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ARCHITECTURE GUIDE

Hitachi Solution for Databases - Oracle Real Application Clusters Database 12c based on Hitachi Advanced Server DS240 and Virtual Storage Platform G1500 with FMD HDE Drives

Reference Architecture Guide

By Libo Jiang

November 2018

Feedback

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Revision History

Revision	Changes	Date
MK-SL-125-00	Initial release	November 30, 2018

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Hitachi Solution for Databases - Oracle Real Application Clusters Database 12c based on Hitachi Advanced Server DS240 and Virtual Storage Platform G1500 with FMD HDE Drives

Reference Architecture Guide

Use this reference architecture guide to see how Hitachi Solution for Databases provides a high performance, integrated, converged solution for Oracle using flash module drives (FMD-HDE) with self-encryption and self-compression on an enterprise class storage array. The environment uses Hitachi Virtual Storage Platform G1500 (VSP G1500), Hitachi Advanced Server DS240 with Intel Xeon Gold 6128 processors, and Hitachi Advanced Server DS120 servers with Intel Xeon Silver 4110 processors. With these products, design an Oracle converged infrastructure to meet your requirements and budget.

This Hitachi Unified Compute Platform Converged Infrastructure (UCP CI) architecture for Oracle Database is engineered, pre-tested, and qualified to provide predictable performance and the highest reliability in demanding, dynamic Oracle environments. This solution is validated to ensure consistent, predictable results.

This proven solution to optimize your Oracle database environment integrates servers, storage systems, and networks. The environment provides reliability, high availability, scalability, and performance while processing small-scale to large-scale on-line transaction processing (OLTP) and online analytical processing (OLAP) workloads. The dedicated servers run Oracle Database 12c R2 with the Oracle Real Application Clusters (RAC) option and use Red Hat Enterprise Linux 7.5 for the operating system. This reference architecture document is for you if you are in one of the following roles:

- Database administrator
- Storage administrator
- Database performance analyzer
- IT professional with the responsibility of planning and deploying an Oracle Database solution

To use this reference architecture guide, you need familiarity with the following:

- Hitachi Virtual Storage Platform G1500
- Hitachi Advanced Server DS240 servers
- Hitachi Advanced Server DS120 servers
- Storage area networks
- Oracle RAC Database 12c Release 2
- Oracle Automatic Storage Management (Oracle ASM)
- Hitachi Adapters for Oracle Database
- Hitachi Storage Adapter for Oracle Enterprise Manager
- Hitachi Server Adapter for Oracle Enterprise Manager
- Red Hat Enterprise Linux
- Red Hat Enterprise Linux Device-Mapper Multipath

Note — Testing of this configuration was in a lab environment. Many things affect production environments beyond prediction or duplication in a lab environment. Follow the recommended practice of conducting proof-of-concept testing for acceptable results in a non-production, isolated test environment that otherwise matches your production environment before your production implementation of this solution.

Solution Overview

This reference architecture implements Hitachi Unified Compute Platform CI for Oracle Real Application Clusters on two nodes using Hitachi Virtual Storage Platform G1500. This environment addresses the high availability, performance, and scalability requirements for OLTP and OLAP workloads. Tailor your implementation of this solution to meet your specific needs.

FMD-HDE drives use a “compression-before-encryption” mechanism to resolve a common low data compression ratio issue and performance degradation that is observed in solutions with application level encryption and all-flash array (AFA) controller-based compression.

Without a holistic strategy for optimizing the Oracle environment, unsystematic growth and its associated uncontrolled costs can create an increasingly expensive cycle. Through a combination of our solutions and expertise in Oracle environments, Hitachi Vantara can help companies control capital and operational costs, while increasing performance, data protection, and flexibility. We can help ensure the right information is available in the right place, at the right time – and for the right cost.

Business Benefits

This reference architecture provides the following benefits:

- Predictable, repeatable, reliable results that are pre-validated
- Faster speed to deploy and increased ability to meet changing needs, with a single source for components and prescriptive guides
- Extreme reliability of Hitachi storage
- Simplified and centralized storage management

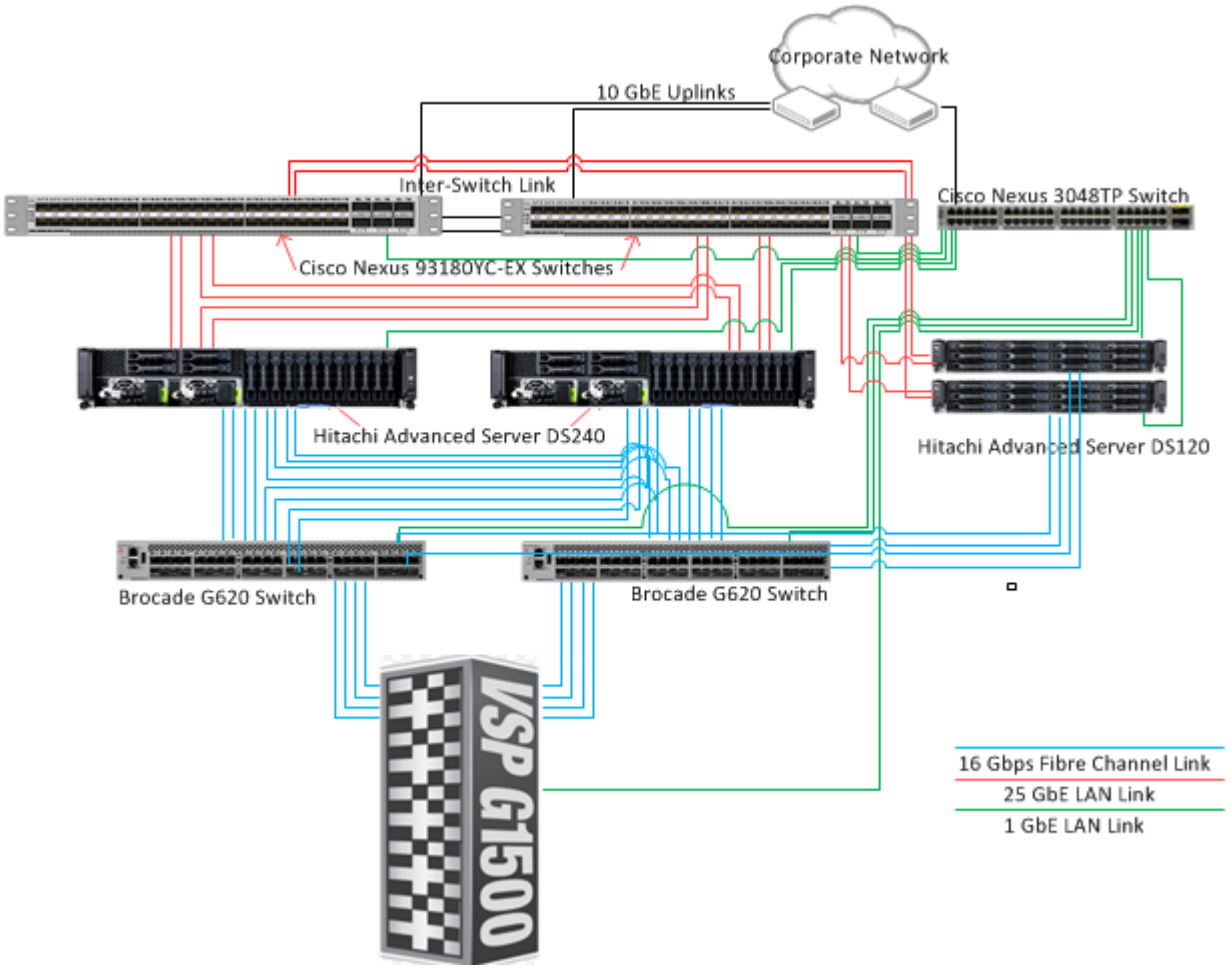
High Level Infrastructure

Figure 1 shows the high-level infrastructure for this solution.

The configuration of Virtual Storage Platform G1500 and Hitachi Advanced Server DS240 have the following characteristics:

- Fully redundant hardware
- Dual fabric connectivity between hosts and storage

Figure 1



To avoid any performance impact to the production database, Hitachi Vantara recommends using a configuration with the following:

- A dedicated storage system for the production database
- A dedicated storage system for storing backup data, if needed

Uplink speed to the corporate network will be dependent on the customer environment and requirements. The Cisco Nexus 93180YC-EX switches can support uplink speeds of 40 GbE or 100 GbE if higher bandwidth is required.

Key Solution Components

The key solution components for this solution are listed inTable 1, Table 2, and Table 3.

TABLE 1. HARDWARE COMPONENTS

Hardware	Detailed Description	Firmware/Version	Quantity
Hitachi Virtual Storage Platform G1500	■ One controller ■ 4 virtual storage director pairs ■ 2 back-end director pairs ■ 2 front-end director pairs ■ 20 × 16 Gb/s Fibre Channel ports used ■ 1,024 GB cache memory ■ 48 × 7 TB FMD DC2s ■ 48 × 7 TB FMD HDEs ■ 4 × 3 TB 7.2k RPM SAS drives	80-06-41-00/00	1

TABLE 1. HARDWARE COMPONENTS (CONTINUED)

Hardware	Detailed Description	Firmware/Version	Quantity
Hitachi Advanced Server DS240 servers	■ 2 × Intel Xeon Gold 6128 CPU @ 3.40GHz ■ 1,536 GB (64 GB × 24) DIMM DDR4 Synchronous Registered (Buffered) 2666 MHz	BIOS:3A02.H1 BMC: 4.23.06	2
	■ 2 × Intel Corporation Ethernet Controller XXV710 for 25 GbE SFP28	■ Driver: i40e ■ Version: 2.1.14-k ■ Firmware: 5.51	
	■ 4 × Emulex LightPulse LPe32002-M2 2-Port 32 Gb Fibre Channel Adapter	Boot: 11.4.204.18 Firmware: 11.4.204.25 Driver: 11.4.204.26	
Hitachi Advanced Server DS120 server	■ 2 × Intel Xeon Sliver Processor 4110, 8-core, 2.1 GHz, 85W ■ 256 GB (32 GB × 8) DIMM DDR4 Synchronous Registered (Buffered) 2666Mhz ■ 1 × 64 GB SATADOM	BIOS:3A10.H3 BMC: 3.75.06 CPLD:10	2
	■ 1 × Intel Corporation Ethernet Controller XXV710 for 25 GbE SFP28	■ Driver: i40en ■ Version: 1.3.1 ■ Firmware: 5.51	
	■ 1 × Emulex LightPulse LPe31002-M6 2-Port 16 Gb Fibre Channel Adapter	Boot: 11.2.154.0 Firmware: 11.2.156.27 Driver: 11.1.0.6	
Brocade Fibre Channel Switches	■ G620 ■ 48 port Fibre Channel switch ■ 16 Gbps SFPs ■ Brocade hot-pluggable SFP+, LC connector	Kernel: 2.6.34.6 Fabric OS: v8.2.0b	2

TABLE 1. HARDWARE COMPONENTS (CONTINUED)

Hardware	Detailed Description	Firmware/Version	Quantity
Cisco Nexus	■ 93180YC-EX ■ 48 × 10/25 GbE fiber ports ■ 6 × 40/100 Gbps Quad SFP (QSFP28) ports	BIOS: version 07.61 NXOS: version 7.0(3)I4(7)	2
Cisco Nexus	■ 3048TP ■ 1 GE 48-Port Gb Ethernet Switch	BIOS: version 4.0.0 NXOS: version 7.0(3)I4(7)	2

Note that spare drives are recommended for production environments.

Certain components may be optional depending on the existing infrastructure and required interconnect topology. This may include the SAN, IP switches, and/or the management servers.

However, this documents the environment tested in the lab to support a full deployment of the architecture including supporting components.

TABLE 2. SOFTWARE COMPONENTS FOR COMPUTE NODES

Software	Version	Function
Red Hat Enterprise Linux	RHEL 7.5 (With Kernel Version - 3.10.0-862.9.1.el7.x86_64)	Operating System
Oracle 12c	12c Release 2 (12.2.1.0)	Database Software
Oracle Real Application Cluster	12c Release 2 (12.2.1.0)	Cluster Software
Oracle Grid Infrastructure	12c Release 2 (12.2.1.0)	Volume Management, File System Software, and Oracle Automatic Storage Management
Red Hat Enterprise Linux Device Mapper Multipath	-	Multipath Software

TABLE 3. SOFTWARE COMPONENTS FOR MANAGEMENT NODES

Software	Version	Function
VMware ESXi	Version 6.5.0 Build 6765664	ESXi for management nodes
VMware vCenter Server	Version 6.5.0 build 7515524	Management cluster
Hitachi Storage Advisor (HSA)	2.3	Storage orchestration software
Hitachi Infrastructure Analytics Advisor (HIAA)	4.0.0-00	Analytics Software
Manager for Hitachi adapters for Oracle Database	2.2.3	Hitachi adapters management Virtual appliance software
Hitachi Storage Adapter for Oracle Enterprise Manager	2.2.3	Storage management software

TABLE 3. SOFTWARE COMPONENTS FOR MANAGEMENT NODES (CONTINUED)

Software	Version	Function
Hitachi Server Adapter for Oracle Enterprise Manager	2.2.3	Server management software
Oracle Enterprise Manager Cloud Control 13c	13c Release 2 (13.2.0.0)	OEM software
Oracle Enterprise Manager Cloud Control 13c plug-ins	13c Release 2	Hitachi Storage and Server OEM plugins

Hitachi Virtual Storage Platform G1500

Hitachi Virtual Storage Platform G1500 (VSP G1500) is an enterprise storage platform. It enables continuous operations, self-managing policy-driven management, and agile IT for cloud applications. Global storage virtualization enables an always-on infrastructure with enterprise-wide scalability. An ideal solution for applications that require zero recovery point and recovery time objectives, Virtual Storage Platform G1500 redefines mission-critical storage virtualization to reset expectations for the data center.

Virtual Storage Platform G1500 is equipped with the virtual storage directors. These directors use Intel Xeon 2.3GHz 8-core microprocessors to efficiently manage the following:

- Front-end and back-end directors
- PCI-Express interface
- Local memory
- Communication between the service processors

Virtual Storage Platform G1500, used in this reference architecture, supports Oracle Real Application Clusters.

Hitachi Storage Virtualization Operating System

Hitachi Storage Virtualization Operating System (SVOS) spans and integrates multiple platforms. It integrates storage system software to provide system element management and advanced storage system functions. Used across multiple platforms, Storage Virtualization Operating System includes storage virtualization, thin provisioning, storage service level controls, dynamic provisioning, and performance instrumentation.

Storage Virtualization Operating System includes standards-based management software on a Hitachi Command Suite (HCS) base. This provides storage configuration and control capabilities for you.

FMD-HDE Drive Features

Hitachi Accelerated Flash

Hitachi Accelerated Flash features a flash module built specifically for enterprise-class workloads. Developed for Hitachi Virtual Storage Platform, Accelerated Flash is available for Hitachi Unified Storage VM and Hitachi Virtual Storage Platform family.

Accelerated Flash features innovative Hitachi-developed embedded flash memory controller technology. Hitachi flash acceleration software speeds I/O processing to increase flash device throughput.

Hitachi Accelerated Flash provides a reliable data storage for the Oracle database file placement with fast data retrieval for the OLTP workload.

FMD Encryption License Key

With the FMD Encryption License Key, the FMD-HDE drives generate and retain the media encryption keys and encrypt and decrypt the data. The media encryption keys used by the FMD-HDE drives are encrypted internally, and they cannot be viewed or output. After successful certification using a certification key, data can be written to and read from these drives. To use FMD Encryption License Key, the software license key and FMD-HDE drives are required.

The FMD Encryption License Key feature enables you to encrypt the data in accelerated compression-enabled parity groups.

Data at-rest encryption (DARE) provided by FMD Encryption License Key

The FMD-based DARE functionality is implemented using cryptographic hardware (chips) that reside on the FMD-HDE drives themselves. The FMD-HDE drives encrypt and decrypt data as it is being written to or read from the drives.

As with Encryption License Key, FMD-based DARE is implemented at the parity group level. The FMD-HDE parity groups can be configured on regular (non-encrypting) BEDs or EBEDs. When the FMD-HDE drives are configured on an EBED, encryption and decryption are performed by the FMD-HDE drives. The spare drives for FMD-HDE parity groups must be FMD-HDE drives.

Hitachi Advanced Server DS240 Server

Hitachi Advanced Server DS240 is a high-performance four socket rackmount server designed for optimal performance and power efficiency. This allows owners to upgrade computing performance without overextending power consumption and offers non-latency support to virtualization environments that require the maximum memory capacity. Hitachi Advanced Server DS240 provides flexible I/O scalability for today's diverse data center application requirements.

Hitachi Advanced Server DS120 Server

Hitachi Advanced Server DS120 provides flexible and scalable configurations for hyper-converged datacenters, provides unleashing computing performance, sophisticated power and thermal design to avoid unnecessary OPEX with quick deployment. For this solution two DS120 servers are used. The two DS120 servers are configured as a VMware vCenter cluster. Virtual machines on the cluster are used to host management applications. The management applications installed depend on customer needs and requirements. The following applications were installed in individual virtual machines in this architecture and would be installed in most cases.

- vCenter
- Oracle Enterprise Manager (OEM) 13c
- Hitachi Storage Adapter for Oracle Enterprise Manager
- Hitachi Server Adapter for Oracle Enterprise Manager
- Oracle Adapter Manager
- Hitachi Storage Advisor (HSA)
- Hitachi Infrastructure Analytics Advisor / Hitachi Datacenter Analytics (HIAA/HDCA)
- HDCA Probe

Other management applications may be installed on additional virtual machines depending on customer needs and requirements.

Red Hat Enterprise Linux

Red Hat Enterprise Linux delivers military-grade security, 99.999% uptime, support for business-critical workloads, and so much more. Ultimately, the platform helps you reallocate resources from maintaining the status quo to tackling new challenges.

Device Mapper Multipathing

Device mapper multipathing (DM-Multipath) allows you to configure multiple I/O paths between server nodes and storage arrays into a single device.

These I/O paths are physical SAN connections that can include separate cables, switches, and controllers. Multipathing aggregates the I/O paths, creating a new device that consists of the aggregated paths.

Oracle Database With the Real Application Clusters Option

Oracle Database has a multi-tenant architecture so you can consolidate many databases quickly and manage them as a cloud service. Oracle Database also includes in-memory data processing capabilities for analytical performance. Additional database innovations deliver efficiency, performance, security, and availability. Oracle Database comes in two editions: Enterprise Edition and Standard Edition 2.

Oracle Real Application Clusters (Oracle RAC) is a clustered version of Oracle Database. It is based on a comprehensive high-availability stack that can be used as the foundation of a database cloud system, as well as a shared infrastructure. This ensures high availability, scalability, and agility for any application.

Oracle Automatic Storage Management (Oracle ASM) is a volume manager and a file system for Oracle database files. This supports single-instance Oracle Database and Oracle Real Application Clusters configurations. Oracle ASM is the recommended storage management solution that provides an alternative to conventional volume managers, file systems, and raw devices.

Hitachi Infrastructure Analytics Advisor

With Hitachi Infrastructure Analytics Advisor, you can define and monitor storage service level objectives (SLOs) for resource performance. You can identify and analyze historical performance trends to optimize storage system performance and plan for capacity growth.

Use Hitachi Infrastructure Analytics Advisor to register resources (storage systems, hosts, servers, and volumes), and set service-level thresholds. You are alerted to threshold violations and possible performance problems (bottlenecks). Using analytics tools, you find which resource has a problem and analyze its cause to help solve the problem. The Infrastructure Analytics Advisor ensures the performance of your storage environment based on real-time SLOs.

Hitachi Storage Advisor

Hitachi Storage Advisor is an infrastructure management solution that unifies storage management solutions such as storage provisioning, data protection, and storage management; simplifies the management of large scale data centers by providing smarter software services; and is extensible to provide better programmability and better control.

Oracle Enterprise Manager

Oracle Enterprise Manager provides a “single pane of glass” that allows you to manage on-premises and cloud-based IT using the same familiar interface you know and use on-premises every day. Oracle Enterprise Manager today is the nerve center of IT operations among thousands of enterprises. Millions of assets in Oracle’s SaaS and PaaS public cloud operations are managed by Enterprise Manager round the clock.

Enterprise Manager is the industry's first complete cloud solution with Cloud Management. This includes self-service provisioning balanced against centralized, policy-based resource management, integrated chargeback and capacity planning, and complete visibility of the physical and virtual environments from applications to disk.

This solution uses Oracle Enterprise Manager Cloud Control, version 13c release 2. This allows you to use these cloud management features:

- Use the Database Cloud Self Service Portal
- Benefit from the Improved Service Catalog
- Perform Snap Cloning using "Test Master Snapshot"
- Take advantage of the Chargeback and Consolidation Planner plugins

For more information, see New Features in Oracle Enterprise Manager Cloud Control 13c

Hitachi Storage Adapter for Oracle Enterprise Manager

Hitachi Storage Adapter for Oracle Enterprise Manager presents an integrated, detailed view of the Hitachi storage supporting your Oracle databases. By gaining visibility into capacity, performance and configuration information, administrators can manage service levels more effectively, and ensure service level agreements (SLAs) are met to support business goals.

Hitachi Server Adapter for Oracle Enterprise Manager

Hitachi Server Adapter for Oracle Enterprise Manager is an Oracle Enterprise Manager plug-in that enables monitoring of Hitachi Advanced servers in Oracle Enterprise Manager.

For Hitachi Advanced servers, it provides visibility into the components, including their status, health, and attributes. In addition, the adapter supplies information about any Oracle database instances running on the servers. Both RAC and non-RAC databases are supported.

VMware ESXi

VMware ESXi is the next-generation hypervisor, providing a new foundation for virtual infrastructure. This innovative architecture operates independently from any general-purpose operating system, offering improved security, increased reliability, and simplified management.

VMware vCenter Server Appliance

The VMware vCenter Server Appliance is a preconfigured Linux virtual machine, which is optimized for running VMware vCenter Server and the associated services on Linux.

vCenter Server Appliance comes as an Open Virtualization Format (OVF) template. The appliance is imported to an ESXi host and configured through the web-based interface. It comes pre-installed with all the components needed to run a vCenter Server, including vCenter SSO (Single Sign-on), Inventory Service, vSphere Web Client and the vCenter Server itself.

Brocade Switches

Brocade and Hitachi Vantara partner to deliver storage networking and data center solutions. These solutions reduce complexity and cost, as well as enable virtualization and cloud computing to increase business agility.

SAN switches are optional and direct connect is also possible under certain circumstances, but customers should check the support matrix to ensure support prior to implementation.

The solution uses Brocade G620 Fibre Channel switches.

Cisco Switches

The Cisco Nexus Switch product line provides a series of solutions that attempt to make it easier to connect and manage disparate data center resources with software-defined networking (SDN). Leveraging the Cisco Unified Fabric, which unifies storage, data and networking (Ethernet/IP) services, the Nexus Switches create an open, programmable network foundation built to support a virtualized data center environment.

The solution uses the following Cisco products:

- Nexus 93180YC-EX, 48-port 10/25 GbE switch
- Nexus 3048TP, 48-port 1GbE Switch

Solution Design

This describes the reference architecture environment to implement Hitachi Unified Compute Platform CI for Oracle with the Real Application Clusters option. The environment uses Hitachi Virtual Storage Platform G1500.

The infrastructure configuration includes the following:

- **Oracle RAC Servers** -There are two server nodes configured in an Oracle Real Application Cluster.
- **Storage System -** There are VVOLs mapped to each port that are presented to the server as LUNs.
- **SAN Connection** - There are SAN connections to connect the Fibre Channel HBA ports to the storage through Brocade G620 switches.

Storage Architecture

This describes the storage architecture for this solution.

Storage Configuration

The storage configuration takes into consideration Hitachi Vantara for Hitachi Virtual Storage Platform and Oracle recommended best practices for the design and deployment of database storage.

The high-level storage configuration diagram for this solution is shown in Figure 2.

Figure 2

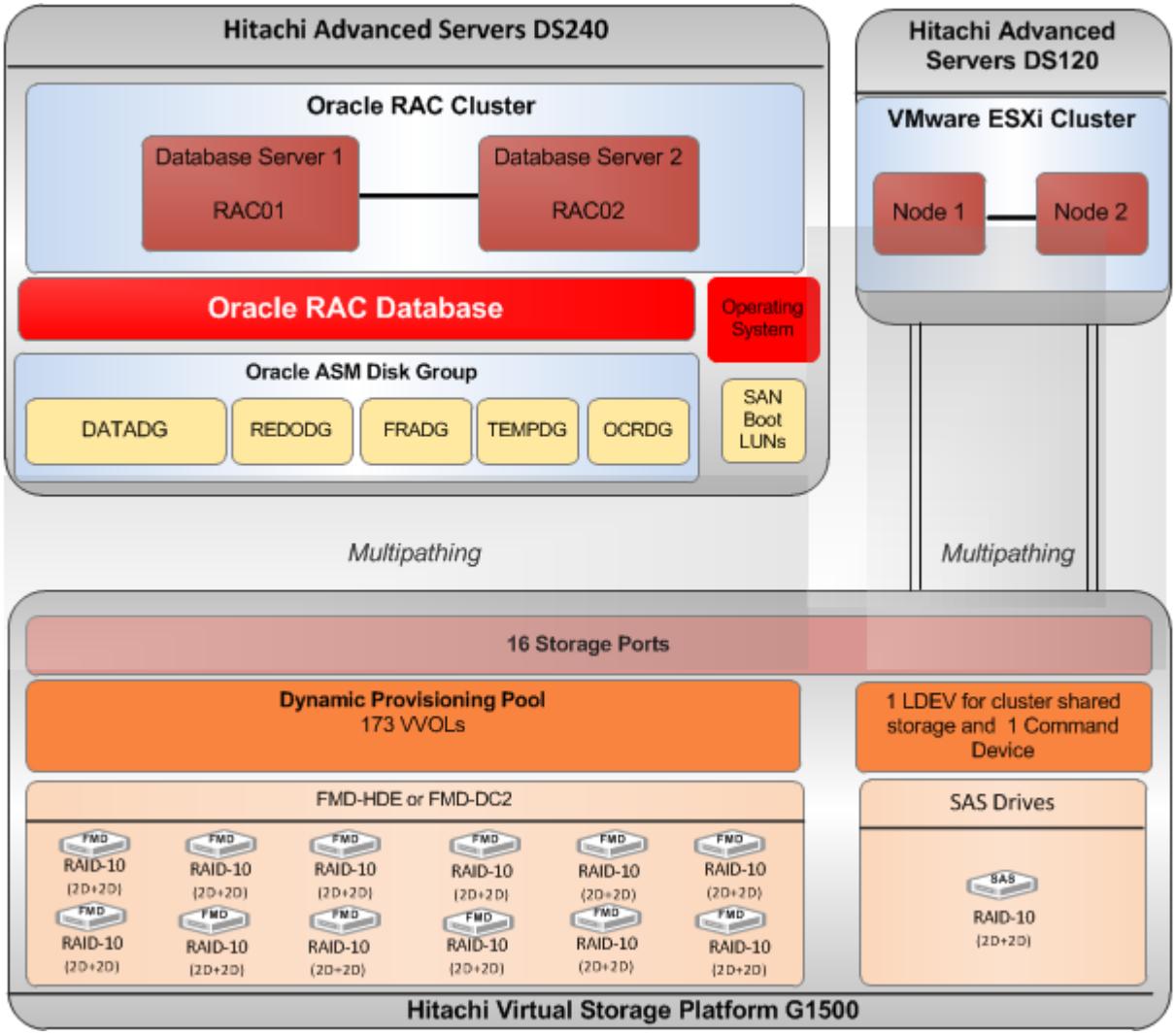


Table 4 shows the storage pool configuration used for this solution and lab verification. Pool 'FMC-Oracle' was used for Oracle TDE vs. self-encryption FMD comparison tests.

TABLE 4. STORAGE POOL CONFIGURATION

Pool Name	FMC-Oracle (FMD-DC2)	HDE-Oracle (FMD-HDE)
Pool Type	Dynamic Provisioning	Dynamic Provisioning
RAID Group	1-1 – 1-6, 2-1 – 2-6	5-1 – 5-6, 6-1 – 6-6
RAID Level	RAID-10 (2D+2D)	RAID-10 (2D+2D)

TABLE 4. STORAGE POOL CONFIGURATION (CONTINUED)

Drive Type	7 TB FMD-DC2	7 TB FMD-HDE
Number of Drives	48	48
Number of Spare Drives	2	2
Number of Pool Volume LDEVs	384	384
Pool Volume LDEV size	409.20 GB	409.20 GB
Physical Pool Capacity	152.19 TB	152.19 TB
Pool Capacity	225.43 TB	225.43 TB

Note — Pool Capacity refers to the guaranteed usable capacity with HAF compression feature. It is larger than the physical pool capacity.

There were two sets of identical VVOLs created during the lab verification, one from pool 'FMC-Oracle' and another from pool 'HDE-Oracle'. Table 5 shows the logical storage configuration for pool 'HDE-Oracle'.

The information in Table 5 – Table 8 also reflects the design for the FMD-DC2 configuration.

TABLE 5. LOGICAL STORAGE CONFIGURATION

Pool Name	HDE-Oracle (FMD-HDE)
Number of VVOLs	173

TABLE 5. LOGICAL STORAGE CONFIGURATION (CONTINUED)

VVOL Size	2 × 280 GB, 128 × 180 GB, 3 × 5 GB, 16 × 20 GB, 8 × 240 GB, 16 × 2000 GB

Purpose	▪ Operating System
	▪ Oracle
	  ▪ System
	  ▪ Sysaux
	  ▪ Undo
	  ▪ Temp
	  ▪ Redo Logs
	  ▪ Parameter and Password file
	  ▪ Oracle Cluster Registry and Voting Disk

Storage Port	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 1B, 2B, 3B, 4B, 5B, 6B, 7B, 8B

There is an additional RAID group consisting of four 3TB 7.2k rpm SAS drives configured as RAID-10 (2D+2D). This is used as shared storage for the management server cluster. A single 3 TB LUN is mapped to four storage ports. Additional LUNs can be mapped if required. While the test environment was configured using a dedicated SAS RAID group for the management server cluster, this can be configured as a dedicated SSD RAID group, a dedicated HDP pool, or it can use capacity on the HDP pool configured for the Oracle environment depending on customer requirements.

Database Layout

The database layout design uses recommended best practices from Hitachi Vantara for Hitachi Virtual Storage Platform G1500 for small random I/O traffic, such as OLTP transactions. The layout also takes into account Oracle ASM best practices when using Hitachi storage. Base the storage design for database layout needs on the requirements of a specific application implementation. The design can vary greatly from one implementation to another based on the RAID configuration and number of drives used during the implementation. The components in this solution set have the flexibility for use in various deployment scenarios to provide the right balance between performance and ease of management for a given scenario.

Oracle ASM Configuration

- **Data and Indexes Tablespace** — Assign an ASM diskgroup with external redundancy for the data and index tablespaces.
- **TEMP Tablespace** — Place TEMP tablespace in this configuration in the Data ASM diskgroup.
- **Undo Tablespace** — Create an UNDO tablespace in this configuration within the Oracle Data ASM diskgroup. Assign one UNDO tablespace for each node in the Oracle RAC environment.
- **Online Redo Logs** — Create ASM diskgroup with external redundancy for Oracle online redo logs.
- **Oracle Cluster Registry and Voting Disk** — Create an ASM diskgroup with normal redundancy to contain the OCR and voting disks and to protect against single disk failure to avoid loss of cluster availability. Place each of these files in this configuration in the OCR ASM diskgroups.
- **Database Block Size Settings** — Set the database block size to 8 KB.
- **db_file_multiblock_read_count** — set this parameter to 64.
- **ASM FILE SYSTEM I/O Settings** — Set the Oracle ASM I/O operations for database files, as follows:

  FILESYSTEMIO_OPTIONS = setall

Table 6 shows the Oracle RAC Database Settings.

TABLE 6. ORACLE RAC DATABASE SETTINGS

Environment	Value
RAC configuration	Yes
ASM	Yes - Oracle RAC Database

Table 7 shows the Oracle Environment Parameters.

TABLE 7. ORACLE ENVIRONMENT PARAMETERS

Setting	Value
DB_CLOCK_SIZE	8 KB
SGA_TARGET	512 GB
PGA_AGGREGATE_TARGET	256 GB
DB_CACHE_SIZE	256 GB
DB_KEEP_CACHE_SIZE	64 GB
DB_RECYCLE_CACHE_SIZE	64 GB
INMEMORY_SIZE	64 GB

TABLE 7. ORACLE ENVIRONMENT PARAMETERS (CONTINUED)

Setting	Value
USE_LARGE_PAGES	TRUE
FILESYSTEMIO_OPTIONS	SETALL
DISK_ASYNCH_IO	TRUE

Table 8 shows the details of the disk mappings from the LUNs from pool 'HDE-Oracle' to the ASM disk groups for Oracle RAC Database tablespaces.

TABLE 8. LUNS AND ORACLE ASM DISK MAPPINGS

ASM Disk Group	*ASM Disk*	*DM-Multipath LUNs*	*LUN Details*	*Purpose*
N/A	N/A	/dev/mapper/mpatha	2 × 280 GB	OS Boot LUNs
OCRDG	OCRDISK1 - OCRDISK3	/dev/mapper/mpathb - /dev/mapper/mpathd	3 × 5 GB	Oracle Cluster Registry and Voting Disk
REDODG	REDODISK1 - REDODISK16	/dev/mapper/mpathe - /dev/mapper/mpathp /dev/mapper/mpathaa - /dev/mapper/mpathad	16 × 20 GB	Online REDO log group
FRADG	FRADISK1 - FRADISK16	/dev/mapper/mpathae - /dev/mapper/mpathap /dev/mapper/mpathba - /dev/mapper/mpathbd	16 × 2000 GB	Flash Recovery Area
TEMPDG	TEMPDISK1 - TEMPDISK16	/dev/mapper/mpathbe - /dev/mapper/mpathbl	8 × 240 GB	Temp
DATADG	DATADISK1 - DATADISK64	/dev/mapper/mpathbm - /dev/mapper/mpathbp /dev/mapper/mpathca - /dev/mapper/mpathcp /dev/mapper/mpathda - /dev/mapper/mpathdp /dev/mapper/mpathea - /dev/mapper/mpathep /dev/mapper/mpathfa - /dev/mapper/mpathfp /dev/mapper/mpathga - /dev/mapper/mpathgp /dev/mapper/mpathha - /dev/mapper/mpathhp /dev/mapper/mpathia - /dev/mapper/mpathip /dev/mapper/mpathja - /dev/mapper/mpathjl	128 × 180 GB	Application Data

Server and Application Architecture

This reference architecture uses two Hitachi Advanced Server DS240 servers for a two-node Oracle RAC configuration.

This provides the compute power for the Oracle RAC database to handle complex database queries and a large volume of transaction processing in parallel. Table 9 describes the details of the server configuration for this solution.

This reference architecture uses two Hitachi Advanced Server DS120 servers for *VMware ESXi* management server configuration.

Details of the VMware ESXi management servers are specified in Table 9.

TABLE 9. HITACHI ADVANCED SERVER DS240 AND DS120 SERVER SPECIFICATIONS

Hitachi Advanced Server	Server	Server Name	Role	CPU Core	RAM
DS240	Oracle Server1	oracle-rac-01	Oracle RAC node 1	24	1,536 GB (64 GB × 24)
	Oracle Server2	oracle-rac-02	Oracle RAC node 2	24	1,536 GB (64 GB × 24)
DS120	Management server 1	*VMware ESXi 1*	Hitachi Storage Advisor VM	16	128 GB (32 GB × 8)
	Management server 2	VMware ESXi 2	Hitachi Infrastructure Analytics Advisor VM Manager for Hitachi Adapters for Oracle Database VM Oracle Enterprise Manager Cloud Control 13c VM	16	128 GB (32 GB × 8)

SAN Architecture

Map the provisioned LDEVs to multiple ports on Hitachi Virtual Storage Platform G1500 (VSP G1500). These LDEV port assignments provide multiple paths to the storage system from the host for high availability. This reference architecture uses 4 dual port Emulex HBAs per DS240 server. Configuration with 2 HBAs per server is also supported.

- 16 SAN switch connections are being used for VSP G1500 Fibre Channel ports.
- 20 SAN switch connections are being used for server HBA ports.

Table 10 shows details of the Fibre Channel switch connect configuration on the Hitachi Virtual Storage Platform G1500 ports.

TABLE 10. SAN HBA CONNECTION CONFIGURATION TO VSP G1500

Server	HBA Ports	Storage Host Group	Switch Zone	Storage System	Storage Port	Brocade G620 Switch
DS240 Server 1	HBA1_1	CN1_HBA1_1	CN1_HBA1_1_G1500_1A	VSP G1500	1A	67
	HBA1_2	CN1_HBA1_2	CN1_HBA1_2_G1500_2A		2A	68
	HBA2_1	CN1_HBA2_1	CN1_HBA2_1_G1500_3A		3A	67
	HBA2_2	CN1_HBA2_2	CN1_HBA2_2_G1500_4A		4A	68
	HBA3_1	CN1_HBA3_1	CN1_HBA3_1_G1500_5A		5A	67
	HBA3_2	CN1_HBA3_2	CN1_HBA3_2_G1500_6A		6A	68
	HBA4_1	CN1_HBA4_1	CN1_HBA4_1_G1500_7A		7A	67
	HBA4_2	CN1_HBA4_2	CN1_HBA4_2_G1500_8A		8A	68
DS240 Server 2	HBA1_1	CN2_HBA1_1	CN2_HBA1_1_G1500_1B		1B	67
	HBA1_2	CN2_HBA1_2	CN2_HBA1_2_G1500_2B		2B	68
	HBA2_1	CN2_HBA2_1	CN2_HBA2_1_G1500_3B		3B	67
	HBA2_2	CN2_HBA2_2	CN2_HBA2_2_G1500_4B		4B	68
	HBA3_1	CN2_HBA3_1	CN2_HBA3_1_G1500_5B		5B	67
	HBA3_2	CN2_HBA3_2	CN2_HBA3_2_G1500_6B		6B	68
	HBA4_1	CN2_HBA4_1	CN2_HBA4_1_G1500_7B		7B	67
	HBA4_2	CN2_HBA4_2	CN2_HBA4_2_G1500_8B		8B	68
DS120 Server 1	HBA1_1	MN1_HBA1_1	MN1_HBA1_1_G1500_7A		7A	67
	HBA1_2	MN1_HBA1_2	MN1_HBA1_2_G1500_8A		8A	68
DS120 Server 2	HBA1_1	MN2_HBA1_1	MN2_HBA1_1_G1500_7B		7B	67
	HBA1_2	MN2_HBA1_2	MN2_HBA1_2_G1500_8B		8B	68

Note — In a production environment, it is recommended to use separate storage ports for the management servers to avoid impact on the database performance. Shared storage ports can be used; however, port utilization should be monitored to avoid performance issues on high performance environments.

Network Architecture

This architecture requires the following separate networks:

- **Private Network (also called cluster interconnect)** — This network must be scalable. In addition, it must meet the low latency needs of the network traffic generated by the cache synchronization of Oracle Real Application Clusters and inter-node communication among the nodes in the cluster.
- **Public Network** — This network provides client connections to the applications and Oracle Real Application Clusters.

Hitachi Vantara recommends using pairs of 25 Gbps NICs for the cluster interconnect network and public network.

Observe these points when configuring private and public networks in your environment:

- For each server in the clusterware configuration, use at least two identical, high-bandwidth, low-latency NICs for the interconnection.
- Use NIC bonding to provide failover and load balancing of interconnections within a server.
- Set all NICs to full duplex mode.
- Use at least two public NICs for client connections to the application and database.
- Use at least two private NICs for the cluster interconnection.

Physical Network Configuration

Figure 3 shows the network configuration in this solution.

Figure 3

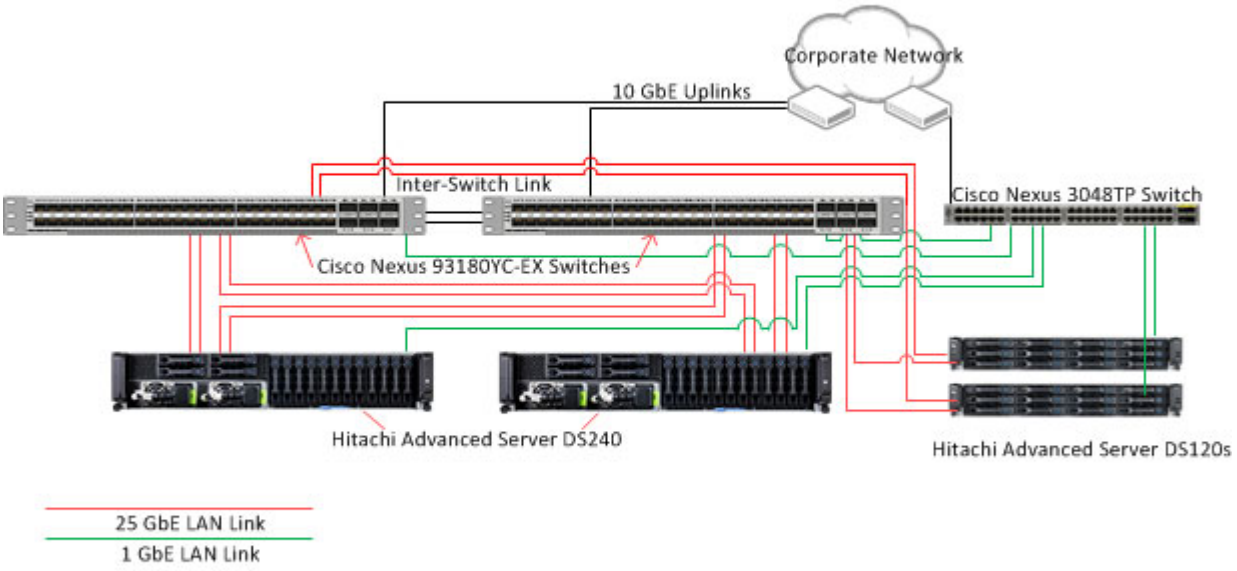


Table 11 shows the network configuration, and Table 12 shows the virtual IP address and SCAN name configuration used when testing the environment. Your values may be different.

When creating NIC Bonding pairs, ports should be used on different cards to avoid single points of failure (SPoF).

TABLE 11. NETWORK CONFIGURATION

Server	NIC Ports	VLAN/ Subnet	NIC Bond	IP Address	Network	Bandwidth (Gbps)	*Cisco Nexus 93180YC-EX Switch*	
							Switch Number	Port
DS240 Server1	NIC - 0	208	Bond0	192.168.208.91	Private	25	1	31
	NIC - 2					25	2	
	NIC - 1	242	Bond1	192.168.242.91	Public	25	1	32
	NIC - 3					25	2	
	BMC-Dedicated NIC	242	-	192.168.242.181	Public Management	1	-	
DS240 Server2	NIC - 0	208	Bond0	192.168.208.92	Private	25	1	33
	NIC - 2					25	2	
	NIC - 1	242	Bond1	192.168.242.92	Public Oracle	25	1	34
	NIC - 3					25	2	
	BMC-Dedicated NIC	242	-	192.168.242.182	Public Management	1	-	
DS120 Server1 mgmt server	BMC-Dedicated NIC	242	-	192.168.242.169	Public Management	1	-	
	NIC - 0	244	-	192.168.244.101	Public	25	1	49
DS120 Server2 mgmt server	BMC-Dedicated NIC	242	-	192.168.242.170	Public Management	1	-	
	NIC - 0	244	-	192.168.244.102	Public	25	1	50

TABLE 12. VIRTUAL IP ADDRESS AND SCAN NAME CONFIGURATION

Server	Virtual IP Address	Scan Name pub-scan
Database Server 1 (DS240 1)	192.168.242.91	192.168.242.222 192.168.242.223 192.168.242.224
Database Server 1 (DS240 2)	192.168.242.92	

Table 13 lists virtual machine configuration running on management server cluster.

TABLE 13. MANAGEMENT SERVER VIRTUAL MACHINES CONFIGURATION

Virtual Machine	vCPU	Virtual Memory	Disk Capacity	IP Address	OS
vCenter	2	10 GB	300 GB	192.168.242.102	VMware Photon Linux 1.0
OEM	16	32 GB	200 GB	192.168.242.16	RHEL 7.4
Hitachi Oracle Adapters	2	6 GB	40 - 50 GB	192.168.242.80	OL 7.3
HSA	4	16 GB	100 GB	192.168.242.81	CentOS 7.2
HIAA/HDCA	4	32 GB	800 GB	192.168.242.194	RHEL 7.3
HDCA Probe	4	10 GB	110 GB	192.168.242.197	RHEL 7.3

Hitachi Applications

The following are the Hitachi applications used for data analytics and performance monitoring during execution of this solution:

- Hitachi Infrastructure Analytics Advisor (HIAA)
- Hitachi Storage Advisor (HSA)

Hitachi Infrastructure Analytics Advisor (HIAA)

The following are the key features of Hitachi Infrastructure Analytics Advisor:

- Unified infrastructure monitoring dashboard
- Advanced reporting
- Storage I/O controls for SLO management
- System and Resource Events
- Granular Data Collection
- End-to-end monitoring

Please refer to the Hitachi Infrastructure Analytics Advisor documentation for more details.

Hitachi Storage Advisor (HSA)

Hitachi Storage Advisor is a unified software management tool that reduces the complexity of managing storage systems by simplifying the setup, management, and maintenance of storage resources.

Some of the key Storage Advisor capabilities include:

- Simplified user experience for managing infrastructure resources.
- Recommended system configurations to speed initial storage system setup and accelerate new infrastructure resource deployments.
- Integrated configuration workflows with Hitachi Vantara recommended practices to streamline storage provisioning and data protection tasks.
- Common, centralized management for supported storage systems.
- A REST-based API to provide full management programmability and control in addition to unified file-based management support.
- Storage Advisor enables automated SAN zoning during volume attaches and detach. Optional auto-zoning eliminates the need for repetitive zoning tasks to be performed on the switch.

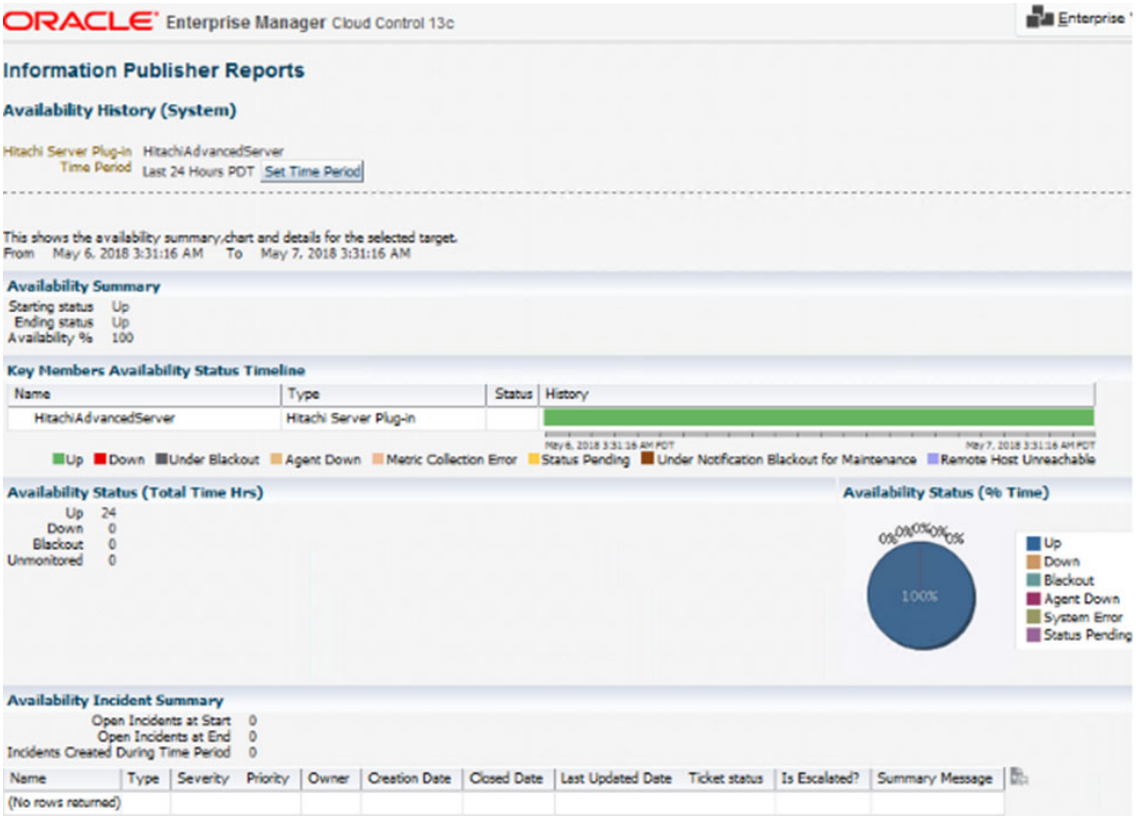
Please refer to the Hitachi Storage Advisor documentation for more details.

Hitachi Server Adapter for Oracle Enterprise Manager

Hitachi Server Adapter for Oracle Enterprise Manager shows the availability summary chart and details for the selected target when the Hitachi Server Adapter plugin is installed in Oracle Enterprise Manager.

Figure 4 shows a System availability history report.

Figure 4



Engineering Validation

This summarizes the key observations from the test results for the Hitachi Unified Compute Platform CI architecture for Oracle RAC deployment with Hitachi Virtual Storage Platform G1500 and Hitachi Advanced Server DS240.

Test Methodology

The test results are demonstrated using Oracle Orion and peakmarks tools.

Oracle Orion

Oracle Orion is a tool for predicting the performance of an Oracle database without having to install Oracle or create a database. Unlike other I/O calibration tools, Oracle Orion is expressly designed for simulating Oracle database I/O workloads using the same I/O software stack as Oracle. Orion can also simulate the effect of striping performed by Oracle Automatic Storage Management.

For more information about Orion, see “I/O Configuration and Design” in the Oracle Database Performance Tuning Guide.

peakmarks

peakmarks is the leading benchmark software for Oracle platforms that is used for the following:

- Performance verification (quality assurance)
- Evaluation of different infrastructure products, technologies, and solutions (price/performance comparison)
- Performance optimization (improvement in efficiency)

This provides transparency and comparability in price versus performance considerations for Oracle infrastructures.

The peakmarks 9.2 tool is used to validate this solution.

Database Configuration

Table 14 shows parameter details for two-node Oracle Real Application Clusters ASM database.

TABLE 14. ORACLE DATABASE CONFIGURATION

Oracle Database Parameter	Value
compatible	12.2.1.0
cluster_database	TRUE
cluster_database_instances	2
Oracle Database size	16 TB
Database Storage Type	ASM
Database fill factor	80%

Test Results

Table 15 and Table 16 list the single-instance & two-instance RAC database results from Orion & peakmarks test cases used to validate this solution with FMD-HDEs.

TABLE 15. ORACLE ORION TEST RESULTS WITH FMD-HDE

Test Case	Test / Workload type	Metric	Single Instance	Two Instances
1	Storage performance - 100% OLTP Random Read (8k)	Max. IO/s	1,103,489	1,873,556
		Avg. RT (ms)	0.89	0.82
2	Storage performance - 100% OLTP Random Writes (8k)	Max. IO/s	726,642	770,611
		Avg. RT (ms)	1.09	1.00

TABLE 15. ORACLE ORION TEST RESULTS WITH FMD-HDE (CONTINUED)

Test Case	Test / Workload type	Metric	Single Instance	Two Instances
3	Storage performance - 100% OLAP Sequential Reads (1024K)	Max. Throughput (GB/s)	12.28	23.01
4	Storage performance - 100% OLAP Sequential Writes (1024K)	Max. Throughput (GB/s)	12.28	12.82

Table 16 lists the results of peakmarks test cases used to validate this solution.

TABLE 16. PEAKMARKS TEST RESULTS WITH FMD-HDE

Test Case	Test / Workload type	Metric	Single Instance	Two Instances
1	Storage performance random read (STO-RR)	IO/s	495,781	813,433
		Avg. RT (ms)	0.82	1.08
2	Storage performance random write (STO-RWF)	IO/s	384,956	575,701
		Avg. RT (ms)	1.10	0.75
3	Storage performance sequential read (STO-SR)	Max. Throughput (GB/s)	11.59	19.85
4	Storage mixed random read write (STO-MIX 20% update ratio)	Total IO/s	421,758	553,658
		Avg. RT (ms)	0.89	0.68
5	Database medium OLTP select performance - 25 rows per transaction (DBX-S25)	Throughput in transactions per second	21,014	40,995
		Throughput in rows per second	583,909	1,024,872
		Avg. RT for SQL statement (ms)	5.44	6.17

TABLE 16. PEAKMARKS TEST RESULTS WITH FMD-HDE (CONTINUED)

Test Case	Test / Workload type	Metric	Single Instance	Two Instances
6	Database medium OLTP update performance - 25 rows per transaction (DBX-U25)	Throughput in Transactions per second	6,161	8,485
		Throughput in Rows per second	154,023	212,130
		Avg. RT for SQL statement (ms)	20.60	29.67
7	Server performance test - OLTP 25 rows per transaction(SRV-S25)	Throughput in transactions per core per second	21,014	20,517
		Throughput in rows per second	504,335	984,816
		Throughput in logical buffer reads per second	12,096,655	22,306,007
		Avg. RT for SQL statement (ms)	0.13	0.28
8	CPU processor performance test - Arithmetic ADD operation (CP2-SA)	Throughput in operations per second	71,699,244,609	103,234,423,164
		Operations per core per second	2,987,468,525	2,150,717,149

* STO-RR results were limited by the number of CPU cores as we are using 6C Intel 6128 CPUs for this reference architecture.

Table 17 lists the single-instance database results from peakmarks test cases used to compare database performance and HDP pool compression ratios between self-encrypting FMD-HDE and Oracle TDE with FMD-DC2. Oracle TDE AES256 was enabled on peakmarks benchmark tablespaces with FMD-DC2. With FMD-HDE, AES256 was used for the self-encryption.

TABLE 17. SINGLE INSTANCE PEAKMARKS TEST RESULTS - SELF-ENCRYPTING FMD-HDE AND ORACLE TDE WITH FMD-DC2

Test Case	*Test / Workload type*	*Metric*	*FMD-HDE*	*Oracle TDE with FMD-DC2*
1	Storage performance random read (STO-RR)	IO/s	495,781	401,828
		Avg. RT	0.82	0.88

TABLE 17. SINGLE INSTANCE PEAKMARKS TEST RESULTS - SELF-ENCRYPTING FMD-HDE AND ORACLE TDE WITH FMD-DC2 (CONTINUED)

Test Case	*Test / Workload type*	*Metric*	*FMD-HDE*	*Oracle TDE with FMD-DC2*
2	Storage performance random write (STO-RWF)	IO/s	384,956	202,910
		Avg. RT (ms)	1.10	0.95
3	Storage performance sequential read (STO-SR)	Max. Throughput (GB/s)	11.59	11
4	Storage mixed random read write (STO-MIX 20% update ratio)	Total IO/s	421,758	382,184
		Avg. RT (ms)	0.89	0.91
5	Database medium OLTP select performance - 25 rows per transaction (DBX-S25)	Throughput in transactions per second	21,014	20,979
		Throughput in rows per second	583,909	524,449
		Avg. RT for SQL statement (ms)	5.44	6.04
6	Database medium OLTP update performance - 25 rows per transaction (DBX-U25)	Throughput in transactions per second	6,161	5,443
		Throughput in rows per second	154,023	136,077
		Avg. RT for SQL statement (ms)	20.60	23.25
7	Server performance test - OLTP 25 rows per transaction(SRV-S25)	Throughput in transactions per core per second	21,014	20,003
		Throughput in rows per second	504,335	480,071
		Throughput in logical buffer reads per second	12,096,655	12,189,022
		Avg. RT for SQL statement (ms)	0.13	0.13

TABLE 17. SINGLE INSTANCE PEAKMARKS TEST RESULTS - SELF-ENCRYPTING FMD-HDE AND ORACLE TDE WITH FMD-DC2 (CONTINUED)

Test Case	*Test / Workload type*	*Metric*	*FMD-HDE*	*Oracle TDE with FMD-DC2*
8	CPU processor performance test - Arithmetic ADD operation (CP2-SA)	Throughput in operations per second	71,699,244,609	71,954,276,253
		Operations per core per second	2,987,468,525	2,998,094,844
9	HDP Pool Compression Ratio		5.98	1.93:1

Table 18 lists the single-instance database results from peakmarks test cases used to compare database performance and HDP pool compression ratios between self-encrypting FMD-HDE with compression and FMD-DC2 without encryption or compression. With FMD-HDE, AES256 was used for the self-encryption.

TABLE 18. SINGLE INSTANCE PEAKMARKS TEST RESULTS - SELF-ENCRYPTING SELF-COMPRESSION FMD-HDE AND FMD-DC2 WITHOUT ENCRYPTION OR COMPRESSION

Test Case	Test / Workload type	Metric	FMD-HDE	FMD-DC2
1	Storage performance random read (STO-RR)	IO/s	495,781	474,323
		Avg. RT	0.82	0.93
2	Storage performance random write (STO-RWF)	IO/s	384,956	387,890
		Avg. RT (ms)	1.10	1.10
3	Storage performance sequential read (STO-SR)	Max. Throughput (GB/s)	11.59	11.06
4	Storage mixed random read write (STO-MIX 20% update ratio)	Total IO/s	421,758	423,876
		Avg. RT (ms)	0.89	0.88
5	Database medium OLTP select performance - 25 rows per transaction (DBX-S25)	Throughput in transactions per second	21,014	23,229
		Throughput in rows per second	583,909	580,750
		Avg. RT for SQL statement (ms)	5.44	5.48

TABLE 18. SINGLE INSTANCE PEAKMARKS TEST RESULTS - SELF-ENCRYPTING SELF-COMPRESSION FMD-HDE AND FMD-DC2 WITHOUT ENCRYPTION OR COMPRESSION (CONTINUED)

Test Case	Test / Workload type	Metric	FMD-HDE	FMD-DC2
6	Database medium OLTP update performance - 25 rows per transaction (DBX-U25)	Throughput in transactions per second	6,161	5,994
		Throughput in rows per second	154,023	149,856
		Avg. RT for SQL statement (ms)	20.60	21.2
7	Server performance test - OLTP 25 rows per transaction(SRV-S25)	Throughput in transactions per core per second	21,014	21,244
		Throughput in rows per second	504,335	509,860
		Throughput in logical buffer reads per second	12,096,655	11,836,291
		Avg. RT for SQL statement (ms)	0.13	0.13
8	CPU processor performance test - Arithmetic ADD operation (CP2-SA)	Throughput in operations per second	71,699,244,609	71,308,876,971
		Operations per core per second	2,987,468,525	2,971,203,207
9	HDP Pool Compression Ratio		5.98	N/A

Conclusions

- As seen in Table 17, Hitachi FMD HDE does not cause Oracle database performance degradation when HAF Compression and Encryption features are both enabled.
- As seen in Table 18, Hitachi FMD HDE can achieve good compression ratios without impacting Oracle database performance by using compression before encryption mechanism.
- As seen in Table 17, use of Oracle TDE will have overhead, and use of FMD-HDE will not. Server or application based encryption requires additional host CPU cycles which means higher standard Oracle database license costs beside the costs from TDE license.
- UCP CI for Oracle with Hitachi VSP G1500 is capable of delivering very high performance to Oracle databases with low core count Intel CPUs and data encryption and compression processed within Hitachi FMD-HDE.

Hitachi Vantara

Corporate Headquarters
2845 Lafayette Street
Santa Clara, CA 96050-2639 USA
HitachiVantara.com | community.HitachiVantara.com

Contact Information
USA: 1-8000446-0744
Global: 1-858-547-4526
HitachiVantara.com/contact

MK-SL-125-00, November 2018