
TPC Benchmark® E

Full Disclosure Report

HP ProLiant DL385p Gen8

Using Microsoft SQL Server 2012 Enterprise Edition SP1

On Microsoft Windows Server 2012 Standard Edition

First Edition
May 15, 2013

First Edition May 15, 2013

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Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL385p Gen8. The operating system used for the benchmark was Microsoft Windows Server 2012 Standard Edition.

TPC Benchmark® E Metrics

The standard TPC Benchmark ® E metrics, tpsE® (transactions per second), price per tpsE ® (three year capital cost per measured tpsE ®) and the availability date are reported as required by the benchmark specification.

TPC Benchmark® Energy Metrics





The standard TPC Benchmark ® Energy metrics, watts per tpsE is optionally reported by the benchmark specification.


Standard and Executive Summary Statements

The following pages contain the Executive Summary of the benchmark results for the system.

Auditor

The benchmark configuration, environment and methodology used to produce and validate the test results, and the pricing model used to calculate the cost per tpsE®, were audited for Doug Johnson for InfoSizing to verify compliance with the relevant TPC specifications.

	HP ProLiant DL385p Gen8 AMD Opteron™ 6386SE Processor C/S with 1 ProLiant DL360 G7		TPC-E Rev 1.12.0
			TPC Pricing 1.7.0
			Report Date May 15, 2013
TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
1416.37 tpsE	\$183 USD/tpsE	May 15, 2013	\$258,734 USD
Database Server Configuration			
Operating System	Database Manager	Processor/Cores/Thread	Memory
Microsoft Windows Server 2012 Standard Edition	Microsoft SQL Server 2012 Enterprise Edition SP1	2/32/32 AMD Opteron™ 6386SE Processor 2.8GHz GHz 16 MB L3	256 Gbyte
<p>Tier B: Server HP ProLiant DL385p Gen8</p> <p>2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor 256 GB Memory 2 x HP 146GB SAS 15K SFF DP ENT HDD 6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)</p> <div>    </div> <p>HP ProLiant DL385p Gen8 10 Gbps Ethernet 10 Gbps Ethernet</p> <div> <p>Tier A: Client</p> <p>1 x ProLiant DL360 G7 2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz 6 x 2GB PC3-10600 Memory 2 x 300GB 6G SAS 10K SFF DP 4 x Onboard 1Gbps Ethernet 1 X HP NC360T PCI-E Dual Port Gigabit Server Adapter</p> <p>Storage</p> <p>4 x HP Smart Array P421i 1GB 4 x HP StorageWorks D2700 Disk Enclosure 24 X HP 400GB 6G SAS MLC SFF (2.5-inch) SSD</p> <p>Priced Only 5 x 500GB 6G SAS 15K SFF DP ENT HDD (60 Day Space)</p> </div>			
Initial Database Size	Redundancy Level: 1	Storage	
6141 GB	RAID10:Log/RAID5:Data	24x 400GB SSD (data), 6x300GB HDD (log), 5x500GB HDD(60Day)	

	HP ProLiant DL385p Gen8				TPC-E	1.12.0
					TPC-Pricing	1.7.0
					Report date	15-May-13
					Availability Date	15-May-13
Description	Part Number	Brand	Unit Price	Qty.	Extended Price	3 Yr Maint Price
Server Hardware (Tier B)						
HP ProLiant DL385p Gen8 8 SFF Configure-to-order Server	653203-B21	1	2,597	1	2,597	
Gen8 AMD Opteron™ 6386SE (2.8GHz/16-core/16MB/140W) Processor	703939-B21	1	1,799	2	3,598	
16GB (1x16GB) Dual Rank x4 PC3-12800R (DDR3-1600) Registered Memory	672633-B21	1	329	16	5,264	
HP 146GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise	652605-B21	1	359	2	718	
HP 300GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise (Log)	652611-B21	1	619	6	3,714	
HP Ethernet 10Gb 2-port NC523SFP+ Adapter	593717-B21	1	629	1	629	
HP Smart Array P421/2GB FBWC 6Gb 2-ports Ext SAS Controller	631674-B21	1	899	4	3,596	
HP 3 year 4 hour 24x7 ProLiant DL38x(p) Hardware Support	U4545E	1	1,216	1		\$1,216
			Subtotal		\$20,116	\$1,216
Server Software						
SQL Server 2012 Enterprise Edition SP1, 2 Core License	7JQ-00256	2	13,473	12	161,670	
Windows Server 2012 Standard Edition	P73-05761	2	735	1	735	
Microsoft Problem Resolution Services	N/A	2	259	1		259
			Subtotal		\$162,405	259
Storage						
HP D2700 Disk Enclosure	AJ941A	1	3,399	4	13,596	
HP 3 year 4 hour 24x7 D2000 Enclosure Hardware Support	UQ540E	1	1,980	4		7,920
HP 400GB 3G SATA MLC SFF (2.5-inch) SC Enterprise Mainstream	653120-B21	1	3,019	24	72,456	
HP 500GB 6G SAS 7.2K rpm SFF DP Midline Hard Drive (60 Day)	507610-B21	1	369	5	1,845	
			Subtotal		87,897	7,920
Client Hardware (Tier A)						
HP ProLiant DL360 G7 CTO Server	579237-B21	1	2,348	1	2,348	
HP DL360 G7 Intel® Xeon® X5670 (2.93GHz/6-core/12MB/95W) Processor	587493-B21	1	2,099	2	4,198	
HP 2GB (1x2GB) Dual Rank x8 PC3-10600 Memory Kit	500656-B21	1	110	6	660	
HP 300GB 6G SAS 10K rpm SFF (2.5-inch) Enterprise 3yr Warranty Hard Drive	507127-B21	1	309	2	618	
HP NC360T PCIe Dual Port Gigabit Server Adapter	412648-B21	1	219	1	219	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	931	1		931
			Subtotal		8,043	931
Client Software						
Microsoft Windows Server 2008 R2 Enterprise Edition	P72-04217	2	2,280	1	2,280	
			Subtotal		2,280	0
Infrastructure						
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4	4	15	
HP Networking 2910al-24G Switch	J9145A	1	1,836	1	1,836	
3-year, 4-hour onsite, 24x7 coverage for hardware	U2856E	1	998	1		998
HP X242 SFP+ SFP+ 1 m Direct Attach Cable	J9281B	1	157	2	314	
HP V142 1075mm deep Pallet 100 series Rack	AF046S	1	789	1	789	
HP LE1901wm 19-inch Widescreen LCD Monitor	NP446A8#ABA	1	149	1	149	
HP PS/2 Keyboard And Mouse Bundle	RC464AA#ABA	1	39	1	39	
			Subtotal		3,142	998
			Total Extended Price		\$283,883	\$11,324
Large Purchase and Net 30 discount (See Note 1)	28.0%		Total Discounts		\$33,375	\$3,098
			Grand Total		\$250,507	\$8,226
Pricing: 1=HP Direct 800-203-6748 2= Microsoft. Note 1: Discount based on HP Direct guidance applies to all lines where pricing = 1. Note 2: All the hardware are available to order. Note 3: The benchmark results were audited by Doug Johnson for InfoSizing. www.infosizing.com.					Three-year Cost of Ownership: USD	
					tpsE	1,416.37
					\$ USD/tpsE	\$183



**HP ProLiant DL385p Gen8
AMD Opteron™ 6386SE Processor
C/S with 1 DL360 G7**

**TPC-E Rev 1.12.0
TPC Pricing 1.7.0**

Report Date
May 15, 2013
Availability Date
May 15, 2013

Numerical Quantities Summary

Reported Throughput	1416.37 tpsE	Configured Customers:			750,000
Response Times (in seconds)		Minimum Average 90 th %tile Maximum			
Broker Volume		0.00	0.02	0.03	0.54
Customer Position		0.00	0.01	0.02	0.63
Market Feed		0.00	0.02	0.04	1.86
Market Watch		0.00	0.01	0.02	0.41
Security Detail		0.00	0.01	0.01	0.29
Trade Lookup		0.00	0.09	0.14	0.53
Trade Order		0.00	0.03	0.05	0.77
Trade Result		0.00	0.03	0.05	1.59
Trade Status		0.00	0.01	0.02	0.54
Trade Update		0.01	0.11	0.15	0.60
Data Maintenance		0.01	0.02		0.09
Transaction Mix		Transaction Count			Mix %
Broker Volume		4,996,878			4.900%
Customer Position		13,256,747			13.000%
Market Feed		1,019,791			1.000%
Market Watch		18,355,544			18.000%
Security Detail		14,276,523			14.000%
Trade Lookup		8,157,946			8.000%
Trade Order		10,299,493			10.100%
Trade Result		10,197,872			10.000%
Trade Status		19,375,413			19.000%
Trade Update		2,039,429			2.000%
Data Maintenance		120			
Ramp-up Time				0:22:00	
Measurement Interval				2:00:00	
Business Recovery Time				1:17:21	
Total Number of Transactions Completed in Measurement Interval				101,975,636	

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Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL385p Gen8 using Microsoft SQL Server 2012 Enterprise Edition SP1. It meets the requirements of the TPC Benchmark® E Standard Specification, Revision 1.12.0 dated June 2010. TPC Benchmark® E was developed by the Transaction Processing Performance Council (TPC). It is the intent of this group to develop a suite of benchmarks to measure the performance of computer systems executing a wide range of applications. Hewlett-Packard Company and Microsoft, Inc. are active participants in the TPC.

The requirements for this Full Disclosure Report are in Clause 9 of TPC Benchmark® E Specification.

TPC Benchmark® E Overview

TPC Benchmark™ E (TPC-E) is an On-Line Transaction Processing (OLTP) workload. It is a mixture of read-only and update intensive transactions that simulate the activities found in complex OLTP application environments. The database schema, data population, transactions, and implementation rules have been designed to be broadly representative of modern OLTP systems. The benchmark exercises a breadth of system components associated with such environments, which are characterized by:

- The simultaneous execution of multiple transaction types that span a breadth of complexity;
- Moderate system and application execution time;
- A balanced mixture of disk input/output and processor usage;
- Transaction integrity (**ACID** properties);
- A mixture of uniform and non-uniform data access through primary and secondary keys;
- Databases consisting of many tables with a wide variety of sizes, attributes, and relationships with realistic content;
- Contention on data access and update.

The TPC-E operations are modeled as follows:

- The database is continuously available 24 hours a day, 7 days a week, for data processing from multiple **Sessions** and data modifications against all tables, except possibly during infrequent (e.g., once a month) maintenance **Sessions**.
- Due to the worldwide nature of the application modeled by the TPC-E benchmark, any of the transactions may be executed against the database at any time, especially in relation to each other.

The TPC-E benchmark simulates the OLTP workload of a brokerage firm. The focus of the benchmark is the central database that executes transactions related to the firm's customer accounts. In keeping with the goal of measuring the performance characteristics of the database system, the benchmark does not attempt to measure the complex flow of data between multiple application systems that would exist in a real environment.

The mixture and variety of transactions being executed on the benchmark system is designed to capture the characteristic components of a complex system. Different transaction types are defined to simulate the interactions of the firm with its customers as well as its business partners. Different transaction types have varying run-time requirements.

Clause 1: General Items

1.1 Orders and Titles

*The order and titles of sections in the **Report** and **Supporting Files** must correspond with the order and titles of sections from the TPC-E Standard Specification (i.e., this document). The intent is to make it as easy as possible for readers to compare and contrast material in different **Reports**. (9.1.1.1)*

The order and titles of the sections in this report correspond with those specified in the TPC-E specification.

1.2 Pricing

*The **FDR** must follow all reporting rules specified in the effective version of the TPC Pricing Specification, located at www.tpc.org. (9.1.1.2)*

The pricing rules for this FDR follow the current standard at the time of publication, TPC Pricing Specification 1.7.0.

1.3 Executive Summary Statement

*The **TPC Executive Summary Statement** must be included near the beginning of the **Report**. (9.2)*

The Executive Summary statement is included after the preamble of this Full Disclosure Report, as well as a separate document.

1.4 Supporting Files

A directory structure for the supporting files must be followed. (9.1.1.3)

The accompanying support files are in the proper structure as defined by the specification.

1.5 Auditor

*The name of the **Auditor** who certified the result must be included after the Price Spreadsheet. (9.2.2.2)*

This Benchmark, Executive Summary, and Full Disclosure Report were audited by Doug Johnson of InfoSizing. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

*Diagrams of both **Measured** and **Priced Configurations** must be **reported** in the **Report**, accompanied by a description of the differences. (9.3.1.2, 9.3.1.3)*

The Benchmarked and Priced configurations of the driver, SUT Server, and DBMS server are illustrated in Figures 1.1 and 1.2.

Figure 1.1 Priced Configuration

Tier B: Server

HP ProLiant DL385p Gen8

2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor
256 GB Memory
2 x HP 146GB SAS 15K SFF DP ENT HDD
6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)



Tier A: Client

1 x ProLiant DL360 G7
2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz
6 x 2GB PC3-10600 Memory
2 x 300GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet
1 X HP NC360T PCI-E Dual Port Gigabit Server Adapter

Storage

4 x HP Smart Array P421/1GB
4 x HP StorageWorks D2700 Disk Enclosure
24 X HP 400GB 6G SAS MLC SFF (2.5-inch) SSD
Priced Only
5 x 500GB 6G SAS 15K SFF DP ENT HDD (60 Day Space)

Figure 1.2 Measured Configuration

Tier B: Server

HP ProLiant DL385p Gen8

2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor
256 GB Memory
2 x HP 146GB SAS 15K SFF DP ENT HDD
6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)



Tier A: Client

1 x ProLiant DL360 G7
2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz
6 x 2GB PC3-10600 Memory
2 x 300GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet
1 x HP NC360T PCI-E Dual Port Gigabit Server Adapter

Storage

4 x HP Smart Array P421/1GB
4 x HP StorageWorks D2700 Disk Enclosure
24 X HP 400GB 6G SAS MLC SFF (2.5-inch) SSD
Measured Only
48 x 500GB 6G SAS 15K SFF DP ENT HDD (Database Backup)

Note: The 48 x 500GB 6G SAS present during the measured run were for data backup only, and were not active during the actual performance measurement or durability runs.

1.7 Hardware Configuration

*A description of the steps taken to configure all of the hardware must be **reported** in the **Report**. Any and all configuration scripts or step by step GUI instructions are **reported** in the **Supporting Files** (see Clause 9.4.1.1). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the hardware environment.*

A description of any firmware updates or patches to the hardware.

A description of any GUI configuration used to configure the system hardware.

*A description of exactly how the hardware is combined to create the complete system. For example, if the **SUT** description lists a base chassis with 1 processor, a processor update package of 3 processors, a NIC controller and 3 disk controllers, a description of where and how the processors, NIC and disk controllers are placed within the base chassis must be **reported** in the **Report**.*

A description of how the hardware components are connected. The description can assume the reader is knowledgeable of computer systems and the TPC-E specification. For example, only a description that Controller 1 in slot A is connected to Disk Tower 5 is required. The reader is assumed to be knowledgeable enough to determine what type of cable is required based upon the component descriptions and how to plug the cable into the components.

The HP ProLiant DL385p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 processor installed, along with 16 x 16 GB DIMMs. The various HBA's, NICS, and other IO cards are installed in the various chassis as defined in the file **HWConfig.pdf** in the \Supporting Files\Introduction\TierB "Introduction" directory. Additionally, the **DiskConfig.pdf** file in the Supporting Files directory shows how the SmartArray storage subsystem was configured.

1.8 Software Configuration

*A description of the steps taken to configure all software must be **reported** in the **Report**. Any and all configuration scripts or step by step GUI instructions are **reported** in the **Supporting Files** (see Clause 9.4.1.2). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the software environment. This includes, but is not limited to:*

A description of any updates or patches to the software.

A description of any changes to the software.

A description of any GUI configurations used to configure the software.

The file **Win2012Setup.pdf** in the \SupportingFiles\Introduction\TierB directory outlines the steps taken to configure the OS and DBMS. The file **SQL2012Setup.doc** in \SupportingFiles\Introduction\TierB likewise outlines the steps taken to setup the DBMS. Other supporting files (registry, configuration) are also included in the respective directories.

Clause 2: Database Design, Scaling & Population Items

2.1 Physical Database Organization

*The physical organization of tables and indices, within the database, must be **reported** in the **Report**.*

The database tables and indices were organized into two SQL Server filegroups as shown in Table 2.1 below. The tables that grew during the run, defined as *growing tables* in the TPC-E specification, were placed in a file group called Growing, while the tables that do not grow during the run, designated as *fixed and scaling*, and were placed in a filegroup called Fixed.

Directory **Clause2** in *Supporting Files* contains the scripts used to create the data base filegroups, tables, constraints, and indices. In addition, files to create TEMPDB files before the build and remove them after the build are included, as well as a script to remove the LOAD_FG files and filegroup after the build and before the initial backup.

Fixed		Growing
Account_Permission	Security	Cash_Transaction
Company	Watch_Item	Holding
Company_Competitor	Watch_List	Holding_History
Customer	Charge	Holding_Summary
Customer_Account	Commission_Rate	Settlement
Customer_TaxRate	Exchange	Trade
Daily_Market	Industry	Trade_History
Financial	Sector	Trade_Request
Last_Trade	Status_Type	
News_Item	TaxRate	
News_Xref	Trade_Type	
Broker	Zip_Code	
Address		

Table 2.1 – FileGroup Table Assignments

2.2 Table and Row Partitioning

*While few restrictions are placed upon horizontal or vertical partitioning of tables and rows in the TPC-E benchmark (see Clause 2.3.3), any such partitioning must be **reported** in the **Report**. (9.3.2.2)*

No partitioning was done for this benchmark.

2.3 Replication, Duplication

*Replication of tables, if used, must be **reported** in the **Report**. (9.3.2.3).*

*Additional and/or duplicated columns in any table must **be** reported in the **Report** along with a statement on the impact on performance. (9.3.2.4)*

No replication or duplication was done for this benchmark.

2.4 Cardinality of Tables

The cardinality (e.g. the number of rows) of each table, as it existed after database load must be **reported** in the **Report**. (9.3.2.5)

The TPC-E database was configured using 750,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
BROKER	7,500
CASH_TRANSACTION	11,923,187,680
CHARGE	15
COMMISSION_RATE	240
SETTLEMENT	12,960,000,000
TRADE	12,960,000,000
TRADE_HISTORY	31,104,030,225
TRADE_REQUEST	0
TRADE_TYPE	5
ACCOUNT_PERMISSION	5,325,184
CUSTOMER	750,000
CUSTOMER_ACCOUNT	3,750,000
CUSTOMER_TAXRATE	1,500,000
HOLDING	663,639,422
HOLDING_HISTORY	17,368,591,534
HOLDING_SUMMARY	37,301,786
WATCH_ITEM	74,987,894
WATCH_LIST	750,000
COMPANY	375,000
COMPANY_COMPETITOR	1,125,000
DAILY_MARKET	670,443,750
EXCHANGE	4
FINANCIAL	7,500,000
INDUSTRY	102
LAST_TRADE	513,750
NEWS_ITEM	750000
NEWS_XREF	750000
SECTOR	12
SECURITY	513,750
STATUS_TYPE	5
ADDRESS	1,125,004
TAXRATE	320
ZIP_CODE	14741

Table 2.2 Initial Cardinality of Tables

2.5 Disk Configuration

The distribution of tables, partitions and logs across all media must be explicitly depicted for the measured and Priced Configurations.(9.3.2.6)

Table 2.3 shows the configuration of the 4 HP SmartArray controllers, configured for database storage. It also shows the 6 X HP 300GB 6G SAS 15K RPM SF Hard Drives configured for the log, connected to 1 x HP Smart Array P420i controller in the internal bay. The database logical volumes were configured in RAID 5, and the log disks were configured as a RAID1+0 volume.

Each data array was partitioned with 3 partitions, one for the Growing FG, one for the Fixed FG, and one for TempDB files. The first 2 partitions were RAW; the 3rd was configured as NTFS. Access to all the TPCE database partitions was by using mount points, no drive letters were used except for the log, and the boot/utility drives.

Controller Type	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
P420i Internal SmartArray	1	2x146GB SAS, Internal RAID1	C:, NTFS	136.7GB	Win2012 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
	2	6x000GB SAS, Internal RAID1+0	L:, RAW	838GB	Database log
P421 SmartArray Adapter	1	6 X 400GB 6G SAS MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1(NTFS)	1600 GB 35 GB 227.8 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	6 X 400GB 6G SAS MLC SFF	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) g:\mnt\temp\2(NTFS)	1600 GB 35 GB 227.8 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	6 X 400GB 6G SAS MLC SFF	g:\mnt\growing\3\ (RAW) g:\mnt\fixed\3\ (RAW) g:\mnt\temp\3(NTFS)	1600 GB 35 GB 227.8 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	6 X 400GB 6G SAS MLC SFF	g:\mnt\growing\4\ (RAW) g:\mnt\fixed\4\ (RAW) g:\mnt\temp\4(NTFS)	1600 GB 35 GB 227.8 GB	Growing FG Fixed FG TempDB files

Table 2.3 Disk/Partition Configuration

The measured configuration also included 12 X HP 500GB 6G SAS 7.2K RPM hard drives attached to each P421 cards. These 4 volumes held backups of the database, and were also used during building of the database. This storage was not an active part of the performance run.

2.6 Database Interface

*A statement must be provided in the **Report** that describes:*

*The **Database Interface** (e.g., embedded, call level) and access language (e.g., **SQL**, **COBOL** read/write) used to implement the **TPC-E Transactions**. If more than one interface / access language is used to implement **TPC-E**, each interface / access language must be described and a list of which interface /access language is used with which **Transaction** type must be **reported**.(9.3.2.7)*

*The data model implemented by the **DBMS** (e.g., relational, network, hierarchical).(9.3.2.7)*

*The methodology used to load the database must be **reported** in the **Report**. (9.3.2.8)*

Client software interfaced to SQL Server through stored procedures invoked by the clients with ODBC calls. The application code was C++.

The data model implemented by Microsoft SQL Server 2012 Enterprise Edition SP1 is relational.

The methodology used to load the database is contained in the file **MSTPCE Database Setup Reference.pdf** in the **CLAUSE2** directory in *SupportingFiles* directory.

Clause 3: Transaction Related Items

3.1 Code Functionality

*A statement that vendor-supplied code is functionally equivalent to **Pseudo-code** in the specification must be **reported** in the **Report**.(9.3.3.1)*

Secondary sponsor-supplied code is functionally equivalent to pseudo-code in the specification.

3.2 Database Footprint

*A statement that the database footprint requirements were met must be **reported** in the **Report**. (9.3.3.2)*

Database footprint requirements were met.

Clause 4: SUT, Driver and Network Related Items

4.1 Network Configuration

*The **Network** configurations of both the measured and **Priced Configurations** must be described and **reported** in the **Report**. This includes the mandatory **Network** between the **Driver** and **Tier A**) and any optional **Database Server** interface networks (9.3.4.1)*

The two ports of the HP 523SFP+ NIC card in the SUT were connected to the 2910-al-24g network switch. Two ports of the HP Proliant DL360 G7 client were also connected to this switch. These connections were used for database traffic. The other built in NICs on the SUT and client were used to access the system by the benchmark driver system, management, etc.

Clause 5: EGen Related Items

5.1 EGen Version

*The version of EGen used in the benchmark must be **reported** in the **Report**. (9.3.5.1)*

EGen Version used for this test was 1.12.0

5.2 EGen Code

*A statement that all required TPC-provided EGen code was used in the benchmark must be **reported** in the **Report**. (9.3.5.2)*

All required TPC provided EGen code was used in this benchmark.

5.3 EGen Modifications

*If the **Test Sponsor** modified EGen, a statement EGen has been modified must be **reported** in the **Report**. All formal waivers from the TPC documenting the allowed changes to EGen must also be **reported** in the **Report** if any of the changes to EGen do not have a formal waiver that must also be **reported** in the **Report**.*

No modifications to EGen were done for this report.

5.4 EGen Loader Extensions

*If the **Test Sponsor** extended EGenLoader the use of the extended EGenLoader and the audit of the extension code by an **Auditor** must be **reported** in the **Report** (9.3.5.4)*

EGen Loader was not extended for this report.

5.5 EGen Loader Make Files

*The make/project files used to compile/link EGenLoader and EGenValidate must be **reported** in the **Supporting Files**. The compiler/linker options and flags used to compile/link EGen Objects for the **SUT** must be **reported** in the **Supporting Files**. (9.3.5.5)*

The Visual C++ project files are in the **Clause3** directory in the *Supporting Files* directory.

Clause 6: Performance Metrics and Response Time Related Items

6.1 EGenDriver and MEE instances

The number of EGenDriverMEE and EGenDriverCE instances used in the benchmark must be reported in the Report (9.3.6.1)

16 instances of both the EGenDriverMEE and EGenDriverCE were used in this report.

6.2 Measured Throughput

The Measured Throughput must be reported in the Report. (9.3.6.2)

Measured tpsE for this run was 1,416.37 tpsE.

Test Run Graph and Steady State Measurement

A Test Run Graph of throughput versus elapsed wall clock time must be reported in the Report for the Trade-Result Transaction.(9.3.6.3)

The method used to determine that the SUT had reached a Steady State prior to commencing the Measurement Interval must be reported in the Report.(9.3.6.4)

After initial ramp-up, throughput and response time were observed until both were constant, generally to within less than a percent of the reported throughput. Throughput and response time were determined by examining the data after the run was terminated. The data was reported over every 60 second window during the test run. Ramp up and steady state can be seen from the graph below.

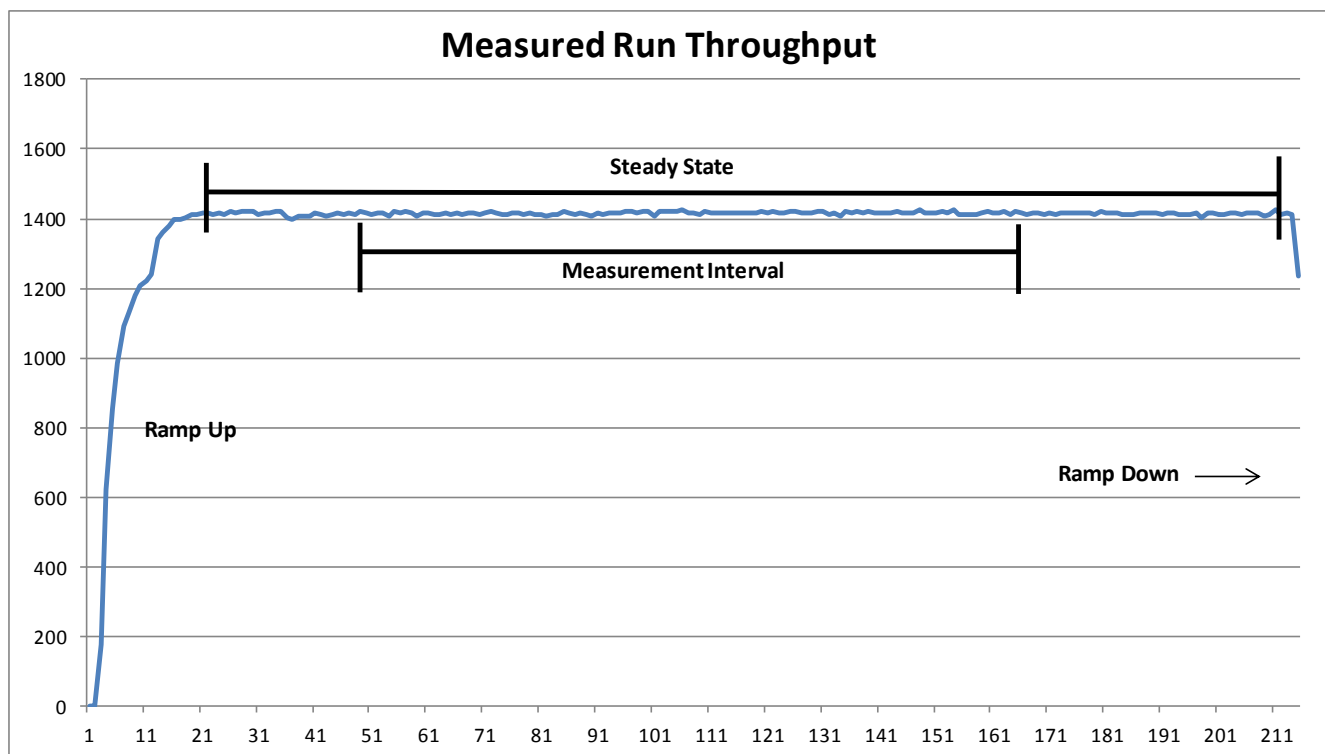


Figure 6.1 Test Run Time/Steady State Measurement Run Data

6.4 Work Measurement

*A description of how the work normally performed during a **Test Run**, actually occurred during the **Measurement Interval** must be **reported** in the **Report** (for example check-pointing, writing **Undo/Redo Log** records, etc). (9.3.6.5)*

During the run, the Customer Emulator engines (Driver Engines) generated transactions via the audited stored procedures as per the TPC-E specification. Each transaction was time-stamped, response time verified, and the transactions logged into individual log files. Communication was done between the Driver Engine Customer Emulators and Market Emulators to the SUT Server emulators, which in turn generated commands via ODBC connections to Microsoft SQL Server 2012 Enterprise Edition SP1. Satisfying these ODBC requests constitute the primary load on the server during the run.

Checkpoints were performed to flush all dirty pages from memory, and write a record of this fact to the transaction log. This was accomplished by setting the SQL Recovery Interval to 32767, which effectively tells SQL to not checkpoint automatically. Near the beginning of the test run, a script was started that did manual checkpoints, specifying an interval of 435 seconds. SQL Server was run with run flag 3502, which caused it to display messages when checkpoints were started and ended. This was used to verify the checkpoints were done in the time intervals as required by the TPC-E specification.

6.5 Transaction Reporting

*The recorded averages over the **Measurement Interval** for each of the **Transaction** input parameters specified by clause 6.4.1 must be **reported** in the **Report**. (9.3.6.6)*

Table 6.2 shows the Averages for the Test Run.

Transaction	Over- all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.98%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.98%	Ok	28.50%	31.50%
		Frame 2	29.98%	Ok	28.50%	31.50%
		Frame 3	30.02%	Ok	28.50%	31.50%
		Frame 4	10.02%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	60.00%	Ok	57.00%	63.00%
		By Customer Acct	34.99%	Ok	33.00%	37.00%
		By Industry	5.01%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	32.99%	Ok	31.00%	35.00%
		Frame 2	32.98%	Ok	31.00%	35.00%
		Frame 3	34.03%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	9.98%	Ok	9.50%	10.50%
		By Company Name	40.01%	Ok	38.00%	42.00%
		Buy on Margin	7.99%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	34.99%	Ok	33.00%	37.00%
		Trade by Qty 100	24.98%	Ok	24.00%	26.00%
		Trade by Qty 200	25.01%	Ok	24.00%	26.00%
		Trade by Qty 400	25.00%	Ok	24.00%	26.00%
		Trade by Qty 800	25.02%	Ok	24.00%	26.00%
		Market Buy	30.00%	Ok	29.70%	30.30%
		Market Sell	30.00%	Ok	29.70%	30.30%
		Limit Buy	19.98%	Ok	19.80%	20.20%
		Limit Sell	10.01%	Ok	9.90%	10.10%
		Stop Loss	10.01%	Ok	9.90%	10.10%

Table 6.2 Average Transaction Parameters

Clause 7: Transaction and System Properties

7.1 ACID Tests

*The results of the ACID tests must be **reported** in the **Report** along with a description of how the ACID requirements were met, and how the ACID tests were run. (9.3.7.1)*

The Atomicity, Consistency, Isolation, and Durability tests are specified by the TPC-E specification. These requirements are translated into audited procedures which are executed either on a fresh database (Isolation, Atomicity, Consistency), or after a test run (Consistency). Instructions for running these tests are included in the file ***MSTPCE ACID Procedures.pdf***. This file, along with results of these tests is contained in the *Supporting Files* directory under **Clause7**.

Durability test consisted of Data Accessibility and Business Recovery tests. The procedures for each are outlined below.

7.2 Redundancy Level and Data Accessibility Tests

*The **Test Sponsor** must **report** in the **Report** the **Redundancy Level** and describe the **Data Accessibility** test(s) used to demonstrate compliance. (9.3.7.2)*

Redundancy level 1 was used for all tests and the measured run.

The Data Accessibility Test for the data disk, and the database transaction log was performed according to the following steps:

1. The rows in the Settlement table were counted to establish the initial count of trades present.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to > 95% of the Reported Throughput.
3. After more 5 minutes of running at $\geq 95\%$ of the Reported Throughput, log disk in the RAID10 log array was pulled, and approximately five minutes later, a data disk in the RAID5 data arrays was pulled.
4. The benchmark was allowed to run for 5 more minutes at steady state, all at $\geq 95\%$ of Reported Throughput.
5. After the 5 minutes, the disks were replaced by different disks of the same size and a rebuild of the volumes started automatically by the Smart Array controllers.
6. The run continued for more than 20 minutes at $\geq 95\%$ of the Reported Throughput.
7. Various reports were run. No errors were reported at any time in this process.
8. The rows in the Settlement table were counted again to establish the final number of trades present in the data base.
9. The initial count was subtracted from the final count and was verified against the reported number of Trade-Result transactions
10. After the two disks were rebuilt, the recovery was considered complete.

7.3 Data Accessibility Graph

A *Data Accessibility Graph* for each run demonstrating a Redundancy Level must be **reported** in the *Report*. (9.3.7.3)

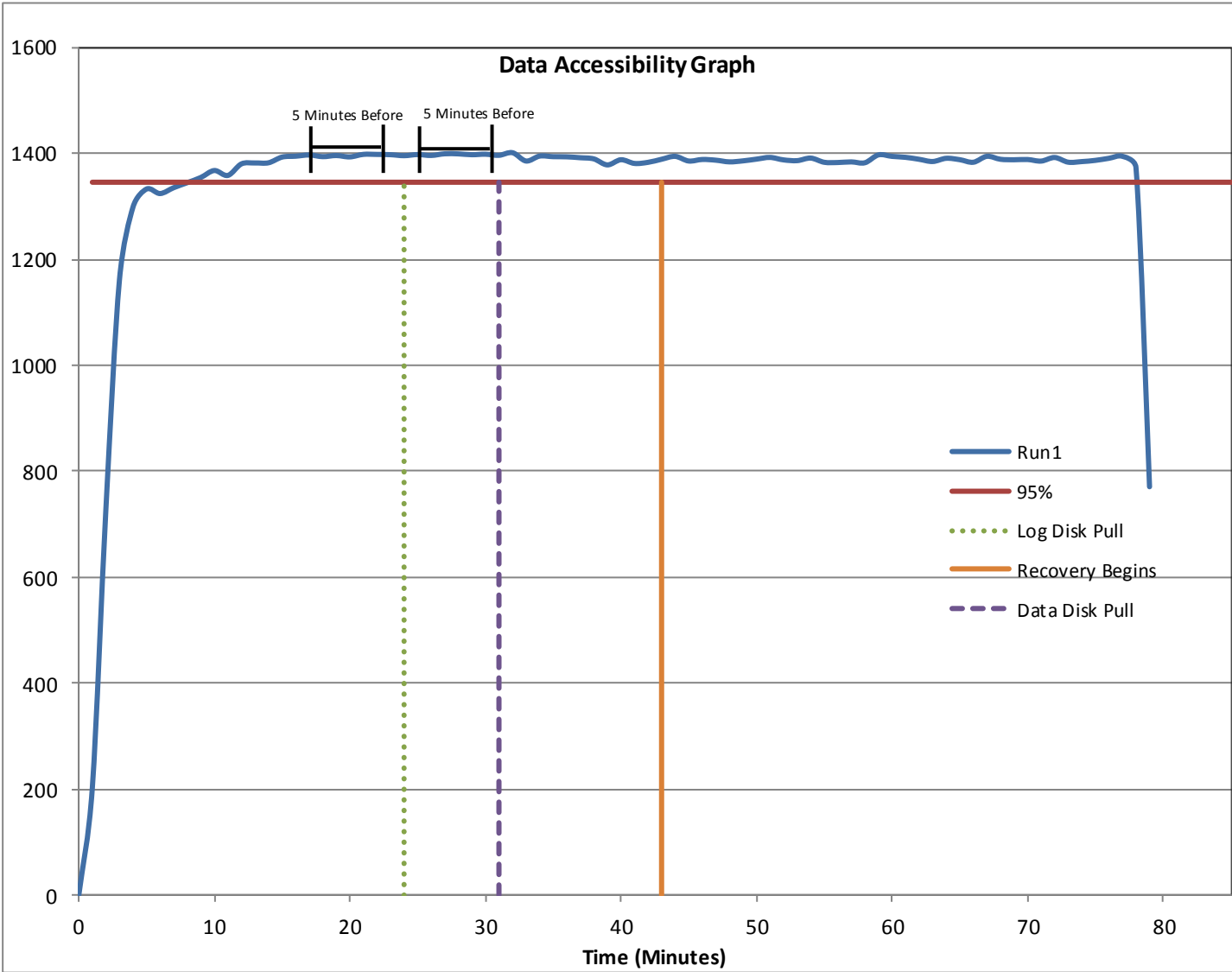


Figure 7.1 Data Accessibility Test Run Graph

7.4 Business Recovery Tests

The *Test Sponsor* must describe in the *Report* the test(s) used to demonstrate *Business Recovery*. (9.3.7.4)

This test measures the time it takes to recover to 95% of the reported throughput after a system power loss.

1. The rows in the Settlement table were counted to establish the initial count of trades present.

2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to >95% of the Reported Throughput.
3. Primary power to Tier B server was removed (i.e., the plug was pulled).
4. Drivers noted transaction failures almost immediately, and the driver environment was terminated.
5. Power was restored to Tier B server, and the machine rebooted. While the machine booted and recovered (step 6), the logs for the first run were processed.
6. After the OS was running, SQL Server was started, which automatically started transaction recovery of the primary TPC-E data base. This process reads the transaction log and reapplies all committed transactions and rollback any incomplete transactions. At the end of this process, the database on disk will be logically consistent.
7. Business Recovery starts with the first line of output produced by Microsoft SQL Server 2012 SP1 Enterprise Edition.
8. After SQL finished recovery of the TPC-E database and reported that the data base was available, the Trade-Cleanup Transaction was executed.
9. The benchmark was started and ramped up as before to >95% of the Reported Throughput.
10. The benchmark was allowed to run at >=95% for 20 minutes.
11. The driver environment was terminated gracefully. No errors were reported.
12. The rows in the Settlement table were counted again to determine the final number of trades present.
13. The initial count was subtracted from the final count, and this number was verified to be greater than or equal to the number of Trade-Result transacts as logged during the run.
14. The Consistency scripts were run to verify the data base was logically consistent.
15. The beginning of the first window of time where >=95% for 20 minutes was noted, which marked the end of the Business Recovery interval.

Business Recovery Time was 1 hour 17 minutes and 21 seconds. This is also reported in the Executive Summary.

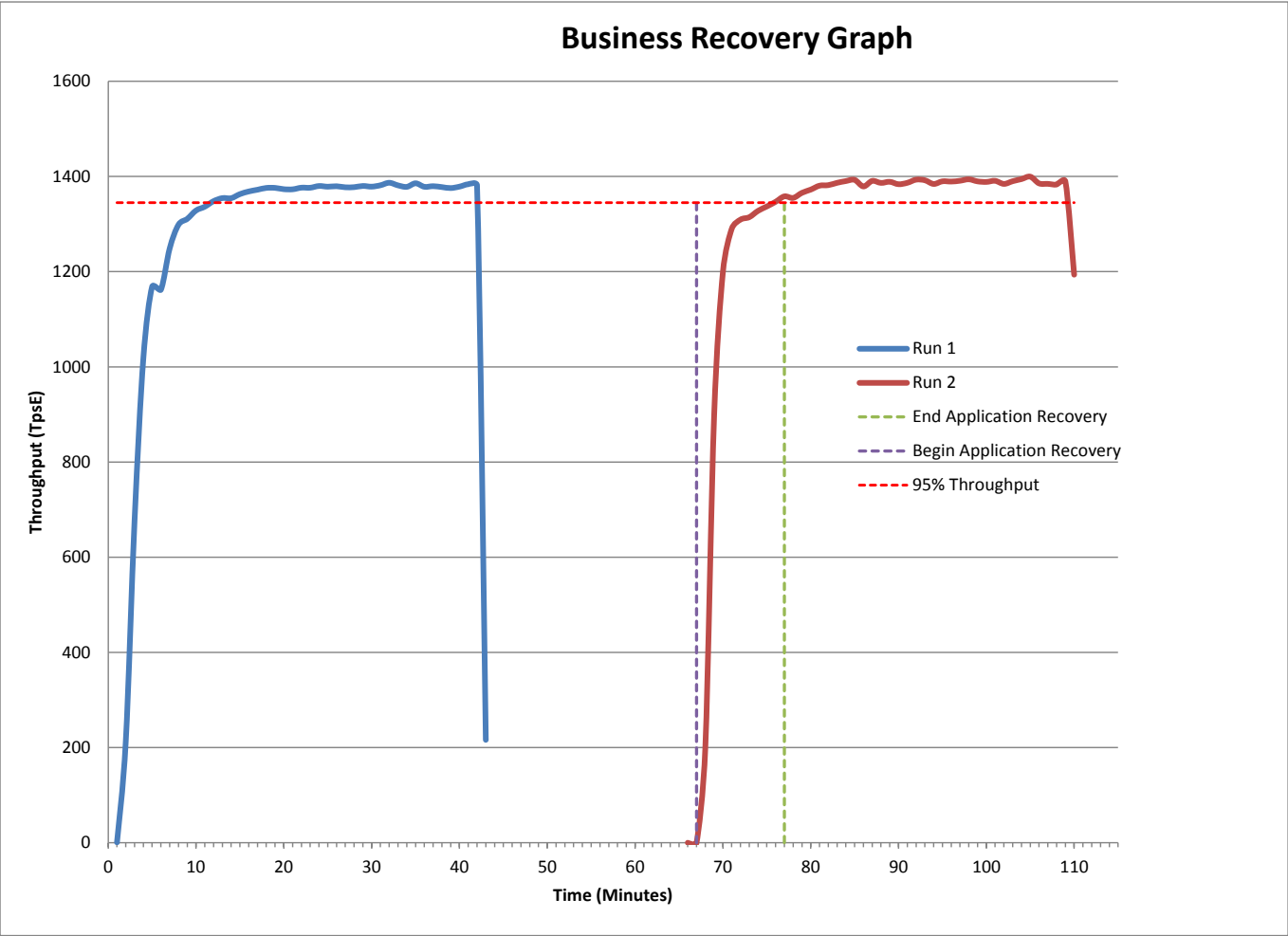


Figure 7.2 Business Recovery Tests Graph

Clause 8: Pricing Related Items

8.1 60-Day Space

Details of the 60-Day Space computations along with proof that the database is configured to sustain a Business Day of growth must be reported in the Report. (9.3.8.1)

Below is the 60 Day Space spreadsheet verified from the IO configuration.

TPC-E Disk Space Requirements										
Customers Used	750,000	Performance	1,416.37	TpsE						
Broker File Group	Initial Rows	Data (KB)	Index size (KB)	Extra 5% (KB)	Total + 5% (KB)	After run (KB)	Growth (KB)	1 Day Growth (KB)	Req. Add. (KB)	
BROKER	7,500	552	648	60	1,260	1,200	-	-	-	60
CASH_TRANSACTION	11,923,187,680	1,229,942,120	2,592,536	61,626,733	1,294,161,389	1,235,645,248	3,110,592	7,136,097	7,136,097	
CHARGE	15	8	8	1	17	16	-	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	-	2
SETTLEMENT	12,960,000,000	617,982,904	1,303,016	30,964,296	650,250,216	621,025,840	1,739,920	3,991,600	3,991,600	
TRADE	12,960,000,000	1,545,365,744	857,917,480	120,164,161	2,523,447,385	2,411,742,848	8,459,624	19,407,462	19,407,462	
TRADE_HISTORY	31,104,030,225	935,459,672	2,438,736	46,894,920	984,793,328	941,009,152	3,110,744	7,136,446	7,136,446	
TRADE_REQUEST	-	-	-	-	-	261,328	261,328	599,520	599,520	
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	-	52
Customer File Group										
ACCOUNT_PERMISSION	5,325,184	293,256	1,960	14,761	309,977	295,248	32	74	14,761	
CUSTOMER	750,000	122,912	36,968	7,994	167,874	159,880	-	-	7,994	
CUSTOMER_ACCOUNT	3,750,000	339,824	83,864	21,184	444,872	423,672	(16)	(36)	21,184	
CUSTOMER_TAXRATE	1,500,000	31,280	560	1,592	33,432	31,984	144	331	1,592	
HOLDING	663,639,422	44,178,304	30,132,000	3,715,515	78,025,819	75,367,280	1,056,976	2,424,839	2,424,839	
HOLDING_HISTORY	17,368,591,534	631,585,280	421,923,744	52,675,451	1,106,184,475	1,057,134,976	3,625,952	8,318,399	8,318,399	
HOLDING_SUMMARY	37,301,786	1,621,880	6,328	81,410	1,709,618	1,628,208	-	-	-	
WATCH_ITEM	74,987,894	2,084,288	7,992	104,614	2,196,894	2,092,552	272	625	104,614	
WATCH_LIST	750,000	18,704	17,552	1,813	38,069	36,256	-	-	1,813	
Market File Group										
COMPANY	375,000	79,704	24,528	5,212	109,444	104,248	16	37	5,212	
COMPANY_COMPETITOR	1,125,000	30,216	28,000	2,911	61,127	58,216	-	-	2,911	
DAILY_MARKET	670,443,750	31,251,792	90,568	1,567,118	32,909,478	31,343,728	1,368	3,139	1,567,118	
EXCHANGE	4	8	8	1	17	16	-	-	1	
FINANCIAL	7,500,000	845,200	2,760	42,398	890,358	848,248	288	661	42,398	
INDUSTRY	102	8	24	2	34	32	-	-	2	
LAST_TRADE	513,750	31,880	560	1,622	34,062	32,440	-	-	1,622	
NEWS_ITEM	750,000	81,313,688	1,320	4,065,750	85,380,758	81,315,040	32	74	4,065,750	
NEWS_XREF	750,000	18,712	560	964	20,236	19,272	-	-	964	
SECTOR	12	8	24	2	34	32	-	-	2	
SECURITY	513,750	70,696	20,080	4,539	95,315	90,800	24	56	4,539	
STATUS_TYPE	5	8	8	1	17	16	-	-	1	
Misc File Group										
ADDRESS	1,125,004	64,904	560	3,273	68,737	65,504	40	92	3,273	
TAXRATE	320	24	16	2	42	56	16	37	37	
ZIP_CODE	14,741	488	40	26	554	528	-	-	26	
TOTALS (KB)		5,122,734,088	1,316,633,496	321,968,379	6,761,335,963					
Initial Database Size (MB)		6,288,445	6,141 GB							
Db/Filegroups										
fixed_fg	4	36,700,160	143,360	114,178	119,886	OK				
growing_fg	4	1,677,721,600	6,553,600	6,174,267	6,222,133	OK				
					MB Available					
Settlements	17,780,810				354,941					
Initial Growing Space (MB)	6,174,267		Database	60 Day Space						
Final Growing Space (MB)	6,195,132	LUNS	4	1	Initial Log size (MB)	1,546	Log LUNS	1		
Delta (MB)	20,864	Disks per LUN	6	5	Final Log size (MB)	120,431	Log Disks	6		
Data Space per Trade (MB)	0.00117342	Disk Capacity (MB)	381,501	476,160	Log Growth (MB)	118,885	Disk Capacity (MB)	286,075		
1 Day Data Growth (MB)	47,866	RAID5 Overhead	16.7%	20.0%	Log Growth/trade (MB)	0.00668614	RAID10 Overhead	50%		
60-Day Overflow (MB)	2,824,070	Total Space (MB)	7,629,724	1,904,640	1 Day log space (MB)	272,737	Log Space (MB)	858,225		
		Total Space Required	9,166,088.92							
		Total Space Priced	9,534,364							
		Total Minus TempDB used	9,471,900	OK						

8.2 Attestation Letter



|

Eric Deehr
Hewlett-Packard Company
14475 NE 24th Street
Bellevue, WA 98007

April 30, 2013

I verified the TPC Benchmark[™] E performance of the following configuration:

Platform: HP ProLiant DL385p Gen8
Operating System: Microsoft Windows Server 2012 Standard Edition
Database Manager: Microsoft SQL Server 2012 Enterprise Edition SP1

The results were:

CPU's Speed	Memory	Disks	Trade-Result 90% Response Time	tpsE
Tier B, Server: HP ProLiant DL385p Gen8				
2 x AMD Opteron 6386SE (2.8GHz)	256 GB (16MB L3)	2 x 146 GB 15K SAS HDD 6 x 300 GB 15K SAS HDD 24 x 400 GB SAS SSD	0.05 Seconds	1416.37
Tier A, One Client: HP ProLiant DL360 G7				
2 x QC Intel Xeon X5670 (2.93 GHz)	12 GB (12MB L3)	2 x 300 GB 10K SAS HDD	n/a	n/a

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 EGen components were verified to be v1.12.0.
- The transactions were correctly implemented.
- The database was properly scaled and populated for 750,000 customers.

- The mandatory network between the driver and the SUT was configured.
- The ACID properties were met.
- Input data was generated according to the specified percentages.
- The reported response times were correctly measured.
- All 90% response times were under the specified maximums.
- The measurement interval was representative of steady state conditions.
- The reported measurement interval was 120 minutes.
- The implementation used Redundancy Level 1.
- The Business Recovery Time of 1:17:21 was correctly measured.
- The 60 day storage requirement was correctly computed.
- The system pricing was verified for major components and maintenance.

Additional Audit Notes:

None.

Respectfully Yours,



Doug Johnson, Auditor



François Raab, President

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Clause 9: Supporting Files

9.1 Supporting Files

*The **Supporting Files** contain human readable and machine executable (i.e., able to be performed by the appropriate program without modification) scripts that are required to recreate the benchmark **Result**. If there is a choice of using a GUI or a script, then the machine executable script must be provided in the **Supporting Files**. If no corresponding script is available for a GUI, then the **Supporting Files** must contain a detailed step by step description of how to manipulate the GUI.(9.4)*

Appendix A: Third Party Pricing Quotes/Pricing

Microsoft:

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

Tel 425 882 8080
Fax 425 936 7329
<http://www.microsoft.com/>

Microsoft

April 26, 2013

Hewlett-Packard
Eric Deehr
One Microsoft Way
Redmond, WA 98055

Here is the information you requested regarding pricing for several Microsoft products to be used in conjunction with your TPC-E benchmark testing.

All pricing shown is in US Dollars (\$).

Part Number	Description	Unit Price	Quantity	Price
Database Management System				
7JQ-00256	SQL Server 2012 Enterprise Edition 2 Core License Open Program - Level C	\$13,472.50	12	\$161,670.00
Database Server Operating System				
P73-05761	Windows Server 2012 Standard 2 Processor License Open Program - Level C Unit Price reflects a 17% discount from the retail unit price of \$882.	\$735.00	1	\$735.00
Tier-A Operating System(s)				
P72-04217	Windows Server 2008 R2 Enterprise Edition Server License with 25 CALs Open Program - Level C Unit Price reflects a 43% discount from the retail unit price of \$3,999.	\$2,280.00	1	\$2,280.00
Support				
N/A	Microsoft Problem Resolution Services Professional Support (1 Incident).	\$259.00	1	\$259.00

SQL Server 2012 Enterprise Edition, Windows Server 2012 Standard, and Windows Server 2008 R2 Enterprise Edition are currently orderable and available through Microsoft's normal distribution channels. A list of Microsoft's resellers can be found in the Microsoft Product Information Center at <http://www.microsoft.com/products/info/render.aspx?view=22&type=how>

Defect support is included in the purchase price. Additional support is available from Microsoft PSS on an incident by incident basis at \$259 call.

This quote is valid for the next 90 days.
Reference ID: TPCE_qhtplyIGYLKTVUKf95957fiiiLjhiJihjHmh.