HITACHI
Inspire the Next

ARCHITECTURE GUIDE

Hitachi Solution for Databases - Oracle XaaS Cloud Foundation based on Hitachi Advanced Server DS220 and Hitachi Virtual Storage Platform G900

Reference Architecture Guide

By Jigisha Pathak

July 2018

Feedback

Hitachi Vantara welcomes your feedback. Please share your thoughts by sending an email message to SolutionLab@HitachiVantara.com. To assist the routing of this message, use the paper number in the subject and the title of this white paper in the text.

Revision History

Revision	Changes	Date
MK-SL-080-00	Initial release	June 26, 2018
MK-SL-080-01	Update incorrect cross-reference to Table 9.	July 3, 2018
MK-SL-080-02	Update the driver version Hitachi Advanced Server DS220 servers in Table 1.	July 5, 2018

Table of Contents

Hitachi Solution for Databases - Oracle XaaS Cloud Foundation based on Hitachi Advanced Server DS220 and Hitachi Virtual Storage Platform G900

Reference Architecture Guide

Use Hitachi Solution for Databases with Oracle Cloud for a XaaS foundation to provide reliability, high availability, scalability, and performance while processing small to large Oracle workloads. This reference architecture guide is a validated cloud solution for Oracle Database 12c running on Oracle VM 3.4.4, with virtual machines using Oracle Linux 7.4.

Oracle Cloud for a XaaS foundation is fast, agile, and aims to be a more efficient use of resources. Cloud deployment aims for IT transformation. You want a fast and flexible journey to reduce cost, quickly scale up or down, and—most importantly—be easy and intuitive.

This solution integrates many innovative technologies from Hitachi Vantara and Oracle. To create an Oracle Database cloud service, this environment uses the following:

- Hitachi Unified Compute Platform CI
- Oracle VM
- Oracle Enterprise Manager (OEM) Cloud Control 13c.

Unified Compute Platform CI includes the following:

- Hitachi Virtual Storage Platform G900 (VSP G900)
- Hitachi Advanced Server DS220 with Intel Xeon Gold 6140 processors for storage and computing resources
- Hitachi Advanced Server DS120 with Intel Xeon Silver 4110 processors for the management servers.

This solution provides a base to migrate to Oracle Database Cloud service:

- Quick database deployment in the cloud
- Validation of virtual machine configurations
- Central monitoring of Hitachi storage and servers, virtual machines, database, and applications

This solution provides the flexibility to select storage and compute resources based on unique requirements. Deploy small databases as well as huge databases, depending on resource availability.

As a cloud solution, this environment provides the following:

- Simple provisioning
- Chargeback or showback
- A centralized user interface using Oracle Enterprise Manager Cloud Control 13c.

More details on these features are provided “Database Deployment” in Hitachi Cloud Foundation for Oracle Database Reference Architecture Guide.

This document is for the following audiences:

- Database administrators
- Storage administrators
- System administrators

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

- Hitachi Virtual Storage Platform G900
- Hitachi Advanced Server DS220 servers
- Hitachi Advanced Server DS120 servers
- Hitachi adapters for Oracle Database[1]
- Storage area networks
- Oracle Database administration
- Oracle Database 12c Release 2 with Oracle RAC option
- Oracle Linux
- Oracle VM
- Oracle Enterprise Manager Cloud Control13c

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

Solution Overview

Use this reference architecture to implement Hitachi Solution for Databases with Oracle Cloud for a XaaS foundation on Hitachi Unified Compute Platform CI for Oracle Database.

Business Benefits

Oracle VM provides the foundation for the cloud infrastructure. It provides fully integrated enterprise management from disk to applications to cloud. It provides rapid enterprise application deployment with Oracle VM templates.

This solution uses an Oracle VM server pool created with multiple Hitachi Advanced Server DS220 servers to deploy virtual machines for an Oracle RAC database. Oracle Cloud for a XaaS foundation provides the flexibility to add or remove servers in the Oracle VM server pool, based on business requirements.

Configure Oracle Enterprise Manager Cloud Control 13c to self-provision and administer the integrated technology stack, including storage, Oracle virtual machines, and Oracle databases.

1. The full list of adapters is in the Oracle Tools and Adapters from Hitachi Vantara section.

Hitachi Advanced Server DS120 uses VMware ESXi and VMware vCenter Server Appliance (VCSA) to deploy virtual machines on the management server cluster. The management servers host the following management applications running on virtual machines:

- Oracle VM Manager
- Oracle Enterprise Manager
- Manager for Hitachi adapters for Oracle Database
- Hitachi Infrastructure Analytics Advisor

You can deploy the manager for Hitachi adapters for Oracle Database as a virtual appliance in VMware ESXi and Oracle VM. Additional management server virtual machines can be deployed, if needed.

High Level Infrastructure

Hitachi Solution for Database with Oracle Cloud for a XaaS foundation includes the following components:

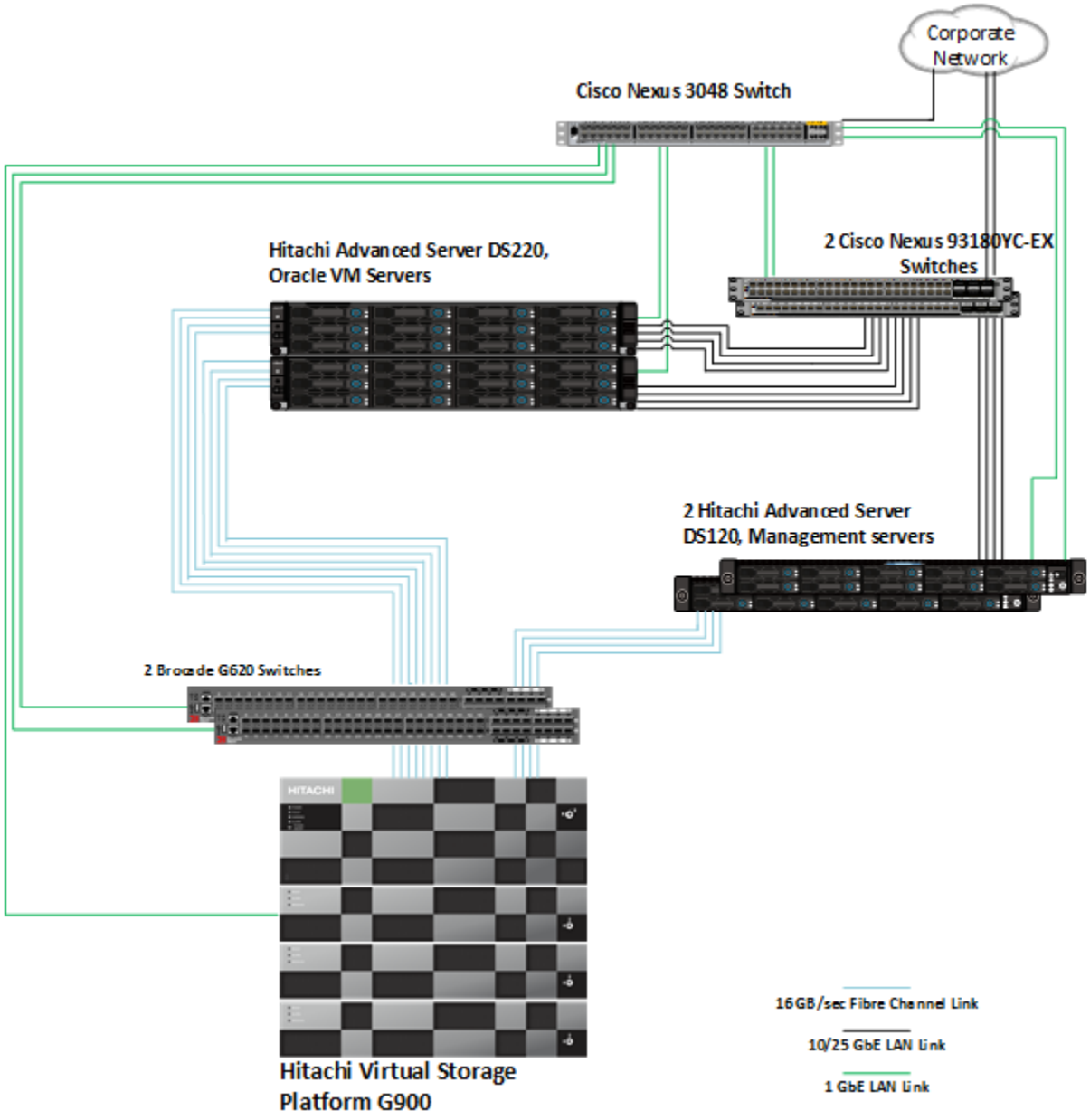
- Hitachi Advanced Server DS220 servers
- Hitachi Advanced Server DS120 servers
- Hitachi Virtual Storage Platform G900 (VSP G900)
- Brocade G620 16 Gb/s SAN infrastructure
- Cisco 10/25 GbE LAN infrastructure

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

The configuration of Virtual Storage Platform G900 and Hitachi Advanced Server DS220 has 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 depends on the customer environment and requirements. The Cisco Nexus 93180YC-EX switches can support uplink speeds of 40 GbE, 100 GbE, or higher if trunked when more bandwidth is required.

Key Solution Components

The key components used for this reference architecture are listed in Table 1 and Table 2.

TABLE 1. HARDWARE COMPONENTS

Hardware	Detailed Description	Firmware/Version	Quantity
Hitachi Virtual Storage Platform G900	■ Two controllers ■ 8 × 16 Gb/s Fibre Channel ports ■ 512 GB cache memory ■ 32 × 1.9 TB SSDs plus 2 spares ■ 4 × 3 TB, 7.2k RPM SAS drives	88-01-03-60/00	1
Hitachi Advanced Server DS220 servers	■ 2 Intel Xeon Gold 6140 CPU @ 2.30 GHz ■ 768 GB (64 GB × 12) DIMM DDR4 synchronous registered (buffered), 2666 MHz	BIOS: 3A10.H3 BMC: 3.75.06 CPLD: 09	2
	■ 2 dual port 25 GbE NIC Intel XXV710 cards ■ 1 dual port 10 GbE NIC Intel X527-DA2 OCP mezzanine card	Driver: i40e Version: 1.6.21 Firmware: 5.51 0x80002bca 1.1568.0	
	■ 2 Emulex LightPulse LPe31002-M6 2-Port 16 Gb/s Fibre Channel adapter	11.2.156.27	

TABLE 1. HARDWARE COMPONENTS (CONTINUED)

Hardware	Detailed Description	Firmware/Version	Quantity
Hitachi Advanced Server DS120 server	▪ 2 Intel Xeon Silver 4110 CPU @ 2.10GHz ▪ 256 GB (32 GB × 8) DIMM DDR4 synchronous registered (buffered), 2666 MHz ▪ Additional hardware dependent on boot option**	BIOS: 3A10.H3 BMC: 3.67.06 CPLD: 10	2
	▪ 2 Dual Port 25 GbE NIC Intel XXV710 card	Driver: i40e Version: 2.1.26 Firmware: 5.51 0x80002bca 1.1568.0	
	▪ 2 Emulex LightPulse LPe31002-M6 2-port 16 Gb/s Fibre Channel adapters	11.2.156.27	
Brocade Fibre Channel G620 switches	▪ 48 ports SFP+ and 4 QSFP ports Fibre Channel switch ▪ 16 Gb/s SFPs ▪ Brocade hot-pluggable SFP+, LC connector	v8.0.1	2
Cisco Nexus 93180YC-EX	▪ 48 × 10/25 GbE SFP+ ports ▪ 6 × 40/100 Gb/s quad SFP (QSFP28) ports	BIOS: version 07.61 ▪ NXOS: version 7.0(3)I4(7)	2
Cisco Nexus 3048TP	▪ 1 GbE 48-Port Ethernet switch	▪ BIOS: Version 4.0.0 ▪ NXOS: version 7.0(3)I4(7)	1

*The solution has been tested with PCIe and OCP Mezzanine NIC cards. It is recommended to use all PCIe cards for consistency and better NIC bonding options.

**SATADOM, or SAN boot, or local boot can be used for the boot option.

TABLE 2. SOFTWARE COMPONENTS FOR COMPUTE NODES

Software	Version	Function
Oracle VM	3.4.4	Oracle virtualization software
Oracle Enterprise Linux	7.4	Guest operating system
Oracle 12c Database	12c Release 2(12.2)	Database software
Oracle 12c Grid Infrastructure	12c Release 2(12.2)	Cluster software

TABLE 3. SOFTWARE COMPONENTS FOR MANAGEMENT NODES

Software	Version	Function
VMware ESXi	Version 6.5.0.13000 Build 7515524	VMware ESXi is for management nodes
VMware vCenter Server	Version 6.5.0 build 4602587	Management cluster
Hitachi Storage Advisor (HSA)	2.3	Storage orchestration software
Hitachi Infrastructure Analytics Advisor (HIAA)	3.3	Analytics software
Hitachi Data Center Analytics (HDCA)	8.1	Storage analytics tool – virtual machine with Red Hat 7.4 operating system
Manager software	2.2.3	Management software for Hitachi adapters Oracle Database that runs on a virtual appliance
Hitachi Storage Adapter for Oracle VM	2.2.3	Storage management software
Hitachi Storage Adapter for Oracle Enterprise Manager	2.2.3	Storage management software
Hitachi Server Adapter for Oracle Enterprise Manager	2.2.3	Server management software
Hitachi Storage Adapter for Oracle Enterprise Manager – Database Cloning	2.2.3	Hitachi Storage management software
Hitachi Storage Adapter for Oracle ASM Storage Reclamation Utility	2.2.3	Hitachi Storage management software
Oracle Enterprise Manager Cloud Control 13c	13c Release 2 (13.2.0.0)	OEM software

TABLE 3. SOFTWARE COMPONENTS FOR MANAGEMENT NODES (CONTINUED)

Software	Version	Function
Oracle Enterprise Manager Cloud Control 13c plug-ins	13c Release 2	Hitachi storage and server OEM plugins
Virtual SVP (vSVP) software from Hitachi	Microcode dependent	Storage management software

Hitachi Virtual Storage Platform G Series Family

The Hitachi Virtual Storage Platform G series family enables the seamless automation of the data center. It has a broad range of efficiency technologies that deliver maximum value while making ongoing costs more predictable. You can focus on strategic projects and to consolidate more workloads while using a wide range of media choices.

The benefits start with Hitachi Storage Virtualization Operating System RF. This includes an all new enhanced software stack that offers up to three times greater performance than our previous midrange models, even as data scales to petabytes.

Virtual Storage Platform G series offers support for containers to accelerate cloud-native application development. Provision storage in seconds, and provide persistent data availability, all the while being orchestrated by industry leading container platforms. Moved these workloads into an enterprise production environment seamlessly, saving money while reducing support and management costs.

Virtual Storage Platform G900 supports Oracle Real Application Clusters.

Hitachi Virtual Storage Platform F Series Family

Use Hitachi Virtual Storage Platform F series family storage for a flash-powered cloud platform for your mission critical applications. This storage meets demanding performance and uptime business needs. Extremely scalable, its 4.8 million random read IOPS allows you to consolidate more applications for more cost savings.

Hitachi Storage Virtualization Operating System RF is at the heart of the Virtual Storage Platform F series family. It provides storage virtualization, high availability, flash optimized performance, quality of service controls, and advanced data protection. This proven, mature software provides common features, management, and interoperability across the Hitachi portfolio. This means you can reduce migration efforts, consolidate assets, reclaim space, and extend life.

Reduce risks and solve problems faster. Integrated power analytics and automation features bring artificial intelligence to your data center. Cloud-assessible monitoring tools give your product support experts access wherever they have an internet connection for fast troubleshooting and remediation.

Virtual Storage Platform F900 supports Oracle Real Application Clusters.

Hitachi Advanced Server DS220

Optimized for performance, high density, and power efficiency in a dual-processor server, Hitachi Advanced Server DS120 delivers a balance of compute and storage capacity. This rack mounted server has the flexibility to power a wide range of solutions and applications.

The highly-scalable memory supports up to 3 TB using 24 slots of 2666 MHz DDR4 RDMM. DS120 is powered by the Intel Xeon scalable processor family for complex and demanding workloads. There are flexible OCP and PCIe I/O expansion card options available. This server supports up to 12 storage devices with up to 4 NVMe.

Hitachi Advanced Server DS120 Server

With a combination of two Intel Xeon Scalable processors and high storage capacity in a 2U rack-space package, Hitachi Advanced Server DS220 delivers the storage and I/O to meet the needs of converged solutions and high-performance applications in the data center.

The Intel Xeon Scalable processor family is optimized to address the growing demands on today's IT infrastructure. The server provides 24 slots for high-speed DDR4 memory, allowing up to 3 TB of memory per node when 238 GB DIMMs are used.

The following applications were installed in individual virtual machines when testing this architecture and could be installed in most implementations.

- Oracle VM Manager
- Oracle Enterprise Manager (OEM) 13c
- Oracle Adapter Manager
- Hitachi Storage Advisor (HSA)
- Hitachi Infrastructure Analytics Advisor and Hitachi Datacenter Analytics
- Hitachi Data Center Analytics probe
- VMware vCenter
- Virtual service processor(vSVP)

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

Hitachi Infrastructure Analytics Advisor

IT analytics solutions from Hitachi include Hitachi Infrastructure Analytics Advisor. This software provides the comprehensive storage performance management and diagnostics required to optimize buisness application servers with storage system performance. Infrastructure Analytics Advisor includes the tools to properly monitor and analyze performance statistics from the application through its entire data path to the shared storage resources.

Infrastructure Analytics Advisor allows you to define custom storage service level objectives (SLOs) for performance and capacity by virtual machine or application server. Continuously monitor these SLOs to ensure compliance to service level agreements. Alerts provide early notification when exceeding service-level thresholds so for quick analysis with built-in diagnostic aids to efficiently determine the root cause of a service level problem.

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.

The solution uses the following Brocade products:

- Brocade G620, 48 port Fibre Channel

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

Cisco Switches

Cisco Nexus data center switches are built for scale, industry-leading automation, programmability, and real-time visibility.

The solution uses the following Cisco products:

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

Oracle VM

Designed for efficiency and optimized for performance, Oracle VM supports x86 and SPARC architectures and a variety of workloads, such as Linux, Microsoft® Windows®, and Oracle Solaris. In addition to solutions that are hypervisor-based, Oracle also offers virtualization built in to hardware and Oracle operating systems to deliver the most complete and optimized solution for your entire computing environment.

Oracle VM Server provides application-driven virtualization. Going beyond simple server consolidation, Oracle VM server virtualization enables rapid enterprise application deployment and simplifies lifecycle management. Oracle VM provides a foundation for Cloud. It is fully integrated virtual machine lifecycle and cloud management solution with Oracle Enterprise Manager Cloud Control 13c.

Oracle Database

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.

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. New cloud management features allow you to do the following:

- 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

Oracle Tools and Adapters from Hitachi Vantara

This solution uses these Oracle tools and adapters from Hitachi Vantara:

- **Hitachi Storage Adapter for Oracle Enterprise Manager**

  Hitachi Storage Adapter for Oracle Enterprise Manager presents an integrated, detailed view of the Hitachi storage or converged infrastructure 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 Storage Adapter for Oracle VM**

  Hitachi Storage Adapter for Oracle VM enables monitoring and managing storage for virtual machines from Oracle VM Manager.

  Provision storage for virtual machines. Instantly clone of Oracle virtual machines with storage using a single user interface that manages and monitors virtual machines and storage infrastructure.

- **Hitachi Server Adapter for Oracle Enterprise Manager**

  Hitachi Server Adapter for Oracle Enterprise Manager makes possible monitoring in Oracle Enterprise Manager of Hitachi servers. This adapter provides you visibility of the status, health, and attributes for the servers. The adapter also supplies information about any Oracle database instances running on the servers.

Solution Design

This describes the reference architecture environment to implement Hitachi Solution for Databases with Oracle Cloud for a XaaS foundation on Hitachi Unified Compute Platform CI. The environment uses Hitachi Virtual Storage Platform G900.

The infrastructure configuration includes the following:

- **Oracle VM Servers** — There are two Oracle VM Servers configured in a server pool 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 configuration to implement this solution uses best practices from the following:

- Hitachi Vantara for Hitachi Virtual Storage Platform
- Oracle for the design and deployment of database storage

Figure 2 illustrates the high-level storage configuration diagram for this solution.

Figure 2

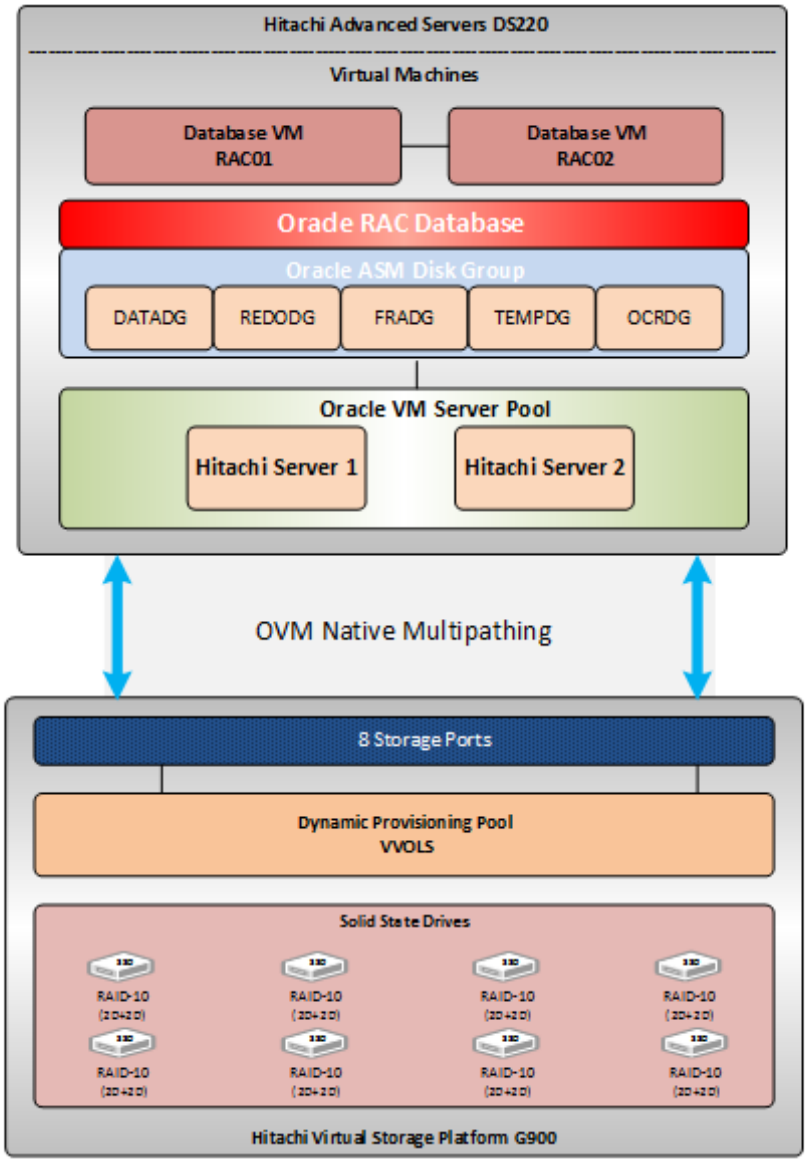


Table 4 shows the storage pool configuration used for this solution.

TABLE 4. STORAGE POOL CONFIGURATION

Pool ID	Unified Compute-Platform-Oracle
Pool Type	Dynamic Provisioning
RAID Group	1-1 – 1-8
RAID Level	RAID-10 (2D+2D)
Drive Type	1.9 TB SSDs
Number of Drives	32
Number of Spare Drives	2
Number of Pool Volume LDEVs	32
Pool Volume LDEV size	880 GB
Pool Capacity	27.5 TB

Table 5 shows the logical storage configuration used in this solution.

TABLE 5. LOGICAL STORAGE CONFIGURATION

Pool ID	Unified Compute-Platform-Oracle
Number of VVOLs	37*
VVOL Size*	2 × 200 GB, 16 × 200 GB, 3 × 5 GB, 8 × 10 GB, 4 × 200 GB, 4 × 40 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, 1B, 2B, 3A, 4A, 3B, 4B

* Less than a total of 91 LUNs were observed to provide better Oracle database virtual machine stability.

There is an additional RAID group consisting of four 3 TB, 7.2k RPM SAS drives configured as RAID-10 (2D+2D). This is shared storage for the management server cluster. Map a single 3 TB LUN 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, you can configure the management server cluster as any of the following ways, depending on your requirements:

- A dedicated SSD RAID group
- A dedicated dynamic provisioning pool
- Capacity on the dynamic provisioning pool configured for the Oracle environment

Database Layout

The database layout design uses recommended practices from Hitachi Vantara for Hitachi Virtual Storage Platform G900 for small random I/O traffic, such as OLTP transactions. The layout also considers the Oracle ASM best practices when using Hitachi Vantara storage.

Base the storage design for database layout needs on the requirements of the specific application implementation. The design can vary greatly from one implementation to another, based on the RAID configuration type 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

Do the following when configuring your Oracle ASM implementation:

- **Data and Indexes Tablespace** — Assign an ASM diskgroup with external redundancy for the data and index tablespaces.
- **TEMP Tablespace** — Place a 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 an 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.
- **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

Set This Environment	To This
RAC configuration	Yes
ASM	Yes — Oracle RAC Database

Table 7 shows the Oracle environment parameters used during performance testing.

TABLE 7. ORACLE ENVIRONMENT PARAMETERS

Set This	To This
DB_CLOCK_SIZE	8 KB
SGA_TARGET	64 GB
PGA_AGGREGATE_TARGET	30 GB
DB_CACHE_SIZE	25 GB
DB_KEEP_CACHE_SIZE	13 GB
DB_RECYCLE_CACHE_SIZE	7 GB
USE_LARGE_PAGES	TRUE

TABLE 7. ORACLE ENVIRONMENT PARAMETERS (CONTINUED)

Set This	To This
FILESYSTEMIO_OPTIONS	SETALL
DISK_ASYNCH_IO	TRUE

Table 8 shows the details of the disk mappings from the LUNs to the ASM disk groups for Oracle RAC Database tablespaces for 2TB database size. This is an example with a single virtual machine pair used during testing. Adjust parameters accordingly when multiple virtual machine pairs are being used.

TABLE 8. LUNS AND ORACLE ASM DISK MAPPINGS

ASM Disk Group	*ASM Disk*	*UDEV Rules*	*LUN Details*	*Purpose*
OCRDG	N/A	/dev/xvd[h-j]1	3 × 5 GB	Oracle Cluster Registry and Voting Disk
DATADG	N/A	/dev/xvd[k-z]1	16 × 200 GB	Application Data
REDODG	N/A	/dev/xvda[a-h]1	8 × 10 GB	Online REDO log group
TEMPDG	N/A	/dev/xvda[i-l]1	4 × 40 GB	Temp
FRADG	N/A	/dev/xvda[m-p]1	4 × 200 GB	Flash Recovery Area *

* The recommendation is to use more LUNs for FRA to accommodate database size and backups. In the testing environment this was not required.

Server and Application Architecture

This reference architecture uses two Hitachi Advanced Server DS220 servers to create a server pool in OVM. The server pool provides flexibility to use as much resource as needed to create database or application virtual machines. This solution was tested in a two-node Oracle RAC configuration in OVM.

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

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

The specifications for the VMware ESXi management server are listed in Table 9.

TABLE 9. HITACHI ADVANCED SERVER DS220 AND DS120 SERVER SPECIFICATIONS

Hitachi Advanced Server	Server Name	Role	CPU Core	RAM
DS220	ovs1	Oracle VM Server	36	768 GB (64 GB × 12)
	ovs2	Oracle VM Server	36	768 GB (64 GB × 12)
DS120	*ESXi1*	Management server 1	16	256 GB (32 GB × 8)
	ESXi2	Management server 2	16	256 GB (32 GB × 8)

SAN Architecture

Map the provisioned LDEVs to multiple ports on Hitachi Virtual Storage Platform G900. These LDEV port assignments provide multiple paths to the storage system from the host for high availability.

- 8 SAN switch connections are being used for Virtual Storage Platform G900 host ports.
- 8 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 G900 ports to Hitachi Advanced Server DS120 and Advanced Server DS220.

TABLE 10. SAN HBA CONNECTION CONFIGURATION TO HITACHI VIRTUAL STORAGE PLATFORM G900

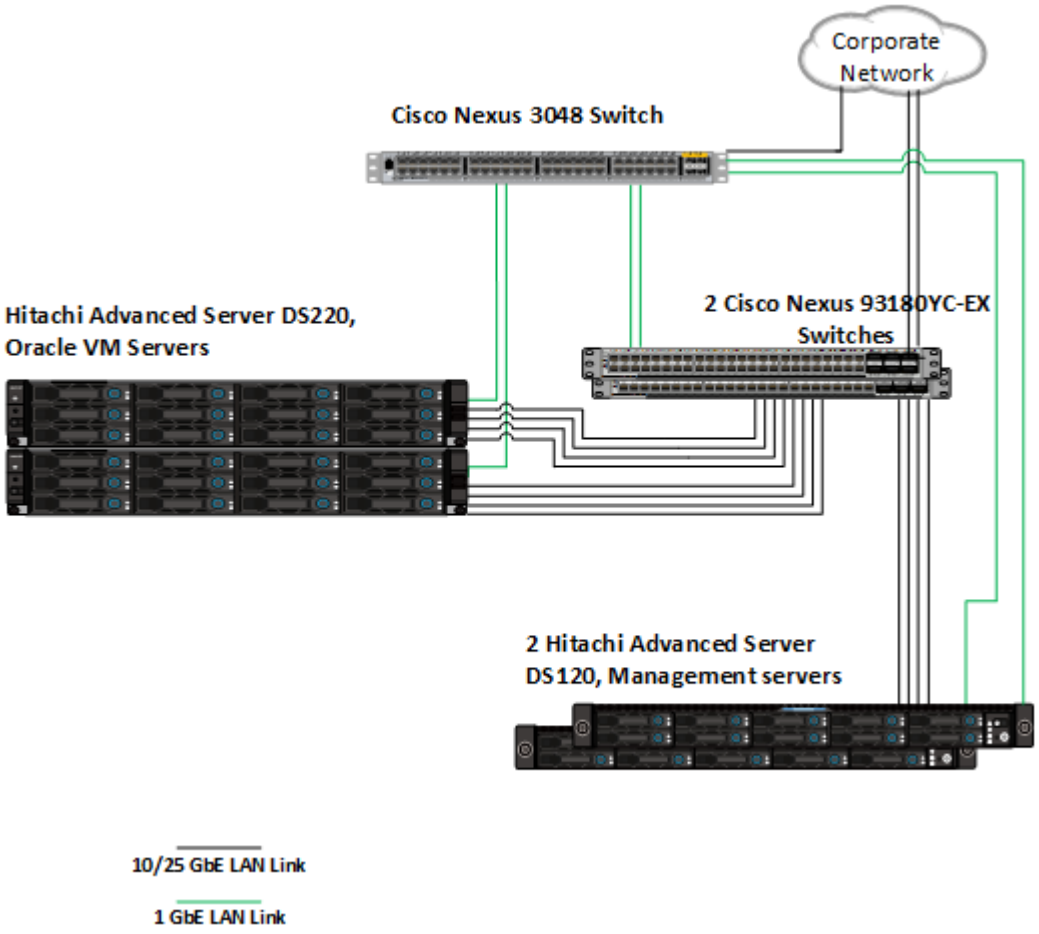
Server	HBA	Host Group Name	Host Name	Switch Zone	Storage Port	Brocade SAN Switch ID
DS220 Server 1	HBA1	CN01	CN01_HBA1_1	CN01_HBA1_1_G900_1A	1A	69
	HBA2	CN01	CN01_HBA1_2	CN01_HBA1_2_G900_2A	2A	70
	HBA3	CN01	CN01_HBA2_1	CN01_HBA2_1_G900_1B	1B	69
	HBA4	CN01	CN01_HBA2_2	CN01_HBA2_2_G900_2B	2B	70
DS220 Server 2	HBA1	CN02	CN02_HBA1_1	CN02_HBA1_1_G900_3A	3A	69
	HBA2	CN02	CN02_HBA1_2	CN02_HBA1_2_G900_4A	4A	70
	HBA3	CN02	CN02_HBA2_1	CN02_HBA2_1_G900_3B	3B	69
	HBA4	CN02	CN02_HBA2_2	CN02_HBA2_2_G900_4B	4B	70
DS120 Server1	HBA1	MN1	MN1HBA1_1	MN1_HBA1_1_G900_1A	1A*	69
	HBA2	MN1	MN1_HBA1_2	MN1_HBA1_2_G900_1B	1B*	70
DS120 Server2	HBA1	MN2	MN2_HBA1_1	MN2_HBA1_1_G900_1A	1A*	69
	HBA2	MN2	MN2_HBA1_2	MN2_HBA1_2_G900_1B	1B*	70

*Depending on customer configuration management servers' ports can be used as shared ports if no additional ports are available

Network Architecture

The high-level network architecture diagram for this solution is shown in Figure 3.

Figure 3



Oracle Real Application Cluster Database 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.

Do the following when configuring private and public networks in your environment:

- Use NIC bonding to provide failover and load balancing of interconnections within a server.
- Set all NICs to full duplex mode.

Configure each Oracle VM Sever node with three bonding interfaces for the following:

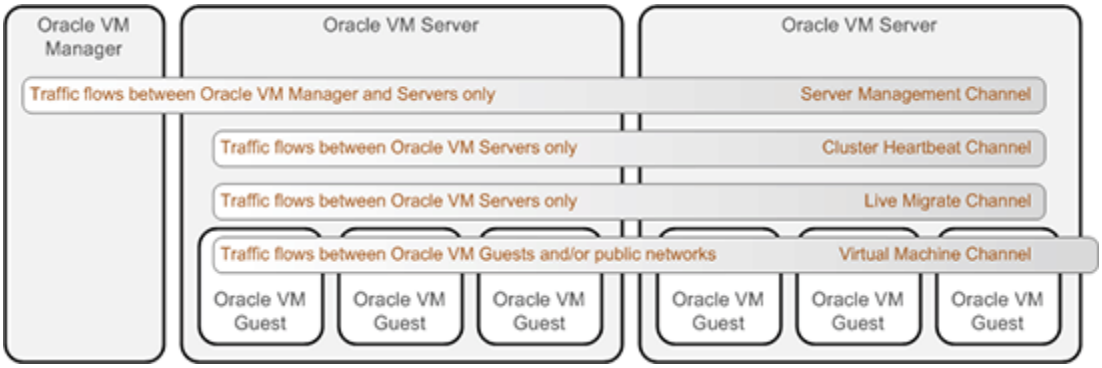
- Management network
- Public network - recommend 2 ports
- Private network – recommend 2 ports

Figure 4 shows the Oracle VM network channels. You can also create a separate network for the Live Migrate channel and Cluster Heartbeat channel if you have sufficient network resources on your Oracle VM Servers within a server pool.

In this architecture, assign the Server Management channel, Cluster Heartbeat channel and Live Migrate channel to the Management network.

Use the Virtual Machine channel for the network traffic between the different virtual machines in a server pool and assigned to the public network and private network in this architecture.

Figure 4



Each virtual machine has public and private vNICs. The recommendation is to use separate VLANs for the following:

- Oracle VM management network
- Oracle RAC database public network
- Oracle RAC database private network

Table 11 lists the network configuration for this solution. Configure the VLAN to fit your network environment.

TABLE 11. NETWORK CONFIGURATION

Server	*NIC Ports*	Subnet	*NIC Bond*	*IP Address*	*Network*	*Bandwidth (Gb/s)*	*Cisco Nexus 93180YC-EX Switch*	
							Switch Number	Port
DS220 Server1*	NIC 1-Port 0	242	Bond0	192.198.242.33	Management/ Public	10	1	5
	NIC 1-Port 1					10	2	5
	NIC 2-Port 0	242	Bond1	192.198.242.34	Public	25	1	2
	NIC 3-Port 0					25	2	
	NIC 2-Port 1	100	Bond2	192.100.10.201	Private	25	1	1
	NIC 3-Port 1					25	2	
DS220 Server2*	NIC 1-Port 0	242	Bond0	192.198.242.36	Management/ Public	10	1	6
	NIC 1-Port 1					10	2	6
	NIC 2-Port 0	242	Bond1	192.198.242.37	Public	25	1	3
	NIC 3-Port 0					25	2	
	NIC 2-Port 1	100	Bond2	192.100.10.202	Private	25	1	4
	NIC 3-Port 1					25	2	
DS120 Management Server1	NIC 1-Port 0	242	Bond0	192.198.242.101	Management/ Public	25	1	49
	NIC 1-Port 1					25	2	49
DS120 Management Server2	NIC 1-Port 0	242	Bond0	192.198.242.102	Management/ Public	25	1	50
	NIC 1-Port 1					25	2	50

*This solution was tested with PCIe and OCP mezzanine NIC cards. The recommendation is to use all PCIe cards for consistency, more bandwidth, and better NIC bonding.

Virtual Machine Configuration

Table 12 lists the virtual machine configuration for Oracle Database used in this solution.

TABLE 12. DATABASE VIRTUAL MACHINE CONFIGURATION

Virtual Machine	vCPU	Virtual Memory	Operating System	Physical Host
Oracle Database Sever Node 1	18	128	Oracle Linux 7.4	OVS1
Oracle Database Sever Node 2	18	128	Oracle Linux 7.4	OVS2

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

TABLE 13. MANAGEMENT SERVER VIRTUAL MACHINES CONFIGURATION

Virtual Machine	vCPU	Virtual Memory	Disk capacity	IP Address	Operating System
vCenter	2	10 GB	300 GB	192.198.242.xxx	VMware Photon Linux 1.0
OEM	16	32 GB	200 GB	192.198.242.xxx	RHEL 7.4
Oracle Adapters	2	6 GB	40 - 50 GB	192.198.242.xxx	OL 7.3
Oracle VM Manager	2	10 GB	100 GB	192.198.242.xxx	OL 7.3/7.4
HSA	4	16 GB	100 GB	192.198.242.xxx	CentOS 7.2
HIAA/HDCA	4	32 GB	800 GB	192.198.242.xxx	RHEL 7.3
HDCA Probe	4	10 GB	110 GB	192.198.242.xxx	RHEL 7.3
vSVP - Storage Virtual Platform G900	2	32		192.198.242.xxx	Microsoft Windows 7 Professional (64 bit)

Hitachi Vantara Applications

This solution uses these Hitachi Vantara applications in the environment.

Hitachi Infrastructure Analytics Advisor (HIAA)

Hitachi Infrastructure Analytics Advisor provides data analytics and performance monitoring for this solution.

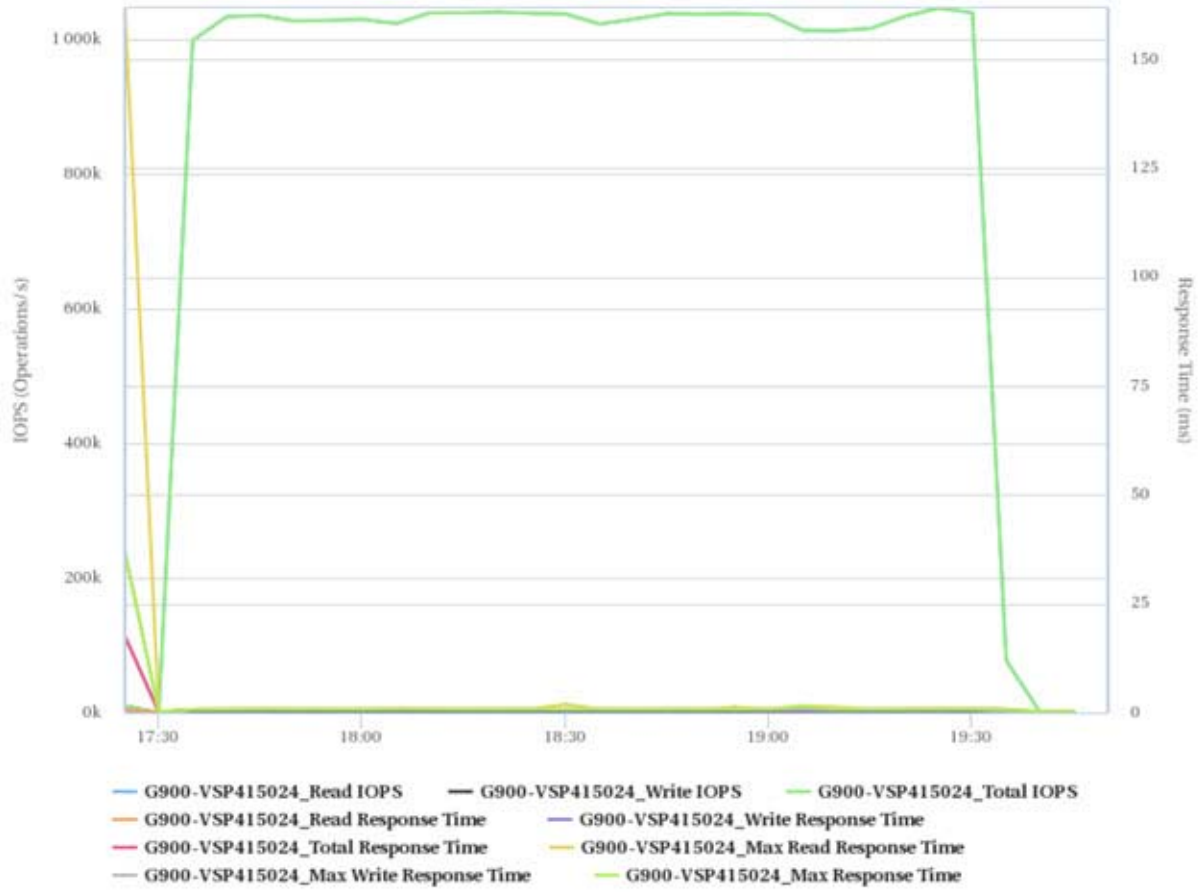
The following are the key features of Infrastructure Analytics Advisor:

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

See Hitachi Infrastructure Analytics Advisor User Guide for more details on the operation of this software.

Figure 5 shows storage IOPS versus response time from Infrastructure Analytics Advisor during performance testing.

Figure 5



Hitachi Storage Advisor

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.

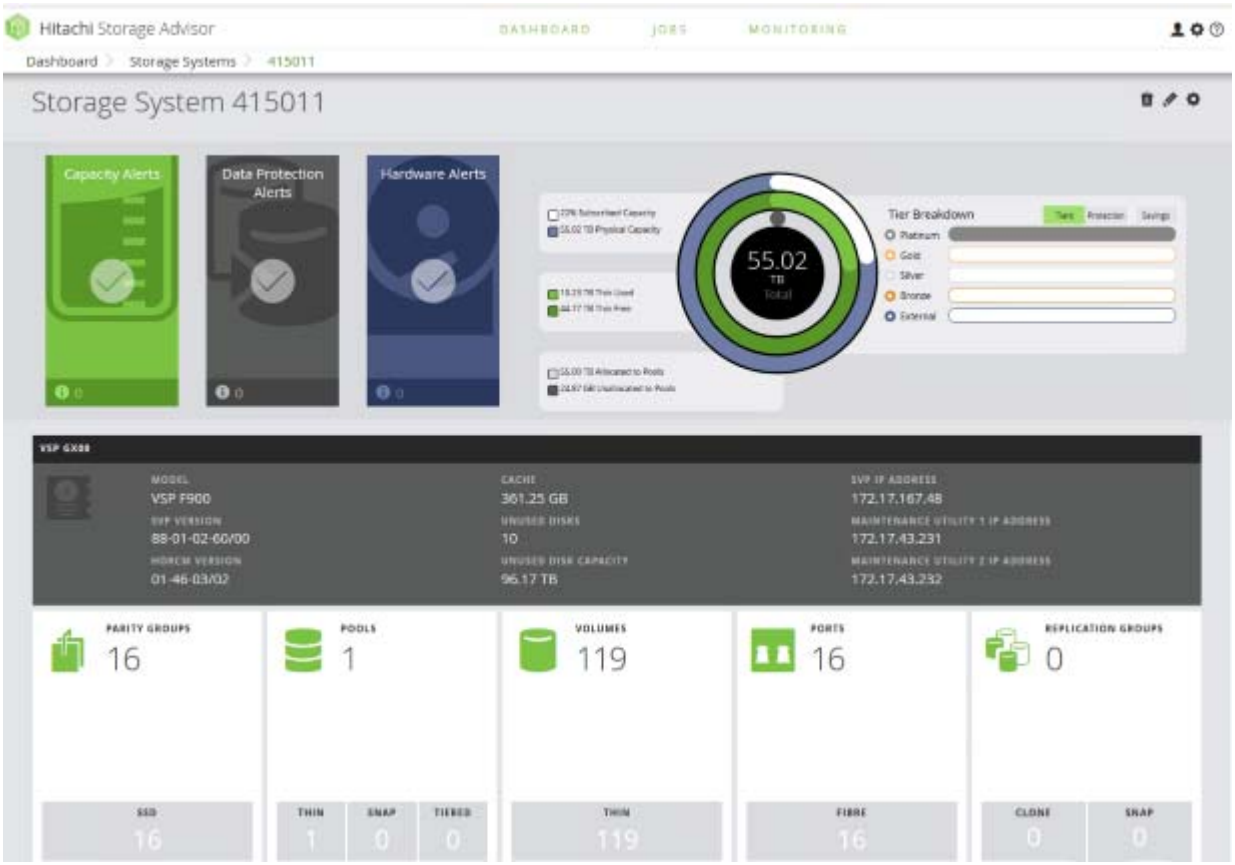
Some of the key Storage Advisor capabilities include:

- 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.
- Enabled automated SAN zoning during volume attaches and detach. Optional auto-zoning eliminates the need for repetitive zoning tasks to be performed on the switch.

See the Hitachi Storage Advisor documentation for more details.

Figure 6 shows Hitachi Storage Advisor with VSP G900 storage system.

Figure 6

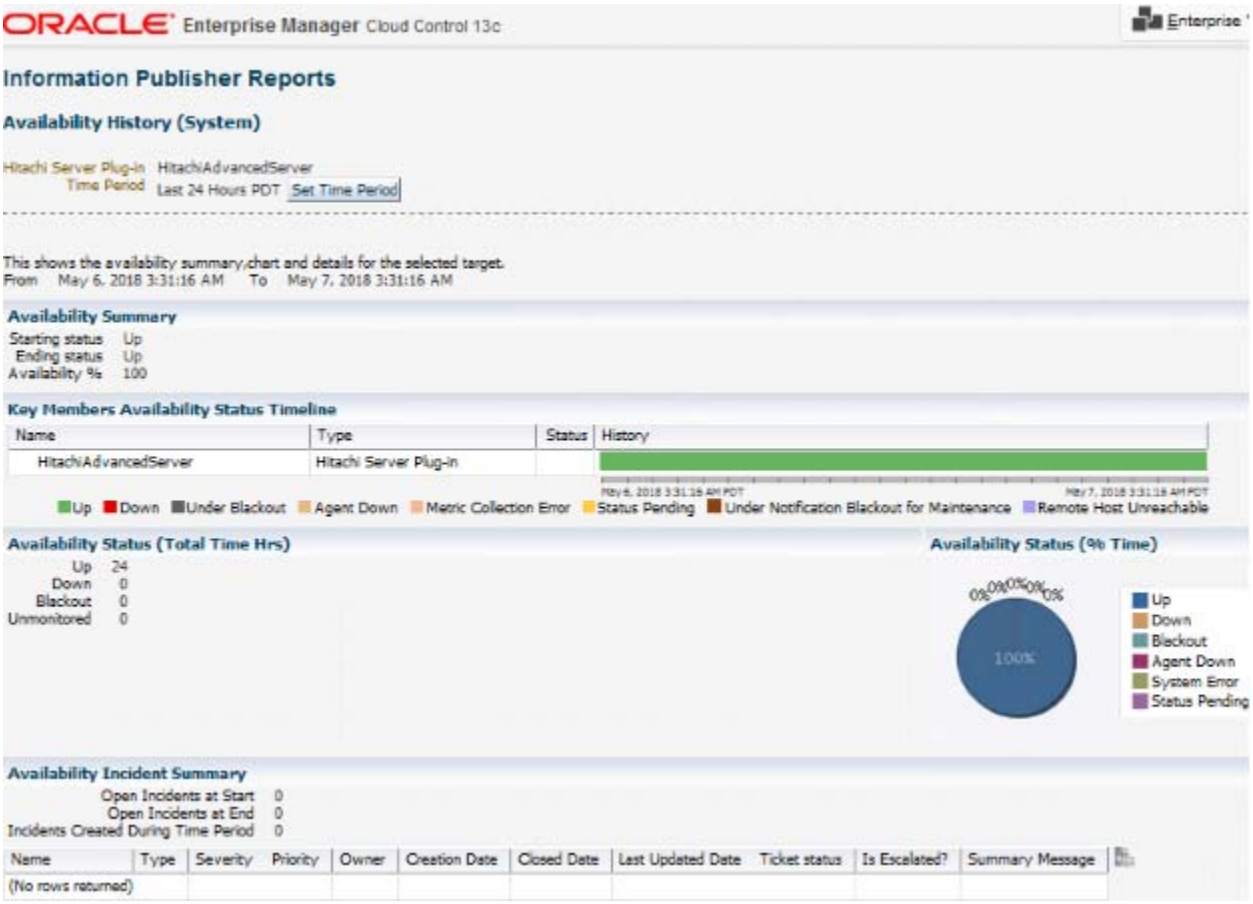


Hitachi Server Adapter for Oracle Enterprise Manager

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 7 shows a system availability history report.

Figure 7



Engineering Validation

This summarizes the key observations from the test results for Hitachi Solution for Databases with Oracle Cloud for a XaaS foundation using Hitachi Unified Compute Platform CI with Hitachi Virtual Storage Platform G900 and Hitachi Advanced Server DS220.

A single virtual machine per hypervisor server was used during the tests. However, this is not a restriction on the use of the architecture.

Test Methodology

The test results are created using Oracle Orion and Peakmarks.

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.

The Oracle Orion tool was used to validate this solution. Orion tests were performed with straight storage mapping, which can yield better performance than traditional storage mapping. Straight storage mapping would limit the availability or redundancy in the architecture.

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 or 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 was used to validate this solution.

Database *Configuration*

Table 14 shows parameter details for two-node Oracle Real Application Clusters ASM database used to evaluate this solution.

TABLE 14. ORACLE DATABASE CONFIGURATION

For This	Use This
compatible	12.2.0
cluster_database	TRUE
cluster_database_instances	2
Oracle Database size	2 TB
Database Storage Type	ASM
Database fill factor	80%

Test Results

Table 15 lists the results of the Oracle Orion test cases used to validate this solution.

TABLE 15. ORACLE ORION TEST RESULTS

Test Case	*Test and Workload Type*	*Metric*	*Value*
1	Storage performance 100% OLTP random read (8k)	Maximum I/Os	1,040,518
		Average RT	1.04 ms
2	Storage performance 100% OLTP random writes (8k)	Maximum I/Os	284,432
		Average RT	1.1 ms
3	Storage performance 100% OLAP sequential reads (1024k)	Maximum Throughput	8.21GB/s
4	Storage performance 100% OLAP sequential writes (1024k)	Maximum Throughput	5.8 GB/s

Table 16 lists the results of the Peakmarks test cases used to validate this solution. These results are based on testing a 2 TB database size.

TABLE 16. PEAKMARKS TEST RESULTS

Test Case	Test and Workload type	Metric	Value
1	Storage performance random read (STO-RR)	Maximum I/Os	814,301*
		Average RT (ms)	1.2
2	Storage performance random write (STO-RWF)	Maximum I/Os	222,388
		Average RT (ms)	1
3	Storage performance sequential read (STO-SR)	Maximum Throughput (GB/s)	8.13
4	Storage mixed random read write (STO-MIX 20% update ratio)	Maximum I/Os	418,645
		Average RT (ms)	0.6
5	Database medium OLTP select performance — 25 rows per transaction (DBX-S25)	Throughput in transactions per second	33,788
		Throughput in rows per second	844,706
		Average RT for SQL statement	0.94
6	Server performance test — (SRV-S25)	Throughput in Queries per second – per Core	14,225
		Throughput in queries per second - Total	512,111
		Throughput in logical buffer reads per second	13,049,925
		Average RT for SQL statement	0.09

*Using 32 SSDs, testing did not fully utilize the capability of Hitachi Virtual Storage Platform G900. If testing had used 64 SSDs, there would have been better results when testing the same hardware configuration. See the Hitachi Solution for Databases - Oracle Real Application Clusters Database 12c based on Hitachi Advanced Server DS220 and Virtual Storage Platform G900 Reference Architecture Guide.

Table 17 lists the results of Peakmarks test cases to observe performance while scaling up the database size, from 2 TB, 4 TB, and 8 TB.

TABLE 17. PEAKMARKS TEST RESULTS FOR SCALING UP DATABASE FROM 2 TB, 4 TB, OR 8 TB

Test Case	Test/Workload type	Metric	2 TB Database size	4 TB Database size	8 TB Database size
1	Storage performance random read (STO-RR)	Maximum I/Os	814,301	802,851	828,646
		Average RT (ms)	1.2	1.4	1.5
2	Storage performance random write (STO-RWF)	Maximum I/Os	222,388	211,469	204,816
		Average RT (ms)	1	1	1
3	Storage performance sequential read (STO-SR)	Maximum Throughput GB/sec	8.13	8.09	8.04
4	Storage mixed random read write (STO-MIX 20% update ratio)	Maximum I/Os	418,645	467,202	492,283
		Average RT (ms)	0.6	0.56	0.56
5	Database medium OLTP select performance - 25 rows per transaction (DBX-S25)	Throughput in transactions per second	33,788	21,680	21,931
6	Server performance test (SRV-S25)	Throughput in queries per second – Total	512,111	516,805	510,952

Table 18 lists the results of Peakmarks test cases to see performance when running a multiple virtual machine workload in a Oracle VM server pool. The database size is 2 TB with an additional virtual machine workload in an Oracle VM server pool. The table has the combined results for all virtual machines.

There are four additional virtual machines running, each having a single instance database with a size of 512 GB, 4 vCPU and 32 GB RAM. All four virtual machines were running less than 10% similar Peakmarks workload when compared to main Oracle RAC database virtual machine.

TABLE 18. PEAKMARKS TEST RESULTS FOR MULTIPLE VIRTUAL MACHINES WORKLOAD IN AN ORACLE VM SERVER POOL

Test Case	Test/Workload type	Metric	All Virtual Machines Combined Results
1	Storage performance random read (STO-RR)	Maximum I/Os	940,616
2	Storage performance random write (STO-RWF)	Maximum I/Os	269,694
3	Storage performance sequential read (STO-SR)	Maximum Throughput GB/sec	10.19
4	Storage mixed random read write (STO-MIX 20% update ratio)	Maximum I/Os	447,926
5	Database medium OLTP select performance - 25 rows per transaction (DBX-S25)	Throughput in transactions per second	26,989
6	Server performance test - OLTP 25 rows per transaction(SRV-S25)	Throughput in queries per second – Total	575,371

Physical Disk Mounting for an Oracle Virtual Machine Guest

To resolve physical disk mounting issues for Oracle VM Guest, configure the following settings:

1. In physical host server (dom0), add the following line to /etc/sysconfig/xencommons then reboot the OVS server:

```
XENSTORED_ARGS="--entry-nb=2048 --transaction=256"
```

2. For database virtual machine stability and better performance, use the following suggested settings:
   (1) Change gnttab_max_nr_frames to 512 instead of 128 for OVM dom0.
   (2) Change xen_blkfront.max_queues=2 in virtual machines guest operating system (domU).

Note — The settings are based on the configuration used for solution testing.

3. If there is a need to use RAID controller QS3516 to install Oracle VM 3.4.4 in local drives, then use the following procedure:

   (1) Download the DUD.iso file (V959603-01.iso Driver Update Disk for Oracle Linux 6 for x86 64bit, 1.8 MB).

   (2) Push the DUD.iso file to the temporary server in the “/root” directory using WinScp or another method.

   (3) Insert an empty USB disk in the temporary server.

   (4) List the USB disk contents, using the “lsblk” utility attached to the server.

   (5) Use the `dd` command to copy the `DUD.iso` file to the USB disk:

   dd if=/root/DUD.iso of=/dev/sdX

   (6) Insert the USB drive directly into the server where you plan to apply the DUD.

Note — Do not format the USB disk after copying the DUD file.

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-080-02, July 2018