

TPC Express Benchmark™ AI Full Disclosure Report

PowerEdge R6625

with 1x PowerEdge R6625
using

Anaconda3 4.12.0

running on

Red Hat Enterprise Linux 8.6

TPCx-AI Version
Report Edition
Report Submitted

1.0.2
First
November 10, 2022

First Edition - November 2022

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Abstract

Dell conducted the TPC Express Benchmark™ AI (TPCx-AI) on the PowerEdge R6625. The software used included Anaconda3 4.12.0. This report provides full disclosure of the results. All testing was conducted in conformance with the requirements of the TPCx-AI Standard Specification, Revision 1.0.2.

Configuration Overview


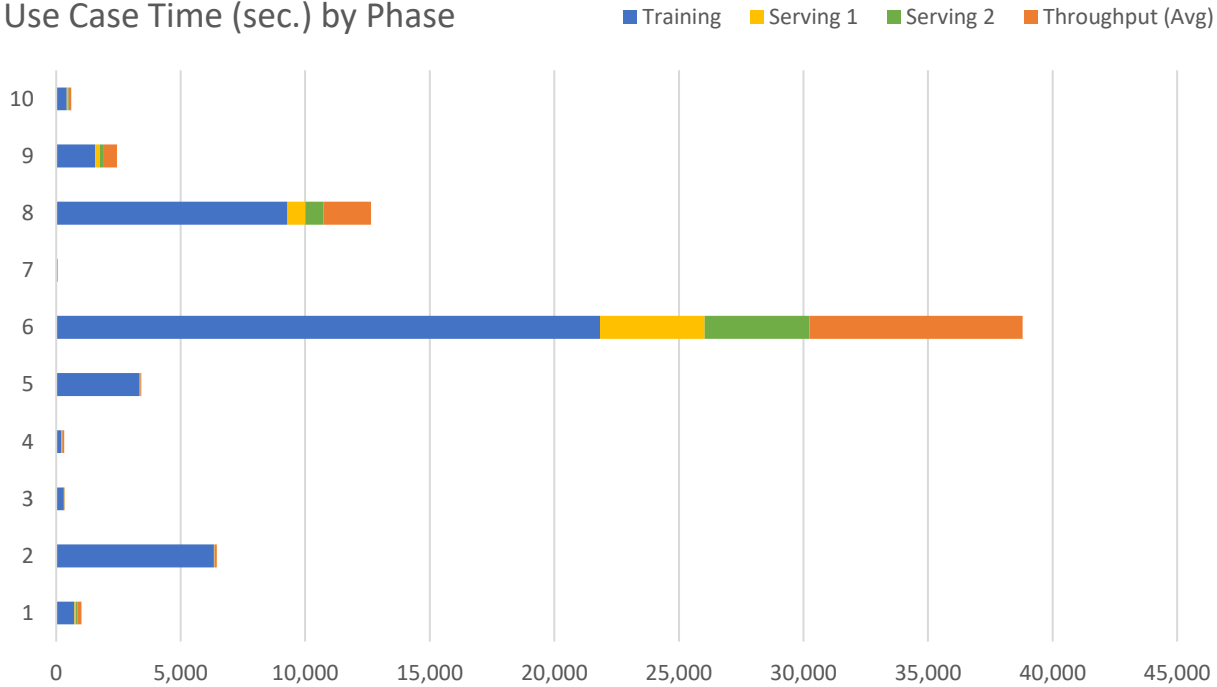
Test Sponsor	Node(s)	Operating System
Dell	1x PowerEdge R6625 (Server)	Red Hat Enterprise Linux 8.6


Metrics Overview


Total System Cost	Performance	Price/Performance	Availability Date
\$71,596 USD	364.59 AIUCpm@30	196.38 USD \$/AIUCpm@30	February 22, 2023

Executive Summary

The [Executive Summary](#) follows on the next several pages.

		<h1>PowerEdge R6625</h1>		TPCx-AI 1.0.2 TPC Pricing 2.8.0 Report Date Nov. 10, 2022																																																							
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Framework Anaconda3 4.12.0	Operating System Red Hat Enterprise Linux 8.6	Other Software N/A	Scale Factor 30	Streams 80																																																							
<h3>Use Case Time (sec.) by Phase</h3>  <table border="1"> <caption>Approximate Use Case Time (sec.) by Phase</caption> <thead> <tr> <th>Phase</th> <th>Training (sec)</th> <th>Serving 1 (sec)</th> <th>Serving 2 (sec)</th> <th>Throughput (Avg) (sec)</th> </tr> </thead> <tbody> <tr><td>1</td><td>1000</td><td>500</td><td>0</td><td>0</td></tr> <tr><td>2</td><td>6000</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>3</td><td>1000</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>4</td><td>1000</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>5</td><td>4000</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>6</td><td>22000</td><td>4000</td><td>3000</td><td>8000</td></tr> <tr><td>7</td><td>1000</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>8</td><td>10000</td><td>1000</td><td>1000</td><td>2000</td></tr> <tr><td>9</td><td>1000</td><td>500</td><td>0</td><td>0</td></tr> <tr><td>10</td><td>1000</td><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>					Phase	Training (sec)	Serving 1 (sec)	Serving 2 (sec)	Throughput (Avg) (sec)	1	1000	500	0	0	2	6000	0	0	0	3	1000	0	0	0	4	1000	0	0	0	5	4000	0	0	0	6	22000	4000	3000	8000	7	1000	0	0	0	8	10000	1000	1000	2000	9	1000	500	0	0	10	1000	0	0	0
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10	1000	0	0	0																																																							
Physical Storage / Scale Factor 400.00	Scale Factor / Physical Memory 0.04	Main Data Redundancy Model RAID 5																																																									
Servers: Total Processors/Cores/Threads	1 2 / 32 / 64																																																										
Server Type Processors Memory Storage Controller Storage Device Network Controller	1x PowerEdge R6625 (Server) 2x AMD EPYC 9174F 16-Core Processor 768 GiB 1x PERC H965i 24G SAS 2x 240 GB M.2 SATA; 3x 3.84 TB NVMe 1x Broadcom NetXtreme 1GB 2-port																																																										

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Maintenance	Hardware							PowerEdge R6625 Server	210-ATCF	1	\$91,636.00	1	\$91,636.00		2.5 Chassis	379-BDTF	1	0	1			NVMe Backplane	379-BDSX	1	0	1			Trusted Platform Module 2.0 V3	461-AAIG	1	0	1			C03-03 : 8x U.2 G4 RAID - Low Z (FPERC 12)	321-BIIN	1	0	1			AMD EPYC 9174F 4.10GHz, 16C/32T, 256M Cache (320W) DDR5-4800	338-CGXE	1	0	1			AMD EPYC 9174F 4.10GHz, 16C/32T, 256M Cache (320W) DDR5-4800	338-CGXE	1	0	1			Performance Optimized	370-AAIP	1	0	1			4800MT/s RDIMMs	370-AHCL	1	0	1			32GB RDIMM, 4800MT/s Dual Rank	370-AGZP	1	0	24			C31, No RAID with NVMe and front PERC	379-BEGI	1	0	1			PERC H965i with floating brackets for lowz	405-ABDN	1	0	1			Front PERC Mechanical Parts,rear load	750-ACFQ	1	0	1			No Hard Drive	400-ABHL	1	0	1			3.84TB Enterprise NVMe Read Intensive AG Drive U.2 Gen4 with carrier	400-BKGL	1	0	3			Performance BIOS Settings	384-BBBL	1	0	1			UEFI BIOS Boot Mode with GPTPartition	800-BBDM	1	0	1			High Performance Fan for CPUgreater than or equal to 180W(2 CPU)	750-ADJI	1	0	1			Dual, Hot-plug, Fully Redundant Power Supply (1+1), 1400W, Mixed Mode, NAF	450-AIQX	1	0	1			Power Cord - C13, 3M, 125V, 15A (North America, Guam, North Marianas, Philippines, Samoa, Vietnam)	450-AALV	1	0	2			Riser Config 2, 1 x 16 LP PCIe slot (CPU1), 2 x 16 LP PCieslot (CPU2)	330-BBNR	1	0	1			PowerEdge R6625 Motherboard	384-BCWP	1	0	1			Broadcom 5720 Dual Port 1GbE Optional LOM	540-BDKD	1	0	1			iDRAC9,Enterprise 15G	385-BBOT	1	0	1			Dell EMC Luggage Tag (x8 or x10 chassis)	350-BBXP	1	0	1			Standard Bezel	325-BCHH	1	0	1			No Quick Sync	350-BBXM	1	0	1			iDRAC,Factory Generated Password	379-BCSF	1	0	1			Red Hat Enterprise Linux 8.6 (Ootpa), kernel 4.18.0-372.9.1.el8.x86_64	605-BBFL	1	0	1			ReadyRails Sliding Rails Without Cable Management Arm or Strain Relief Bar	770-BECD	1	0	1			Cable Management Arm	770-BDMT	1	0	1			Keyboard and Optical Mouse, USB, Black, English	570-AAKV, 580-ADJC	1	0	1			BOSS-S2 controller card + with 2 M.2 240GB (RAID 1)	403-BCMG	1	0	1			No Systems Documentation, NoOpenManage DVD Kit	631-AACK	1	0	1			PowerEdge R6625 Shipping Material 4	340-COXQ	1	0	1			PowerEdge R6625 CCC Marking, No CE Marking	389-DTIQ	1	0	1			US Order	332-1286	1	0	1			Dell Hardware Limited Warranty Plus On-Site Service	828-3901	1	\$200.01	1		\$200.01	ProSupport Mission Critical:4-Hour 7x24 On-Site Service with Emergency Dispatch 3 Years	828-3855	1	\$940.00	1		\$940.00	ProSupport Mission Critical:7x24 HW / SW Technical Support and Assistance 3 Years	828-3847	1	\$1,816.00	1		\$1,816.00	Dell 24 Monitor	210-AIWG	1	\$169.99	1		\$169.99					Subtotal	\$91,636.00	\$3,126.00	Software							Anaconda Pro 1 Subscription (1 year)		2	\$10,000.00	1		\$10,000.00					Subtotal	\$0.00	\$10,000.00	Large Purchase Discount (35%)*					-\$32,072.60	-\$1,094.10					Total	\$59,563.40	\$12,031.90
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Power Cord - C13, 3M, 125V, 15A (North America, Guam, North Marianas, Philippines, Samoa, Vietnam)	450-AALV	1	0	2																																																																																																																																																																																																																																																																																																																																																					
Riser Config 2, 1 x 16 LP PCIe slot (CPU1), 2 x 16 LP PCieslot (CPU2)	330-BBNR	1	0	1																																																																																																																																																																																																																																																																																																																																																					
PowerEdge R6625 Motherboard	384-BCWP	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Broadcom 5720 Dual Port 1GbE Optional LOM	540-BDKD	1	0	1																																																																																																																																																																																																																																																																																																																																																					
iDRAC9,Enterprise 15G	385-BBOT	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Dell EMC Luggage Tag (x8 or x10 chassis)	350-BBXP	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Standard Bezel	325-BCHH	1	0	1																																																																																																																																																																																																																																																																																																																																																					
No Quick Sync	350-BBXM	1	0	1																																																																																																																																																																																																																																																																																																																																																					
iDRAC,Factory Generated Password	379-BCSF	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Red Hat Enterprise Linux 8.6 (Ootpa), kernel 4.18.0-372.9.1.el8.x86_64	605-BBFL	1	0	1																																																																																																																																																																																																																																																																																																																																																					
ReadyRails Sliding Rails Without Cable Management Arm or Strain Relief Bar	770-BECD	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Cable Management Arm	770-BDMT	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Keyboard and Optical Mouse, USB, Black, English	570-AAKV, 580-ADJC	1	0	1																																																																																																																																																																																																																																																																																																																																																					
BOSS-S2 controller card + with 2 M.2 240GB (RAID 1)	403-BCMG	1	0	1																																																																																																																																																																																																																																																																																																																																																					
No Systems Documentation, NoOpenManage DVD Kit	631-AACK	1	0	1																																																																																																																																																																																																																																																																																																																																																					
PowerEdge R6625 Shipping Material 4	340-COXQ	1	0	1																																																																																																																																																																																																																																																																																																																																																					
PowerEdge R6625 CCC Marking, No CE Marking	389-DTIQ	1	0	1																																																																																																																																																																																																																																																																																																																																																					
US Order	332-1286	1	0	1																																																																																																																																																																																																																																																																																																																																																					
Dell Hardware Limited Warranty Plus On-Site Service	828-3901	1	\$200.01	1		\$200.01																																																																																																																																																																																																																																																																																																																																																			
ProSupport Mission Critical:4-Hour 7x24 On-Site Service with Emergency Dispatch 3 Years	828-3855	1	\$940.00	1		\$940.00																																																																																																																																																																																																																																																																																																																																																			
ProSupport Mission Critical:7x24 HW / SW Technical Support and Assistance 3 Years	828-3847	1	\$1,816.00	1		\$1,816.00																																																																																																																																																																																																																																																																																																																																																			
Dell 24 Monitor	210-AIWG	1	\$169.99	1		\$169.99																																																																																																																																																																																																																																																																																																																																																			
				Subtotal	\$91,636.00	\$3,126.00																																																																																																																																																																																																																																																																																																																																																			
Software																																																																																																																																																																																																																																																																																																																																																									
Anaconda Pro 1 Subscription (1 year)		2	\$10,000.00	1		\$10,000.00																																																																																																																																																																																																																																																																																																																																																			
				Subtotal	\$0.00	\$10,000.00																																																																																																																																																																																																																																																																																																																																																			
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				Total	\$59,563.40	\$12,031.90																																																																																																																																																																																																																																																																																																																																																			
<p>Pricing: 1 = Dell; 2 = Anaconda</p> <p>* Discount applies to all line items where Source = 1. Discount based upon total system cost as purchased by a regular customer.</p> <p>Audited by Doug Johnson, InfoSizing</p>	<p>Total System Cost (USD): \$71,596</p> <p>AIUCpm@30: 364.59</p> <p>\$/AIUCpm@30: \$196.38</p>																																																																																																																																																																																																																																																																																																																																																								
<p><i>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.</i></p>																																																																																																																																																																																																																																																																																																																																																									

	<h1>PowerEdge R6625</h1>		TPCx-AI	1.0.2
			TPC Pricing	2.8.0
			Report Date	Nov. 10, 2022
<u>Numerical Quantities</u>				
AIUCpm@30	364.59	T_{Load}	6.32	
Scale Factor	30	T_{LD}	6.32	
Streams	80	T_{PTT}	1,145.16	
Kit Version	1.0.2	T_{PST1}	54.34	
Execution Status	Pass	T_{PST2}	54.48	
Accuracy Status	Pass	T_{PST}	54.48	
		T_{TT}	15.07	
Test Times				
Overall Run Start Time	2022-10-23 12:39:23.182			
Overall Run End Time	2022-10-24 07:19:25.693			
Overall Run Elapsed Time	67,202.511			
Load Test Start Time	2022-10-23 12:44:09.595			
Load Test End Time	2022-10-23 12:44:15.933			
Load Test Elapsed Time	6.338			
Power Training Start Time	2022-10-23 12:44:15.935			
Power Training End Time	2022-10-24 00:59:14.891			
Power Training Elapsed Time	44,098.956			
Power Serving 1 Start Time	2022-10-24 00:59:14.894			
Power Serving 1 End Time	2022-10-24 02:26:48.576			
Power Serving 1 Elapsed Time	5,253.682			
Power Serving 2 Start Time	2022-10-24 02:26:48.579			
Power Serving 2 End Time	2022-10-24 03:54:53.628			
Power Serving 2 Elapsed Time	5,285.049			
Scoring Start Time	2022-10-24 03:55:30.479			
Scoring End Time	2022-10-24 03:58:24.774			
Scoring Elapsed Time	174.295			
Throughput Start Time	2022-10-24 03:58:24.790			
Throughput End Time	2022-10-24 07:19:25.690			
Throughput Elapsed Time	12,060.900			



PowerEdge R6625

TPCx-AI 1.0.2
 TPC Pricing 2.8.0
 Report Date Nov. 10, 2022

Numerical Quantities (continued)

Use Case Times & Accuracy

Use Case	Training (sec)	Serving 1 (sec)	Serving 2 (sec)	Throughput (avg)	Accuracy
UC01	741.469	64.411	63.882	154.247	0.000
UC02	6,330.192	16.074	16.117	86.097	0.150
UC03	311.857	4.636	4.638	13.189	3.553
UC04	203.830	23.883	23.660	68.210	0.706
UC05	3,358.038	10.646	10.592	45.498	0.016
UC06	21,836.421	4,191.985	4,214.859	8,554.806	0.544
UC07	28.226	9.117	9.251	26.446	1.002
UC08	9,283.332	725.052	733.361	1,900.105	0.760
UC09	1,576.243	168.350	168.666	524.123	1.000
UC10	429.238	39.432	39.923	101.030	0.817

Use Case Serving Times (sec.)

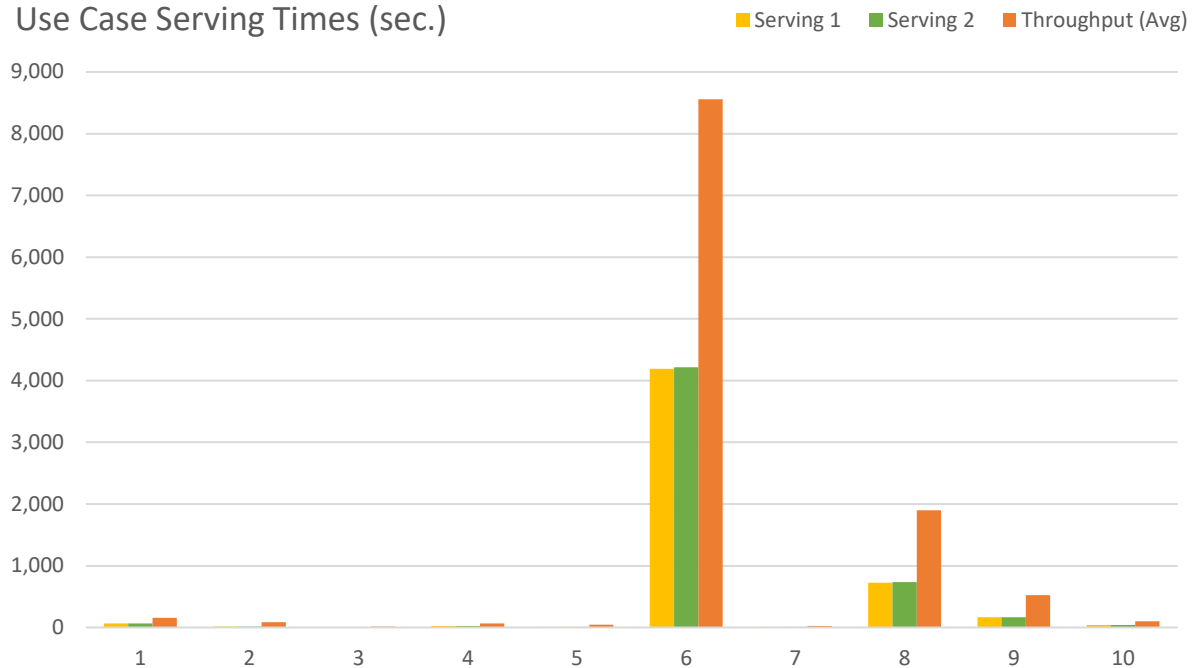


Table of Contents

Abstract..... 3

Executive Summary 3

Table of Contents..... 8

Clause 0 – Preamble10

 0.1 TPC Express Benchmark™ AI Overview10

Clause 1 – General Items12

 1.1 Test Sponsor12

 1.2 Parameter Settings12

 1.3 Configuration Diagrams12

 1.3.1 Measured Configuration.....13

 1.3.2 Differences Between the Measured and the Priced Configurations.....13

Clause 2 – SW Components & Data Distribution14

 2.1 Roles and Dataset Distribution.....14

 2.2 File System Implementation.....14

 2.3 Execution Engine, Frameworks, Driver & Libraries14

 2.4 Applied Patches.....14

Clause 3 – Workload Related Items.....15

 3.1 Hardware & Software Tuning.....15

 3.2 Kit Version & Modifications15

 3.3 Use Case Elapsed Times.....15

 3.4 SUT Validation Test Output21

 3.5 Configuration Parameters22

Clause 4 – SUT Related Items.....23

 4.1 Specialized Hardware/Software23

 4.2 Configuration Files23

 4.3 SUT Environment Information.....23

 4.4 Data Storage to Scale Factor Ratio.....23

 4.5 Scale Factor to Memory Ratio.....23

 4.6 Output of Tests23

 4.7 Additional Sponsor Files23

 4.8 Model Optimizations23

Clause 5 – Metrics and Scale Factor24

 5.1 Reported Performance Metrics24

5.2 Throughput Test Stream Times.....25

Auditor's Information26

Third-Party Price Quotes.....29

 Anaconda29

Supporting Files Index31

Clause 0 – Preamble

0.1 TPC Express Benchmark™ AI Overview

Artificial intelligence (AI) has become a key transformational technology of our times. Advances in neural networks and other machine learning techniques have made it possible to use AI on a variety of use cases. From the public sector to aerospace, defense and academia, new and improved ways to use AI techniques are changing the way we harness data and analytics. This along with advances in compute, interconnect and memory technologies have made possible to solve complicated challenges that will ultimately benefit customers in production datacenter and cloud environments.

Abundant volumes of rich data from text, images, audio and video are the essential starting point for creating a benchmark that would represent the myriad of use cases and customers. TPC Express Benchmark™ AI (TPCx-AI) is created in keeping with the TPC tradition of emulating real world AI scenarios and data science use cases. Unlike most other AI benchmarks, the TPCx-AI uses a diverse dataset and is able to scale across a wide range of scale factors. TPCx-AI may later expand with additional use cases and add additional flexibility for a greater variety of implementations.

The benchmark defines and provides a means to evaluate the System Under Test (SUT) performance as a general-purpose data science system that:

- Generates and processes large volumes of data.
- Trains preprocessed data to produce realistic machine learning models.
- Conducts accurate insights for real-world customer scenarios based on the generated models.
- Can scale to large scale distributed configurations.
- Allows for flexibility in configuration changes to meet the demands of the dynamic AI landscape.

The benchmark models real-life examples of companies and public-sector organizations that use a range of analytics techniques, both AI and more traditional machine learning approaches, as well as the potential application of these techniques in situations like those in which they have already been successfully deployed. In addition, the benchmark measures end to end time to provide insights for individual use cases, as well as throughput metrics to simulate multiuser environments for a given hardware, operating system, and data processing system configuration under a controlled, complex, multi-user AI or machine learning data science workload.

The purpose of TPC benchmarks is to provide relevant, objective performance data to industry users. To achieve that purpose, TPC benchmark specifications require benchmark runs 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-AI models and represents complex, high data volume, decision support environments).
- Would plausibly be implemented.

The TPCx-AI kit is available from the TPC website (see www.tpc.org/tpcx-ai/ for more information). Users must sign up and agree to the TPCx-AI 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-AI copyright. The TPCx-AI kit includes: TPCx-AI Specification document (this document), TPCx-AI Users Guide (README.md) documentation, scripts to set up the benchmark environment, code to execute the benchmark workload, Data Generator, use case related files, and Benchmark Driver.

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

This benchmark was sponsored by Dell Inc..

1.2 Parameter Settings

The [Supporting Files Archive](#) contains the parameters and options used to configure the components involved in this benchmark.

1.3 Configuration Diagrams

The measured configuration diagram is shown below. In addition, any differences between the measured and the priced configurations are described.

1.3.1 Measured Configuration

Nodes:	1	
Processors/Cores/Threads:	2/32/64	Storage Devices: 5
Total Memory:	768 GiB	Storage Capacity: 12,000 GB

The diagram illustrates the hardware configuration of a server node. It features two CPUs, CPU 0 and CPU 1, connected via xGMI. CPU 0 is connected to DIMMs 0, 1, 2, 3, 11, and 12. CPU 1 is connected to DIMMs 12, 13, 14, 15, and 23. Both CPUs are connected to a RAID Card, which is connected to a RAID 5 array of three NVME SSDs. CPU 0 is also connected to two 240GB M.2 SATA SSDs (RAID1, DELL BOSS S1 OS) and a NIC.

<u>Server</u>	
Server	1x PowerEdge R6625
Procs/Cores/Threads:	2/16/32
Processor Model:	2x AMD EPYC 9174F 16-Core Processor
Memory:	768 GiB
Storage Controller:	1x PERC H965i 24G SAS
Storage Devices:	2x 240 GB M.2 SATA 3x 3.84 TB NVMe
Network Controller:	1x Broadcom NetXtreme 1GB 2-port

The distribution of software components over server nodes is detailed in [Clause 2](#).

1.3.2 Differences Between the Measured and the Priced Configurations

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

Clause 2 – SW Components & Data Distribution

2.1 Roles and Dataset Distribution

Table 2-1 describes the distribution of the dataset across all media in the SUT.

Server	Host Name	SW Services	Storage	Contents
1x PowerEdge R6625	R6625-03	All	2x 240 GB M.2 SATA 3x 3.84 TB NVMe	OS Data

Table 2-1 Software Components and Dataset Distribution

2.2 File System Implementation

A local file system provided by Red Hat Enterprise Linux 8.6 / Anaconda3 4.12.0 was used for data generation and the Load Test. The data set was not relocated after generation and before the Load Test.

2.3 Execution Engine, Frameworks, Driver & Libraries

Anaconda3 4.12.0 consisted of the following components.

Component	Version
python	3.8.13
setuptools	63.4.1
pandas	1.4.4
scikit-learn	1.1.2
xgboost	1.5.0
numpy	1.23.1
nose	1.3.7
scipy	1.9.1
statsmodels	0.12.2
patsy	0.5.2
tqdm	4.64.1
keras	2.8.0
tensorflow	2.8.2
joblib	1.1.0
opencv	4.6.0
pyyaml	6
matplotlib	3.5.2
jinja2	3.0.3
pycryptodome	3.15.0

Table 2-2 Software Components

For a detailed listing of installed libraries, please see the envInfo logs in the [Supporting Files](#).

2.4 Applied Patches

No additional vendor-supported patches were applied to the SUT.

Clause 3 – Workload Related Items

3.1 Hardware & Software Tuning

The [Supporting Files](#) archive contains all hardware and software configuration scripts.

3.2 Kit Version & Modifications

Table 3-1 shows the version of the TPCx-AI used to produce this result along with any kit files that were modified to facilitate system, platform, and framework differences.

TPCx-AI Kit Version	1.0.2
<u>Modified File</u>	<u>Description of Changes</u>
tools/python/dataRedundancyInformation.sh	Added platform specific data collection.
tools/python/python-ks.yaml	Adjusted for software versions used.
See Auditor's Note	

Table 3-1 Kit Version & Modifications

3.3 Use Case Elapsed Times

Below are the elapsed times for each use case. Use cases are grouped based on whether they use Deep Learning or Machine Learning techniques.

Type	UC ID	P1	P2	T1	T2	T3	T4
Deep Learning	2	16.074	16.117	60.270	67.268	79.298	80.160
	5	10.646	10.592	65.095	64.371	26.648	29.509
	9	168.350	168.666	442.659	401.745	453.309	459.672
Machine Learning	1	64.411	63.882	128.496	143.229	117.443	142.876
	3	4.636	4.638	10.946	14.564	25.567	13.990
	4	23.883	23.660	50.312	59.480	44.396	67.732
	6	4,191.985	4,214.859	9,082.743	8,392.103	8,256.037	8,341.729
	7	9.117	9.251	24.097	16.354	21.751	18.217
	8	725.052	733.361	1,900.262	1,920.880	1,771.268	1,913.819
	10	39.432	39.923	97.972	94.227	106.878	98.132

Type	UC ID	T5	T6	T7	T8	T9	T10
Deep Learning	2	19.873	92.003	104.597	76.882	82.514	113.965
	5	40.397	44.521	37.676	9.301	44.301	50.314
	9	470.881	685.501	678.005	752.357	505.040	561.775
Machine Learning	1	159.777	203.947	153.847	93.819	131.553	157.758
	3	14.423	18.059	14.206	11.312	9.843	13.028
	4	70.026	182.489	95.453	127.802	109.718	65.988
	6	8,795.589	8,793.544	7,743.350	8,962.505	8,326.570	8,892.376
	7	26.393	19.435	24.606	51.582	26.824	16.128
	8	2,162.998	1,893.171	1,507.916	1,756.360	1,634.852	1,878.834
	10	164.846	83.092	190.783	70.841	99.581	78.262

Type	UC ID	T11	T12	T13	T14	T15	T16
Deep Learning	2	112.965	102.881	120.509	146.786	87.555	16.541
	5	60.812	22.792	33.741	58.957	42.423	95.900
	9	789.782	573.373	462.215	473.431	664.354	516.593
Machine Learning	1	156.666	86.798	128.243	156.195	205.237	136.755
	3	15.693	6.577	23.638	9.530	24.614	5.224
	4	62.507	65.354	130.690	54.642	88.197	29.074
	6	8,466.842	8,678.420	8,757.587	8,331.695	7,621.618	8,955.100
	7	22.354	34.275	40.734	16.114	58.217	32.490
	8	1,617.342	2,044.570	2,103.551	1,843.399	1,947.748	2,060.334
	10	104.948	77.771	78.549	94.962	103.728	101.233

Type	UC ID	T17	T18	T19	T20	T21	T22
Deep Learning	2	145.165	96.969	95.369	97.336	60.273	79.627
	5	45.575	56.512	53.314	33.399	42.435	28.942
	9	625.960	542.967	422.912	468.927	470.977	479.212
Machine Learning	1	161.509	128.998	117.468	118.074	181.700	176.963
	3	11.127	13.267	9.276	16.220	9.239	11.269
	4	28.625	62.186	48.545	64.910	66.633	49.393
	6	8,738.767	8,837.415	8,471.921	7,763.714	7,958.141	8,442.970
	7	28.886	26.245	23.193	36.155	22.228	19.250
	8	1,999.097	1,872.125	1,790.310	2,116.666	1,821.038	1,930.931
	10	149.305	98.548	76.971	95.144	123.912	81.349

Type	UC ID	T23	T24	T25	T26	T27	T28
Deep Learning	2	85.032	102.305	146.238	16.117	161.680	114.301
	5	27.932	61.576	39.568	16.414	46.316	55.609
	9	522.090	541.315	427.674	670.362	540.535	602.128
Machine Learning	1	154.193	135.683	132.406	261.879	144.431	274.815
	3	21.108	11.710	11.852	15.457	18.740	10.151
	4	49.153	53.201	48.800	188.491	61.302	62.872
	6	8,846.945	8,879.632	8,313.012	8,831.242	8,889.669	7,856.935
	7	38.961	18.318	18.038	21.343	24.095	30.516
	8	1,575.064	1,884.858	1,857.859	1,913.840	2,043.791	1,452.965
	10	140.327	60.046	94.129	115.344	82.482	150.841

Type	UC ID	T29	T30	T31	T32	T33	T34
Deep Learning	2	72.487	32.338	35.061	74.597	105.710	72.600
	5	48.848	42.936	64.065	45.130	58.696	31.355
	9	483.656	466.084	466.692	471.173	553.986	445.154
Machine Learning	1	158.708	178.269	147.079	160.667	133.118	117.928
	3	4.690	8.028	28.399	10.783	14.499	13.449
	4	67.225	58.600	116.391	66.062	65.453	52.871
	6	8,751.035	8,982.413	7,876.093	8,911.361	7,890.485	8,380.460
	7	24.482	24.230	64.823	11.015	21.870	35.608
	8	2,237.389	1,809.356	2,200.689	2,074.829	2,126.350	1,749.005
	10	101.850	103.973	230.655	85.682	86.115	75.892

Type	UC ID	T35	T36	T37	T38	T39	T40
Deep Learning	2	68.944	70.723	82.653	89.528	127.982	167.566
	5	75.227	27.856	44.586	52.699	19.599	100.039
	9	444.943	520.760	453.730	905.163	446.712	498.936
Machine Learning	1	116.855	131.586	139.845	176.036	133.301	142.572
	3	16.141	16.298	11.619	13.671	15.310	12.027
	4	49.289	56.089	61.302	67.251	72.718	72.293
	6	8,341.704	8,367.078	8,777.940	7,720.355	9,014.579	8,120.038
	7	18.359	25.419	18.863	30.634	22.066	53.546
	8	1,995.731	1,836.383	2,218.951	2,005.887	2,067.673	1,660.705
	10	79.218	103.972	95.077	109.082	100.833	116.992

Type	UC ID	T41	T42	T43	T44	T45	T46
Deep Learning	2	107.548	75.650	91.721	146.849	30.000	102.397
	5	45.717	22.769	8.982	45.359	57.438	43.254
	9	614.518	391.508	596.345	626.523	459.420	516.619
Machine Learning	1	170.534	142.397	98.491	118.231	147.662	142.277
	3	8.529	5.458	14.838	30.710	9.659	9.639
	4	59.499	41.371	60.954	67.982	60.513	49.495
	6	8,292.671	9,143.745	8,936.882	8,824.396	9,083.242	8,382.981
	7	25.647	19.712	19.761	23.322	23.988	20.233
	8	2,040.571	1,953.633	2,010.548	1,863.203	1,968.632	1,427.748
	10	97.825	115.840	94.523	94.080	68.189	74.341

Type	UC ID	T47	T48	T49	T50	T51	T52
Deep Learning	2	64.791	23.649	98.604	106.373	21.264	153.843
	5	28.282	65.976	39.504	75.152	11.788	53.669
	9	468.612	462.387	396.669	519.689	522.348	581.845
Machine Learning	1	142.111	128.833	127.395	197.601	120.060	132.473
	3	14.658	9.365	8.043	24.234	23.643	11.295
	4	52.274	97.335	163.443	52.619	51.082	96.941
	6	7,902.708	8,784.131	9,044.142	8,249.399	8,854.219	8,409.158
	7	21.741	22.318	14.386	38.067	24.222	20.915
	8	2,216.805	2,232.986	1,631.643	1,481.166	2,011.125	1,365.976
	10	82.245	75.434	94.704	100.826	76.241	93.236

Type	UC ID	T53	T54	T55	T56	T57	T58
Deep Learning	2	66.179	104.170	75.980	110.682	88.655	67.429
	5	55.747	52.644	40.840	70.146	44.884	34.580
	9	465.378	506.229	521.199	582.934	560.331	521.105
Machine Learning	1	106.619	88.645	242.153	95.651	209.858	146.923
	3	13.816	12.268	10.463	14.506	30.391	12.461
	4	38.772	60.508	70.164	113.275	63.556	57.734
	6	8,731.650	8,856.116	8,159.765	8,808.516	7,886.230	8,503.234
	7	13.988	22.378	41.956	62.771	23.278	21.596
	8	2,272.672	1,994.997	1,939.662	1,955.176	1,986.709	1,894.137
	10	83.439	75.703	192.359	103.308	103.403	106.837

Type	UC ID	T59	T60	T61	T62	T63	T64
Deep Learning	2	55.907	99.527	60.018	30.676	91.114	123.962
	5	23.604	62.348	33.254	46.744	50.005	47.402
	9	640.753	420.817	496.026	751.612	460.584	508.992
Machine Learning	1	130.399	118.415	342.121	179.027	243.401	207.124
	3	11.979	13.080	8.385	5.465	10.952	15.525
	4	66.560	76.091	62.002	32.381	44.235	67.144
	6	7,869.452	8,416.514	8,466.419	8,979.494	8,669.073	7,918.318
	7	20.207	23.144	16.140	11.992	21.521	57.714
	8	2,059.855	1,843.219	1,659.761	1,424.128	2,188.875	1,866.085
	10	105.229	95.384	113.676	97.007	88.745	138.622

Type	UC ID	T65	T66	T67	T68	T69	T70
Deep Learning	2	69.805	118.611	97.002	93.575	28.993	61.310
	5	62.258	79.598	32.424	46.002	45.910	79.559
	9	339.347	627.821	479.307	499.288	398.823	398.040
Machine Learning	1	218.850	133.523	131.887	179.776	96.603	121.128
	3	13.517	11.139	9.462	11.195	5.369	8.824
	4	71.401	60.533	53.780	55.683	40.309	31.082
	6	8,935.586	8,323.684	8,775.185	8,735.503	9,314.289	8,853.953
	7	21.651	35.937	18.898	24.338	25.101	24.721
	8	1,913.643	1,409.450	2,212.502	2,324.134	1,761.109	2,231.666
	10	95.253	89.240	132.105	85.008	95.998	114.312

Type	UC ID	T71	T72	T73	T74	T75	T76
Deep Learning	2	149.397	103.986	160.658	68.765	30.350	19.703
	5	42.461	60.479	44.096	53.288	43.237	24.782
	9	592.708	416.020	523.984	403.741	779.691	453.883
Machine Learning	1	110.356	147.030	112.371	127.421	215.633	189.728
	3	5.448	14.026	10.306	17.346	9.340	5.134
	4	62.686	55.938	49.198	61.480	76.600	65.772
	6	8,404.631	8,377.729	8,532.086	8,296.517	8,679.720	8,892.895
	7	21.740	22.737	19.043	23.253	65.316	10.296
	8	2,025.921	1,706.380	1,572.648	1,627.531	1,838.754	2,207.405
	10	75.508	91.047	68.937	92.162	124.950	70.952

Type	UC ID	T77	T78	T79	T80
Deep Learning	2	85.299	26.853	77.427	134.402
	5	21.082	42.724	45.897	10.536
	9	466.909	462.107	471.567	661.400
Machine Learning	1	165.231	118.098	171.410	295.600
	3	7.947	7.810	11.970	21.394
	4	66.074	83.005	58.981	64.811
	6	8,932.169	9,040.131	8,781.416	8,974.807
	7	22.022	13.202	24.561	24.116
	8	2,026.484	1,872.517	2,258.619	1,531.537
	10	99.015	79.325	100.092	93.760

Table 3-2 Use Case Elapsed Times

3.4 SUT Validation Test Output

<u>Validation Run Report</u>			
AIUCpm@1	256.60	T _{Load}	0.60
Scale Factor	1	T _{LD}	0.60
Streams	80	T _{PTT}	31.02
Kit Version	1.0.2	T _{PST1}	4.00
Execution Status	Pass	T _{PST2}	4.00
Accuracy Status	Pass	T _{PST}	4.00
		T _{TT}	0.40
Test Times			
Overall Run Start Time	2022-10-23 12:02:49.714		
Overall Run End Time	2022-10-23 12:37:31.304		
Overall Run Elapsed Time	2,081.590		
Load Test Start Time	2022-10-23 12:04:06.180		
Load Test End Time	2022-10-23 12:04:06.799		
Load Test Elapsed Time	0.619		
Power Training Start Time	2022-10-23 12:04:06.801		
Power Training End Time	2022-10-23 12:26:58.449		
Power Training Elapsed Time	1,371.648		
Power Serving 1 Start Time	2022-10-23 12:26:58.451		
Power Serving 1 End Time	2022-10-23 12:28:20.191		
Power Serving 1 Elapsed Time	81.740		
Power Serving 2 Start Time	2022-10-23 12:28:20.193		
Power Serving 2 End Time	2022-10-23 12:29:41.730		
Power Serving 2 Elapsed Time	81.537		
Scoring Start Time	2022-10-23 12:30:18.794		
Scoring End Time	2022-10-23 12:32:04.985		
Scoring Elapsed Time	106.191		
Throughput Start Time	2022-10-23 12:32:05.001		
Throughput End Time	2022-10-23 12:37:31.300		
Throughput Elapsed Time	326.299		
(continued on next page)			

Validation Run Report (continued)

Accuracy Metrics					
Use Case	Metric Name	Metric	Criteria	Threshold	Status
1	N/A	0.000	N/A	0.00	Pass
2	word_error_rate	0.328	<=	0.50	Pass
3	mean_squared_log_error	4.582	<=	5.40	Pass
4	f1_score	0.701	>=	0.65	Pass
5	mean_squared_log_error	0.013	<=	0.50	Pass
6	matthews_corrcoef	0.462	>=	0.19	Pass
7	median_absolute_error	0.891	<=	1.80	Pass
8	accuracy_score	0.717	>=	0.65	Pass
9	accuracy_score	1.000	>=	0.90	Pass
10	accuracy_score	0.817	>=	0.70	Pass

3.5 Configuration Parameters

The [Supporting Files](#) archive contains all Global Benchmark Parameter and Use Case Specific Parameter settings.

Clause 4 – SUT Related Items

4.1 Specialized Hardware/Software

No Specialized Hardware/Software was used in the SUT.

4.2 Configuration Files

The [Supporting Files](#) archive contains all configuration files.

4.3 SUT Environment Information

All envInfo.log files are included in the [Supporting Files](#) archive.

4.4 Data Storage to Scale Factor Ratio

The details of the Data Storage Ratio are provided below.

Node Count	Disks	Size (GB)	Total (GB)
1	2	240	480
1	3	3,840	11,520

Total Storage (GB)	12,000
Scale Factor	30
Data Storage Ratio	400.00

4.5 Scale Factor to Memory Ratio

The details of the Memory to Scale Factor Ratio are provided below.

Nodes	Memory (GiB)	Total (GiB)
1	768	768

Scale Factor	30
Total Memory (GiB)	768
SF / Memory Ratio	0.04

4.6 Output of Tests

The [Supporting Files](#) archive contains the output files of all tests.

4.7 Additional Sponsor Files

The [Supporting Files](#) archive contains any additional files that were used.

4.8 Model Optimizations

The [Supporting Files](#) archive contains any model optimization files that were used.

Clause 5 – Metrics and Scale Factor

5.1 Reported Performance Metrics

Metric Overview

TPCx-AI Performance Metric	364.59	AIUCpm@30
TPCx-AI Price/Performance Metric	196.38	\$/AIUCpm@30
TPCx-AI Scale Factor	30	
TPCx-AI Stream Count	80	

Test Times

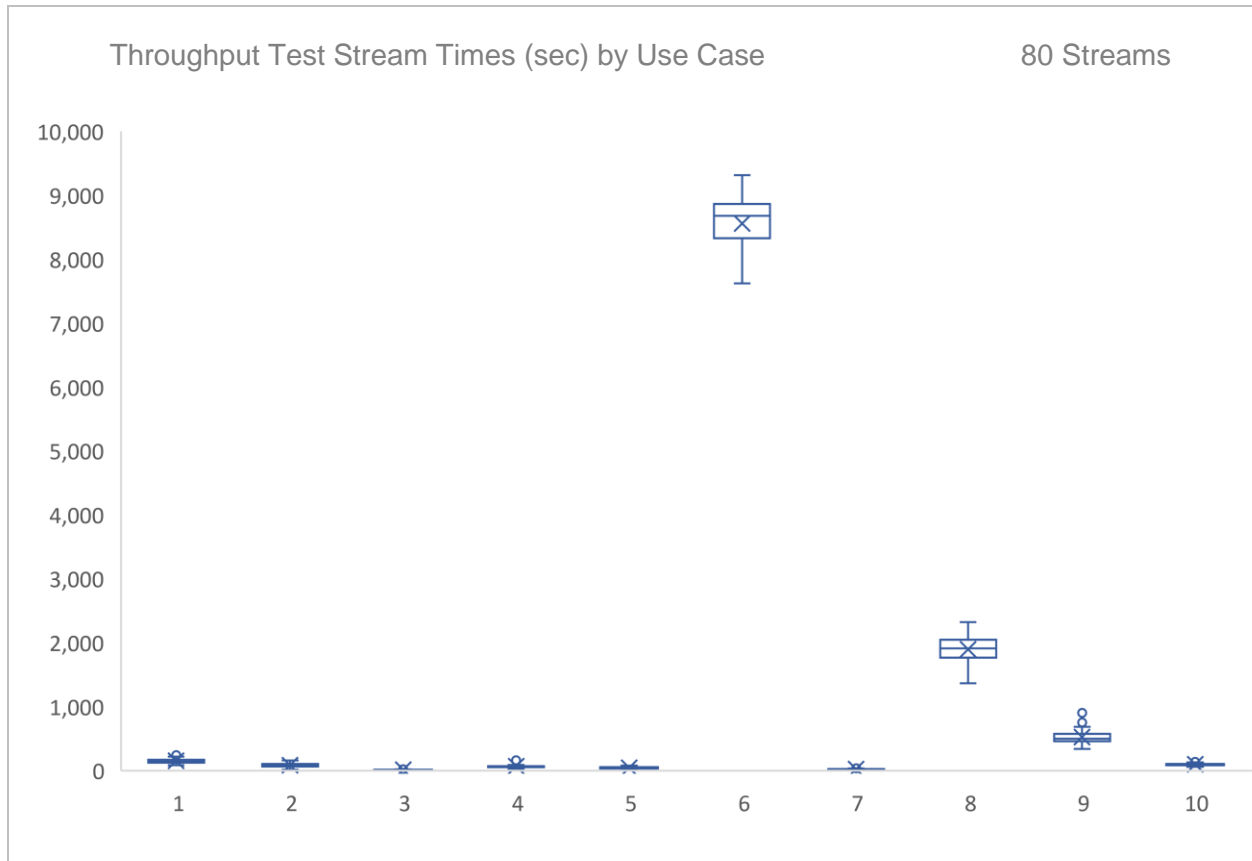
Overall Run Start Time	2022-10-23 12:39:23.182
Overall Run End Time	2022-10-24 07:19:25.693
Overall Run Elapsed Time	67,202.511
Load Test Start Time	2022-10-23 12:44:09.595
Load Test End Time	2022-10-23 12:44:15.933
Load Test Elapsed Time	6.338
Power Training Start Time	2022-10-23 12:44:15.935
Power Training End Time	2022-10-24 00:59:14.891
Power Training Elapsed Time	44,098.956
Power Serving 1 Start Time	2022-10-24 00:59:14.894
Power Serving 1 End Time	2022-10-24 02:26:48.576
Power Serving 1 Elapsed Time	5,253.682
Power Serving 2 Start Time	2022-10-24 02:26:48.579
Power Serving 2 End Time	2022-10-24 03:54:53.628
Power Serving 2 Elapsed Time	5,285.049
Scoring Start Time	2022-10-24 03:55:30.479
Scoring End Time	2022-10-24 03:58:24.774
Scoring Elapsed Time	174.295
Throughput Start Time	2022-10-24 03:58:24.790
Throughput End Time	2022-10-24 07:19:25.690
Throughput Elapsed Time	12,060.900

Accuracy Metrics

Use Case	Metric Name	Metric	Criteria	Threshold	Status
1	N/A	0.000	N/A	0.00	Pass
2	word_error_rate	0.150	<=	0.50	Pass
3	mean_squared_log_error	3.553	<=	5.40	Pass
4	f1_score	0.706	>=	0.65	Pass
5	mean_squared_log_error	0.016	<=	0.50	Pass
6	matthews_corrcoef	0.544	>=	0.19	Pass
7	median_absolute_error	1.002	<=	1.80	Pass
8	accuracy_score	0.760	>=	0.65	Pass
9	accuracy_score	1.000	>=	0.90	Pass
10	accuracy_score	0.817	>=	0.70	Pass

5.2 Throughput Test Stream Times

The following chart shows the minimum, 1st quartile, median, mean (X), 3rd quartile, and maximum stream times by use case for the Throughput Test. Outliers are marked with “o”.



Auditor's Information

This benchmark was audited by Doug Johnson, InfoSizing.

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

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

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



Nicholas Wakou
 Dell Inc.
 701 E. Parmer Ln. Bld. 2
 Austin, TX 78753

November 8, 2022

I verified the TPC Express Benchmark™ AI v1.0.2 performance of the following configuration:

Platform: 1x Dell PowerEdge R6625
 Operating System: Red Hat Enterprise Linux 8.6
 Additional Software: Anaconda3 4.12.0

The results were:

Performance Metric 364.59 AIUCpm@30

Secondary Metrics	T _{LD}	6.32
	T _{PTT}	1,145.16
	T _{PST}	54.48
	T _{TT}	15.07

System Under Test 1x Dell PowerEdge R6625 with:

CPU	2x AMD EPYC 9174F 16-Core Processor		
Memory	768 GiB		
Storage	Qty	Size	Type
	2	240 GB	M.2 SATA
	3	3.84 TB	NVMe

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 v1.0.2.
- All checksums were validated for compliance.
- Any modifications to shell scripts were reviewed for compliance.
- No modifications were made to any of the Java code.
- The generated dataset was properly scaled to 30 GB.

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- The generated dataset used for testing was protected by RAID 5.
- 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:

Two files were erroneously reported as having incorrect checksums. This is due to a minor issue in the TPC-provided kit. The TPCx-AI Subcommittee is aware of this and will correct it in a future release of the kit.

Respectfully Yours,

A handwritten signature in cursive script that reads "Doug Johnson". The signature is written in black ink and has a long, sweeping horizontal line extending to the right.

Doug Johnson, Certified TPC Auditor

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Third-Party Price Quotes

Anaconda



ORDER FORM

Anaconda, Inc.
 1108 Lavaca Street, Ste. 110-645
 Austin, TX 78701
 Phone: (512) 222-5440

Order Form #: Q-05986-1
Date: 11/3/2022
Expires On: 3/17/2023
Payment Terms: Net 30
Subscription Term: 12 months

Prepared For:
 Seamus Jones
 512 993 7801
 seamus.jones@dell.com

Bill To:
 Dell
 1 Dell Way
 Round Rock, TX 78682
 United States

Ship To:
 Dell
 1 Dell Way
 Round Rock, TX 78682
 United States

Subscriptions

PRODUCT	Year	QTY	SKU	DESCRIPTION	UNIT PRICE	EXTENDED UNIT PRICE	EXTENDED PRICE
Anaconda Professional User License	Year 1	40	SFT.PRO-USER	Individual user license for Anaconda Professional	\$250.00	\$10,000.00	\$10,000.00
Subscriptions SUBTOTAL:							\$10,000.00
Subscriptions TOTAL:							\$10,000.00

Grand Total: \$10,000.00

Order Form Notes

This software repository includes:

- 1 Year Tier 1 Support
- 1 Year Tier 2 Support
- Anaconda3 (Anaconda3-2022.05-Linux-x86_64)
- Conda Version 4.12.0
- Python Version 3.8.13
- Setuptools Version 63.4.1
- Pandas Version 1.4.4
- Scikit-learn Version 1.1.2
- Xgboost Version 1.5.0
- Numpy Version 1.23.1
- Nose Version 1.3.7
- Scipy Version 1.9.1
- Statsmodels Version 0.12.2
- Patsy Version 0.5.2
- Tqdm Version 4.64.1
- Keras Version 2.8.0

Tensorflow Version 2.8.2
 Joblib Version 1.1.0
 Opencv Version 4.6.0
 Pyyaml Version 6
 Matplotlib Version 3.5.2
 Jinja2 Version 3.0.3
 Pycryptodome Version 3.15.0
Please contact Anaconda with any questions:
 Edward Schneider
 eschneider@anaconda.com

Terms and Conditions

1. This **Order Form** is subject to the terms and conditions found at <https://www.anaconda.com/anaconda-master-subscription-agreement> and/or any other similar master terms and conditions negotiated and currently in effect between Anaconda, Inc. ("Anaconda") and Customer, as applicable (the "Agreement"). In the event Customer's subscription comes with Support Services, these services are bound by the Anaconda Support Policy found at <https://www.anaconda.com/anaconda-support-and-maintenance-policy>, unless otherwise stated in the agreement.
2. Any **changes** to this Order Form or the Agreement shall be effective only in a writing that has been properly executed by both Anaconda and Customer. Similarly, any pre-printed terms and/or conditions included with or attached to any Customer purchase order shall be null and void, and no reference to, or delivery of, any of Anaconda's products, services, or information to Customer following receipt of any purchase order shall be deemed an acknowledgment of, or an agreement to, any terms or conditions associated with any such purchase order.
3. This Order Form will renew in accordance with the terms of the Agreement.

IN WITNESS WHEREOF, the parties, acting through their authorized representative and intending to be bound, have executed this Order Form to be effective as of the Effective Date.

Anaconda, Inc.	Customer	Dell
Signature	Signature	
Name	Name	
Title	Title	
Date	Date	

Supporting Files Index

The Supporting Files archive for this disclosure contains the following structure.

Supporting Files Directory	Description
CheckIntegrity/...	Output of CHECK_INTEGRITY test (if the phase is not done as part of the Validation and Performance Test).
PerformanceTest/...	Performance Test output files.
ValidationTest/...	Validation Test output files.
Additional files used by Dell	
Sponsor/ModelOptimization/...	Details of model optimization.
Sponsor/ModifiedKitFiles/...	2 modified file(s). See Auditor's Note.
Sponsor/Tuning/...	All tuning files used.