DELL EMC

Dell Inc.

TPC Express Benchmark™ HS
Full Disclosure Report

Dell PowerEdge R6515

(with 16x PowerEdge R6515 Servers; 1x PowerEdge R7515 Server)

Running

Cloudera Enterprise 7.1.4

on

SUSE Linux Enterprise Server 12 SP5

TPCx-HS Version	2.0.3
Report Edition	First
Report Submitted	March 22, 2021

First Edition - March 2021

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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
Dell	PowerEdge R6515	Cloudera Enterprise 7.1.4	SUSE Linux Enterprise Server 12 SP5

TPC Express Benchmark™ HS Metrics			
Total System Cost	HSph@100TB	Price/Performance	Availability Date
$1,344,855	43.76	$30,732.52	April 15, 2021

Executive Summary

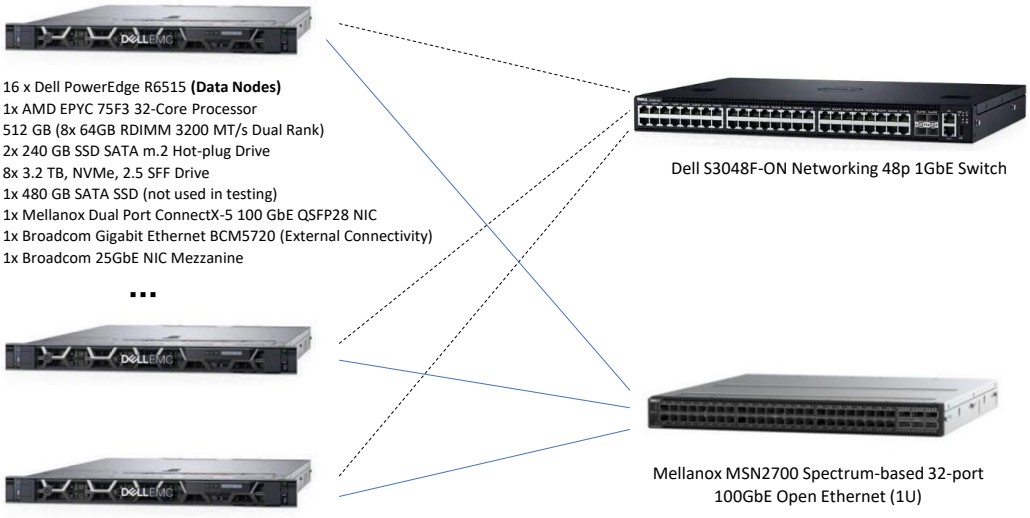
The Executive Summary follows on the next several pages.

DELL EMC	**Dell PowerEdge R6515**	TPCx-HS 2.0.3 TPC Pricing 2.6.0 Report Date Mar. 22, 2021

Availability Date	TPCx-HS Performance	Price/Performance	Total System Cost
April 15, 2021	**43.76 HSph@100TB**	**$30,732.52 $ / HSph@100TB**	**$1,344,855 USD**

System Under Test Configuration Overview

Scale Factor	Hadoop Software	Operating System	Other Software
100	Cloudera Enterprise 7.1.4	SUSE Linux Enterprise Server 12 SP5	None



Physical Storage/Scale Factor: 4.19	Scale Factor/Physical Memory: 11.76
Total Number of Servers: Total Processors/Cores/Threads:	17 (16x PowerEdge R6515; 1x PowerEdge R7515) 17/544/1,088

Server Configuration:	Per PowerEdge R6515	Per PowerEdge R7515
Processors	1x AMD EPYC 75F3 32-Core	1x AMD EPYC 75F3 32-Core
Memory	512 GiB	512 GiB
Storage Controller	BOSS-S1	BOSS-S1, HBA330 Mini
Storage Device	2x 240GB M.2 SATA SSD 8x 3.2TB NVMe	2x 240GB M.2 SATA SSD 2x 480GB SATA 6Gbps SSD
Network	1x Mellanox Dual-port 100 Gb QSFP 1x Broadcom 25 Gb NIC Mezzanine	1x Mellanox Dual-port 100 Gb QSFP

Connectivity:	1x MSN2700 32-port 100 GbE Switch; 1x S3048F-ON 48p 1 GbE Switch
Total Rack Units:	16x(1U)+1x(2U)+1x(1U) +1x(1U) = 16U +2U + 1U + 1U = 20U

DELL EMC	Dell PowerEdge R6515	TPCx-HS	2.0.3
		TPC Pricing	2.6.0
		Report Date	Mar. 22, 2021

Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
HARDWARE COMPONENTS						
PowerEdge R6515 - Data Nodes		1	$80,457.66	16	$1,287,322.56	
2.5 Chassis	379-BDTF	1		16		
PowerEdge R6515 Server	210-ASVR	1		16		
No Trusted Platform Module	461-AADZ	1		16		
2.5" Chassis with up to 10 Hard Drives, including up to 8 SAS/SATA or 9 NVME Drives	321-BERT	1		16		
AMD EPYC 75F3 3.3GHz, 32C/64T, 256M Cache (280W) DDR4-3200	338-BZRK	1		16		
Heatsink for CPU equal to or greater than 180W	412-AASC	1		16		
Performance Optimized	370-AAIP	1		16		
3200MT/s RDIMMs	370-AEVR	1		16		
Unconfigured RAID	780-BCDS	1		16		
HBA330 12Gbps SAS HBA Controller, Minicard	405-AAJU	1		16		
Performance BIOS Settings	384-BBBL	1		16		
UEFI BIOS Boot Mode with GPT Partition	800-BBDM	1		16		
No Additional Mid Fan	384-BBSO	1		16		
Dual, Hot Plug, Redundant Power Supply (1+1), 550W	450-AGUJ	1		16		
Riser Config 2, 2x16 LP PCIe slot	330-BBNN	1		16		
PowerEdge R6515 Motherboard, with 2 x 1Gb Onboard LOM (BCM5720) V2	384-BCNQ	1		16		
iDRAC9,Enterprise x5	385-BBOT	1		16		
Broadcom 57414 Dual Port 25GbE SFP28 LOM Mezz Card	540-BCKU	1		16		
LCD Bezel for x10 chassis	350-BBXK	1		16		
BOSS controller card + with 2 M.2 Sticks 240G (RAID 1),LP	403-BCHI	1		16		
No Quick Sync	350-BBKR	1		16		
iDRAC,Legacy Password	379-BCSG	1		16		
iDRAC Group Manager, Enabled	379-BCQV	1		16		
Enterprise Linux OS, Non Factory Installed, Requires Subscription Selection	605-BBFL	1		16		
SUSE Linux Enterprise Server, 1-2 SKT w Unlimited VMs, L3 Subscription, 3 Year	528-CHFF	1		16		
No Media Required	605-BBFN	1		16		
ReadyRails Sliding Rails Without Cable Management Arm	770-BCJI	1		16		
No Internal Optical Drive	429-AAIQ	1		16		
No Systems Documentation, No OpenManage DVD Kit	631-AACK	1		16		
PowerEdge R6515 Shipping	340-CMZJ	1		16		
PowerEdge R6515 x4 or x10 Shipping Material	343-BBMS	1		16		
PowerEdge R6515 CCC Marking	389-DUHM	1		16		
Basic Next Business Day 36 Months	709-BBFL	1		16		included
Prosupport Plus and 4Hr Mission Critical Initial, 36 Month(s)	865-BBNF	1		16		included
64GB RDIMM, 3200MT/s, Dual Rank	370-AEVP	1		128		
480GB SSD SATA Mix Use 6Gbps 512 2.5in Hot-plug AG Drive, 3 DWPD, 2628 TBW	400-AZUT	1		16		
Dell 3.2TB, NVMe, Mixed Use Express Flash, 2.5 SFF Drive, U.2, PM1725b with Carrier	400-BEFE	1		128		
Power Cord - C13, 3M, 125V, 15A (North America, Guam, North Marianas, Philippines, Samoa, Vietnam)	450-AALV	1		32		
Mellanox ConnectX-5 EX Dual Port 40/100GbE QSFP28 Adapter, PCIe Low Profile	540-BCIX	1		16		
SUSE Linux Enterprise Server, 1-2 SKT w Unlimited VMs, L3 Subscription, 3 Year, Digitally Fulfilled	528-CHFF	1		16		included
GCP Operations Management	929-8509	1		16		

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DELL EMC	Dell PowerEdge R6515	TPCx-HS	2.0.3
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Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
PowerEdge R7515 - Master Node		1	$47,268.70	1	$47,268.70	
2.5 Chassis	379-BDTF	1		1		
SAS/SATA/NVMe Capable Backplane	379-BDSW	1		1		
PowerEdge R7515 Server	210-ASVQ	1		1		
No Trusted Platform Module	461-AADZ	1		1		
Chassis with up to 24 x 2.5" Hard Drives Including Maximum of 12 NVME Drives	321-BERS	1		1		
AMD EPYC 75F3 3.3GHz, 32C/64T, 256M Cache (280W) DDR4-3200	338-BZRK	1		1		
Standard Heatsink	412-AASE	1		1		
Performance Optimized	370-AAIP	1		1		
3200MT/s RDIMMs	370-AEVR	1		1		
Unconfigured RAID	780-BCDS	1		1		
HBA330 12Gbps SAS HBA Controller, Minicard	405-AAJU	1		1		
Performance BIOS Settings	384-BBBL	1		1		
UEFI BIOS Boot Mode with GPT Partition	800-BBDM	1		1		
High Performance Fan	750-AAWT	1		1		
Dual, Hot-plug, Redundant Power Supply (1+1), 1100W	450-ADWM	1		1		
Riser Config 2, 2 x 16 FH + 2 x 16 LP PCIe slot	330-BBNL	1		1		
PowerEdge R7515 Motherboard, with 2 x 1Gb Onboard LOM (BCM5720) V2	384-BCNR	1		1		
iDRAC9,Enterprise x5	385-BBOT	1		1		
PowerEdge 2U Standard Bezel	350-BBWP	1		1		
BOSS controller card + with 2 M.2 Sticks 240G (RAID 1),FH	403-BCHP	1		1		
No Quick Sync	350-BBKU	1		1		
iDRAC,Legacy Password	379-BCSG	1		1		
iDRAC Group Manager, Enabled	379-BCQV	1		1		
Enterprise Linux OS, Non Factory Installed, Requires Subscription Selection	605-BBFL	1		1		
SUSE Linux Enterprise Server, 1-2 SKT w Unlimited VMs, L3 Subscription, 3 Year	528-CHFF	1		1		
No Media Required	605-BBFN	1		1		
ReadyRails Sliding Rails	770-BBBQ	1		1		
No Internal Optical Drive	429-AAIQ	1		1		
No Systems Documentation, No OpenManage DVD Kit	631-AACK	1		1		
PowerEdge R7515 Shipping	340-CMZG	1		1		
PowerEdge R7515 Ship Material	340-CODN	1		1		
PowerEdge R7515 CCC Marking, No CE Marking	343-BBPQ	1		1		
GCP Operations Management	929-8509	1		1		
Basic Next Business Day 36 Months	709-BBFM	1		1		included
Prosupport Plus and 4Hr Mission Critical Initial, 36 Month(s)	865-BBNF	1		1		included
On-Site Installation Declined	900-9997	1		1		
64GB RDIMM, 3200MT/s, Dual Rank	370-AEVP	1		8		
480GB SSD SATA Read Intensive 6Gbps 512 2.5in Hot-plug AG Drive, 1 DWPD, 876 TBW	400-AXTV	1		2		
Jumper Cord - C13/C14, 4M, 250V, 12A (North America, Guam, North Marianas, Philippines, Samoa)	492-BBDV	1		2		
Mellanox ConnectX-5 EX Dual Port 40/100GbE QSFP28 Adapter, PCIe Low Profile	540-BCIX	1		1		
SUSE Linux Enterprise Server, 1-2 SKT w Unlimited VMs, L3 Subscription, 3 Year, Digitally Fulfilled	528-CHFF	1		1		included

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Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
Mellanox® Passive Copper cable, ETH 100GbE, 100Gb/s, QSFP28, 2m, Black, 30AWG, CA-N	AA319963	1	$96.67	2	$193.34	
APC NetShelter SX Deep Enclosure - Rack - cabinet - black - 24U - 19-inch	A7522217	1	$1,129.99	1	$1,129.99	
APC Basic Rack PDU AP9567 - 0U - 120V NEMA 5-15 Input / (14) NEMA 5-15 Output	A7541364	1	$189.99	1	$189.99	
ASUS VE248Q 24 Inch LED monitor - Widescreen Full HD Monitor	A6732050	1	$136.99	3	$410.97	
Logitech MK200 Media Keyboard and Mouse Combo	A6859396	1	$24.99	3	$74.97	
C2G 6ft Cat6 Snagless Unshielded (UTP) Ethernet Network Patch Cable - Black - patch cable - 6 ft - black	A7052140	1	$5.99	17	$101.83	
Dell C13 to C14, PDU Style, 250 V Power Cord, North America - 6.5 feet	450-ACHI	1	$11.93	34	$405.62	
32-port Mellanox Spectrum SN2700 - Switch - L3 - managed - 32 x 100 Gigabit QSFP28	A8628811	1	$20,008.99	1	$20,008.99	
Mellanox M-1 Global Support Gold Plus. 2hr committed TAC response (24x7). 3 years	A9878902	1	$3,234.06	1		$3,234.06
PowerSwitch S3048-ON		1	$15,066.51	1	$15,066.51	
Dell Networking S3048-ON, 48x 1GbE, 4x SFP+ 10GbE ports, Stacking, IO to PSU air, 1x AC PSU, DNOS 9	210-AEDM	1		1		
ProSupport Plus: Mission Critical 4-Hour 7x24 On-Site Service with Emergency Dispatch, Initial Year	802-7419	1		1		
ProSupport Plus: 7x24 HW/SW Tech Support and Assistance, 3 Year	802-7434	1		1		included
ProSupport Plus: Mission Critical 4-Hour 7x24 On-Site Service with Emergency Dispatch, 2 Year Extended	802-7435	1		1		included
HARDWARE COMPONENTS Subtotal					$1,375,407.53	
SOFTWARE COMPONENTS						
Cloudera CDP - 3 year 24x7 support		1	$40,800.00	17	$693,600.00	
SOFTWARE COMPONENTS Subtotal					$693,600.00	
TOTAL						**$2,069,007.53**
Large Purchase Discount (35%)*						-724,152.64

Pricing: 1 = Dell;

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

Audited by Doug Johnson, InfoSizing

Three-Year Cost of Ownership:	**$1,344,855**
HSph@100TB:	**43.76**
$ / HSph@100TB:	**$30,732.52**

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.

DELL EMC	Dell PowerEdge R6515	TPCx-HS	2.0.3
		TPC Pricing	2.6.0
		Report Date	Mar. 22, 2021

Numerical Quantities

Performance Run – Run 1	
Scale Factor	100TB
Run Start Time	2021-03-06 10:51:08.000
Run End Time	2021-03-06 13:08:10.000
Run Elapsed Time	8,225.000
HSGen Start Time	2021-03-06 10:51:09.000
HSGen End Time	2021-03-06 11:17:52.000
HSGen Elapsed Time	1,604.683
HSSort Start Time	2021-03-06 11:17:57.000
HSSort End Time	2021-03-06 12:54:55.000
HSSort Elapsed Time	5,819.095
HSValidate Start Time	2021-03-06 12:55:00.000
HSValidate End Time	2021-03-06 13:08:10.000
HSValidate Elapsed Time	791.539

Repeatability Run – Run 2	
Scale Factor	100TB
Run Start Time	2021-03-06 13:34:57.000
Run End Time	2021-03-06 15:50:38.000
Run Elapsed Time	8,144.000
HSGen Start Time	2021-03-06 13:34:58.000
HSGen End Time	2021-03-06 14:01:45.000
HSGen Elapsed Time	1,607.958
HSSort Start Time	2021-03-06 14:01:49.000
HSSort End Time	2021-03-06 15:37:32.000
HSSort Elapsed Time	5,743.504
HSValidate Start Time	2021-03-06 15:37:37.000
HSValidate End Time	2021-03-06 15:50:38.000
HSValidate Elapsed Time	782.760

Run Reports

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

Test Run 1 Details	Total Time =	8225
	Total Size =	1000000000000
	Scale-Factor =	100

TPCx-HS Performance Metric (HSph@SF): 43.7694

==========

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

Test Run 2 Details	Total Time =	8144
	Total Size =	1000000000000
	Scale-Factor =	100

TPCx-HS Performance Metric (HSph@SF): 44.2047

==========

DELL EMC	Dell PowerEdge R6515	TPCx-HS 2.0.3 TPC Pricing 2.6.0 Report Date Mar. 22, 2021

Revision History

Date	Edition	Description
March 22, 2021	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 assess 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 Dell 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

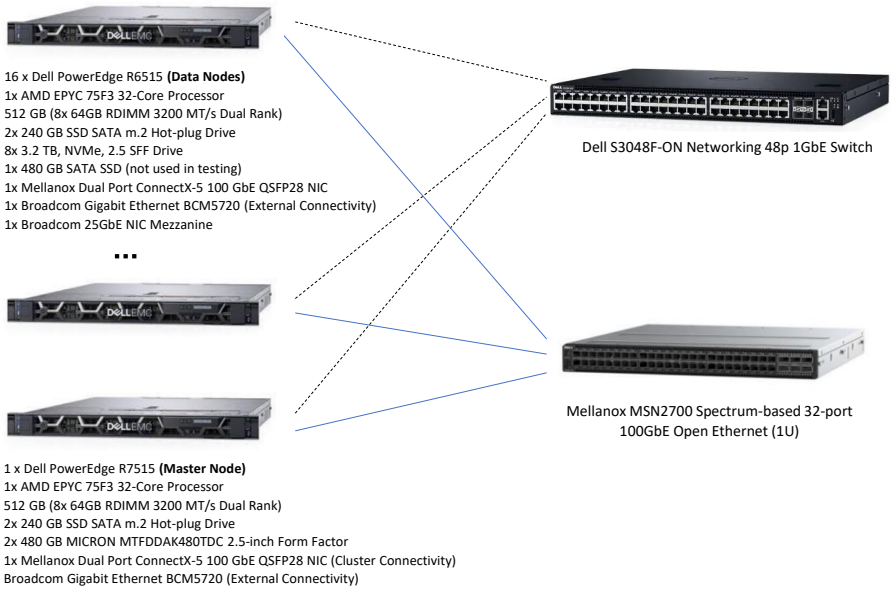

Figure 1-1 Measured Configuration

The measured configuration consisted of:

- Total Nodes: 17 (16x PowerEdge R6515; 1x PowerEdge R7515)
- Total Processors/Cores/Threads: 17/544/1,088
- Total Memory: 8.50TiB
- Total Number of Storage Drives/Devices: 164
- Total Storage Capacity: 418.72TB

Server node details:

16x PowerEdge R6515 Servers, each with:

- Processors/Cores/Threads: 1/32/64
- Processor Model: AMD EPYC 75F3 32-Core
- Memory: 512 GiB
- Controller: BOSS-S1
- Drives:
  - 2x 240GB M.2 SATA SSD
  - 8x 3.2TB NVMe
- Network:
  - 1x Mellanox Dual-port 100 Gb QSFP
  - 1x Broadcom 25 Gb NIC Mezzanine

1x PowerEdge R7515 Servers, each with:

- Processors/Cores/Threads: 1/32/64
- Processor Model: AMD EPYC 75F3 32-Core
- Memory: 512 GiB
- Controller: BOSS-S1, HBA330 Mini
- Drives:
  - 2x 240GB M.2 SATA SSD
  - 2x 480GB SATA 6 Gbps SSD
- Network: Mellanox Dual-port 100 Gb QSFP

Network connectivity detail:

- 1x MSN2700 32-port 100 GbE Switch; 1x S3048F-ON 48p 1GbE Switch

The distribution of software components over server nodes is detailed in section 1.5.

1.3.2 Priced Configuration

There are no differences between the priced configuration and the measured configuration.

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	Boss Controller card	sda	Operating System, Root, swap, Hadoop Master
2-3	Boss Controller card	sda	Operating System, Root, swap, Hadoop Master
2-3	NVMe	nvme0n1, nvme1n1, nvme2n1, nvme3n1, nvme4n1	Data, Temp
4-17	Boss Controller card	sda	Operating System, Root, swap, Hadoop Master
4-17	NVMe	nvme0n1, nvme1n1, nvme2n1, nvme3n1, nvme4n1	Data, Temp

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
Node	Resource Manager	Node Manager	NameNode	DataNode	QuorumPeer
1	X		X		X
2-3					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 7.1.4 (fully HDFS compatible at the API level).

Map/Reduce implementation and corresponding version must be disclosed.

Cloudera Enterprise 7.1.4 (compatible equivalent to Hadoop 3.1.1.7).

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 =                8225
                        Total Size =       1000000000000
                        Scale-Factor =              100

TPCx-HS Performance Metric (HSph@SF):           43.7694

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


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

Test Run 2 Details      Total Time =                8144
                        Total Size =       1000000000000
                        Scale-Factor =              100

TPCx-HS Performance Metric (HSph@SF):           44.2047

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

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	bcf0b946a49d1249c9da174b5d9805f1
TPCx-HS-master_MR2.jar	492cbc51a1a60c28b43d96c79d08683d
TPCx-HS-master.sh	c619a0819571ecd00cd75d2b76ba8c64

2.4 Benchmark Kit Changes

The required data protection was provided by HDFS Erasure Coding rather than the default three-way data replication. A policy of RS-6-3-1024k was used. Therefore, each block group consisted of 6 data blocks and 3 parity blocks. Each block within a given block group was placed on a different node thus ensuring the required data protection.

To collect the necessary data for auditing, the HSDataCheck.sh script was modified. In accordance with the TPCx-HS Standard Specification, this change received prior approval from the TPCx-HS subcommittee.

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
2	480 GB	0.96
128	3.2 TB	409.60
Total Storage (TB)		**418.72**

Table 3-1 Storage Device Capacities

Scale Factor = 100

Data Storage Ratio = (Total Storage (TB) / SF) = **4.19**

3.2 Memory Ratio

The Scale Factor to memory ratio must be disclosed.

Total Configured Memory (TiB) = 8.50

Scale Factor to Memory Ratio = (SF / Total Memory(TiB)) = **11.76**

Clause 4 – Metrics Related Items

4.1 HSGen Time

The HSGen time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSGen	1,604.683	1,607.958

Table 4-1 HSGen Times

4.2 HSSort Time

The HSSort time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSSort	5,819.095	5,743.504

Table 4-2 HSSort Times

4.3 HSValidate Time

The HSValidate time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSValidate	791.539	782.760

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)	5.000	4.000
HSDataCheck (post-sort)	5.000	5.000

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@100TB	43.76	44.20

Table 4-5 Performance Metrics

Run 1 Price-Performance: 30,732.52 $/ HSph@100TB

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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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

Mohan Rokkam
Senior Principal Engineer, PowerEdge Technical Marketing
Dell Inc.
1 Dell Way
Round Rock, TX 78682

March 21, 2021

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

Platform:	Dell PowerEdge 6515 (16x PowerEdge 6515, 1x PowerEdge 7515) 16x Dell PowerEdge 6515 Servers (Data Nodes) 1x Dell PowerEdge 7515 Server (Master Node)
Operating System:	SUSE Linus Enterprise Server 12 SP5
Apache Hadoop Compatible Software:	Cloudera Enterprise 7.1.4

The results were:

Performance Metric	**43.76 HSph@100TB**
Run Elapsed Time	8,225.00 Seconds

Cluster	**16x PowerEdge 6515, 1x PowerEdge 7515 with:**		
CPUs	1x AMD® EPYC 75F3 32-Core Processor (all nodes)		
Memory	512 GiB (all nodes)		
Storage	***Qty***	***Size***	***Type***
	2	240 GB	M.2 SATA SSD (all nodes)
	8	3.2 TB	NVMe (data nodes)
	2	480 GB	SATA 6Gbps SSD (Master 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 100 TB

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- The generated dataset and the sorted dataset were erasure coded with a policy of RS-6-3-1024k
- 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:

None.

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

All components are available directly through the Test Sponsor (Dell Inc.).