TPC Benchmark® E
Full Disclosure Report

HP ProLiant DL580 G7

using Microsoft SQL Server 2008 R2 Enterprise Edition
on Microsoft Windows Server 2008 R2 SP1 Enterprise Edition

First Edition
April 5, 2011

First Edition April 5, 2011

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All performance data contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly. Hewlett-Packard Company does not warrant or represent that a user can or will achieve similar performance expressed in transactions per second (tpsE ®) or normalized price/performance ($/tpsE ®). No warranty of system performance or price/performance is expressed or implied in this report.

Printed in U.S.A., April 5, 2011

Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL580 G7. The operating system used for the benchmark was Microsoft Windows Server 2008 R2 SP1 Enterprise Edition. The report also includes the results of the TPC Benchmark® Energy (TPC-Energy) test conducted on the same system.

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 by Lorna Livingtree of Performance Metrics, Inc. to verify compliance with the relevant TPC specifications.

	HP ProLiant DL580 G7 **Intel Xeon E7-4870 2.40 GHz 30MB L3** **C/S with 4 ProLiant DL360 G7**	**TPC-E Rev 1.12.0** **TPC Pricing 1.6.0** **Report Date** **April 5, 2011**

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
2454.51 tpsE	$291 USD/tpsE	June 20, 2011	$713,369 USD

Database Server Configuration

Operating System	Database Manager	Processor/Cores/Thread	Memory
Microsoft Windows Server 2008 R2 SP1 Enterprise Edition	Microsoft SQL Server 2008 R2 Enterprise Edition	4/40/80 Intel Xeon E7-4870 EX 2.40 GHz 30MB L3	1024 Gbyte

Tier B: Server
HP ProLiant DL580 G7

4 x Intel Xeon Processor E7-4870 2.40 GHZ
1024GB Memory

2 x HP 72GB SAS 15K SFF DP ENT HDD

Database Log

4 x HP 400GB SSD (internal)

Tier A: Clients

4 x ProLiant DL360 G7
2 x Hex-Core Intel Xeon X5670 Processor 2.93Ghz(ea)
2 x 300GB 6G SAS 10K SFF DP(ea)
2 x Onboard 1GbpsEthernet(ea)
1 x HP NC360T PCI-E Dual Port (ea)

Storage

11 x HP Smart Array P812/1GB
44 x HP StorageWorks D2700 Disk Enclosure
950 x 72GB 6G SAS 15K SFF DP ENT HDD
150 x 146GB 6G SAS 15K SFF DP ENT HDD

Initial Database Size	Redundancy Level: 1	Storage
11,000 GB	RAID10:Log/RAID10:Data	950x72GB 15K, 150x146GB 15K , 4x400GB SSD

	HP ProLiant DL580 G7				TPC-E	1.12.0
					TPC-Pricing	1.6.0
					Report date	5-Apr-11
					Availability Date	20-Jun-11
Description	**Part Number**	**Brand**	**Unit Price**	**Qty.**	**Extended Price**	**3 Yr Maint Price**
Server Hardware (Tier B)						
HP DL580R07 CTO Chassis	643086-B21	1	5,100	1	5,100	
E7-4870 DL580 G7 2P FIO Kit	643067-L21	1	11,998	1	11,998	
E7-4870 DL580 G7 Kit	643067-B21	1	5,999	2	11,998	
DL580G7/DL980G7 (E7) Memory Cartridge	644172-B21	1	200	4	800	
HP 16GB (1x16GB) Dual Rank x4 PC3L-10600 Reg. Memory Kit	627812-B21	1	1,899	64	121,536	
HP 72GB SAS 15K SFF DP ENT HDD	512545-B21	1	279	2	558	
512MB Flash Backed Write Cache for P410i	534916-B21	1	429	1	429	
HP Smart Array P812/1G FBWC 2-ports Int/4-ports Ext PCIe x8 SAS	487204-B21	1	1,299	11	14,289	
HP LE1851w 18.5-Inch wide Monitor	NK033AA#ABA	1	159	1	159	
HP PS/2 Keyboard And Mouse Bundle	RC464AA#ABA	1	39	1	39	
Slim 12.7mm SATA DVD Optical Kit	481041-B21	1	90	1	90	
1200W CS Slvr Ht Plg Pwr Supply Kit	500172-B21	1	329	4	1,316	
HP 3y 4h 24x7 ProLiant DL58x HW Support ,Proliant Server DL58x	U4545E	1	1,397	1		$1,397
			Subtotal		**$168,312**	**$1,397**
Server Software						
SQL Server 2008 R2 Enterprise Edition, Per Processor License	810-08527	2	19,188	4	76,752	
Windows Server 2008 R2 Enterprise Edition	P72-04217	2	2,280	1	2,280	
Microsoft Problem Resolution Services	N/A	2	259	1		259
			Subtotal		**$79,032**	**259**
Storage						
HP StorageWorks D2700 Disk Enclosure	AJ941A	1	3,399	44	149,556	
HP StorageWorks D2700 Disk Enclosure (10% Spares)	AJ941A	1	3,399	5	16,995	
HP 72GB 6G SAS 15K SFF DP ENT HDD	512545-B21	1	279	950	265,050	
HP 146GB 6G SAS 15K SFF DP ENT HDD	512547-B21	1	369	150	55,350	
HP 146GB 6G SAS 15K SFF DP ENT HDD (10% Spares)	512547-B21	1	369	15	5,535	
HP 72GB 6G SAS 15K SFF DP ENT HDD (10% Spares)	512545-B21	1	279	95	26,505	
HP 400GB 6G SAS MLC SSD	632504-B21	1	5,999	4	23,996	
HP 5642 Pallet Unassembled Rack	358254-B21	1	865	2	1,730	
			Subtotal		**544,717**	**0**
Client Hardware (Tier A)						
HP ProLiant DL360 G7 CTO Server	579237-B21	1	1,441	4	5,764	
HP DL360 G7 Intel Xeon X5670 (2.93Ghz/6-core/12MB/95W) Proc	588062-B21	1	1,999	8	15,992	
HP 2GB (1x2GB) Dual Rank x8 PC3-10600 Memory Kit	500656-B21	1	110	24	2,640	
HP 300GB 6G SAS 10K SFF DP ENT HDD	507127-B21	1	409	8	3,272	
HP NC360T PCI-E Dual Port Gigabit Server Adapter	412648-B21	1	209	4	836	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	698	4		2,792
			Subtotal		**28,504**	**2,792**
Client Software						
Microsoft Windows Server 2008 R2 Standard (x64)	P73-04980	2	711	4	2,844	
			Subtotal		**2,844**	**0**
HP ProCurve 2910al-24G Switch 24-port 10/100/1000 basic Layer 3	J9145A#ABA	1	2,609	2	5,218	
3-year, 4-hour onsite, 24x7 coverage for hardware	U4835E	1	227	2		454
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4	20	74	
			Subtotal		**5,292**	**454**
		Total Extended Price			**$828,701**	**$4,902**
HP's Large Configuration Discount *	16.0%	**Total Discounts**			**$119,492**	**$743**
		Grand Total			**$709,209**	**$4,159**

Pricing: 1=HP Direct 800-203-6748 2= Microsoft. Note 1: Discount based on HP Direct guidence applies to all lines where pricing = 1. Note 2: All the hardware are available to order. Note 3: The benchmark results were audited by Lorna Livingtree of Performance Metrics.

Three-year Cost of Ownership: USD	**$713,369**
tpsE	**2,454.51**
$ USD/tpsE	**$291**

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

HP ProLiant DL580 G7

Intel Xeon E7-4870 2.40 GHz 30MB L3

TPC-E Rev 1.12.0
TPC Pricing 1.6.0

Report Date
April 5, 2011

Availability Date
June 20, 2011

Numerical Quantities Summary

Reported Throughput	2454.51 tpsE	Configured Customers:	1,250,000

Response Times (in seconds)	Minimum	Average	90th %tile	Maximum
Broker Volume	0.00	0.04	0.07	0.27
Customer Position	0.00	0.03	0.05	20.33
Market Feed	0.00	0.03	0.05	20.72
Market Watch	0.00	0.03	0.06	1.08
Security Detail	0.00	0.01	0.03	0.91
Trade Lookup	0.00	0.40	0.59	1.85
Trade Order	0.00	0.07	0.11	20.60
Trade Result	0.00	0.07	0.13	5.54
Trade Status	0.00	0.02	0.03	1.44
Trade Update	0.01	0.45	0.61	1.87
Data Maintenance	0.00	0.07		0.87

Transaction Mix	Transaction Count	Mix %
Broker Volume	8,660,046	4.900%
Customer Position	22,975,962	13.000%
Market Feed	1,767,263	1.000%
Market Watch	31,812,680	18.000%
Security Detail	24,743,211	14.000%
Trade Lookup	14,138,665	8.000%
Trade Order	17,850,589	10.100%
Trade Result	17,672,529	9.999%
Trade Status	33,580,180	19.000%
Trade Update	3,534,402	2.000%
Data Maintenance	120	

Ramp-up Time	0:35:54
Measurement Interval	2:00:00
Business Recovery Time	1:03:14
Total Number of Transactions Completed in Measurement Interval	176,735,527

Table of Contents

Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL580 G7 using Microsoft SQL Server 2008 R2 Enterprise Edition. 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 **T**ransaction Processing **P**erformance **C**ouncil (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 anytime, 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 1.6.0.

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 Lorna Livingtree of Performance Metrics, Inc.. 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 the same and illustrated in Figure 1.1.

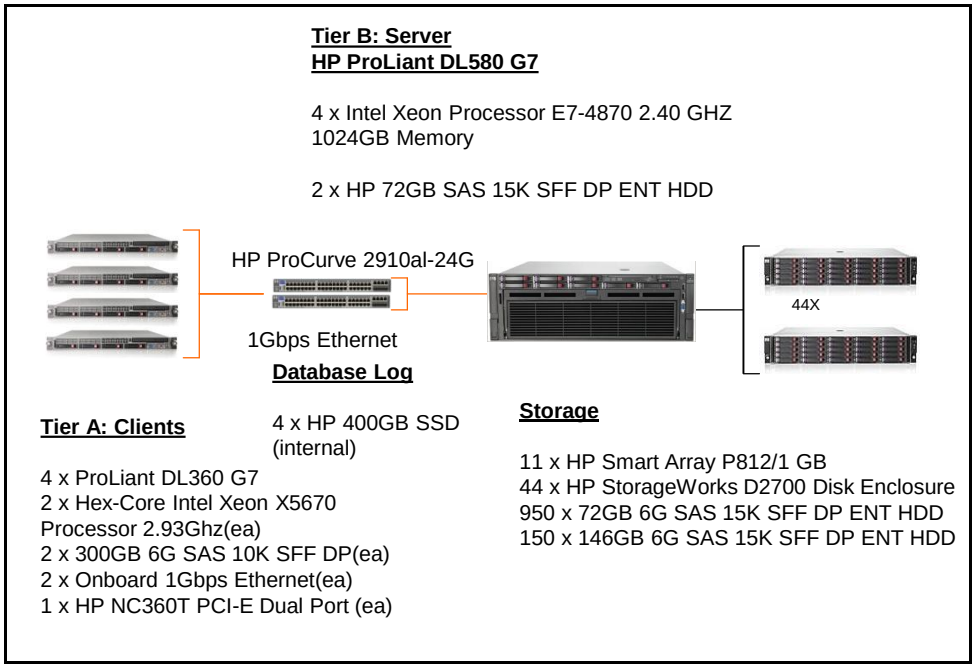

Figure 1.1 Benchmarked and Priced Configuration

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 DL580 G7, in the benchmarked configuration, consists of a single cabinet with 4 sockets. Each socket has 1 processor installed, along with 64 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 and disk subsystem were 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 **Win2008Setup.pdf** in the *\SupportingFiles\Introduction\TierB* directory outlines the steps taken to configure the OS and DBMS. The file **SQL2008Setup.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	Broker
Company	Watch_Item	Address
Company_Competitor	Watch_List	Cash_Transaction
Customer	Charge	Holding
Customer_Account	Commission_Rate	Holding_History
Customer_TaxRate	Exchange	Holding_Summary
Daily_Market	Industry	Settlement
Financial	Sector	Trade
Last_Trade	Status_Type	Trade_History
News_Item	TaxRate	Trade_Request
News_Xref	Trade_Type	
	Zip_Code	

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 1,250,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
ACCOUNT_PERMISSION	8875013
ADDRESS	1875004
BROKER	12500
COMPANY	19877070594
COMPANY_COMPETITOR	15
CUSTOMER	240
CUSTOMER_ACCOUNT	625000
CUSTOMER_TAXRATE	1875000
DAILY_MARKET	1250000
FINANCIAL	6250000
LAST_TRADE	2500000
NEWS_ITEM	1117406250
NEWS_XREF	4
SECURITY	12500000
WATCH_ITEM	1105956963
WATCH_LIST	28955148899
CASH_TRANSACTION	62162653
HOLDING	102
HOLDING_HISTORY	856250
HOLDING_SUMMARY	1250000
SETTLEMENT	1250000
TRADE	12
TRADE_HISTORY	856250
TRADE_REQUEST	21605560779
CHARGE	5
COMMISSION_RATE	320
EXCHANGE	21605708425
INDUSTRY	51853750736
SECTOR	0
STATUS_TYPE	5
TAXRATE	125017846
TRADE_TYPE	1250000
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 1100 Drives configured for data connected to 11 HP SmartArray P812 controllers in 44 x D2700 enclosures, and 4 SSD Drives configured for the log connected to 1 x HP Smart Array P410i controller in internal bay. The disks were configured as RAID1+0 arrays across 2 D2700 enclosures for a total of 50 drives each.

Each data array was partitioned with 3 types of partitions: Growing, Fixed, and Backup. The first two types were used during the performance run, and the Backup partition was used for database backups. The first 2 partitions were RAW; the 3rd was configured as NTFS. Access to all the partitions was by using mount points, no drive letters were used except for the log and the boot/utility drives.

SA #, Type	Cab, Bay, Chassis, Slot	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
1, P410i	Internal,1-6,0,0	1	2x72GB SAS, Internal RAID1	C:, NTFS	72GB	Win2008 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
		2	4x400GB SSD, Internal RAID1+0	L:, RAW	745GB	Database log
2, P812	1-4,1-100,1,1	3	50x72GB SAS 2 x D2700 RAID1+0	c:\mnt\growing\1\ (RAW) c:\mnt\fixed\1\ (RAW) c:\mnt\backup\1 (NTFS)	475 GB 25 GB 1208.25 GB	Growing FG Fixed FG Backup
		4	50x72GB SAS 2 x D2700 RAID1+0	c:\mnt\growing\2\ (RAW) c:\mnt\fixed\2\ (RAW) c:\mnt\backup\2 (NTFS)	475 GB 25 GB 1208.25 GB	Growing FG Fixed FG Backup

Table 2.3 Disk/Partition Configuration

The configuration of HP SmartArray P812 controller number 2 was duplicated 10 more times, incrementing the mount points, making a total of 22 groups of mount points. (growing, fixed, and backup) Also note that 3 arrays used 146GB drives, which created a larger backup partition of 2917.40GB.

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 2008 R2 Enterprise Edition 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 network configurations for both the priced and reported configurations are the same. All network connections were through two HP ProCurve 2910al-24G networking switches. The 1 driver machine and the 4 client machines were networked via their built in 1Gbps ports and one external HP 360T dual port NIC while the other was used for access by the driver during the runs. The DBMS server used one internal quad port 1Gbps NIC for data base traffic during the measured run. Figures 1.1 shows configuration of the network.

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 included in the **EgenMakeFiles** directory in the **Clause5** 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)***

8 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 2,454.51 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.

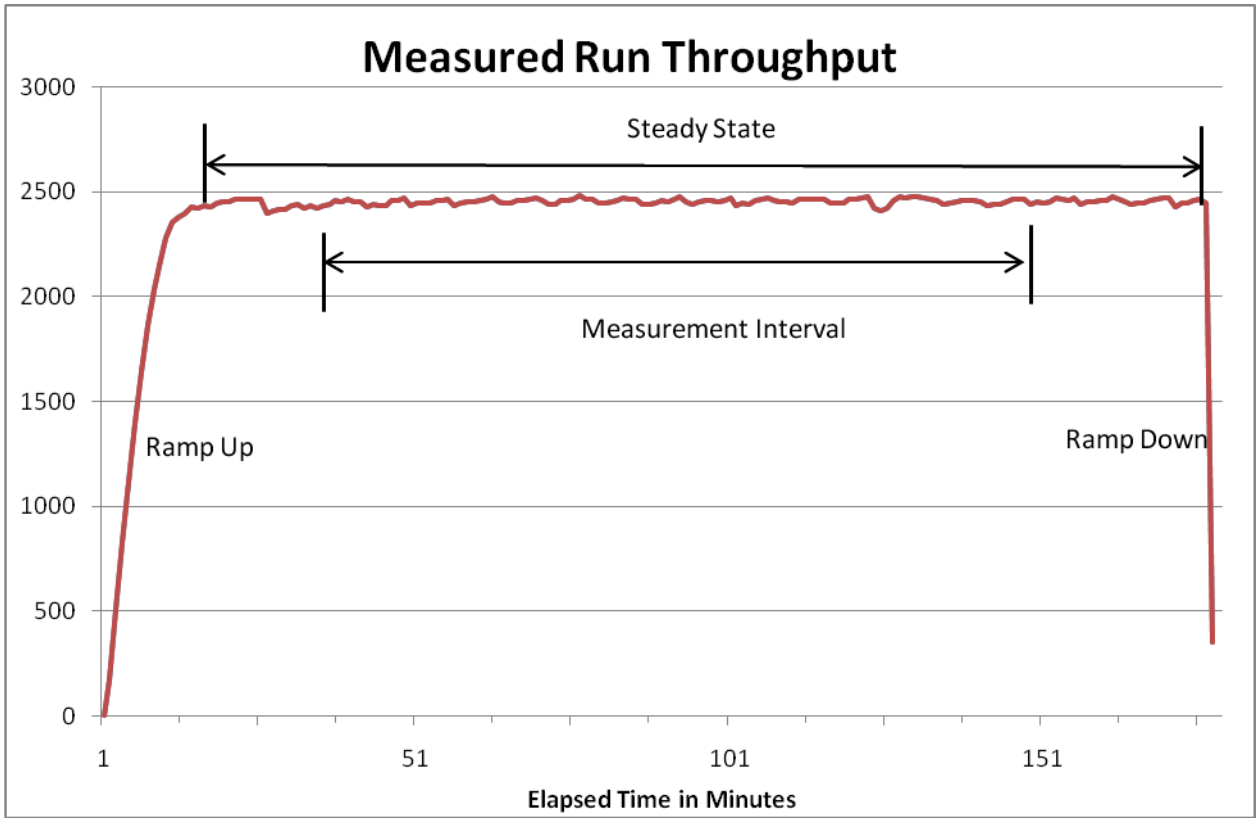

Figure 6.1 Test Run Time/Steady State Measurement Run Data

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 2008 R2 Enterprise Edition. 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	50.00%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.99%	Ok	28.50%	31.50%
		Frame 2	30.00%	Ok	28.50%	31.50%
		Frame 3	30.00%	Ok	28.50%	31.50%
		Frame 4	10.00%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	60.01%	Ok	57.00%	63.00%
		By Customer Acct	35.00%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	32.99%	Ok	31.00%	35.00%
		Frame 2	33.01%	Ok	31.00%	35.00%
		Frame 3	34.00%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	9.99%	Ok	9.50%	10.50%
		By Company Name	39.99%	Ok	38.00%	42.00%
		Buy on Margin	7.99%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	35.02%	Ok	33.00%	37.00%
		Trade by Qty 100	25.01%	Ok	24.00%	26.00%
		Trade by Qty 200	25.01%	Ok	24.00%	26.00%
		Trade by Qty 400	24.99%	Ok	24.00%	26.00%
		Trade by Qty 800	24.98%	Ok	24.00%	26.00%
		Market Buy	30.02%	Ok	29.70%	30.30%
		Market Sell	30.01%	Ok	29.70%	30.30%
		Limit Buy	19.98%	Ok	19.80%	20.20%
		Limit Sell	10.00%	Ok	9.90%	10.10%
		Stop Loss	9.99%	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), 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 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 >= 95% of the Reported Throughput, a data disk in the RAID10 data arrays was pulled, and a few seconds later, a log disk in the RAID10 log array was pulled.
4. The benchmark was allowed to run for 5 more minutes at steady state, all at >= 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 >=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)***

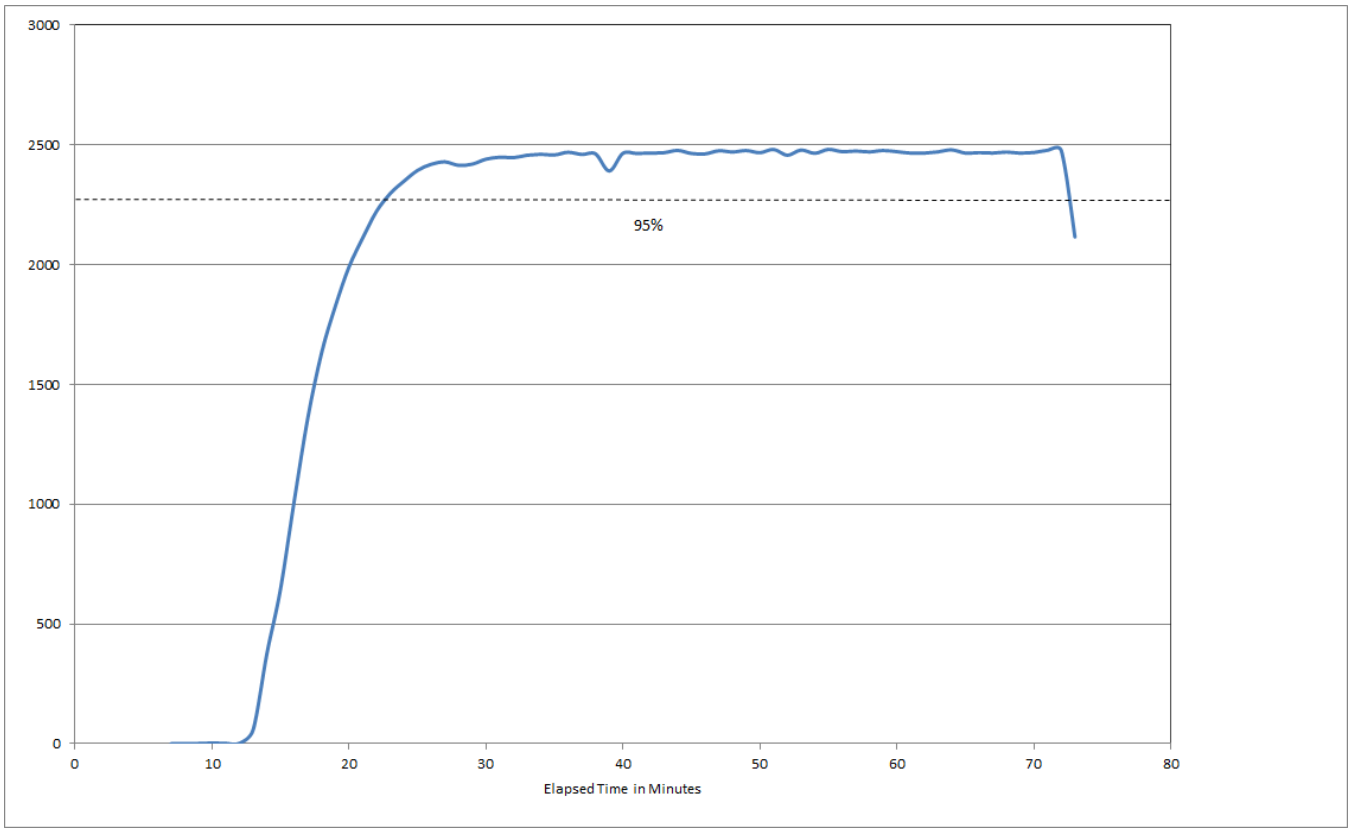

Figure 7.1 Data Accessibility Test Run Graph

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 while the servers were booting back up.
5. Power was restored to Tier B server, and the machines rebooted.
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 2008 R2 Enterprise Edition.
8. After SQL finished recovery of TPC-E 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 was calculated, 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 3 minutes and 14 seconds. This is also reported in the Executive Summary.

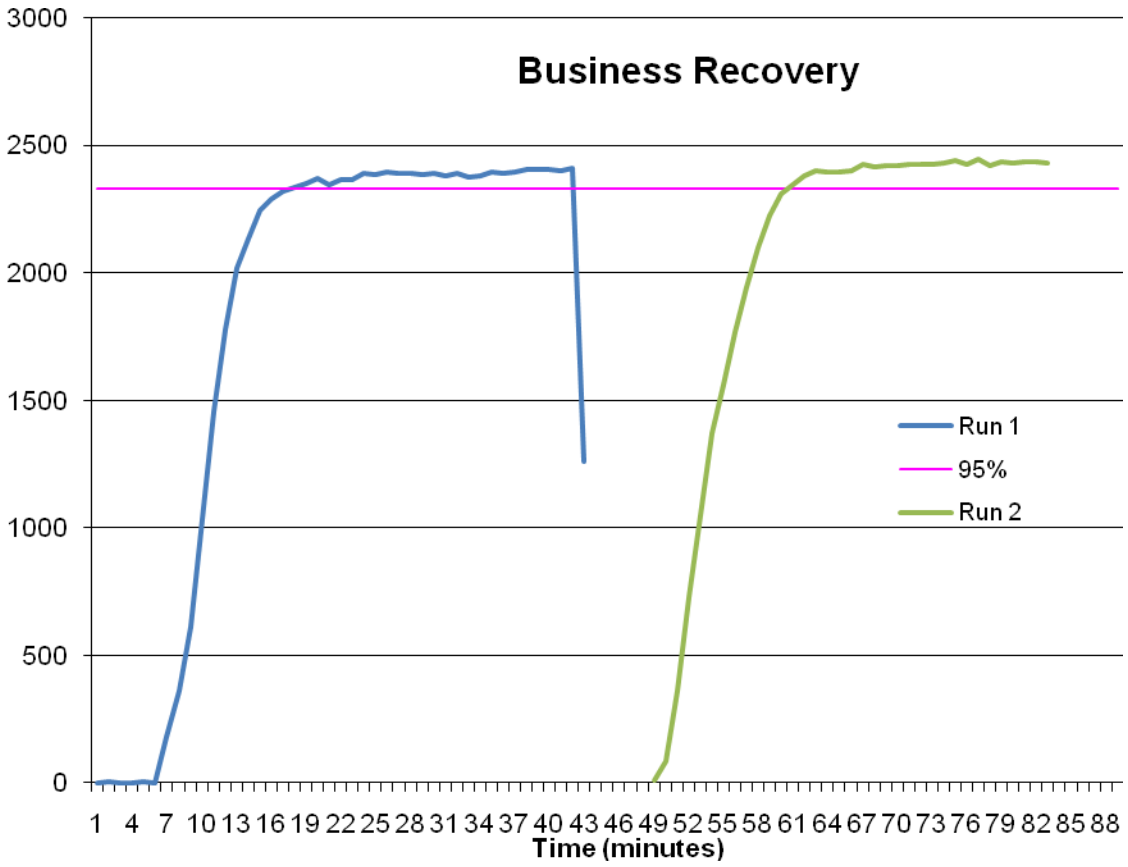

Figure 7.2 Business Recovery Tests Graph

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 as prepared by the auditor and verified from the IO configuration.

Space calulcations for TPC-E		Customers:	1,250,000								
		TpsE:	2,454.51								
		TradeResult count:	25,252,241							Database File Groups	
Table	Rows	Data(KB)	Index(KB)	Total	Total + 5%	Rows After	Data After(KB)	Index After(KB)	Growth	Fixed	Growing
ACCOUNT_PERMISSION	8875013	488856	3904	492,760	517,398	8875013	488888	3944	72	492,832	
ADDRESS	1875004	108312	1472	109,784	115,273	1875004	108368	1472	56		109,840
BROKER	12500	912	1176	2,088	2,192	12500	912	1176	0		2,088
CASH_TRANSACTION	19877070594	2056420592	4336840	2,060,757,432	2,163,795,304	19900304024	2060923160	4350552	4516280		2,065,273,712
CHARGE	15	8	8	16	17	15	8	8	0	16	
COMMISSION_RATE	240	16	16	32	34	240	16	16	0	32	
COMPANY	625000	133144	39192	172,336	180,953	625000	133144	39192	0	172,336	
COMPANY_COMPETITOR	1875000	50504	42240	92,744	97,381	1875000	50504	42240	0	92,744	
CUSTOMER	1250000	204976	55784	260,760	273,798	1250000	204984	55792	16	260,776	
CUSTOMER_ACCOUNT	6250000	566488	122064	688,552	722,980	6250000	566488	122064	0	688,552	
CUSTOMER_TAXRATE	2500000	52304	1472	53,776	56,465	2500000	52416	1488	128	53,904	
DAILY_MARKET	1117406250	52261072	152808	52,413,880	55,034,574	1117406250	52261904	153016	1040	52,414,920	
EXCHANGE	4	8	8	16	17	4	8	8	0	16	
FINANCIAL	12500000	1408800	5312	1,414,112	1,484,818	12500000	1408928	5408	224	1,414,336	
HOLDING	1105956963	74122704	46755504	120,878,208	126,922,118	1106612752	75647760	46762408	1531960		122,410,168
HOLDING_HISTORY	28955148899	1052919376	608894040	1,661,813,416	1,744,904,087	28989189867	1056335424	610907072	5429080		1,667,242,496
HOLDING_SUMMARY	62162653	2715528	11256	2,726,784	2,863,123	62163359	2715528	11256	0		2,726,784
INDUSTRY	102	8	24	32	34	102	8	24	0	32	
LAST_TRADE	856250	53456	1472	54,928	57,674	856250	53456	1472	0	54,928	
NEWS_ITEM	1250000	135523040	2936	135,525,976	142,302,275	1250000	135523056	2960	40	135,526,016	
NEWS_XREF	1250000	31280	1472	32,752	34,390	1250000	31280	1472	0	32,752	
SECTOR	12	8	24	32	34	12	8	24	0	32	
SECURITY	856250	118304	32312	150,616	158,147	856250	118304	32312	0	150,616	
SETTLEMENT	21605560779	1030542248	2175240	1,032,717,488	1,084,353,362	21630813020	1033068008	2183248	2533768		1,035,251,256
STATUS_TYPE	5	8	8	16	17	5	8	8	0	16	
TAXRATE	320	40	16	56	59	320	40	16	0	56	
TRADE	21605708425	2578524368	1307444640	3,885,969,008	4,080,267,458	21631107451	2581730336	1307725616	3486944		3,889,455,952
TRADE_HISTORY	51853750736	1560145464	4071208	1,564,216,672	1,642,427,506	51914409890	1564791912	4091128	4666368		1,568,883,040
TRADE_REQUEST	0	0	0	-	-	146785	39472	41424	80896		80,896
TRADE_TYPE	5	8	1032	1,040	1,092	5	8	1032	0	1,040	
WATCH_ITEM	125017846	3494280	14064	3,508,344	3,683,761	125017846	3494384	14184	224	3,508,568	
WATCH_LIST	1250000	31296	26720	58,016	60,917	1250000	31296	26720	0	58,016	
ZIP_CODE	14741	488	168	656	689	14741	488	168	0	656	
Totals in KB		8549917896	1974194432	10524112328	11050317944		8569780504	1976578920	22247096	194923192	10351436232
									file size	3276800	62259200
Database File Groups	Allocated size MB	Required size MB	Diff						# of files	22	22
Fixed_FG	563,200	190,355	372,845						total in KB (*8)	57671680	10957619200
Growing_FG	10,700,800	10,108,824	591,976								

Growing Space	22,245,296	KB
per Trade Results	0.88	KB
Data Growth	62,272,393	KB
60 Day Space	14,260,455,925	KB
60 Day Space	13,600	GB
Log space before in MB	54,905	10.981	500000
Log space after in MB	216,865	43.373	500000
per Trade Results	0.006	
Log Growth	453,383	MB
Total 8 hours log space	508,288	MB
Total 8 hours log space	496.37	GB

	Count	Formatted size GB	Total GB Configured	Total Needed
Data Disks configured	950	68.33	64,914	
	150	136.67	20,501	
	0	0	-	
RAID 10 overhead 50%			(42,707)	
Data Disks space total			**42,707**	13,600
Log Disks configured	4	372.52	1,490	
RAID 10 overhead 50%			(745)	
Log Disk space total			745	496

8 .1 Attestation Letter

MR. ERIC DEEHR
PERFORMANCE ENGINEER
Hewlett-Packard Company
14475 NE 24th St.
Bellevue, WA 98007

APRIL 5, 2011

I have verified the TPC Benchmark™ E for the following configuration:

Platform: HP ProLiant DL580 G7

Database Manager: Microsoft SQL Server 2008 R2 SP1 Enterprise Edition

Operating System: Microsoft Windows Sever 2008 R2 Enterprise Edition

Server (Tier B): DL580 G7			
CPU's	Memory	Disks (total)	TpsE
4 Intel Xeon 10 core @ 2.4 Ghz	1024 GB	952 @ 72GB 150 @ 146GB 4 @ 400GB	**2,454.51**
Clients (Tier A): 4 X ProLiant DL360 G7			
2 Intel Xeon 6 core @ 2.93 Ghz	12 GB	2 @ 300 GB	Na

In my opinion, these performance results were produced in compliance with the TPC requirements for the benchmark. The following attributes of the benchmark were given special attention:

- All EGen components were verified to be version 1.12.0
- The database files were properly sized and populated for 1,250,000 customers.
- The transaction components were properly implemented.
- The required network between the driver and the transaction harness was configured.
- The ACID properties were successfully demonstrated.
- The database was verified to have no Trade-Request rows prior to the start of the test run.
- The test run met all the requirements for timing, mix, and response times.
- Input data was generated according to the specified percentages.
- One and only one Data-Maintenance process was running during the test run.
- There were no inactive load units during the test run.

- Eight hours of mirrored log space was present on the measured system.
- Eight hours of growth space was present on the measured system.
- The data for the 60 day space calculation was verified.
- The steady state portion of the test was 120 minutes.
- One checkpoint was taken after steady state and before the measured interval.
- Checkpoint interval was verified to be equal to or less than 7.5 minutes.
- The system pricing was checked for major components and maintenance.
- Third party quotes were verified for compliance.
- The FDR was reviewed and verified as required.

Auditor Notes: None.

Sincerely,

Lorna Livingtree
TPC Certified Auditor

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 1, 2011

Hewlet-Packard
Jason Goertz
One Microsoft Way
Redmond, WA 98052

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
810-08527	**SQL Server 2008 R2 Enterprise Edition** *Per Processor License* *Open Program - Level C* *Unit Price reflects a 20% discount from the retail unit price of $23,848.*	$19,188	4	$76,752
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	1	$2,280
P73-04980	**Windows Server 2008 R2 Standard Edition** *Server License with 10 CALs* *Open Program - Level C* *Unit Price reflects a 31% discount from the retail unit price of $1,029.*	$711	4	$2,844
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259	1	$259

SQL Server 2008 R2 Enterprise Edition, Windows Server 2008 R2 Enterprise Edition, and Windows Server 2008 R2 Standard 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_qhtplylGYLKTVUKfhlhIjhiIiliIjlf85757.

Appendix B: Notes on Availability

The availability date of June 20, 2011 is dependent solely on the HP 400GB 6G SAS MLC SSD, used for the SQL log. Everything else is available on May 4, 2011 or sooner.