TPC Express Benchmark™ IoT
Full Disclosure Report
for
Dell PowerEdge R7415
(with 8x Dell PowerEdge R7415 Servers)
Using
HBase 2.0.0 on
Cloudera Distribution for Apache Hadoop
Enterprise Edition 6.0
and
Red Hat Enterprise Linux Server Release 7.5

Second Edition -- April 02, 2021
(First Edition released on May 24, 2019)
First Edition - TBD

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<table>
<thead>
<tr>
<th>Total System Cost</th>
<th>TPCx-IoT Performance Metric</th>
<th>Price/Performance</th>
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</thead>
<tbody>
<tr>
<td>265,084 USD</td>
<td>354,811.45 IoTps</td>
<td>747.12 USD $/kIoTps</td>
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### Number of Records
- **600 Millions**

### DBMS Software
- **HBase 2.0.0 on Cloudera Distribution for Apache Hadoop 6.0**

### Operating System
- **Red Hat Enterprise Linux Server Release 7.5**

### Other Software
- None

### Availability Date
- May 24, 2019

### System Configuration

**Total Number of Servers:** 8

**Total Processors/Cores/Threads:** 8/192/384

#### Server Configuration (each)

<table>
<thead>
<tr>
<th>Processors</th>
<th>1x AMD EPYC 7401P 2.0GHz 24-Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>256GB</td>
</tr>
<tr>
<td>Storage Controller</td>
<td>Perc H740P</td>
</tr>
<tr>
<td>Storage Device</td>
<td>1x 240GB SSD SATA (all nodes)</td>
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<tr>
<td>7x</td>
<td>1x Dell 1.6TB NVMe (Data Nodes)</td>
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<tr>
<td>Network</td>
<td>1x Mellanox Dual Port 25GbE SFP28 NIC</td>
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<tr>
<td>Connectivity</td>
<td>Dell S-Series (S5048F-ON) Network Switch</td>
</tr>
</tbody>
</table>

### Total Rack Units:

\[
\text{Total Rack Units} = (8 \times R7415) + (1 \times S5048F-ON) = (8 \times 2) + (1 \times 1) = 17RU
\]
### Dell PowerEdge R7415

**Description** | **Qty** | **Extended Price** | **3 y. Maint. Price** | **Part Number** | **Key** | **Unit Price**
--- | --- | --- | --- | --- | --- | ---
**Hardware Components**

**PowerEdge R7415 Server**

- PowerEdge R7415/R715 Motherboard: 210-AKBR 1 $23,129.00 7 $163,333.00
- 32GB DDR4-2666 1 0.00 7 0.00
- No Trusted Platform Module 1 0.00 7 0.00
- Chassis with up to 24 2.5" Drives including Maximum of 8 SAS/SATA or up to 23 NVMe Drives: 321-BH3L 1 0.00 7 0.00
- PowerEdge R7415 Shipping: 340-BYTL 1 0.00 7 0.00
- PowerEdge R7415 x16 or x10 Drive Shipping Material: 343-BB1J 1 0.00 7 0.00
- AMD EPYC™ 7401P 2.0GHz/2.8GHz, 24/48T, 64M Cache (155W/170W) BDD14-2400/2666: 338-BXCT 1 0.00 7 0.00
- Standard Brackets: 322-BBHH 1 0.00 7 0.00
- 2660IF’s BBRMs: 370-BAHE 1 0.00 7 0.00
- Performance Optimized: 376-BAE 1 0.00 7 0.00
- Unconfigured RAID: 710-BCHS 1 0.00 7 0.00
- PERC H740P RAID Controller, 8GB NV Cache, Mini card: 485-AMMS 1 0.00 7 0.00
- Red Hat Enterprise Linux 7/8 Factory Installed: 421-2727 1 $8,000 3 $8,000
- iDRAC9, Enterprise: 355-BBKT 1 0.00 7 0.00
- iDRAC Group Manager, Disabled: 379-BQYJ 1 0.00 7 0.00
- iDRAC Factory Generated Password: 379-BQSF 1 0.00 7 0.00
- Root GUI: 1, 2 x 16 GB: 330-BRJJ 1 0.00 7 0.00
- On-Board IOM: 512-BREHP 1 0.00 7 0.00
- No Internal Optical Drive: 429-AXJD 1 0.00 7 0.00
- Dual, Hot-plug, Redundant Power Supply (1+1) 490W for x21 chassis: 456-AGZB 1 0.00 7 0.00
- No Bezel: 338-BBBW 1 0.00 7 0.00
- Dell EMC Luggage Tag: 330-BBBH 1 0.00 7 0.00
- No Quick Sync: 330-BBBK 1 0.00 7 0.00
- Performance BBS Settings: 344-BBHH 1 0.00 7 0.00
- IEEE 802.11ax/Wireless with NIST Security: 300-BBBH 1 0.00 7 0.00
- ReadyRails Sliding Rails With Cable Management Arm: 720-BBBH 1 0.00 7 0.00
- No Systems Documentation, No OpenManage RMM Kit: 631-AMKA 1 0.00 7 0.00
- US Order: 332-1236 1 0.00 7 0.00
- Dell Hardware Limited Warranty Plus On-Site Service: 316-3312 1 $280,00 7 1,400
- ProSupport Mission Critical: 7x24 BW, 10 x 20 Technical Support: 316-3218 1 $7,432.00 7 10,866
- 24/7 Customer Support: 316-3313 1 $28,200 7 1,834
- Thank you choosing Dell ProSupport, for tech support, visit //www.dell.com/support or call 1-800-953-3335 909-3139 1 0.00 7 0.00
- On-Site Installation Declined: 909-0999 1 0.00 7 0.00
- 32GB BBRM 2660IF’s Dual Rank: 338-011Y 1 0.00 7 0.00
- 2100GP SSD SATA Mixed Use 664b 512b 2.5in Hot Plug S410 Business: 400-BBMS 1 0.00 7 0.00
- Dell 1.6TB NVMe, Mixed Use Express Flash, 2.5 SATA Refresh, U2, PM1725a with Carrier: 680-SWLD 1 0.00 7 0.00
- Mellanox ConnectX-4 Lx Dual Port 25GbE SEP20, PCIe Gen3, Low Profile: 486-BSLD 1 0.00 7 0.00
- C13 to C14, PDU Style, 12 AMP, 6.5 Feet (2m) Power Cord, North America: 622-BBHD 1 0.00 7 0.00
- Dell EMC 5040F-ON Switch, 48x 25GbE, 4x 100GbE QSFP28, 10 to PSE-2 PSE-2S810: 210-AHNH 1 $23,129.00 7 25,129
- (QSFP28, 10 to PSE airflow, 2x PSE, I/O Software, Rights to use L2 on E89, SG04-40N: 631-RUOR 1 0.00 7 0.00
- Dell Networking, Cable, SEP20 to SEP20, 25GbE Passive Copper Twinax Direct Attach Cable, 2 Meter: 476-SEET 1 0.00 7 0.00
- Dell EMC S5048F Series For Sale: 313-BBDG 1 0.00 7 0.00
- US No Canada Ship Charge: 332-1236 1 0.00 7 0.00
- Force10, Power Cord, 125V, 10A, 10 Feet, NEMA 5-15/15: 430-A#-# 1 0.00 7 0.00
- Dell Hardware Limited Warranty 1 Year: 315-5961 1 0.00 7 0.00
- ProSupport Mission Critical Package, 1-hour 7x24 On-Site Service with Emergency Responder, 1 Year: 315-5956 1 0.00 7 0.00
- ProSupport Mission Critical Package, 1-hour 7x24 On-Site Service with Emergency Responder, 2 Years: 315-5977 1 0.00 7 0.00
- ProSupport Mission Critical: 7x24 BW, SW Technical Support and Assistance: 3 Years: 315-5987 1 0.00 7 0.00
- Dell Limited Hardware Warranty Extended Year(s): 975-3461 1 0.00 7 0.00
- Thank you choosing Dell ProSupport, for tech support, visit //www.dell.com/support or call 1-800-953-3335 909-3139 1 0.00 7 0.00
- Intel 3rd Party Software Warranty provided by Vendor: 997-6336 1 0.00 7 0.00
- On-Site Installation Declined: 909-9997 1 0.00 7 0.00
- APC NetShelter SX 24U 600mm x 1070mm Deep Enclosure: 37063800 1 $10,799 9 1 $10,799
- Rack PHE, Basic, Zero U, 120V, 5-15 input, (14) 5-15 output: 37541364 1 $17,499 1 17,499
- LegiTech MK120 Keyboard and Mouse: 36999510 1 $15.99 1 15.99
- Dell 24” Monitor: 210-A4PG 1 0.00 7 0.00

**Subtotal** $191,732.97 $20,212.00
**Dell PowerEdge R7415**

**Report Date:** April 02, 2021

---

### Description

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<th>PowerEdge R7415 Server</th>
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<th>3 yr. Maint. Price</th>
<th>Part Number</th>
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<td>ReadyRails Sliding Rails With Cable Management Arm</td>
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<td>314-3B41</td>
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<td>$1,133.00</td>
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<tr>
<td>Thank you choosing Dell ProSupport. For tech support, visit //www.dell.com/support or call 1-800-945-3355</td>
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<td></td>
<td>309-3368</td>
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**Sub Total:** $20,360.00

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### HARDWARE COMPONENTS

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<th>Unit Price</th>
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<td>1 Dell EMC</td>
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<tr>
<td>* Discount based upon total system cost as purchased by a regular customer.</td>
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<tr>
<td><strong>Subtotal</strong></td>
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<td>$212,092.97</td>
<td>$22,112.00</td>
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### SOFTWARE COMPONENTS

**Subtotal:** $0.00

---

### TOTAL

**Subtotal:** $0.00

---

### Large Purchase Discount (35%)

**Subtotal:** $74,232.54

---

### Pricing:

**Total:** $195,728.00

---

### Three-Year Cost Ownership:

- **IoTps:** $744,172
- **$/kIoTps:** $265,084
### Measurement Results for Performance Run

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<th>Value</th>
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<td>Warmup Run - Start Time</td>
<td>2019-02-10 21:21:37</td>
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<tr>
<td>Warmup Run - End Time</td>
<td>2019-02-10 22:08:45</td>
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<td>Warmup Run Elapsed Time in Seconds</td>
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<tr>
<td>Measured Run Start Time</td>
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<td>Measured Run End Time</td>
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<td>Total Time In Seconds</td>
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### Measurement Results for Repeatability Run

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<td>Warmup Run End Time</td>
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<td>Warmup Run Elapsed Time in Seconds</td>
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<td>Total Time In Seconds</td>
<td>1,676.257</td>
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Run Report for Performance Run

===============================================
TPCx-IoT Performance Metric (IoTps) Report

Total Time For Warmup Run In Seconds = 2,826.72
Total Time In Seconds = 1,691.04
Total Number of Records = 600 Millions

TPCx-IoT Performance Metric (IoTps): 354,811.45

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

Run Report for Repeatability Run

===============================================
TPCx-IoT Performance Metric (IoTps) Report

Total Time For Warmup Run In Seconds = 2,608.36
Total Time In Seconds = 1,676.26
Total Number of Records = 600 Millions

TPCx-IoT Performance Metric (IoTps): 357,940.34

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Report Date: April 02, 2021
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**Abstract**

This document contains the methodology and results of the TPC Express BenchmarkTM IoT (TPCx-IoT) test conducted in conformance with the requirements of the TPCx-IoT Standard Specification, Revision 1.0.3.

The test was conducted for a Scale Factor of 600 Millions records with 8 Dell R7415 Servers running HBase 2.0.0 on Cloudera Distribution for Apache Hadoop Edition 6.0.0 on Red Hat Enterprise Linux Server Release 7.5.

This benchmark is now submitted for the Peer Review Board consisting of members of the TPCx-IoT subcommittee.

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**Measured Configuration**

<table>
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<tr>
<th>Company Name</th>
<th>Cluster Node</th>
<th>Virtualization</th>
<th>Operating System</th>
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<tbody>
<tr>
<td>Dell Inc.</td>
<td>Dell R7415 Server</td>
<td>Not Used</td>
<td>Red Hat Enterprise Linux Server Release 7.5</td>
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**TPC Express Benchmark© IoT Metrics**

<table>
<thead>
<tr>
<th>Total System Cost</th>
<th>IoTps</th>
<th>Price/Performance</th>
<th>Availability Date</th>
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<tbody>
<tr>
<td>265,084 USD</td>
<td>354,811.45</td>
<td>$747.12 USD</td>
<td>May 24, 2019</td>
</tr>
</tbody>
</table>
TPC Express Benchmark™ IoT Overview

TPC Express Benchmark™ IoT (TPCx-IoT) was developed to provide an objective measure of hardware, operating system and commercial NoSQL database 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 IoT Gateway systems in general. The TPCx-IoT stresses both hardware and software including database APIs and network connections to the database. This workload can be used to assess a broad range of NoSQL databases. The TPCx-IoT can be used to assess a range of NoSQL implementations in a technically rigorous and directly comparable and vendor-neutral manner. The metric effectively represents the total number of records that can be inserted into a NoSQL database per second while running queries against the database.

The TPCx-IoT kit is available from the TPC (See www.tpc.org/tpcx-iot for more information). Users must sign-up and agree to the TPCx-IoT 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-IoT copyright. The TPCx-IoT Kit includes: TPCx-IoT Specification document, TPCx-IoT 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-IoT models and represents a NoSQL database mimicking an IoT gateway system)

- 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.

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.

**Measured Configuration:**

![Diagram of measured configuration](image)

The measured configuration consisted of:

- Total Nodes: 8
- Total Processor/Cores/Threads: 8/192/384
- Total Memory: 2.048TB
- Total Number of Storage Devices: 15
- Total Storage Capacity: 13.12TB

Server nodes details:

- 8x Dell PowerEdge R7415 Servers, each with:
  - Processors/Cores/Threads: 1/24/48
  - Processor Model: 1x AMD EPYC™ 7401P 2.0GHz 24-core
  - Memory: 256GB (8 x 32GB RDIMM 2666MT/s Dual Rank)
  - Drives: 1x 240GB SSD SATA (for all Servers) 1x Dell 1.6TB NVMe (for all Data Node Servers)
  - Network: 1x Mellanox Dual Port 25GbE SFP28 NIC
**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**

<table>
<thead>
<tr>
<th>Server Node</th>
<th>Controller</th>
<th>Disk Drive</th>
<th>Description of Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perc HP740p</td>
<td>1 (SSD)</td>
<td>Operating System, Swap, Hadoop Master, Root, Temp</td>
</tr>
<tr>
<td>2-8</td>
<td>Perc HP740p</td>
<td>1 (SSD)</td>
<td>Operating System, Swap, Root, Temp</td>
</tr>
<tr>
<td>2-8</td>
<td>NVMe</td>
<td>NVMe0n1</td>
<td>Data, Temp</td>
</tr>
</tbody>
</table>

**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: Software Component Distribution**

<table>
<thead>
<tr>
<th>Node</th>
<th>NameNode</th>
<th>DataNode</th>
<th>HDFS</th>
<th>HBase</th>
<th>YARN</th>
<th>Zoo Keeper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2-5</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6-8</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

*NoSQL Database version must be disclosed.*
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-IoT 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 Performance Run

TPCx-IoT Performance Metric (IoTps) Report

Total Time For Warmup Run In Seconds = 2,826.72
Total Time In Seconds = 1,691.04
Total Number of Records = 600 Millions

TPCx-IoT Performance Metric (IoTps): 354,811.45

Run Report for Repeatability Run

TPCx-IoT Performance Metric (IoTps) Report

Total Time For Warmup Run In Seconds = 2,608.36
Total Time In Seconds = 1,676.26
Total Number of Records = 600 Millions

TPCx-IoT Performance Metric (IoTps): 357,940.34
2.3 Benchmark Kit Identification

Version number of TPCx-IoT kit and checksum for the jar file and master Programs must be reported.

Kit Version 1.0.3

- 24d1e8079cfdd240f266041bca0333b5 ./TPC-IoT-master.sh
- 68379f9375c7b584fc3253dfe9c4f7a6 ./tpcx-iot/lib/core-0.13.0-SNAPSHOT.jar
- 7bebfe1e17d5c2b380df575fad160d7f8 ./IoT_cluster_validate_suite.sh

2.4 Benchmark Kit changes

No Modifications were made to the TPC provided kit.
Clause 3: Scale Factors and Metrics

3.1 Total Run Time

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Run Time</td>
<td>1,691.04</td>
<td>1,676.26</td>
</tr>
</tbody>
</table>

3.2 Performance and Price Performance

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

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoTps</td>
<td>354,811.45</td>
<td>357,940.34</td>
</tr>
<tr>
<td>$/kIoTps</td>
<td>$747.12</td>
<td></td>
</tr>
</tbody>
</table>

3.3 System Configuration Information

<table>
<thead>
<tr>
<th>Storage System Software</th>
<th>Operating System</th>
<th>Other Software</th>
<th>System Availability Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red Hat Enterprise Linux Server Release 7.5</td>
<td></td>
<td>May 24, 2019</td>
</tr>
</tbody>
</table>

Cloudera 6.0.0

<table>
<thead>
<tr>
<th>Component</th>
<th>Package Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Hadoop</td>
<td>hadoop-3.0.0+cdh6.0.0</td>
</tr>
<tr>
<td>HBase</td>
<td>hbase-2.0.0+cdh6.0.0</td>
</tr>
<tr>
<td>YARN</td>
<td>yarn-3.0.0+cdh6.0.0</td>
</tr>
<tr>
<td>Zookeeper</td>
<td>zookeeper-3.4.5+cdh6.0.0</td>
</tr>
</tbody>
</table>
## Supporting File Index

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

<table>
<thead>
<tr>
<th>Storage System Software</th>
<th>Operating System</th>
<th>System Availability Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause 1</td>
<td>Parameters and options used to configure and tune the SUT</td>
<td>Supporting Files Archive/Clause1</td>
</tr>
<tr>
<td>Clause 2</td>
<td>Configuration Scripts and Run Report</td>
<td>Supporting Files Archive/Clause2</td>
</tr>
<tr>
<td>Clause 3</td>
<td>System Configuration Details</td>
<td>Supporting Files Archive/Clause3</td>
</tr>
</tbody>
</table>