Hewlett Packard Enterprise

Hewlett Packard Enterprise Company

TPC Express Benchmark™ HS
Full Disclosure Report

HPE DL325 Gen10

(with 1x ProLiant DL325 Gen10 Servers; 16x ProLiant DL325 Gen10 Servers)

Running

Hortonworks Data Platform, HDP 3.1

on

Red Hat Enterprise Linux Server 7.6

TPCx-HS Version	2.0.3
Report Edition	First
Report Submitted	August 7, 2019

First Edition - August 2019

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The pricing information in this document is believed to accurately reflect the current prices as of the publication date. However, the Sponsor provides no warranty of the pricing information in this document.

Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary because of these and other factors. Therefore, the TPC Express Benchmark™ V should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

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.

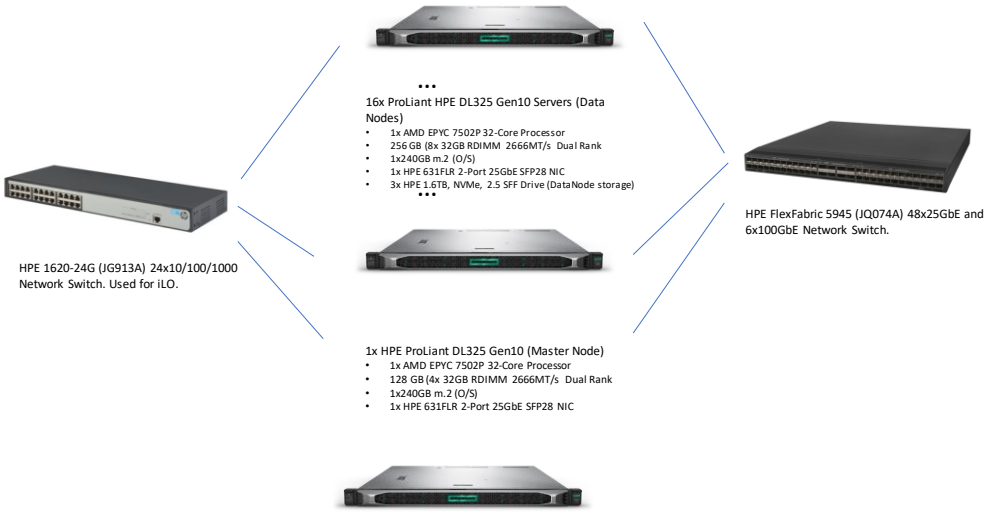
Measured Configuration			
Company Name	Cluster Node	Hadoop Software	Operating System
HPE	ProLiant DL325 Gen10	Hortonworks Data Platform, HDP 3.1	Red Hat Enterprise Linux Server 7.6

TPC Express Benchmark™ HS Metrics			
Total System Cost	HSph@10TB	Price/Performance	Availability Date
$592,870	23.66	$25,057.91	August 26, 2019

Executive Summary

The Executive Summary follows on the next several pages.

Hewlett Packard Enterprise	HPE DL325 Gen10		TPCx-HS 2.0.3 TPC Pricing 2.4.0 Report Date Aug. 07, 2019
Availability Date	TPCx-HS Performance	Price/Performance	Total System Cost
August 26, 2019	**23.66 HSph@10TB**	**$25,057.91 $ / HSph@10TB**	**$592,870 USD**
System Under Test Configuration Overview			
Scale Factor	Hadoop Software	Operating System	Other Software
10	Hortonworks Data Platform, HDP 3.1	Red Hat Enterprise Linux Server 7.6	N/A



Physical Storage/Scale Factor: 8.09	Scale Factor/Physical Memory: 2.42
Total Number of Servers: Total Processors/Cores/Threads:	17x ProLiant DL325 Gen10 17/544/1,088
Server Configuration: Processors Memory Storage Controller Storage Device Network	Per ProLiant DL325 Gen10 1x AMD EPYC 7502P 32-Core Processor 256 GiB (128 GiB Mgmt. node) Dual m.2 SATA, NVM Express 1x 240 GB m.2 SATA 3x HPE 1.6 TB NVMe (data nodes) 1x HPE 631FLR 2-Port 25GbE SFP28 NIC
Connectivity: Total Rack Units:	HPE FlexFabric 5945 Switch HPE 1620-24G 24x10/100/1000 Network Switch (used for iLO) 17 (1U) + 1 (1U) + 1 (1U) = 19U

Hewlett Packard Enterprise

HPE DL325 Gen10

TPCx-HS	2.0.3
TPC Pricing	2.4.0
Report Date	Aug. 07, 2019

Description	Source	Part Number	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
Server Hardware						
HPE DL325 Gen10 8SFF CTO Server	1	P04654-B21	$1,350	17	$22,950	
HPE DL325 Gen10 8SFF CTO Server, EPYC 1x7502P	1	P16639-L21	$3,459	17	$58,803	
HPE 32GB 2Rx4 PC4-2933-R	1	P00924-B21	$1,170	132	$154,440	
HPE 800W CS Platinum Plus AC Power Supply	1	865414-B21	$379	17	$6,443	
HPE DL325 Gen10 8SFF (NVMe backplane) CTO Server	1	P04662-B21	$1,699	17	$28,883	
HPE Dual M.2 SSD enablement option DL/ML	1	878783-B21	$159	17	$2,703	
HPE 240GB m.2 SATA SSD	1	P04556-B21	$379	17	$6,443	
HPE 1.6 TB NVMe, MO001600KWVNB	1	P10222-B21	$3,120	48	$149,760	
HPE Ethernet 10/25G Network Adapter 631FLR-SFP28	1	817709-B21	$749	17	$12,733	
HPE 3Y FC 24x7 DL325 Gen10 SVC	1	HB4G8E	$1,355	17		$23,035
HPE iLO Adv incl 3yr TS U E-LTU	1	E6U64ABE	$469	17		$7,973
HP V194 18.5" HD 1366x768 LED Monitor (1 + 2 spare)	3	V5E94A6#ABA	$95	3	$285	
HP PS/2 Keyboard And Mouse Bundle (1 + 2 spare)	3	H3C53AA#ABA	$30	3	$90	
			Subtotal		**$443,533**	**$31,008**
Network						
HPE 1620-24G Switch + 2 spares	1	JG913A	$299	3	$897	
5ft (1.5m) Cat6 Snagless Unshielded (UTP) PVC CM 17 + 2 spares	2	C6-UTPSGPVCBE	$2	19	$38	
HPE 5945 48SFP28 8QSFP28 Switch	1	JQ074A	$30,970	1	$30,970	
HPE 25Gb SFP28 to SFP28 3m DAC 34 + 10% spares	1	844477-B21	$222	39	$8,658	
HPE 3Y FC 24x7 FF 5945 Switch SVC	1	HB4S3E	$8,003	1		$8,003
			Subtotal		**$40,563**	**$8,003**
Rack						
HPE 42U 600x1075mm Adv G2 Kit Pllt Rack	1	P9K07A	$1,179	1	$1,179	
HPE 24A High Voltage Core Only Corded PDU + 2 spares	1	252663-D74	$259	3	$777	
			Subtotal		**$1,956**	**$0**

(Continued on next page)

Hewlett Packard Enterprise

HPE DL325 Gen10

TPCx-HS	2.0.3
TPC Pricing	2.4.0
Report Date	Aug. 07, 2019

(Continued from previous page)

Description	Source	Part Number	Unit Price	Qty	Extended Price	3 Yr. Maint. Price
Server Software						
Hortonworks 1yr 24x7	1	G7M27A	$2,000	51	$102,000	
RHEL Svr 2 Sckt/2 Gst 3yr 24x7 E-LTU	1	G3J30AAE	$3,702	17	$62,934	
			Subtotal		**$164,934**	**$0**
		Total Extended Price			**$650,986**	**$39,011**
		Total Discounts			**$97,127**	**$0**
		Grand Total			**$553,859**	**$39,011**

Pricing: 1 = HPE; 2 = fs.com; 3 = hp.factoryoutletstore.com

* All discounts are based on US list prices and for similar quantities and configurations. A 20% discount was based on the overall specific components pricing from vendor 1 in this single quotation. Discounts for similarly sized configurations will be similar to those quoted here, but may vary based on the components in the configuration.

Sales contact: HPE WW Headquarters, 3000 Hanover St., Palo Alto, CA 94304-1185 (650) 857-1501 or HPE: 855-472-5233

Audited by Doug Johnson, InfoSizing

Three-Year Cost of Ownership: $592,870

HSph@10TB: 23.66

$ / HSph@10TB: $25,057.91

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.

Hewlett Packard Enterprise	HPE DL325 Gen10	TPCx-HS 2.0.3 TPC Pricing 2.4.0 Report Date Aug. 07, 2019

Numerical Quantities

Performance Run – Run 2	
Scale Factor	10TB
Run Start Time	2019-06-29 21:42:48.000
Run End Time	2019-06-29 22:08:05.000
Run Elapsed Time	1,521.000
HSGen Start Time	2019-06-29 21:42:49.000
HSGen End Time	2019-06-29 21:47:39.000
HSGen Elapsed Time	291.849
HSSort Start Time	2019-06-29 21:47:45.000
HSSort End Time	2019-06-29 22:04:28.000
HSSort Elapsed Time	1,003.856
HSValidate Start Time	2019-06-29 22:04:35.000
HSValidate End Time	2019-06-29 22:08:05.000
HSValidate Elapsed Time	212.256

Repeatability Run – Run 1	
Scale Factor	10TB
Run Start Time	2019-06-29 21:07:58.000
Run End Time	2019-06-29 21:32:41.000
Run Elapsed Time	1,487.000
HSGen Start Time	2019-06-29 21:07:59.000
HSGen End Time	2019-06-29 21:12:51.000
HSGen Elapsed Time	293.497
HSSort Start Time	2019-06-29 21:12:57.000
HSSort End Time	2019-06-29 21:29:07.000
HSSort Elapsed Time	971.217
HSValidate Start Time	2019-06-29 21:29:13.000
HSValidate End Time	2019-06-29 21:32:41.000
HSValidate Elapsed Time	209.960

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Run Reports

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

Test Run 2 Details	Total Time =	1521
	Total Size =	100000000000
	Scale-Factor =	10

TPCx-HS Performance Metric (HSph@SF): 23.6686

==========

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

Test Run 1 Details	Total Time =	1487
	Total Size =	100000000000
	Scale-Factor =	10

TPCx-HS Performance Metric (HSph@SF): 24.2130

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Hewlett Packard Enterprise	HPE DL325 Gen10	TPCx-HS 2.0.3 TPC Pricing 2.4.0 Report Date Aug. 07, 2019

Revision History

Date	Edition	Description
August 7, 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 Hewlett Packard Enterprise Company.

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

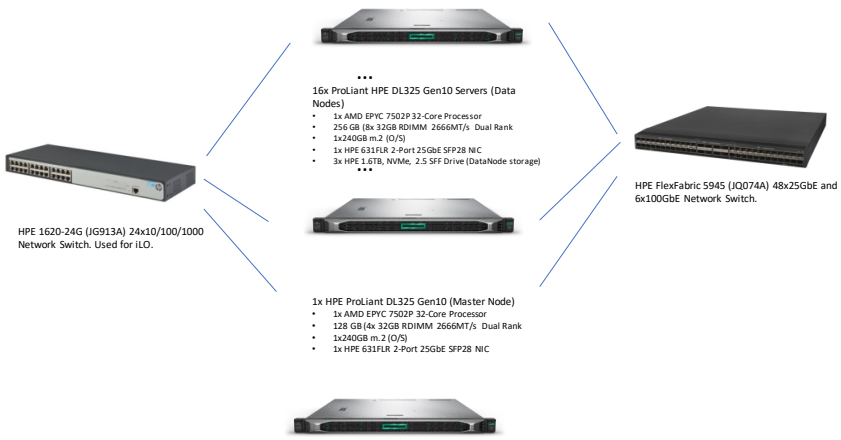

Figure 1-1 Measured Configuration

The measured configuration consisted of:

- Total Nodes: 17 (1x ProLiant DL325 Gen10; 16x ProLiant DL325 Gen10)
- Total Processors/Cores/Threads: 17/544/1,088
- Total Memory: 4.13TiB
- Total Number of Storage Drives/Devices: 65
- Total Storage Capacity: 80.88TB

Server node details:

- 17x ProLiant DL325 Gen10 Servers, each with:
  - Processors/Cores/Threads: 1/32/64
  - Processor Model: AMD EPYC 7502P 32-Core Processor
  - Memory: 256 GiB (128 GiB Mgmt. node)
  - Controller: Dual m.2 SATA NVM Express
  - Drives:
    - 1x 240 GB m.2 SATA
    - 3x HPE 1.6 TB NVMe (data nodes)
  - Network: 1x HPE 631FLR 2-Port 25GbE SFP28 NIC

Network connectivity detail:

- HPE FlexFabric 5945 Switch
- HPE 1620-24G 24x10/100/1000 Network Switch (used for iLO)

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	m.2	sda	Operating System, Root, Swap, Hadoop Master
2-3	m.2	sda	Operating System, Root, Swap, Hadoop Master
2-3	NVMe	nvme0n1, nvme1n1, nvme2n1	Data, Temp
4-17	m.2	sda	Operating System, Root, Swap, Hadoop Master
4-17	NVMe	nvme0n1, nvme1n1, nvme2n1	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		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.

Hortonworks Data Platform, HDP 3.1 (fully HDFS compatible at the API level).

Map/Reduce implementation and corresponding version must be disclosed.

Hortonworks Data Platform, HDP 3.1 (compatible equivalent to Hadoop 3.1.1).

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

Test Run 1 Details      Total Time =                1487
                        Total Size =        100000000000
                        Scale-Factor =                10

TPCx-HS Performance Metric (HSph@SF):            24.2130

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


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

Test Run 2 Details      Total Time =                1521
                        Total Size =        100000000000
                        Scale-Factor =                10

TPCx-HS Performance Metric (HSph@SF):            23.6686

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

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

HSDataCheck.sh was modified to collect HDFS Erasure Coding data.

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)
17	240 GB	4.08
48	1.6 TB	76.80
Total Storage (TB)		**80.88**

Table 3-1 Storage Device Capacities

Scale Factor = 10

Data Storage Ratio = (Total Storage (TB) / SF) = **8.09**

3.2 Memory Ratio

The Scale Factor to memory ratio must be disclosed.

Total Configured Memory (TiB) = 4.13

Scale Factor to Memory Ratio = (SF / Total Memory(TiB)) = **2.42**

Clause 4 – Metrics Related Items

4.1 HSGen Time

The HSGen time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSGen	293.497	291.849

Table 4-1 HSGen Times

4.2 HSSort Time

The HSSort time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSSort	971.217	1,003.856

Table 4-2 HSSort Times

4.3 HSValidate Time

The HSValidate time must be disclosed for Run1 and Run2.

	Run 1	Run 2
HSValidate	209.960	212.256

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)	6.000	6.000
HSDataCheck (post-sort)	6.000	7.000

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@10TB	24.21	23.66

Table 4-5 Performance Metrics

Run 2 Price-Performance: 25,057.91 $/ HSph@10TB

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.

www.sizing.com
63 Lourdes Drive
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

Mr. Craig A. Estepp
Hewlett Packard Enterprise
11445 Compaq Center Dr West
Houston, TX 77070

July 30, 2019

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

Platform:	HPE DL 325 Gen10 (with 17x HPE DL 325 Gen10 Servers)
Operating System:	Red Hat Enterprise Linux Server 7.6
Apache Hadoop Compatible Software:	Hortonworks Data Platform, HDP 3.1

The results were:

Performance Metric	**23.66 HSph@10TB**
Run Elapsed Time	1,521.00 Seconds

Cluster	**17x HPE DL 325 Gen10 Servers, each node with:**		
CPUs	1 x AMD EPYC 7502P (2.50 GHz, 32-core, 16 MB L3)		
Memory	256 GiB (16 data nodes), 128 GiB (1 Mgmt. node)		
Storage	***Qty***	***Size***	***Type***
	1	240GB	SSD SATA (All nodes)
	3	1.6TB	NVMe (16 data nodes)

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 10TB
- The generated dataset and the sorted dataset were erasure coded with a policy of RS-6-3-1024k

63 Lourdes Dr. | Leominster, MA 01453 | 978-343-6562 | www.sizing.com

- 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 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.

In order 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.

Respectfully Yours,

Doug Johnson, Certified TPC Auditor

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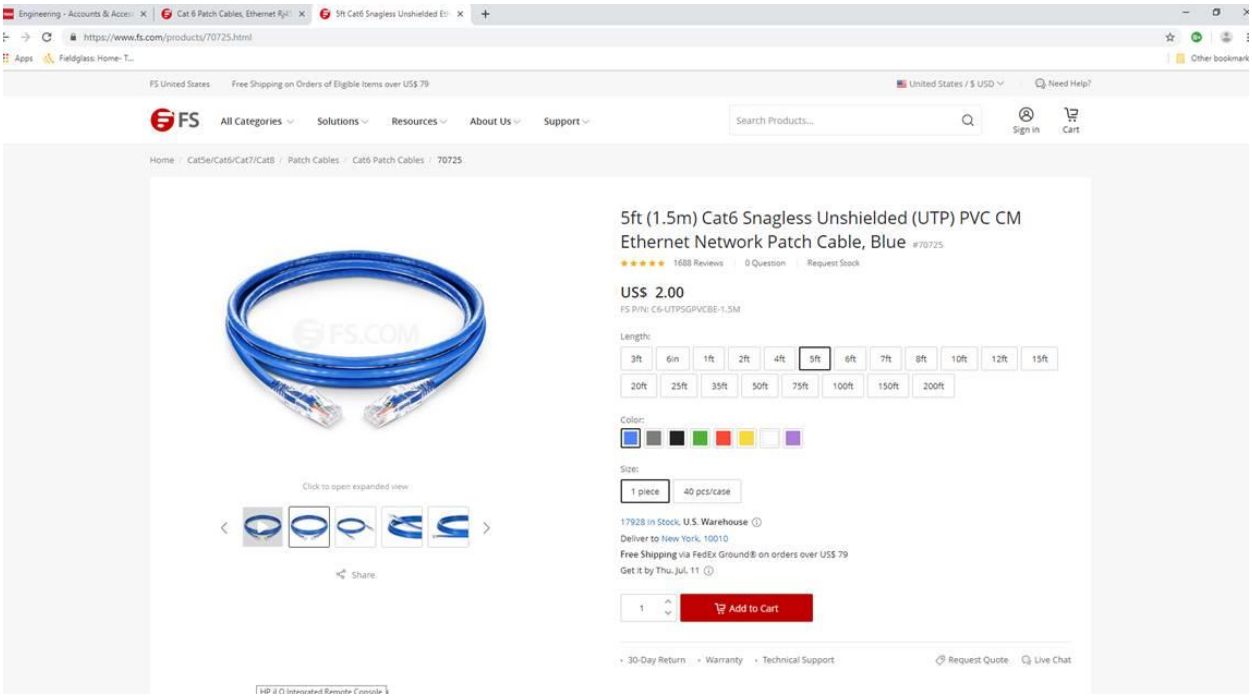
Supporting Files Index

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

fs.com



hp.factorystoreoutlet.com