Huawei Technologies Co., Ltd.

TPC Express Benchmark™ HS (TPCx-HS)

Full Disclosure Report

for

Huawei FusionInsight for Big Data

(with 16 Huawei Tecal RH2288 V2 Servers)

using

Huawei FusionInsight 2.5

and

Red Hat Enterprise Linux Server 6.5

First Edition

September 14, 2015

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Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, the TPC Express Benchmark™ HS 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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	Huawei FusionInsight for Big Data	TPCx-HS Rev. 1.3.0 TPC-Pricing Rev. 1.7.0
		Report Date: September 14, 2015

Total System Cost	TPCx-HS Performance Metric	Price/Performance
493,886 USD	**10.29** HSph@3TB	**47,997 USD** $/HSph@3TB

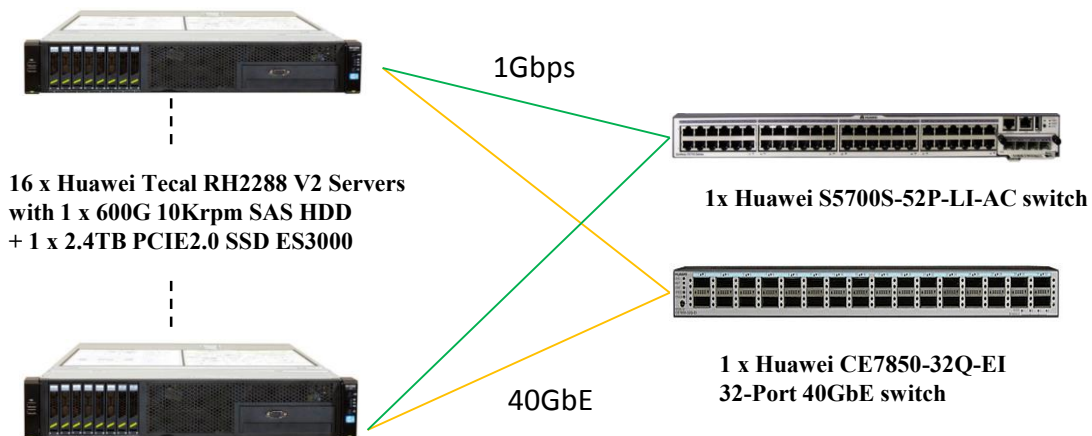| Scale Factor	Apache Hadoop Compatible Software	Operating System	Other Software	Availability Date
3TB	Huawei FusionInsight 2.5	Red Hat Enterprise Linux Server 6.5	None	September 14, 2015

System Configuration

1Gbps

16 x Huawei Tecal RH2288 V2 Servers with 1 x 600G 10Krpm SAS HDD + 1 x 2.4TB PCIE2.0 SSD ES3000

1x Huawei S5700S-52P-LI-AC switch

1 x Huawei CE7850-32Q-EI 32-Port 40GbE switch

40GbE

Physical Storage/Scale Factor: 16.00	Scale Factor/Physical Memory: 0.75

Servers:	16 x Huawei Tecal RH2288 V2 Server
Total Processors/Cores/Threads	32/256/512
Server Configuration:	
Processors	2 x Intel® Xeon® Processor E5-2680 v2, 2.70 GHz, 20MB L3
Memory	256GB
Storage Controller	1 x Symbios Logic MegaRAID SAS 2208
Storage Device	1 x 600GB 10K SAS HDD (internal)
	1 x 2.4TB Huawei ES3000 PCIe SSD Card
Network	1 x Mellanox MCX314A-BCBT ConnectX-3 Dual-port 40/56GbE QSFP
Connectivity:	1 x Huawei CE7850-32Q-EI 40 GbE switch
	1 x Huawei S5700S-52P-LI-AC 1Gbps switch (for cluster management)

	TPCx-HS Rev. 1.3.0
Huawei FusionInsight for Big Data	TPC-Pricing Rev. 1.7.0
	Report Date: September 14, 2015

Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Year Maint.
Hardware Components						
RH2288 V2 (Chassis for 8HDD)	02310JUP	1	1,210	16	$19,360	
BIOS license	05200143	1	0	16	$0	
2U RISER CARD MODULE	02310JUC	1	79	16	$1,264	
Internal Mini SAS SM36	04050434	1	0	32	$0	
SR320BC SAS/SATA RAID Card,RAID0,1,10,5,50,6,60,512MB Cache(LSI2208),Support Battery and SuperCap	02310QNL	1	449	16	$7,184	
X86 series,FCLGA2011,2700MHz,0.9V,64bit, 130000mW,SandyBridge EP Xeon E5-2680,8Core,ECP Dedicated	41020283	1	3,199	32	$102,368	
Heat sink-DKBA0.485.0386.ASM-CPU Heat sink-105X70X60mm-Cu	21161133	1	0	32	$0	
Memory Module, DDR3 RDIMM, 16GB, 240pin, 1.1ns, 1866000KHz, 1.5V, ECC, 2Rank(1G*4bit), Height 30mm	06200172	1	389	240	$93,360	
Memory Module, DDR3 RDIMM, 16GB, 240pin, 1.25ns, 1600000KHz, 1.5V,ECC, 2Rank(1G*4bit), Height 30mm	06200121	1	389	16	$6,224	
Hard Disk-600GB-SAS 6.0Gb/s-10000rpm, 2.5"-16MB or above, Hot-swap-Built-in-Front Panel	02310KPU	1	499	16	$7,984	
Tecal RH2285,750W golden power supply module	98080310	1	279	32	$8,928	
Power Cords Cable,China AC Power 250V10A,3.0m,PISM,227IEC53-1.0^2(3C),C13SF,Black	04041104	1	0	32	$0	
UC-10KM Conversion Connector,ATEN,PS/2 to USB, No Document, Black	06040070	1	0	16	$0	$13,693
RH2285&RH2288 V2 Server QuickStart Guide-(V100R002_04)	31505276	1	0	16	$0	
CD-ROM Driver,CD 24X/DVD 8X,12.7*128*126.1mm,In,SATA,5V power,include panel	06020085	1	59	1	$59	
USM,US1WIN11,Universal Service Manager V2,USM,ServiceCD	05116363	1	0	16	$0	
Rechargeable battery,Li-ion battery, 1.5V, 1500mAh, Battery Group, with 27inch cable For LSISAS2208 CARD	24020944	1	299	16	$4,784	
Plastic-DKBA4.409.1970-Battery and Cap Holder - RH2285 - PC+ABS	21201623	1	0	16	$0	
IT Equipment Cable,Raid Board to Battery Cable,0.7m,H20(1.25),20*UL1571 28AWG,H20(1.25)	04050438	1	0	16	$0	
2U Static Rail Kit	21240434	1	28	16	$448	
40GBase-eSR4 Optical Transceiver,QSFP+, 40G, Multi-mode (850nm, 0.3km , MPO) (Connect to four SFP+ Optical Transceiver)	02310RMB	1	3,200	32	$102,400	
Optical Cable Assembly, MPO/PC, MPO/PC, Multimode(OM3), GJFH 8A1a(LSZH), 15m, 3.5mm, 8 Cores, 0mm/0mm	14130923	1	55	16	$880	
Server Management Agent	88032SCU	1	99	1	$99	
Network Card, 40 Gigabit, 64bit, QSFP, 2 ports, PCIE 3.0 X8 - 15b3-1007-1, No Driver CD	06310093	1	696	16	$11,136	
The 4th Generation PCIE SSD Card (2.4TB)	03030PWG	1	24,000	16	$384,000	$7,469
GDC,SC1B01IDCU,RH2285 Service Data Center Cabinet,IDCU(2*220V)	02114327	1	1,300	2	$2,600	
S5700S-52P-LI-AC, S5700S-52P-LI-AC, S5700S-52P-LI-AC(48 Ethernet 10/100/1000 ports, 4 Gig SFP, AC 110/220V)	02353835	1	2,451	1	$2,451	$883
Basic Configuration,CloudEngine 7800, CE7850-EI-B00, CE7850-32Q-EI Switch (2*600W AC Power Module, 2*FAN Box)	02359250	1	30,528	1	$30,528	$10,990
Hardware subtotal					**$786,057**	**$33,036**

	TPCx-HS Rev. 1.3.0
Huawei FusionInsight for Big Data	TPC-Pricing Rev. 1.7.0
	Report Date: September 14, 2015

Description	Part Number	Source	Unit Price	Qty	Extended Price	3 Year Maint.
Software Components						
RedHat Enterprise Linux, English Version, Server Version(2CPU), 6.x, up to 1 guest, 32/64bit, No Document, 3 year 7*24 service	05200360	1	3,112	16	$49,792	included in RH2288
FusionInsight HD standard edition-1 year Subscription Service-new-per server	88032VYT	1	3,960	16	$63,360	included
FusionInsight HD standard edition-1 year Subscription Service-renewal-per server	88033CWX	1	3,960	32	$126,720	included
Software subtotal					**$239,872**	
Total					**$1,025,929**	**$33,034**
Lenovo Thinkvision L2251X black 22" 5ms LCD Monitor	N82E16824146178	2	100	3	300	
Lenovo IGF 0A34032 Ultraslim wireless kb & mouse	0ZK-003P-00001	2	54	3	162	
Large Purchase Discount		1			-$551,146	-$14,395

Pricing:1 = Huawei, 2 = newegg.com		
Discounts: 54% for products and 44% for service. All discounts are based on US list prices and for similar quantities and configurations. The discounts are based on the overall specific	**Three-Year Cost of Ownership**	**$493,886**
	HSph@3TB	**10.29**
Audited by Francois Raab of InfoSizing, inc.	**$/HSph@3TB**	**$47,997**

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. 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 components. For complete details, see the pricing sections of the TPC benchmark specifications. If you find that the stated prices are not available according to these terms, please inform at pricing@tpc.org. Thank you.

Measurement Results for Performance Run

Scale Factor	3TB
Run Start Time	2015-09-08 16:13:35
Run End Time	2015-09-08 16:31:00
Run Elapsed Time	1,049.000
HSGen Start Time	2015-09-08 16:13:35
HSGen End Time	2015-09-08 16:18:05
HSGen Elapsed Time	271.626
HSSort Start Time	2015-09-08 16:18:09
HSSort End Time	2015-09-08 16:29:20
HSSort Elapsed Time	672.522
HSValidate Start Time	2015-09-08 16:29:24
HSValidate End Time	2015-09-08 16:31:00
HSValidate Elapsed Time	97.460

Measurement Results for Repeatability Run

Run Start Time	2015-09-08 16:32:08
Run End Time	2015-09-08 16:49:28
Run Elapsed Time	1,044.000
HSGen Start Time	2015-09-08 16:32:08
HSGen End Time	2015-09-08 16:36:33
HSGen Elapsed Time	266.637
HSSort Start Time	2015-09-08 16:36:37
HSSort End Time	2015-09-08 16:47:50
HSSort Elapsed Time	674.684
HSValidate Start Time	2015-09-08 16:47:54
HSValidate End Time	2015-09-08 16:49:28
HSValidate Elapsed Time	95.589

Run Report for Performance Run

```
================================================
  TPCx-HS Performance Metric (HSph@SF) Report

   Test Run 1 details: Total Time = 1049
                       Total Size = 30000000000
                       Scale-Factor = 3.0000

  TPCx-HS Performance Metric (HSph@SF): 10.2986
================================================
```

Run Report for Repeatability Run

```
================================================
  TPCx-HS Performance Metric (HSph@SF) Report

   Test Run 2 details: Total Time = 1044
                       Total Size = 30000000000
                       Scale-Factor = 3.0000

  TPCx-HS Performance Metric (HSph@SF): 10.3448
================================================
```

Table of Contents

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 1.3.0.

The test was conducted at a Scale Factor of 3TB with 16 Huawei Tecal RH2288 V2 Servers running Huawei FusionInsight 2.5 on Red Hat Enterprise Linux Server 6.5.

Measured Configuration

Company Name	Cluster Node	Virtualization	Operating System
Huawei Technologies Co., Ltd.	Huawei Tecal RH2288 V2 Server	n/a	Red Hat Enterprise Linux Server 6.5

TPC Express Benchmark© HS Metrics

Total System Cost	HSph@3TB	Price/Performance	Availability Date
493,886 USD	10.29	47,997 USD	September 14, 2015

Preface

TPC Express Benchmark™ HS Overview

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. The 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. The TPCx-HS can be used to asses 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-H 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 Huawei Technologies Co., Ltd.

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

7.4.4   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.*

Measured Configuration
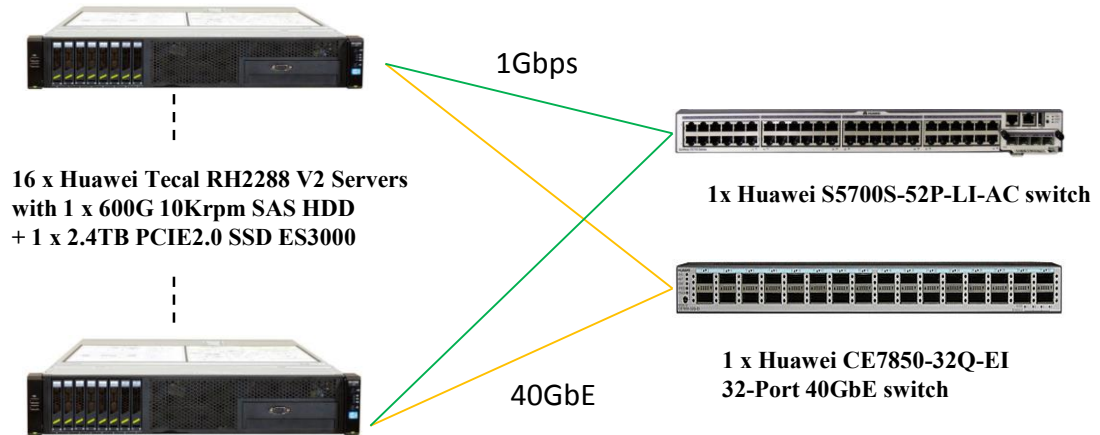
The measured configuration consisted of:
- Total Nodes: 16
- Total Processors/Cores/Threads: 32/256/512
- Total Memory: 4TB
- Total Number of Storage Drives/Devices: 32
- Total Storage Capacity: 48.00TB

Server nodes details:
- 16 x Huawei Tecal RH2288 V2 Servers, each with:
  - Processors/Cores/Threads: 2/16/32
  - Processor Model: Intel® Xeon® Processor E5-2680 v2, 2.70 GHz, 20MB L3
  - Memory: 256GB
  - Controller: 1 x Symbios Logic MegaRAID SAS 2208
  - Drives:
    - 1 x 600GB 10Krpm SAS HDD
    - 1 x 2.4TB Huawei ES3000 PCIe SSD Card
  - Network: 1 x Mellanox MCX314A-BCBT ConnectX-3 Dual-port 40/56GbE QSFP

Network connectivity detail:
- 1 x Huawei CE7850-32Q-EI 40GbE switch
- 1 x Huawei S5700S-52P-LI-AC 1Gbps switch (for cluster management)

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

Priced Configuration

There are no differences between the priced and measured configurations.

1.4 Dataset Distribution

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

Table 1.4 describes the distribution of the dataset across all media in the system.

Table 1.4: Dataset Distribution

Server Node	Controller	Disk Drive	Description of Content
1 - 16	MegaRAID 2208	0 (HDD)	Operating system, root, swap, Hadoop Master
1 - 16	PCIe slot	1 (SSD)	Data, Temp

1.5 Software Components Distribution

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

Table 1.5 describes the distribution of the software components across the system.

Table 1.5: Dataset Distribution

	Map/Reduce	Yarn		HDFS			ZooKeeper
Node	JobHistoryServer	ResourceMgr.	NodeMgr.	NamedNode	JournalNode	DataNode	QuorumPeer
0	x	x	x	x	x	x	x
1		x	x	x	x	x	x
2			x		x	x	x
3			x			x	
4			x			x	
5			x			x	
6			x			x	
7			x			x	
8			x			x	
9			x			x	
10			x			x	
11			x			x	
12			x			x	
13			x			x	
14			x			x	
15			x			x	

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

Huawei FusionInsight 2.5 - FS (fully HDFS compatible at the API level).

Map/Reduce implementation and corresponding version must be disclosed.

YARN M/R v2 on Huawei FusionInsight 2.5 (compatible equivalent to Hadoop 2.7.0).

Clause 2: Workload Related Items

2.1 Hardware & Software Tunable

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.

- **Run1 Performance Summary**

```
=============================================
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 1 details: Total Time = 1049
                    Total Size = 30000000000
                    Scale-Factor = 3.0000

TPCx-HS Performance Metric (HSph@SF): 10.2986
=============================================
```

- **Run2 Performance Summary**

```
=============================================
TPCx-HS Performance Metric (HSph@SF) Report

Test Run 2 details: Total Time = 1044
                    Total Size = 30000000000
                    Scale-Factor = 3.0000

TPCx-HS Performance Metric (HSph@SF): 10.3448
=============================================
```

2.3 Benchark Kit Identification

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

The version number of the TPCx-HS kit used is 1.3.0. The md5sum for the TPCx-HS kit files used during the benchmark are:

TPCx-HS-master.jar 4ceaefc51c698c0733b57244b7760808

BigData_cluster_validate_suite.sh 58c13ddb98a2d1228f2df10f4a087a71

TPCx-HS-master.sh 70ba6b440de47b4e4a902bf4983ee4c1

2.4 Benchark 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.

Table 3.1: Storage Device Capacity

Qty	Capacity (GB)	Total (GB)
16	600	9,600
16	2,400	38,400
Total Storage (TB)		**48.00**

Scale Factor = 3TB

Data Storage Ratio = (Storage / SF) = **16.00**

3.2 Memory Ratio

The Scale Factor to memory ratio must be disclosed.

Total Configured Memory = 4TB

Scale Factor to Memory Ratio = (SF / Memory) = **0.75**

Clause 4: Scale Factors and Metrics

4.1 HSGen Time

The HSGen time must be disclosed for Run1 and Run2.

	Run1	Run2
HSGen	271.626	266.637

4.2 HSSort Time

The HSSort time must be disclosed for Run1 and Run2.

	Run1	Run2
HSSort	672.522	674.684

4.3 HSValidate Time

The HSValidate time must be disclosed for Run1 and Run2.

	Run1	Run2
HSValidate	97.460	95.589

4.4 HSDataCheck Times

Both HSDataCheck times must be disclosed for Run1 and Run2.

	Run1	Run2
HSDataCheck (pre-Sort)	4.000	4.000
HSDataCheck (post-Sort)	4.000	4.000

4.5 Performance & Price-Performance

The performance metric (HSph@SF) must be disclosed for Run1 and Run2. Price-performance metric ($/HSph@SF) must be disclosed for the performance run.

	Run1	Run2
HSph@3TB	10.29	10.34

$/HSph@3TB	47,997 USD

Auditors' Information and Attestation Letter

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 Francois Raab for InfoSizing, inc.

> www.sizing.com
> 20 Kreg Lane
> Manitou Springs, CO 80829
> 719-473-7555.

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

A copy of the auditor's attestation letter is included in the next two pages.

InfoSizing
The Right Metric For Sizing IT

TPC Transaction Processing Performance Council
Certified Auditors

Mr. Jianhuan Wen
Vice Director of Shannon Laboratory
Central Research Institute
Huawei 2012 Laboratories
Huawei Base B2
Bantian, Longgang District
Shenzhen, China 518129

September 11, 2015

I verified the TPC Express Benchmark™ HS v1.3.0 performance of the following configuration:

Platform:	Huawei FusionInsight for Big Data with 16 Huawei Tecal RH2288 V2 Servers
Operating System:	Red Hat Enterprise Linux Server 6.5
Apache Hadoop Compatible Software:	Huawei FusionInsight 2.5

The results were:

Performance Metric	**10.29 HSph@3TB**
Run Elapsed Time	1,049.00 Seconds

Cluster	**16 x Huawei Tecal RH2288 V2 Server (each with)**		
CPUs	2 x Intel® Xeon® Processor E5-2680 v2, 2.70 GHz, 20MB L3		
Memory	256 GB		
Storage	**Qty**	**Size**	**Type**
	16	600GB	10K SAS HDD (internal)
	16	2.4TB	Huawei ES3000 PCIe SSD Card

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

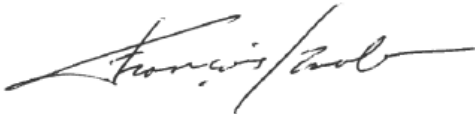The following verification items were given special attention:

- All TPC-provided components were verified to be v1.3.0
- 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 3TB

- The generated dataset and the sorted dataset were replicated a minimum of 3-ways
- 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,

François Raab, President

Supporting File Index

The following index outlines the information included in the supporting files archive.

Clause	Description	Archive File Pathname
Clause 1	Parameters and options used to configure the system	SupportingFilesArchive\Clause1
Clause 2	Configuration scripts	SupportingFilesArchive\Clause2
Clause 3	System configuration details	SupportingFilesArchive\Clause3
Clause 4	Run report	SupportingFilesArchive\Clause4