Hitachi Hybrid Cloud Solution Use Case Study for Oracle Application Performance at an Equinix Data Center

Best Practices Guide

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Feedback

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Revision history

Revision	Changes	Date
MK-SL-285-00	Initial release	January 17, 2024

Best Practices Guide

The Equinix colocation was chosen for performance measurement because it offered high-speed and low latency connections to the major hyperscalers, such as Amazon Web Services. In fact, Hitachi Vantara has collaborated with Equinix to create a new near-cloud hybrid solution called Hitachi Cloud Connect for Equinix.

This guide provides insight to clients using Hitachi Virtual Storage Platform (VSP) enterprise-class storage at Equinix International Business Exchange™ (IBX) data centers worldwide and includes the option for customers to procure this solution through one agreement and invoice, greatly simplifying and accelerating their time to market. By using Equinix IBX data centers and Equinix Fabric™ to interconnect sources of data to applications, VSP storage systems enable organizations to locate their data next to clouds while still maintaining control by enabling applications such as data protection and back-up for hybrid- and multi-cloud data availability.

The Hitachi hybrid cloud case study for performance measurement at Equinix platform is a fast, agile offering from Hitachi Vantara that makes efficient use of available resources. The goal of performance measurement is to compare differences between databases accessed from on-prem clients and AWS EC2 clouds, because you want a fast and flexible journey to reduce costs and quickly scale your environment up or down. Also, you can decide how a hybrid cloud solution is most suitable for your application.

Follow these best practices to implement this Hitachi Hybrid Cloud case study at Equinix DC for Databases with Oracle 19c using Hitachi Virtual Storage Platform E series and Hitachi Advanced Server HA820 G2. This solution is engineered, pre-tested, and qualified to provide high performance and high reliability in demanding, dynamic Oracle environments.

Case study overview

In this hybrid cloud case study we used Oracle Database on the Hitachi enterprise-level VSP E series storage system and Hitachi Advanced Server HA820 G2 with Intel Xeon 3rd generation Scalable Processors. The Hitachi servers provide reliability, high availability, and scalability while processing small to large Oracle workloads. This case study provides performance benchmarking while accessing databases from on-premises clients and using the AWS EC2 client. In this study an Oracle Database node is deployed on hosts at the Equinix Data Center with Oracle Linux 8.8 UEK6 and two client virtual machines (VMs) with Windows server 2019 64-bit.

For this measurement, we created an Oracle database instance at the Equinix data center, accessed from an on-prem VM and an AWS EC2 cloud VM using an Oracle client. To access data, we used HammerDB client software that has pre-defined workloads for OLTP and OLAP. Both test cases run the same benchmark tests and query time, or transaction throughput measured. The intent of the test is to check storage IO throughput and latency using an on-prem client and an AWS EC2 client. The following components were used to create and configure the hybrid cloud:

- Hitachi Storage Platform VSP E series used as storage resource at Equinix DC.
- Hitachi Advanced Server HA820 G2 with Intel(R) Xeon(R) Gold 6226 CPU @ 2.70GHz 48C CPUs for storage and computing resources.
- Oracle Database Enterprise Edition.
- Oracle Client software.
- HammerDB software.

Running Oracle Database on the Equinix platform provides the following benefits:

- Reduced overhead of configuration to minimize infrastructure and software licensing costs.
- Simplified management with Hybrid Cloud.
- Easier to access data from the cloud.
- You can see how hybrid cloud is suitable for your application as you move to the cloud.

This case study 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 professionals responsible for planning and deploying an application to the cloud

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

- Hitachi Virtual Storage Platform (VSP) at an Equinix data center including its resources
- Hitachi Advanced Server HA820 G2 servers at an Equinix data center, including its resources
- Storage Area Networks
- Oracle Database administration
- Oracle Database 19c
- Oracle Linux
- Windows Server 2019

Business benefits

The hybrid cloud case study at the Equinix data center provides the foundation for a cloud infrastructure. It provides fully integrated enterprise management from disk to cloud applications. This cloud solution using the Equinix platform is easily deployed to configure, monitor, and access an Oracle database from virtual machines located in a cloud environment with enterprise-grade performance.

The following are some benefits of this hybrid cloud solution:

- Provision data in a colocation and use applications running in the cloud, so customers can keep data within their control but leverage both the public and private cloud for performance.
- Reduce operation and support costs while increasing IT efficiency and agility — on premises and in the cloud.
- Add or remove client VMs on an AWS cloud based on business requirements.
- Achieve high Oracle Database performance with VSP E series storage systems at an Equinix data center.
- Access data from AWS EC2 cloud VMs with no or minimal latency.

High-level infrastructure

Hitachi Solution for Databases with Oracle includes the following components:

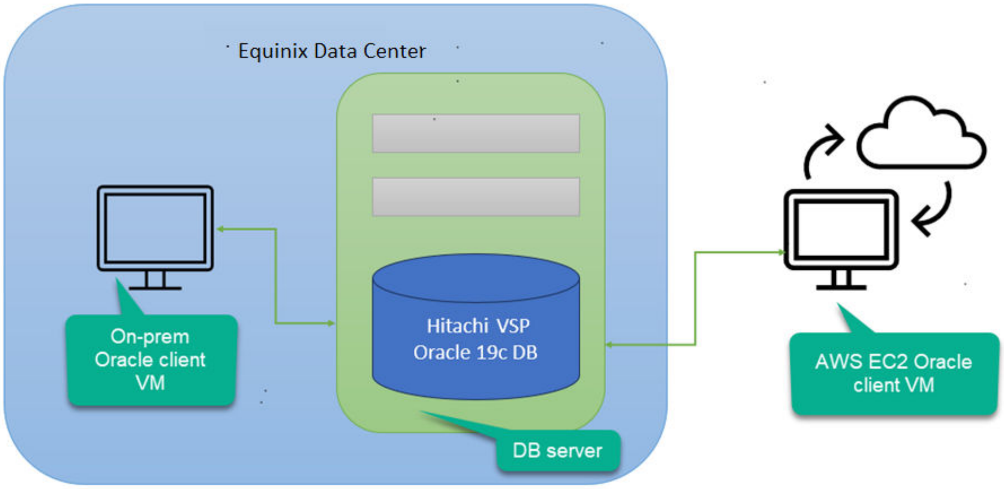
- Hitachi Advanced Server HA820 G2 servers at an Equinix data center
- Hitachi Virtual Storage Platform E series at an Equinix data center
- Brocade G720 32 Gbps SAN infrastructure
- Cisco 10/25 GbE LAN infrastructure

The Virtual Storage Platform E series and Hitachi Advanced Server HA820 G2 configuration has the following characteristics:

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

> **Note:** Data volumes can also be configured on a VSP E1090 or other VSP storage systems at the Equinix data center.

The following figure shows a high-level reference diagram for this cloud solution.



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

- Dual HBA with two ports each for accessing the storage system.
- Dual port NIC with high bandwidth according to business requirements to avoid any network latency and to provide resiliency.

The uplink speed to the corporate network depends on the customer environment and requirements. The Cisco Nexus 93180YC-FX3 switches used in this guide can support uplink speeds of 40 GbE or 100 GbE if higher bandwidth is required.

Note: Testing of this configuration was in a lab environment. Many factors 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.

Key components

The key components for this case study are listed in the following tables. Detailed component information is provided in Product descriptions (on page 21).

Hardware components

The following table lists the hardware components used in this case study.

Vendor	Hardware	Detailed Description	Software Version	Quantity
Hitachi Vantara	Equinix Platform DB host HA820 G2	Intel(R) Xeon(R) Gold 6226 CPU @ 2.70GHz 32GB × 8 DDR4 (256 GiB) DIMM	Oracle Linux Server 8.8 UEK6 5.4.17-2136.321.4.1.el8uek.x86_64 Oracle Database 19c EE 19.3	1
Hitachi Vantara	On-Prem Oracle Client VM	Intel(R) Xeon(R) Gold 6140 CPU @ 2.30GHz 4 vCPU (16 Gb)	Windows server 2019 64-bit Oracle client 19.3 HammerDB 4.8	1
Hitachi Vantara	AWS EC2 Oracle Client VM	Intel(R) Xeon(R) CPU E5-2666 v3 CPU @ 2.90 GHz 4 vCPU (15 GB)	Windows server 2019 64-bit Oracle client 19.3 HammerDB 4.8	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.

Software components

The following table lists software components for respective nodes.

Software	Version	Function
Oracle Linux	8.8 with 5.4.17-2136.321.4.1.el8uek.x86_64	Operating system for Database host at Equinix data center
Windows Server	2019 64-bit	Operating system for Oracle client VMs
Oracle Database	19c (Version 19.3.0.0.0)	Database software at Equinix data center
Oracle Client	19c (Version 19.3.0.0.0)	Oracle Client software at client VMs
HammerDB	4.8	Benchmarking and load testing software at client VMs
Oracle ASMlib	2.0.17	Oracle Software for ASM
DM-Multipath	OS native	Multipath Software

Case study design

This section describes how to implement the Hitachi Hybrid Cloud case study for Oracle Databases at an Equinix data center. The environment uses Hitachi Virtual Storage Platform E series (specifically the VSP E1090).

The infrastructure configuration includes the following:

- Oracle DB hosts — There are hosts configured for an Oracle database environment at the Equinix data center.
- Oracle Client VM — There are two VMs: an on-premises VM and an AWS EC2 VM.
- Storage System — There are vVols mapped to each port that are presented to the server as LUNs at the Equinix data center.
- SAN Connection — There are SAN connections to connect the Fibre Channel HBA ports to the storage through Brocade G720 switches.

The server uses SAN boot with RAID 6 protection. The following table shows the VSP E1090 logical storage configuration used in this case study.

ASM disk group	Total number of dynamic provisioning volumes	Dynamic provisioning volume sizes (GB)	Purpose	Storage Ports
DATA	10	200 GB	OLTP Application Tablespaces, System Sysaux, Undo	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
REDO	2	20 Gb	Online Redo Logs and Control Files	
TEMP	1	200 GB	Temp Tablespace	
FRA	1	200 GB	Incremental Backups, Archived Redo Logs, Control File and Auto backups	
OCR	3	15 GB	Oracle Cluster Registry and Voting Disk	
N/A	1	350 GB	SAN Boot OS Volumes	

Additional LUNs can be mapped according to business requirements.

Database layout

The database layout design uses recommended practices from Hitachi Vantara for VSP E1090 for small random I/O traffic, such as OLTP transactions. The layout also considers Oracle ASM best practices when using Hitachi Vantara storage.

The base of the storage design for the database layout depends 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 to be used in various deployment scenarios to provide the right balance between performance and ease of management for a given scenario.

Oracle Database ASM configurations

Complete the following 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 initial parameters

The following table shows the Oracle Database settings.

Environment	Value
ASM	Yes – to support Oracle Database
sga_target	96512 M
pga_aggregate_target	32149 M
cpu_count	48
db_file_multiblock_read_count	128
processes	3840
db_writer_processes	6

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.

ASM Disk Group	ASM Disk	UDEV Rules	LUN Details	Purpose
N/A	N/A	/dev/xvd[a]1	1 × 350 GB	OS and Oracle Database
DATA1	DATA1-DATA10	/dev/xvd[b-k]1	10 × 200 GB	Application data
REDO	REDO01-REDO02	/dev/xvd[l]1, /dev/xvd[m]1	2 × 20 Gb	Online REDO log group
FRA	FRA1	/dev/xvd[n]1	1 × 200 GB	Flash recovery area
TEMP	TEMP1	/dev/xvd[o]1	1 × 200 GB	Temporary Tablespace

Oracle client VM configurations

The following table lists management server VM configuration details.

Virtual Machine	vCPU	Virtual Memory	Disk capacity	IP Address
On-premises Oracle client VM	8	16 GB	200 GB	192.168.242.xx
AWS EC2 Oracle client VM	8	16 GB	200 GB	192.168.242.xx

Server and application architecture

This hybrid cloud case study uses one Hitachi Advanced Server HA820 G2 servers with 3rd Generation Intel Xeon Scalable Processors for each storage system architecture that was tested. This provides the compute power for the Oracle database to manage complex database queries and a large volume of transaction processing in parallel.

The following table lists the details of the server configurations used during this case study.

Server Make and Model	Server Host Name	Role	CPU Type	CPU Core	RAM
Hitachi Advanced Server HA820 G2	Compute node	Oracle Linux 8.8 Database host	Intel(R) Xeon(R) Gold 6226 CPU @ 2.70GHz	48 (2 × 2 12)	256 GB (32 GB × 8)
On-prem Oracle client	VM1	Windows server 2019 64-bit On-premises VM for Oracle client 19c HammerDB 4.8	Intel(R) Xeon(R) Gold 6140 CPU @ 2.30GHz	2 × 2	16 GB
AWS EC2 Oracle client VM	VM2	Windows server 2019 64-bit AWS EC2 VM for Oracle client 19c HammerDB 4.8	Intel(R) Xeon(R) CPU E5-2666 v3 CPU @ 2.90 GHz	2 × 2	15 GB

SAN architecture

Map the provisioned LDEVs to multiple ports on Hitachi Virtual Storage Platform E1090. These LDEV port assignments provide multiple paths to the storage system from the host for high availability. This reference architecture uses two dual port HPE SN1610E HBAs per Advanced Server HA820 G2.

The following are used for compute servers:

- 4 SAN switch connections are used for VSP E1090 Fibre Channel ports.
- 4 SAN switch connections are used for server HBA ports.

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

The following table lists the network configuration for servers and VSP E1090.

Name	IP Address
Oracle Linux DB host	192.168.242.xx
On-prem Oracle client VM	192.168.242.xx
AWS EC2 Oracle client VM	192.168.242.xx
VSP E1090	192.168.242.xx
VSP E1090 CTL1	192.168.242.x
VSP E1090 CTL2	192.168.242.x

Engineering validation

This section summarizes the key lab verification tests performed on Hitachi Hybrid Cloud case study for Databases at the Equinix Data Center using Hitachi Virtual Storage Platform E1090 and Hitachi Advanced Server HA820 G2.

Database configuration

The following tables list parameter details for an Oracle database host.

Oracle Database Parameter	Value
Compatible	19.3.0.0.0
Oracle Database size	2 TB
Database storage type	ASM
Database fill factor	60%

Item	Value
Operating System DB server	Oracle Linux 8.8
Operating System on Oracle client VMs	Windows Server 2019 64-bit
Workload Type	OLTP (TPROC-C) / OLAP (TPROC-H)
Database Size	2 TB
Number of vCPUs	48
Virtual Memory	256 Gb

Test methodology

HammerDB

HammerDB is leading, open-source benchmarking and load testing software for many relational database management systems (RDBMS) in the world.

For more information about HammerDB, see https://www.hammerdb.com/.

The test results are demonstrated using HammerDB for OLAP and OLTP test cases.

HammerDB is benchmark software for many RDBMS platforms. It is used in our tests for the following:

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

This provides transparency and comparability in price versus performance considerations for cloud infrastructures. The HammerDB version 4.8 tool is used to validate this performance measurement.

HammerDB configuration

For testing purposes, after HammerDB software is downloaded on the Oracle client VM, data needs to be loaded into the database for the first time. We used the following configuration to load data. For data loading prerequisites see Installation and Configuration (hammerdb.com).

```
hammerdb>dbset bm TPROC-H
Benchmark set to TPROC-H for Oracle

hammerdb>print dict
Dictionary Settings for Oracle
connection {
 system_user      = system
 system_password = manager
 instance         = orcl
 rac              = 0
}
tpch        {
 scale_fact          = 1000
 tpch_user           = tpch1000
 tpch_pass           = tpch
 tpch_def_tab        = tpchtab
 tpch_def_temp       = temp
 num_tpch_threads    = 40
 tpch_tt_compat      = false
 total_querysets     = 1
 raise_query_error   = false
 verbose             = false
 degree_of_parallel = 2
 refresh_on          = false
 update_sets         = 1
 trickle_refresh     = 1000
 refresh_verbose     = false
 cloud_query         = false
}

hammerdb>
```

Where:

```
Scale_factor – Size of database in GB
Tpch_user – Username
Tpch_def_tab – Default tablespace for user
Num_tpch_threads – Number of parallel sessions to load data
```

The rest of the parameters are default, and they do not require changes. For specific usage details see Configuring Schema Build Options (hammerdb.com).

Case study results

The following table provides HammerDB test result details for the TPROC-H (OLAP) workload.

The TPROC-H workload is designed for simulating OLAP query processing where we can measure performance of analytic decision support systems. In analytic or reporting database systems, high bandwidth of reads and minimal write operations are required. In the TPROC-H OLAP HammerDB workload, there is a standard set of 22 queries in one iteration. Geo Mean is the average time taken for one query executed in seconds. We executed a workload with different test cases by increasing the number of worker processes or by scaling up the number of users.

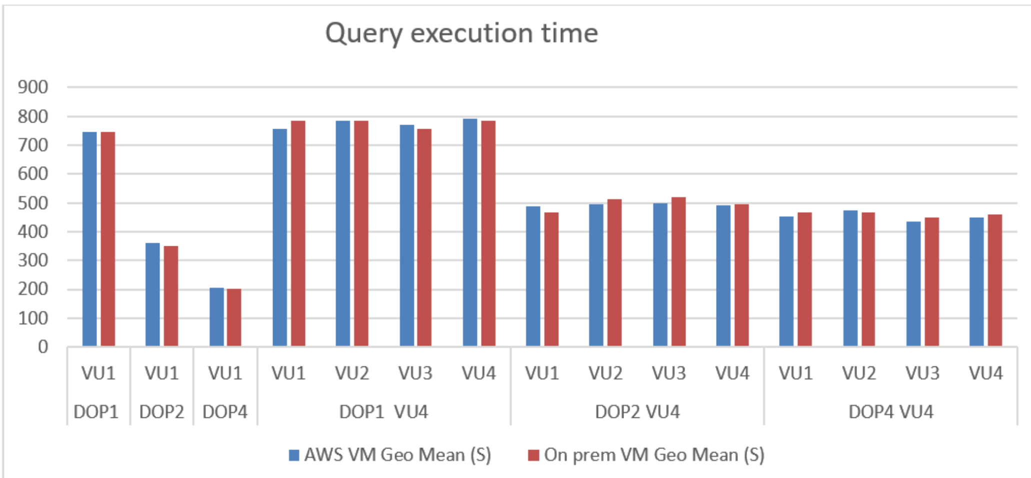
Where:

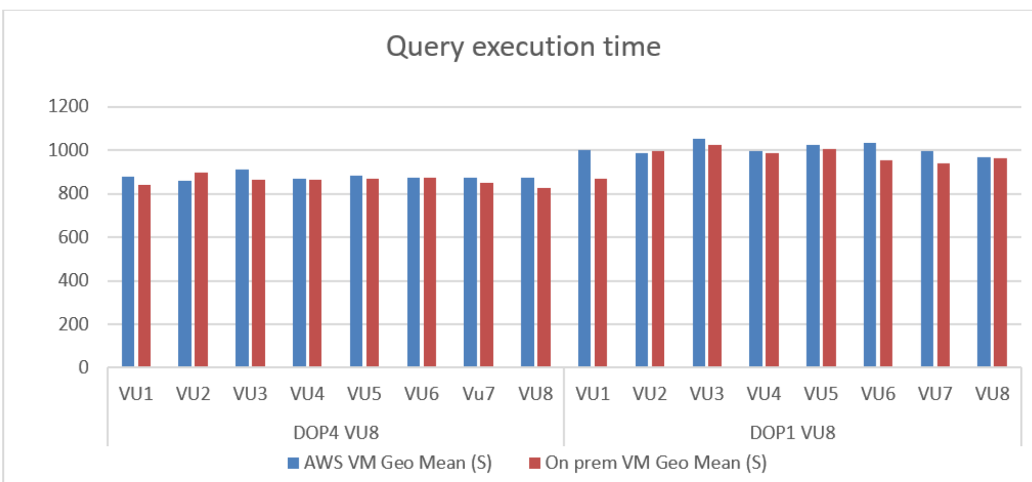
```
DOP – Degree of parallelism
VU – Number of Virtual users or concurrent sessions
Geo Mean –Geometric Mean for queries or average time of single query execution in
seconds
```

DB Size: 1.3 Tb		AWS EC2 VM	On prem VM
		Geo Mean (S)	Geo Mean (S)
DOP1	VU1	746.49	747.36
DOP2	VU1	359.62	350.31
DOP4	VU1	206.57	201.15
DOP1 VU4	VU1	758.34	784.99
	VU2	785.07	785.00
	VU3	770.38	756.38
	VU4	793.16	786.69
DOP2 VU4	VU1	488.05	468.34
	VU2	494.08	514.44
	VU3	498.73	519.11
	VU4	490.46	495.97
DOP4 VU4	VU1	451.49	466.74
	VU2	474.68	466.55
	VU3	436.78	450.35
	VU4	450.57	458.87
DOP4 VU8	VU1	876.07	842.34
	VU2	857.29	895.33
	VU3	909.43	862.28
	VU4	868.65	866.01
	VU5	884.13	869.58
	VU6	872.93	872.98
	Vu7	874.5	849.09
	VU8	874.78	826.35
DOP1 VU8	VU1	1001.04	869.27
	VU2	987.53	997.11
	VU3	1052.43	1021.78
	VU4	995.17	986.53

DB Size: 1.3 Tb		AWS EC2 VM	On prem VM
	VU5	1023.83	1002.97
	VU6	1032.22	954.48
	VU7	995.62	939.71
	VU8	966.29	962.15

The following graphs illustrate the query execution time between an on-premises VM and an AWS cloud VM.



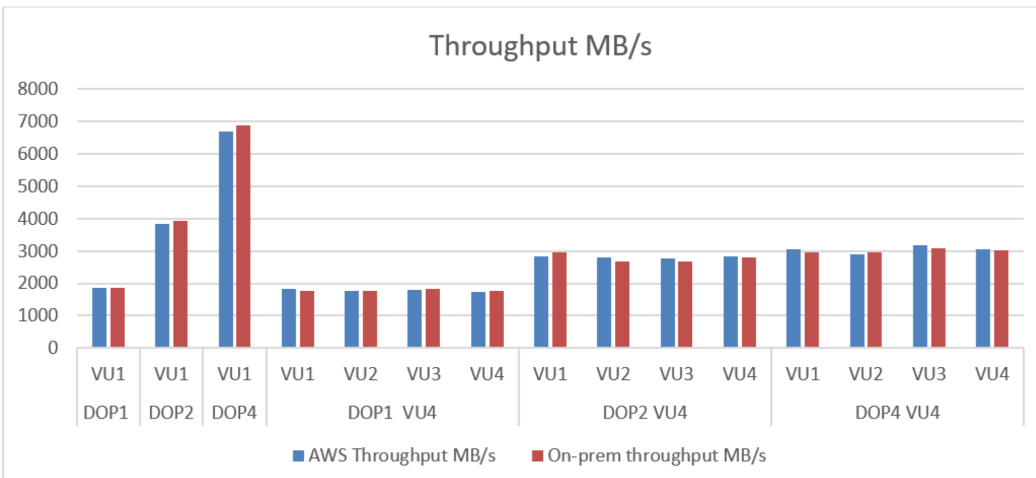


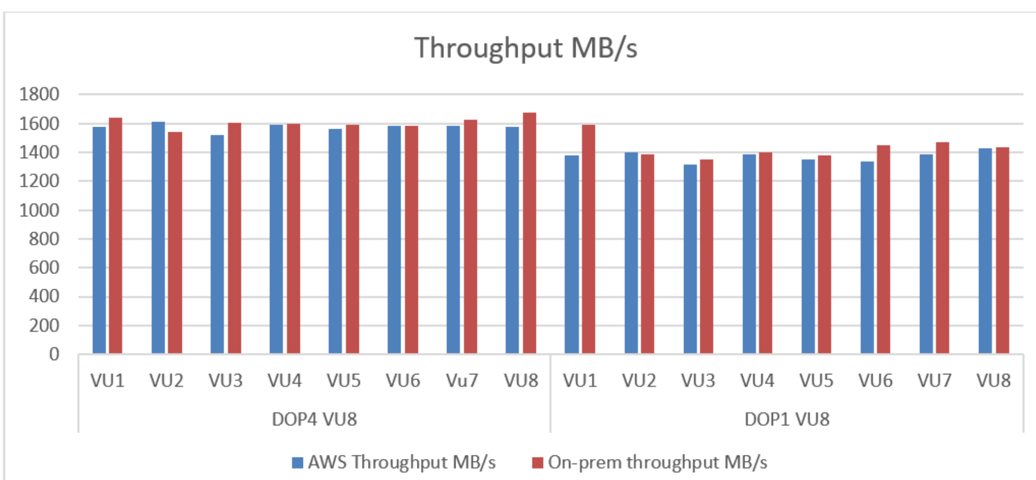
From the same test, we calculated storage throughput received for the TPROC-H (OLAP) workload. In OLAP, the system performance indicator is the amount of data read from disk. We measured this as throughput in megabytes at the Equinix data center.

DB Size: 1.3 TB		AWS Throughput	On-prem Throughput
		MB/s	MB/s
DOP1	VU1	1851.86	1849.71
DOP2	VU1	3844.05	3946.21
DOP4	VU1	6692.16	6872.48
DOP1 VU4	VU1	1822.92	1761.04
	VU2	1760.86	1761.01
	VU3	1794.43	1827.65
	VU4	1742.9	1757.23
DOP2 VU4	VU1	2832.49	2951.7
	VU2	2797.92	2687.19
	VU3	2771.84	2663.01
	VU4	2818.57	2787.26
DOP4 VU4	VU1	3062.06	2961.82
	VU2	2912.27	2963.02
	VU3	3164.98	3069.61
	VU4	3068.11	3012.61
DOP4 VU8	VU1	1577.95	1641.14
	VU2	1612.52	1544.01
	VU3	1520.07	1603.91
	VU4	1591.43	1596.28
	VU5	1563.57	1589.73
	VU6	1583.63	1583.54
	Vu7	1580.78	1628.09
	VU8	1580.28	1672.89
DOP1 VU8	VU1	1380.96	1590.29
	VU2	1399.85	1386.4

DB Size: 1.3 TB		AWS Throughput	On-prem Throughput
	VU3	1313.53	1352.93
	VU4	1389.1	1401.27
	VU5	1350.22	1378.3
	VU6	1339.24	1448.32
	VU7	1388.48	1471.09
	VU8	1430.62	1436.68

The following are graphical representations of the throughput results.





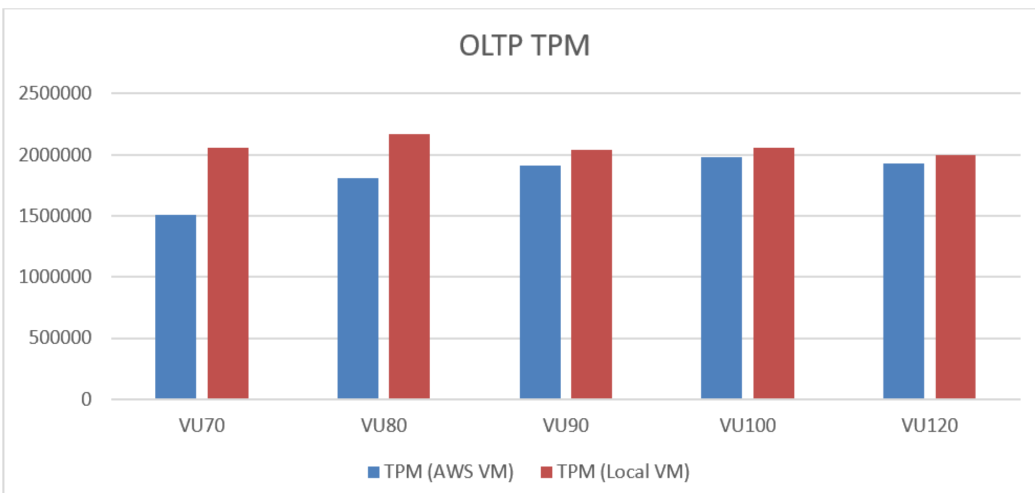
The following table provides HammerDB test result details for the TPROC-C (OLTP) workload.

This workload is designed to test an online transaction processing system (OLTP) using the HammerDB database. During this workload the database receives many requests for data changes from a number of users concurrently. The key performance metric is the number of transactions performed in a minute (TPM).

Where:

```
VU – Number of Virtual users or concurrent users or sessions to database for transactions.
TPM – Transaction per minute
```

Workload	TPM (AWS VM)	TPM (On-prem VM)
VU70	1,511,994	2,058,819
VU80	1,807,478	**2,167,585**
VU90	1,915,137	2,044,234
VU100	**1,977,667**	2,057,270
VU120	1,930,039	2,001,539



Note: For OLTP workloads, HammerDB does not report response time for each transaction.

Conclusion

The Hitachi Hybrid Cloud case study using Hitachi Virtual Storage Platform E series and Hitachi Advanced Server HA820 G2 on the Equinix platform have been tested and validated as an ideal platform for cloud workloads.

The following are some key observations on performance measurement:

- From the OLAP query execution time table, it is observed that the query execution time is very close for Oracle Client in on-premises VMs and AWS EC2 Cloud VMs.
- From the storage throughput table, it is observed that data scanned/read or disk throughput from storage for both test cases is also very close.
- From the OLTP TPM table, we measured the transactions per minute (TPM) for Oracle Client in on-premises VMs. Performance was up to 27% more than the TPM in AWS Cloud VMs with a smaller numbers of virtual users (VUs). However, the difference in peak TPM measured across all VUs between on-prem VMs (VU100) and AWS Cloud VMs (VU80) is less than 9%. The percentage of performance impact for running Oracle clients in the public cloud should be acceptable for customers who cannot store data in the public cloud.

Product descriptions

These products are used in this reference architecture.

Hitachi Virtual Storage Platform E series family

The Hitachi Virtual Storage Platform E series family provides agile and automated storage built upon the innovative technologies found in our high-end enterprise systems. The expansion of the VSP E series portfolio includes 2 new all-NVMe flash models that deliver super charged, ultra-low latency performance for the business-critical applications that small and midsized businesses rely on.

- Improve IT agility: “Faster-to-market” for IT projects with proven high-performance infrastructure. Brings “enterprise-class” features and benefits to customers of all sizes whose business is outpacing their existing infrastructure and supports modern business processes like DevOPs.
- Financial elasticity that aligns costs to business goals, growth, and use: Customers can “have it their way” with purchase, lease, or cloud-like consumption models.
- Improved workforce efficiency: a better digital experience which boosts customer satisfaction (with both internal LOBs and end-users) and increases business productivity and profitability.

Hitachi Advanced Server HA820 G2

Hitachi Advanced Server HA820 G2 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 maximum memory capacity. Hitachi Advanced Server HA820 G2 provides flexible I/O scalability for today’s diverse data center application requirements.

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

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 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.

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