PURESTORAGE®

TECHNICAL WHITE PAPER

Oracle Backup and Restore with FlashArray//C

High-capacity, high-performance storage for Oracle data protection.

Contents

Executive Summary

Today, most business-critical applications run on high-performance all-flash storage arrays, but some capacity-oriented applications like backup and restore still use hybrid flash and traditional disk systems. Traditional systems can suffer from inconsistent performance, complex management tools, and a lack of modern data services. Hybrid flash total cost of ownership (TCO) can be higher than warranted for backup and restore applications. Pure Storage® FlashArray//C provides an all-flash option for capacity-oriented applications delivering industry-standard performance with lower-TCO. Oracle backup and restore is ideally suited to leverage the benefits of FlashArray//C as a storage target. In addition, the extreme scalability of FlashArray//C, up to 7.3PB effective storage in three- to nine-rack units, ensures that making FlashArray//C your Oracle backup and restore target is a smart business decision for today and tomorrow.

Testing executed by Pure engineers demonstrate that Pure FlashArray//C is an ideal target storage device for Oracle Recovery Manager (RMAN) backups and an ideal single storage repository for snapshots of Oracle instances. Together, Oracle RMAN and Pure FlashArray//C provide a cost-effective, scalable, high-performance, and high-capacity enterprise-class data protection solution.

Introduction

This document details the test results that show Pure FlashArray//C is an excellent Oracle RMAN backup target for both file and block and is an effective and efficient part of a robust backup strategy. It also highlights tuning parameters to optimize Oracle backup performance when using a Pure FlashArray//C storage system as a direct network attached storage (NAS) target for RMAN backups.

Pure FlashArray//C is the first all-quad-level cell (QLC) flash array. QLC flash is a capacity optimized NAND flash memory technology that delivers a per-terabyte cost that matches or beats hard-disk drives (HDDs) while still delivering NVMe performance with higher capacities. FlashArray//C leverages QLC to deliver optimal NVMe performance, hyper-consolidation, and simplified management of your data for capacity-oriented workloads. Oracle Recovery Manager satisfies the most pressing demands of high-performing, efficient, manageable backup and recovery tasks for all Oracle data formats. Oracle RMAN leverages FlashArray//C consistent all-flash NVMe performance to provide unparalleled data protection—at a lower TCO than hybrid storage.

Solution Overview

For decades, organizations have relied on Oracle databases for their business-critical applications and, therefore, must be able to protect and recover their data or risk interruption to their business. Oracle RMAN is a built-in tool that allows database administrators (DBA) to easily back up and recover the data in an Oracle database. RMAN ensures that transaction integrity is preserved, and sufficient data is maintained to recover the database to any supported recovery granularity or point in time. Oracle RMAN utilizes a target storage device for backup and recovery files. The solution tested four Oracle instances and includes Oracle RMAN for backup and restore with Pure Storage FlashArray//C with Purity data storage software as the target as shown below in Figure 1.

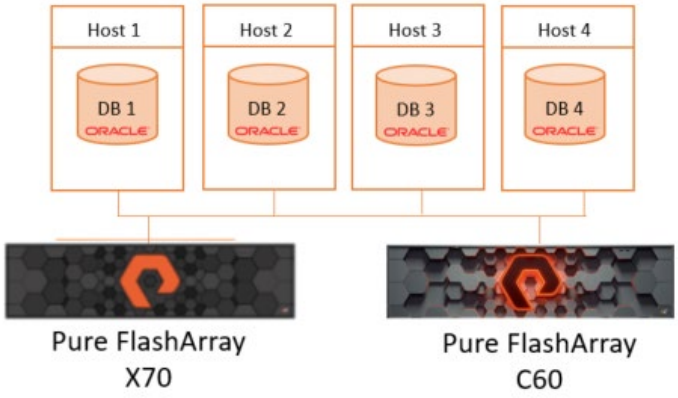

Figure 1: Oracle RMAN with FlashArray//C solution.

Oracle Recovery Manager (RMAN)

A complete high availability and disaster recovery strategy must include dependable data backup, restore, and recovery procedures. Oracle RMAN provides a comprehensive foundation for efficient Oracle database backup and recovery. RMAN is designed to work intimately with the server, providing block-level corruption detection during backup and restore. RMAN optimizes performance and space consumption during backup with file multiplexing and backup set compression, and integrates with Oracle Secure Backup, as well as third party media management products for tape backup.

RMAN takes care of all underlying database procedures before and after backup or restore, freeing dependency on OS and SQL*Plus scripts. It provides a common interface for backup tasks across different host operating systems and offers features such as parallelization of backup/restore data streams, backup files retention policy, and detailed history of all backups, that are not available through user-managed methods. Oracle RMAN is the preferred Oracle database backup and recovery foundation for a complete high availability and disaster recovery strategy.

Oracle RMAN Concepts and Terminology

Oracle RMAN has a set of important definitions and parameters that are unique and must be understood to optimize backups of Oracle databases.

Types of backups. RMAN supports several different kinds of backups:

- A *full backup*, as its name implies, is a backup of the entire database.
- An *incrementally updated backup* applies the incremental level 1 backup to the latest image backup copy, rolling it forward to the point in time when the level 1 incremental was created.

- A *partial backup* can be of a single portion or multiple portions of the database, but not necessarily the entire database.
- An *incremental backup* uses a facility within Oracle to track changes to the database that occur between backup operations to backup only specific pieces of the database that have been altered.
- An *image backup* makes exact copies of the Oracle database files with the result appearing as a copy of the files when viewed from the operating system.

For all these backups, RMAN processes the data to be backed up and consolidates it into one or more files called a backup set. The choice of backup type has a direct impact on the ability of deduplication to identify redundancy.

Backup Set. A backup set is a set of one or more files that is written by RMAN as the output of a backup operation. The DBA can characterize a backup set in several different ways through different naming facilities as well as a separate tagging facility. A backup set can hold interleaved data from different Oracle data files. The total number and size of backup sets depends mostly on an internal RMAN algorithm. However, RMAN behavior can be influenced with the MAXSETSIZE parameter in the CONFIGURE or BACKUP command. By limiting the size of the backup set, the MAXSETSIZE parameter indirectly limits the number of files in the set and can possibly force RMAN to create additional backup sets. Also, you can specify BACKUP … FILESPERSET to specify the maximum number of files in each backup set.

Pure Storage FlashArray//C

Pure Storage FlashArray systems are all solid-state systems, providing NVMeoF-RoCE (called DirectFlash® Fabric), FC, and iSCSI block storage access and file access with SMB and NFS. The FlashArray family has three members: FlashArray//X for performance-oriented workloads, FlashArray//XL for large applications on fewer arrays, and FlashArray//C for capacity-oriented workloads. All data is both deduplicated and compressed by FlashArray prior to being written. There is no performance penalty for deduplicating and compressing data in-line, which enables an effective capacity of 3.3PB for //X, 5.5PB for //XL, and up to 7.3PB for //C.

Figure 2: Front view of FlashArray//C.

FlashArray//C, shown above in Figure 2, was introduced to the Pure FlashArray family to create a capacity-optimized platform based on QLC with all the ease of use, robust data services, and data protection services of Purity data storage software. Building on the success of FlashArray//X, FlashArray//C was introduced to provide customers with large capacity arrays that provide consistent performance with higher latency. The higher latency profile of the FlashArray//C system is partially due to Purity updates made to accommodate the use of native QLC NAND while still providing high reliability. QLC NAND requires greater care writing and deleting stored data due to the complexity of the cell design, lower cell durability, and the fact that read and write operations require slightly more time (and energy) to be completed. As a result, FlashArray//C performance as measured by latency can be as low as 1 millisecond (Purity 6.1.9 and higher). As workloads transition from low thread counts

and low throughput to high thread counts and high throughput, read latency on FlashArray//C gradually increases from 1 to 3.5 milliseconds. While write latency remains consistent throughout the IO range, the read latency increase means there is a premium on using multiple, parallel read workloads, applications, and IO streams—such as Oracle RMAN backups—to drive maximum overall performance. Purity improvements to FlashArray//C deduplication crawling speed and efficiency have resulted in increased overall data reduction rates which narrow the gap with FlashArray//X. This deduplication improvement puts relative data reduction rates for FlashArray//C at about 80–85% of FlashArray//X.

In addition, FlashArray//C is currently the only Pure Storage FlashArray™ offering file services. FlashArray file services adds native, multi-protocol file storage and access to FlashArray//C for a unified block and file platform that eliminates the trouble and expense of running two environments. Now customers have a choice for their RMAN backup destination: file and block. Using file services on FlashArray//C provides an option to create a central NFS mount that can serve as a RMAN destination for many Oracle databases. With FlashArray file services, both your file-based data and block-based data can benefit from a unified data layer, a shared pool of capacity, and global data reduction. FlashArray//C now offers the same reliability, data reduction, and simplicity users know and love from FlashArray//X block storage services for NAS file storage.

FlashArray//C is ideally suited for Oracle RMAN, allowing for large database backup and restore while realizing consistent all-flash performance at 99.9999% availability with non-disruptive upgrades for the most demanding 24x7 operations and lower costs than hybrid storage. It enables IT organizations to simplify data protection operations by eliminating complex siloed approaches to Oracle RMAN backups across multiple disparate hybrid disk-based solutions. A single FlashArray//C data store is an ideal consolidated, capacity-optimized Oracle RMAN backup target and Oracle snapshot repository.

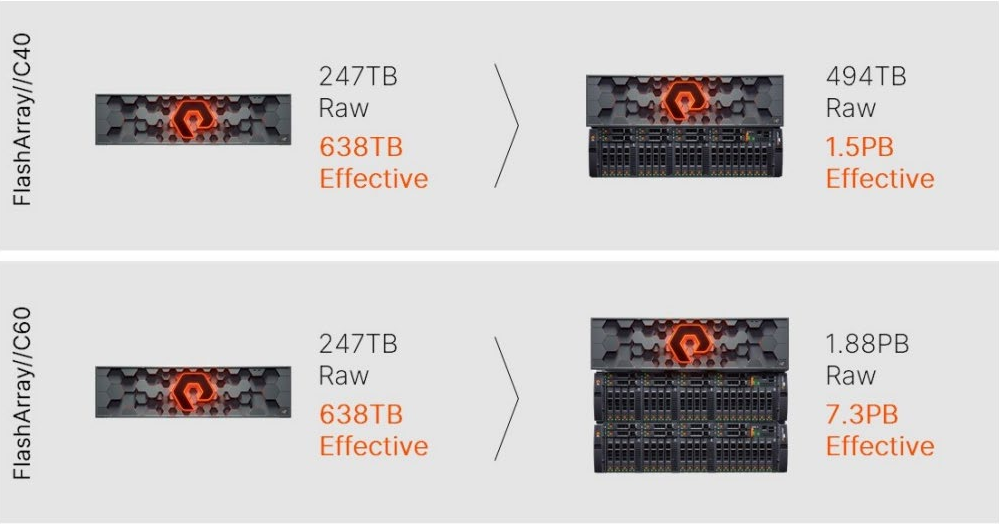

Figure 3: FlashArray//C scalability.

The extreme scalability of FlashArray//C (shown above in Figure 3) delivers consistent performance via its end-to-end all-NVMe architecture and density configurations that span 1.5PB effective in 3U to more than 7.3PB effective in 9U. Simple hardware, software, and cloud management tools are designed to make everything work together seamlessly.

Examples of this inherent simplicity include:

- One box with only six cables and a 30-minute installation with no manual (with available Pure Professional Services or partner installation)
- Inline data-reduction and end-to-end encryption
- Seamless expansion with a flexible buying program (Evergreen Storage™ subscription) for non-disruptive rapid upgrades and expansion
- No performance tuning required
- APIs for automation
- AI-driven cloud management
- All array software included

FlashArray and Oracle RMAN together deliver a simple, efficient, cost-effective backup and restore solution due to:

- Simple, rapid deployment of FlashArray //C as a RMAN Oracle backup target
- FlashArray//C providing always-on storage optimization (compression and dedupe) for your Oracle backups
- Ability to use FlashArray//C for both Oracle RMAN backups and as an Oracle snapshot repository
- SafeMode™ Snapshots for replication, mobility, and ransomware protection
- Ability to back up both block and file
- FlashArray//C providing flash performance at traditional disk economics while still delivering Oracle RMAN recovery/restore speeds exceeding industry standards

Purity

The Purity operating environment powers FlashArray//C to deliver comprehensive data services for capacity-oriented applications. Purity data storage software provides the confidence of knowing that your data is stored in a way that ensures data efficiency, security, and availability due to its key components:

- **Data reduction:** Purity delivers the industry's most granular and complete data reduction for unmatched storage efficiency. Only unique blocks of data are saved on flash, which removes duplicates that fixed-block architectures often miss. In addition, repetitive binary patterns are removed before data is deduplicated and compressed, streamlining the data reduction process.
- **Always-on encryption:** Purity's "encrypt everything" approach provides built-in enterprise-grade data security without user intervention or key management. Pure Storage EncryptReduce™ encrypts data in-flight without affecting data compression and deduplication. It also provides physical security through the Key Management Interoperability Protocol (KMIP).
- **High availability:** Purity ensures business continuity by reducing risk of downtime while keeping mission-critical applications and data online and accessible. Designed from the ground up for flash, Purity RAID-HA protects against concurrent dual-drive failures and initiates re-builds automatically within minutes and detects and heals bit-errors. Purity also treats performance variability as a failure and uses parity to work around bottlenecks to deliver consistent latency.

- **Non-disruptive everything:** Downtime isn't an option when hundreds of applications are hosted on the storage array. With Purity, flash capacity can be expanded, controllers upgraded, failed components replaced, and Purity software itself upgraded—all without taking the storage offline or impacting application performance. Purity is truly non-disruptive.
- **Intelligent quality of service (QoS):** Purity continuously tunes infrastructure using always-on QoS to prevent workloads from hogging resources. Without artificial limits on workloads, utilization of the array is maximized, and full performance for all workloads is assured.
- **Snapshots:** Purity snapshots are completely portable and provide simple, built-in, local and cloud protection for FlashArray//C data. Purity's portable snapshot technology encapsulates metadata with data, making the snapshot portable. This means you can offload it from a Pure FlashArray to the cloud in a format that is recoverable by any FlashArray. Purity snapshots enable free movement of space-efficient copies between FlashArray, to FlashBlade®, third party NFS servers, and the cloud. Data portability is central to a unified data management strategy. Snapshots offer infinitely configurable policies and a near-infinite means of offloading snapshots for replication and mobility.

  In addition, SafeMode Snapshots can be enabled to provide ransomware protection. Pure snapshots have always been immutable, high-performance, and highly storage-efficient. SafeMode adds additional protection to snapshots to prevent hackers from compromising admin credentials to a storage array to irrevocably delete snapshots. Snapshots are key to a data protection strategy with the ability to recover from ransomware attacks.

Pure Storage FlashArray//C powered by Purity data storage software is enterprise-ready and provides proven six nines of availability, non-disruptive upgrades, and consistent industry-standard performance for the most demanding environments.

Solution Benefits

The Oracle RMAN and Pure FlashArray//C solution has been verified by Pure to operate effectively and efficiently. The key benefits of Oracle RMAN backup and restore using FlashArray//C are:

- High performance and efficiency
  - Backup/restore performance that consistently exceeds industry standards
  - Purity continuously tunes FlashArray//C using always-on QoS
  - Achieves maximum productivity with minimum cost
- Cost optimization
  - All-flash performance with the economics of hybrid arrays
  - Easily scalable to high capacities for future demands
- Flexible and simple deployment
  - A single effective solution for both block and file backup
  - Ideal combination of snapshots for quick and fast recovery and RMAN for avoiding a single point of failure
  - Leverages the same operating system as your primary array, making it easier to back up your production data
- Highly available and reliable
  - Built for 99.9999% availability with NVMe
  - Purity RAID-HA protects against concurrent dual-drive failures within the array and initiates re-builds automatically within minutes, and detects and heals bit-errors

Tuning Parameters for Oracle RMAN on FlashArray//C

There are several options that affect how RMAN performs when executing backup operations in general. Some of these options also specifically affect how RMAN will interact with a FlashArray//C storage system. Below is a summary of the RMAN tunning parameters recommended for an ideally configured Oracle RMAN on a Pure FlashArray//C data protection solution.

MAXOPENFILES. This parameter controls the number of Oracle datafiles that RMAN can have open for reading at any one time. The MAXOPENFILES parameter also effects the amount of system memory consumed by RMAN during a backup operation. Reading from multiple files can improve throughput of the backup operation but will consume more resources including system memory consumed by I/O buffers. To minimize the number of I/O buffers that RMAN allocates, adjust MAXOPENFILES to the smallest value possible while still achieving acceptable or SLA-specific performance objectives for backup operations.

FILESPERSET. This parameter on the "begin backup" RMAN command tells RMAN how many Oracle data files it can combine into a single backup set. In other words, it controls the multiplexing of Oracle data into the backup sets. When used with commands that create backup sets, this specifies the maximum number of files to include in each created backup set. By default, RMAN divides files among backup sets to make optimal use of channel resources. The number of files to be backed up is divided by the number of channels. If the result is less than 64, then it is the number of files placed in each backup set.

Compression. RMAN provides several types of native compression. All supported versions of RMAN can apply a lossless compression algorithm to the data being written to the backup set. Turning on RMAN lossless compression results in less disk space being used at the cost of significantly greater CPU consumption during the backup operation as compared to the alternate compression type. When using a Pure FlashArray//C storage system as the primary target for RMAN backups, because the FlashArray provides always-on compression by default, substantial CPU savings can be achieved on the RMAN host by turning off compression at the RMAN level. Therefore, we recommend that you turn off Oracle RMAN compression. In addition, pre-compression of the backup streams will randomize the data patterns and vastly reduce deduplication provided by FlashArray//C.

Encryption. RMAN offers the option to encrypt backup sets to increase security. Any backup set can be encrypted except for "image" backup sets. As with compression, encryption by RMAN will randomize the data patterns and vastly reduce deduplication provided by FlashArray//C. In addition, because the FlashArray provides always-on encryption by default, substantial CPU saving can be achieved on the RMAN host by turning off encryption at the RMAN level. Therefore, we recommend that you turn off Oracle RMAN encryption when using a Pure FlashArray//C storage system as the primary target for RMAN backups, unless mandated by local security policy.

Channels and parallelism. RMAN backs up Oracle data files using a series of separate processes, called channels, which run in parallel, i.e., separate running programs and/or threads. Typically, while one process is waiting on I/O to complete a given set of reads/writes, another process can be performing similar tasks on a separate set of files. By keeping these channels running simultaneously against data stored on different disks, the overall RMAN backup can complete in less time than if the entire process ran sequentially against a single file at a time. The DBA can also define a global setting for parallelism and allow RMAN to balance the I/O load as best it can, or the DBA can manually define these channels. Manual definition of the channels by the DBA is recommended to achieve the best performance since specific knowledge of the FlashArray//C storage environment can be leveraged.

Following these best practices for RMAN parameters will maximize the performance of an Oracle RMAN on Pure FlashArray//C data protection solution.

The tests that are documented below were limited by the performance of the network infrastructure that was available. The network card on the database host was 10Gbps and the network port was capable of 25Gbps. Backup and Recovery performance would be improved with additional network resources.

Test Environment

Server Details

All servers has the configuration as shown below in Table 1 and were running Oracle Linux 7.6 kernel version 4.1.12-124.36.1.el7uek.x86_64.

Component	Description
Processor	2x Intel Xeon CPU E5-2697 v2 @ 2.70GHz (2 CPUs with 12 cores each)
Memory	512GB @ 2.4GHz (16 x 32GB
HBA	2x 32GB Emulex
NIC	2x Intel Corporation 82599ES 10-Gigabit

Table 1: Server configuration.

Kernel Parameters

The Linux default network and network device settings might not produce optimum throughput (bandwidth) and latency numbers for large parallel jobs. There are kernel parameter values that can be adjusted to optimize the system. We used the following kernel parameter with values as shown below in Table 2 throughout the testing.

Kernel Parameter	Value
rmem_default (defines the default receive window size)	echo '67108864' > /proc/sys/net/core/rmem_default
rmem_max (defines the maximum receive window size)	echo '67108864' > /proc/sys/net/core/rmem_max
wmem_default (defines the default send window size)	echo '67108864' > /proc/sys/net/core/wmem_default
wmem_max (defines the maximum send window size)	echo '67108864' > /proc/sys/net/core/wmem_max
tcp_rmem (three values that represent the minimum, default, and maximum size of the TCP socket receive buffer)	echo '67108864' > /proc/sys/net/core/rmem_max
tcp_wmem (three values that represent the minimum, default, and maximum size of the TCP socket write buffer)	echo '67108864' > /proc/sys/net/core/wmem_max
tcp_adv_win_scale (value of 1 means the socket buffer will be divided evenly between TCP windows size and application)	echo 1 >/proc/sys/net/ipv4/tcp_adv_win_scale
tcp_slot_table_entries (tune the NFS client by setting the maximum number of [TCP] RPC requests that can be in flight)	echo 256 > /proc/sys/sunrpc/tcp_slot_table_entries
tcp_mtu_probing (controls TCP Packetization-Layer Path MTU Discovery. 1 Enabled when an ICMP black hole detected)	sysctl -w net.ipv4.tcp_mtu_probing=1

Table 2: Values for Kernel Parameters during testing.

Oracle Configuration

The Oracle system was configured as follows:

- Oracle 19.3
- Using ASM (ASMFD)
- HugePages enabled (Hugepage size 2M)

ORACLE dNFS

Oracle dNFS (direct Network File System) is the NFS client functionality directly integrated in the Oracle RDBMS server. dNFS makes the task of configuring an Oracle database on NAS storage much simpler, instead of standard NFS (aka kernel NFS). Direct NFS Client on Oracle 12c supports NFSv3, NFSv4, and NFSv4.1 protocols to access the NFS server.

The key benefits of Direct NFS Client include simplicity, ease of administration, load balancing, high availability, and cost effectiveness. Oracle has optimized the I/O code path by avoiding kernel overhead, and as such dNFS can improve I/O performance. Direct NFS Client can perform concurrent direct I/O by bypassing operating system level caches. It also performs asynchronous I/O, which allows processing to continue while the I/O request is submitted and processed. These two key performance and scalability features provide unparalleled performance when compared to kernel NFS clients. Another key feature of direct NFS client is high availability. Direct NFS Client delivers optimized performance by automatically load balancing requests across all specified paths (up to four parallel network paths). If one network path fails, then dNFS Client will reissue I/O commands over any remaining paths, ensuring fault tolerance and high availability.

One of the primary challenges of Kernel NFS administration is inconsistency with configurations across different platforms. Direct NFS Client eliminates this problem by providing a standard NFS client implementation across all platforms supported by the Oracle Database. This also makes NFS a viable option on platforms like Windows which don't natively support NFS.

As NFS is a shared file system, it supports Real Application Cluster (RAC) databases as well as single instance databases. Direct NFS Client recognizes when an instance is part of an RAC and automatically optimizes the mount points for RAC, relieving the administrator of having to manually configure the NFS parameters.

Connectivity

Multiple network connections should be configured between the Oracle RMAN server and the Pure FlashArray to maximize throughput and provide redundancy. It is also recommended that these network interfaces be dedicated to RMAN to segregate the backup traffic for administrative and security reasons. Normally, a dedicated VLAN can provide this segregation within the network infrastructure. The tests configurations leveraged multiple connectivity paths for backup and restore as shown below in Figure 4.

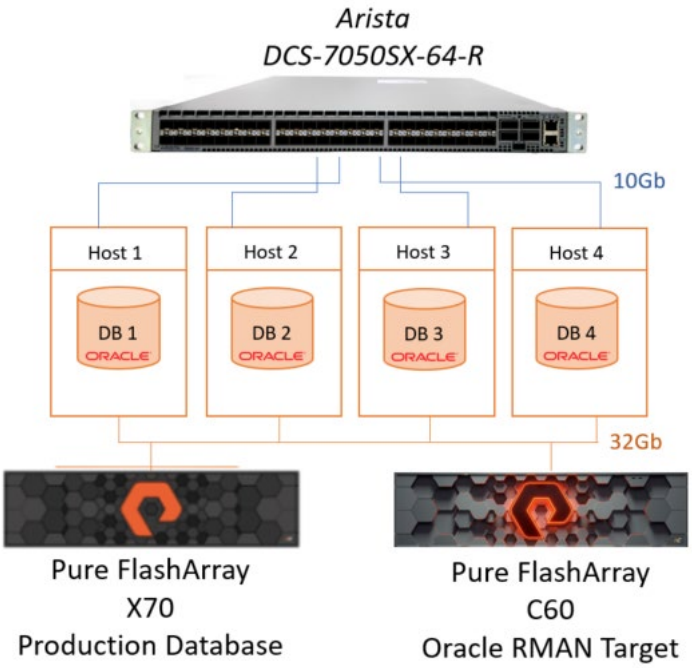

Figure 4: Test environment connectivity.

Test Details

Extensive tests were performed to stress test the FlashArray//C60 as an Oracle RMAN backup target for both file and block. Purity 6.1.3 version was used to ensure all required File services performance enhancements were included.

Host/Database Details

Each server ran an independent Oracle database instance configured with a different Data Size and Datafile Size.

Test Configurations

Tests were run with varying values for the following configuration:

- Oracle dNFS
- RMAN section size
- File system mount points
- Number of virtual interfaces (VIFs)
- RMAN channels
- Parallelism of database backups running concurrently on different hosts

Test Case Results

Below are the results of the testing:

- All tests were successfully executed.
- The performance of a single backup run was found to be limited by the bandwidth of the network card (10Gbps) on the database host.
- When multiple backups were run in parallel, the throughput was limited by the bandwidth of the port (25Gbps) configured by file services.
- Oracle dNFS was found to makes a difference only if the number of channels is low. Without dNFS, max throughput was achieved with 12 RMAN channels, whereas with dNFS, similar performance was achieved with only 4 RMAN channels.

File Services (NFS target) Backup and Restore Test Results

File Services (NFS target) RMAN backup performance average max was 2.579GB/s with four concurrent RMANs and 16 RMAN channels. Graph test results are shown below in Figure 5. During concurrent backups, each database ran on a different host and databases were backed up by RMAN in parallel.

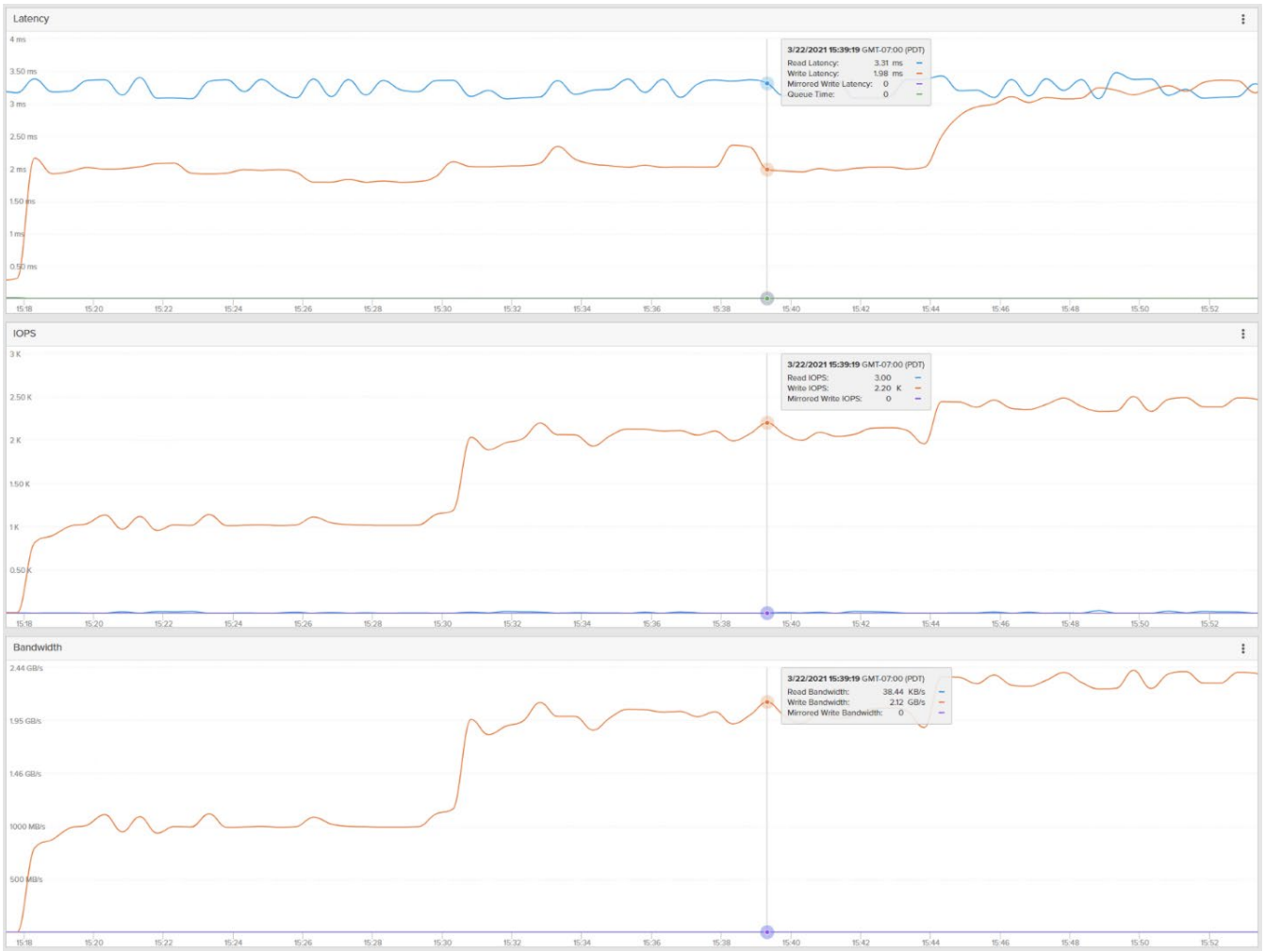

Figure 5: NFS backup results.

File Services (NFS target) RMAN restore performance average max was 1.16GB/s. Because this was a single database restore test, performance was limited by the capacity of the NIC on the host. A single database of size 2TB was restored with 64 restore channels in 36 minutes as shown below in Figure 6.

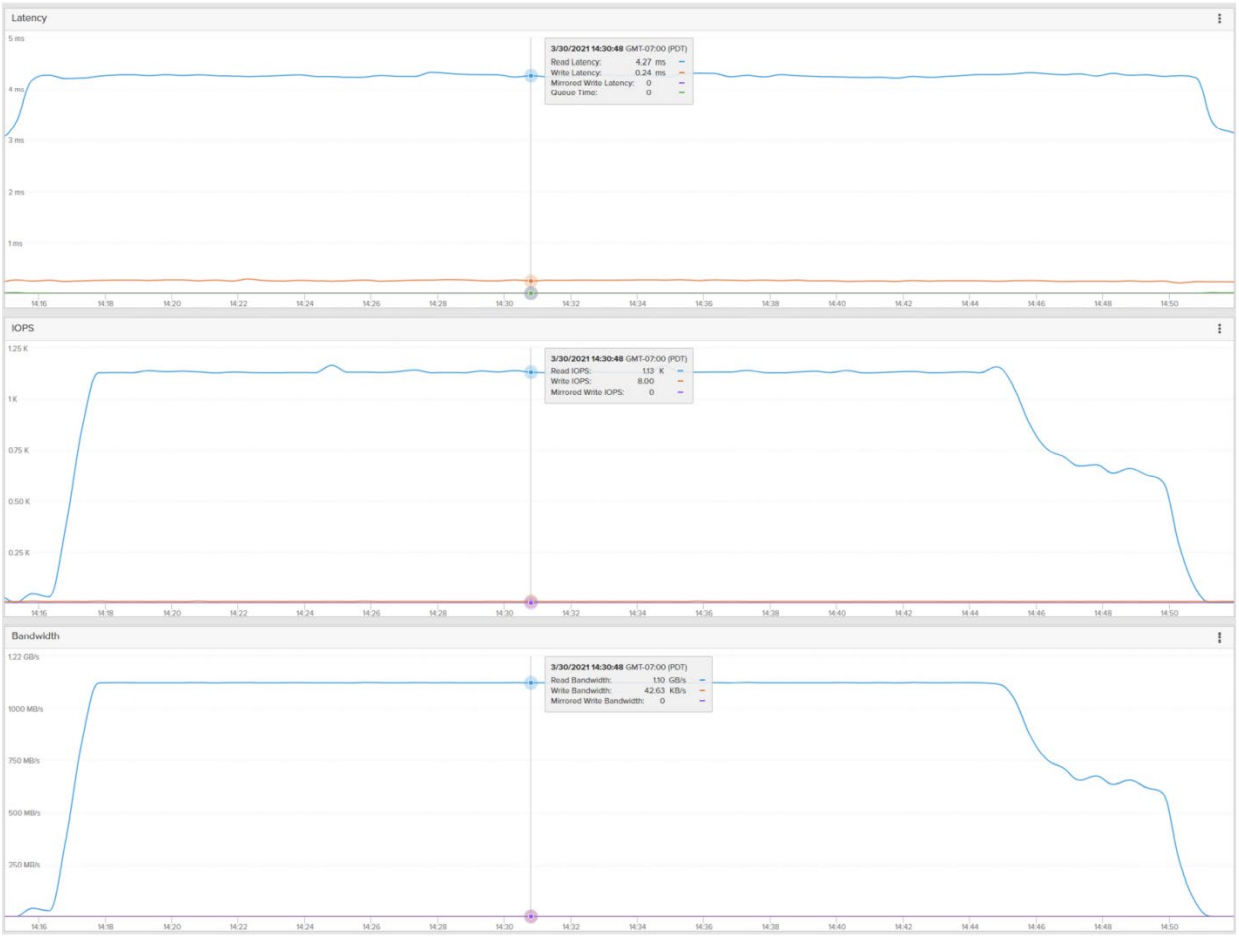

Figure 6: NFS restore results.

Block (on 32G FC) Backup and Restore Test Results

Block (on 32G Fibre Channel) RMAN backup performance max was 4.6GB/s with 16 RMAN channels as shown below in Figure 7.

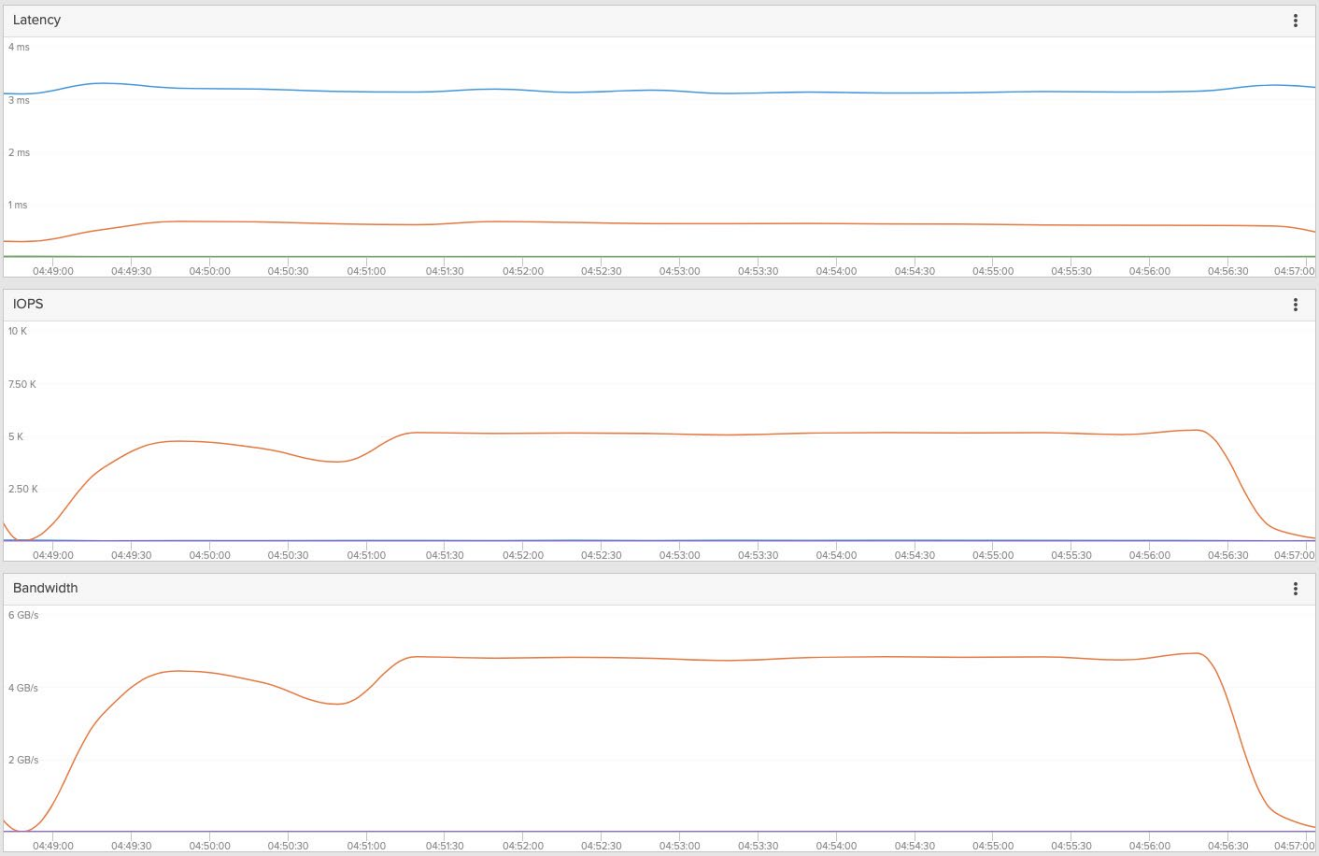

Figure 7. Block Backup Results

Block (on 32G Fibre Channel) RMAN restore performance max was 4.27GB/s. A single database of size 2TB was restored with 8 restore channels in 9.75 minutes.

Test Analysis

Analysis of the test results show that Oracle RMAN backup and restore using Pure FlashArray//C as a target operates effectively and efficiently. The performance of FlashArray//C as a backup and restore target was only limited by bandwidth of the network card (10Gbps) on the database host and/or the port (25Gbps) configured by file services. Enabling Oracle dNFS allows for maximum performance with a minimal number of channels.

Best Practices for FlashArray//C and Oracle RMAN

Using a Pure FlashArray//C storage system as a target for RMAN backups is straightforward because the system appears as normal disk storage. However, planning and consideration of best practices for capacity, network throughput, replication bandwidth, and recovery operations is recommended to ensure the system meets the requirements for backup windows, recovery time objectives, desired retention, and disaster recovery.

Capacity requirements should be determined by the size of the databases being protected, the type of backups being performed, and retention requirements.

It is recommended that multiple network connections be configured between the Oracle RMAN server and the Pure FlashArray//C system to maximize throughput and provide redundancy. It is also recommended that these network interfaces be dedicated to RMAN to segregate the backup traffic for administrative and security reasons.

The Oracle RMAN compression and encryption processes, which modify the backup data stream while the backup is in progress, are detrimental to deduplication. This is because all deduplication techniques rely on being able to identify repeated data patterns. When a backup of otherwise unchanged data is compressed or encrypted during execution of the backup, the resultant data stream will be different each time the backup is executed even though the data is unchanged. This will have an impact on deduplication and cause less redundancy to be detected, resulting in the consumption of more physical storage for each backup. In addition, compression and encryption executed by Oracle RMAN will take CPU cycles, which can be avoided by having FlashArray perform compression and encryption. Best practice is to disable Oracle RMAN compression and encryption when using FlashArray//C as the target for Oracle RMAN and utilize the more effective and efficient compression and encryption from FlashArray//C.

A robust backup plan will have many tiers of backup each having an important place in the overall backup and restore strategy. Oracle RMAN backup with FlashArray//C as a target really complements FlashArray Purity Snapshot backups. For example, if an entire database needs to be restored, a snapshot on the local FlashArray//X or a replicated snapshot on the FlashArray//C will be the quicker option, instead of restoring from Oracle RMAN. Similarly, if only specific tables or a datafile needs to be restored, restoring from RMAN would be the better choice.

Conclusion

Maximizing the value of an Oracle data protection strategy requires careful consideration of the benefits and trade-offs of each approach. Capacity and bandwidth requirements must be balanced with administrative and budgetary constraints to ensure that business-critical Oracle databases are reliably backed up and recoverable within defined service level agreement parameters. Testing executed by Pure engineers confirms that Oracle RMAN and Pure FlashArray//C provide a cost effective, scalable, high-performance, high-capacity enterprise-class data protection solution. Pure FlashArray//C is easily deployed as the storage infrastructure for a balanced, business savvy Oracle data protection strategy, enabling customers to meet financial and business goals today and easily scale for growth tomorrow.

Additional Resources

- Discover Pure Storage Data Protection Solutions.
- Learn more about FlashArray//C.
- Learn how to optimized Oracle with Pure.

Appendix

The script used to set values used for the kernel parameters was:

```
echo 67108864 >/proc/sys/net/core/rmem_default
echo 67108864 >/proc/sys/net/core/rmem_max
echo 67108864 >/proc/sys/net/core/wmem_default
echo 67108864 >/proc/sys/net/core/wmem_max
echo "16384 67108864 67108864" >/proc/sys/net/ipv4/tcp_rmem
echo "16384 67108864 67108864" >/proc/sys/net/ipv4/tcp_wmem
echo 1 >/proc/sys/net/ipv4/tcp_adv_win_scale
echo 256 > /proc/sys/sunrpc/tcp_slot_table_entries
sysctl -w net.ipv4.tcp_mtu_probing=1
sysctl -w net.core.netdev_max_backlog=300000
```

File Services (NFS target) Backup and Restore Full Test Results

File Services (NFS target) RMAN backup performance average max was 2.579GB/s with 4 concurrent RMANs and 16 RMAN channels as shown below in Table 3. During concurrent backups, each database ran on a different host and databases were backed up by RMAN in parallel.

Test-ID	Concurrent RMANs	RMAN Channels	Throughput GB/s
400	1	4	1.08
403	1	8	1.07
404	1	12	1.09
406	2	16	1.970
408	3	12	2.80
409	4	16	2.579

Table 3: Oracle RMAN backup performance test results with FlashArray//C target.

The average max performance average for File Services (NFS target) RMAN was 1.16GB/s as shown below in Table 4. Because this was a single database restore test, performance was limited by the capacity of the NIC on the host. A single database of size 2TB was restored in these tests. The number of channels the backup was taken with are noted in the Backup Channels column.

Test ID	Restore Channels	Backup Channels	Time (mins)
504	4	4	196
505	16	4	93
506	16	16	90
507	24	16	60
508	32	16	46
510	48	16	38

Table 4: Oracle RMAN restore performance test results from FlashArray//C.

Block (on 32G FC) Backup and Restore Full Test Results

Block (on 32G Fibre Channel) RMAN backup performance max was 4.6GB/s as shown below in Table 5.

Test ID	Concurrent RMANs	RMAN Channels	Throughput GB/s
302	1	4	2.02
303	1	8	2.9
304	1	12	3.8
310	1	16	4.6

Table 5: Oracle RMAN backup performance test results with FlashArray//C target.

Block (on 32G Fibre Channel) RMAN restore performance max was 4.27 GB/s as shown below in Table 6. A single database of size 2TB was restored in these tests.

Test ID	Restore Channels	Backup Channels	Time (mins)	Throughput GB/s
602	4	4	16.16	2.57
603	8	8	9.75	4.27
604	12	12	10.3	4.04
605	16	16	10.29	4.04

Table 6: Oracle RMAN restore performance test results from FlashArray//C.

File Services (NFS target) Backup Test Results varying the dNFS setting

dNFS was found to makes a difference only if the number of channels is low. Without dNFS, max throughput was achieved with 12 RMAN channels as shown in Table 7 below. With dNFS, similar throughput was achieved with only 4 RMAN channels as shown in Table 8 below.

DNFS	RMAN Channels	RMAN Section Size	Mount Point Count	Number of VIFs	Time (secs)	Throughput (MB/s)
Off	4	2048M	4	2	2,606	812
Off	8	2048M	8	2	2,188	967
Off	12	2048M	12	2	2,103	1,006
Off	12	2048M	12	2	2,041	1,010
Off	12	1024M	12	2	2,018	1,020
Off	12	512M	12	2	2,018	1,020
Off	12	4096M	12	2	1,924	1,070
Off	12	8192M	12	2	2,016	1,030

Table 7: Oracle RMAN backup performance test results from FlashArray//C with dNFS off.

DNFS	RMAN Channels	RMAN Section Size	Mount Point Count	Number of VIFs	Time (secs)	Throughput (MB/s)
On	4	2048M	4	2	1945	1,060
On	8	2048M	8	2	1941	1,060
On	12	2048M	12	2	1894	1,090
On	12	1024M	12	2	1893	1,090
On	12	512M	12	2	1898	1,090
On	12	4096M	12	2	1891	1,090
On	12	8192M	12	2	1894	1,090
On	12	4096M	12	2	2,934	1,080
On	4	4096M	4	16	2,089	1,013
Off	12	512M	12	2	2,018	1,020
Off	12	4096M	12	2	1,924	1,070
Off	12	8192M	12	2	2,016	1,030

Table 8. dNFS ON - Oracle RMAN Backup Performance Test Results from FlashArray//C.

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