Cisco Systems, Inc.

TPC Express Benchmark™ HS
Full Disclosure Report

Cisco Data Intelligence Platform

(with 1x Cisco UCS C240 M5 Server; 16x Cisco UCS C240 M5 Servers)

Running

Cloudera Enterprise Basic 6.3.0

on

Red Hat Enterprise Linux Server 7.6

TPCx-HS Version	2.0.3
Report Edition	First
Report Submitted	December 10, 2019

First Edition - December 2019

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All performance data contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly. No warranty of system performance or price/performance is expressed or implied in this report.

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Abstract

This document contains the methodology and results of the TPC Express Benchmark™ HS (TPCx-HS) test conducted in conformance with the requirements of the TPCx-HS Standard Specification, Revision 2.0.3.

The benchmark results are summarized below.

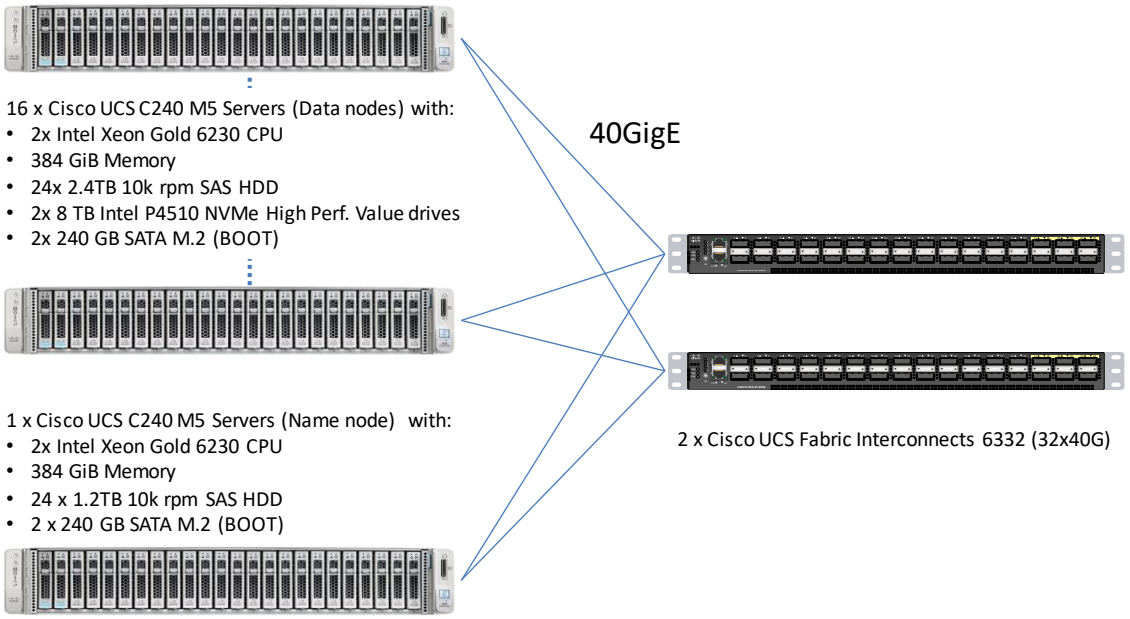
Measured Configuration			
Company Name	Cluster Node	Hadoop Software	Operating System
Cisco	Cisco UCS C240 M5	Cloudera Enterprise Basic 6.3.0	Red Hat Enterprise Linux Server 7.6

TPC Express Benchmark™ HS Metrics			
Total System Cost	HSph@1TB	Price/Performance	Availability Date
$1,014,330	12.54	$80,887.56	December 10, 2019

Executive Summary

The Executive Summary follows on the next several pages.

CISCO	**Cisco Data Intelligence Platform**		TPCx-HS 2.0.3 TPC Pricing 2.5.0 Report Date Dec. 10, 2019
Availability Date	TPCx-HS Performance	Price/Performance	Total System Cost
December 10, 2019	**12.54 HSph@1TB**	**$80,887.56 $ / HSph@1TB**	**$1,014,330 USD**
System Under Test Configuration Overview			
Scale Factor	Hadoop Software	Operating System	Other Software
1	Cloudera Enterprise Basic 6.3.0	Red Hat Enterprise Linux Server 7.6	n/a



Physical Storage/Scale Factor: 1,214.56	Scale Factor/Physical Memory: 0.16

Servers: Total Processors/Cores/Threads:	17 (1x Cisco UCS C240 M5; 16x Cisco UCS C240 M5) 34/680/1,360	
Server Configuration: Processors Memory Storage Controller Storage Device Network	1x Cisco UCS C240 M5: 2x Intel(R) Xeon(R) Gold 6230 384 GiB 1x 12G SAS Modular RAID 2x 240GB SATA M.2 24x 1.2TB 10k rpm SAS HDD VIC 1387 Dual Port 40Gb	16x Cisco UCS C240 M5: 2x Intel(R) Xeon(R) Gold 6230 384 GiB 1x 12G SAS Modular RAID 2x 240GB SATA M.2 24x 2.4TB 10k rpm SAS HDD 2x 8TB Intel NVMe VIC 1387 Dual Port 40Gb
Connectivity: Total Rack Units:	2x Cisco UCS Fabric Interconnect 6332 (32x40G) (17 x UCS C240 M5) + (2 x FI 6332) = (17x2) + (2x1) = 36RU	

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Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
Hardware						
UCS C240 M5 24 SFF + 2 rear drives w/o CPU,mem,HD,PCIe,PS	UCSC-C240-M5SX	1	$4,939.00	16	$79,024.00	
SNTC 24X7X4OS UCS C240 M5 24 SFF + 2 rear drives w/o CPU,mem	CON-OSP-C240M5SX	1	$3,102.75	17		$52,746.75
Riser 1 incl 3 PCIe slots (x8, x16, x8); slot 3 req CPU2	UCSC-PCI-1-C240M5	1	$199.00	16	$3,184.00	
Cisco VIC 1387 Dual Port 40Gb QSFP CNA MLOM	UCSC-MLOM-C40Q-03	1	$2,192.00	16	$35,072.00	
240GB SATA M.2	UCS-M2-240GB	1	$535.00	32	$17,120.00	
Ball Bearing Rail Kit for C220 & C240 M4 & M5 rack servers	UCSC-RAILB-M4	1	$220.00	16	$3,520.00	
IMC SW (Recommended) latest release for C-Series Servers.	CIMC-LATEST	1	$0.00	16	$0.00	
Big Data and Analytics Platform (Hadoop/IoT/ITOA/AI/ML)	UCS-SID-INFR-BD	1	$0.00	16	$0.00	
Big Data and Analytics (Hadoop/IoT/ITOA)	UCS-SID-WKL-BD	1	$0.00	16	$0.00	
Mini Storage carrier for M.2 SATA/NVME (holds up to 2)	UCS-MSTOR-M2	1	$0.00	16	$0.00	
Super Cap cable for UCSC-RAID-M5HD	CBL-SC-MR12GM5P	1	$0.00	16	$0.00	
Super Cap for UCSC-RAID-M5, UCSC-MRAID1GB-KIT	UCSC-SCAP-M5	1	$0.00	16	$0.00	
Cisco 12G Modular RAID controller with 4GB cache	UCSC-RAID-M5HD	1	$2,900.00	16	$46,400.00	
2.4 TB 12G SAS 10K RPM SFF HDD (4K)	UCS-HD24TB10K4KN	1S	$2,065.00	352	$726,880.00	
32GB DDR4-2933-MHz RDIMM/2Rx4/1.2v	UCS-MR-X32G2RT-H	1	$2,043.00	192	$392,256.00	
C240 Rear UCS-RAID-M5HD SAS cbl(1)kitinclfan,bkpln	UCSC-RSAS-240M5X	1	$0.00	16	$0.00	
C240 M5 Front NVMe cable (1)	CBL-NVME-C240SFF	1	$0.00	16	$0.00	
8TB 2.5in U.2 Intel P4510 NVMe High Perf. Value Endurance	UCSC-NVMEHW-I8000	1	$14,675.00	32	$469,600.00	
2.4 TB 12G SAS 10K RPM SFF HDD (4K)	UCS-HD24TB10K4KN	1	$2,065.00	32	$66,080.00	
Riser 2C incll 3 PCIe slots (3 x8) supports front+rear NVMe	UCSC-PCI-2C-240M5	1	$199.00	16	$3,184.00	
Cisco UCS 1050W AC Power Supply for Rack Server	UCSC-PSU1-1050W	1	$729.00	32	$23,328.00	
Power Cord, 125VAC 13A NEMA 5-15 Plug, North America	CAB-9K12A-NA	1	$0.00	32	$0.00	
Heat sink for UCS C240 M5 rack servers 150W CPUs & below	UCSC-HS-C240M5	1	$0.00	32	$0.00	
Intel 6230 2.1GHz/125W 20C/27.50MB DCP DDR4 2933 MHz	UCS-CPU-I6230	1	$6,500.00	32	$208,000.00	
Cisco R42612 standard rack, w/side panels	RACK2-UCS2	1	$6,241.00	1	$6,241.00	
SNTC 8X5XNBD, Cisco R42612 standard rack, w side panels	CON-SNT-RCK2UCS2	1	$300.00	1		$300.00
(Not sold standalone) UCS 6332 1RU FI/12 QSFP+	UCS-SP-FI6332	1	$24,400.00	2	$48,800.00	
ONSITE 24X7X4 (Not sold standalone) UCS 6332 1RU FI/No PSU/3	CON-OSP-SPFI6332	1	$7,011.90	2		$14,023.80
UCS 6332/ 6454 Power Supply/100-240VAC	UCS-PSU-6332-AC	1	$0.00	4	$0.00	
Power Cord, 125VAC 13A NEMA 5-15 Plug, North America	CAB-9K12A-NA	1	$0.00	4	$0.00	
40GBASE-CR4 Passive Copper Cable, 3m	QSFP-H40G-CU3M	1	$0.00	16	$0.00	
QSFP40G BiDi Short-reach Transceiver	QSFP-40G-SR-BD	1	$0.00	8	$0.00	
UCS Manager v3.2	N10-MGT015	1	$0.00	2	$0.00	
UCS 6332/ 6454 Fan Module	UCS-FAN-6332	1	$0.00	8	$0.00	
UCS 6332/ 6454 Chassis Accessory Kit	UCS-ACC-6332	1	$0.00	2	$0.00	
3rd Gen FI Per port License to connect C-direct only	UCS-LIC-6300-40GC=	1	$1,388.00	20	$27,760.00	

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Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
UCS C240 M5 24 SFF + 2 rear drives w/o CPU,mem,HD,PCIe,PS	UCSC-C240-M5SX	1	$4,939.00	1	$4,939.00	
Riser 1 incl 3 PCIe slots (x8, x16, x8); slot 3 req CPU2	UCSC-PCI-1-C240M5	1	$199.00	1	$199.00	
Cisco VIC 1387 Dual Port 40Gb QSFP CNA MLOM	UCSC-MLOM-C40Q-03	1	$2,192.00	1	$2,192.00	
240GB SATA M.2	UCS-M2-240GB	1	$535.00	2	$1,070.00	
Ball Bearing Rail Kit for C220 & C240 M4 & M5 rack servers	UCSC-RAILB-M4	1	$220.00	1	$220.00	
IMC SW (Recommended) latest release for C-Series Servers.	CIMC-LATEST	1	$0.00	1	$0.00	
Big Data and Analytics Platform (Hadoop/IoT/ITOA/AI/ML)	UCS-SID-INFR-BD	1	$0.00	1	$0.00	
Big Data and Analytics (Hadoop/IoT/ITOA)	UCS-SID-WKL-BD	1	$0.00	1	$0.00	
Mini Storage carrier for M.2 SATA/NVME (holds up to 2)	UCS-MSTOR-M2	1	$0.00	1	$0.00	
Super Cap cable for UCSC-RAID-M5HD	CBL-SC-MR12GM5P	1	$0.00	1	$0.00	
Super Cap for UCSC-RAID-M5, UCSC-MRAID1GB-KIT	UCSC-SCAP-M5	1	$0.00	1	$0.00	
Cisco 12G Modular RAID controller with 4GB cache	UCSC-RAID-M5HD	1	$2,900.00	1	$2,900.00	
32GB DDR4-2933-MHz RDIMM/2Rx4/1.2v	UCS-MR-X32G2RT-H	1	$2,043.00	12	$24,516.00	
Riser 2C incll 3 PCIe slots (3 x8) supports front+rear NVMe	UCSC-PCI-2C-240M5	1	$199.00	1	$199.00	
Cisco UCS 1050W AC Power Supply for Rack Server	UCSC-PSU1-1050W	1	$729.00	2	$1,458.00	
Power Cord, 125VAC 13A NEMA 5-15 Plug, North America	CAB-9K12A-NA	1	$0.00	2	$0.00	
Heat sink for UCS C240 M5 rack servers 150W CPUs & below	UCSC-HS-C240M5	1	$0.00	2	$0.00	
UCS C-Series M5 SFF drive blanking panel	UCSC-BBLKD-S2	1	$0.00	2	$0.00	
Intel 6230 2.1GHz/125W 20C/27.50MB DCP DDR4 2933 MHz	UCS-CPU-I6230	1	$6,500.00	2	$13,000.00	
1.2 TB 12G SAS 10K RPM SFF HDD	UCS-HD12TB10K12N	1	$1,533.00	24	$36,792.00	
Software						
Red Hat Enterprise Linux (1-2 CPU,1-2 VN); 3-Yr Support Req	RHEL-2S2V-3A	1	$0.00	17	$0.00	
ISV 24X7 RHEL Server 2Socket-OR-2Virtual; ANNUAL List Price	CON-ISV1-EL2S2V3A	1	$3,897.00	17	$66,249.00	
Cloudera Ent. Basic, Node LIC, Gold	UCS-BD-CEBN-GD=	1	$0.00	17	$0.00	
Cloudera Ent. Basic, Node LIC, Gold - 3 Year	UCS-BD-CEBN-GD-3Y	1	$10,461.54	17	$177,846.18	
			Hardware & Software Subtotals		$2,488,029.18	$67,070.55
Large Purchase Discount 1						
61% for products and 35% for service		1			$1,517,697.80	$23,474.69
			Hardware & Software Totals		**$970,331.38**	**$43,595.86**
Infrastructure						
ViewSonic VA2246M 22" Monitor		2	$83.39	3	$250.17	
Logitech MK120 USB Wired Keyboard/mouse		2	$12.25	3	$36.75	
				Totals	**$970,618.30**	**$43,595.86**

Pricing: 1 = Cisco; 2 = CDW

* Discount applies to all line items where Key = 1. Discount based upon total system cost as purchased by a regular customer.

S: One or more components of the measured configuration have been substituted in the priced configuration. See the FDR for details.

Audited by Doug Johnson, InfoSizing

Three-Year Cost of Ownership:	**$1,014,330**
HSph@1TB:	**12.54**
$ / HSph@1TB:	**$80,887.56**

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.

	Cisco Data Intelligence Platform	TPCx-HS 2.0.3 TPC Pricing 2.5.0 Report Date Dec. 10, 2019

Numerical Quantities

Performance Run – Run 1	
Scale Factor	1TB
Run Start Time	2019-11-21 16:06:09.000
Run End Time	2019-11-21 16:10:54.000
Run Elapsed Time	287.000
HSGen Start Time	2019-11-21 16:06:10.000
HSGen End Time	2019-11-21 16:07:20.000
HSGen Elapsed Time	71.096
HSSort Start Time	2019-11-21 16:07:22.000
HSSort End Time	2019-11-21 16:10:20.000
HSSort Elapsed Time	178.718
HSValidate Start Time	2019-11-21 16:10:23.000
HSValidate End Time	2019-11-21 16:10:54.000
HSValidate Elapsed Time	32.471

Repeatability Run – Run 2	
Scale Factor	1TB
Run Start Time	2019-11-21 16:11:29.000
Run End Time	2019-11-21 16:16:09.000
Run Elapsed Time	282.000
HSGen Start Time	2019-11-21 16:11:30.000
HSGen End Time	2019-11-21 16:12:37.000
HSGen Elapsed Time	68.672
HSSort Start Time	2019-11-21 16:12:40.000
HSSort End Time	2019-11-21 16:15:35.000
HSSort Elapsed Time	176.488
HSValidate Start Time	2019-11-21 16:15:38.000
HSValidate End Time	2019-11-21 16:16:09.000
HSValidate Elapsed Time	32.466

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Run Reports

Run Report for Performance Run – Run 1
==========
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 1 Details	Total Time =	287
	Total Size =	10000000000
	Scale-Factor =	1

TPCx-HS Performance Metric (HSph@SF): 12.5470

==========

Run Report for Repeatability Run – Run 2
==========
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 2 Details	Total Time =	282
	Total Size =	10000000000
	Scale-Factor =	1

TPCx-HS Performance Metric (HSph@SF): 12.7713

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Cisco Data Intelligence Platform

TPCx-HS	2.0.3
TPC Pricing	2.5.0
Report Date	Dec. 10, 2019

Revision History

Date	Edition	Description
December 10, 2019	First	Initial Publication

Table of Contents

Clause 0 – Preamble

0.1 TPC Express Benchmark™ HS Overview

The TPC Express Benchmark™ HS (TPCx-HS) was developed to provide an objective measure of hardware, operating system and commercial Apache Hadoop File System API compatible software distributions, and to provide the industry with verifiable performance, price-performance and availability metrics. The benchmark models a continuous system availability of 24 hours a day, 7 days a week.

Even though the modeled application is simple, the results are highly relevant to hardware and software dealing with Big Data systems in general. TPCx-HS stresses both hardware and software including Hadoop run-time, Hadoop File-system API compatible systems and MapReduce layers. This workload can be used to asses a broad range of system topologies and implementation of Hadoop clusters. TPCx-HS can be used to assess a broad range of system topologies and implementation methodologies in a technically rigorous and directly comparable and vendor-neutral manner.

The TPCx-HS kit is available from the TPC (See www.tpc.org/tpcx-hs for more information). Users must sign-up and agree to the TPCx-HS 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-HS copyright. The TPCx-HS Kit includes: TPCx-HS Specification document, TPCx-HS Users Guide documentation, shell scripts to set up the benchmark environment and Java code to 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-HS models and represents Hadoop run-time and Hadoop File-system API compatible systems);
- 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 and rules for energy measurement are included in the TPC Energy Specification. Further information is available at www.tpc.org.

Clause 1 – General Items

1.1 Test Sponsor

A statement identifying the benchmark sponsor(s) and other participating companies must be provided

This benchmark was sponsored by Cisco Systems, Inc..

1.2 Parameter Settings

Settings must be provided for all customer-tunable parameters and options which have been changed from the defaults found in actual products, including by not limited to:

- *Configuration parameters and options for server, storage, network and other hardware component incorporated into the pricing structure;*
- *Configuration parameters and options for operating system and file system component incorporated into the pricing structure;*
- *Configuration parameters and options for any other software component incorporated into the pricing structure;*
- *Compiler optimization options.*

Comment 1: In the event that some parameters and options are set multiple times, it must be easily discernible by an interested reader when the parameter or option was modified and what new value it received each time.

Comment 2: This requirement can be satisfied by providing a full list of all parameters and options, as long as all those that have been modified from their default values have been clearly identified and these parameters and options are only set once.

The supporting files contain the parameters and options used to configure the components involved in this benchmark.

1.3 Configuration Diagrams

Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences. This includes, but is not limited to:

- *Total number of nodes used;*
- *Total number and type of processors used/total number of cores used/total number of threads used (including sizes of L2 and L3 caches);*
- *Size of allocated memory, and any specific mapping/partitioning of memory unique to the test;*
- *Number and type of disk units (and controllers, if applicable;*
- *Number of channels or bus connections to disk units, including their protocol type;*
- *Number of LAN (e.g., Ethernet) connections and speed for switches and other hardware components physically used in the test or are incorporated into the pricing structure;*
- *Type and the run-time execution location of software components.*

1.3.1 Measured Configuration

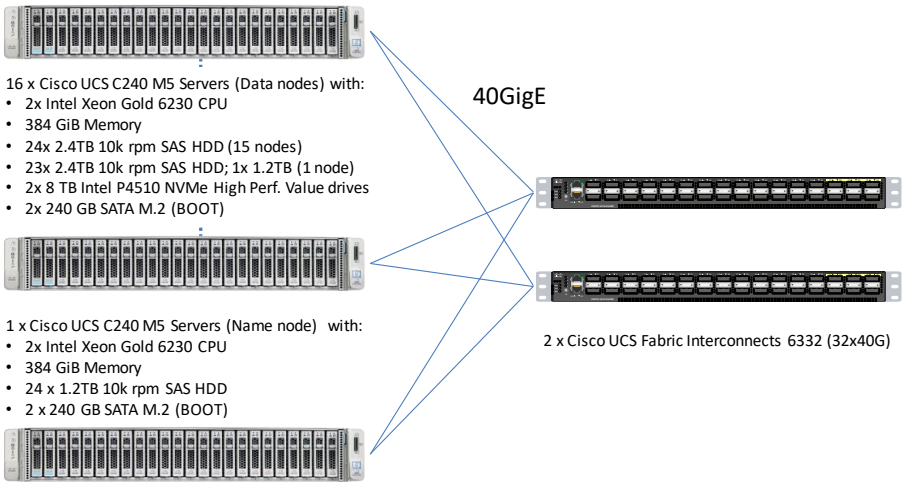

Figure 1-1 Measured Configuration

The measured configuration consisted of:

- Total Nodes: 17 (1x Cisco UCS C240 M5; 16x Cisco UCS C240 M5)
- Total Processors/Cores/Threads: 34/680/1,360
- Total Memory: 6.38TiB
- Total Number of Storage Drives/Devices: 474
- Total Storage Capacity: 1,214.56TB

Server node details:

- 17x Cisco UCS C240 M5 Servers, each with:
  - Processors/Cores/Threads: 2/40/80
  - Processor Model: Intel(R) Xeon(R) Gold 6230
  - Memory: 384 GiB
  - Controller: 1x 12G SAS Modular RAID
  - Drives:
    - 2x 240GB SATA M.2 (all nodes)
    - 24x 1.2TB 10k rpm SAS HDD (name node)
    - 2x 8TB Intel NVMe (16 data nodes)
    - 24x 2.4TB 10k rpm SAS HDD (15 data nodes)
    - 23x 2.4TB 10k rpm SAS HDD; 1x 1.2TB 10k rpm SAS HDD (1 data node)
  - Network: VIC 1387 Dual Port 40Gb

Network connectivity detail:

- 2x Cisco UCS Fabric Interconnect 6332 (32x40G)

The distribution of software components over server nodes is detailed in section **Error! Reference source not found.**.

1.3.2 Priced Configuration

The priced configuration substituted one 2.4TB 10k rpm SAS HDD for one 1.2TB 10K rpm SAS HDD in the measured configuration on one of the data nodes.

1.4 Dataset Distribution

The distribution of dataset across all media must be explicitly described.

Table 1-1 describes the distribution of the dataset across all media in the system.

Server Node	Controller	Disk Drive	Description of Content
1	Cisco 12G Modular RAID controller with 4GB cache	1-24 (HDD, RAID-1)	RAID-1 Disk for Data and Temp
1	Embedded RAID PCH SATA	0 (2 x SSD, RAID-1)	Boot Disk for Operating System, Root, Swap, Hadoop Master
2-17	Cisco 12G Modular RAID controller with 4GB cache	1-24(HDD, RAID-0)	Data
2-17	Embedded RAID PCH SATA	0 (2 x SSD, RAID-1)	Boot Disk for Operating system, Root, Swap, Hadoop Master
2-17	NVME-Direct-Attached	25-26 (2 x NVMe)	Temp (NodeManager Local Directories, NodeManager Container Log Directories)

Table 1-1Dataset Distribution

1.5 Software Components Distribution

The distribution of various software components across the system must be explicitly described.

Table 1-2 Describes the distribution of the software components across the system.

	Map/Reduce		HDFS		ZooKeeper	Spark
Node	Resource Manager	Node Manager	NameNode	DataNode	QuorumPeer	HistoryServer
1	X		X		X	
2		X		X	X	X
3		X		X	X	
4-17		X		X		

Table 1-2 Software Component Distribution

Distributed file system implementation and corresponding Hadoop File System API version must be disclosed.

Cloudera Enterprise Basic 6.3.0 (fully HDFS compatible at the API level).

Map/Reduce implementation and corresponding version must be disclosed.

Cloudera Enterprise Basic 6.3.0 (compatible equivalent to Hadoop 3.0.0).

Clause 2 – Workload Related Items

2.1 Hardware & Software Tunables

Script or text used to set for all hardware and software tunable parameters must be reported.

The Supporting File Archive contains all configuration scripts.

2.2 Run Report

The run report generated by TPCx-HS benchmark kit must be reported.

The Supporting File Archive contains the full run report. Following are extracts from the run report that lists the performance summary for both runs.

```
Run Report for Run 1 – Performance Run
=====================================================
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 1 Details      Total Time =                287
                        Total Size =         10000000000
                        Scale-Factor =               1

TPCx-HS Performance Metric (HSph@SF):          12.5470

=====================================================


Run Report for Run 2 – Repeatability Run
=====================================================
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 2 Details      Total Time =                282
                        Total Size =         10000000000
                        Scale-Factor =               1

TPCx-HS Performance Metric (HSph@SF):          12.7713

=====================================================
```

2.3 Benchmark Kit Identification

Version number of TPCx-HS kit and checksum for HSGen, HSSort and HSValidate Programs must be reported.

Kit Version 2.0.3

File	MD5
BigData_cluster_validate_suite.sh	57f7cd68251a9aba0feb6648630ff5da
HSDataCheck.sh	faeff3091759aac98080be4e39f7896a
TPCx-HS-master_MR2.jar	492cbc51a1a60c28b43d96c79d08683d
TPCx-HS-master.sh	c619a0819571ecd00cd75d2b76ba8c64

2.4 Benchmark Kit Changes

No modifications were made to the TPC-provided kit.

Clause 3 – SUT Related Items

3.1 Data Storage Ratio

The data storage ratio must be disclosed.

Table 3-1 describes the details of the storage devices configured on the system and their capacity.

Quantity	Capacity	Total (TB)
34	240 GB	8.16
384	2.4 TB	921.60
32	8.0 TB	256.00
24	1.2 TB	28.80
Total Storage (TB)		**1,214.56**

Table 3-1 Storage Device Capacities

Scale Factor = 1

Data Storage Ratio = (Total Storage (TB) / SF) = **1,214.56**

3.2 Memory Ratio

The Scale Factor to memory ratio must be disclosed.

Total Configured Memory (TiB) = 6.38

Scale Factor to Memory Ratio = (SF / Total Memory(TiB)) = **0.16**

Clause 4 – Metrics Related Items

4.1 HSGen Time

The HSGen time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSGen	71.096	68.672

Table 4-1 HSGen Times

4.2 HSSort Time

The HSSort time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSSort	178.718	176.488

Table 4-2 HSSort Times

4.3 HSValidate Time

The HSValidate time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSValidate	32.471	32.466

Table 4-3 HSValidate Times

4.4 HSDataCheck Times

Both HSDataCheck times must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSDataCheck (pre-sort)	2.000	3.000
HSDataCheck (post-sort)	3.000	3.000

Table 4-4 HSDataCheck Times

4.5 Performance & Price-Performance

The performance metric (HSph@SF) must be disclosed for Run 1 and Run 2. Price-performance metric ($/HSph@SF) must be disclosed for the performance run.

	Run 1	Run 2
HSph@1TB	12.54	12.77

Table 4-5 Performance Metrics

Run 1 Price-Performance: 80,887.56 $/ HSph@1TB

Auditor's Information & Letter of Attestation

The auditor's agency name, address, phone number, and Attestation letter must be included in the full disclosure report. A statement should be included specifying who to contact in order to obtain further information regarding the audit process.

This benchmark was audited by Doug Johnson, InfoSizing.

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Leominster, MA 10453
978-343-6562

This benchmark's Full Disclosure Report (FDR) can be downloaded from www.tpc.org.

A copy of the auditor's Letter of Attestation follows.

InfoSizing
The Right Metric For Sizing IT

TPC
Certified Auditor

Karthik Krishna
Cisco Systems Inc.
3800 Zanker Road
San Jose, CA 95134

December 9, 2019

I verified the TPC Express Benchmark™ HS v2.0.3 performance of the following configuration:

Platform:	Cisco Data Intelligence Platform (17x Cisco UCS C240 M5 Servers)
Operating System:	Red Hat Enterprise Linux Server 7.6
Apache Hadoop Compatible Software:	Cloudera Enterprise Basic v6.3.0

The results were:

Performance Metric	**12.54 HSph@1TB**
Run Elapsed Time	287.00 Seconds

Cluster	**17x Cisco UCS C240 M5 with:**		
CPUs	2x Intel Xeon Gold 6230 (2.10 GHz, 20-core, 27.5 MB L3)		
Memory	384 GiB (all nodes)		
Storage	***Qty***	***Size***	***Type***
	2	240GB	SATA M.2 (All nodes)
	24	2.4TB	10k rpm SAS HDD (16 data nodes)
	2	8TB	Intel NVMe (16 data nodes)
	24	1.2TB	10k rpm SAS HDD (name node)

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 v2.0.3
- No modifications were made to any of the Java code
- Any and all modifications to shell scripts were reviewed for compliance
- All checksums were validated for compliance
- The generated dataset was properly scaled to 1TB
- The generated dataset and the sorted dataset were replicated 3-ways

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- The elapsed times for all phases and runs were correctly measured and reported
- The Storage and Memory Ratios were correctly calculated and reported
- The system pricing was verified for major components and maintenance
- The major pages from the FDR were verified for accuracy

Additional Audit Notes:

The measured configuration included (1) 1.2TB 10k rpm SAS HDD disk on one data node that was substituted by (1) 2.4TB 10k rpm disk in the priced configuration. Based on the specifications of these disks, it is my opinion that this substitution has no significant effect on performance.

Respectfully Yours,

Doug Johnson, Certified TPC Auditor

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Supporting Files Index

Clause	Description	Archive File Pathname
Clause 1	Parameters and options used to configure the system	SupportingFiles/Clause1
Clause 2	Configuration scripts and Run Report	SupportingFiles/Clause2
Clause 3	System configuration details	SupportingFiles/Clause3

Third-Party Price Quotes

CDW