TPC Benchmark® E
Full Disclosure Report

HP ProLiant DL380 G7
using Microsoft SQL Server 2008 R2 Enterprise Edition
on Microsoft Windows Server 2008 R2 Enterprise Edition

First Edition
May 11, 2010

First Edition May 11, 2010

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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.

Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL380 G7 using Microsoft SQL Server 2008 R2 Enterprise Edition. The operating system used for the benchmark was Microsoft Windows Server 2008 R2 Enterprise 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.

Standard and Executive Summary Statements

The following pages contain the Executive Summary of the benchmark results for the HP ProLiant DL380 G7 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 to verify compliance with the relevant TPC specifications.

	HP Proliant DL380 G7	**TPCE Rev 1.10.0**
		TPC Pricing 1.5.0
		Report Date **May 11, 2010**

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
1,110.11	$294 USD/tpsE	May 11, 2010	$325,481 USD

Database Server Configuration			
Operating System	**Database Manager**	**Processor/Cores/Thread**	**Memory**
Microsoft Windows Server 2008 R2 Enterprise Edition	Microsoft SQL Server 2008 R2 Enterprise Edition	2/12/24	96GB

Tier B: Server
HP Proliant DL380G7

2 x Intel Xeon Processor x5680
96GB Memory
2 x HP 72GB 3G SAS 10K SFF DP

HP ProCurve 2510-48

1Gbps Ethernet

24X

Database Log

4 x HP 300GB
6G SAS 10K SFF
DP (internal)

Storage

6 x HP Smart Array P411/512 MB
24 x HP StorageWorks MSA70 Array
528 x 72GB 6G SAS 15K SFF DP

Tier A: Clients

2 x ProLiant DL360g5
2 x Quad-Core Intel Xeon
processor E5420 2.50Ghz
8 x 72GB SAS 10K SFF DP
2 x Onboard 1Gbps Ethernet
2 x HP NC360T PCI-E Dual Port

Priced Configuration

Initial Database Size	Redundancy Level : 1	Storage
4761 GB	RAID10 : Log/ RAID10 : Data	528x72GB, 4x300GB

HP ProLiant DL380G7					TPC-E TPC-Pricing Report date Availability Date	1.10.0 1.5.0 11-May-10 11-May-10

Description	Part Number	Brand	Unit Price	Qty.	Extended Price	3 Yr Maint Price
Server Hardware (Tier B)						
HP DL380G7 SFF CTO Chassis	583914-B21	1	1,591	1	1,591	
Intel® Xeon® Processor x5680 DL380G7 Kit 3.33 GHz	587498-B21	1	2,299	2	4,598	
HP 8GB 2Rx4 PC3-8500R-7 Kit	516423-B21	1	990	12	11,880	
HP 72GB 3G SAS 10K SFF DP ENT HDD	384842-B21	1	259	2	518	
HP Smart Array P411/512 MB with BBWC Controller	462832-B21	1	649	6	3,894	
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	
HP R1.5 kVA 1U NA UPS	AF419A	1	739	1	739	
HP 300GB SAS 10K SFF DP ENT HDD	512547-B21	1	499	4	1,996	
HP 3y 4h 24x7 ProLiant DL38x HW Support ,Proliant Server DL38x	U4545E	1	837	1		$837
				Subtotal	**$25,414**	**$837**
Server Software						
SQL Server 2008 R2 Enterprise Edition, Per Processor License	*	2	23,358	2	46,716	
Windows Server 2008 Enterprise Edition R2	P72-03868	2	2,320	1	2,320	
Microsoft Problem Resolution Services	N/A	2	259	1		259
				Subtotal	**$49,036**	**259**
Storage						
HP StorageWorks MSA70 Array	418800-B21	1	3,199	24	76,776	
HP StorageWorks MSA70 Array (10% Spares)	418800-B21	1	3,199	3	9,597	
HP 146GB 6G SAS 15K SFF DP ENT HDD	512547-B21	1	579	0	0	
HP 72GB 6G SAS 15K SFF DP ENT HDD	512545-B21	1	349	528	184,272	
HP 72GB 6G SAS 15K SFF DP ENT HDD (10% Spares)	512545-B21	1	349	53	18,497	
HP 5642 Pallet Unassembled Rack	358254-B21	1	865	2	1,730	
				Subtotal	**290,872**	**0**
Client Hardware (Tier A)						
HP ProLiant DL360 G5 E5420 2.50GHz Quad Core 2GB Rack Server	457925-001	1	2,499	2	4,998	
HP 72GB 3G SAS 10K SFF DP ENT HDD	384842-B21	1	259	8	2,072	
HP NC360T PCI-E Dual Port Gigabit Server Adapter	412648-B21	1	229	2	458	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	698	2		1,396
				Subtotal	**7,528**	**1,396**
Client Software						
Microsoft Windows Server 2008 Standard (x64)	P73-04190	2	725	2	1,450	
				Subtotal	**1,450**	**0**
Infrastructure						
HP ProCurve Switch 2510-48	J9020A	1	759	1	759	
3-year, 4-hour onsite, 24x7 coverage for hardware	U4835E	1	227	1		227
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4	9	33	
				Subtotal	**792**	**227**
			Total Extended Price		**$375,092**	**$2,719**
Large Purchase and Net 30 discount (See Note 1)	16.0%		**Total Discounts**		**$51,937**	**$394**
			Grand Total		**$323,155**	**$2,325**

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. MS software part number * is available on May 6, 2010 - see MS quote in the FDR. Note 3: The benchmark results were audited by Lorna Livingtree of Performance Metrics.

Three-year Cost of Ownership: USD	**$325,481**
tpsE	**1,110.11**
$ USD/tpsE	**$294**

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 DL380 G7	TPCE Rev 1.10.0 TPC Pricing 1.5.0 Report Date May 11, 2010 Availability Date May 11, 2010

Numerical Quantities Summary				
Reported Throughput	**1,110.11**	**Configured Customers:**		**560,000**
Response Times (in seconds)	Minimum	Average	90th %tile	Maximum
Broker Volume	0.00	0.06	0.12	4.83
Customer Position	0.00	0.05	0.09	10.89
Market Feed	0.00	0.07	0.25	17.25
Market Watch	0.00	0.05	0.11	6.02
Security Detail	0.00	0.02	0.05	5.57
Trade Lookup	0.00	0.81	1.01	16.32
Trade Order	0.00	0.12	0.19	11.39
Trade Result	0.00	0.12	0.19	18.78
Trade Status	0.00	0.05	0.13	11.88
Trade Update	0.01	0.90	1.03	5.62
Data Maintenance	0.01	0.19		1.04
Transaction Mix		**Transaction Count**	**Mix %**	
Broker Volume		3,917,415	4.900%	
Customer Position		10,392,248	13.000%	
Market Feed		799,250	1.000%	
Market Watch		14,389,677	18.001%	
Security Detail		11,191,680	14.000%	
Trade Lookup		6,394,764	7.999%	
Trade Order		8,074,332	10.100%	
Trade Result		7,992,798	9.998%	
Trade Status		15,189,532	19.001%	
Trade Update		1,598,553	2.000%	
Data Maintenance		120		
Ramp-up Time		01:24:14		
Measurement Interval		2:00:00		
Business Recovery Time		01:12:23		
Total Number of Transactions Completed in Measurement Interval		79,940,249		

Table of Contents

Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL380 G7 using Microsoft SQL Server 2008 R2 Enterprise Edition. It meets the requirements of the TPC Benchmark ® E Standard Specification, Revision 1.10.0 dated February 11, 2010 TPC Benchmark® E was developed by the **T**ransaction **P**rocessing **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 1.5.0.

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. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

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

The priced and benchmark configuration is the same and shown in Fig 1.1. We used 528 x 72GB 15k drives for data and 4 x 300GB 10k drives for log.

Tier B: Server
HP Proliant DL380G7

2 x Intel Xeon Processor x5680
96GB Memory
2 x HP 72GB 3G SAS 10K SFF DP

HP ProCurve 2510-48

1Gbps Ethernet

Database Log

4 x HP 300GB
6G SAS 10K SFF
DP (internal)

Storage

6 x HP Smart Array P411/512 MB
24 x HP StorageWorks MSA70 Array
528 x 72GB 6G SAS 15K SFF DP

24X

Tier A: Clients

2 x ProLiant DL360g5
2 x Quad-Core Intel Xeon
processor E5420 2.50Ghz
8 x 72GB SAS 10K SFF DP
2 x Onboard 1Gbps Ethernet
2 x HP NC360T PCI-E Dual Port

Priced Configuration

Figure 1.1 Priced and benchmarked 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 DL380 G7, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 Intel Xeon x5680 processor installed, along with 12 x 8 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 *\SupportingFiles\Introduction\TierB* "Introduction" directory. Additionally, the **DiskConfig.pdf** file in the *SupportingFiles* directory shows how the Smartarray/MSA disk 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 **Win2008Setup.pdf** in the *\SupportingFiles\Introduction\TierB* directory outlines the steps taken to configure the OS and DBMS. The file **DiskDriverCfg.pdf** in *RaidDriver* outlines the steps to configure the disk driver used for the Smart Array Controllers. The file **PerfDriver.reg** is the registry entry for the initial performance driver settings. 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,* were placed in a filegroup called Fixed.

Directory **Clause2** in *SupportingFiles* 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
Address	Watch_Item	Holding
Company	Watch_List	Holding_History
Company_Competitor	Charge	Holding_Summary
Customer	Commission_Rate	Settlement
Customer_Account	Exchange	Trade
Customer_TaxRate	Industry	Trade_History
Daily_Market	Sector	Trade_Request
Financial	Status_Type	News_Item
Last_Trade	TaxRate	
Nex_Xref	Trade_Type	
Broker	Zip_Code	

Table 2.1 – FileGroup Table Assignements

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 560,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
ACCOUNT_PERMISSION	3975625
ADDRESS	840004
BROKER	5600
COMPANY	280000
COMPANY_COMPETITOR	840000
CUSTOMER	560000
CUSTOMER_ACCOUNT	2800000
CUSTOMER_TAXRATE	1120000
DAILY_MARKET	500598000
FINANCIAL	5600000
LAST_TRADE	383600
NEWS_ITEM	560000
NEWS_XREF	560000
SECURITY	383600
WATCH_ITEM	56080679
WATCH_LIST	560000
CASH_TRANSACTION	8902669512
HOLDING	495324990
HOLDING_HISTORY	12968628846
HOLDING_SUMMARY	27855286
SETTLEMENT	9676800000
TRADE	9676800000
TRADE_HISTORY	23224340382
TRADE_REQUEST	0
CHARGE	15
COMMISSION_RATE	240
EXCHANGE	4
INDUSTRY	102
SECTOR	12
STATUS_TYPE	5
TAXRATE	320
TRADE_TYPE	5
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 528 HP 72GB 15KRPM 2.5 Single Port SAS Drives configured for data connected to 6 HP Smart Array P411 controllers in 24 x MSA70 enclosures, and 4 HP 300GB 10KRPM 2.5 Single Port SAS Drives configured for the log connected to 1 HP Smart Array P410i controller in internal bay. All 24 MSA70 were configured as RAID1+0 arrays across all 22 disks in each enclosure, including the log.

Each data array was partitioned with 12 partitions: Growing, Fixed, and Backup. The first 10 partitions were used during the performance run, and the Backup partitions were used for database backups. The first 10 partitions were RAW, the 11 and 12th partitions were 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	2x72 SCSI, Internal RAID1	C:, NTFS	72GB	Win2008 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
		1	4x300 SCSI, Internal RAID1	E:, RAW	558.7GB	Database log
2, P411	1-4,1-88,1,1	2	88x72 SAS MSA70 RAID1+0	C:\e-grow\gw1\ (RAW) C:\e-grow\gw2\ (RAW) C:\e-grow\gw3\ (RAW) C:\e-grow\gw4\ (RAW) C:\e-grow\gw5\ (RAW) C:\e-fix\fx1\ (RAW) C:\e-fix\fx2\ (RAW) C:\e-fix\fx3\ (RAW) C:\e-fix\fx4\ (RAW) C:\e-fix\fx5\ (RAW) C:\e-back\back01\ (NTFS) C:\e-back\back02\ (NTFS)	209.0GB 209.0GB 209.0GB 209.0GB 209.0GB 6.2 GB 6.2 GB 6.2 GB 6.2 GB 6.2 GB 965.3GB 965.3GB	Grow FG Grow FG Grow FG Grow FG Grow FG Fixed FG Fixed FG Fixed FG Fixed FG Fixed FG Backup Backup

Table 2.3 Disk/Partition Configuration

SA #, Type	Cab, Bay, Chassis, Slot	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
3, P411	5-8,1-88,1,1	3	88x72 SAS MSA70 RAID1+0	C:\e-grow\gw6\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw7\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw8\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw9\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw10\ (RAW)	209.0GB	Grow FG
				C:\e-fix\fx6 (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx7\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx8\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx9\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx10\ (RAW)	6.2 GB	Fixed FG
				C:\e-back\back03\ (NTFS)	965.3GB	Backup
				C:\e-back\back04\ (NTFS)	965.3GB	Backup
4, P411	9-12,1-88,1,1	4	88x72 SAS MSA70 RAID1+0	C:\e-grow\gw11\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw12\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw13\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw14\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw15\ (RAW)	209.0GB	Grow FG
				C:\e-fix\fx11\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx12\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx13\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx14\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx15\ (RAW)	6.2 GB	Fixed FG
				C:\e-back\back05\ (NTFS)	965.3GB	Backup
				C:\e-back\back06\ (NTFS)	965.3GB	Backup
5, P411	13-16,1-88,1,1	5	88x72 SAS MSA70 RAID1+0	C:\e-grow\gw16\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw17\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw18\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw19\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw20\ (RAW)	209.0GB	Grow FG
				C:\e-fix\fx16\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx17\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx18\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx19\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx10\ (RAW)	6.2 GB	Fixed FG
				C:\e-back\back07\ (NTFS)	965.3GB	Backup
				C:\e-back\back08\ (NTFS)	965.3GB	Backup
6, P411	17-20,1-88,1,1	6	88x72 SAS MSA70 RAID1+0	C:\e-grow\gw21\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw22\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw23\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw24\ (RAW)	209.0GB	Grow FG
				C:\e-grow\gw25\ (RAW)	209.0GB	Grow FG
				C:\e-fix\fx21\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx22\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx23\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx24\ (RAW)	6.2 GB	Fixed FG
				C:\e-fix\fx25\ (RAW)	6.2 GB	Fixed FG
				C:\e-back\back09\ (NTFS)	965.3GB	Backup
				C:\e-back\back10\ (NTFS)	965.3GB	Backup
7, P411	21-	6	88x72 SAS	C:\e-grow\gw26\ (RAW)	209.0GB	Grow FG

24,1-88,1,1		MSA70 RAID1+0	C:\e-grow\gw27\ (RAW)	209.0GB	Grow FG
			C:\e-grow\gw28\ (RAW)	209.0GB	Grow FG
			C:\e-grow\gw29\ (RAW)	209.0GB	Grow FG
			C:\e-grow\gw30\ (RAW)	209.0GB	Grow FG
			C:\e-fix\fx26\ (RAW)	6.2 GB	Fixed FG
			C:\e-fix\fx27\ (RAW)	6.2 GB	Fixed FG
			C:\e-fix\fx28\ (RAW)	6.2 GB	Fixed FG
			C:\e-fix\fx29\ (RAW)	6.2 GB	Fixed FG
			C:\e-fix\fx30\ (RAW)	6.2 GB	Fixed FG
			C:\e-back\back11\ (NTFS)	965.3GB	Backup
			C:\e-back\back12\ (NTFS)	965.3GB	Backup

Table 2.3 Disk/Partition Configuration (continued)

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 configuration for both the priced and reported configurations are the same. All network connections were through a single HP ProCurve 2510-48 networking switch. The 1 driver machine and the 2 client machines were networked via one of their built in 1Gbps port, while the other was used for access by the driver during the runs. The DBMS server used an internal quad port NIC for data base traffic and management access 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 1.10.0

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 *SupportingFiles* 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)

24 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 1,110.11 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 rampup, 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.
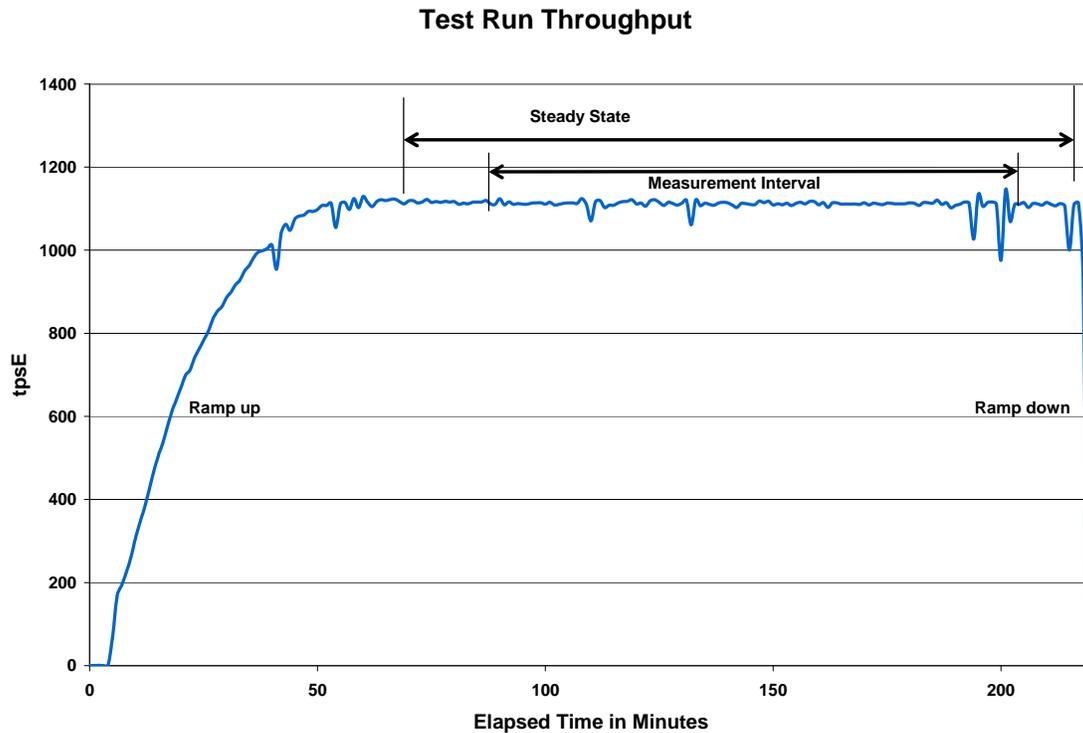
Test Run Throughput

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 checkpointing, 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 timestamped, 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	49.99%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.98%	Ok	28.50%	31.50%
		Frame 2	30.00%	Ok	28.50%	31.50%
		Frame 3	30.02%	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	34.98%	Ok	33.00%	37.00%
		By Industry	5.01%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	33.01%	Ok	31.00%	35.00%
		Frame 2	32.98%	Ok	31.00%	35.00%
		Frame 3	34.01%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.00%	Ok	9.50%	10.50%
		By Company Name	40.01%	Ok	38.00%	42.00%
		Buy on Margin	8.01%	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	24.99%	Ok	24.00%	26.00%
		Trade by Qty 200	25.00%	Ok	24.00%	26.00%
		Trade by Qty 400	25.01%	Ok	24.00%	26.00%
		Trade by Qty 800	24.99%	Ok	24.00%	26.00%
		Market Buy	29.98%	Ok	29.70%	30.30%
		Market Sell	30.00%	Ok	29.70%	30.30%
		Limit Buy	19.99%	Ok	19.80%	20.20%
		Limit Sell	10.02%	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), 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 are contained in the *SupportingFiles* 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. The benchmark was terminated gracefully, and the 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)*
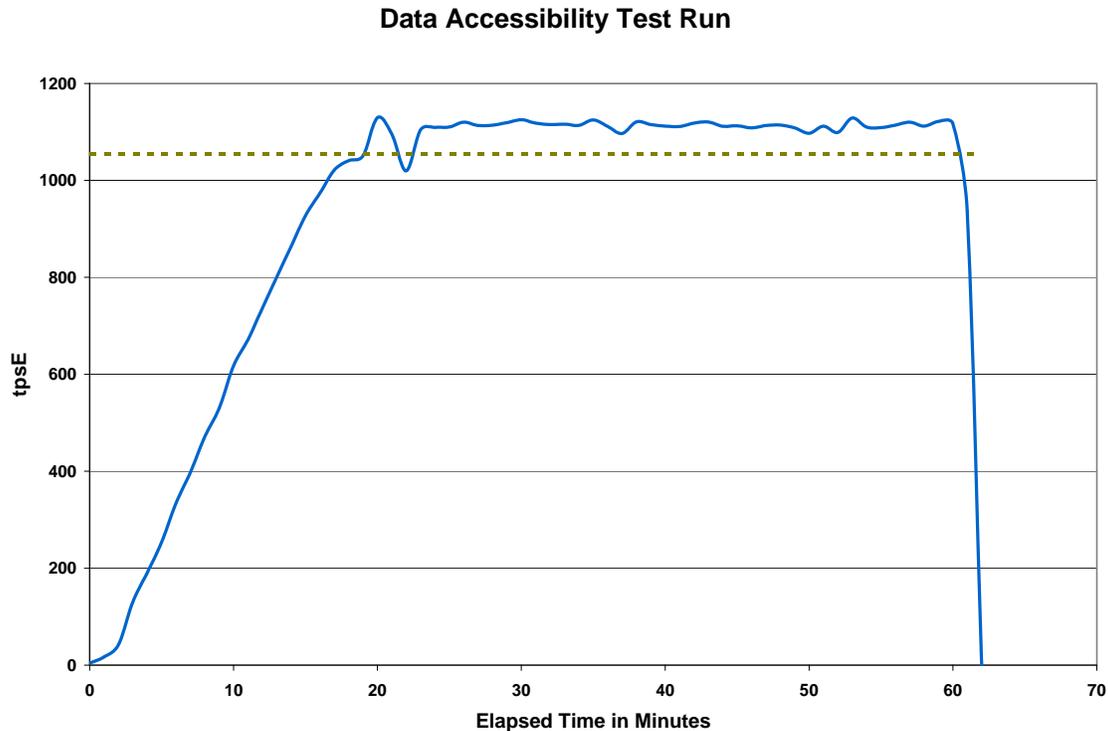
Data Accessibility Test Run

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 take so 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 (ie, 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 servers, and the machines rebooted.
6. After the OS was running, SQL Server was started, which automatically started transaction recovery of the primary TPCE 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 TPCE 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 12 minutes and 23 seconds. This is also reported in the Executive Summary.
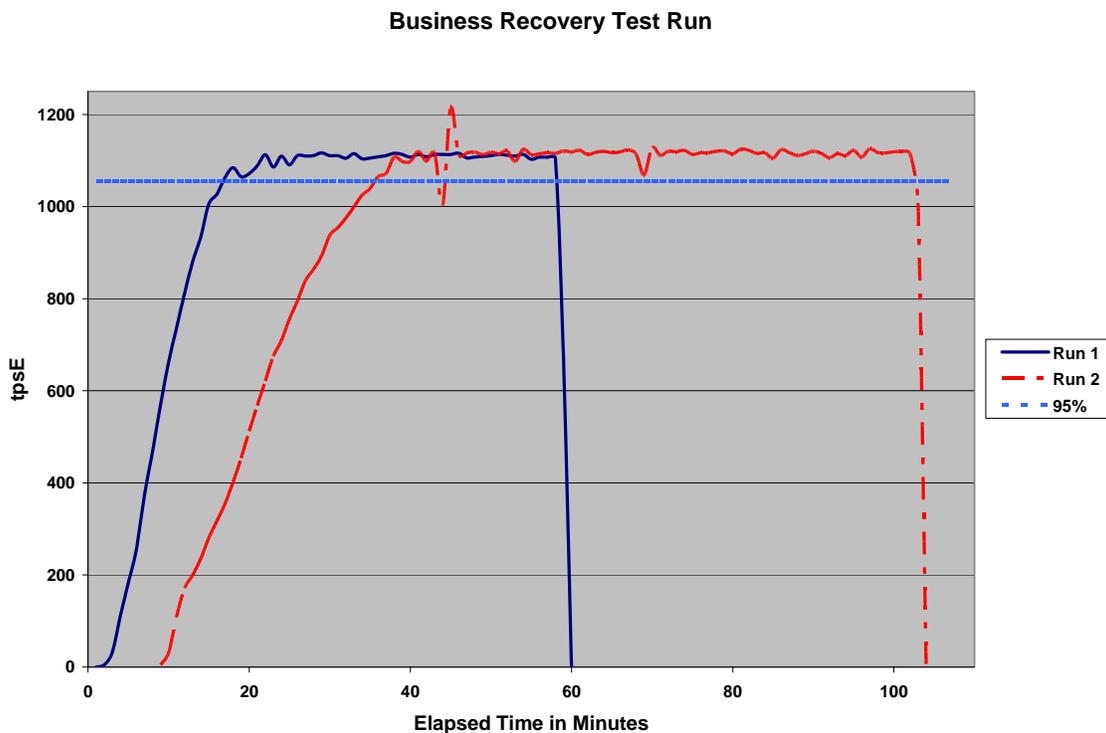
Business Recovery Test Run

Figure 7.2 The 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:	560,000				
				TpsE:	1,110.11				
				TradeResult count:	13,227,367				

Table	Rows	Data(KB)	Index(KB)	Total	Total + 5%	Rows After	Data After(KB)	Index After(KB)	Growth
ACCOUNT_PERMISSION	3975625	338448	2280	340,728	357,764	3975625	338600	2432	304
ADDRESS	840004	48464	640	49,104	51,559	840004	48520	640	56
BROKER	5600	408	560	968	1,016	5600	408	560	-
CASH_TRANSACTION	8902669512	917817808	1936200	919,754,008	965,741,708	8914837469	920263152	1945032	2,454,176
CHARGE	15	8	8	16	17	15	8	8	-
COMMISSION_RATE	240	16	16	32	34	240	16	16	-
COMPANY	280000	60944	17296	78,240	82,152	280000	60960	17304	24
COMPANY_COMPETITOR	840000	22584	18752	41,336	43,403	840000	22584	18752	-
CUSTOMER	560000	94864	24992	119,856	125,849	560000	94880	25000	24
CUSTOMER_ACCOUNT	2800000	253736	54600	308,336	323,753	2800000	253736	54608	8
CUSTOMER_TAXRATE	1120000	23368	640	24,008	25,208	1120000	23512	656	160
DAILY_MARKET	500598000	25814656	90872	25,905,528	27,200,804	500598000	25815832	91104	1,408
EXCHANGE	4	8	8	16	17	4	8	8	-
FINANCIAL	5600000	658920	2360	661,280	694,344	5600000	659112	2512	344
HOLDING	495324990	32879816	20785024	53,664,840	56,348,082	495659273	33698096	20789136	822,392
HOLDING_HISTORY	12968628846	471586600	272576920	744,163,520	781,371,696	12986464941	473178712	273655896	2,671,088
HOLDING_SUMMARY	27855286	1206352	4920	1,211,272	1,271,836	27855357	1206352	4920	-
INDUSTRY	102	8	24	32	34	102	8	24	-
LAST_TRADE	383600	23736	640	24,376	25,595	383600	23736	640	-
NEWS_ITEM	560000	60714344	1248	60,715,592	63,751,372	560000	60714360	1256	24
NEWS_XREF	560000	13944	640	14,584	15,313	560000	13944	640	-
SECTOR	12	8	24	32	34	12	8	24	-
SECURITY	383600	60432	14272	74,704	78,439	383600	60464	14280	40
SETTLEMENT	9676800000	512970296	1081952	514,052,248	539,754,860	9690027367	514424368	1087160	1,459,280
STATUS_TYPE	5	8	8	16	17	5	8	8	-
TAXRATE	320	24	16	40	42	320	40	16	16
TRADE	9676800000	1152443496	578494504	1,730,938,000	1,817,484,900	9690095988	1154130224	582953928	6,146,152
TRADE_HISTORY	23224340382	698476504	1822176	700,298,680	735,313,614	23256117718	700970616	1833208	2,505,144
TRADE_REQUEST	0	0	0	-	-	65539	12176	12568	24,744
TRADE_TYPE	5	8	1032	1,040	1,092	5	8	1032	-
WATCH_ITEM	56080679	1551472	6128	1,557,600	1,635,480	56080679	1551616	6304	320
WATCH_LIST	560000	13968	11904	25,872	27,166	560000	13968	11904	-
ZIP_CODE	14741	488	176	664	697	14741	488	176	-
Totals in KB	65547581568	3877075736	876950832	4754026568	4991727896		3887580520	882531752	16085704

					file size
Database File Groups	Allocated size MB	Required size MB	Diff		# of files
Fixed	191,700	92,228	99,472 OK		total in KB (*8)
Growing	6,419,700	4,782,531	1,637,169 OK		
Total	6,611,400	4,874,758			
Total in GB	6,456.4	4,760.5			

			%	size
Growing Space	16,082,976	KB		
per Trade Results	1.22	KB		
Data Growth	38,873,309	KB		
60 Day Space	7,086,425,122	KB		
60 Day Space	6,758	GB		
Log space before in MB	1,339		0.2678875	500000
Log space after in MB	87,634		17.526844	500000
per Trade Results	0.007			
Log Growth	208,579	MB		
Total 8 hours log space	209,918	MB		
Total 8 hours log space	205.00	GB		

	Count	Formatted size GB	Total GB Configured	Total Needed
Data Disks configured	0	33.37	-	
	528	66.85	35,297	
	0	135.49	-	
RAID 10 overhead 50%			(17,648)	
Data Disks space total			**17,648**	6,758
Log Disks configured	4	279.35	1,117	
RAID 10 overhead 50%			(559)	
Log Disk space total			559	205

...ation Letter

May 10, 2010

Mr. Paul Cao
Senior System Engineer
Hewlett-Packard Company
20555 SH 249
Houston, TX 77070

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

Platform: HP ProLiant DL380 G7

Database Manager: Microsoft SQL Server 2008 R2 Enterprise Edition

Operating System: Microsoft Windows Server 2008 R2 Enterprise Edition

Transaction Monitor: Microsoft COM+

System Under Test:			
CPU's	Memory	Disks (total)	TpsE
2 Xeon 6 core @ 3.33 Ghz	Main: 96 GB	530 @ 72 GB 4 @ 300 GB	**1110.11**
2 Clients (Tier A): ProLiant DL360 G5			
1 Intel quad core @ 2.50 Ghz	2 GB	4 @ 72 GB	NA	**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 1.9.0.
- The database files were properly sized and populated for 560,000 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 on 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.
- Checkpoint interval was verified to be equal to or less than 7.5 minutes and no two checkpoints lasted longer than 15 minutes.
- The system pricing was checked for major components and maintenance.
- Third party quotes were verified for compliance.
- The FDR, Executive Summary and Supporting Files were reviewed and verified as required.

Auditor Notes: None.

Sincerely,

Lorna Livingtree

Lorna Livingtree, 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

May 5, 2010

Hewlett-Packard Company
Paul Cao
20555 SH 249
Houston, TX 77070

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
*	**SQL Server 2008 R2 Enterprise Edition** *Per Processor License* *Open Program - No Level* *Unit Price reflects a 19% discount from the retail unit price of $28,749.*	$23,358	2	$46,716
P72-03868	**Windows Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - No Level* *Unit Price reflects a 42% discount from the retail unit price of $3,999.*	$2,320	1	$2,320
P73-04190	**Windows Server 2008 Standard Edition** *Server License with 5 CALs* *Open Program - No Level* *Unit Price reflects a 27% discount from the retail unit price of $999.*	$725	2	$1,450
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259	1	$259

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

SQL Server 2008 R2 Enterprise Edition will be orderable and available by May 6, 2010.

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

This quote is valid for the next 90 days.