Hewlett Packard Enterprise

TPC Express Benchmark™ AI
Full Disclosure Report

ProLiant DL380a Gen11

with 1x ProLiant DL380a Gen11
using

Anaconda Pro

running on

Red Hat Enterprise Linux 8.6

TPCx-AI Version	1.0.2
Report Edition	First
Report Submitted	June 12, 2023

First Edition - June 2023

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Abstract

HPE conducted the TPC Express Benchmark™ AI (TPCx-AI) on the ProLiant DL380a Gen11. The software used included Anaconda Pro. 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
HPE	1x ProLiant DL380a Gen11 (Server)	Red Hat Enterprise Linux 8.6

Metrics Overview

Total System Cost	Performance	Price/Performance	Availability Date
$89,568 USD	618.97 AIUCpm@10	144.71 USD $/AIUCpm@10	June 12, 2023

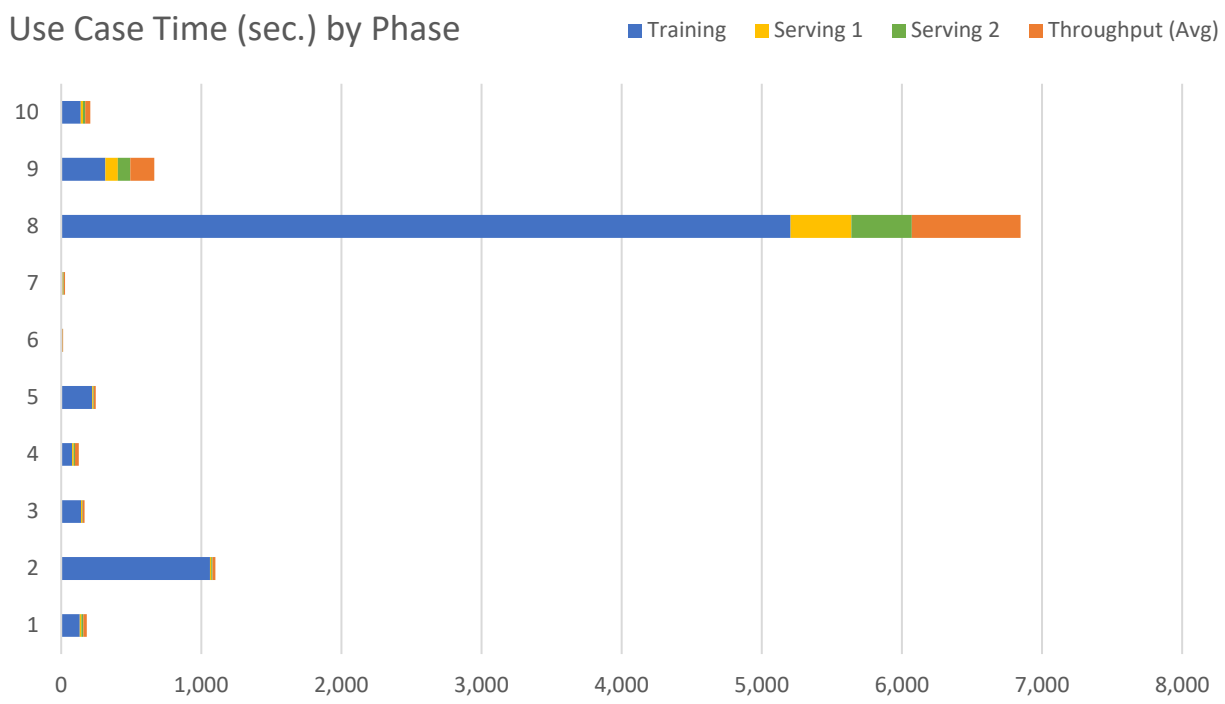
Executive Summary

The Executive Summary follows on the next several pages.

Hewlett Packard Enterprise	ProLiant DL380a Gen11	TPCx-AI 1.0.2 TPC Pricing 2.8.0 Report Date Jun. 12, 2023

TPCx-AI Performance	Total System Cost	Price/Performance	Availability Date
618.97 AIUCpm@10	**$89,568 USD**	**$144.71 USD/AIUCpm@10**	**June 12, 2023**

Framework	Operating System	Other Software	Scale Factor	Streams
Anaconda Pro	Red Hat Enterprise Linux 8.6	N/A	10	100



Physical Storage / Scale Factor	Scale Factor / Physical Memory	Main Data Redundancy Model
96.00	0.01	RAID 1

Servers: Total Processors/Cores/Threads	1 2 / 64 / 128

Server Type	1x ProLiant DL380a Gen11 (Server)
Processors	2x Intel(R) Xeon(R) Platinum 8462Y+ (2.8 GHz, 32-core)
Memory	1,024 GiB
Storage Controller	1x NS204i-u Gen11
Storage Device	2x 480 GB NVMe
Network Controller	1x Mellanox MCX562A-ACAI 10/25Gb 2-port

Hewlett Packard Enterprise

ProLiant DL380a Gen11

TPCx-AI	1.0.2
TPC Pricing	2.8.0
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Description	Part Number	Source	List Price	Qty	Extended Price	1-Yr. Maintenance
Server Hardware						
HPE DL380a Gen11 4DW CTO Svr	P05175-B21	1	$3,392.00	1	$3,392.00	
Intel Xeon-Platinum 8462Y+ 2.8GHz 32-core 300W Processor for HPE	P49603-B21	1	$14,268.00	2	$28,536.00	
HPE 64GB (1x64GB) Dual Rank x4 DDR5-4800 CAS-40-39-39 EC8 Registered Smart Memory Kit	P43331-B21	1	$4,068.00	16	$65,088.00	
HPE Alletra 4120 High Performance Heat Sink Kit	P51832-B21	1	$175.00	2	$350.00	
HPE 1600W Flex Slot Platinum Hot Plug Low Halogen Power Supply Kit	P38997-B21	1	$685.00	2	$1,370.00	
HPE MCX562A-ACAI Ethernet 10/25Gb 2-port SFP28 OCP3 Adapter	P10112-B21	1	$1,040.00	1	$1,040.00	
HPE 3 Year Tech Care Essential wDMR DL380a Gen11 HW Service	H38YLE	1	$22,626.00	1		$22,626.00
HPE USB US Keyboard/Mouse Kit (incld 2 spares)	631341-B21	1	$32.00	3	$96.00	
HPE 42U 600x1200mm Adv G2 Kit Shock Rack	H6J67A	1	$6,600.00	1	$6,600.00	
				Subtotal	**$106,472.00**	**$22,626.00**
Storage						
HPE NS204i-u Gen11 Ht Plg Boot Opt Dev	P48183-B21	1	$1,994.00	1	$1,994.00	
HPE DL3XX Gen11 Ball Bearing Rail 8 Kit	P52345-B21	1	$375.00	1	$375.00	
				Subtotal	**$2,369.00**	**$0.00**
Other						
HP V22v G5 FHD Monitor (incld 2 spares)	65P56AA#ABA	3	$129.99	3	$389.97	
				Subtotal	**$389.97**	**$0.00**
Software Components						
RHEL Svr Sckt/2 Gst 1yr 24x7 E-LTU	J8J36A	1	$1,214.00	1	$1,214.00	
Anaconda Pro Subscription	NA	2	$10,000.00	1	$10,000.00	
				Subtotal	**$11,214.00**	**$0.00**
				Total Extended Price	$120,444.97	$22,626.00
				Total Discounts	$48,978.00	$4,525.00
				Grand Totals	$71,466.97	$18,101.00

Pricing: 1 = HPE; 2 = Anaconda;3 = Hewlett Packard Inc.

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

Audited by Doug Johnson, InfoSizing

Total System Cost (USD): $89,568

AIUCpm@10: 618.97

$/AIUCpm@10: $144.71

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated Line Items. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed Line Items. For complete details, see the pricing section of the TPC Benchmark Standard. If you find that the stated prices are not available according to these terms, please inform the TPC at pricing@tpc.org. Thank you.

Hewlett Packard Enterprise	ProLiant DL380a Gen11	TPCx-AI	1.0.2
		TPC Pricing	2.8.0
		Report Date	Jun. 12, 2023

Numerical Quantities

AIUCpm@10	**618.97**	T_{Load}	3.90
Scale Factor	10	T_{LD}	3.90
Streams	100	T_{PTT}	152.56
		T_{PST1}	12.47
Kit Version	1.0.2	T_{PST2}	12.56
Execution Status	Pass	T_{PST}	12.56
Accuracy Status	Pass	T_{TT}	1.18

Test Times

Overall Run Start Time	2023-05-04 20:12:49.629
Overall Run End Time	2023-05-04 23:00:16.969
Overall Run Elapsed Time	10,047.340
Load Test Start Time	2023-05-04 20:15:37.280
Load Test End Time	2023-05-04 20:15:41.197
Load Test Elapsed Time	3.917
Power Training Start Time	2023-05-04 20:15:41.200
Power Training End Time	2023-05-04 22:17:40.394
Power Training Elapsed Time	7,319.194
Power Serving 1 Start Time	2023-05-04 22:17:40.397
Power Serving 1 End Time	2023-05-04 22:27:27.844
Power Serving 1 Elapsed Time	587.447
Power Serving 2 Start Time	2023-05-04 22:27:27.847
Power Serving 2 End Time	2023-05-04 22:37:14.850
Power Serving 2 Elapsed Time	587.003
Scoring Start Time	2023-05-04 22:38:12.937
Scoring End Time	2023-05-04 22:40:35.402
Scoring Elapsed Time	142.465
Throughput Start Time	2023-05-04 22:40:35.421
Throughput End Time	2023-05-04 23:00:16.966
Throughput Elapsed Time	1,181.545

Hewlett Packard Enterprise	ProLiant DL380a Gen11	TPCx-AI	1.0.2
		TPC Pricing	2.8.0
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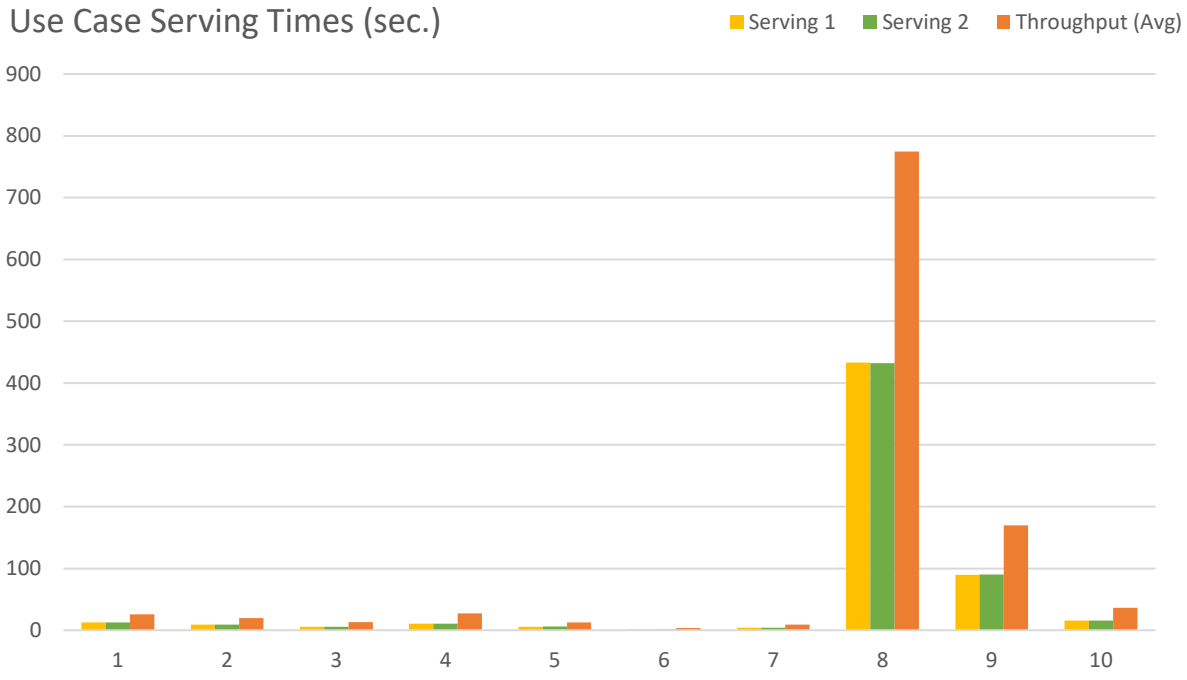
Numerical Quantities (continued)

Use Case Times & Accuracy

Use Case	Training (sec)	Serving 1 (sec)	Serving 2 (sec)	Throughput (avg)	Accuracy
UC01	132.763	12.791	12.815	25.492	0.000
UC02	1,062.946	8.921	8.965	19.551	0.255
UC03	142.729	5.512	5.558	12.936	3.609
UC04	78.300	10.549	10.449	27.376	0.707
UC05	222.770	5.703	5.823	12.570	0.083
UC06	8.207	0.974	0.995	3.382	0.548
UC07	10.293	3.977	4.088	9.077	1.030
UC08	5,206.010	433.246	432.219	774.821	0.726
UC09	314.499	89.799	90.105	169.648	1.000
UC10	140.575	15.869	15.884	36.385	0.816



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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 Hewlett Packard Enterprise.

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:	2/64/128	Storage Devices:	2
Total Memory:	1,024 GiB	Storage Capacity:	960 GB

HPE ProLiant DL380a Gen121

	Server
Server	1x ProLiant DL380a Gen11:
Procs/Cores/Threads:	2/32/64
Processor Model:	2x Intel(R) Xeon(R) Platinum 8462Y+ (2.8 GHz, 32-core)
Memory:	1,024 GiB
Storage Controller:	1x NS204i-u Gen11
Storage Devices:	2x 480 GB NVMe
Network Controller:	1x Mellanox MCX562A-ACAI 10/25Gb 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 ProLiant DL380a Gen11	zodiac-01	All	2x 480 GB 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 / Anaconda Pro 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

Anaconda Pro consisted of the following components.

Component	Version
python	3.9.13
setuptools	59.8.0
pandas	1.5.2
scikit-learn	1.2.0
Xgboost	1.7.1
numpy	1.23.5
nose	1.3.7
scipy	1.10.0
statsmodels	0.13.5
patsy	0.5.2
tqdm	4.64.1
keras	2.10.0
tensorflow	2.10.0
joblib	1.1.0
PyYAML	6
Jinja	2.11.3
opencv	4.5.5

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 flies that were modified to facilitate system, platform, and framework differences.

TPCx-AI Kit Version	1.0.2
Modified File tools/python/python-ks.yaml See Auditor's Note	Description of Changes Adjusted for software versions used.

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	8.921	8.965	15.211	17.437	20.828	18.720
	5	5.703	5.823	18.066	10.274	9.249	9.084
	9	89.799	90.105	157.130	170.041	175.494	179.154
Machine Learning	1	12.791	12.815	24.342	36.726	24.460	28.934
	3	5.512	5.558	18.201	10.554	8.518	13.067
	4	10.549	10.449	25.146	30.748	25.053	37.250
	6	0.974	0.995	3.905	3.713	3.614	2.886
	7	3.977	4.088	7.137	8.506	9.391	9.030
	8	433.246	432.219	772.826	814.684	844.671	634.023
	10	15.869	15.884	36.853	37.231	38.514	33.611

Type	UC ID	T5	T6	T7	T8	T9	T10
Deep Learning	2	16.111	17.091	20.741	19.806	20.338	18.392
	5	9.929	17.491	9.900	13.408	19.268	24.510
	9	179.713	168.003	161.651	144.430	173.970	176.303
Machine Learning	1	21.867	17.935	35.514	26.016	33.947	24.728
	3	13.242	10.949	12.276	18.490	5.982	15.884
	4	18.956	17.669	23.034	20.037	23.474	26.033
	6	3.120	2.697	2.284	3.998	3.821	4.236
	7	8.700	8.411	8.693	7.709	7.335	4.128
	8	825.817	840.359	821.200	646.322	827.639	835.750
	10	28.586	33.878	38.059	36.742	31.226	36.642

Type	UC ID	T11	T12	T13	T14	T15	T16
Deep Learning	2	16.951	20.434	22.049	18.213	20.010	16.503
	5	13.850	9.358	11.774	12.734	9.051	12.340
	9	185.215	172.430	174.280	175.619	146.438	179.862
Machine Learning	1	39.495	28.159	25.038	24.116	26.491	24.680
	3	9.691	13.776	14.935	11.044	15.011	10.115
	4	25.292	35.481	27.552	28.275	29.386	26.589
	6	3.649	4.221	3.671	2.851	3.704	3.405
	7	5.221	10.842	8.807	8.649	9.904	11.093
	8	613.366	634.287	616.667	824.928	630.149	804.483
	10	33.436	36.075	36.639	43.541	49.406	45.379

Type	UC ID	T17	T18	T19	T20	T21	T22
Deep Learning	2	18.245	20.088	14.791	16.866	18.834	19.636
	5	7.914	9.518	24.692	9.045	10.396	10.536
	9	169.555	181.039	172.829	178.456	177.773	178.367
Machine Learning	1	33.002	25.269	27.127	24.494	25.364	22.928
	3	15.341	14.655	10.825	13.830	15.081	12.464
	4	27.176	36.980	21.745	23.707	29.535	22.026
	6	3.723	3.160	3.807	2.982	4.105	4.128
	7	10.646	6.203	10.505	8.016	9.306	9.295
	8	645.602	636.450	776.132	832.023	634.786	803.538
	10	36.810	38.540	30.496	37.689	37.109	35.106

Type	UC ID	T23	T24	T25	T26	T27	T28
Deep Learning	2	17.384	21.693	16.364	14.655	17.925	19.531
	5	21.194	11.844	18.703	17.017	9.123	12.254
	9	153.772	179.569	176.166	159.888	180.878	151.286
Machine Learning	1	22.465	24.914	25.686	24.844	34.820	27.585
	3	14.062	12.778	10.367	14.917	13.647	16.888
	4	30.291	27.491	25.287	21.701	25.386	27.077
	6	4.303	4.282	3.025	2.251	4.323	2.708
	7	12.316	9.697	7.581	8.022	8.501	10.840
	8	833.356	830.221	802.314	857.892	625.678	832.409
	10	35.068	31.126	45.246	31.512	34.964	34.272

Type	UC ID	T29	T30	T31	T32	T33	T34
Deep Learning	2	20.673	14.838	16.876	19.069	13.809	30.571
	5	11.349	12.428	9.019	14.122	9.850	9.494
	9	175.962	181.764	179.350	173.037	153.115	183.606

Machine Learning	1	21.129	24.485	24.072	23.719	29.152	24.633
	3	8.782	12.532	12.264	14.741	12.222	14.775
	4	35.347	23.470	17.805	39.694	42.158	24.835
	6	2.678	3.264	2.292	3.572	2.381	3.376
	7	11.242	8.542	8.162	6.727	9.979	9.697
	8	831.471	811.725	813.917	821.417	860.372	786.839
	10	33.882	31.770	28.930	38.575	31.099	31.225

Type	UC ID	T35	T36	T37	T38	T39	T40
Deep Learning	2	31.009	18.965	21.042	23.415	17.413	20.091
	5	10.090	10.219	21.219	12.852	31.914	11.507
	9	174.062	176.022	178.601	159.011	179.976	157.613
Machine Learning	1	19.400	27.531	24.434	24.383	26.510	38.196
	3	13.016	9.681	12.253	12.701	11.685	14.470
	4	29.564	25.609	33.054	32.065	26.770	29.686
	6	5.388	2.922	2.716	2.232	3.120	3.871
	7	10.703	10.098	7.900	9.632	9.309	10.343
	8	818.447	643.918	631.353	826.159	806.950	815.388
	10	35.426	46.297	34.597	39.154	34.595	31.923

Type	UC ID	T41	T42	T43	T44	T45	T46
Deep Learning	2	15.646	17.872	21.196	19.804	14.725	12.898
	5	12.597	11.702	9.278	22.911	19.277	9.013
	9	172.128	148.308	176.344	183.387	177.458	149.805
Machine Learning	1	17.624	23.998	22.690	21.412	22.495	36.735
	3	11.464	9.384	14.142	13.289	11.025	17.145
	4	23.835	25.121	38.513	26.857	23.779	28.564
	6	2.473	3.485	3.459	2.891	3.899	3.420
	7	9.295	9.183	9.687	5.641	13.132	7.900
	8	726.177	862.592	816.277	626.675	826.679	857.016
	10	51.416	44.573	34.617	43.850	31.965	36.279

Type	UC ID	T47	T48	T49	T50	T51	T52
Deep Learning	2	18.126	12.118	19.626	22.613	16.568	14.708
	5	9.289	22.304	10.730	11.446	7.903	11.018
	9	179.489	177.495	150.107	156.073	175.071	151.622
Machine Learning	1	33.086	27.062	26.042	23.806	22.058	22.165
	3	12.815	14.176	14.991	12.766	20.257	13.898
	4	30.952	28.378	27.478	26.646	26.445	23.257
	6	3.156	2.658	3.942	4.228	4.519	3.888
	7	6.738	12.483	10.545	9.137	7.408	9.911
	8	658.322	826.737	796.765	843.865	776.884	860.548
	10	32.589	32.423	44.323	38.038	24.606	42.467

Type	UC ID	T53	T54	T55	T56	T57	T58
Deep Learning	2	30.521	31.633	17.318	16.386	22.054	25.825
	5	12.452	11.265	9.596	11.967	12.213	11.731
	9	181.613	175.918	182.700	171.582	158.170	172.941
Machine Learning	1	21.496	23.736	24.108	18.276	27.550	28.099
	3	13.531	14.525	8.630	12.524	14.019	18.398
	4	25.221	24.504	21.569	21.611	29.344	22.973
	6	3.231	3.051	2.925	2.350	3.916	3.137
	7	10.020	9.382	9.870	6.097	9.653	7.933
	8	690.277	810.201	661.183	793.606	783.085	794.915
	10	36.636	33.412	37.810	29.609	42.359	34.194

Type	UC ID	T59	T60	T61	T62	T63	T64
Deep Learning	2	15.725	16.856	15.689	18.528	21.539	16.188
	5	8.482	11.857	12.318	17.175	12.387	7.613
	9	155.528	172.567	170.107	164.870	179.612	178.707
Machine Learning	1	23.776	20.135	22.891	26.265	24.347	18.284
	3	10.018	13.265	15.751	14.162	11.662	13.563
	4	27.317	28.898	39.178	29.795	28.358	26.054
	6	2.622	2.889	3.313	3.811	3.419	3.497
	7	8.223	8.363	9.440	9.653	8.748	10.167
	8	826.200	803.185	664.831	650.875	613.186	668.133
	10	50.827	45.917	37.058	33.968	34.947	35.267

Type	UC ID	T65	T66	T67	T68	T69	T70
Deep Learning	2	15.076	21.487	17.207	31.229	18.585	17.316
	5	21.234	9.665	9.049	12.245	8.711	8.925
	9	145.082	156.452	172.519	175.437	142.869	174.640
Machine Learning	1	25.315	36.434	19.934	26.497	27.406	22.648
	3	11.891	13.407	10.768	14.546	11.644	16.815
	4	30.650	21.465	30.403	27.954	24.194	25.040
	6	2.752	3.903	2.040	2.524	4.360	3.255
	7	13.115	10.751	12.652	10.090	10.158	8.407
	8	862.375	837.950	843.270	649.235	649.822	819.748
	10	31.656	39.052	31.913	33.330	38.661	47.241

Type	UC ID	T71	T72	T73	T74	T75	T76
Deep Learning	2	17.296	16.562	30.805	25.154	13.125	17.639
	5	8.479	9.031	8.854	16.645	13.795	12.978
	9	175.471	171.016	151.758	172.237	163.711	175.295
Machine Learning	1	26.408	39.371	28.003	22.731	26.648	25.558
	3	11.542	13.415	13.398	13.903	17.651	13.865
	4	23.312	28.947	23.824	24.351	25.772	37.330
	6	4.242	3.293	5.576	3.812	3.503	3.638
	7	9.600	9.176	6.833	9.885	10.526	8.190
	8	813.986	816.950	850.041	843.643	844.776	659.137
	10	48.448	31.716	33.826	33.185	37.239	37.668

Type	UC ID	T77	T78	T79	T80	T81	T82
Deep Learning	2	21.480	16.784	19.937	16.419	20.669	30.749
	5	7.418	13.938	9.152	9.389	10.994	12.743
	9	178.624	180.427	180.219	186.480	158.270	180.930
Machine Learning	1	23.786	19.886	23.398	20.187	26.712	22.762
	3	16.362	9.861	14.208	7.495	10.570	13.365
	4	34.049	31.388	29.394	27.799	23.837	27.665
	6	3.752	3.387	2.119	3.886	4.526	1.822
	7	10.756	9.138	9.560	5.346	9.291	10.801
	8	821.358	705.597	826.340	655.219	832.415	648.379
	10	34.411	33.657	32.266	36.738	41.213	37.568

Type	UC ID	T83	T84	T85	T86	T87	T88
Deep Learning	2	31.988	16.773	19.553	18.435	20.602	19.594
	5	11.444	18.296	31.520	8.837	7.829	9.968
	9	186.477	145.636	176.278	177.119	186.105	152.976
Machine Learning	1	17.999	21.746	13.060	23.884	22.046	26.030
	3	12.448	11.518	13.653	17.627	8.726	11.982
	4	25.220	35.924	29.872	21.565	25.758	30.392
	6	2.571	3.189	5.235	3.041	4.951	2.509
	7	8.320	10.337	4.109	13.568	6.105	9.477
	8	830.553	854.600	846.497	830.136	848.577	838.475
	10	31.440	34.043	33.375	34.574	30.680	39.255

Type	UC ID	T89	T90	T91	T92	T93	T94
Deep Learning	2	19.086	16.536	14.190	15.892	20.334	21.841
	5	8.895	23.159	10.060	8.761	7.489	11.764
	9	178.916	175.642	151.882	168.117	148.146	172.837
Machine Learning	1	21.432	27.900	27.627	20.049	25.515	26.150
	3	12.641	9.893	10.767	13.725	10.332	15.565
	4	40.108	21.292	29.045	20.646	29.363	23.716
	6	2.411	2.431	3.745	3.103	3.917	2.929
	7	8.203	12.743	8.725	6.627	5.843	8.110
	8	811.366	831.265	844.255	797.586	811.222	663.930
	10	29.734	30.726	46.442	25.152	37.165	38.731

Type	UC ID	T95	T96	T97	T98	T99	T100
Deep Learning	2	16.557	19.272	31.903	33.141	18.571	16.486
	5	7.628	11.282	8.820	9.253	17.202	8.451
	9	172.543	152.413	152.941	180.540	157.072	174.664
Machine Learning	1	37.641	26.651	24.187	23.535	28.320	25.022
	3	10.780	8.865	11.357	9.798	17.785	10.354
	4	26.195	25.027	23.648	30.248	23.710	25.388
	6	1.607	1.768	5.627	3.190	3.498	3.570
	7	8.234	10.523	10.041	10.052	7.570	9.415
	8	839.796	864.756	826.398	823.956	825.599	709.132
	10	35.818	36.486	37.990	35.508	34.374	36.843

Table 3-2 Use Case Elapsed Times

3.4 SUT Validation Test Output

Validation Run Report

AIUCpm@1	262.02	T_{Load}	0.59
Scale Factor	1	T_{LD}	0.59
Streams	100	T_{PTT}	30.38
		T_{PST1}	3.87
Kit Version	1.0.2	T_{PST2}	3.83
Execution Status	Pass	T_{PST}	3.87
Accuracy Status	Pass	T_{TT}	0.39

Test Times

Overall Run Start Time	2023-05-04 19:26:08.283
Overall Run End Time	2023-05-04 20:10:18.163
Overall Run Elapsed Time	2,649.880
Load Test Start Time	2023-05-04 19:28:01.505
Load Test End Time	2023-05-04 19:28:02.112
Load Test Elapsed Time	0.607
Power Training Start Time	2023-05-04 19:28:02.114
Power Training End Time	2023-05-04 19:56:22.853
Power Training Elapsed Time	1,700.739
Power Serving 1 Start Time	2023-05-04 19:56:22.856
Power Serving 1 End Time	2023-05-04 19:58:17.361
Power Serving 1 Elapsed Time	114.505
Power Serving 2 Start Time	2023-05-04 19:58:17.365
Power Serving 2 End Time	2023-05-04 20:00:11.504
Power Serving 2 Elapsed Time	114.139
Scoring Start Time	2023-05-04 20:01:08.532
Scoring End Time	2023-05-04 20:03:41.973
Scoring Elapsed Time	153.441
Throughput Start Time	2023-05-04 20:03:41.991
Throughput End Time	2023-05-04 20:10:18.159
Throughput Elapsed Time	396.168

(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	0.267	<=	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	0.012	<=	0.50	Pass
6	matthews_corrcoef	0.462	>=	0.19	Pass
7	median_absolute_error	0.894	<=	1.80	Pass
8	accuracy_score	0.715	>=	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	480	960

Total Storage (GB)	960
Scale Factor	10
Data Storage Ratio	96.00

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	1,024	1,024

Scale Factor	10
Total Memory (GiB)	1,024
SF / Memory Ratio	0.01

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	618.97	AIUCpm@10
TPCx-AI Price/Performance Metric	144.71	$/AIUCpm@10
TPCx-AI Scale Factor	10	
TPCx-AI Stream Count	100	

Test Times

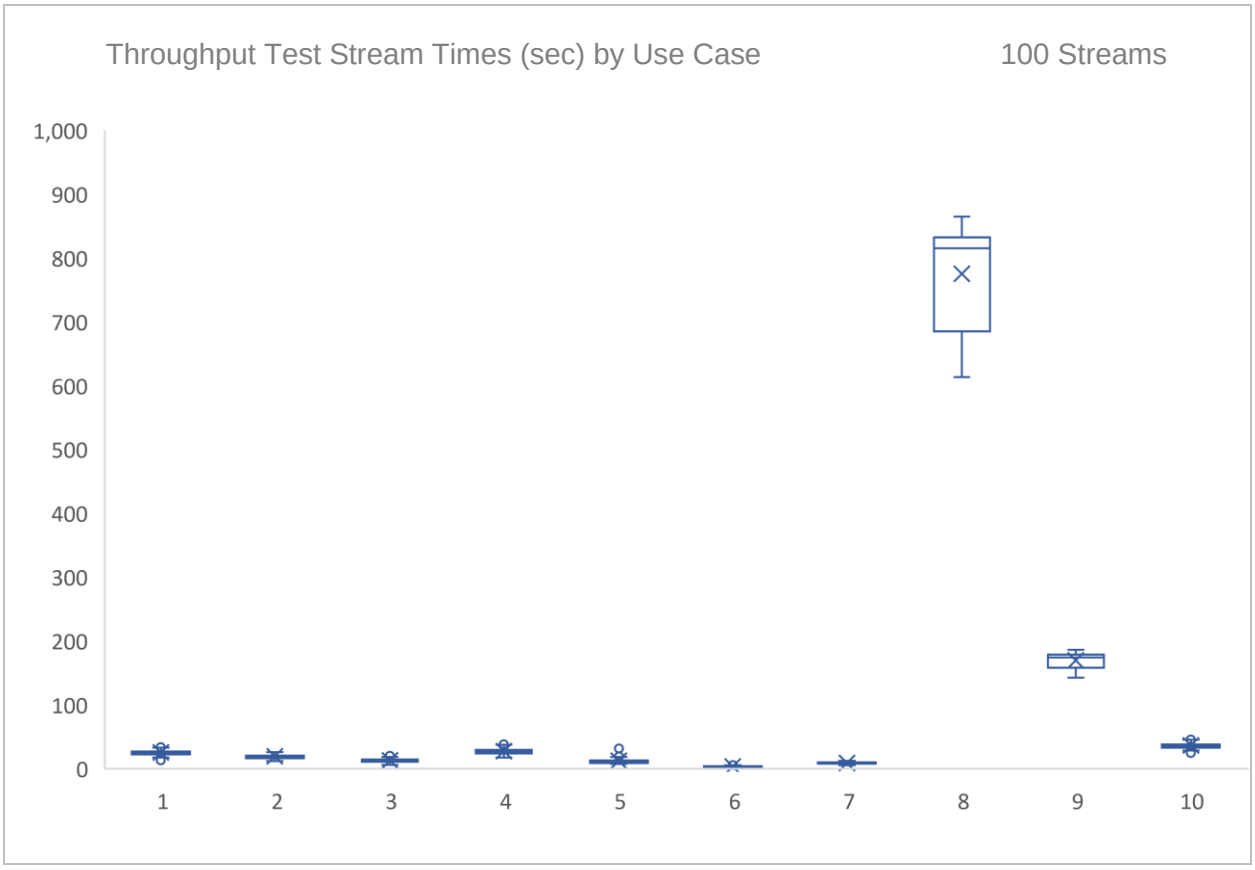
Overall Run Start Time	2023-05-04 20:12:49.629
Overall Run End Time	2023-05-04 23:00:16.969
Overall Run Elapsed Time	10,047.340
Load Test Start Time	2023-05-04 20:15:37.280
Load Test End Time	2023-05-04 20:15:41.197
Load Test Elapsed Time	3.917
Power Training Start Time	2023-05-04 20:15:41.200
Power Training End Time	2023-05-04 22:17:40.394
Power Training Elapsed Time	7,319.194
Power Serving 1 Start Time	2023-05-04 22:17:40.397
Power Serving 1 End Time	2023-05-04 22:27:27.844
Power Serving 1 Elapsed Time	587.447
Power Serving 2 Start Time	2023-05-04 22:27:27.847
Power Serving 2 End Time	2023-05-04 22:37:14.850
Power Serving 2 Elapsed Time	587.003
Scoring Start Time	2023-05-04 22:38:12.937
Scoring End Time	2023-05-04 22:40:35.402
Scoring Elapsed Time	142.465
Throughput Start Time	2023-05-04 22:40:35.421
Throughput End Time	2023-05-04 23:00:16.966
Throughput Elapsed Time	1,181.545

Accuracy Metrics

Use Case	Metric Name	Metric	Criteria	Threshold	Status
1	N/A	0.000	N/A	0.00	Pass
2	word_error_rate	0.255	<=	0.50	Pass
3	mean_squared_log_error	3.609	<=	5.40	Pass
4	f1_score	0.707	>=	0.65	Pass
5	mean_squared_log_error	0.083	<=	0.50	Pass
6	matthews_corrcoef	0.548	>=	0.19	Pass
7	median_absolute_error	1.030	<=	1.80	Pass
8	accuracy_score	0.726	>=	0.65	Pass
9	accuracy_score	1.000	>=	0.90	Pass
10	accuracy_score	0.816	>=	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.

InfoSizing
The Right Metric For Sizing IT

TPC
Certified Auditor

Paul Cao
Hewlett Packard Enterprise
3-West.103
1701 East Mossy Oaks Road
Spring, TX 77389

June 11, 2023

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

Platform:	1x ProLiant DL380a Gen11
Operating System:	Red Hat Enterprise Linux 8.6
Additional Software:	Anaconda Pro

The results were:

Performance Metric	**618.97 AIUCpm@10**	
Secondary Metrics	T_{LD}	3.90
	T_{PTT}	152.56
	T_{PST}	12.56
	T_{TT}	1.18

System Under Test	**1x ProLiant DL380a Gen11 with:**		
CPUs	2x Intel® Xeon® Platinum 8462Y+ (2.8 GHz, 32-core)		
Memory	1,024 GiB		
Storage	***Qty***	***Size***	***Type***
	2	480 GB	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 10 GB.

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- The generated dataset used for testing was protected by RAID 1.
- 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,

Doug Johnson, Certified TPC Auditor

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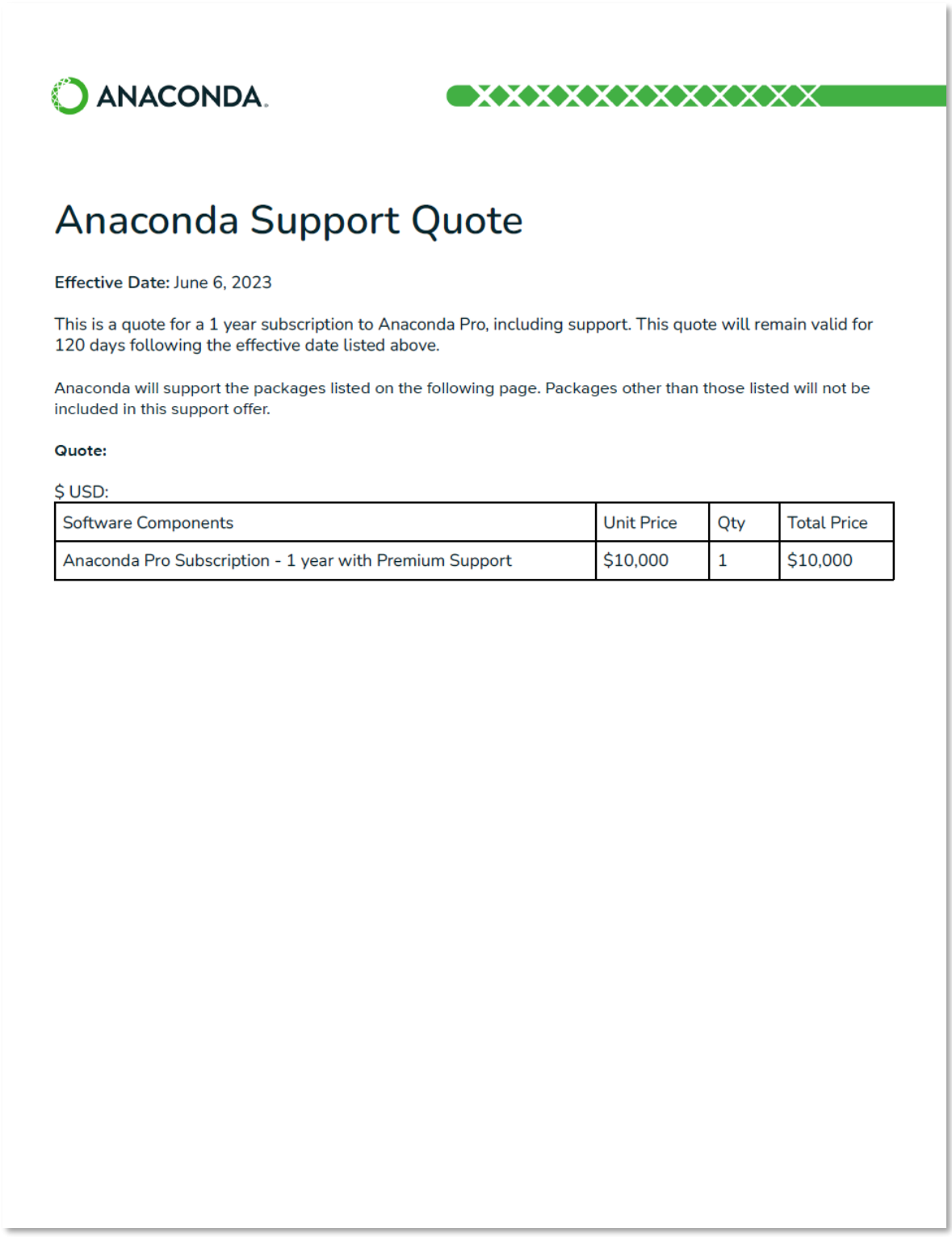
Third-Party Price Quotes

Anaconda



ANACONDA.

Anaconda Support Quote

Effective Date: June 6, 2023

This is a quote for a 1 year subscription to Anaconda Pro, including support. This quote will remain valid for 120 days following the effective date listed above.

Anaconda will support the packages listed on the following page. Packages other than those listed will not be included in this support offer.

Quote:

$ USD:

Software Components	Unit Price	Qty	Total Price
Anaconda Pro Subscription - 1 year with Premium Support	$10,000	1	$10,000

ANACONDA.

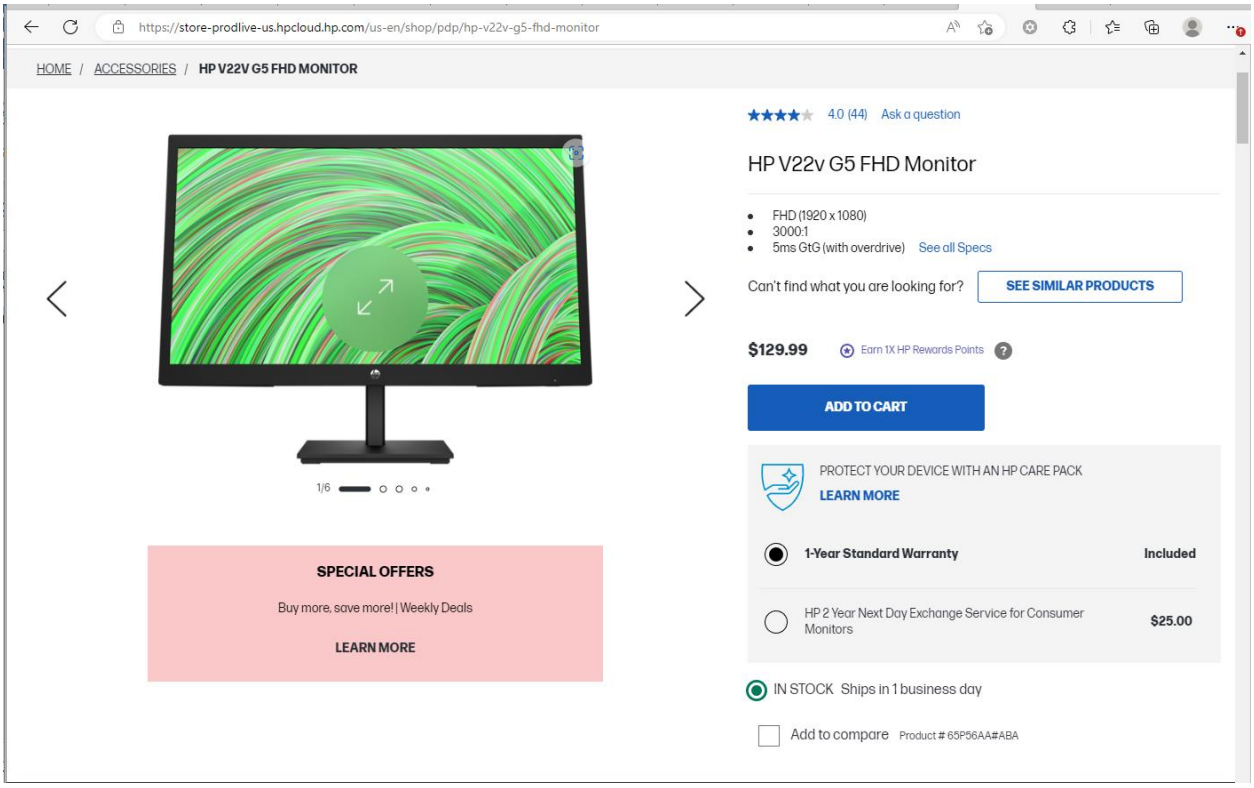
Included packages:

package name	source	version
python	main-anaconda	3.9.13
setuptools	main-anaconda	59.8.0
pandas	main-anaconda	1.5.2
scikit-learn	main-anaconda	1.2.0
Xgboost	main-anaconda	1.7.1
numpy	main-anaconda	1.23.5
nose	main-anaconda	1.3.7
scipy	main-anaconda	1.10.0
statsmodels	main-anaconda	0.13.5
patsy	main-anaconda	0.5.2
tqdm	main-anaconda	4.64.1
keras	main-anaconda	2.10.0
tensorflow	main-anaconda	2.10.0
joblib	main-anaconda	1.1.0
PyYAML	main-anaconda	6
Jinja2	main-anaconda	2.11.3
opencv	main-anaconda	4.5.5

Contact Sales: sales@anaconda.com | (512) 222-5440

Anaconda Inc.
1108 Lavaca Street Suite 110-645
Austin, TX, 78701, USA

Hewlett Packard Inc.



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 HPE	
Sponsor/ModelOptimization/…	Details of model optimization.
Sponsor/ModifiedKitFiles/…	1 modified file(s).
Sponsor/Tuning/…	All tuning files used.