TPC Benchmark® E
Full Disclosure Report

HP ProLiant DL385 G7
using Microsoft SQL Server 2008 R2 Enterprise Edition
on Microsoft Windows Server 2008 R2 Enterprise Edition

First Edition
April 7, 2010

First Edition April 7, 2010

Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL385 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 DL385 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 DL385 G7

TPCE Rev 1.9.0
TPC Pricing 1.5.0
Report Date April 7, 2010

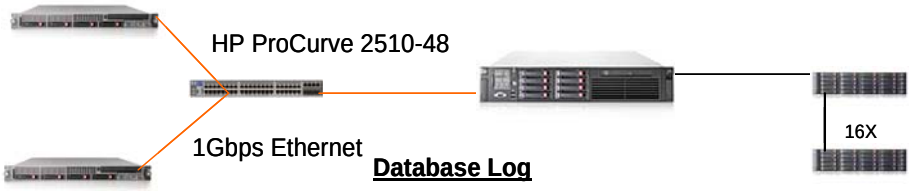
TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
887.38	$296 USD/tpsE	May 6, 2010	$262,023 USD

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	2/24/24	128GB

Tier B: Server
HP Proliant DL385G7

2 x AMD Opteron Processor 6176 SE 2.30 GHZ
128GB Memory
1 x HP NC360T PCI Express Dual Port Gigabit Server Adapter
2 x HP 72GB 3G SAS 10K 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

Database Log

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

Storage

5 x HP Smart Array P411/512 MB
16 x HP StorageWorks MSA2700 Array
400 x 72GB 6G SAS 15K SFF DP

Priced Configuration

Initial Database Size	Redundancy Level : 1	Storage
3822 GB	**RAID10 : Log/ RAID10 : Data**	**400x72GB 15K , 4x300GB 10K**

	HP ProLiant DL385G7				TPC-E	1.9.0
					TPC-Pricing	1.5.0
					Report date	7-Apr-10
					Availability Date	6-May-10

Description	Part Number	Brand	Unit Price	Qty.	Extended Price	3 Yr Maint Price
Server Hardware (Tier B)						
HP DL385G7 CTO Chassis	573122-B21	1	1,511	1	1,511	
AMD Opteron Processor 6176 SE 2.30 GHz	585322-L21	1	1,799	2	3,598	
HP 8GB 2Rx4 PC3-8500R-7 Kit	516423-B21	1	990	16	15,840	
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	5	3,245	
HP NC360T PCI Express Dual Port Gigabit Server Adapter	412648-B21	1	229	1	229	
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		**$27,874**	**$837**
Server Software						
SQL Server 2008 R2 Enterprise Edition, Per Processor License	*	2	23,358	2	46,716	
Windows Server 2008 R2 Enterprise Edition	P72-03868	2	2,320	1	2,320	
Microsoft Problem Resolution Services	N/A	2	245	1		245
			Subtotal		**$49,036**	**245**
Storage						
HP StorageWorks MSA70 Array	418800-B21	1	3,199	16	51,184	
HP StorageWorks MSA70 Array (10% Spares)	418800-B21	1	3,199	2	6,398	
HP 72GB 6G SAS 15K SFF DP ENT HDD	512545-B21	1	349	400	139,600	
HP 72GB 6G SAS 15K SFF DP ENT HDD (10% Spares)	512545-B21	1	349	40	13,960	
HP 5642 Pallet Unassembled Rack	358254-B21	1	865	2	1,730	
			Subtotal		**212,872**	**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)	P73-04980	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	12	44	
			Subtotal		**803**	**227**
			Total Extended Price		**$299,563**	**$2,705**
HP's Large Configuration Discount *	16.0%		**Total Discounts**		**$39,852**	**$394**
			Grand Total		**$259,711**	**$2,311**

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 not available until 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	**$262,023**
TpsE	**887.38**
$ USD/tpsE	**$296**

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 DL385 G7	TPCE Rev 1.9.0 TPC Pricing 1.5.0 Report Date April 7, 2010 Availability Date May 6, 2010

Numerical Quantities Summary

Reported Throughput	887.38	Configured Customers:	450,000

Response Times (in seconds)	Minimum	Average	90th %tile	Maximum
Broker Volume	0.01	0.05	0.08	1.87
Customer Position	0.00	0.04	0.07	2.68
Market Feed	0.00	0.04	0.10	2.67
Market Watch	0.00	0.03	0.06	1.88
Security Detail	0.00	0.02	0.03	1.81
Trade Lookup	0.00	0.65	0.85	3.77
Trade Order	0.00	0.09	0.15	1.98
Trade Result	0.00	0.10	0.16	4.35
Trade Status	0.00	0.03	0.05	2.06
Trade Update	0.01	0.72	0.86	3.72
Data Maintenance	0.00	0.06		0.31

Transaction Mix	Transaction Count	Mix %
Broker Volume	3,130,191	4.900%
Customer Position	8,305,074	13.000%
Market Feed	638,924	1.000%
Market Watch	11,499,432	18.000%
Security Detail	8,943,758	14.000%
Trade Lookup	5,110,211	7.999%
Trade Order	6,452,229	10.100%
Trade Result	6,389,169	10.001%
Trade Status	12,138,275	19.000%
Trade Update	1,277,631	2.000%
Data Maintenance	120	

Ramp-up Time	00:35:23
Measurement Interval	2:00:00
Business Recovery Time	00:46:49
Total Number of Transactions Completed in Measurement Interval	63,884,894

Table of Contents

Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL385 G7 using Microsoft SQL Server 2008 R2 Enterprise Edition. It meets the requirements of the TPC Benchmark ® E Standard Specification, Revision 1.9.0 dated Sept 2009 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 1.5.0.

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 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.

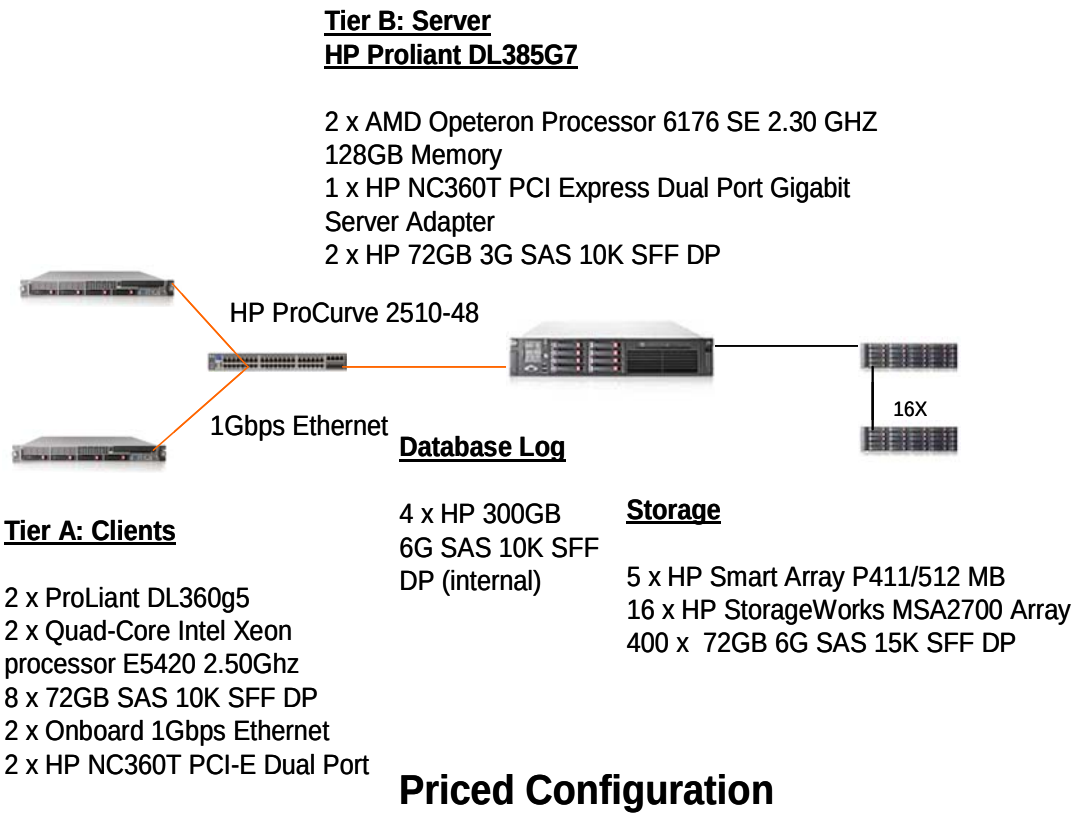


Figure 1.1 Benchmarked and Priced Configuration

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 DL385 G7, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 AMD Opteron™ 6176 SE processor installed, along with 16 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	
Last_Trade	TaxRate	
News_Item	Trade_Type	
Nex_Xref	Zip_Code	
Broker		

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 450,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
ACCOUNT_PERMISSION	3194960
ADDRESS	675004
BROKER	4500
COMPANY	225000
COMPANY_COMPETITOR	675000
CUSTOMER	450000
CUSTOMER_ACCOUNT	2250000
CUSTOMER_TAXRATE	900000
DAILY_MARKET	402266250
FINANCIAL	4500000
LAST_TRADE	308250
NEWS_ITEM	450000
NEWS_XREF	450000
SECURITY	308250
WATCH_ITEM	44997980
WATCH_LIST	450000
CASH_TRANSACTION	7153891344
HOLDING	398093037
HOLDING_HISTORY	10421231676
HOLDING_SUMMARY	22381071
SETTLEMENT	7776000000
TRADE	7776000000
TRADE_HISTORY	18662415027
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 400 HP 72GB 15K RPM 2.5 SFF SAS Drives configured for data connected to 4 HP Smart Array P410i controllers in 16 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 controllers in internal bay. All 16 MSA70 were configured as RAID1+0 arrays across all 25 disks in each enclosure, including the log.

Each data array was partitioned with 3 partitions: Growing, Fixed, and Backup. The first two 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	2x72 SCSI, Internal RAID1	C:, NTFS	72GB	Win2008 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
		2	4x300 SCSI, Internal RAID1	E:, RAW	558.7GB	Database log
2, P411	1-4,1-50,1,1	3	50x72 SAS MSA70 RAID1+0	C:\e-back\back01\ (NTFS) C:\e-fix\fx1\ (RAW) C:\e-grow\gw1\ (RAW)	1.0 TB 17.6 GB 673.8 GB	Backup Fixed FG Grow FG
		4	50x72 SAS MSA70 RAID1+0	C:\e-back\back02\ (NTFS) C:\e-fix\fx2\ (RAW) C:\e-grow\gw2\ (RAW)	959.7 TB 17.6 GB 675.8 GB	Backup Fixed FG Grow FG

Table 2.3 Disk/Partition Configuration

SA #, Type	Cab, Bay, Chassis, Slot	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
3, P411	5-8,1-50,1,2	5	50x72 SAS MSA70 RAID1+0	C:\e-back\back03\ (NTFS) C:\e-fix\fx3\ (RAW) C:\e-grow\gw3\ (RAW)	1.0 TB 17.6 GB 673.8 GB	Backup Fixed FG Grow FG
		6	50x72 SAS MSA70 RAID1+0	C:\e-back\back04\ (NTFS) C:\e-fix\fx4\ (RAW) C:\e-grow\gw4\ (RAW)	959.7 TB 17.6 GB 675.8 GB	Backup Fixed FG Grow FG
4, P411	9-12,1-50,1,3	7	50x72 SAS MSA70 RAID1+0	C:\e-back\back05\ (NTFS) C:\e-fix\fx5\ (RAW) C:\e-grow\gw5\ (RAW)	1.0 TB 17.6 GB 673.8 GB	Backup Fixed FG Grow FG
		8	50x72 SAS MSA70 RAID1+0	C:\e-back\back06\ (NTFS) C:\e-fix\fx6\ (RAW) C:\e-grow\gw6\ (RAW)	959.7 TB 17.6 GB 675.8 GB	Backup Fixed FG Grow FG
5, P411	13-16,1-50,1,4	9	50x72 SAS MSA70 RAID1+0	C:\e-back\back07\ (NTFS) C:\e-fix\fx7\ (RAW) C:\e-grow\gw7\ (RAW)	1.0 TB 17.6 GB 673.8 GB	Backup Fixed FG Grow FG
		10	50x72 SAS MSA70 RAID1+0	C:\e-back\back08\ (NTFS) C:\e-fix\fx8\ (RAW) C:\e-grow\gw8\ (RAW)	959.7 TB 17.6 GB 675.8 GB	Backup Fixed FG Grow FG

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 Windows 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 a single dual port 1Gbps NIC for data base traffic during the measured run (two ports in all), and another quad port NIC for management access, both of which are priced. 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 1.9.0

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)***

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 887.38 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.

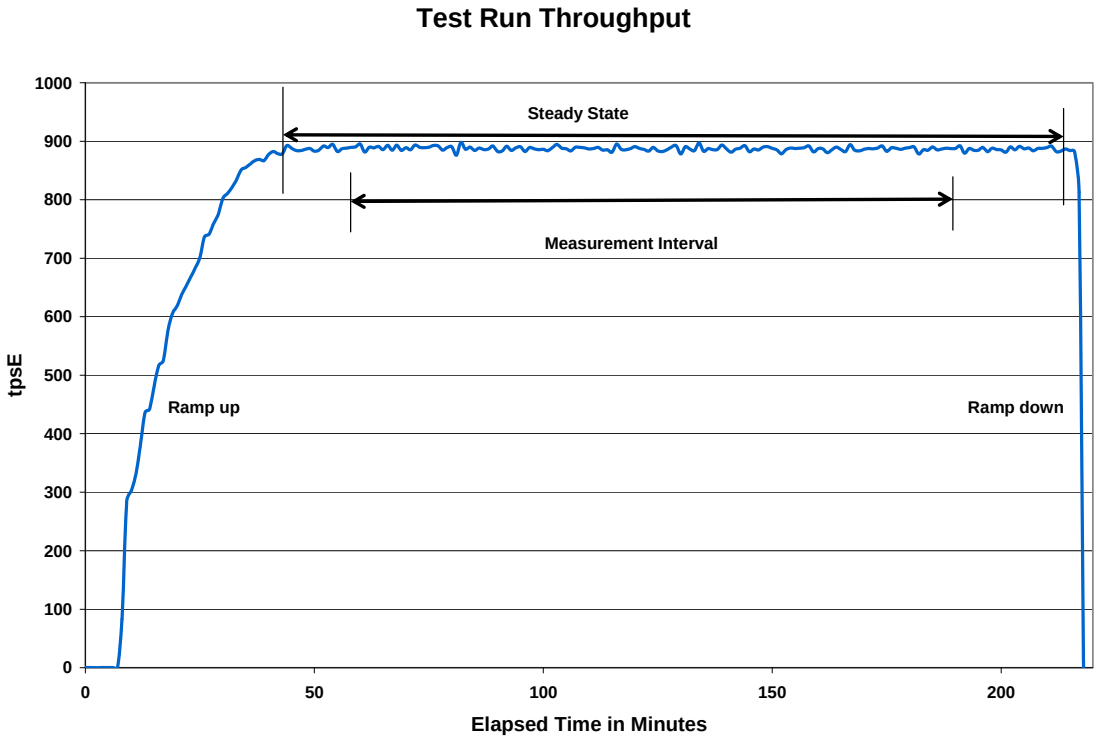


Figure 6.1 Test Run Time/Steady State Measurement Run Data

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 Windows 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	50.01%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.96%	Ok	28.50%	31.50%
		Frame 2	30.05%	Ok	28.50%	31.50%
		Frame 3	29.99%	Ok	28.50%	31.50%
		Frame 4	10.00%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	59.99%	Ok	57.00%	63.00%
		By Customer Acct	35.01%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	33.01%	Ok	31.00%	35.00%
		Frame 2	33.10%	Ok	31.00%	35.00%
		Frame 3	33.88%	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	7.98%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	35.03%	Ok	33.00%	37.00%
		Trade by Qty 100	25.00%	Ok	24.00%	26.00%
		Trade by Qty 200	24.97%	Ok	24.00%	26.00%
		Trade by Qty 400	25.04%	Ok	24.00%	26.00%
		Trade by Qty 800	24.99%	Ok	24.00%	26.00%
		Market Buy	30.00%	Ok	29.70%	30.30%
		Market Sell	30.01%	Ok	29.70%	30.30%
		Limit Buy	20.00%	Ok	19.80%	20.20%
		Limit Sell	9.99%	Ok	9.90%	10.10%
		Stop Loss	10.00%	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)***

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 server, 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 Windows 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 46 Minutes and 49 Seconds. This is also reported in the Executive Summary.

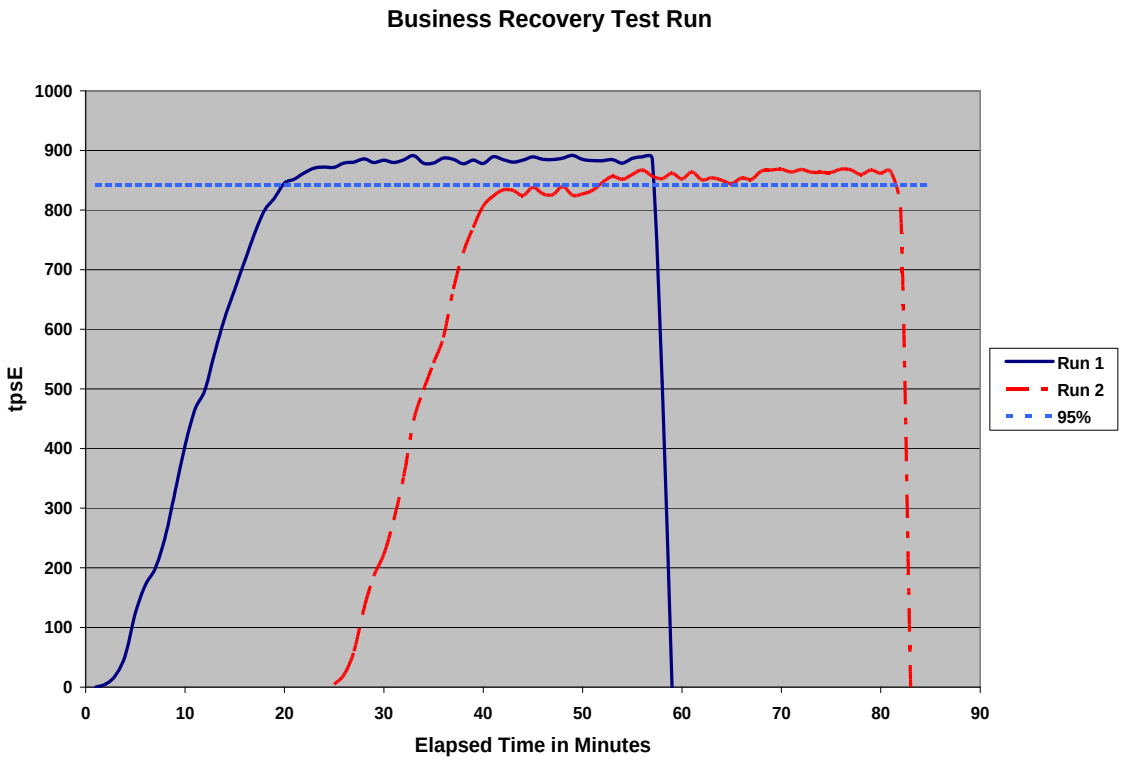


Figure 7.2 The Business Recovery Tests Graph

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: 450,000
TpsE: 887.36
TradeResult count: 10,686,801

Table	Rows	Data(KB)	Index(KB)	Total	Total + 5%	Rows After	Data After(KB)	Index After(KB)	Growth
ACCOUNT_PERMISSION	3194960	272016	1800	273,816	287,507	3194960	272168	1928	280
ADDRESS	675004	38976	456	39,432	41,404	675004	39008	456	32
BROKER	4500	328	456	784	823	4500	328	456	-
CASH_TRANSACTION	7153891344	737112376	1554800	738,667,176	775,600,535	7163723450	739083136	1561288	1,977,248
CHARGE	15	8	8	16	17	15	8	8	-
COMMISSION_RATE	240	16	16	32	34	240	16	16	-
COMPANY	225000	48952	13752	62,704	65,839	225000	48952	13752	-
COMPANY_COMPETITOR	675000	18160	15128	33,288	34,952	675000	18160	15128	-
CUSTOMER	450000	76256	19760	96,016	100,817	450000	76280	19760	24
CUSTOMER_ACCOUNT	2250000	203912	43832	247,744	260,131	2250000	203912	43832	-
CUSTOMER_TAXRATE	900000	18808	456	19,264	20,227	900000	18952	456	144
DAILY_MARKET	402266250	20695632	72488	20,768,120	21,806,526	402266250	20696832	72744	1,456
EXCHANGE	4	8	8	16	17	4	8	8	-
FINANCIAL	4500000	529504	1880	531,384	557,953	4500000	529672	2016	304
HOLDING	398093037	26356592	16649640	43,006,232	45,156,544	398369204	27008720	16652112	654,600
HOLDING_HISTORY	10421231676	378953976	219034496	597,988,472	627,887,896	10435638874	380234688	219899568	2,145,784
HOLDING_SUMMARY	22381071	965576	3872	969,448	1,017,920	22381501	965576	3872	-
INDUSTRY	102	8	24	32	34	102	8	24	-
LAST_TRADE	308250	19064	464	19,528	20,504	308250	19064	464	-
NEWS_ITEM	450000	48788280	968	48,789,248	51,228,710	450000	48788296	976	24
NEWS_XREF	450000	11248	464	11,712	12,298	450000	11248	464	-
SECTOR	12	8	24	32	34	12	8	24	-
SECURITY	308250	48544	11344	59,888	62,882	308250	48552	11344	8
SETTLEMENT	7776000000	412207984	869272	413,077,256	433,731,119	7786686801	413376072	872936	1,171,752
STATUS_TYPE	5	8	8	16	17	5	8	8	-
TAXRATE	320	24	16	40	42	320	40	16	16
TRADE	7776000000	924528872	463846552	1,388,375,424	1,457,794,195	7786740122	925888792	467420704	4,934,072
TRADE_HISTORY	18662415027	561275744	1463640	562,739,384	590,876,353	18688083833	563268344	1471048	2,000,008
TRADE_REQUEST	0	0	0	-	-	53321	7968	9240	17,208
TRADE_TYPE	5	8	1032	1,040	1,092	5	8	1032	-
WATCH_ITEM	44997980	1239272	4840	1,244,112	1,306,318	44997980	1239416	4976	280
WATCH_LIST	450000	11248	9440	20,688	21,722	450000	11248	9440	-
ZIP_CODE	14741	488	72	560	588	14741	488	72	-
Totals in KB	52672132793	3113421896	703621008	3817042904	4007895049		3121855976	708090168	12903240

file size
# of files
total in KB (*8)

Database File Groups	Allocated size MB	Required size MB	Diff	
Fixed	143,600	74,052	69,548	OK
Growing	5,519,600	3,839,924	1,679,676	OK
Total	5,663,200	3,913,977		
Total in GB	5,530.5	3,822.2		

Growing Space	12,900,672	KB
per Trade Results	1.21	KB
Data Growth	30,850,126	KB
60 Day Space	5,668,050,483	KB
60 Day Space	5,405	GB

		%	size
Log space before in MB	2,354	0.58852345	400000
Log space after in MB	124,178	31.044624	400000
per Trade Results	0.011		
Log Growth	291,326	MB	
Total 8 hours log space	293,680	MB	
Total 8 hours log space	286.80	GB	

	Count	Formatted size GB	Total GB Configured	Total Needed
Data Disks configured	0	33.37	-	
	400	66.85	26,740	
	0	135.49	-	
RAID 10 overhead 50%			(13,370)	
Data Disks space total			**13,370**	5,405
Log Disks configured	4	279.35	1,117	
RAID 10 overhead 50%			(559)	
Log Disk space total			559	287

8.1 Attestation Letter

April 7, 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 DL385 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 AMD 12 core @ 2.3 Ghz	Main: 128 GB	402 @ 72 GB 4 @ 300 GB	**887.38**
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 450,000 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, 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

March 25, 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.