

Hitachi Solution for Databases – Oracle Real Application Cluster (RAC) virtualized on Oracle Linux Virtualization Manager with VSP E990 and DS220 G2

Reference Architecture Guide

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Revision history

Revision	Changes	Date
MK-SL-202-01	Support for DS220 G2	January 11, 2022
MK-SL-202-00	Initial release	June 18, 2020

Reference Architecture Guide

Hitachi Solution for Databases with Oracle RAC virtualized on Oracle Linux Virtualization Manager using Virtual Storage Platform E990 and Hitachi Advanced Server DS220 G2 with Ice Lake Server Scalable Processors provides reliability, high availability, and scalability while processing small to large Oracle workloads. This reference architecture provides a virtualized Oracle RAC Database 19c on Oracle Linux Virtualization Manager 4.3.10. In this solution Oracle RAC Database nodes are deployed on Oracle KVM hosts with Oracle Linux 7.9 UEK 6 and test VMs with Oracle Linux 8.5 UEK 6.

Hitachi Solution for Databases with Oracle RAC Virtualization Manager is a fast, agile offering from Hitachi Vantara that makes efficient use of the deployed resources. Oracle RAC virtualization using Oracle Linux Virtualization Manager aims for IT transformation, as you want a fast and flexible journey to reduce cost and quickly scale your environment up or down.

Oracle Linux Virtualization Manager release 4.3.10 supports multiple hosts running Oracle Linux KVM. The heart of the manager is the oVirt Engine which is used to discover KVM hosts and configure storage and networking for the virtualized data center. This solution integrates many innovative technologies from Hitachi Vantara and Oracle. To create an Oracle RAC Virtualization Manager environment the following components are used:

- Hitachi Virtual Storage Platform E990 (VSP E990) used as storage resource.
- Hitachi Advanced Server DS220 G2 with Intel Xeon Platinum 8368 38C CPUs for storage and computing resources.
- Hitachi Advanced Server DS120 G2 Intel Xeon Processor 4310 with 12-core processors for the management servers.
- Oracle Linux Virtualization Manager 4.3.10.
- Oracle Real Application Clusters (RAC).

Running Oracle RAC on Oracle Linux Virtualization Manager provides following benefits:

- Reduced overhead for hypervisor to minimize infrastructure and software licensing costs.
- Simplified management with Oracle Linux Virtualization Manager.
- Easier to move VMs to the cloud.

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

This document is for the following audiences:

- Database administrators
- Storage administrators

- System administrators
- IT professional responsible for planning and deploying an Oracle Database solution

To use this document, you need familiarity with the following:

- Hitachi Virtual Storage Platform E990
- Hitachi Advanced Server DS220 G2 servers
- Hitachi Advanced Server DS120 G2 servers
- Storage Area Networks
- Oracle Database administration
- Oracle Database 19c Release Update 12
- Oracle Linux
- Oracle Linux Virtualization Manager



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

Use this reference architecture to implement Hitachi Solution for Databases with Oracle RAC virtualized on Oracle Linux Virtualization Manager using Virtual Storage Platform E990 and Hitachi Advanced Server DS220 G2. This solution is engineered, pre-tested, and qualified to provide high performance and high reliability in demanding, dynamic Oracle environments. This reference architecture implements Hitachi Solution for Databases for an Oracle Real Application Clusters database using Hitachi Virtual Storage Platform E990.

Business benefits

Oracle Linux Virtualization Manager provides the foundation for the cloud infrastructure. It provides fully integrated enterprise management from disk to cloud applications. This virtualization management platform can be easily deployed to configure, monitor, and manage an Oracle Linux Kernel-based Virtual Machine (KVM) environment with enterprise-grade performance and support from Oracle.

Here are some benefits of this reference architecture:

- Create Oracle Linux Virtualization Manager clusters with multiple Hitachi Advanced Server DS220 G2 servers to deploy virtual machines for an Oracle database deployment.
- Oracle Virtualization reduces operation and support costs while increasing IT efficiency and agility —on premises and in the cloud.
- Add or remove servers in the Oracle Linux Virtualization Manager pool based on business requirements.

- Achieve high Oracle Database performance with VSP E990 storage.
- Provide a solution for customers who are looking for converged Oracle products – not covered by Hitachi VSP G700, VSP G800, VSP G900, or VSP 5000 for Oracle RAC.

High-level infrastructure

Hitachi Solution for Databases with Oracle RAC includes the following components:

- Hitachi Advanced Server DS220 G2 servers
- Hitachi Advanced Server DS120 G2 servers
- Hitachi Virtual Storage Platform E990
- Brocade G620 32 Gbps SAN infrastructure
- Cisco 10/25 GbE LAN infrastructure

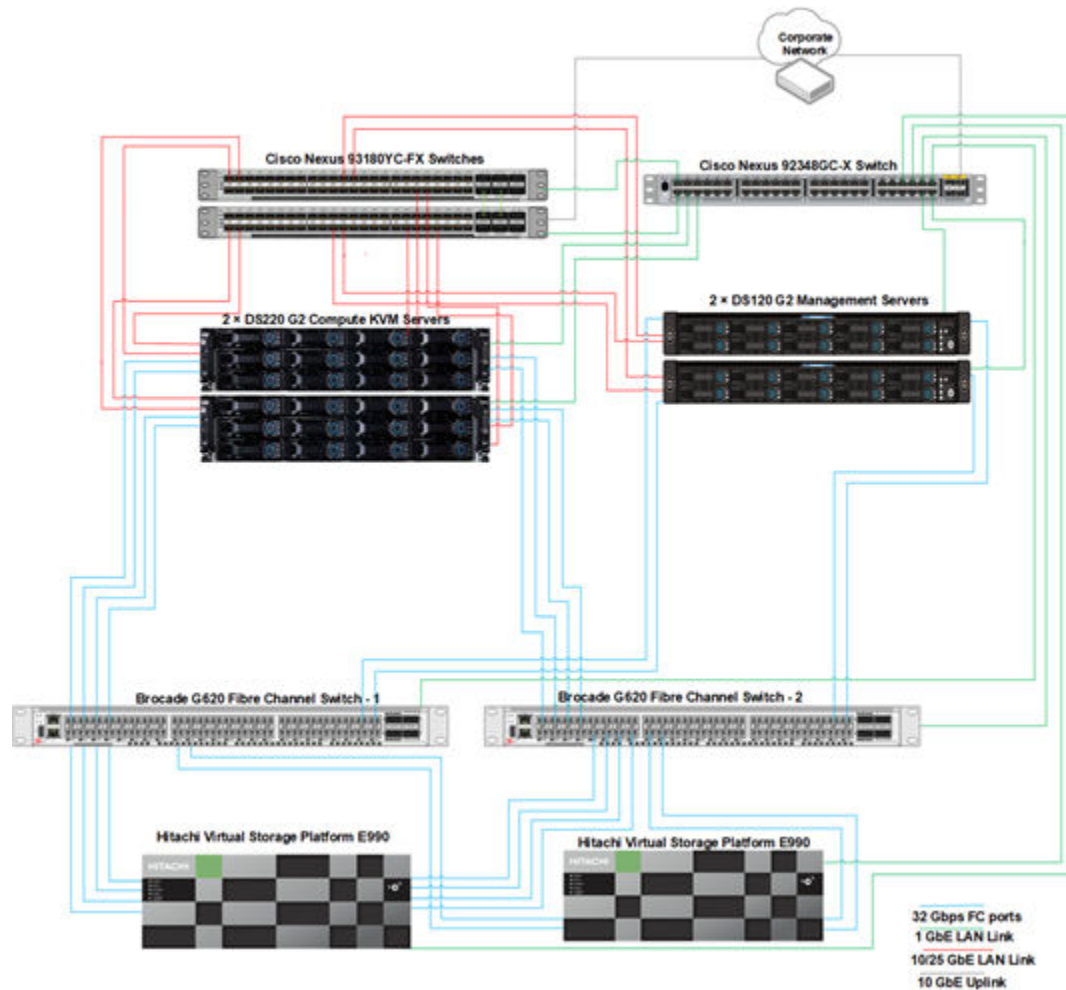


Note: The VSP E990 is not required in your environment. Data volumes can also be configured on the VSP E790 or other VSP storage arrays.

The configuration of Virtual Storage Platform E990 and Hitachi Advanced Server DS220 G2 has the following characteristics:

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

The following figure shows the high-level infrastructure for this solution.



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

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

The uplink speed to the corporate network depends on the customer environment and requirements. The Cisco Nexus 93180YC-FX switches used in this reference architecture can support uplink speeds of 40 GbE or 100 GbE if higher bandwidth is required.


Key solution components

The key solution components for this solution are listed in the following tables. Detailed component information is provided in [Product descriptions \(on page 24\)](#).

Table 1 Hardware Components

Vendor	Hardware	Detail Description	Version	Quantity
Hitachi Vantara	Hitachi Virtual Storage Platform E990	6 × CHA pairs (6 × 32Gbps Fibre Channel ports) 624.50 GB cache memory 24 x 1.9 TB Backend NVMe SDDs	93_02_02_60/00	1
	Hitachi Virtual Storage Platform E990 – Management node storage system	Two Controllers 4 × 32 Gbps Fibre Channel ports 16 × 12 Gbps backend SAS ports 1024 GB cache memory 32 ×3.8 TB NVMe SSDs*	93-02-02-60/00	1
Hitachi Vantara	Hitachi Advanced Server DS220 G2	2 × Intel Xeon Platinum 8368 38C CPU @ 2.40GHz 768 GB (64GB × 12) DIMM DDR4-3200 Synchronous Registered (Buffered) 3200 MHz	BIOS: 3A12.H03 BMC: 3.16.06 CPLD: 07	2
		2 × Intel XXV710 Dual Port 25 GbE SFP28 NIC cards	Driver: i40e Driver Version: 2.8.20-k Firmware: 8.40	
		2 × Emulex LightPulse LPe35002-M2 2-Port 32 Gb Fibre Channel adapters	Driver: lpfc Driver Version: 12.8.0.10 Firmware: 12.6.240.21	

Vendor	Hardware	Detail Description	Version	Quantity
	Hitachi Advanced Server DS120 G2	2 × Intel Xeon Processor 4310, 12-core, 2.10 GHz, 120W	BIOS: S5XH3A12.H03	2
		256 GB (32 GB × 8) DIMM DDR4-3200 Synchronous Registered (Buffered) 3200 MHz	BMC: 3.16.06 CPLD: 07	
		1 × 256 GB NVMe 0.3DWPD M.2 SSD for boot		
		1 × Dual Port 25 GbE NIC Intel E810 PCIe card	Driver Version: 1.8.1.6 Firmware: 7.30	
		1 × Emulex LightPulse LPe35002-M2 2-Port 32Gb Fibre Channel Adapters	Driver: lpfc Driver Version: 12.8.0.10 Firmware: 12.8.351.47	
Brocade	G620 Fibre Channel switches	48 × 32Gbps ports Fibre Channel switch 32 Gbps SFPs	Kernel: 2.6.34.6 Fabric OS: v9.0.0b	2
Cisco	Cisco Nexus N9K-C93180YC-FX	48 × 10/25 GbE ports 6 × 40/100 Gbps Quad SFP (QSFP28) ports	BIOS version: 07.65 NXOS: version 7.0(3)I7(6)	2
	Cisco-C92348GC-X	1 GE 48-Port Gb Ethernet switch	BIOS: version 5.37 NXOS: 9.3(3)	1

 **Note:** The solution was tested with PCIe and OCP Mezzanine NIC cards. Using all PCIe cards is recommended for consistency and better NIC bonding options. SATADOM, SAN boot, or local boot can be used for the boot option.


 **Note:** Customers can choose larger capacity SSDs to fit their business requirements.

Table 2 Software Components for Compute Nodes

Software	Version	Function
Oracle Linux	7.9 with 5.4.17-2011.6.2.el7uek.x86_64 on OLVM 7.9 with 5.4.17-2136.300.7.el7uek.x86_64 on KVM hosts 8.5 with 5.4.17-2136.301.1.4.el8uek.x86_64 on RAC VMs	Operating system
Oracle Database	19c (Version 19.12.0.0.0)	Database software
Oracle Grid Infrastructure	correct to 19c (Version 19.12.0.0.0)	Volume management, file system software, and Oracle automatic storage management

Table 3 Software Components for Management Nodes

Software	Version	Function
ESXi	7.0 U2	Hypervisor for management server
vCenter Server	7.0 U2	VMware cluster management server
Hitachi Device Manager - Storage Navigator	Microcode dependent	Storage management software
Hitachi Ops Center	10.7.0	Hitachi infrastructure management software
Oracle Linux Virtualization Manager	4.3.10	Server virtualization management platform

Solution design

This section describes the reference architecture environment to implement Hitachi Solution for Databases with Oracle RAC virtualized on Oracle Linux Virtualization Manager. The environment uses Hitachi Virtual Storage Platform E990.

The infrastructure configuration includes the following:

- Oracle KVM hosts – There are two hosts configured in an Oracle database environment.
- Management Node – One Oracle Linux Virtualization Manager node is used to manage KVM hosts.
- 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.

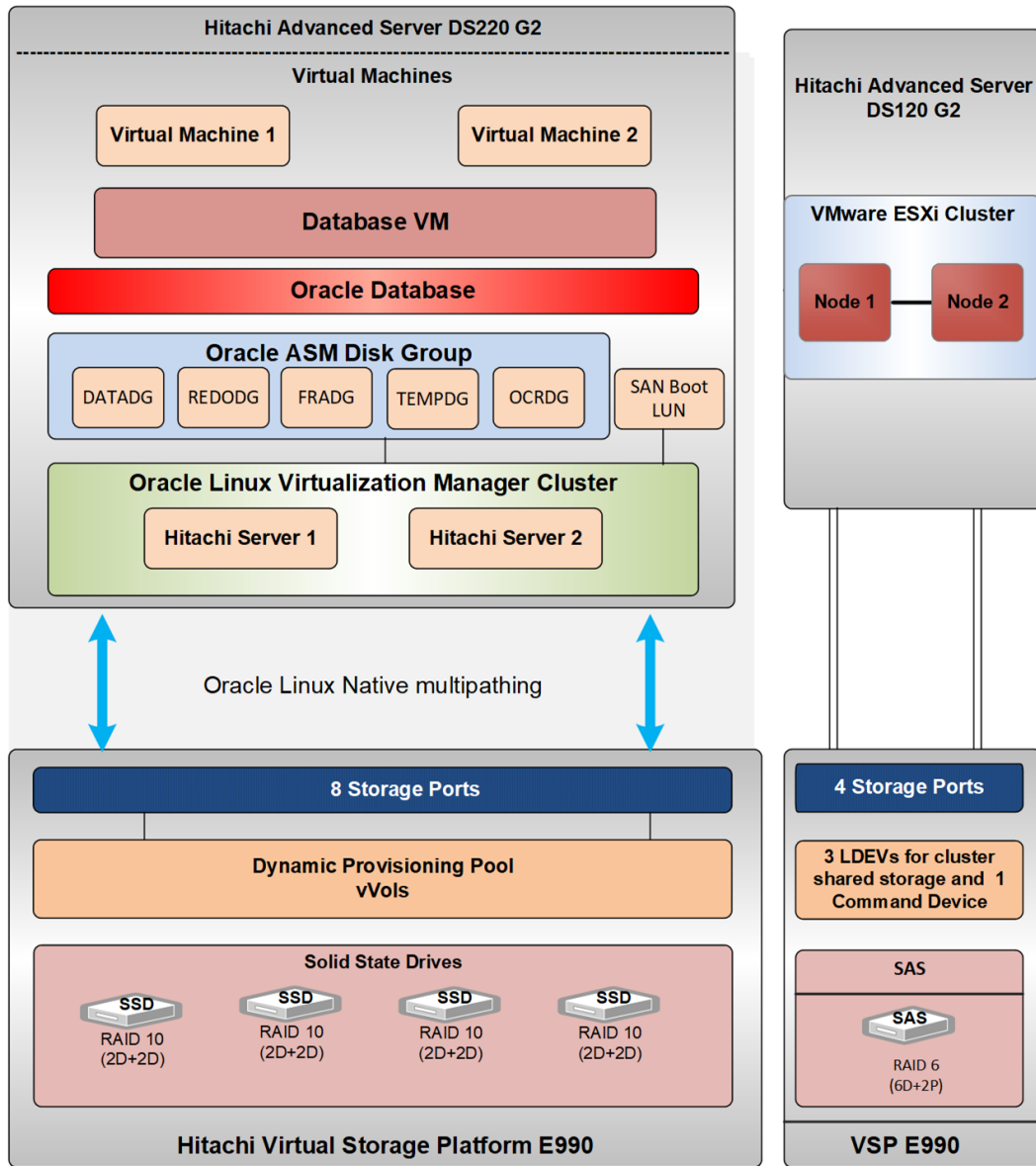
Storage architecture

This section describes the storage architecture for this solution.

Storage configuration

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

The following figure illustrates the high-level storage configuration for this solution.



The following table shows the storage pool configuration used for this solution.

Table 4 Dynamic Provisioning Pool for VSP E990

Pool ID	Oracle RAC-Pool
Pool Type	Dynamic Provisioning Pool
RAID Group	1-1 to 1-6
RAID Level	RAID 10 (2D+2D)
Drive Type	1.9 TB SSD
Number of Drives	16
Number of LDEVs	16

Pool ID	Oracle RAC-Pool
LDEV Size(s)	880 GB
Pool Capacity	13.74 TB

In this solution, servers use SAN boot with RAID 10 protection. The following table shows the logical storage configuration used in this solution.

Table 5 VSP E990 Logical Storage Configuration

ASM disk group	Total number of dynamic provisioning volumes	Dynamic provisioning volume sizes (GB)	Purpose	Storage Ports
DATA	16	200 GB	OLTP Application Tablespaces, System Sysaux, Undo	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
REDO	8	10 GB	Online Redo Logs and Control Files	
TEMP	4	40 GB	Temp logs	
FRA	2	200 GB	Incremental Backups, Archived Redo Logs, Control File and Auto backups	
OCR	3	60 GB	Oracle Cluster Registry and Voting Disk	
N/A	2	200 GB	SAN Boot OS Volumes	

The following table shows the VSP E990 configuration for management servers.

Table 6 VSP E990 Configuration for Management Servers

Item	Value/Description
Purpose	VMware datastores CCI device
RAID Level	RAID 6 (6D+2P)
Drive Type	1.9 TB SSD
Number of Drives	16

Item	Value/Description
Number of Spare Drives	0
Number of LDEVs	10
LDEV Size(s)	2048 GB
Number and Size of CCI device	1 × 100 MB
Storage Port for Management Servers	5C, 6C

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 dynamic provisioning pool, and 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 E990 for small random I/O traffic, such as OLTP transactions. The layout also considers 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 in the implementation.

The components in this solution 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 configurations

- Data and Indexes Tablespace - Assign an ASM diskgroup with external redundancy for the data and index tablespaces.
- TEMP Tablespace - Place the TEMP tablespace in this configuration in the TEMP ASM diskgroup.
- Undo Tablespace - Create an UNDO tablespace in this configuration within the Oracle Data ASM diskgroup.
- 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.

Oracle initial parameters

The following table shows the Oracle Database settings.

Table 7 Oracle Database Settings

Environment	Value
RAC	Yes
ASM	Yes – to support Oracle RAC Database

Oracle ASM disk mappings

The following table shows the details of the disk mappings from the LUNs to the ASM disk groups for Oracle Database tablespaces for the 2 TB database size. This is an example with a single instance database virtual machine. Adjust parameters accordingly when multiple virtual machine pairs are used.

Table 8 LUN Disk Mappings to ASM Groups

ASM Disk Group	ASM Disk	UDEV Rules	LUN Details	Purpose
N/A	N/A	/dev/xvd[a-b]1	2 × 200 GB	OS and Oracle Database
OCRDG	OCR1-OCR3	/dev/xvd[c-e]1	3 × 60 GB	Oracle cluster registry and voting disk
DATADG	DATA1-DATA16	/dev/xvd[f-u]1	16 × 200 GB	Application data
REDODG	REDO1-REDO8	/dev/xvd[v-z]1, /dev/xvda[a-c]1	8 × 10 GB	Online REDO log group
FRADG	FRA1-FRA4	/dev/xvda[d-e]1	4 × 200 GB	Flash recovery area
TEMPDG	TEMP1-TEMP4	/dev/xvda[f-i]1	4 × 40 GB	Temporary Tablespace

Management server configurations

The following table lists management server virtual machine (VM) configuration details.

Table 9 Management Server Virtual Machine Configuration

Virtual Machine	vCPU	Virtual Memory	Disk capacity	IP Address
vCenter Server	2	10 GB	300 GB	192.168.242.xx

Virtual Machine	vCPU	Virtual Memory	Disk capacity	IP Address
Oracle Linux Virtualization Manager	4	16 GB	200 GB	192.168.242.xx
Hitachi Ops Center Administrator	4	16 GB	100 GB	192.168.242.xx
Hitachi Ops Center Analyzer	4	32 GB	800 GB	192.168.242.xx
Hitachi Ops Center Analyzer detail view	4	10 GB	110 GB	192.168.242.xx

Server and application architecture

This reference architecture uses two Hitachi Advanced Server DS220 G2 servers with 2nd Generation Intel Xeon Scalable Processors for each storage system architecture that was tested.

This provides the compute power for the Oracle database to handle complex database queries and a large volume of transaction processing in parallel.

Two Hitachi Advanced Server DS120 G2 servers are used for VMware ESXi management server configuration.

The following table lists the details of the server configurations for this solution.

Table 10 Hitachi Advanced Server DS220 G2 and DS120 G2 Specifications

Server Make and Model	Server Host Name	Role	CPU Type	CPU Core	RAM
DS220 G2	server-01	Oracle Linux KVM Host for Oracle RAC VM (KVM host1)	2 × Intel Xeon Platinum 8368 38C CPU	76 (2 × 38C)	768 GB (64 GB × 12)
	server-02	Oracle Linux KVM Host for Oracle RAC VM (KVM host2)		76 (2 × 38C)	768 GB (64 GB × 12)
DS120 G2	ESXi_101	Management server for Hitachi management Applications	2 Intel Xeon Processor 4310, 12-core	24 (2 × 12C)	256 GB (32 GB × 8)
	ESXi_103			24 (2 × 12C)	256 GB (32 GB × 8)

SAN architecture

Map the provisioned LDEVs to multiple ports on Hitachi Virtual Storage Platform E990. These LDEV port assignments provide multiple paths to the storage system from the host for high availability. This reference architecture uses two dual port Emulex HBAs per Advanced Server DS220 G2.

Compute servers

- 8 SAN switch connections are used for VSP E990 Fibre Channel ports.
- 8 SAN switch connections are used for server HBA ports.

Management servers

- 4 SAN switch connections are used for VSP E990 Fibre Channel ports.
- 4 SAN switch connections are used for management server HBA ports.

The following tables list details of the Fibre Channel switch connect configuration on Hitachi VSP E990 and VSP E990 ports.

Table 11 SAN HBA Connection Configuration to Hitachi Virtual Storage Platform E990

Server	HBA	Host Group Name	Host Name	Switch Zone	Storage System	Storage Port	Brocade G620 Switch
DS220 G2 Server 1	HBA1	CN31	CN31_H BA1_1	CN31_H BA1_1_A SE42_43 _1A	VSP E990	1A	31
	HBA2	CN31	CN31_H BA1_2	CN31_H BA1_2_A SE42_43 _2A		2A	32
	HBA3	CN31	CN31_H BA2_1	CN31_H BA2_1_A SE42_43 _3A		3A	31
	HBA4	CN31	CN31_H BA2_2	CN31_H BA2_2_A SE42_43 _4A		4A	32
DS220 G2 Server 2	HBA1	CN32	CN32_H BA1_1	CN32_H BA1_1_A SE42_43 _5A		5A	31

Server	HBA	Host Group Name	Host Name	Switch Zone	Storage System	Storage Port	Brocade G620 Switch
	HBA2	CN32	CN32_H BA1_2	CN32_H BA1_2_A SE42_43 _6A		6A	32
	HBA3	CN32	CN32_H BA2_1	CN32_H BA2_1_A SE42_43 _7A		7A	31
	HBA4	CN32	CN32_H BA2_2	CN32_H BA2_2_A SE42_43 _8A		8A	32

Table 12 SAN HBA Connection Configuration to Hitachi Virtual Storage Platform E990

Server	HBA	Host Group Name	Host Name	Switch Zone	Storage Port	Brocade G620 Switch
DS120 G2 Server1	HBA1	MN33	MN33_HB A1	MN33_HB A1_ASE42 _43_5C	5C	69
	HBA2	MN33	MN33_HB A2	MN33_HB A2_ASE42 _43_6C	6C	70
DS120 G2 Server2	HBA1	MN34	MN34_HB A1	MN34_HB A1_ASE42 _43_5C	5C	69
	HBA2	MN34	MN34_HB A2	MN34_HB A2_ASE42 _43_6C	6C	70



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

Network architecture

Do the following when configuring 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 KVM sever node with at least the bonding interfaces for the following:

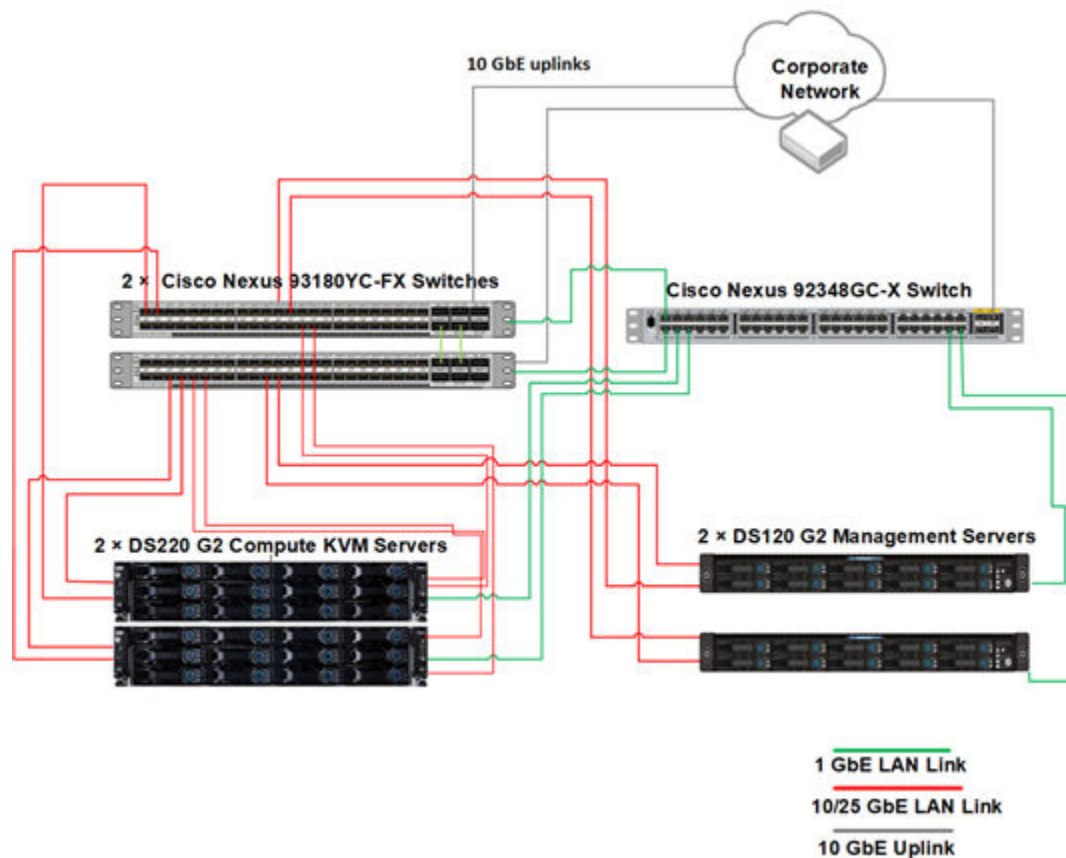
- Management network
- Public network
- Private network

Each virtual machine has public, private, and management vNICs. Use separate VLANs for the following:

- Oracle KVM management network
- Private Oracle database network
- Public network

Physical network configuration

The following figure shows the IP network switch connection.



The following tables list the network configurations for this solution.

Table 13 DS220 G2 and DS120 G2 Network Configuration

Server	NIC Ports	Subnet	NIC Bond	IP Address	Network	Bandwidth (Gbps)	Cisco Nexus 93180YC-FX Switch	
							Switch Number	Port
DS220 G2 Server1	NIC 1-Port 0	242	Bond0	192.198.242.204	Management/Public	10	1	41
	NIC 1-Port 1					10	2	
	NIC 2-Port 0	100	Bond1	192.168.100.xx	Private	25	1	
	NIC 2-Port 1					25	2	
DS220 G2 Server2	NIC 1-Port 0	242	Bond0	192.198.242.206	Management/Public	10	1	43
	NIC 1-Port 1					10	2	
	NIC 2-Port 0	100	Bond2	192.168.100.xx	Private	25	1	
	NIC 2-Port 1					25	2	

Server	NIC Ports	Subnet	NIC Bond	IP Address	Network	Bandwidth (Gbps)	Cisco Nexus 93180YC-FX Switch	
							Switch Number	Port
DS120 G2 Management Server1	NIC 1-Port 0	242	Bond0	192.198.242.101	Management/Public	25	1	49
	NIC 1-Port 1					25	2	
DS120 G2 Management Server2	NIC 1-Port 0	242	Bond0	192.198.242.102	Management/Public	25	1	50
	NIC 1-Port 1					25	2	



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

Table 14 Network configuration for servers and VSP E990

Name	IP Address
Oracle Linux KVM host 1	192.168.242.xx
Oracle Linux KVM host 2	192.168.242.xx
Management Server 1	192.168.242.xx
Management Server 2	192.168.242.xx
VSP E990	192.168.242.xx
VSP E990 CTL1	192.168.242.x
VSP E990 CTL2	192.168.242.x

Table 15 Network configuration for switches

Switch Type	Model	Switch Name	IP Address for MGMT port
Cisco 1GbE Management Network Switch	Cisco Nexus C92348GC-X	C92348GC-X -1	192.168.242.xx
Cisco 10G/25GbE Network Switch	Cisco Nexus N9K-C93180YC-FX	Cisco C93180YC-FX-1	192.168.242.xx
Cisco 10G/25GbE Network Switch	Cisco Nexus N9K-C93180YC-FX	Cisco C93180YC-FX-2	192.168.242.xx
Brocade Fibre Channel SAN Switch	G620	SAN-switch 1	192.168.242.xx
Brocade Fibre Channel SAN Switch	G620	SAN-switch 2	192.168.242.xx

Engineering validation

This section summarizes the key lab verification tests performed on Hitachi Solution for Databases - Oracle Real Application Cluster (RAC) virtualized on Oracle Linux Virtualization Manager using Hitachi Virtual Storage Platform E990 and Hitachi Advanced Server DS220 G2.

Database configuration

The following table lists parameter details for a two-node Oracle ASM database.

Table 16 Oracle ASM Database Parameters

Oracle Database Parameter	Value
Compatible	19.3.0.0.0
Oracle Database size	1 TB
Database storage type	ASM
Database fill factor	80%

Test environment

The following table lists configuration details for VSP E990 testing.

Table 17 Test Environment

Item	Value
Operating System on VMs	OL 8.5
Workload Type	OLTP/OLAP
Database Size	1 TB
Number of vCPUs	32
Virtual Memory	64 GB per VM
Host Cluster VM Network	2 × 10 Gbps NIC Bonding

Test methodology

The test results are demonstrated using Orion I/O workload and peakmarks OLTP test cases.

Orion

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

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

peakmarks

The test results are demonstrated using peakmarks OLTP test cases.

[peakmarks](#) is benchmark software for Oracle platforms. It was used in our tests for the of the following:

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

This provides transparency and comparability in price versus performance considerations for Oracle infrastructures. The peakmarks 9.6 tool is used to validate this solution.

Test results

The following table provides Orion test result details.

Table 18 Orion test results

Test Category	Test Case	Test Result	
		Throughput	RT (ms)
Orion	8 KB Random Read	4,16,289 IOPS	1.12
	8 KB Random Write	2,90,286 IOPS	0.5
	1 MB Sequential Read	11.435 GBps	N/A
	1 MB Sequential Write	2.396	N/A

The following table provides peakmarks test results.

Test Category	Test Case	Test Results	
		Throughput	RT (ms)
peakmarks	STO-READ	7.59 GBps	N/A
	STO-Random 100% read	335,540 IOPs	0.954
	STO-Random 80% read 20% write	317,173 IOPs	0.858
	STO-Random 50% read 50% write	244,885 IOPs	0.553
	SRV-SCAN	61.822 GBps	N/A
	DA- ROWSTORE	47.584 GBps	N/A
	DA-LOW/STO	10.394 GBps	N/A
	TP-LIGHT 1 RPT 0 % update	392,604 tps	0.197
	TP-LIGHT 1 RPT 20 % update	280,287 tps	0.396
	TP-LIGHT 1 RPT 30% update	223,516 tps	0.455
	TP-MEDIUM 25 RPT 0% update	102,492 tps	0.168
	TP-MEDIUM 25 RPT 20% update	18,772 tps	0.917
	TP-MEDIUM 25 RPT 30% update	15,677 tps	0.877

Conclusion

Hitachi Virtual Storage Platform E990 and Hitachi Advanced Server DS220 has been tested and validated as an ideal platform for virtualized workloads. It was tested on Oracle RAC database as well as with multiple environments running at the same time.

Product descriptions

These products are used in this reference architecture.

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 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](#) powers the Hitachi Virtual Storage Platform (VSP) family. 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.

Flash performance is optimized with a patented flash-aware I/O stack, which accelerates data access. Adaptive inline data reduction increases storage efficiency while enabling a balance of data efficiency and application performance. Industry-leading storage virtualization allows SVOS RF to use third-party all-flash and hybrid arrays as storage capacity, consolidating resources for a higher ROI and providing a high-speed front end to slower, less-predictable arrays.

Hitachi Advanced Server DS220 G2

With a combination of two Intel Xeon Scalable processors and high storage capacity in a 2U rack-space package, [Hitachi Advanced Server DS220 G2](#) 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 32 slots for high-speed DDR4 memory, allowing up to 4 TB memory capacity with RDIMM population (128 GB × 32) or 8TB (512 GB × 16) with Intel Optane Persistent Memory population.

DS220 G2 comes in three storage configurations to allow for end user flexibility. The first configuration supports 24 2.5-inch non-volatile memory express (NVMe) drives, the second supports 24 2.5-inch serial-attached SCSI (SAS), serial-ATA (SATA) and up to 8 NVMe drives, and the third supports 12 3.5-inch SAS or SATA and up to 8 NVMe drives. All the configurations support hot-pluggable, front-side-accessible drives as well as 2 optional 2.5-inch rear mounted drives. The DS220 G2 delivers high I/O performance and high capacity for demanding applications and solutions.

Hitachi Advanced Server DS120 G2

With support for two Intel Xeon Scalable processors in just 1U of rack space, the [Hitachi Advanced Server DS120 G2](#) delivers exceptional compute density. It provides flexible memory and storage options to meet the needs of converged and hyperconverged infrastructure solutions, as well as for dedicated application platforms such as internet of things (IoT) and data appliances.

The Intel Xeon Scalable processor family is optimized to address the growing demands on today's IT infrastructure. The server provides 32 slots for high-speed DDR4 memory, allowing up to 4 TB memory capacity with RDIMM population (128 GB × 32) or 8 TB (512 GB × 16) of Intel Optane Persistent Memory. DS120 G2 supports up to 12 hot-pluggable, front-side-accessible 2.5-inch non-volatile memory express (NVMe), serial-attached SCSI (SAS), serial-ATA (SATA) hard disk drive (HDD), or solid-state drives (SSD). The system also offers 2 onboard M.2 slots.

With these options, DS120 G2 can be flexibly configured to address both I/O performance and capacity requirements for a wide range of applications and solutions.

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:

- 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.
- 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.

Oracle Linux Virtualization Manager

[Oracle Linux Virtualization Manager](#) is a new server virtualization management platform that can be easily deployed to configure, monitor, and manage an Oracle Linux Kernel-based Virtual Machine (KVM) environment with enterprise-grade performance and support from Oracle.

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 used to 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 file system for Oracle database files. This supports both 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.

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 is 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. These include vCenter SSO (Single Sign-on), Inventory Service, vSphere Web Client, and the vCenter Server itself.

Brocade switches from Broadcom

Brocade and Hitachi Vantara have partnered 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.

Brocade Fibre Channel switches deliver industry-leading performance, simplifying scale-out network architectures. Get the high-performance, availability, and ease of management you need for a solid foundation to grow the storage network you want.

Cisco Nexus switches

The Cisco Nexus switch product line provides a series of solutions that 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.

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