMC Data Domain 880 appliance.

Better Visibility to Find and Fix Performance Issues

Backup speed can also be affected by performance bottlenecks that may not be obvious without close observation. Oracle’s DTrace Analytics, a feature that is included in the appliance at no cost, makes it easier to trace the source of performance bottlenecks and fix them. DTrace Analytics enables administrators to drill down for in-depth analysis of key storage subsystems using built-in instrumentation that provides real-time visibility throughout the data path. Real-time statistical graphs can be used to quickly locate and isolate problems as well as optimize storage performance and capacity use.

Savings

The direct-connect architecture of this solution saves significant costs beyond those directly associated with the Oracle RMAN backup target because it obviates the need for a media server to connect devices. In addition, the high-speed InfiniBand connection to the Oracle ZFS Storage ZS3-BA leverages the pre-existing InfiniBand interfaces in Oracle Exadata. This makes the InfiniBand fabric less complex and more economical to set up than a 10 GbE fabric, primarily because the InfiniBand fabric requires less additional hardware.

Traditional architectures that require software licenses and support for disk-based backup media management software can make TCO go up significantly higher for a 160 TB database (e.g., a full rack Oracle Exadata). Oracle ZFS Storage ZS3-BA enables organizations to leverage Oracle RMAN, which is included in the Oracle Database at no cost, rather than paying for third-party backup software licenses and support. This direct-connect architecture also leverages the internally managed InfiniBand fabric.

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1 Pricing includes third-party software licenses for 360 TB capacity, eight Oracle Database client licenses for the eight database nodes, and three years of support. Third-party licensing and support costs are based on estimated street prices found on the Internet.
network in the Oracle Exadata system, which saves the cost of upgrading a LAN segment to handle high-speed I/O traffic between the Oracle Exadata system and the backup storage device.

Industry-Leading TCO

The Oracle ZFS Storage ZS3-BA offers a TCO that is more than 5x better than that of the currently available EMC Data Domain 990 appliance.

A three-year TCO analysis of the Oracle ZFS Storage ZS3-BA versus competitive systems is shown in Table 1:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>THREE-YEAR TCO</th>
<th>TCO ADVANTAGE FOR ORACLE ZFS STORAGE ZS3-BA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle ZFS Storage ZS3-BA</td>
<td>$417,804</td>
<td>n/a</td>
</tr>
<tr>
<td>EMC Data Domain 990</td>
<td>$2,167,449</td>
<td>Oracle ZFS Storage ZS3-BA TCO is more than 5x better than a single EMC system.</td>
</tr>
</tbody>
</table>

This big price advantage, coupled with outstanding throughput, means that IT managers can reduce their capital outlay for backup and restore systems while still meeting their objectives for backup and recovery times.

Cost-Saving Features of Oracle ZFS Storage ZS3-BA

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2 Three-year TCO data was computed by Oracle using non-discounted list prices from data available on the Internet. All system TCOs were computed as an initial hardware sale. Subsequent year cost data takes into consideration annual costs for service, power, cooling, and floor space, which are estimated based on documented specifications for the equipment.
Integrated High-Performance Disk-to-Disk Backup with the Oracle ZFS Storage ZS3-BA

Oracle ZFS Storage ZS3-BAs offer several features that help reduce costs:

- High-throughput architecture and a densely populated configuration enable a low-cost solution with a small footprint and low energy costs.
- The intuitive BUI management interface and simplified administrative procedures help reduce operations costs by reducing administration time.
- Fast provisioning and configuration can help reduce initial setup costs.
- Data compression of the Oracle RMAN backup is performed in the appliance without impacting the database server. Compression can improve storage efficiency and thus reduce capital expenditures by reducing storage capacity requirements.
- Disaster recovery can be accomplished without third parties through the Data Guard capabilities included with the Oracle Database and with the replication services available on Oracle ZFS Storage ZS3-BA.

The fact that all software features and data services, except for replication and clones (licensed separately), are included in the cost of Oracle ZFS Storage ZS3-BAs enables Oracle customers to achieve significant savings compared to competitive systems that require the purchase of additional software licenses.

Conclusion

When a large enterprise database get corrupted or damaged, the time required to restore the database and resume normal business operations can be extremely critical. In cases where a fully redundant standby site cannot be justified, a reliable and fast recovery solution can be a good alternative. The Oracle ZFS Storage ZS3-BA offers integrated high performance, enabling industry-leading restore throughput in a cost-effective backup and restore solution for Oracle engineered systems.

The appliance is simple to provision and the InfiniBand network configuration has been pretested, saving valuable time for administrators. Performance of disk-to-disk backup and restore operations is aided by the high-speed InfiniBand network and high sustained I/O throughput in the storage appliance.

The system is architected to be attached directly to Oracle Exadata or Oracle SuperCluster, enabling backups and restores to take advantage of Oracle RMAN functionality that is available only for direct-attached devices. In addition, customers save the extra licensing costs associated with avoiding the purchase of a media server between the appliance and the client system. These features enable this cost-effective backup solution to offer significantly higher performance than traditional network attached storage solutions.

Perhaps most important, this simple and fast backup solution is available at a TCO that is more than 4.2x lower than a similar EMC Data Domain 990 configuration.
Integrated High-Performance Disk-to-Disk Backup with the Oracle ZFS Storage ZS3-BA

References

Visit the web sites listed in Tables 2 and 3 for additional information.

| TABLE 2. WEB SITES FOR ADDITIONAL INFORMATION |
|-----------------|------------------------------------------|
| **PRODUCT OR SOLUTION AREA** | **WEB SITE URL** |
| Oracle Exadata | www.oracle.com/exadata/ |
| Oracle SuperCluster | http://www.oracle.com/supercluster/ |
| Oracle ZFS Storage ZS3-BA | www.oracle.com/us/products/servers-storage/storage/unified-storage |
| Oracle Recovery Manager | www.oracle.com/goto/RMAN |

| TABLE 3. RELATED WHITE PAPERS |
|-------------------------------|------------------------------------------|
| **WHITE PAPER TITLE** | **WEB SITE URL** |