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Hitachi Solution for Databases - Oracle Real Application Clusters Database 19c with Hitachi Advanced Server DS220 and Global-active Device using Virtual Storage Platform E990 and Hitachi Ops Center Protector

Reference Architecture Guide

By Hitachi Vantara

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Feedback

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Revision History

Revision	Changes	Date
MK-SL-217-00	Initial release	December 22, 2020

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Hitachi Solution for Databases - Oracle Real Application Clusters Database 19c with Hitachi Advanced Server DS220 and Global-active Device using Virtual Storage Platform E990 and Hitachi Ops Center Protector

Reference Architecture Guide

Use this reference architecture guide to design a solution with Hitachi Ops Center Protector to protect Hitachi Solution for Databases for Oracle Real Application Clusters (Oracle RAC). This solution is for Oracle RAC on Extended Distance Clusters (stretched) in a two-site environment using global-active device in Hitachi Virtual Storage Platform.

This reference architecture guide explains the following:

- How to use Hitachi Ops Center Protector to deploy global-active device to add backup and recovery capabilities in an Oracle environment to achieve zero recovery point objective (RPO) and recovery time objective (RTO).
- How to use global-active device without using an external storage system for quorum configuration in a two-site replication environment with Virtual Storage Platform E990 series to provide data protection for Oracle Database.
- How to use Hitachi Ops Center Protector to perform automated two-datacenter swap global-active device replication on demand and automated recovery of global-active device replication in an error or suspended state.
- How Hitachi Ops Center Protector integrates with Oracle RMAN using the SBT interface.

The Hitachi Solution for Databases 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 and you can tailor the implementation of these best practices to meet your specific data backup and recovery needs.

This proven solution optimizes your Oracle Database environment, and integrates servers, storage systems, network, and storage software. It provides reliability, high availability, scalability, and performance while processing small-scale to large-scale OLTP workloads. The dedicated servers run Oracle Database 19c Enterprise Edition Release Update 19.3.0.0.0 with Automated Storage Management (ASM) features for the Real Application Clusters (RAC) environment. The operating system is Oracle Linux Server release 7.8.

The best practices in this guide are valid for all storage systems that support global-active device and are not limited to the storage environment used to validate this reference architecture.

This document is for you if you are in one of the following roles:

- Database administrator
- Storage administrator
- Database performance analyzer
- IT professional responsible for planning and deploying an Oracle Database solution

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

- Hitachi Virtual Storage Platform G and E Series (such as VSP G800, VSP G900, and VSP E990)
- Hitachi Advanced Server DS220 servers
- Hitachi Advanced Server DS120 servers
- Storage area networks
- Oracle RAC Database 19c Version 19.3.0.0.0
- Oracle Automatic Storage Management (Oracle ASM)
- Hitachi Global-active Device
- Hitachi Ops Center Protector
- Hitachi Adapters for Oracle Database
- Hitachi Storage Adapter for Oracle Enterprise Manager
- Hitachi Server Adapter for Oracle Enterprise Manager
- Oracle Linux
- Device-Mapper Multipath on Oracle Linux

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 Solution for Databases for Oracle Real Application Clusters on Extended Distance Clusters on four nodes using Hitachi Virtual Storage Platform E990. This environment addresses the high availability, performance, and scalability requirements for OLTP and OLAP workloads and how Hitachi Ops Center Protector integrates with Oracle RMAN using the SBT interface. Your solution implementation can be tailored to meet your specific needs.

Continuous application availability in traditional and cloud designs requires continuous storage. This solution uses Hitachi Storage Virtualization Operating System RF (SVOS) and enterprise-class Hitachi Virtual Storage Platform E series systems for the following:

- Global storage virtualization
- Distributed continuous storage
- Zero recovery time and point objectives (RTO/RPO)
- Simplified distributed system design and operations

Global storage virtualization creates global-active device volumes which are storage volumes with the ability to have read and write copies of the same data in two systems at the same time. The active-active storage design enables production workloads on both systems in a local or stretched cluster configuration while maintaining full data consistency and protection.

Configuring Oracle Real Application Clusters on Extended Distance Clusters with global-active device allows you to create and maintain synchronous, remote copies of data volumes on Hitachi Virtual Storage Platform systems.

Business Benefits

This reference architecture provides the following benefits:

- Continuous server I/O when an unplanned outage, such as disaster or hardware failure, prevents access to a data volume of the database.
- Automated configuration for global-active devices and quick recovery of global-active device pairs in error or suspended state storage operations using the Hitachi Ops Center Protector GUI without knowing how to manually configure Hitachi HORCM.
- Automated pause, resume, two datacenter replication swap, dissociate, revert, teardown, and delete global-active devices using Hitachi Ops Center Protector for planned outages.
- Easy to understand global-active device internal operations using Hitachi Ops Center Protector informative log messages. This helps to quickly identify and troubleshoot problems.
- Backup data can be stored in datastores managed by Hitachi Ops Center Protector using the Oracle Recovery Manager (RMAN) tool.

High-level Infrastructure

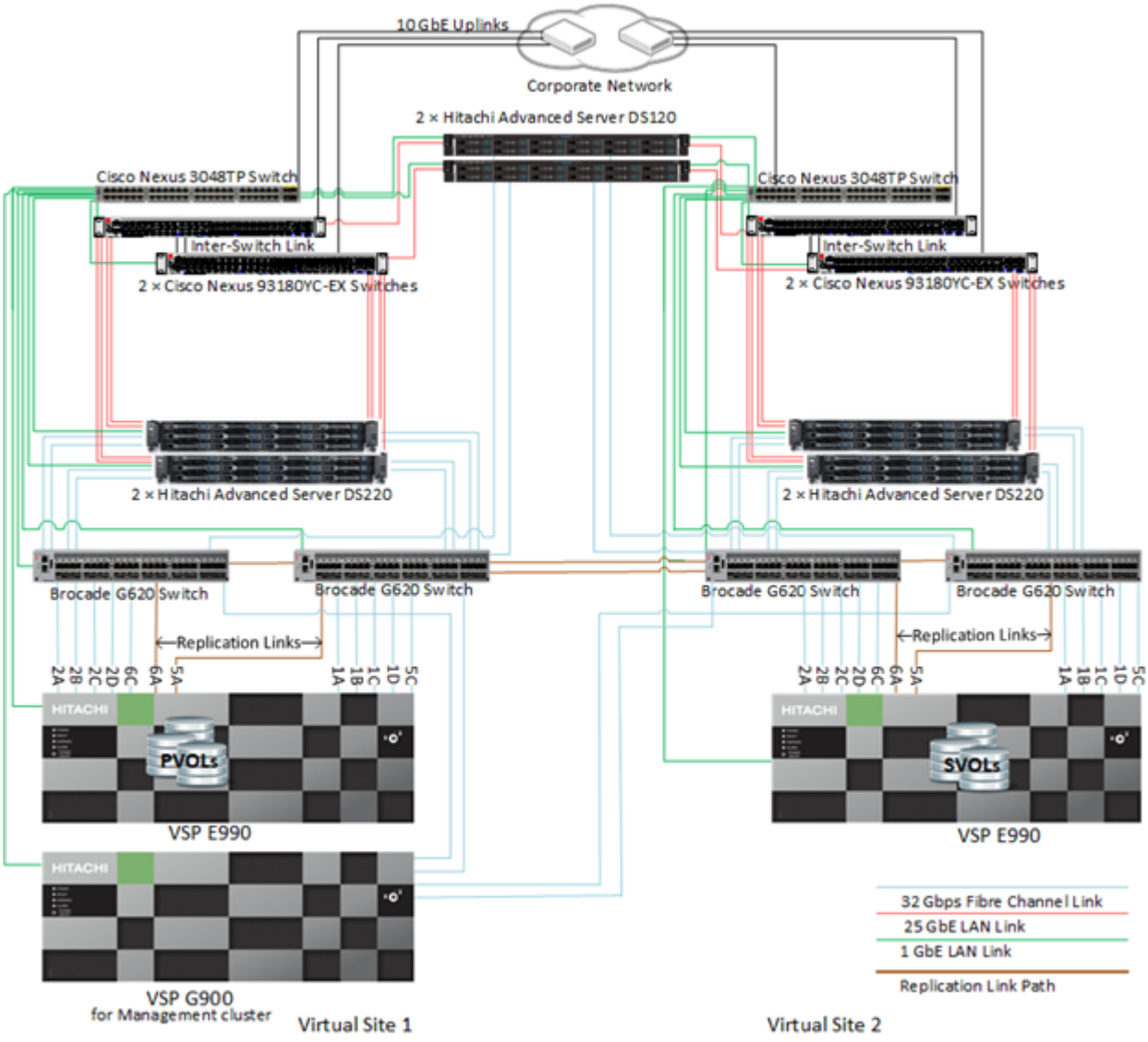
Figure 1 shows the infrastructure for this solution.

The Virtual Storage Platform E990 and Hitachi Advanced Server DS220 configuration have the following characteristics:

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

This global-active device infrastructure is hosted in a LAN environment with two logical sites (Virtual Site 1 and Virtual Site 2). With a WAN, the physical configuration would be different.

Figure 1



To avoid a performance impact on 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

The uplink speed to the corporate network depends on your environment and requirements. The Cisco Nexus 93180YC-EX switches can support uplink speeds of 25 GbE, 40 GbE, or 100 GbE if higher bandwidth is required.

Note –Virtual Site 1 and Virtual Site 2 were configured for the lab environment, and the management server setup was configured at Virtual Site 1. In two-site configurations at production sites, the management server can reside at Site 1 or Site 2. You can use the same storage system used for compute nodes or use a separate storage system. Match your production environment requirements to the configuration before implementation of this solution.

Key Solution Components

The key solution components for this solution are listed in Table 1, Table 2, and Table 3. Detailed component information is provided in Product Descriptions.

TABLE 1. HARDWARE COMPONENTS

Hardware	Detailed Description	Firmware/Version	Quantity

Hitachi Virtual Storage Platform E990	▪ Two × Controllers
	▪ 8 × 32 Gbps Fibre Channel ports
	▪ 1 × drive chassis with:
	  ▪ 4 × drive trays
	  ▪ 4 × CHB pairs (12 × 32 Gbps Fibre Channel ports in use)
	  ▪ 1024 GB cache memory
	  ▪ 16 × 3.8 TB NVMe SSDs (fewer capacity SSDs that are larger can also be used)
	▪ Note that two spare drives are recommended for production environments.
		93_02_02_60/00	2

Hitachi Virtual Storage Platform G900	▪ 4 × 32 Gbps Fibre Channel ports ▪ 512 GB cache memory ▪ 4 × 6.0 TB 7.2K RPM SAS Drives	88-02-03-60/00	1
Hitachi Advanced Server DS220	▪ 2 × Intel ® Xeon ® Platinum 8276L CPUs @ 2.2 GHz ▪ 768 GB (64 GB × 12) DIMM ▪ DDR4 synchronous registered (buffered) 2666 MHz	BIOS: 3B16.H01 BMC: 4.65.06 CPLD: 11	4
	▪ 2 × Intel XXV710 Dual Port 25 GbE NIC cards	Driver: i40e Driver Version: 2.8.20-k Firmware: 6.02	
	▪ 2 × Emulex LightPulse LPe32002-M2 2-Port 32 Gb Fibre Channel adapters (Virtual Site 1) ▪ 2 × Emulex LightPulse LPe31002-M6 16 Gb Fibre Channel adapters (Virtual Site 2)	Driver: lpfc Driver Version: 12.0.0.13 Firmware: 12.2.299.23	

TABLE 1. HARDWARE COMPONENTS (CONTINUED)

Hardware	Detailed Description	Firmware/Version	Quantity
Hitachi Advanced Server DS120	▪ 2 x Intel Xeon Gold Processor 6240, 18-core, 2.60GGHz, 85W 256 GB (32 GB × 8) DIMM ▪ DDR4 synchronous registered (buffered) 2666 MHz ▪ 1 × 64 GB MLC SATADOM for boot	BIOS: 3B16.H00 BMC: 4.64.06 CPLD:11	2
	▪ 1 × Dual Port 25 GbE NIC Intel XXV710 PCIe card	Firmware: 1.7.17 Driver: lpfc Driver version: 6.80	
	▪ 1 × Emulex LightPulse LPe32002-M2 2-Port 32 Gb Fibre Channel adapters	Firmware: 12.0.193.13 Driver: lpfc Driver version: 12.0.193.14	
Brocade Fibre Channel Switches	▪ G620 ▪ 48 port Fibre Channel switch ▪ 32 Gbps SFPs	Kernel: 2.6.34.6 Fabric OS: v8.2.0b	4
Cisco Nexus Network Switches	▪ C93180YC-EX ▪ 48 × 10/25 GbE fiber ports ▪ 6 × 40/100 Gbps Quad SFP (QSFP28) ports	BIOS: version 07.65 NXOS: version 7.0(3)I7(6)	4
	▪ 3048TP ▪ 1 GE 48-Port Gb Ethernet Switch	BIOS: version 4.0.0 NXOS: version 7.0(3)I4(7)	2

TABLE 2. SOFTWARE COMPONENTS FOR COMPUTE NODES

Software	Version/Release	Function
Oracle Linux Server	7.8 (Kernel Version - 4.14.35-2025.400.9.1.el7uek.x86_64)	Operating System
Oracle 19c	19c (Version 19.3.0.0.0)	Database Software
Oracle Real Application Cluster	19c (Version 19.3.0.0.0)	Cluster Software
Oracle Grid Infrastructure	19c (Version 19.3.0.0.0)	Volume Management, File System Software, and Oracle Automatic Storage Management
Oracle Linux 'device-mapper-multipath' package	0.4.9-131.0.1	Multipath Software
Oracle 'oracleasmlib' package	2.0.12-1	The Oracle userspace library for Oracle Automatic Storage Management

TABLE 3. SOFTWARE COMPONENTS FOR MANAGEMENT NODES

Software	Version	Function
Hitachi Storage Virtualization Operating System	SVOS RF 9.4.0	Global-active Device Replication software
Virtual SVP (vSVP)	Microcode dependent	Storage management software
Hitachi Ops Center Protector	7.0.1.81207-R7.0 (the latest version is recommended)	Data protection software
Hitachi Command Control Interface software (CCI)	01-57-03/01	Storage configuration and data management software
Hitachi Ops Center	10.5	Hitachi Infrastructure Management Software
Hitachi Adapters for Oracle Databases	v03.0.0	Hitachi Adapters Management Virtual Appliance 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
VMware ESXi	Version 6.7.0 Build 15160138	ESXi for management nodes
VMware vCenter Server	Version 6.7.0 Build 15976714	Management cluster

Solution Design

This section describes the reference architecture environment to implement Hitachi Solutions for Databases for Oracle Real Application Clusters on Extended Distance Clusters on four nodes using Hitachi Virtual Storage Platform. The environment used for testing and validation of this solution used two Hitachi Virtual Storage Platform E990 storage systems.

The infrastructure configuration included the following:

- **Site 1**
  - **Oracle RAC Servers** – Two server nodes configured in an Oracle Real Application Cluster.
  - **Storage System** –vVols mapped to each port that were presented to the servers as LUNs.
  - **SAN Connections** –SAN connections to connect the Fibre Channel HBA ports to the storage through Brocade G620 switches.
- **Site 2**
  - **Oracle RAC Servers** – Two server nodes configured in an Oracle Real Application Cluster.
  - **Storage System** –vVols mapped to each port that were presented to the server as LUNs.
  - **SAN Connection** –SAN connections between the Fibre Channel HBA ports to the storage using Brocade G620 switches.

Note – Testing used global-active device pairs without setting a volume in an external storage system as the quorum disk volume.

- **Management server cluster**
  - One Hitachi Ops Center Protector master node installed on the virtual machine.
- **Proxy node**
  - A virtual machine that is managed and monitored by global-active device for pair operations is required for the P-VOLs only.
- **SAN Connection** –32 Gbps Fibre Channel HBA ports connected to the storage front-end ports through a switched SAN fabric at Virtual Site 1. Each 16 Gbps Fibre Channel HBA port was connected to the storage front-end ports through a switched SAN fabric at Virtual Site 2.

Note – 16 Gb Fibre Channel adapters were used at Virtual Site 2 servers due to equipment availability for testing. It is recommended to have the same configuration at all sites.

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 best practices for the database storage design and deployment.

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

Figure 2

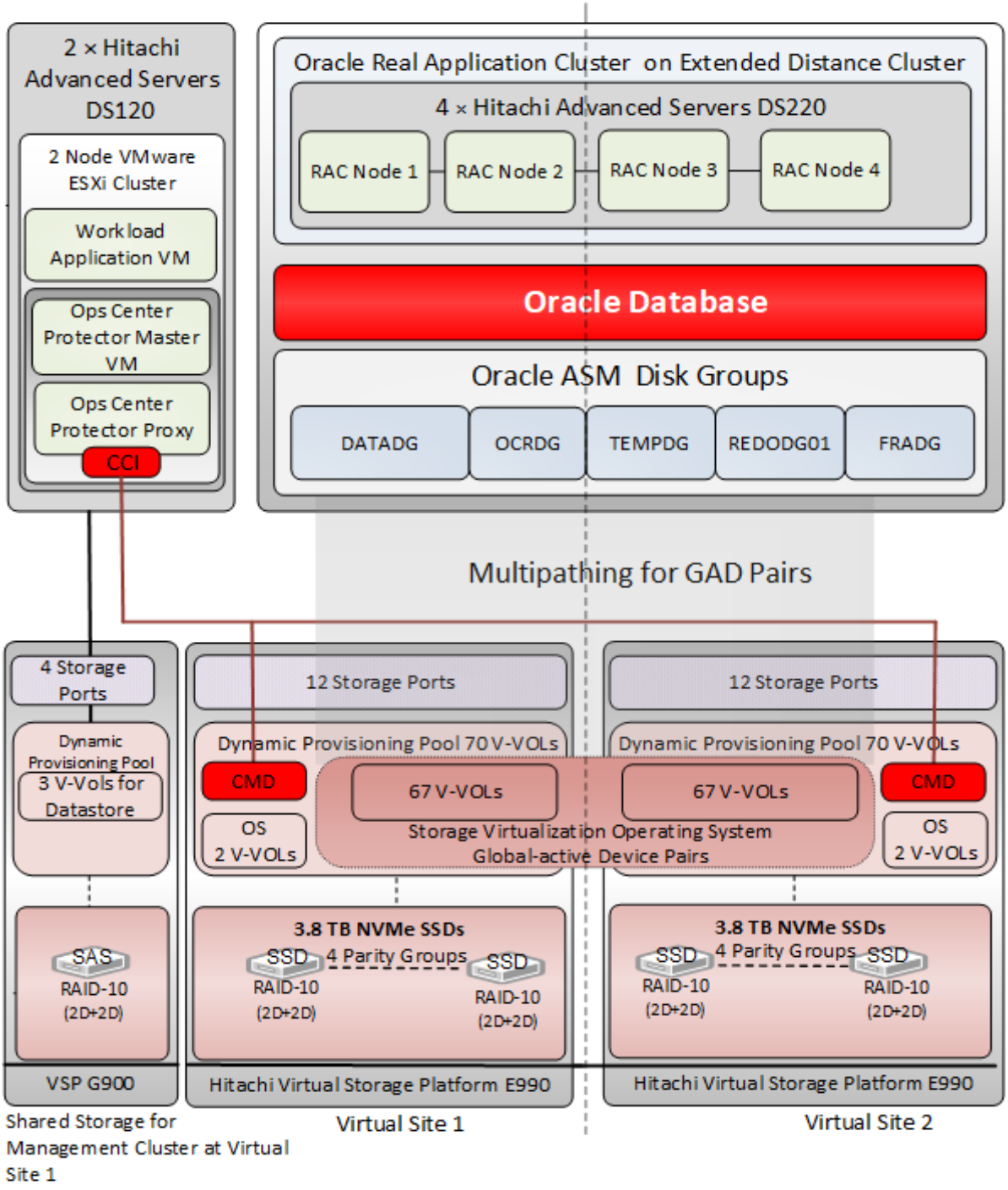


Table 4 lists the storage pool configuration used for this solution. In the current configuration a single pool is used for Operating System (OS), command device (CMD) and Oracle LDEVs. However, you can create OS, CMD, and Oracle LDEVs in different storage pools, as needed.

TABLE 4. STORAGE POOL CONFIGURATION

Site	Site 1	Site 2
Pool Name	Oracle_Pool	Oracle_Pool
Pool Type	Dynamic Provisioning	Dynamic Provisioning
RAID Group	1-11 – 1-14	1-11 – 1-14
RAID Level	RAID-10 (2D+2D)	RAID-10 (2D+2D)
Drive Type	3.8 TB SSDs	3.8 TB SSDs
Number of Drives	16	16
Number of Pool Volume LDEVs	32	32
Pool Volume LDEV size	880 GB	880 GB
Pool Capacity	27.5 TB	27.5 TB

TABLE 5. LOGICAL STORAGE CONFIGURATION

Site	Site 1			Site 2		
Pool ID	Oracle_Pool			Oracle_Pool		
Number of vVols	1	2	67 P-VOLs	1	2	67 S-VOLs
vVol Size	100 MB	380 GB	3 × 15 GB, 32 × 200 GB, 16 × 20 GB, 8 × 240 GB, 8 x 2.0 TB	100 MB	380 GB	3 × 15 GB, 32 × 200 GB, 16 × 20 GB, 8 × 240 GB, 8 x 2.0 TB

TABLE 5. LOGICAL STORAGE CONFIGURATION (CONTINUED)

Purpose	Command Device	OS	▪ Oracle ASM Disk Groups ▪ OCRDG ▪ DATADG ▪ REDODG ▪ TEMPDG ▪ FRADG	Command Device	OS	▪ Oracle ASM Disk Groups ▪ OCRDG ▪ DATADG ▪ REDODG ▪ TEMPDG ▪ FRADG
Storage Port	5C, 6C		1A, 1B, 1C, 1D, 2A, 2B, 2C, 2D	5C, 6C		1A, 1B, 1C, 1D, 2A, 2B, 2C, 2D

TABLE 6. VSP G900 CONFIGURATION FOR MANAGEMENT SERVERS

Item	Value/Description
Purpose	VMware Datastores CCI device
RAID level	RAID-10 (2D+2D)
Drive type	6.0 TB 7.2K RPM SAS
Number of drives	4
Number of spare drives	2
Number of LDEVs	3
LDEV size(s)	3000 GB
Number and size of CCI devices	1 × 100 MB
Storage port for management servers	7A, 7B, 8A, 8B

An additional RAID group consisting of four 3 TB 7.2k rpm SAS drives configured as RAID-10 (2D+2D) was used as shared storage for the management server cluster. A 3 TB LUN and a command device were 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 your requirements.

Database Layout

The database layout design follows the recommended best practices from Hitachi Vantara when using Hitachi Virtual Storage Platform E990 for small random I/O traffic, such as OLTP transactions, and for large I/O traffic, such as OLAP. The layout also considers the Oracle ASM best practices when using Hitachi storage systems. Base the storage design for the database layout on the requirements of your 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 can be used 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 disk group with external redundancy for the data and index tablespaces.
- **TEMP Tablespace** – Place the TEMP tablespace in the Data ASM disk group.
- **UNDO Tablespace** – Create an UNDO tablespace in this configuration within the Oracle Data ASM disk group. Assign one UNDO tablespace for each node in the Oracle RAC environment.
- **Online REDO Logs** – Create an ASM disk group with external redundancy for Oracle online REDO logs.
- **Oracle Cluster Registry and Voting Disk** – Create an ASM disk group 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 disk groups.
- **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:
  - RAC configuration – Yes
  - ASM – Yes, Oracle RAC Database

Table 7 shows the Oracle environment parameters.

TABLE 7. ORACLE ASM AND DATABASE PARAMETERS

Category	Item	Value
Oracle RAC option	RAC configuration	Yes
	ASM	Yes – to support Oracle RAC database
Oracle ASM environment parameters	OCR	3 × 15 GB
	DATA	32 × 200 GB
	REDO	16 × 20 GB
	TEMP	8 × 240 GB
	FRA	8 × 2,000 GB

TABLE 7. ORACLE ASM AND DATABASE PARAMETERS (CONTINUED)

Category	Item	Value
Oracle Database environment parameters	SGA_TARGET	384 GB
	PGA_AGGREGATE_TARGET	154 GB
	DB_CACHE_SIZE	172 GB
	DB_KEEP_CACHE_SIZE	76 GB
	DB_RECYCLE_CACHE_SIZE	20 GB
	LOG_BUFFER	512 MB
	USE_LARGE_PAGES	TRUE
	FILESYSTEMIO_OPTIONS	SETALL
	DB_FILE_MULTIBLOCK_READ_COUNT	128
	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.

TABLE 8. LUNS AND ORACLE ASM DISK MAPPINGS FOR ORACLE DATABASE IN SITE 1 AND SITE 2

ASM Disk Group	ASM Disk	DM-Multipath LUNs	LUN Details	Purpose
NA	NA	/dev/mapper/mpatha	4 × 380 GB	OS and Oracle RAC Clusterware and database binary
OCRDG	OCR1 - OCR3	/dev/mapper/mpathaa - /dev/mapper/mpathac	3 × 15 GB	Oracle Cluster Registry and Voting Disk
DATADG	DATADISK1 – DATADISK32	/dev/mapper/mpathaa - /dev/mapper/mpathai /dev/mapper/mpathd - /dev/mapper/mpathz	32 × 200 GB	Application Data
REDODG	REDO1 - REDO16	/dev/mapper/mpathaj - /dev/mapper/mpathay	16 × 20 GB	Online REDO log group

TABLE 8. LUNS AND ORACLE ASM DISK MAPPINGS FOR ORACLE DATABASE IN SITE 1 AND SITE 2 (CONTINUED)

ASM Disk Group	ASM Disk	DM-Multipath LUNs	LUN Details	Purpose
FRADG	FRADISK1 – FRADISK8	/dev/mapper/mpathbh - / dev/mapper/mpathbo	8 × 2.0 TB	Flash Recovery Area
TEMPDG	TEMPDG1 – TEMPDG8	/dev/mapper/mpathaz, / dev/mapper/mpathba - / dev/mapper/mapthbg	8 x 240 GB	Temporary Tablespace

Server and Application Architecture

This reference architecture uses four Hitachi Advanced Server DS220 servers for a four-node Oracle RAC in an extended distance clusters 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 the VMware ESXi management server configuration.

TABLE 9. HITACHI ADVANCED SERVER DS220 AND DS120 SERVER SPECIFICATIONS

Hitachi Advanced Server	Server	Server Name	Role	CPU Cores	RAM
DS220 at Virtual Site 1	Oracle Server1	rac01	Oracle RAC node 1	36	768 GB (64 GB × 12)
	Oracle Server2	rac02	Oracle RAC node 2	36	768 GB (64 GB × 12)
DS220 at Virtual Site 2	Oracle Server3	rac03	Oracle RAC node 3	36	768 GB (64 GB × 12)
	Oracle Server4	rac04	Oracle RAC node 4	36	768 GB (64 GB × 12)

TABLE 9. HITACHI ADVANCED SERVER DS220 AND DS120 SERVER SPECIFICATIONS (CONTINUED)

Hitachi Advanced Server	Server	Server Name	Role	CPU Cores	RAM
DS120 at Virtual Site 1	Management server	VMware ESXi 1	Hitachi Ops Center Protector Master VM	18	256 GB (32 GB × 8)
		VMware ESXi 2	Hitachi Ops Center Protector Proxy VM Workload application VM Manager for Hitachi Adapters for Oracle Database VM Oracle Enterprise Manager Cloud Control 13c VM Ops Center Analyzer and Detail View Server Ops Center Probe VM	18	256 GB (32 GB × 8)

SAN Architecture

Map the provisioned LDEVs to multiple ports on two Hitachi Virtual Storage Platform E990 storage systems. These LDEV port assignments provide multiple paths to the storage system from the host for high availability.

Virtual Site 1

- 12 SAN switch connections for VSP E990 storage ports
- 8 SAN switch connections for server HBA ports
- Management cluster connections
  - 4 SAN switch connections for VSP G900 storage ports
  - 4 SAN switch connections for server HBA ports

Virtual Site 2

- 12 SAN switch connections for VSP E990 storage ports
- 8 SAN switch connections for server HBA ports

Table 10 shows details of the Fibre Channel switch connect configuration on the Hitachi Virtual Storage Platform E990 storage ports.

TABLE 10. SAN HBA CONNECTION CONFIGURATION BETWEEN DS220 AND VSP E990, DS120 AND VSP G900

Server	HBA Ports	Switch Zone	Connection	Storage Ports	Brocade G620 Switch
DS220 Server at Virtual Site 1	DS220_1_HBA1_1	DS220_1_HBA1_1_E990_33_1A	Local	1A	SAN-switch 1
		DS220_1_HBA1_1_E990_34_1A	Remote	1A	SAN-switch 1
	DS220_1_HBA1_2	DS220_1_HBA1_1_E990_33_1A	Local	2A	SAN-switch 2
		DS220_1_HBA1_1_E990_34_1A	Remote	2A	SAN-switch 2
	DS220_1_HBA2_1	DS220_1_HBA1_1_E990_33_1A	Local	1B	SAN-switch 1
		DS220_1_HBA1_1_E990_34_1A	Remote	1B	SAN-switch 1
	DS220_1_HBA2_2	DS220_1_HBA1_1_E990_33_1A	Local	2B	SAN-switch 2
		DS220_1_HBA1_1_E990_34_1A	Remote	2B	SAN-switch 2
DS220 Server at Virtual Site 1	DS220_2_HBA1_1	DS220_2_HBA1_1_E990_33_1C	Local	1C	SAN-switch 1
		DS220_2_HBA1_1_E990_34_1C	Remote	1C	SAN-switch 1
	DS220_2_HBA1_2	DS220_2_HBA1_1_E990_33_2C	Local	2C	SAN-switch 2
		DS220_2_HBA1_1_E990_34_2C	Remote	2C	SAN-switch 2
	DS220_2_HBA2_1	DS220_2_HBA1_1_E990_33_1D	Local	1D	SAN-switch 1
		DS220_2_HBA1_1_E990_34_1D	Remote	1D	SAN-switch 1
	DS220_2_HBA2_2	DS220_2_HBA1_1_E990_33_2D	Local	2D	SAN-switch 2
		DS220_2_HBA1_1_E990_34_2D	Remote	2D	SAN-switch 2
DS220 Server at Virtual Site 2	DS220_3_HBA1_1	DS220_3_HBA1_1_E990_33_1A	Remote	1A	SAN-switch 3
		DS220_1_HBA1_1_E990_34_1A	Local	1A	SAN-switch 3
	DS220_3_HBA1_2	DS220_1_HBA1_1_E990_33_1A	Remote	2A	SAN-switch 4
		DS220_1_HBA1_1_E990_34_1A	Local	2A	SAN-switch 4
	DS220_3_HBA2_1	DS220_1_HBA1_1_E990_33_1A	Remote	1B	SAN-switch 3
		DS220_1_HBA1_1_E990_34_1A	Local	1B	SAN-switch 3
	DS220_3_HBA2_2	DS220_1_HBA1_1_E990_33_1A	Remote	2B	SAN-switch 4
		DS220_1_HBA1_1_E990_34_1A	Local	2B	SAN-switch 4

TABLE 10. SAN HBA CONNECTION CONFIGURATION BETWEEN DS220 AND VSP E990, DS120 AND VSP G900 (CONTINUED)

Server	HBA Ports	Switch Zone	Connection	Storage Ports	Brocade G620 Switch
DS220 Server at Virtual Site 2	DS220_4_HBA1_1	DS220_2_HBA1_1_E990_33_1C	Remote	1C	SAN-switch 3
		DS220_2_HBA1_1_E990_34_1C	Local	1C	SAN-switch 3
	DS220_4_HBA1_2	DS220_2_HBA1_1_E990_33_2C	Remote	2C	SAN-switch 4
		DS220_2_HBA1_1_E990_34_2C	Local	2C	SAN-switch 4
	DS220_4_HBA2_1	DS220_2_HBA1_1_E990_33_1D	Remote	1D	SAN-switch 3
		DS220_2_HBA1_1_E990_34_1D	Local	1D	SAN-switch 3
	DS220_4_HBA2_2	DS220_2_HBA1_1_E990_33_2D	Remote	2D	SAN-switch 4
		DS220_2_HBA1_1_E990_34_2D	Local	2D	SAN-switch 4
DS120 Server Virtual Site 1	DS120_1_HBA1_1	DS120_1_HBA1_1_G900_50_1C	Local	1C	SAN-switch 1
	DS120_1_HBA1_2	DS120_1_HBA1_2_G900_50_2C	Local	2C	SAN-switch 2
DS120 Server Virtual Site 1	DS120_2_HBA1_1	DS120_2_HBA1_1_G900_50_1D	Local	1D	SAN-switch 1
	DS120_2_HBA1_2	DS120_2_HBA1_2_G900_50_2D	Local	2D	SAN-switch 2

Table 11 shows the SAN Switch Architecture between two VSP E990 storage systems.

TABLE 11. SAN SWITCH ARCHITECTURE BETWEEN VSP E990 STORAGE SYSTEMS

Storage System	Storage Ports	Switch Zone	Storage System	Storage Ports	Purpose
Virtual Site 1 VSP E990	5A	E990_33_5A_E990_34_5A	Virtual Site 2 VSP E990	5A	Replication link/ Remote Connection
	6A	E990_34_6A_E990_33_6A		6A	Replication link/ Remote Connection

Table 12 shows the SAN switch architecture between two VSP E990 storage systems and the ESXi cluster.

TABLE 12. SAN SWITCH ARCHITECTURE BETWEEN VSP E990 STORAGE SYSTEMS AND ESXI CLUSTER

Site	Server	HBA Ports	Switch Zone	Storage System	Purpose
Virtual Site 1	ESXi Server 1	ESX1_HBA1_1	ESX1_HBA1_1_E990_33_5C	Virtual Site 1 VSP E990	Command device
		ESX1_HBA1_2	ESX1_HBA1_1_E990_34_6C	Virtual Site 2 VSP E990	
	ESXi Server 2	ESX2_HBA1_1	ESX1_HBA1_1_E990_33_5C	Virtual Site 1 VSP E990	
		ESX2_HBA1_2	ESX1_HBA1_1_E990_34_6C	Virtual Site 2 VSP E990	

Note – In a production environment, it is recommended to use separate storage ports for the management servers and quorum disks to avoid impacting 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.
- **BMC/management network** – The Baseboard Management Controller (BMC) provides remote management capabilities, including console redirection, logging, and power control.

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 Oracle 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.

Table 13 shows the network configuration, and Table 14 shows the virtual IP address and SCAN name configuration used when testing the environment. Your values might be different.

When creating NIC bonding pairs, ports should be used on different cards to avoid single point of failure (SPoF). It is recommended that BMC connections go to a separate switch on the management network.

TABLE 13. NETWORK CONFIGURATION

Server	NIC Ports	VLAN/ Subnet	NIC Bond	Subnet	Network	Bandwidth (Gbps)	Cisco Nexus 93180YC-EX Switch	
							Switch Number	Port
DS220 Server 1	NIC1 PORT 1	208	Bond0	208	Private	25	1	31
	NIC2 PORT 1					25	2	
	NIC1 PORT 2	242	Bond1	242	Public Oracle	25	1	32
	NIC2 PORT 2					25	2	
	BMC-Dedicated NIC	244	-	244	Public Management	1	-	
DS220 Server 2	NIC1 PORT 1	208	Bond0	208	Private	25	1	33
	NIC2 PORT 1					25	2	
	NIC1 PORT 2	242	Bond1	242	Public Oracle	25	1	34
	NIC2 PORT 2					25	2	
	BMC-Dedicated NIC	244	-	244	Public Management	1	-	

TABLE 13. NETWORK CONFIGURATION (CONTINUED)

Server	NIC Ports	VLAN/ Subnet	NIC Bond	Subnet	Network	Bandwidth (Gbps)	Cisco Nexus 93180YC-EX Switch	
							Switch Number	Port
DS220 Server 3	NIC1 PORT 1	208	Bond0	208	Private	25	1	35
	NIC2 PORT 1					25	2	
	NIC1 PORT 2	242	Bond1	242	Public Oracle	25	1	36
	NIC2 PORT 2					25	2	
	BMC-Dedicated NIC	244	-	244	Public Management	1	-	
DS220 Server 4	NIC1 PORT 1	208	Bond0	208	Private	25	1	37
	NIC2 PORT 1					25	2	
	NIC1 PORT 2	242	Bond1	242	Public Oracle	25	1	38
	NIC2 PORT 2					25	2	
	BMC-Dedicated NIC	244	-	244	Public Management	1	-	
DS120 management server1	NIC1 PORT 1	242	-	242	Public	25	1	39
	BMC-Dedicated NIC	244	-	244	Public Management	1	-	

TABLE 13. NETWORK CONFIGURATION (CONTINUED)

Server	NIC Ports	VLAN/ Subnet	NIC Bond	Subnet	Network	Bandwidth (Gbps)	Cisco Nexus 93180YC-EX Switch	
							Switch Number	Port
DS120 management server2	NIC1 PORT 1	242	-	242	Public	25	1	40
	BMC-Dedicated NIC	244	-	244	Public Management	1		

TABLE 14. VIRTUAL IP AND SCAN NAME CONFIGURATION

Server	Virtual IP Subnet	Subnet and Scan Name
Database Server 1 (DS220 1)	242	242 sgrac-cluster-scan
Database Server 2 (DS220 2)		
Database Server 3 (DS220 3)		
Database Server 4 (DS220 4)		

TABLE 15. MANAGEMENT SERVER VIRTUAL MACHINE CONFIGURATION

Virtual Machine	vCPU	Virtual Memory	Disk capacity	Subnet	OS
Hitachi Ops Center Protector	2	8 GB	300 GB	242	Windows Server 2012 R2 Standard
Swingbench	2	8 GB	100 GB		Windows Server 2012 R2 Standard
vCenter	2	10 GB	300 GB		VMware Photon Linux 1.0
OEM	16	32 GB	200 GB		RHEL 7.6
Oracle Adapters	2	6 GB	40 - 50 GB		OL 7.3
Ops Center Analyzer	4	16 GB	100 GB		Oracle Linux Server release 7.8
Ops Center Analyzer Probe	4	32 GB	800 GB		Oracle Linux Server release 7.8
vSVP - Storage Virtual Platform E990	2	32	120 GB	167	Microsoft Windows 7 (64-bit)

Global-active Device Setup Pre-configuration

Before setup of global-active device configuration using Hitachi Ops Center Protector, manual pre-configuration steps must be performed at Virtual Site 1 and Virtual Site 2 on VSP E990 storage systems. Manual pre-configuration includes creation of pools, vVols, host groups, zone configuration, multipathing configuration, and creation of the quorum disk. This environment makes use of adding a quorum disk without an LDEV.

Table 16 shows the manual pre-configuration needed on Virtual Site 1 and Virtual Site 2 on VSP E990 storage systems before setting up global-active device using Hitachi Ops Center Protector.

TABLE 16. MANUAL PRE-CONFIGURATION ON VSP E990

	Virtual Site 1	Virtual Site 2
Pool Name	Oracle_Pool	Oracle_Pool
vVols	70 vVols ▪ 1 x Command Device ▪ 2 x OS ▪ 67 P-VOLs for Oracle Database	70 vVols ▪ 1 x Command Device ▪ 2 x OS ▪ 67 Global-active device S-VOLs will be created using Hitachi Ops Center Protector
Host Groups	22 Host Groups ▪ 16 x Oracle ASM Disks ▪ (8 x Local, 8x Remote) ▪ 2 x Remote Paths ▪ 2 x Operating Systems ▪ 2 x Command Device	22 Host Groups ▪ 16 x Oracle ASM Disks ▪ (8 x Local, 8x Remote) ▪ 2 x Remote Paths ▪ 2 x Operating Systems ▪ 2 x Command Device
Zone configuration	22 Zones	22 Zones
Quorum disk	Add quorum disk without using LDEV	Add quorum disk without using LDEV
Multipathing	4 owner paths per server for Oracle database P-VOLs	4 owner paths per server for Oracle database P-VOLs
	(4 non-owner paths will be added after global-active device setup, with a total 8 of paths per server Oracle database P-VOLs) See Table 10, “SAN HBA Connection Configuration Between DS220 and VSP E990, DS120 and VSP G900,” on page 16 for details of owner (local) and non-owner (remote) paths	(4 non-owner paths will be added after global-active device setup, with a total of 8 paths per server Oracle database S-VOLs) See Table 10, “SAN HBA Connection Configuration Between DS220 and VSP E990, DS120 and VSP G900,” on page 16 for details of owner (local) and non-owner (remote) paths

Engineering Validation

This summarizes the key observations from the test results for the Hitachi Unified Compute Platform CI architecture for Oracle Real Application Clusters on Extended Distance Clusters in a logical two-site environment using Hitachi Ops Center Protector and global-active device in a Hitachi Virtual Storage Platform for Oracle RAC deployment with Hitachi Virtual Storage Platform E990 and Hitachi Advanced Server DS220.

Solution Tests

Testing this solution consisted of the following procedures:

- Perform global-active device replication for the Oracle database and OCR disks to the secondary VSP E990 storage system using Hitachi Ops Center Protector.
- Recover Oracle Database after storage links failure on Virtual Site 2 storage systems.
- Perform storage replication operations using Hitachi Ops Center Protector.
- Perform backup and recovery operations using Hitachi Ops Center Protector and Oracle RMAN SBT integration.

Test Methodology

The global-active device component test results were demonstrated using the Swingbench tool.

Swingbench

The Swingbench workload generation application was used. Swingbench is a free load generator (and benchmark tool) designed to stress test an Oracle database. Swingbench consists of a load generator, a coordinator, and a cluster overview. The software enables a load to be generated and the transactions and response times to be charted.

Swingbench can be used to demonstrate and test technologies such as Real Application Clusters, online table rebuilds, standby databases, and online backup and recovery. See the Swingbench documentation for more information.

Workload Configuration

Testing ran simulated and synthetic workloads using Swingbench. This simulated the workloads for Hitachi Virtual Storage Platform G900 with Storage Virtualization Operating System to test the global-active device.

Test Results

The following tables provide test result details.

TABLE 17. GLOBAL-ACTIVE DEVICE COMPONENT FAILURE

Use Case	Services Impacted After Failure	Services Affected During Recovery	Total Service Downtime
Recover Oracle Database after Virtual Site 2 storage link failure	No	No	From zero to seconds*
Recover Oracle Database after path failure between servers and local storage system	No	No	Zero

TABLE 17. GLOBAL-ACTIVE DEVICE COMPONENT FAILURE

Use Case	Services Impacted After Failure	Services Affected During Recovery	Total Service Downtime
Perform global-active device 2-datacenter swap operations from primary to secondary and secondary to primary devices	No	No	Zero
Perform global-active device pair pause, resume, teardown, and delete operations	No	No	Zero

* See Oracle documentation for best practices for application continuity or transparent application continuity configuration.

TABLE 18. RMAN SBT INTEGRATION

Use Case	Operation	Status
Configure Hitachi Ops Center Protector policy, data flow, and RMAN channel	RMAN SBT Integration	Success
RMAN backup operations using SBT channel	Full Backup	Success
	Archive log Backup	Success
	Incremental Backup	Success
RMAN recovery operations using SBT channel	Recover to Current Position	Success
	Recover to System Change Number (SCN)	Success
	Recover to Point in Time	Success

Table 19 shows the benefits of using Hitachi Ops Center Protector versus using manual commands for global-active device setup and configuration.

TABLE 19. BENEFITS OF USING HITACHI OPS CENTER FOR GLOBAL-ACTIVE DEVICE SETUP AND CONFIGURATION

Global-active Device Setup and Configuration	Using Manual Commands	Using Hitachi Ops Center Protector
Web-Based UI for management flexibility	No	Yes
Quick and easy automated global-active device setup and recovery of global-active device replication in error or suspended state storage operations	No	Yes
One-click global-active device pair pause, resume, swap, dissociate, revert, teardown, delete, re-setup global-active device pair replication, and option-less administration	No	Yes
Automated global-active device HORCM configuration and setup. No need for HORCM storage command knowledge to set up and manage global-active device	No	Yes
Informative log messages and monitoring that explain the process of global-active device pairing, pause, resume, swap, teardown, and delete operations	No	Yes
Option to select secondary site storage pool, quorum disk, and mapping multiple host groups on a single screen	No	Yes
RMAN SBT integration allows Oracle RMAN to use Hitachi Ops Center Protector managed datastores	No	Yes

Conclusion

- Test results show that this reference architecture built with Hitachi Virtual Storage Platform E990 and Hitachi Advanced Server DS220 delivers nonstop operations with synchronous data replication and ensures superior disaster recovery.
- This solution reduces Total Cost of Ownership (TCO) by using a virtualized volume for the quorum disk in a global-active device environment because it eliminates dependency on external storage and Fibre Channel and network connections for external storage.
- Hitachi Ops Center Protector provides robust features and a user-friendly web-based user interface to create, manage, and administer global-active device pairs to achieve higher data protection and performance for Oracle Database environments.
- Hitachi Ops Center Protector integrates with Oracle RMAN using the SBT interface, which allows the database administrator to store data in datastores managed by Protector. The integration leverages Protector's Unified Backup Infrastructure to enable the RMAN backup to both on-site and cloud targets in a flexible and efficient way.

Product Descriptions

Hitachi Virtual Storage Platform E990

Hitachi Virtual Storage Platform E990 supercharges business application performance with all-NVMe storage. It uses Hitachi Ops Center, so you can improve IT operations with the latest AI and ML capabilities. Advanced data reduction in Virtual Storage Platform E990 enables you to run data reduction with even the most performance hungry applications.

The all-NVMe architecture in Virtual Storage Platform E990 delivers consistent, low-microsecond latency to reduce latency costs for critical applications. This predictable performance optimizes storage resources.

With Virtual Storage Platform E990 and the rest of Hitachi's midrange storage family, you have agile and automated data center technology. These systems allow you to cost-effectively meet your current digital expectations and give you the ability to address future challenges, as your application data needs and service levels evolve. With time-tested, proven availability and scalability, Hitachi Vantara delivers infrastructure solutions that help you maximize your data center advantage.

Hitachi Storage Virtualization Operating System RF

Hitachi Storage Virtualization Operating System RF (SVOS RF) 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.

SVOS RF integrates with Hitachi's Base and Advanced software packages to deliver superior availability and operational efficiency. You gain active-active clustering, data-at-rest encryption, insights via machine learning, and policy-defined data protection with local and remote replication.

Hitachi Ops Center

Manage, optimize, orchestrate and protect your data with advanced IT analytics and automation using Hitachi Ops Center. Achieve new insights, accelerate resource delivery, eliminate risks, and speed innovation to modernize your data center operations.

Use the power of AI operations with the following:

- Protector. Meet tight service level requirements when protecting critical data and applications. Automatically support secondary business functions with data copies staff need to do their jobs. Make better use of backup data for activities, such as e-discovery and analysis. Simplify administration and replication management. Do it all with no disruption to production application availability and performance.
- Analyzer. Improve IT operations with machine learning (ML) to drive resource service levels, utilization, and automation at lower costs. Obtain operational visibility from virtual machines, servers, SAN switches to shared storage resources to optimize an application's full data path.
- Automator. Deliver resources up to 70% faster than manual processes. Free staff to focus on strategic initiatives.

Hitachi Advanced Server DS220

Hitachi Advanced Server DS220 is a high-performance two-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 DS220 provides flexible I/O scalability for today's diverse data center application requirements.

Hitachi Advanced Server DS120

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 RAM using 24 slots of 2666 MHz DDR4 RDIMM. 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 small form factor storage devices with up to 4 NVMe.

The following applications were installed in individual virtual machines in this architecture and would be installed in most cases.

- Hitachi Ops Center
- Oracle Enterprise Manager (OEM) 13c
- Hitachi Storage Adapter for Oracle Enterprise Manager
- Hitachi Server Adapter for Oracle Enterprise Manager
- Oracle Adapter Manager
- vCenter Server

Other management applications can be installed on additional virtual machines depending on your requirements.

Hitachi Ops Center Protector

Hitachi Ops Center Protector provides a modern, holistic approach to data protection, recovery, and retention. It has a unique workflow-based policy engine, presented in an easy-to-use whiteboard-style user interface that helps map copy-data management processes to business priorities. A wide range of fully integrated hardware storage-based and host-based incremental-forever data capture capabilities are included that can be combined into complex workflows to automate and simplify copy-data management.

Benefits:

- Choose the right technology for each workload, based on service level requirements, but manage them from one place.
- Drag-and-drop a range of protection, retention, and repurposing capabilities to easily create and manage complex workflows.
- Automate and orchestrate Hitachi storage-assisted snapshots, clones, and replications to eliminate backup windows.
- Automate the mounting of Hitachi storage-based snapshots, clones and replications for proxy backup and repurposing.
- Hitachi Ops Center Protector supports a wide range of data storage targets, including repository, block, and file-based storage.

Product Features:

- Automate and orchestrate data copy technologies.
- Storage snapshots for instant copy and restore.
- Remote replication for high availability, DR.
- Full-copy clones for seamless DR testing.
- Application-consistent copies for simple recovery.
- Host-based sources and cloud-based targets.
- Automatically create, refresh, and expire copies.
- Patented, granular role-based access controls.
- Full RESTful API for easy integration.

Oracle Linux

Oracle Linux (OL, formerly known as Oracle Enterprise Linux) is a Linux distribution packaged and freely distributed by Oracle, available partially under the GNU General Public License. It is compiled from Red Hat Enterprise Linux source code, replacing Red Hat branding with Oracle branding.

Oracle Database with 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.

VMware ESXi

VMware ESXi is a foundation for the virtual infrastructure used for the management applications in this architecture. This allows the environment to operate independently from any general-purpose operating system, offering security, reliability, and simplified management. This reference architecture uses VMware ESXi for the management servers only.

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.

This reference architecture uses VMware vCenter Server Appliance for the management server cluster only.

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.

For version details about the hardware components, see the Oracle UCP CI Composable and XaaS Interoperability Matrix at the Hitachi Interoperability Reports site:

https://support.hitachivantara.com/en/answers/interoperability.html

See the following link for more information:

https://www.broadcom.com/products/fibre-channel-networking/switches/g620-switch

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 1 GbE switch

Network switches are optional, but customers should check the support matrix to ensure support prior to implementation. See the following links for more information:

https://support.hitachivantara.com/en/answers/interoperability.html

https://www.cisco.com/c/en/us/support/switches/nexus-93180yc-ex-switch/model.html

https://www.cisco.com/c/en/us/support/switches/nexus-3048-switch/model.html

Device Mapper Multipathing

Device mapper multipathing (DM-Multipath) on Oracle Linux 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.

Ops Center Administrator

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

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.

For More Information

Hitachi Vantara Global Services offers experienced storage consultants, proven methodologies and a comprehensive services portfolio to assist you in implementing Hitachi products and solutions in your environment. For more information, see the Services website.

Demonstrations and other resources are available for many Hitachi products. To schedule a live demonstration, contact a sales representative or partner. To view on-line informational resources, see the Resources website.

Hitachi Academy is your education destination to acquire valuable knowledge and skills on Hitachi products and solutions. Our Hitachi Certified Professional program establishes your credibility and increases your value in the IT marketplace. For more information, see the Hitachi Vantana Training and Certification website.

For more information about Hitachi products and services, contact your sales representative, partner, or visit the Hitachi Vantara website.

Hitachi Vantara

Corporate Headquarters
2535 Augustine Drive
Santa Clara, CA 95054 USA
www.HitachiVantara.com | community.HitachiVantara.com

Regional Contact Information
USA: 1-800-446-0744
Global: 1-858-547-4526
HitachiVantara.com/contact

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