Hewlett Packard Enterprise

Hewlett Packard Enterprise Company

TPC Express Benchmark™ Big Bench (TPCx-BB)

Full Disclosure Report

for

Hewlett Packard Enterprise ProLiant DL for Big Data

(w/ 18x HPE ProLiant DL380 Gen10, 3x HPE ProLiant DL360 Gen10)

using

Cloudera for Apache Hadoop (CDH) 5.11.1

and

Red Hat Enterprise Linux Server 7.3

First Edition

July 9, 2017

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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 as a result of these and other factors. Therefore, the TPC Express Benchmark™ BB 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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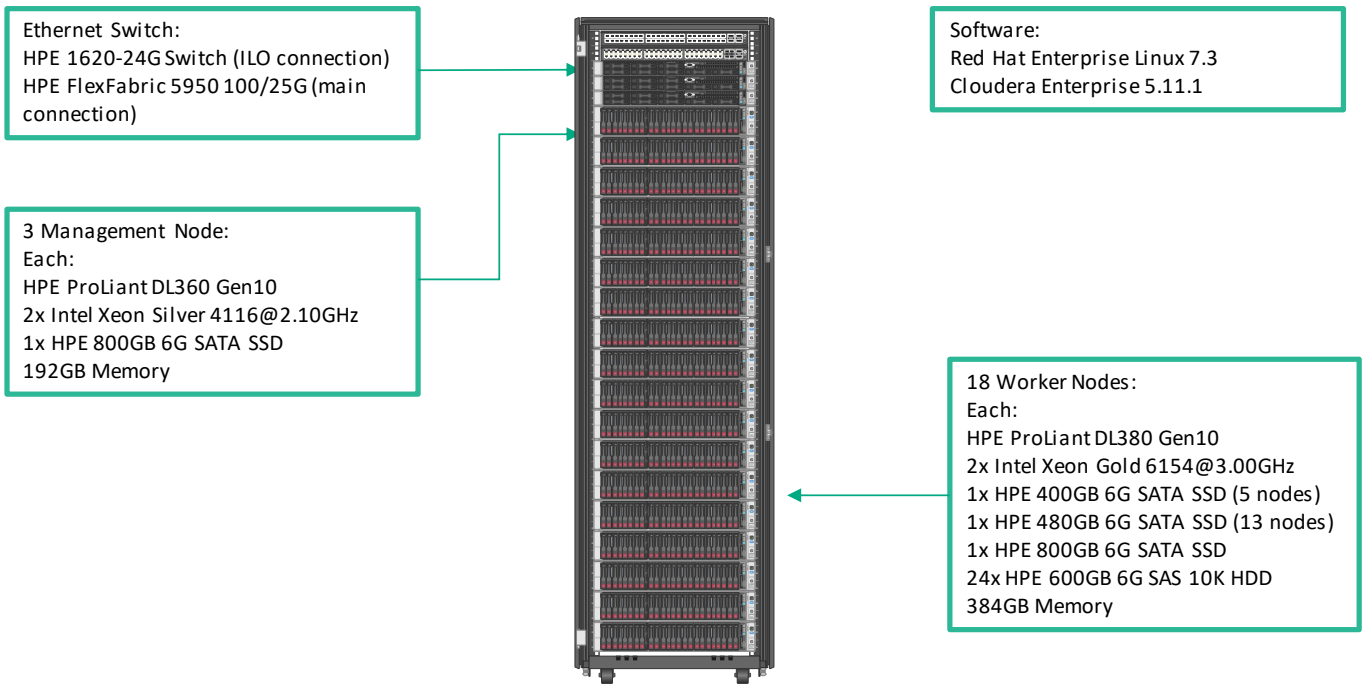
Hewlett Packard Enterprise	**Hewlett Packard Enterprise ProLiant DL for Big Data**	TPCx-BB Rev. v1.2.0 TPC-Pricing Rev. v2.1.1 Report Date: July 9, 2017
Total System Cost	TPCx-BB Performance Metric	Price/Performance
879,682 USD	**1,491.23** BBQpm@10000	**589.91 USD** $/BBQpm@10000

Framework	Operating System	Other Software	Availability Date	Scale Factor	Streams
Cloudera for Apache Hadoop (CDH) 5.11.1	Red Hat Enterprise Linux Server 7.3	OpenJDK 1.8.0_102 (1 node) Java 1.8.0_131 (20 nodes)	July 9, 2017	10000	2

System Configuration



Physical Storage/Scale Factor: 28.42	Scale Factor/Physical Memory: 1.34

Servers:	18x HPE ProLiant DL380 Gen10, 3x HPE ProLiant DL360 Gen10	
Total Processors/Cores/Threads	42/720/1440	
Server Configuration:	**Per HPE ProLiant DL380 Gen10:**	**Per HPE ProLiant DL360 Gen10:**
Processors	2x Intel Xeon Gold 6154 @ 3.00GHz	2x Intel Xeon Silver 4116 @ 2.10GHz
Memory	384GB	192GB
Storage Controller	HPE Smart Array P4081-a SR	HPE Smart Array P4081-a SR
Storage Device	1x HPE 400GB (5 nodes) 1x HPE 480GB (13 nodes) 1x HPE 800GB 6G SATA SSD 24x HPE 600GB 10K HDD	1x HPE 800GB 6G SATA SSD
Network	HPE Ethernet 25G Adapter	HPE Ethernet 25G Adapter
Connectivity:	HPE 1620-24G Switch (ILO connection) HPE FlexFabric 5950 100/25G (main connection)	

Hewlett Packard Enterprise

Hewlett Packard Enterprise ProLiant DL for Big Data

TPCx-BB Rev. v1.2.0
TPC-Pricing Rev. v2.1.1

Report Date:
July 9, 2017

Description	Price Key	Part Number	Unit Price	Qty	Extended Price	3 Yr Maint Price
Server Hardware						
HPE DL360 Gen10 8SFF CTO Server	1	867959-B21	$2,149	3	$6,447	
HPE DL360 Gen10 Intel Xeon Silver 4116 CPU @ 2.10GHz	1	874449-B21	$1,569	3	$4,707	
HPE DL360 Gen10 Intel Xeon Silver 4116 CPU @ 2.10GHz	1	874449-L21	$1,569	3	$4,707	
HPE 16GB 1Rx4 PC4-2666V-R Smart Kit	1	835955-B21	$589	36	$21,204	
HPE 800W CS Platinum Plus AC Power Supply	1	865414-B21	$759	6	$4,554	
HPE 96W Smart Storage Battery 145mm Cbl	1	875241-B21	$99	3	$297	
HPE 800GB 6G SATA MU-2 SFF SC SSD	1	872359-B21	$1,509	3	$4,527	
HPE Ethernet 25G Network Adapter	1	Q7M97A	$999	3	$2,997	
HPE 3Y FC 24x7 DL360 Gen10 SVC	1	H8QF0E	$1,565	3		$4,695
HPE iLO Adv incl 3yr TS U E-LTU	1	E6U64ABE	$469	3		$1,407
HP W1972a 18.5-In LED Monitor (1 + 2 spare)	1	B7M13A8#ABA	$80	3	$240	
HP PS/2 Keyboard And Mouse Bundle (1 + 2 spare)	1	B1T13AA#ABA	$28	3	$84	
			Subtotal		**$49,764**	**$6,102**
HPE DL380 Gen10 24SFF CTO Server	1	868704-B21	$2,107	18	$37,926	
HPE DL380 Gen10 High Perf Fan Kit	1	867810-B21	$239	18	$4,302	
HPE DL380 Gen10 2SFF Bay Kit	1	826687-B21	$149	18	$2,682	
HPE Intel Xeon Gold 6154 CPU @ 3.00GHz Kit	1	826888-B21	$4,795	18	$86,310	
HPE Intel Xeon Gold 6154 CPU @ 3.00GHz Kit	1	826888-L21	$4,795	18	$86,310	
HPE 32GB 2Rx4 PC4-2666T-R Kit	1	815100-B21	$985	216	$212,760	
HPE 600GB SAS 6G 10K SFF SC DS HDD	1	872477-B21	$545	432	$235,440	
HPE 480GB 6G SATA RI-2 SFF SC SSD	1	804593-B21	$609	13	$7,917	
HPE 400GB 6G SATA RI-2 SFF SC SSD	1	804665-B21	$719	5	$3,595	
HPE 800GB 6G SATA WI-2 SFF SC SSD	1	804671-B21	$1,389	18	$25,002	
HPE Smart Array P408i-a SR	1	804331-B21	$659	18	$11,862	
HPE 12Gb DL380 Gen10 SAS Expander Card	1	870549-B21	$699	18	$12,582	
HPE 800W FS Univ Ht Plg LH Pwr Sply Kit	1	865414-B21	$516	36	$18,576	
HPE Ethernet 25G Network Adapter	1	Q7M97A	$999	18	$17,982	
HPE 3Y FC 24x7 DL380 Gen10 SVC	1	H8QP7E	$2,127	18		$38,286
HPE iLO Adv incl 3yr TS U E-LTU	1	E6U64ABE	$469	18		$8,442
			Subtotal		**$763,246**	**$46,728**

Hewlett Packard Enterprise

Hewlett Packard Enterprise ProLiant DL for Big Data

TPCx-BB Rev. v1.2.0
TPC-Pricing Rev. v2.1.1

Report Date:
July 9, 2017

Description	Price Key	Part Number	Unit Price	Qty	Extended Price	3 Yr Maint Price
Network						
HPE 1620-24G Switch	1	JG913A	$299	1	$299	
HPE FlexFabric 5950 32QSFP28 Switch	1	JH321A	$34,990	1	$34,990	
HPE 58x0AF 650W AC Power Supply	1	JC680A	$749	2	$1,498	
HPE X712 Fan Tray	1	JH389A	$149	6	$894	
CAT6 UTP 1G Ethernet Network Cable 7ft (42 cables)	2	C6-UTPSMPVCYL-2M	$2	42	$84	
HPE 100Gb QSFP28 to 4x25Gb SFP28 3m DAC	1	845416-B21	$699	6	$4,194	
		Subtotal			**$41,959**	**$0**
Rack						
HPE 42U 600x1075mm Adv G2 Kit Pllt Rack	1	P9K07A	$1,699	1	$1,699	
HPE 24A High Voltage Core Only Corded PDU	1	252663-D74	$259	2	$518	
		Subtotal			**$2,217**	**$0**
Server Software						
Cloudera Ent Basic Ed 1yr 24x7	1	G7M27A	$2,304	63	$145,152	
RHEL Svr 2 Sckt/2 Gst 3yr 24x7 E-LTU	1	G3J30AAE	$3,889	21	$81,669	
		Subtotal			**$226,821**	**$0**
		Total Extended Price			**$1,084,007**	**$52,830**
		Total Discounts (30%)			**$257,155**	**$0**
Sales contact: HPE WW Headquarters, 3000 Hanover St., Palo Alto, CA 94304-1185 (650) 857-1501 or HPE: 855-472-5233		**Grand Total**			**$826,852**	**$52,830**

Pricing:1 = {Source 1}; 2 = {Source 2}

(1) All discounts are based on US list prices and for similar quantities and configurations. The discounts are based on the overall specific components pricing from respective vendors 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.

Audited by Doug Johnson of InfoSizing

Three-Year Cost of Ownership	**$879,682**
BBQpm@10000	**1,491.23**
$/BBQpm@10000	**$ 589.91**

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.

Numerical Quantities

Scale Factor	10000
Streams	2
SUT Validation Test	PASS

Performance Run (Run 2)

Overall Run Start Time	2017-06-26 14:36:26.986
Overall Run End Time	2017-06-27 02:51:05.334
Overall Run Elapsed Time	44,078.348
Load Test Start Time	2017-06-26 14:36:26.987
Load Test End Time	2017-06-26 15:11:59.851
Load Test Elapsed Time	2,132.864
Power Test Start Time	2017-06-26 15:11:59.852
Power Test End Time	2017-06-26 20:04:29.616
Power Test Elapsed Time	17,549.764
Throughput Test Start Time	2017-06-26 20:04:29.616
Throughput Test End Time	2017-06-27 02:51:05.334
Throughput Test Elapsed Time	24,395.718
Performance Metric (BBQpm@ 10000)	1,491.23

Repeatability Run (Run 1)

Overall Run Start Time	2017-06-26 01:34:26.908
Overall Run End Time	2017-06-26 13:46:14.824
Overall Run Elapsed Time	43,907.916
Load Test Start Time	2017-06-26 01:34:26.909
Load Test End Time	2017-06-26 02:09:36.513
Load Test Elapsed Time	2,109.604
Power Test Start Time	2017-06-26 02:09:36.515
Power Test End Time	2017-06-26 07:02:24.536
Power Test Elapsed Time	17,568.021
Throughput Test Start Time	2017-06-26 07:02:24.536
Throughput Test End Time	2017-06-26 13:46:14.824
Throughput Test Elapsed Time	24,230.288
Performance Metric (BBQpm@ 10000)	1,496.35

Performance Run Report (Run 2)

```
************
TPCx-BB
Result
v1.2
************
INFO: T_LOAD = 2132.864
INFO: T_LD = 0.1 * T_LOAD: 213.2864
INFO: T_PT = 11526.0848087096
INFO: T_T_PUT = 24395.718
INFO: T_TT = 12197.859
INFO: === Checking validity of the final result ===
INFO: OK: All required BigBench phases were performed.
INFO: OK: All 30 queries were running in the power test.
INFO: OK: All 30 queries were running in the first throughput test.
INFO: OK: Pretend mode was inactive. All commands were executed.
INFO: === Final result ===
INFO: VALID BBQpm@10000 = 1491.23874722434
```

Repeatability Run Report (Run 1)

```
************
TPCx-BB
Result
v1.2
************
INFO: T_LOAD = 2109.604
INFO: T_LD = 0.1 * T_LOAD: 210.9604
INFO: T_PT = 11528.6296315375
INFO: T_T_PUT = 24230.288
INFO: T_TT = 12115.144
INFO: === Checking validity of the final result ===
INFO: OK: All required BigBench phases were performed.
INFO: OK: All 30 queries were running in the power test.
INFO: OK: All 30 queries were running in the first throughput test.
INFO: OK: Pretend mode was inactive. All commands were executed.
INFO: === Final result ===
INFO: VALID BBQpm@10000 = 1496.35769773795
```

Summary details of the run reports are shown above. For the complete run reports, see the Support Files Archive.

Table of Contents

Abstract

This document contains the methodology and results of the TPC Express Benchmark™ Big Bench (TPCx-BB) test conducted in conformance with the requirements of the TPCx-BB Standard Specification, Revision v1.2.0.

The test was conducted at a Scale Factor of 10000 with 21 nodes (18x HPE ProLiant DL380 Gen10, 3x HPE ProLiant DL360 Gen10) running Cloudera for Apache Hadoop (CDH) 5.11.1 on Red Hat Enterprise Linux Server 7.3.

Measured Configuration

Company Name	Cluster Node	Virtualization	Operating System
Hewlett Packard Enterprise Company	18x HPE ProLiant DL380 Gen10 3x HPE ProLiant DL360 Gen10	n/a	Red Hat Enterprise Linux Server 7.3

TPC Express Benchmark© Big Bench Metrics

Total System Cost	BBQpm@10000	Price/Performance	Availability Date
879,682 USD	1,491.23	589.91 USD	July 9, 2017

Preface

TPC Express Benchmark™ Big Bench Overview

Big data analytics is a growing field of research and business. The significant decrease in the overall cost of hardware, the emergence of Open Source based analytics frameworks, along with the greater depth of data mining capabilities allows new types of data sources to be correlated with traditional data sources. For example, online retailers used to record only successful transactions on their website, whereas modern systems are capable of recording every interaction. The former allowed for simple shopping basket analysis techniques, while the current level of detail in monitoring makes detailed user modeling possible. The growing demands on data management systems and the new forms of analysis have led to the development of a new type of ***Big Data Analytics Systems (BDAS)****.*

Similar to the advent of ***Database Management Systems****, there is a vastly growing ecosystem of diverse approaches to enabling Big Data Analytics Systems. This leads to a dilemma for customers of* ***BDAS****, as there are no realistic and proven measures to compare different* ***BDAS*** *solutions. To address this, TPC has developed TPCx-BB (BigBench), which is an express benchmark for comparing* ***BDAS*** *solutions. The TPCx-BB Benchmark was developed to cover essential functional and business aspects of big data use cases. The benchmark allows for an objective measurement of* ***BDAS*** *System under Test, and provides the industry with verifiable performance, price/performance, and availability metrics.*

The TPCx-BB kit is available from the TPC website (see www.tpc.org for more information). Users must sign-up and agree to the TPCx-BB End User Licensing Agreement (EULA) to download the kit. All related work (such as collaterals, papers, derivatives) must acknowledge the TPC and include the TPCx-BB copyright. The TPCx-BB kit includes: TPCx-BB Specification document (this document), TPCx-BB Users Guide documentation, shell scripts to set up the benchmark environment, Java code to execute the benchmark workload, Data Generator, ***Query*** *files, and Benchmark Driver.*

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-BB models and represents a Big Data Analytics System such as Hadoop ecosystem or 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 components used by the SUT.*
- *Configuration parameters and options for Operating System and file system components used by the SUT.*
- *Configuration parameters and options for any other software components (e.g compiler optimization options) used by the SUT.*

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.

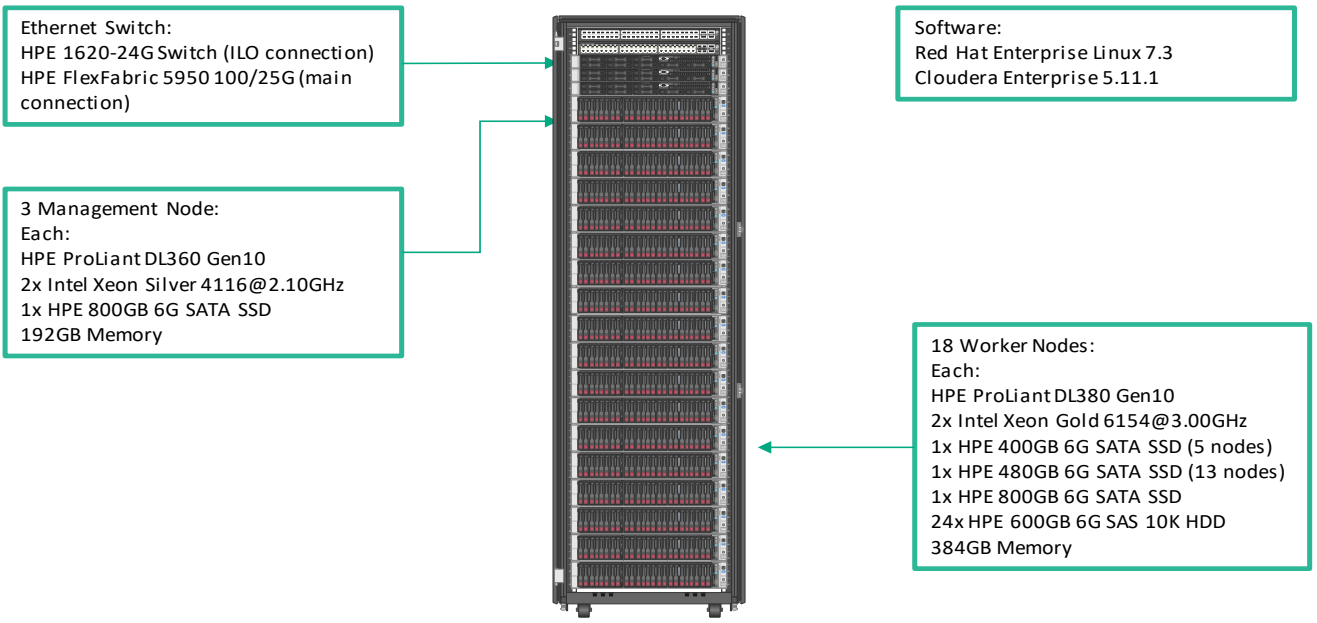
The Supporting Files Archive contains the parameters and options used to configure the components involved in this benchmark.

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: 21
- Total Processors/Cores/Threads: 42/720/1440
- Total Memory: 7,488
- Total Number of Storage Drives/Devices: 471
- Total Storage Capacity: 284,240

Network connectivity detail:

- HPE 1620-24G Switch (ILO connection), HPE FlexFabric 5950 100/25G (main connection)

Server nodes details:

18x HPE ProLiant DL380 Gen10, each with:

- Processors/Cores/Threads: 2/36/72
- Processor Model: 2x Intel Xeon Gold 6154 @ 3.00GHz
- Memory: 384GB
- Controller: 1x HPE Smart Array P4081-a SR
- Drives:
  - 1x HPE 400GB SSD (5 nodes)
  - 1x HPE 480GB SSD (13 nodes)
  - 1x HPE 800GB SSD
  - 24x HPE 600GB 10K HDD
- Network: HPE Ethernet 25G Adapter

3x HPE ProLiant DL360 Gen10, each with:

- Processors/Cores/Threads: 2/24/48
- Processor Model: 2 x Intel Xeon Silver 4116 2.10GHz
- Memory: 192GB
- Controller: 1x HPE Smart Array P4081-a SR
- Drives:
  - 1 x HPE 800GB SSD
- Network: HPE Ethernet 25G Adapter

The distribution of software components over server nodes is detailed in section 2.1.

Priced Configuration

There are no differences between the priced and measured configurations.

Clause 2: Software Components and Dataset Distribution

2.1 Roles and Dataset Distribution

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

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

Table 1.4: Software Components and Dataset Distribution

Server	Role(s)	Count	Virtual	Host Name(s)	HW/SW Configuration	Storage Setup
Worker	HDFS DataNode/Hive Gateway/YARN Node Manager/Spark Gateway	18	N	skl21-[04-21]	• HPE DL380 Gen10 • HW/SW Config (Intel Xeon Gold 6154, 2, 3.0GHz, 72) • Memory: 384GB • Storage: 24 x 600GB SAS HDD, 1 x 480GB or 400GB SSD, 1x800GB SSD • Network: HPE Ethernet 25G NIC • OS: RHEL 7.3 • Cloudera CDH 5.11	OS: HPE 480GB or 400GB SSD, Intermediate/Shuffle/Temp Data/ Distributed FS: 1 x 800GB SSD, 24 x HPE 600GB 6G SAS 10k HDD
Cloudera Manager Node #1	HDFS Balancer/HDFS Namenode/Hive Gateway/Cloudera Management Services Alert Publisher/Cloudera Management Services Event Server/Hive Metastore Server/Hue Server/Cloudera Management Services/YARN JobHistory Server/YARN ResourceManager/ZooKeeper Server/Spark Gateway/Spark History	1	N	skl21-01	• HPE DL360 Gen10 Server • HW/SW Config (Intel E5-2640v4, 2, 2.4GHz, 40) • Memory: 256GB • Storage: 1 x 800GB SSD • Network: HPE 560 SFP+10G NIC • OS: RHEL 6.7 • Cloudera CDH 5.6	OS: HPE 800GB 6G SATA SSD
Cloudera Manager Node #2	Hive Gateway/HiveServer2/ZooKeeper Server	1	N	skl21-02	• HPE DL360 Gen9 Server • HW/SW Config (Intel E5-2640v4, 2, 2.4GHz, 40) • Memory: 256GB • Storage: 1 x 800GB SSD • Network: HPE 560 SFP+10G NIC • OS: RHEL 6.7 • Cloudera CDH 5.6	OS: HPE 800GB 6G SATA SSD
Cloudera Manager Node #3	HDFS SecondaryNameNode/Hive Gateway/Cloudera Management Service Activity Monitor/ZooKeeper Server	1	N	skl21-03	• HPE DL360 Gen9 Server • HW/SW Config (Intel E5-2640v4, 2, 2.4GHz, 40) • Memory: 256GB • Storage: 1 x 800GB SSD • Network: HPE 560 SFP+10G NIC • OS: RHEL 6.7 • Cloudera CDH 5.6	OS: HPE 800GB 6G SATA SSD

2.2 Distributed File System Implementation

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

Cloudera for Apache Hadoop (CDH) 5.11.1 (fully HDFS compatible at the API level).

2.3 Engine Implementation

The Engine implementation and corresponding version must be disclosed.

Component	Version
Hive	1.1.0
HDFS	2.6.0
YARN	2.6.0
Spark	1.6.0
MapReduce	2.6.0
Zookeeper	3.4.5

2.4 Frameworks

Frameworks and Engine used in the benchmark should be disclosed.

Framework	Version
CDH	5.11.1
Hive	1.1.0
HDFS	2.6.0
YARN	2.6.0
Spark	1.6.0
MapReduce	2.6.0
Zookeeper	3.4.5

2.5 Applied Patches

Any additional vendor supported patches applied to the SUT should be disclosed.

No additional patches were applied.

Clause 3: Workload Related Items

3.1 Hardware & Software Tunable

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

The Supporting Files Archive contains all configuration scripts.

3.2 Kit Version

Version number of the TPCx-BB kit must be included in the Report.

TPCx-BB Kit Version
v1.2

3.3 Run Report

The run report generated by TPCx-BB benchmark kit must be included in the Report.

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

- **Run1 Report Summary (Repeatability Run)**

```
**********
TPCx-BB
Result
v1.2
**********
INFO: T_LOAD = 2109.604
INFO: T_LD = 0.1 * T_LOAD: 210.9604
INFO: T_PT = 11528.6296315375
INFO: T_T_PUT = 24230.288
INFO: T_TT = 12115.144
INFO: === Checking validity of the final result ===
INFO: OK: All required BigBench phases were performed.
INFO: OK: All 30 queries were running in the power test.
INFO: OK: All 30 queries were running in the first throughput test.
INFO: OK: Pretend mode was inactive. All commands were executed.
INFO: === Final result ===
INFO: VALID BBQpm@10000 = 1496.35769773795
```

- **Run2 Report Summary (Performance Run)**

```
**********
TPCx-BB
Result
v1.2
**********
INFO: T_LOAD = 2132.864
INFO: T_LD = 0.1 * T_LOAD: 213.2864
INFO: T_PT = 11526.0848087096
INFO: T_T_PUT = 24395.718
INFO: T_TT = 12197.859
INFO: === Checking validity of the final result ===
INFO: OK: All required BigBench phases were performed.
INFO: OK: All 30 queries were running in the power test.
INFO: OK: All 30 queries were running in the first throughput test.
INFO: OK: Pretend mode was inactive. All commands were executed.
INFO: === Final result ===
INFO: VALID BBQpm@10000 = 1491.23874722434
```

3.4 Query Elapsed Times

Elapsed times of all power and throughput Queries needs to be reported from the Performance Run, grouped respectively as Structured, semi-structured and unstructured buckets.

Query Type	Query Number	Power	Throughput	
		Stream 1	Stream 1	Stream 2
Structured	1	209.762	495.543	221.913
	6	471.188	508.777	674.512
	7	397.487	678.818	1,019.170
	9	394.853	564.729	511.026
	11	129.311	166.555	183.093
	13	197.269	357.508	309.214
	14	72.999	125.153	121.366
	15	135.604	167.809	135.927
	16	501.052	503.518	838.246
	17	317.299	505.828	337.234
	20	336.542	386.947	400.406
	21	632.636	712.485	907.308
	22	106.436	107.407	154.482
	23	155.286	210.543	151.007
	24	198.110	211.855	205.386
	25	475.457	666.815	543.574
	26	281.691	1,020.517	739.400
	29	235.668	396.063	285.507
Semi-structured	2	1,945.288	3,141.017	2,164.161
	3	1,108.326	1,356.830	1,297.903
	4	1,633.076	2,317.832	2,673.773
	5	736.168	921.286	1,298.572
	8	683.809	834.323	702.720
	12	718.058	1,512.328	903.377
	30	1,917.744	2,041.016	2,488.606
Unstructured	10	363.661	392.080	442.015
	18	2,210.156	2,544.926	3,194.452
	19	610.683	1,009.477	613.684
	27	68.640	156.741	74.272
	28	305.467	380.972	397.452

3.5 Validation Test Output

Output report from successful SUT Validation test must be included in the Report.

Query Number	Query Execution	Output Validation
1	PASS	PASS
2	PASS	PASS
3	PASS	PASS
4	PASS	PASS
5	PASS	PASS
6	PASS	PASS
7	PASS	PASS
8	PASS	PASS
9	PASS	PASS
10	PASS	PASS
11	PASS	PASS
12	PASS	PASS
13	PASS	PASS
14	PASS	PASS
15	PASS	PASS
16	PASS	PASS
17	PASS	PASS
18	PASS	PASS
19	PASS	PASS
20	PASS	PASS
21	PASS	PASS
22	PASS	PASS
23	PASS	PASS
24	PASS	PASS
25	PASS	PASS
26	PASS	PASS
27	PASS	PASS
28	PASS	PASS
29	PASS	PASS
30	PASS	PASS

3.6 Global Framework Parameters

Global Framework parameter settings files must be included in the Report.

The Supporting File Archive contains the global framework parameter settings files.

3.7 Kit Modifications

Test Sponsor kit modifications files must be included in the Report.

The following files were modified by the Test Sponsor to facilitate system, platform and Framework differences.

- bigBench-configs/conf/bigBench.properties
- bigBench-configs/conf/userSettings.conf
- bigBench-configs/hive/conf/engineSettings.conf
- bigBench-configs/hive/conf/engineSettings.sql
- bigBench-configs/hive/population/hiveCreateLoad.sql
- bigBench-configs/hive/queries/q01/engineLocalSettings.sql
- bigBench-configs/hive/queries/q02/engineLocalSettings.sql
- bigBench-configs/hive/queries/q03/engineLocalSettings.sql
- bigBench-configs/hive/queries/q04/engineLocalSettings.sql
- bigBench-configs/hive/queries/q05/engineLocalSettings.sql
- bigBench-configs/hive/queries/q06/engineLocalSettings.sql
- bigBench-configs/hive/queries/q07/engineLocalSettings.sql
- bigBench-configs/hive/queries/q08/engineLocalSettings.sql
- bigBench-configs/hive/queries/q09/engineLocalSettings.sql
- bigBench-configs/hive/queries/q10/engineLocalSettings.sql
- bigBench-configs/hive/queries/q11/engineLocalSettings.sql
- bigBench-configs/hive/queries/q12/engineLocalSettings.sql
- bigBench-configs/hive/queries/q13/engineLocalSettings.sql
- bigBench-configs/hive/queries/q14/engineLocalSettings.sql
- bigBench-configs/hive/queries/q15/engineLocalSettings.sql
- bigBench-configs/hive/queries/q16/engineLocalSettings.sql
- bigBench-configs/hive/queries/q17/engineLocalSettings.sql
- bigBench-configs/hive/queries/q18/engineLocalSettings.sql
- bigBench-configs/hive/queries/q19/engineLocalSettings.sql
- bigBench-configs/hive/queries/q20/engineLocalSettings.sql
- bigBench-configs/hive/queries/q21/engineLocalSettings.sql
- bigBench-configs/hive/queries/q22/engineLocalSettings.sql
- bigBench-configs/hive/queries/q23/engineLocalSettings.sql
- bigBench-configs/hive/queries/q24/engineLocalSettings.sql
- bigBench-configs/hive/queries/q25/engineLocalSettings.sql
- bigBench-configs/hive/queries/q26/engineLocalSettings.sql
- bigBench-configs/hive/queries/q27/engineLocalSettings.sql
- bigBench-configs/hive/queries/q28/engineLocalSettings.sql
- bigBench-configs/hive/queries/q29/engineLocalSettings.sql
- bigBench-configs/hive/queries/q30/engineLocalSettings.sql

Clause 4: SUT Related Items

4.1 Specialized Hardware/Software

Specialized Hardware/Software used in the SUT must be included.

No specialized hardware or software was used.

4.2 Framework Configuration Files

All Framework configuration files from SUT, for the performance run.

All Framework configuration files are included in the Supporting Files Archive.

4.3 SUT Environment Information

SUT environment info in form of envinfo.log from a representative worker node form every role in the server.

All envinfo.log files are included in the Supporting Files Archive.

4.4 Data Storage to Scale Factor Ratio

The data storage ratio must be disclosed.

Nodes	Disks	Size (GB)	Total (GB)
3	1	800	2,400
5	1	400	2,000
13	1	480	6,240
18	1	800	14,400
18	24	600	259,200

Total Storage (GB)	284,240
Scale Factor	10000
Data Storage Ratio	28.42

4.5 Scale Factor to Memory Ratio

The Scale Factor to memory ratio must be disclosed.

Nodes	Memory (GB)	Total (GB)
3	192	576
18	384	6,912

Scale Factor	10000
Total Memory (GB)	7,488
SF / Memory Ratio	1.34

Clause 5: Metrics and Scale Factors

5.1 Performance Run Metric

The Reported Performance Metric (BBQpm@SF for the Performance Run) must be disclosed in the Report.

Performance Run
BBQpm@10000 1,491.23

5.2 Repeatability Run Metric

The Performance Metric (BBQpm@SF) for the Repeatability Run must be disclosed in the Report..

Repeatability Run
BBQpm@10000 1,496.35

5.3 Price-Performance Metric

The Reported Performance Metric (BBQpm@SF for the Performance Run) must be disclosed in the Report.

Price / Performance
$BBQpm@10000 589.91

5.4 Scale Factor

The Scale Factor used for the Result must be disclosed in the Report.

Scale Factor
10000

5.5 Stream Count

The number of streams in the throughput run used for the Result must be disclosed in the Report.

Streams
2

5.6 Elapsed Run Times

The total elapsed time for the execution of the Performance Run and Repeatability Run must be disclosed in the Report.

Run	Elapsed Time	Seconds
Run 1	12:11:47.916	43,907.916
Run 2	12:14:38.348	44,078.348

5.7 Elapsed Test Times

The total time for each of the three tests must be disclosed for the Performance Run and the Repeatability Run.

Test	Performance Run	Repeatability Run
Load Test	2,132.864	2,109.604
Power Test	17,549.764	17,568.021
Throughput Test	24,395.718	24,230.288

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 Doug Johnson, InfoSizing.

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63 Lourdes Drive
Leominster, MA 01453
978-343-6562.

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. Paul Cao
Hewlett Packard Enterprise
11445 Compaq Center Dr West
Houston, TX 77070

July 7, 2017

I verified the TPC Express Benchmark™ BB v1.2.0 performance of the following configuration:

Platform:	Hewlett Packard Enterprise ProLiant DL for Big Data (w/ 18x HPE ProLiant DL380 Gen 10, 3x HPE ProLiant DL360 Gen10)
Operating System:	Red Hat Enterprise Linux Server 7.3
Apache Hadoop Compatible Software:	Cloudera for Apache Hadoop (CDH) 5.11.1

The results were:

Performance Metric	**1,491.23 BBQpm@10000GB**
Run Elapsed Time	12:14:38.348 (44,078.348 Seconds)

Cluster	**18x HPE ProLiant DL380 Gen 10 (Data nodes), 3x HPE ProLiant DL360 Gen10 (Management nodes)**
CPUs	2 x Intel Xeon Gold 6154 (3.30 GHz, 18-core, 25 MB L3) (Data nodes) 2 x Intel Xeon Silver 4116 (2.10 GHz, 12-core, 16 MB L3) (Mgmt. nodes)
Memory	384GB (Data nodes), 192GB (Mgmt. nodes)

Storage	*Qty*	*Size*	*Type*
	1	800GB	6G SATA SSD (OS, Mgmt. nodes)
	1	400GB	6G SATA SSD (OS, 5 Data nodes)
	1	480GB	6G SATA SSD (OS, 13 Data nodes)
	1	800GB	6G SATA SSD (Temp, Data nodes)
	24	600GB	6G SAS 10K HDD (Data, 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 v1.2.0
- No modifications were made to any of the Java code
- Any and all modifications to shell scripts were reviewed for compliance

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

- The tested Scale Factor (10000GB) was confirmed to be valid for publication
- All validation queries executed successfully and produced compliant results
- No errors were reported during the run
- 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:

From the TPCx-BB Kit's README:

Q28 Depending on the Hadoop distribution version can fail automated Engine Validation due to empty space characters when the output is written to HDFS. Manually open the result file and validate the reference values and written values.

Query 28 failed automated Engine Validation. A manual validation was performed as part of this audit to confirm the only differences were due to white space.

Respectfully Yours,

Doug Johnson, TPC Auditor

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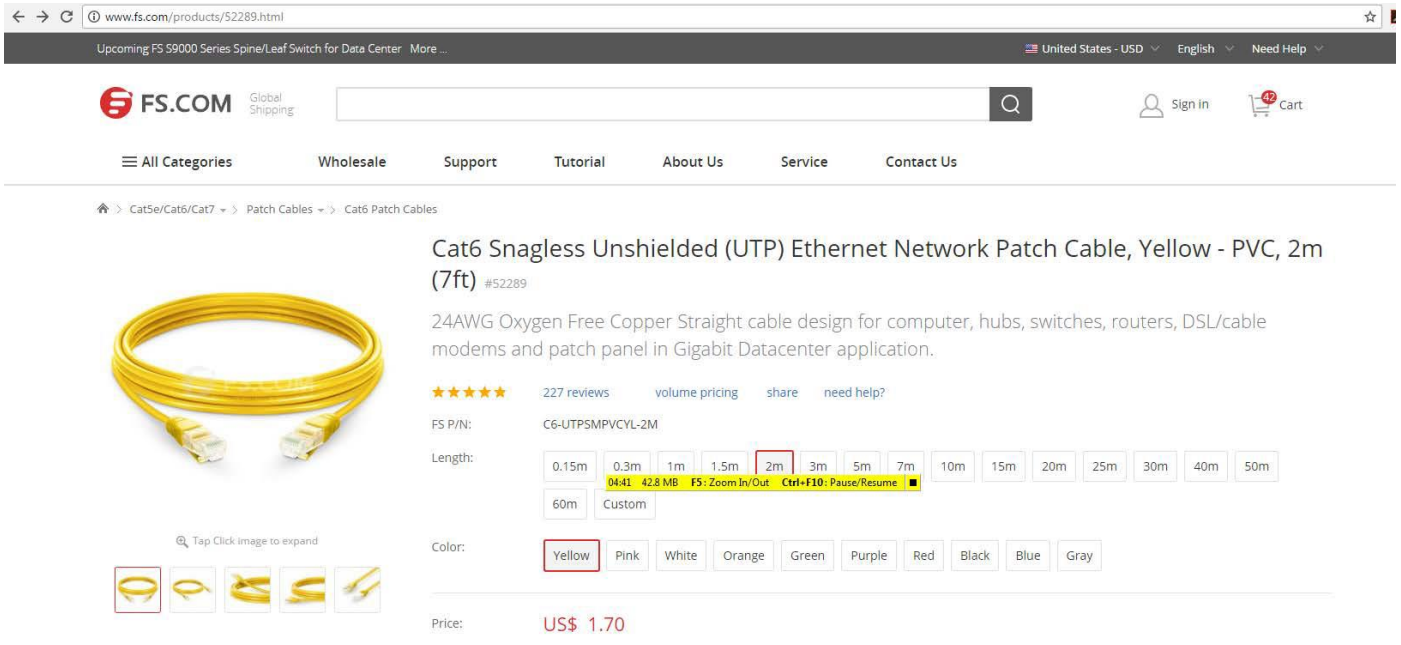
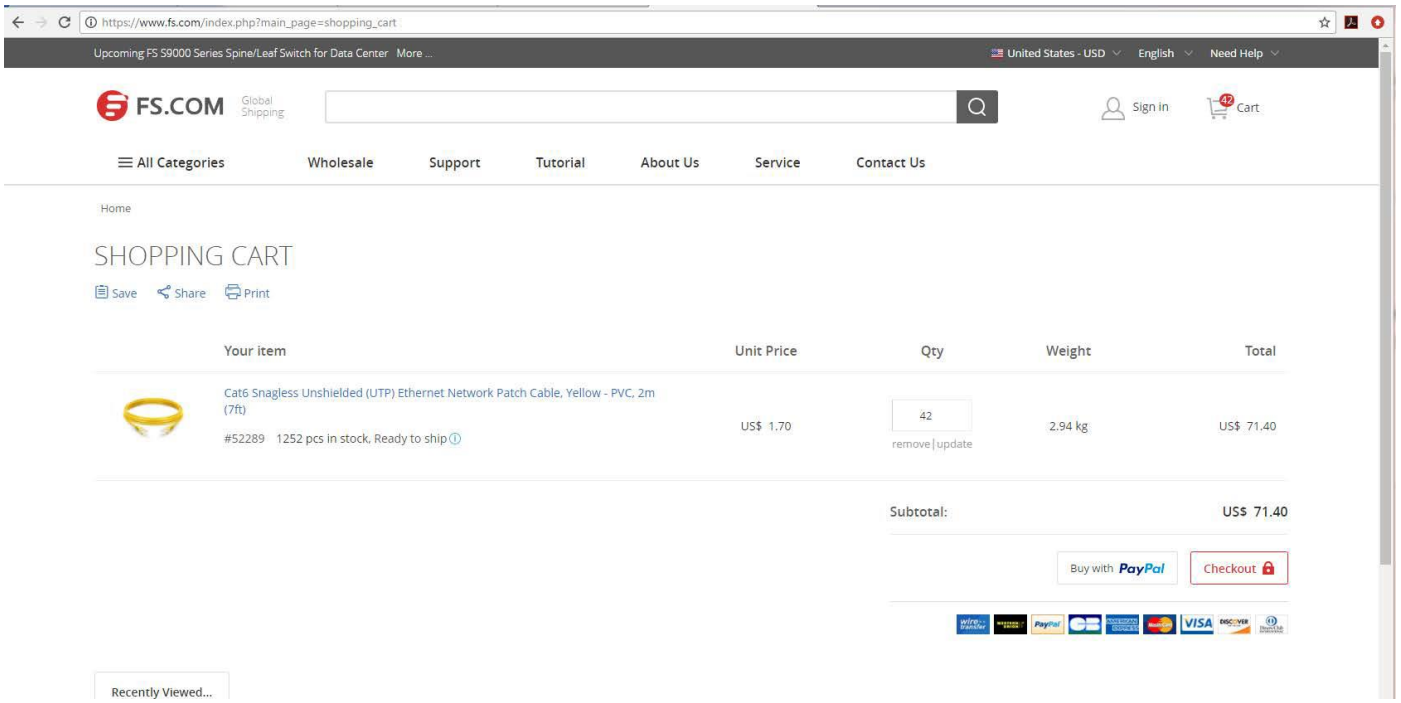
Third Party Price Quotes





Supporting File Index

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

Description	Archive File Pathname
Clause 1 - General Items	
The Supporting Files Archive contains the parameters and options used to configure the components involved in this benchmark	Supporting-Files-3TB-BDW-3-2016\
Validation Run Files	Supporting-Files-3TB-BDW-3-2016\Validation-run-logs-20160322-155451-hive-sf3000
Performance Run Files	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000
Repeatability Run Files	upporting-Files-3TB-BDW-3-2016\Repeatability-run-logs-20160324-002413-hive-sf3000
Clause 3 - Workload Related Items	
Benchmark Generic Parameters	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\conf\userSettings.conf
Query Parameters used in the benchmark execution Settings	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\conf\queryParameters.sql
Benchmark Global Framework Parameters Settings	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\conf\engineSettings.sql
Benchmark Global Framework Parameters Settings	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\conf\engineSettings.conf
Load Test script	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\population\hiveCreateLoad.sql
Queries specific optimization parameters settings	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\queries\q[01-30]\engineLocalSettings.conf
Queries specific optimization parameters settings	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive\queries\q[01-30]\engineLocalSettings.sql
Clause 4 - SUT Related Items	
Data Redundancy report	Supporting-Files-3TB-BDW-3-2016\hdfs-data-redundancy-report.txt
Benchmark execution script	Supporting-Files-3TB-BDW-3-2016\run-all.sh
Hardware and Software Report from a representative node	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\run-logs\envInfo-hsw04\envInfo.log
All Framework configuration files are included in the Supporting Files Archive	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hadoop
	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\hive
	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\bigBench-configs\spark
Clause 5 - Metric and Scale Factor Related Items	
Benchmark Performance Report	Supporting-Files-3TB-BDW-3-2016\logs-20160323-080841-hive-sf3000\run-logs\BigBenchResult.log
Validation Test Report	Supporting-Files-3TB-BDW-3-2016\Validation-run-logs-20160322-155451-hive-sf3000\run-logs\BigBenchResult.log