Super Micro Computer, Inc.

TPC Express Benchmark™ HCI
Full Disclosure Report

AS-1114S-WN10RT

running

VMware vSphere 7.0 Update 2

TPCx-HCI Version	1.1.8
Report Edition	First
Report Submitted	November 30, 2021

First Edition - November 2021

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Abstract

Supermicro conducted the TPC Express Benchmark™ HCI (TPCx-HCI) on the AS-1114S-WN10RT. The software used included:

- Red Hat Enterprise Linux for Virtual Datacenters
- VMware vSphere 7.0 Update 2, comprising:
  - VMware vSphere 7 Enterprise Plus
  - VMware vSAN 7 Standard
  - VMware vCenter Server 7 Standard for vSphere 7

This report provides full disclosure of the methodology and results. All testing was conducted in conformance with the requirements of the TPCx-HCI Standard Specification, Revision 1.1.8.

The benchmark results are summarized in the follow table.

Hardware	Software	Total System Cost (USD)	tpsHCI	USD/tpsHCI	Availability Date
AS-1114S-WN10RT	VMware vSphere 7.0 Update 2	$237,573	4,790.18	$49.60	Currently Available

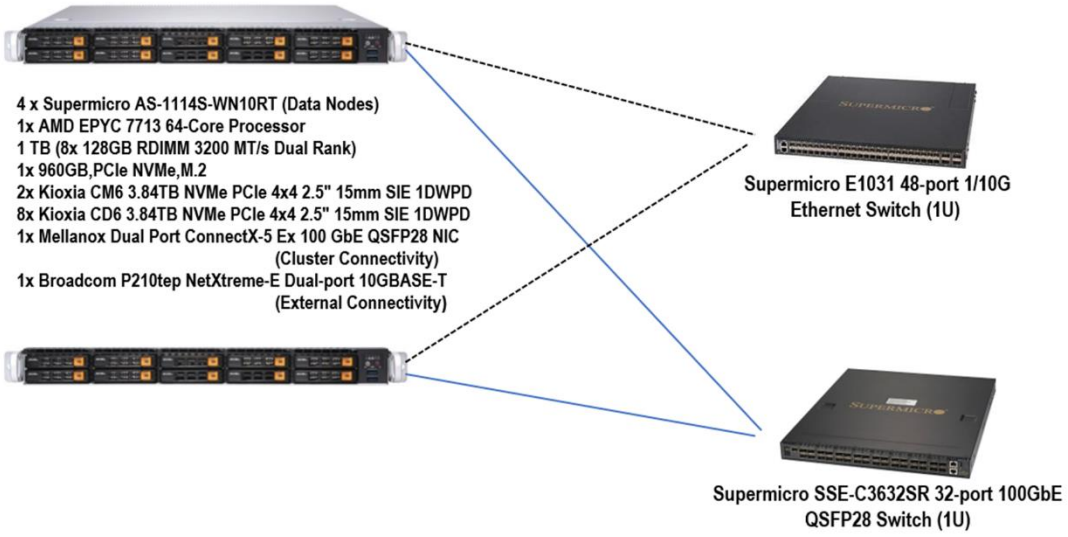
Executive Summary

The Executive Summary follows on the next several pages.

SUPERMICRO	**AS-1114S-WN10RT**		TPCx-HCI 1.1.8 TPC Pricing 2.7.0 Report Date Nov. 30, 2021
Availability Date	TPCx-HCI Throughput	Price/Performance	Total System Cost
Currently Available	**4,790.18 tpsHCI**	**$49.60 USD / tpsHCI**	**$237,573 USD**

System Under Test Configuration Overview

Virtualization Software	Guest VM OS	Processor Description	Memory Size
VMware vSphere 7.0 Update 2	Red Hat Enterprise Linux 7.7	AMD EPYC 7713 2.0GHz, 256MB L3	4,096 GB



Data Accessibility Node Recovery Time: 2:05:38.00

4x AS-1114S-WN10RT each with:

- 1x AMD EPYC 7713 2.0 GHz (1 Proc/64 Cores/128 Threads)
- 8x 128 GB RDIMM 3200 MT/s Dual Rank
- 1x 960GB NVMe M.2
- 2x 3.84 TB CM6 NVMe
- 8x 3.84 TB CD6 NVMe
- 1x Mellanox Dual Port ConnectX-5 Ex 100 GbE
- 1x Broadcom P210tep NexXtreme-E Dual Port 10GBASE-T

1x Supermicro E1031 48-port 1/10 G Switch
1x Supermicro SSE-C3632SR 32-port 100 GbE Switch

AS-1114S-WN10RT

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Description	Part Number	Key	Unit Price	Qty	Extended Price	3 yr. Maint. Price
HARDWARE COMPONENTS						
Data Nodes						
H12SSW-NTR, CSE-116TS-R706WBP5-N10,RoHS	AS-1114S-WN10RT	1	$1,477.00	4	$5,908.00	
128GB DDR4-3200 4Rx4 LP (16Gb) ECC 3DS 2H RDIMM,RoHS	MEM-DR412L-HL01-EF	1	$924.00	32	$29,568.00	
Kioxia CM6 3.84TB NVMe PCIe 4x4 2.5" 15mm SIE 1DWPD	HDS-TUN-KCM6XRUL3	1	$875.00	8	$7,000.00	
Kioxia CD6 3.84TB NVMe PCIe 4x4 2.5" 15mm SIE 1DWPD	HDS-TUN0-KCD6XLUL3	1	$616.00	32	$19,712.00	
Mellanox ConnectX-5 EN network card 100GbE dual-port	AOC-MCX516A-CDAT	1	$1,060.00	4	$4,240.00	
Milan 7713 DP/UP 64C/128T 2.0G 256M 225W SP3	PSE-MLN7713-0344	1	$7,029.00	4	$28,116.00	
960GB,PCIe NVMe,M.2 22x80mm,3D TLC,1DWPD	HDS-MMN-MTFDHBA9	1	$182.00	4	$728.00	
Broadcom P210tep NexXtreme-E Dual Port 10GBASE-T	(included)	1	(included)	4	(included)	
Out of Band Firmware Management License-BIOS Flash /Setting	SFT-OOB-LIC	1	$15.00	4	$60.00	
ASSEMBLY FEE	MC0037	1	$25.00	4	$100.00	
0% 3 YRS LABOR, 3 YRS PARTS, 1 YR CRS UNDER LIMITED WRNTY	EWCSC	1	(included)	4		(included)
On Site 4hrs 24x7x365 Support 3 Years with Extended Wrnty	OS4HR3	1	$516.28	4		$2,065.10
Network and Cables						
E1031 48-port 1/10G Ethernet ToR switch	SSE-G3648BR	1	$1,675.00	1	$1,675.00	
Cumulus-Linux SW 1G perpetual license with 3 yr Cumulus	SFT-CLSPL1G-3Y	1	$1,475.00	1	$1,475.00	
On Site 4hrs 24x7x365 Support 3 Years with Extended Wrnty	OS4HR3	1	$315.00	1		$315.00
32-port 100GbE QSFP28,B2F,2x800W R0872-F0004-01,HF	SSE-C3632SR	1	$7,375.00	1	$7,375.00	
Cumulus-Linux Software 100G Perpetual License with 3 yr SnS	SFT-CLSNWPL-100G-3	1	$6,399.00	1	$6,399.00	
On Site 4hrs 24x7x365 Support 3 Years with Extended Wrnty	OS4HR3	1	$1,377.40	1		$1,377.40
ETHERNET,QSFP28,100GbE,PASSIVE,LSZH,3m,Molex,RoHS	CBL-NTWK-0943-SQ28	1	$165.60	10	$1,656.00	
ETHERNET,CAT6,RJ45,SNAGLESS,YELLOW,15FT (4.6M),28AWG,Ro	CBL-C6-YL15FT-P	1	$12.80	5	$64.00	
ETHERNET,CAT6,RJ45,SNAGLESS,GREEN,UTP,15FT(4.5M),28AWG,RoHS	CBL-C6-GN15FT-P	1	$12.80	5	$64.00	
Other Hardware Components						
42U Enclosure system	SRK-42SE-11	1	$1,516.30	1	$1,516.30	
Rack PDU, Switched, 2U, 30A, 208V, (16)C13	AP7911B	2	$1,075.00	2	$2,150.00	
PWCD,US,IEC60320 C14 TO C13,4FT,16AWG,RoHS/REACH	CBL-PWCD-0373-IS	1	$7.70	12	$92.40	
12 inches monitor with 4 year Equipment protection plan (incl. 2 spares)	LONCEVON-12	3	$95.99	3	$287.97	
Logitech MK200 Media Keyboard and Mouse Combo (incl. 2 spares)	920-002714	3	$28.12	3	$84.36	
HARDWARE COMMPNENTS				**Subtotal**	**$118,271.03**	**$3,757.50**
SOFTWARE COMPONENTS						
Red Hat Enterprise Linux for Virtual Datacenters, 3 Year Premium (2 sockets)	SFT-RH-RH00001F3	1	$9,830.00	4	$39,320.00	
VMware vSAN 7 Standard per CPU Socket (3 year Production Support 24X7 included)	SFT-VM-ST7STDC3Y	1	$3,521.00	8	$28,168.00	
VMware vSphere 7 Enterprise Plus per CPU Socket (3 year Production Support 24X7 included)	SFT-VM-VS7EPLC3Y	1	$4,947.00	8	$39,576.00	
VMware vCenter Server 7 Standard for vSphere 7 – Per Instance (3 year Production Support 24X7 included)	SFT-VM-VCS7STDC3Y	1	$8,480.00	1	$8,480.00	
SOFTWARE COMMPNENTS				**Subtotal**	**$115,544.00**	**$0.00**
				Totals	**$233,815.03**	**$3,757.50**

Pricing: 1 = Supermicro; 2 = APC.com; 3 = Amazon.com

Audited by Doug Johnson, InfoSizing

Three-Year Cost of Ownership:	**$237,573**
TPCx-HCI Throughput:	**4,790.18**
$ USD/tpsHCI:	**$49.60**

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated Line Items. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed Line Items. For complete details, see the pricing section of the TPC Benchmark Standard. If you find that the stated prices are not available according to these terms, please inform the TPC at pricing@tpc.org. Thank you.

AS-1114S-WN10RT

TPCx-HCI	1.1.8
TPC Pricing	2.7.0
Report Date	Nov. 30, 2021

Guest VM Details

Database Manager	VM Memory (Total)	vCPUs (Total)	DB Initial Size	Configured Customers	Active Customers
PostgreSQL 10.6	2,561 GiB	540	30,963.3 GB	2,400,000	2,400,000

Transaction Response Times (in seconds)

Transaction Type	Min	Avg	90th%	Max
Broker-Volume	0.001	0.005	0.009	2.198
Customer-Position	0.001	0.012	0.022	6.802
Market-Watch	0.000	0.006	0.011	4.025
Security-Detail	0.002	0.016	0.028	1.972
Trade-Lookup	0.000	0.035	0.059	2.627
Trade-Order	0.001	0.016	0.027	6.898
Trade-Result	0.002	0.021	0.035	6.859
Trade-Status	0.001	0.006	0.010	5.252
Trade-Update	0.005	0.061	0.085	2.597
Data-Maintenance	0.002	0.008	0.014	0.247
Market-Feed	0.001	0.005	0.009	0.576

Transaction Mix

Transaction Type	Transaction Count	Mix Percentage
Broker-Volume	13,449,322	3.900%
Customer-Position	51,727,995	15.000%
Market-Watch	58,624,997	17.000%
Security-Detail	55,176,788	16.000%
Trade-Lookup	31,036,456	9.000%
Trade-Order	34,829,922	10.100%
Trade-Result	34,489,302	10.001%
Trade-Status	62,073,582	18.000%
Trade-Update	3,448,571	1.000%
Data-Maintenance	4,800	N/A
Market-Feed	287,996	N/A
Transaction Total		344,856,935
Measurement Interval		02:00:00
Business Recovery Time		00:14:40
Redundancy Level Details		Redundancy Level 3
Auditor		Doug Johnson, InfoSizing

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Clause 0 – Preamble

0.1 TPC Express Benchmark™ HCI Overview

The TPC Express Benchmark™ HCI (TPCx-HCI) measures the performance of a virtualized server platform under a demanding database workload. It stresses CPU and memory hardware, storage, networking, hypervisor, and the guest operating system. TPCx-HCI workload is database-centric and models many properties of cloud services, such as multiple VMs running at different load demand levels, and large fluctuations in the load level of each VM. Another unique characteristic of TPCx-HCI is an elastic workload that varies the load delivered to each of the VMs by as much as 16x, while maintaining a constant load at the host level.

The TPCx-HCI kit is available from the TPC (See www.tpc.org/TPCx-HCI for more information). Users must sign-up and agree to the TPCx-HCI User Licensing Agreement (ULA) to download the kit. Re-distribution of the kit is prohibited. All related work (such as collaterals, papers, derivatives) must acknowledge the TPC and include TPCx-HCI copyright. The TPCx-HCI Kit includes: TPCx-HCI Specification document, TPCx-HCI Users Guide documentation, and all software necessary to set up the benchmark environment and execute the benchmark load.

The purpose of TPC benchmarks is to provide relevant, objective performance data to industry users. To achieve that purpose, TPC benchmark specifications require that benchmark tests be implemented with systems, products, technologies, and pricing that:

- Are generally available to users.
- Are relevant to the market segment that the individual TPC benchmark models or represents (e.g., TPCx-HCI models and represents multiple concurrent operating and application environments running on a platform).
- Would plausibly be implemented by a significant number of users in the market segment the benchmark models or represents.

The use of new systems, products, technologies (hardware or software) and pricing is encouraged so long as they meet the requirements above. Specifically prohibited are benchmark systems, products, technologies, or pricing (hereafter referred to as "implementations") whose primary purpose is performance optimization of TPC benchmark results without any corresponding applicability to real-world applications and environments. In other words, all "benchmark special" implementations that improve benchmark results but not real-world performance or pricing, are prohibited.

The rules for pricing are included in the TPC Pricing Specification.

Further information is available at www.tpc.org.

Clause 1 – General Items

1.1 Test Sponsor

This benchmark was sponsored by Super Micro Computer, Inc..

1.2 Configuration Diagrams

The priced configuration diagram is shown above in the Executive Summary. The measured configuration diagram is shown below in Figure 1-1. In addition, any differences between the priced and the measured configurations are described.

1.2.1 Measured Configuration Diagram

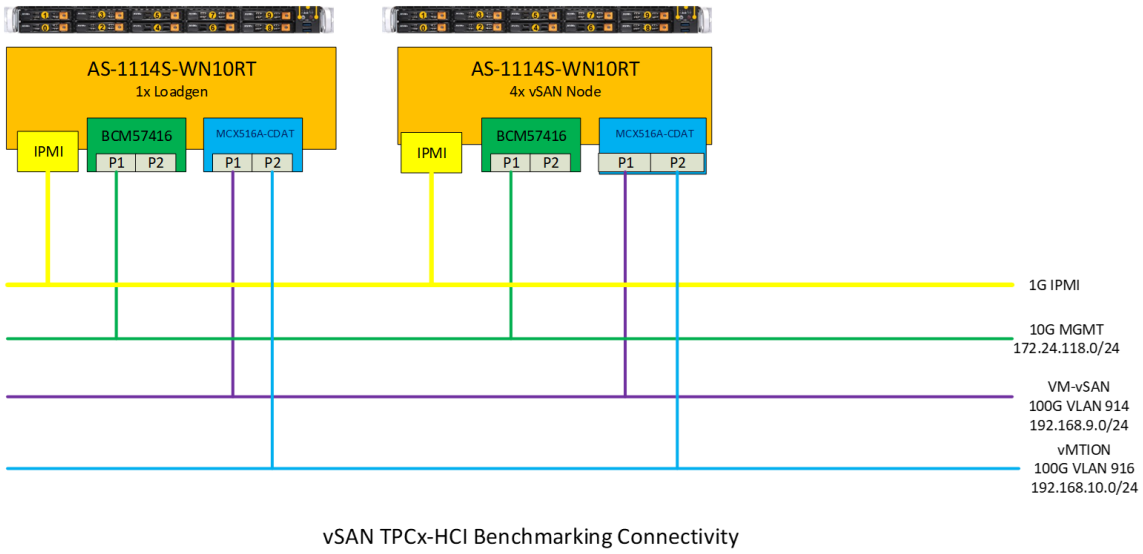

Figure 1-1 Measured Configuration

1.2.2 Differences Between the Priced and the Measured Configurations

The measured configuration included one additional AS-11145-WN10RT server (used to load-drive the workload) which is not part of the SUT and therefore not priced.

1.3 Hardware Setup Steps

Detailed instructions for installing and configuring the hardware used in the System Under Test (SUT) are included in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

1.4 Software Setup Steps

Detailed instructions for installing and configuring the software used in the SUT are included in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

Clause 2 – Database Design, Scaling, & Population

This section provides details of the process used to create the database environment.

2.1 Database Creation Steps

Detailed instructions for creating the database environment used in the SUT are included in the Supporting Files. Also included is the output captured from running setup.sh. Please see the Supporting Files Index for a summary of the files available.

Table 2-1 provides details on the distribution of tables, partitions, and logs across all media.

Disk Type	Usage	Count	Host File System	Guest File System	Guest Use	Overall Size (60 VMs)
960 GB, PCIe NVMe, M.2	Host root	4: 1 in each of 4 servers	/ and auxiliary datastore	N/A	N/A	N/A
Kioxia CD6 3.84 TB NVMe	vSAN Capacity layer	32: 8 in each of 4 servers	vSAN file system “vsanDatastore”	/	Root	360 GB
Kioxia CM6 3.84 TB NVMe	vSAN Cache layer	8: 2 in each of 4 servers		/dbstore	Database data	35,974 GB
				/pg_wal	Database redo log	1,944 GB

Table 2-1 Distribution of Tables, Partitions, and Logs Across Media

2.2 Database Load Methodology

Supermicro used the setup.sh script provided with the TPCx-HCI benchmark kit to load the databases. The necessary data is generated with the required properties and loaded it into the databases. The output from the script is available in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

Clause 3 – Transactions

All transaction implementation details are handled by the TPC's TPCx-HCI benchmark kit. Therefore, the TPCx-HCI Standard Specification, Revision 1.1.8 does not have any disclosure requirements for this clause.

Clause 4 – SUT, Driver, & Network

4.1 Network Configuration Description

The priced and measured configurations had identical networking, consisting of the following on each of the 4 nodes:

- A 1GbE connection for IPMI.
- A dual-port Broadcom BCM57416 NetXtreme-E 10GBASE-T RDMA Ethernet Controller. One port was unused. The other port was used for “Management Network”. The vCenter Server Appliance accessed the hosts on this network.
- A dual-port Mellanox ConnectX-5 EN 100GbE card. Both ports were connected to the 100GbE Switch. One port carried the vSAN traffic and the transactions coming from the driver. The other port carried the vMotion traffic.

Clause 5 – Benchmark Kit

5.1 Version

Supermicro used the required TPC-provided benchmark kit for this benchmark. Table 5-1 shows the version of the kit Supermicro used.

TPCx-HCI Benchmark Kit Version
1.1.8

Table 5-1 Benchmark Kit Version

5.2 Modifications

The only modifications made to the TPC-provided kit were for environment settings.

Clause 6 – Performance Metrics & Response Times

6.1 VGenDriver Configuration

6.1.1 Customer Emulator (CE)

A TPCx-HCI Customer Emulator (VCE) process is created by invoking vce.jar. The number of VCE processes is controlled by the configuration parameter NUM_DRIVER_HOSTS in the vcfg.properties file. The number of CE threads used to present the CE load to the SUT is controlled by the configuration parameter NUM_CE_DRIVERS.

Table 6-1 summarizes the configuration of VGenDriverCE used for this benchmark. Additional configuration details can be found in vcfg.properties.

VCE Processes	10
Total CE Threads	650

Table 6-1 VGenDriverCE Configuration

6.1.2 Market Exchange Emulator (MEE)

A TPCx-HCI Market Exchange Emulator (VMEE) process is created by invoking vmee.jar. The number of VMEE processes is controlled by the configuration parameter NUM_VMEE_PROCESSES in the vcfg.properties file.

Each MEE has one thread pool for handling Trade-Result transactions and another thread pool for handling Market-Feed Transactions. The size of these thread pools is controlled by the configuration parameters MEE_TR_POOL and MEE_MF_POOL, respectively.

Table 6-2 summarizes the configuration of VGenDriverMEE used for this benchmark. Additional configuration details can be found in vcfg.properties.

VMEE Processes	1
MEEs	200
Total Trade-Result Threads	1,000
Total Market-Feed Threads	200

Table 6-2 VGenDriverMEE Configuration

6.2 Overall Throughput

The TPCx-HCI Standard Specification:

- Defines Nominal Throughput as 2.00 tpsHCI per 1,000 Active Customers
- Requires Measured Throughput to be between 80% and 102% of Nominal Throughput
- Sets Reported Throughput to:
  - Measured Throughput when it is less than Nominal Throughput
  - Nominal Throughput when Measured Throughput is between Nominal Throughput and 102% of Nominal Throughput

Table 6-3 summarizes the overall throughput results for this benchmark.

Measured Throughput	4,790.18 tpsHCI
Reported Throughput	4,790.18 tpsHCI

Active Customers	2,400,000
80% Nominal	3,840.00 tpsHCI
Nominal Throughput	4,800.00 tpsHCI
102% Nominal	4,896.00 tpsHCI

Table 6-3 Overall Throughput Results & Nominal Throughput Summary

6.3 Measured Throughput by Group

Table 6-4 shows the measured throughput for each Group over the Measurement Interval. The TPCx-HCI Standard Specification requires each Group's measured throughput to be within 2% of its expected value.

Tile	Group	Expected	tpsHCI	Delta
1	1	95.80	95.73	-0.07%
1	2	191.60	193.10	0.78%
1	3	287.41	286.69	-0.25%
1	4	383.21	382.55	-0.17%
2	1	95.80	95.69	-0.11%
2	2	191.60	193.11	0.79%
2	3	287.41	286.65	-0.26%
2	4	383.21	382.53	-0.18%
3	1	95.80	95.71	-0.09%
3	2	191.60	193.09	0.78%
3	3	287.41	286.70	-0.25%
3	4	383.21	382.51	-0.18%
4	1	95.80	95.69	-0.11%
4	2	191.60	193.14	0.80%
4	3	287.41	286.69	-0.25%
4	4	383.21	382.53	-0.18%
5	1	95.80	95.67	-0.14%
5	2	191.60	193.14	0.80%
5	3	287.41	286.66	-0.26%
5	4	383.21	382.52	-0.18%

Table 6-4 Measured Throughput by Group

6.4 Test Run Graph

Figure 6-1 shows the throughput versus elapsed wall clock time for the Trade-Result transaction.

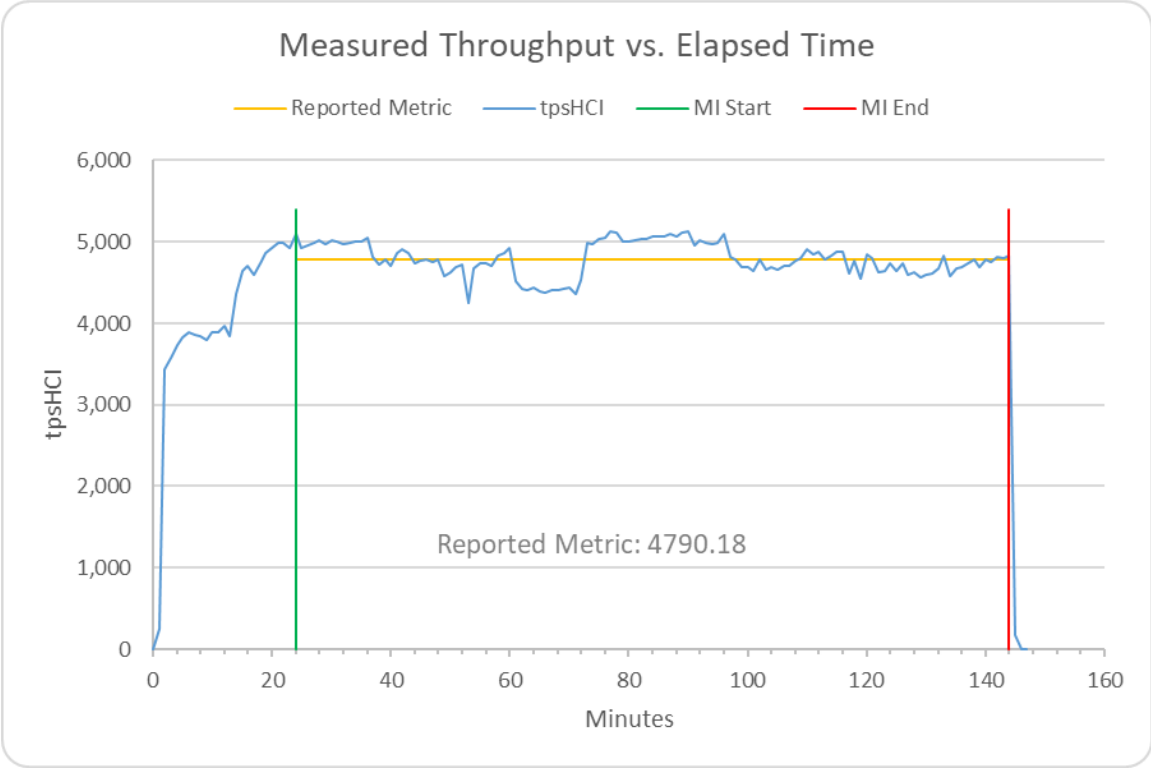

Figure 6-1 Test Run Graph

6.5 Transaction Input Parameter Mix Percentages

Table 6-5 shows the mix percentages over the Measurement Interval for key transaction input parameters.

	Setting	Mix	Required Range		
Customer-Position			Min	Target	Max
By Tax ID	True	50.00%	48.00%	50.00%	52.00%
Get History	True	50.00%	48.00%	50.00%	52.00%
Market-Watch			Min	Target	Max
Security Chosen By	Watch List	59.99%	57.00%	60.00%	63.00%
	Account ID	35.01%	33.00%	35.00%	37.00%
	Industry	5.00%	4.50%	5.00%	5.50%
Security Detail			Min	Target	Max
Access LOB	True	1.00%	0.90%	1.00%	1.10%
Trade-Lookup			Min	Target	Max
Frame to Execute	1	40.00%	38.00%	40.00%	42.00%
	2	30.00%	28.50%	30.00%	31.50%
	3	20.00%	19.00%	20.00%	21.00%
	4	10.00%	9.50%	10.00%	10.50%
Trade-Order			Min	Target	Max
By Third Party	True	10.01%	9.50%	10.00%	10.50%
By Company Name	True	39.99%	38.00%	40.00%	42.00%
Buy On Margin	True	8.01%	7.50%	8.00%	8.50%
Rollback	True	0.99%	0.94%	0.99%	1.04%
LIFO	True	35.00%	33.00%	35.00%	37.00%
Trade Quantity	100	25.01%	24%	25%	26%
	200	25.00%	24%	25%	26%
	400	24.99%	24%	25%	26%
	800	25.00%	24%	25%	26%
Trade Type	Limit Buy	20.01%	19.8%	20%	20.2%
	Limit Sell	10.00%	9.9%	10%	
	Market Buy	30.00%	29.7%	30%	30.3%
	Market Sell	29.99%	29.7%	30%	30.3%
	Stop Loss	10.00%	9.9%	10%	10.1%
Trade-Update			Min	Target	Max
Frame to Execute	1	45.00%	43%	45%	47%
	2	33.05%	31%	33%	35%
	3	21.96%	20%	22%	24%

Table 6-5 Transaction Input Parameter Mix Percentages

Clause 7 – Transaction & System Properties

7.1 Atomicity

The following atomicity tests were conducted on all Tier-B VMs using the xVAudit.Atomicity application provided with the TPCx-HCI benchmark kit.

- Commit Test
- Rollback Test

The results of these tests are available in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

7.2 Consistency

The following consistency conditions were tested on the initial population of all Tier-B VM databases using the xVAudit.Consistency application provided with the TPCx-HCI benchmark kit. NOTE: these conditions are all also re-evaluated at the conclusion of the Business Recovery test.

- Consistency Condition 1
- Consistency Condition 2
- Consistency Condition 3

The results of these tests are available in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

7.3 Isolation

The following isolation tests were conducted on all Tier-B VMs using the xVAudit.Isolation applications provided with the TPCx-HCI benchmark kit.

- P1 Test in Read-Only
- P1 Test in Read-Write
- P2 Test in Read-Write

The results of these tests are available in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

7.4 Data Accessibility

Data Accessibility tests the SUT's ability to maintain database operations with full data access after the permanent irrecoverable failure of any single Durable Medium containing database tables, recovery log data, or database metadata.

7.4.1 Redundancy Level

Table 7-1 shows the redundancy level, as defined in the TPCx-HCI Standard Specification, provided by the SUT.

Redundancy Level
Level 3

Table 7-1 Redundancy Level

7.4.2 Test Description

Validation of Redundancy Level 1 was accomplished by performing the following steps.

1) The current number of completed trades, *count1*, was determined.
2) A test run was started using the same configuration as was used in the measured run except for the driver load and the distribution of VMs (as allowed by the specification).
3) The Data Accessibility Throughput Requirements were met for at least 20 minutes.
4) An instantaneous and complete loss of power was induced on the chosen node.
5) After at least 20 minutes had passed, the node was powered on and the necessary recovery process was started.
6) The test run continued for at least 20 minutes.
7) The test run terminated gracefully.
8) The new number of completed trades, *count2*, was determined.
9) The number of Trade-Results successfully completed (*count2* – *count1*) was verified to be equal to the number of successful Trade-Result transaction reported by the driver.
10) Successful completion of the recovery process was confirmed.

7.4.3 Data Accessibility Graph

Figure 7-1 shows the measured throughput versus elapsed time for the Data Accessibility test.

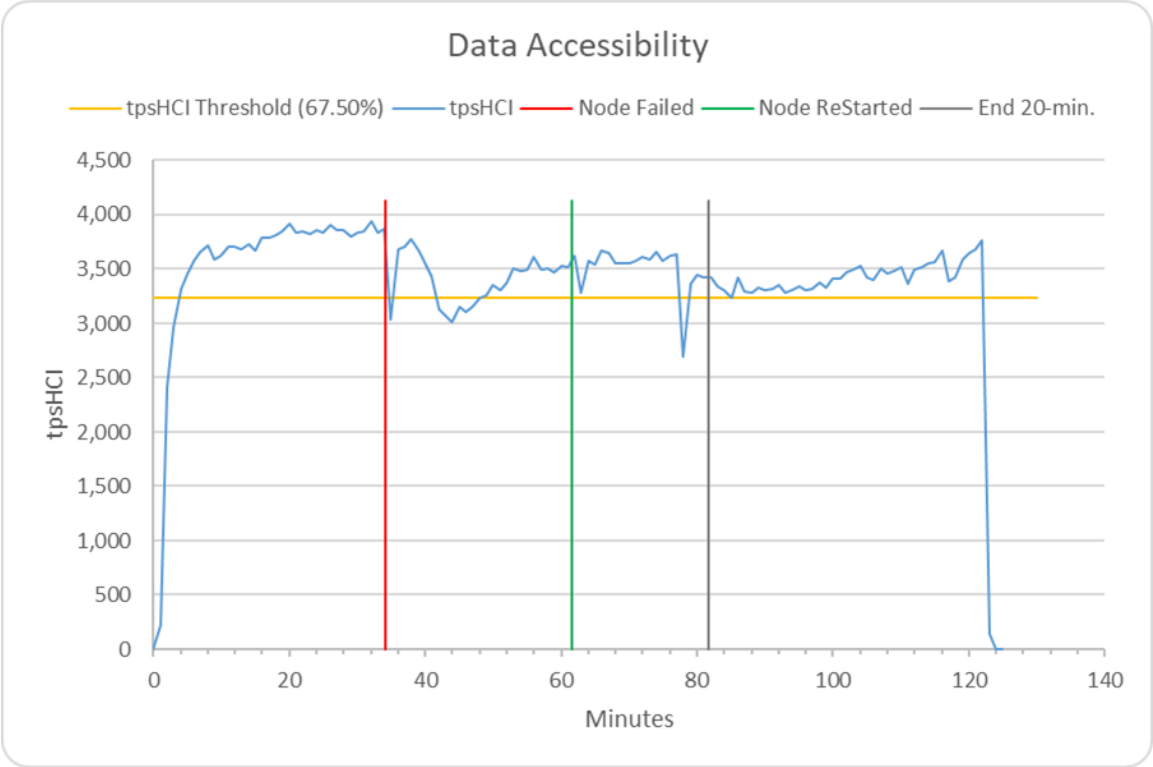

Figure 7-1 Data Accessibility Test Run Graph

7.5 Business Recovery

Business Recovery tests the SUTs ability to recover from a Loss of Processing failure as defined in the TPCx-HCI Standard Specification and restore certain operational criteria.

7.5.1 Test Description

Business Recovery was evaluated by performing the following steps.

1) The current number of completed trades, *count1*, was determined.
2) A test run was started using the same configuration as was used in the measured run.
3) The Durability Throughput Requirements were met for at least 20 minutes.
4) The failure was induced by instantaneously powering off Tile 1 Group 4 VM 3.
5) The test run was terminated.
6) Tile 1 Group 4 VM 3 was powered back on; Postgres was started and began automatic database recovery. The timestamp in the Postgres log for when the service started is considered the start of Database Recovery. The timestamp in the Postgres log for when the database was ready to accept connections is considered the end of Database Recovery.

7) A test run was started using the same configuration as was used in the measured run. The time when the driver started submitting transactions is considered the start of Application Recovery.
8) The run proceeded until a 20-minute window existed such that the first minute of the window and the entire window both had a tpsHCI that was at least 95% of the Reported Throughput. The time of the beginning of the window is considered the end of Application Recovery.
9) The test run terminated gracefully, and it was verified that the driver did not report any errors.
10) The new number of completed trades, *count2*, was determined.
11) The number of Trade-Results successfully completed (*count2* – *count1*) was verified to be equal to or greater than the number of successful Trade-Result transaction reported by the driver. In the case of an inequality, it was verified that the difference was less than or equal to the maximum number of Trade-Result transactions that could be simultaneously in-flight from the SUT to the driver.
12) Consistency of all databases was verified.

7.5.2 Business Recovery Times

Table 7-2 summarizes the key times associated with the Business Recovery test.

Event	Elapsed Time
Database Recovery	00:00:40
Application Recovery	00:14:00
Business Recovery	00:14:40

Table 7-2 Business Recovery Test Times

7.5.3 Business Recovery Time Graph

Figure 7-2 shows the measured throughput versus elapsed time for the Business Recovery test.

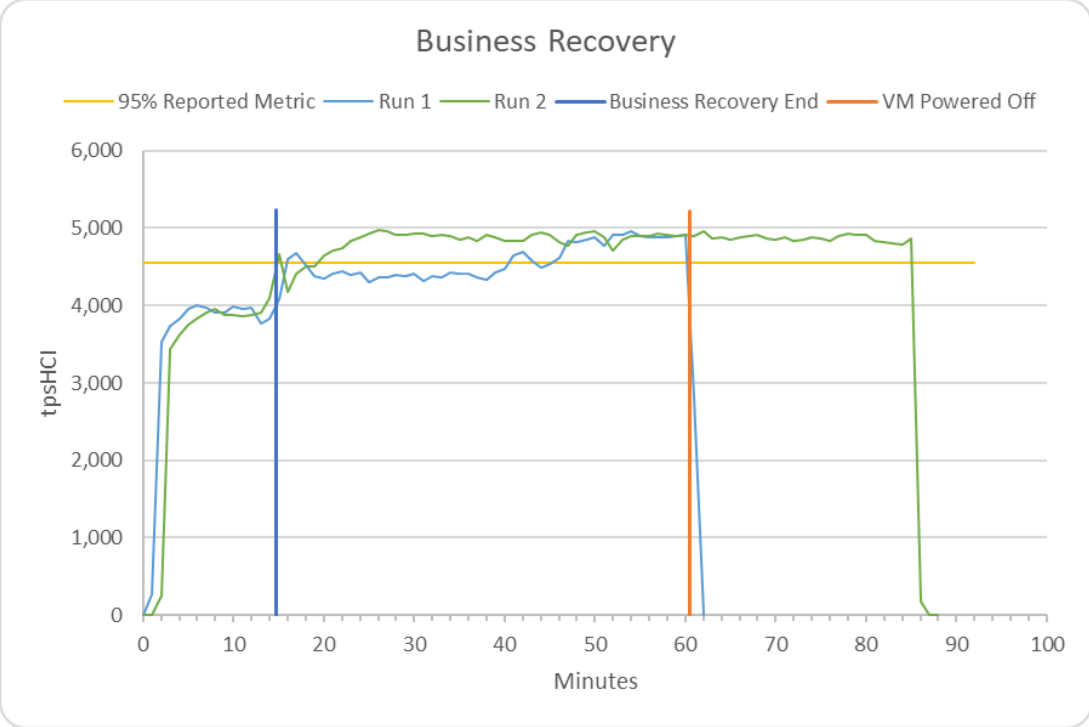

Figure 7-2 Business Recovery Time Graph

Clause 8 – Pricing

8.1 Business Day Space Calculations

To satisfy the requirements in Clauses 5.6.6.4 and 5.6.6.5 of the Standard Specification, it was verified that the file systems containing the database data and database log had at least 10% free space before and after the performance test. Details are available in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

8.2 Pricing Related Metrics

Table 8-1 contains all pricing related metrics. The total solution, as priced, will be generally available on the Availability Date.

Pricing Related Metrics	
Total Price	$237,573
Performance Metric	4,790.18 tpsHCI
Price/Performance Metric	$49.60 USD/tpsHCI
Availability Date	Currently Available

Table 8-1 Pricing Related Metrics

8.3 Additional Pricing Details

All additional pricing disclosure items, such as line item details and pricing calculations, are included in the Executive Summary.

Letter of Attestation

InfoSizing
The Right Metric For Sizing IT

TPC
Certified Auditor

Siva Yarramaneni
Supermicro Micro Computer, Inc.
980 Rock Avenue
San Jose, CA 95131

November 29, 2021

I verified the TPC Express Benchmark™ HCI v1.1.8 performance of the following configuration:

Platform:	Supermicro AS-1114S-WN10RT
Virtualization Software	VMware vSphere 7.0 Update 2
Guest VM OS:	Red Hat Enterprise Linux 7.7

The results were:

Performance Metric	**4,790.18 tpsHCI**
Configured Customers	2,400,000
Active Customers	2,400,000
Tile Count	5

Server	**4x AS-1114S-WN10RT, each with:**		
CPUs	1 x AMD EPYC 7713 2.0 GHz, 256 MB L3		
Memory	1,024 GB		
Storage	***Qty***	***Size***	***Type***
	1	960 GB	M.2 NVMe
	2	3.84 TB	CM6 NVMe
	8	3.84 TB	CD6 NVMe

In my opinion, these performance results were produced in compliance with the TPC requirements for the benchmark.

The following verification items were given special attention:

- All TPC-provided components were verified to be version 1.1.8
- No modifications were made to the TPC-provided kit
- All databases were properly scaled and populated
- Each Group contributed the appropriate overall load to the SUT
- The mandatory network between the driver and the SUT was configured
- The ACID properties were met
- Input data was generated according to the specified percentages

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- All 90% response times were under the specified maximums
- The measurement interval was 120 minutes
- The implementation used Redundancy Level 3
- The Business Recovery Time of 00:14:40 was correctly measured
- The system pricing was verified for major components and maintenance
- The major pages from the FDR were verified for accuracy

Additional Audit Notes:

None.

Respectfully Yours,

Doug Johnson, Certified TPC Auditor

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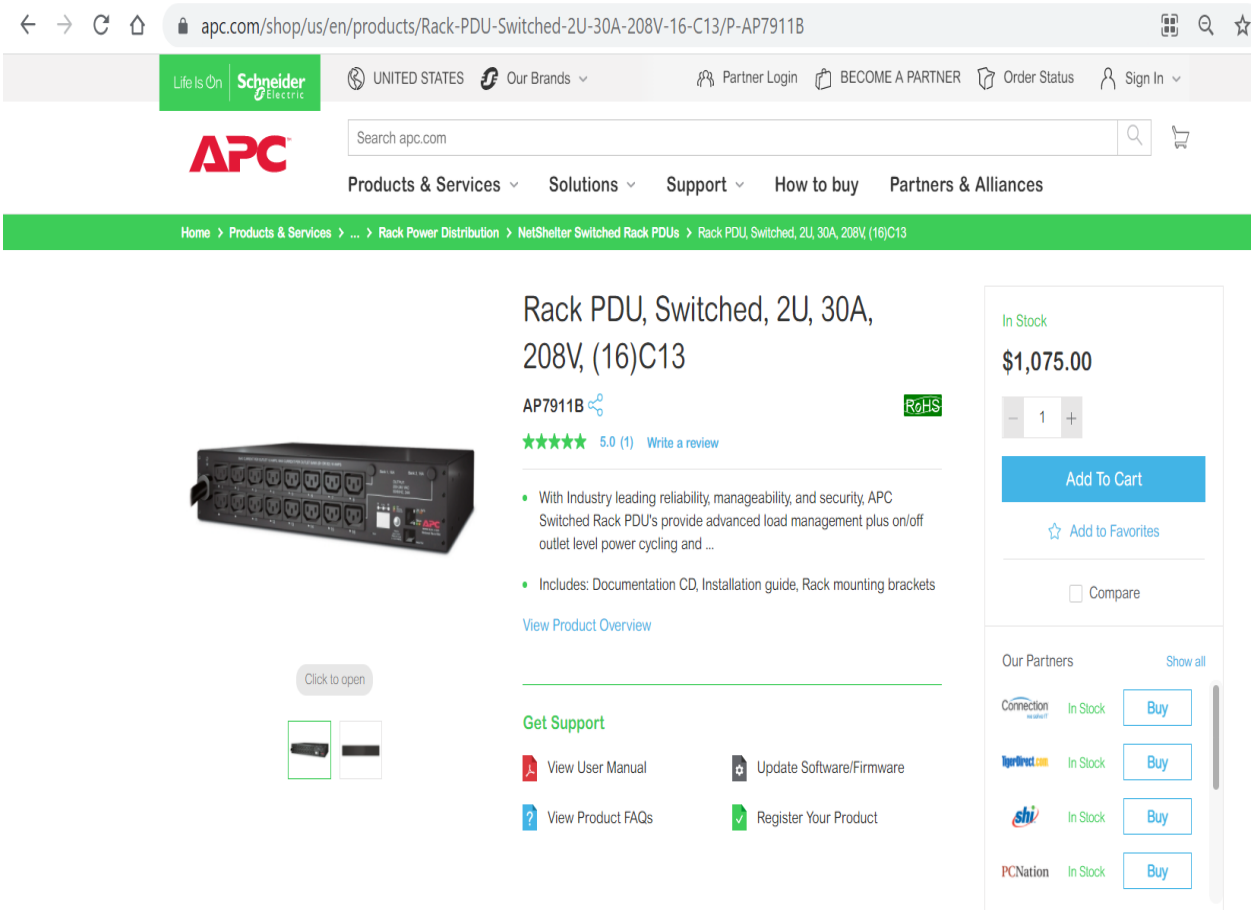
Supporting Files Index

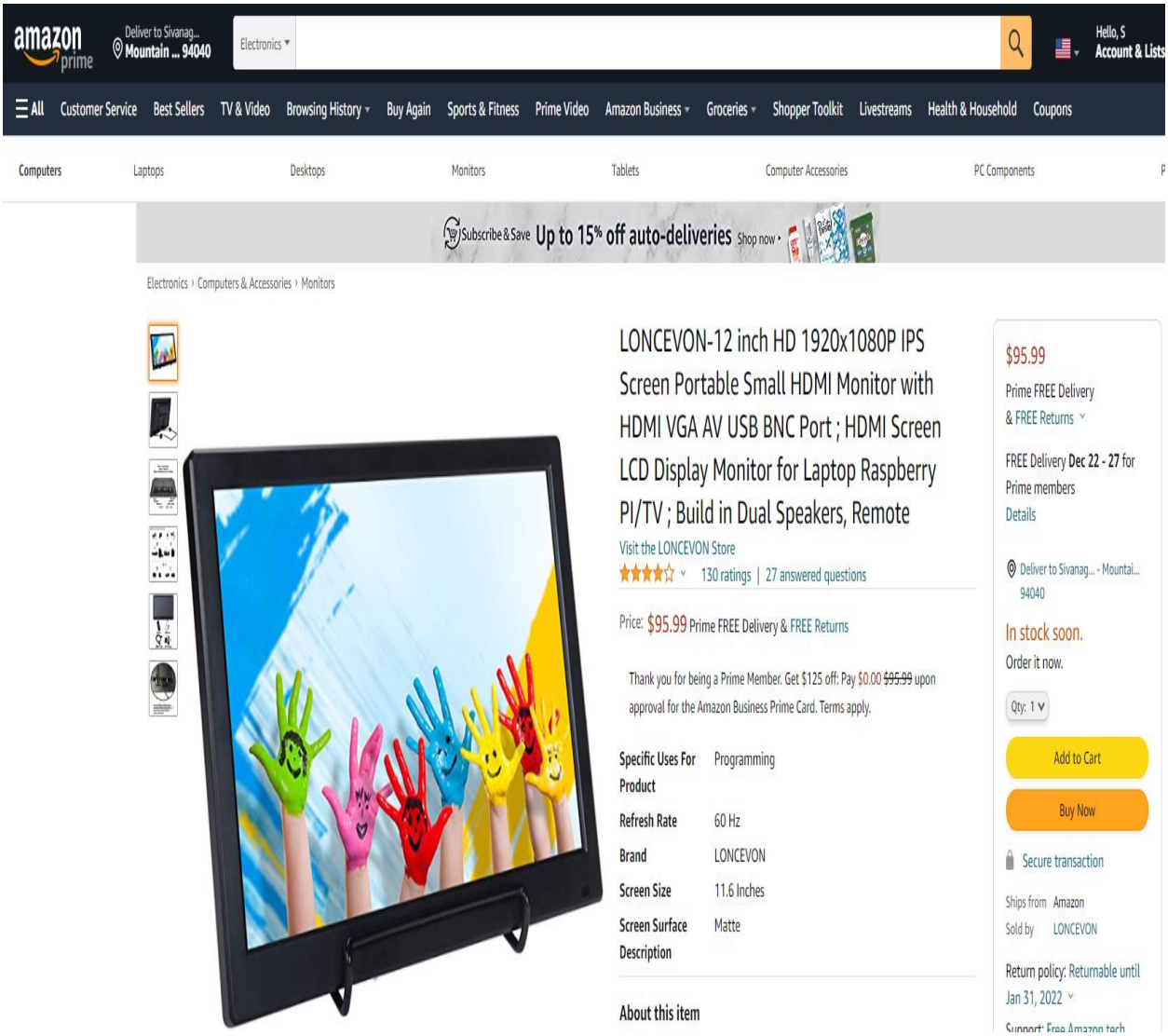
Clause	Description	Pathname
Introduction	Database tunable parameters	Introduction/vm#/DBtune.txt
	OS tunable parameters	Introduction/vm#/OStune.txt
	VM tunable parameters	Introduction/vm#/VMtune.txt
Clause 2	Log of database creation	Clause2/vm#/setup.out
Clause 4	Kit modifications	Clause4/*
Clause 5	Database growth	Clause5/vm#/DatabaseGrowth
Clause 6	ACID test output	Clause6/ACID output/*
Clause 10	Driver configuration	Clause10/vcfg.properties
	VGenLoader parameters	Clause10/create_TPCx-V_flat_files.sh
	CE VGenLogger output	Clause10/VGenLogger/CElogger-#.log
	DM VGenLogger output	Clause10/ VGenLogger/DM_Msg-*tile-group-vconn*.log
	MEE VGenLogger output	Clause10/ VGenLogger/MEE_Msg-*tile-group-vconn*.log

Third-Party Price Quotes

APC.com



Amazon.com


amazon prime
Deliver to Sivanag...
Mountain ... 94040
Electronics
Hello, S
Account & Lists
All
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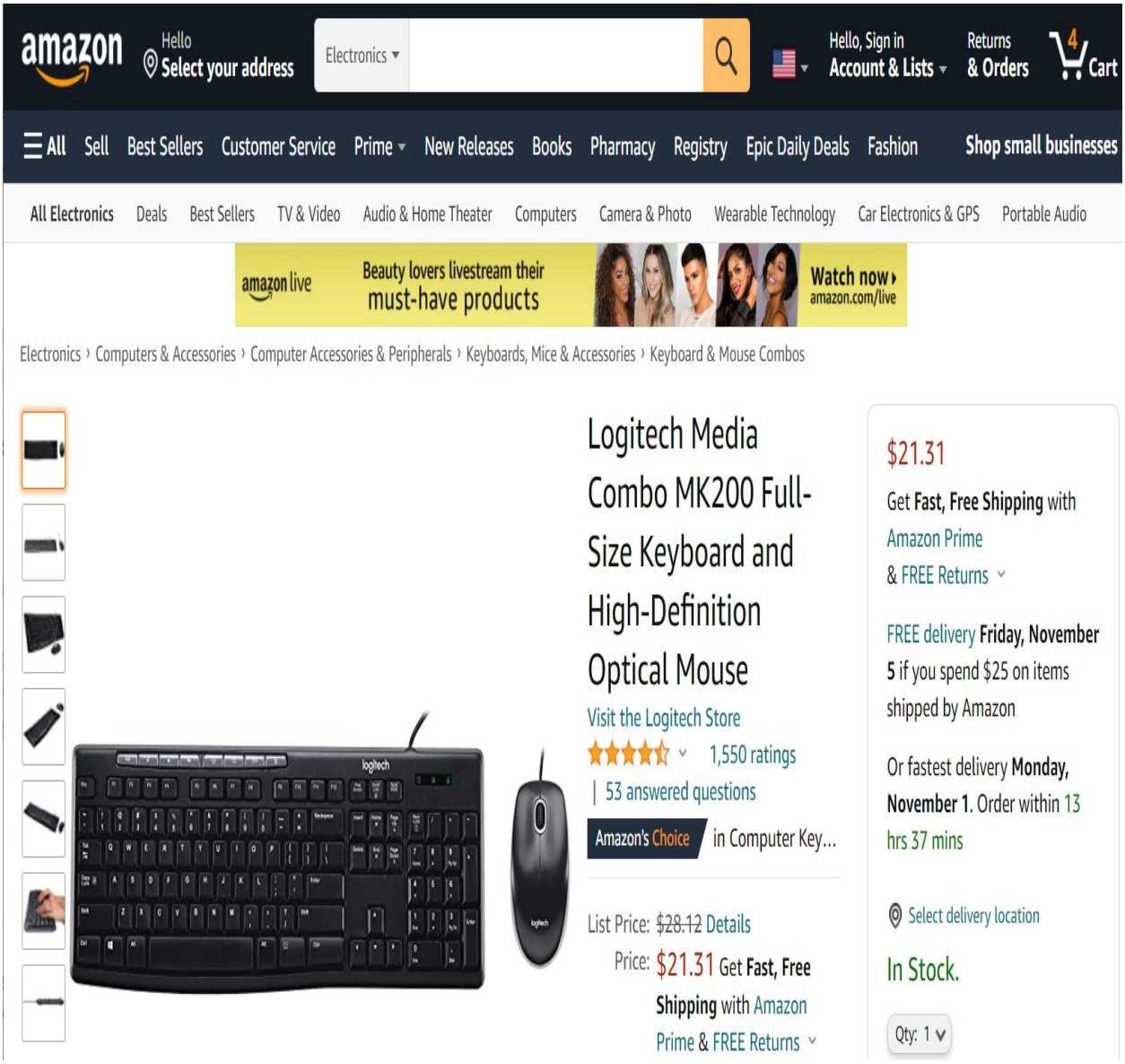
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Or fastest delivery Monday, November 1. Order within 13 hrs 37 mins
Select delivery location
In Stock.
Qty: 1

vcfg.properties

This file (included here for easy reference) is also included in the Supporting Files. Please see the Supporting Files Index for a summary of the files available.

```
: '
/*
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 *
 * This document and associated source code (the "Work") is a part of a
 * benchmark specification maintained by the TPC.
 *
 * The TPC reserves all right, title, and interest to the Work as provided
 * under U.S. and international laws, including without limitation all patent
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 *
 * No Warranty
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 *     OR OTHERWISE, ARISING IN ANY WAY OUT OF THIS OR ANY OTHER AGREEMENT
 *     RELATING TO THE WORK, WHETHER OR NOT SUCH AUTHOR OR DEVELOPER HAD
 *     ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.
 */
'
################################################################################
#
# VM Configuration
#
# The specification defines 1 to 6 Tiles. Each Tile contans 4 Groups.
# Each Group contains 3 VMs
#
VM_GROUPS = "4"
VM_TILES = "5"

#
################################################################################

################################################################################
#
# Runtime Configuration
#
```

```
# RUN_ITERATION_SEC: the combined runtime for all load phases. This value is
# divided  by the number of phases to determine the run duration for each phase.
#
# For a valid run, RAMUP_SEC has to be >= 720 seconds. Incldued in Ramp-up is
# DRIVER_SCALEUP_SEC, which is the time to graudally log in CE threads and
# start submitting transactions. We are at full load after DRIVER_SCALEUP_SEC.
# A 30-60 second DRIVER_SCALEUP_SEC is usually adequate. After transactions
# start executing at full load, it takes 6 minutes for limit-order Trade-Results
# transactions to reach their steady-state throughput. So you want the
# difference between RAMPUP_SEC and DRIVER_SCALEUP_SEC to be at least 6 mintues
#
# DRIVER_RAMPDN_SEC: the number of seconds to ramp down the load at the end
# of the final measurement phase before terminating the run.
RUN_ITERATION_SEC = "7200"
DRIVER_SCALEUP_SEC = "60"
RAMPUP_SEC = "1440"
DRIVER_RAMPDN_SEC = "60"

VCE_POLL_PER_PHASE = "11"

# NUM_RUN_ITERATIONS: the number of times to run a full set of all load phases
# NUM_RUN_PHASES: the number of load phases in a single run iteration
NUM_RUN_ITERATIONS = "1"
NUM_RUN_PHASES = "10"

LOAD_BAL_SCRIPT = "/opt/VDriver/scripts/rhel6/activate_load_balancing.sh -t 3 -o drsAdvOptions.json"
#
##############################################################################

##############################################################################
#
# VDriver Configuration
#
# VDriver (prime) hostname and RMI listening port
VDRIVER_RMI_HOST = "driver"
VDRIVER_RMI_PORT = "30000"
#
##############################################################################

##############################################################################
#
# VCe Configuration
#
# NUM_DRIVER_HOSTS: the number of CE *processes* (i.e. how many invocations of
# vce.jar) that you want to drive load against the SUT.  A value of 1 usually
# suffices, unless you need to drive the load from multiple driver systems
NUM_DRIVER_HOSTS = "10"

# Default and index-specific VCe driver hostnames and ports for RMI
# communication between processes (These let the VDriver process know where to
# contact the VCE processes to send benchmark control commands). There must be
# one host/port pair combination for each NUM_DRIVER_HOSTS (additional entries
# are ignored).
VCE_RMI_HOST[] = "driver"
VCE_RMI_PORT[] = "30100"

# Indexes for VCE start from 1
VCE_RMI_PORT[1] = "30101"
```

```
VCE_RMI_PORT[2] = "30102"
VCE_RMI_PORT[3] = "30103"
VCE_RMI_PORT[4] = "30104"
VCE_RMI_PORT[5] = "30105"
VCE_RMI_PORT[6] = "30106"
VCE_RMI_PORT[7] = "30107"
VCE_RMI_PORT[8] = "30108"
VCE_RMI_PORT[9] = "30109"
VCE_RMI_PORT[10] = "30110"

# NUM_CE_DRIVERS: the total number of CE threads that you want to drive load
# against the SUT VMs. If you are using multiple DRIVER_HOSTS, you can specify
# the  number of CEs to start on each host by using the indexed version of this
# key. Otherwise, the CEs per host are distributed evenly between hosts.
NUM_CE_DRIVERS[] = "650"

# Indexed version. Index values start from 1
#NUM_CE_DRIVERS[1] = "2"

##############################################################################

##############################################################################
#
# VMEE Configuration
#
# The number of VMEE processes the VDriver should talk to. Each VMEE spawns
# a number of "mee" threads, each of which is dedicated to a single
# Tile/Group/vconnector process
# Typically, a single VMEE process on a single system is enough, but you can
# run multiple processes, and run them from different systems
NUM_VMEE_PROCESSES = "1"

# These settings specify the host name and port number a given VMEE is
# listening on. vDriver will use these to connect to the VMEE processes. If
# starting the VMEE processes manually (i.e. not using the provided script),
# the values specified here must match those used on the VMEE command line
# (-rh and -rp) when starting a given VMEE process.
#
# Unindexed value - used as a default if a given indexed value is not specified.
VMEE_RMI_HOST[] = "driver"
VMEE_RMI_PORT[] = "30200"
#
# Indexed values (1 to (NUM_VMEE_PROCESSES) will be used if they exist).
#VMEE_RMI_HOST[1] = "driver"
VMEE_RMI_PORT[1] = "30201"
VMEE_RMI_PORT[2] = "30202"
VMEE_RMI_PORT[3] = "30203"
VMEE_RMI_PORT[4] = "30204"
VMEE_RMI_PORT[5] = "30205"


# These settings specify individual MEE configuration options. The MEE
# threads are divided between the VMEE processes.  There is a 1-1
# mapping between vconnector processes on Tier A VMs and MEEs. The
# VMEE process will have one MEE for each vconnector process
#
# MEE_TXN_HOST - host name the MEE will listen on (for connections from SUT
#                SendToMarket in a vconnector process)
```

```
# MEE_TXN_PORT - port number the MEE will listen on (for connections from SUT
#               SendToMarket in a vconnector process)
# MEE_MF_POOL - Size of the Market-Feed thread pool (should be 1 for TPCx-V)
# MEE_TR_POOL - Size of the Trade-Result thread pool (adjust this based on load)
#
# The indexes used for these parameters are [tile][group][vconn], indicating
# the vconnector (index) in a given group on a given tile that the MEE is
# connected to.
#
# Unindexed value - used as a default if a given indexed value is not specified.
MEE_TXN_HOST[] = "driver"
MEE_TXN_PORT[] = "30300"
MEE_MF_POOL[] = "1"
MEE_TR_POOL[] = "5"
#
# (Indexed values will be used if they exist. Add more entries for additional
# tiles.)
#
# Tile 1 Group 1
# MEE_TXN_HOST[1][1] = "driver"
# MEE_TXN_PORT[1][1][1] = "31101"
# Tile 1 Group 2
# MEE_TXN_HOST[1][2] = "driver"
# MEE_TXN_PORT[1][2][1] = "31201"
# Tile 1 Group 3
# MEE_TXN_HOST[1][3] = "driver"
# MEE_TXN_PORT[1][3][1] = "31301"
# Tile 1 Group 4
# MEE_TXN_HOST[1][4] = "driver"
# MEE_TXN_PORT[1][4][1] = "31401"


##############################################################################

##############################################################################
#
# VConnector Configuration
#
# VConnector is the process on the Tier A VM1 that receives transactions from
# the CE and MEE drivers, and submits them to the VM2 and VM3 databases

#
# Number of times to retry a failed DB transaction before reporting failure
NUM_TXN_RETRIES = "25"

# The "vconnector" is the process on the Tier A VM (VM1) that receives
# transactions from the driver and submits them to the database. There can be
# be one or more vconnector processes on each Tier A. NUM_VCONN_PER_GROUP
# is the number of VConnector processes running on each Tier A VM (The
# requests will be distributed across all of these processes). Each process
# is multi-threaded, and one process may be enough. But if you see odbc
# contention issues on the Tier A VM1, increase this value
NUM_VCONN_PER_GROUP = "10"

# Default VConnector hostnames and ports
VCONN_RMI_HOST[] = "vm1"
VCONN_RMI_PORT[] = "30400"
VCONN_TXN_HOST[] = "vm1"
```

```
VCONN_TXN_PORT[] = "31000"
# The common case is to set an unindexed CONN_DSN_LABELS[]  = "PSQL2,PSQL3
# and VCONN_NUM_DBS[] = "2" to cover the whole SUT
VCONN_DSN_LABELS[]  = "PSQL2,PSQL3"
VCONN_NUM_DBS[] = "2"

# Index-specific hostnames and ports. Add more entries for additional tiles.
# All host/port entries are of the form VCONN_RMI_HOST[tile][group][index]
# The harness will automatically increment "index" if there are multiple
# VConnector processes per group (i.e. NUM_VCONN_PER_GROUP > 1) unless values
# for every tile/group/index are specified here. So the options for specifying
# these values are:
#
#   To automatically increment port numbers for multiple VConnector processes:
#
#   VCONN_RMI_HOST[1][1] = "vm1"
#   VCONN_RMI_PORT[1][1][] = "42000"    (VCONN_RMI_PORT[1][1][1] = "42000",
#                                VCONN_RMI_PORT[1][1][2] = "42001", ...)
#   VCONN_TXN_HOST[1][1] = "vm1"
#   VCONN_TXN_PORT[1][1][] = "44000"    (VCONN_TXN_PORT[1][1][1] = "44000",
#                                VCONN_TXN_PORT[1][1][2] = "44001", ...)
#   Or, in the case of 3 VConnector processes per group, to specifically assign
#   values for each port (in this example, for Tile 1 Group 1):
#   VCONN_RMI_HOST[1][1] = "vm1"
#   VCONN_RMI_PORT[1][1][1] = "51100"
#   VCONN_RMI_PORT[1][1][2] = "32109"
#   VCONN_RMI_PORT[1][1][3] = "25432"
#   VCONN_TXN_HOST[1][1] = "vm1"
#   VCONN_TXN_PORT[1][1][1] = "41100"
#   VCONN_TXN_PORT[1][1][2] = "11243"
#   VCONN_TXN_PORT[1][1][3] = "27211"
#
VCONN_RMI_HOST[1][1] = "vm1"
VCONN_TXN_HOST[1][1] = "vm1"
VCONN_RMI_HOST[1][2] = "vm4"
VCONN_TXN_HOST[1][2] = "vm4"
VCONN_RMI_HOST[1][3] = "vm7"
VCONN_TXN_HOST[1][3] = "vm7"
VCONN_RMI_HOST[1][4] = "vm10"
VCONN_TXN_HOST[1][4] = "vm10"
VCONN_RMI_HOST[2][1] = "vm13"
VCONN_TXN_HOST[2][1] = "vm13"
VCONN_RMI_HOST[2][2] = "vm16"
VCONN_TXN_HOST[2][2] = "vm16"
VCONN_RMI_HOST[2][3] = "vm19"
VCONN_TXN_HOST[2][3] = "vm19"
VCONN_RMI_HOST[2][4] = "vm22"
VCONN_TXN_HOST[2][4] = "vm22"
VCONN_RMI_HOST[3][1] = "vm25"
VCONN_TXN_HOST[3][1] = "vm25"
VCONN_RMI_HOST[3][2] = "vm28"
VCONN_TXN_HOST[3][2] = "vm28"
VCONN_RMI_HOST[3][3] = "vm31"
VCONN_TXN_HOST[3][3] = "vm31"
VCONN_RMI_HOST[3][4] = "vm34"
VCONN_TXN_HOST[3][4] = "vm34"
VCONN_RMI_HOST[4][1] = "vm37"
VCONN_TXN_HOST[4][1] = "vm37"
```

```
VCONN_RMI_HOST[4][2] = "vm40"
VCONN_TXN_HOST[4][2] = "vm40"
VCONN_RMI_HOST[4][3] = "vm43"
VCONN_TXN_HOST[4][3] = "vm43"
VCONN_RMI_HOST[4][4] = "vm46"
VCONN_TXN_HOST[4][4] = "vm46"
VCONN_RMI_HOST[5][1] = "vm49"
VCONN_TXN_HOST[5][1] = "vm49"
VCONN_RMI_HOST[5][2] = "vm52"
VCONN_TXN_HOST[5][2] = "vm52"
VCONN_RMI_HOST[5][3] = "vm55"
VCONN_TXN_HOST[5][3] = "vm55"
VCONN_RMI_HOST[5][4] = "vm58"
VCONN_TXN_HOST[5][4] = "vm58"

#
#
###############################################################################

###############################################################################
#
# VDm Configuration
#
# VDm hostname and RMI listening port
VDM_RMI_HOST = "driver"
VDM_RMI_PORT = "30001"
#
# The Data-Maintenance transaction is supposed to run once every 60 seconds
VDM_REQ_INTERVAL_SEC = "60"
#
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#
# Group-specific Load Configuration
#
# Set CUST_CONFIGURED and CUST_ACTIVE for each Tile/Group with the index
# parameters below. SCALE_FACTOR, LOAD_RATE, and INIT_TRADE_DAYS are not
# typically changed from their defaults; the unindexed parameters should suffice
CUST_CONFIGURED[] = "5000"
CUST_ACTIVE[] = "5000"
SCALE_FACTOR[] = "500"
LOAD_RATE[] = "2000"
INIT_TRADE_DAYS[] = "125"

# Group-specific values
CUST_CONFIGURED[1] = "48000"
CUST_ACTIVE[1] = "48000"
#
CUST_CONFIGURED[2] = "96000"
CUST_ACTIVE[2] = "96000"
#
CUST_CONFIGURED[3] = "144000"
CUST_ACTIVE[3] = "144000"
#
CUST_CONFIGURED[4] = "192000"
CUST_ACTIVE[4] = "192000"
#
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#GROUP_PCT_DIST_PHASE[1] = "1.0"
GROUP_PCT_DIST_PHASE[1] = "0.10,0.20,0.30,0.40"
GROUP_PCT_DIST_PHASE[2] = "0.05,0.10,0.25,0.60"
GROUP_PCT_DIST_PHASE[3] = "0.10,0.05,0.20,0.65"
GROUP_PCT_DIST_PHASE[4] = "0.05,0.10,0.05,0.80"
GROUP_PCT_DIST_PHASE[5] = "0.10,0.05,0.30,0.55"
GROUP_PCT_DIST_PHASE[6] = "0.05,0.35,0.20,0.40"
GROUP_PCT_DIST_PHASE[7] = "0.35,0.25,0.15,0.25"
GROUP_PCT_DIST_PHASE[8] = "0.05,0.65,0.20,0.10"
GROUP_PCT_DIST_PHASE[9] = "0.10,0.15,0.70,0.05"
GROUP_PCT_DIST_PHASE[10] = "0.05,0.10,0.65,0.20"

# Use DB_CONN_BUFFER_PCT_GROUP to modify the initial number of connections
# opened by the CEs to each Tier A VM for each group (the index value indicates
# the group number). Use values greater than 1.0 to increase the number of
# connections (up to the theoretical maximum) and values less than 1.0 to
# decrease the number of initial connections.
DB_CONN_BUFFER_PCT_GROUP[1] = "1.2"
DB_CONN_BUFFER_PCT_GROUP[2] = "1.2"
DB_CONN_BUFFER_PCT_GROUP[3] = "1.2"
DB_CONN_BUFFER_PCT_GROUP[4] = "1.2"

#
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#
# Misc Configuration Parameters
# These values are unlikely to need to be modified
#

# Log names:
# CE log file names
CE_MIX_LOG = "CE_Mix.log"
CE_ERR_LOG = "CE_Error.log"

# MEE base file names for logging purposes.
MEE_LOG = "MEE_Msg"
MEE_MIX_LOG = "MEE_Mix"
MEE_ERR_LOG = "MEE_Err"

# VDm log file names
VDM_TRANSACTION_LOG = "DM_Txn"
VDM_MESSAGE_LOG = "DM_Msg"

RESULT_DIR = "results"
LOG_DIR = "."
SORT_MIX_LOGS = "0"
SORTED_LOG_NAME_APPEND = "sorted"
LOG_SAMPLE_SEC = "60"
# VGEN_INPUT_FILE_DIR = ""
DEBUG_LEVEL = "0"
SUPPRESS_WARNINGS = "1"
CHECK_TIME_SYNC = "1"
COLLECT_CLIENT_LOGS = "0"

TIME_SYNC_TOLERANCE_MSEC = "1000"
```

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# CE_EXIT_DELAY_SEC is the number of seconds the user wants to wait to allow
# "cleanup" before final exit. This is mostly in case there are "retries" going
# on that need to have time to time out before a final exit.
CE_EXIT_DELAY_SEC = "10"

# NUM_TXN_METRICS is the number of metrics created for report purposes
NUM_TXN_METRICS = "5"
NUM_TXN_TYPES = "12"

CE_MIX_PARAM_INDEX = "1,2"
# BrokerVolumeMixLevel,CustomerPositionMixLevel,
# MarketWatchMixLevel,SecurityDetailMixLevel,
# TradeLookupMixLevel,TradeOrderMixLevel,
# TradeStatusMixLevel,TradeUpdateMixLevel
#CE_MIX_PARAM_1 = "0,0,0,0,0,1000,0,0"
CE_MIX_PARAM_1 = "39,150,170,160,90,101,180,10"
# CE_MIX_PARAM_2 = "59,130,180,140,80,101,190,20"
# TXN_TYPE
# "-1" = EGEN-GENERATED MIX
# "0" = SECURITY_DETAIL
# "1" = BROKER_VOLUME
# "2" = CUSTOMER_POSITION
# "3" = MARKET_WATCH
# "4" = TRADE_STATUS
# "5" = TRADE_LOOKUP
# "6" = TRADE_ORDER
# "7" = TRADE_UPDATE
```