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 4, 2011

First Edition May 4, 2011

Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL380 G7. The operating system used for the benchmark was Microsoft Windows Server 2008 R2 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 Doug Johnson of InfoSizing to verify compliance with the relevant TPC specifications.

HP ProLiant DL380 G7

Intel Xeon X5690 3.46 GHz 12MB L3

C/S with 1 ProLiant DL360 G7

TPC-E Rev 1.12.0

TPC Pricing 1.6.0

Report Date
May 4, 2011

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
1284.14 tpsE	$250 USD/tpsE	May 4, 2011	$320,984 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 Intel Xeon X5690 3.46 GHz 12MB L3	192 Gbyte

Tier B: Server
HP ProLiant DL380 G7

2 x Intel Xeon Processor X5690 3.46 GHZ
192 GB Memory

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

Database Log

4 x HP 500GB HDD
(internal)

Tier A: Clients

1 x ProLiant DL360 G7
1 x Quad-Core Intel Xeon X5630 Processor 2.53Ghz
3x 2GB PC3-10600 Memory
2 x 146GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet

Storage

2 x Violin Memory Systems V3205 Flash Array
4 x 500GB 6G SAS 7.2K SFF DP Midline HDD (log)

Priced Only
1x HP SmartArray P411/512MB (60 Day Space)
1x HP StorageWorks MSA70 Array (60 day space)
5x HP 500GB 6G SAS 7.2K RPM SFF HDD (60 day Space)

Initial Database Size	Redundancy Level: 1	Storage
5,622 GB	RAID10:Log/RAID3:Data	2x 3205 Violin Array, 4x500GB HDD (log), 5x500GB HDD(60Day)

	HP ProLiant DL380 G7				TPC-E	1.12.0
					TPC-Pricing	1.6.0
					Report date	May 4, 2011
					Availability Date	May 4, 2011
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	2,249	1	2,249	
Intel® Xeon® Processor x5690 DL380G7 Kit 3.46 GHz	633410-B21	1	2,299	2	4,598	
HP 16GB (1x16GB) Dual Rank x4 PC3L-10600 Reg. Memory Kit	627812-B21	1	1,349	12	16,188	
HP 72GB 6G SAS 15K rpm SFF Dual Port Hard Drive	512545-B21	1	279	2	558	
HP LE1901wm 19-inch Widescreen LCD Monitor	NP446A8#ABA	1	149	1	149	
HP PS/2 Keyboard And Mouse Bundle	RC464AA#ABA	1	39	1	39	
HP R1.5 kVA 1U NA UPS	AF419A	1	739	1	739	
HP 500GB 6G SAS 7.2K rpm SFF Dual Port Midline Hard Drive	507610-B21	1	349	4	1,396	
HP 3y 4h 24x7 ProLiant DL38x HW Support ,Proliant Server DL38x	U4545E	1	931	1		$931
			Subtotal		**$25,916**	**$931**
Server Software						
SQL Server 2008 R2 Enterprise Edition, Per Processor License	810-08529	2	23,370	2	46,740	
Windows Server 2008 R2 Enterprise Edition	P72-04219	2	2,320	1	2,320	
Microsoft Problem Resolution Services	N/A	2	259	1		259
			Subtotal		**$49,060**	**259**
Storage						
Violin Memory Systems V3205 Flash Memory Array	V-3205	3	100,500	2	201,000	
Violin Premium Support 1 years of 4h 24 x7 support	VS-PM1Y	3	12,000	3		36,000
HP Smart Array P411/512 MB with BBWC Controller	462832-B21	1	649	1	649	
HP StorageWorks MSA70 Array (60 Day)	418800-B21	1	3,199	1	3,199	
HP 3year 4hour 24x7 MSA 60/70 HW Support (60 Day)	UF303E	1	1,982	1		$1,982
HP 500GB 6G SAS 7.2K rpm SFF DP Midline Hard Drive (60 Day)	507610-B21	1	349	5	1,745	
HP 5642 Pallet Unassembled Rack	358254-B21	1	865	1	865	
			Subtotal		**207,458**	**37,982**
Client Hardware (Tier A)						
HP ProLiant DL360 G7 CTO Server	579237-B21	1	2,098	1	2,098	
HP DL360 G7 Intel Xeon X5630 (2.53Ghz/4-core/12MB/80W) Proc	587478-B21	1	799	1	799	
HP 2GB (1x2GB) Dual Rank x8 PC3-10600 Memory Kit	500656-B21	1	110	3	330	
HP 146GB 6G SAS 10K rpm SFFDual Port Hard Drive	512547-B21	1	369	2	738	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	750	1		750
			Subtotal		**3,965**	**750**
Client Software						
Microsoft Windows Server 2008 R2 Standard (x64)	P73-00352	2	870	1	870	
			Subtotal		**870**	**0**
Infrastructure						
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4	4	15	
			Subtotal		**15**	**0**
		Total Extended Price			**$287,284**	**$39,922**
Large Purchase and Net 30 discount (See Note 1)	16.0%	**Total Discounts**			**$5,636**	**$586**
		Grand Total			**$281,648**	**$39,336**

Pricing: 1=HP Direct 800-203-6748 2= Microsoft. 3= Violin Memory Systems 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 Doug Johnson.

Three-year Cost of Ownership: USD	**$320,984**
tpsE	**1,284.14**
$ USD/tpsE	**$250**

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 DL380 G7 Intel Xeon X5690 3.46 GHz 12MB L3	TPC-E Rev 1.12.0 TPC Pricing 1.6.0 Report Date May 4, 2011 Availability Date May 4, 2011

Numerical Quantities Summary					
Reported Throughput	1284.14 tpsE	Configured Customers:			700,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.02	0.03	0.08
Customer Position		0.00	0.02	0.03	0.99
Market Feed		0.00	0.02	0.04	1.03
Market Watch		0.00	0.02	0.03	0.78
Security Detail		0.00	0.01	0.02	0.58
Trade Lookup		0.00	0.09	0.13	0.31
Trade Order		0.00	0.05	0.07	1.36
Trade Result		0.00	0.06	0.08	1.51
Trade Status		0.00	0.01	0.02	1.41
Trade Update		0.01	0.11	0.14	1.11
Data Maintenance		0.01	0.02		0.07
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			4,530,563		4.900%
Customer Position			12,019,737		13.000%
Market Feed			924,589		1.000%
Market Watch			16,642,715		18.000%
Security Detail			12,944,393		14.000%
Trade Lookup			7,396,827		8.000%
Trade Order			9,338,494		10.100%
Trade Result			9,245,860		10.000%
Trade Status			17,567,706		19.000%
Trade Update			1,849,068		2.000%
Data Maintenance			120		
Ramp-up Time					0:33:59
Measurement Interval					2:00:00
Business Recovery Time					0:31:20
Total Number of Transactions Completed in Measurement Interval					92,459,952

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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 1.12.0 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 Doug Johnson of InfoSizing. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

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

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

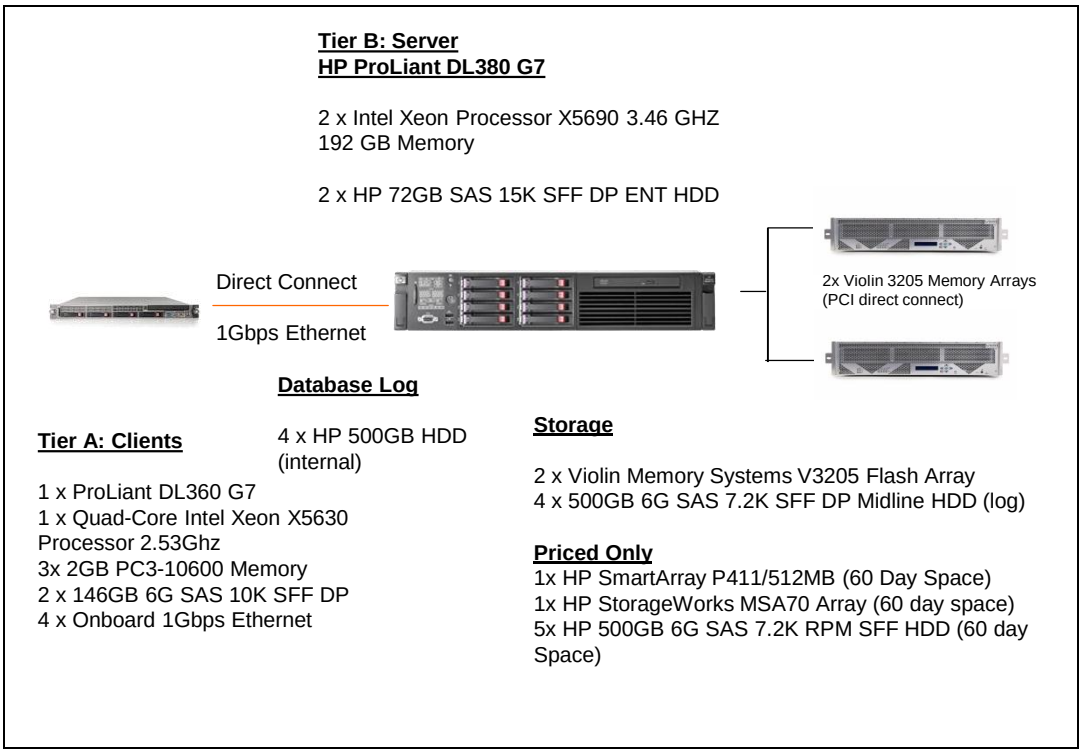

Figure 1.1 Priced Configuration

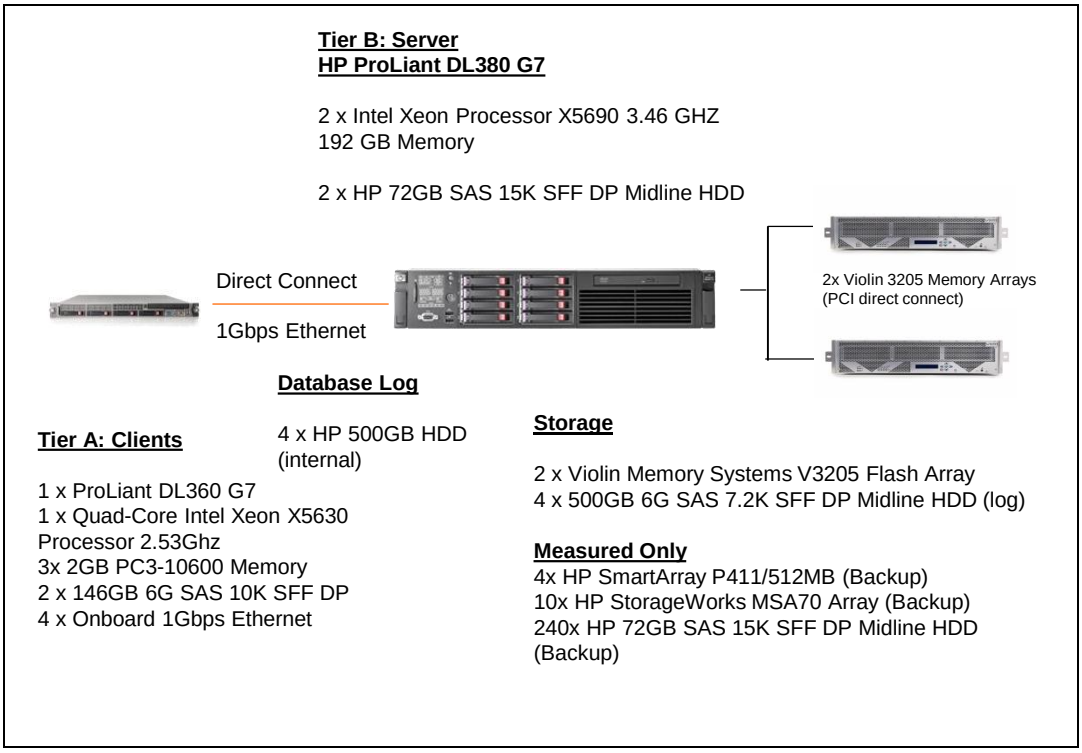

Figure 1.2 Measured Configuration

Note: Disk arrays present during the measured run were for data backup only, and were not used for the actual performance measurement or durability runs.

1.7 Hardware Configuration

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

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

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

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

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

The HP ProLiant DL380 G7, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 processor installed, along with 12 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 Violin Memory System Arrays storage 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 700,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
ACCOUNT_PERMISSION	4970435
ADDRESS	1050004
BROKER	7000
COMPANY	11128313461
COMPANY_COMPETITOR	15
CUSTOMER	240
CUSTOMER_ACCOUNT	350000
CUSTOMER_TAXRATE	1050000
DAILY_MARKET	700000
FINANCIAL	3500000
LAST_TRADE	1400000
NEWS_ITEM	625747500
NEWS_XREF	4
SECURITY	7000000
WATCH_ITEM	619323786
WATCH_LIST	16210715451
CASH_TRANSACTION	34817571
HOLDING	102
HOLDING_HISTORY	479500
HOLDING_SUMMARY	700000
SETTLEMENT	700000
TRADE	12
TRADE_HISTORY	479500
TRADE_REQUEST	12096000000
CHARGE	5
COMMISSION_RATE	320
EXCHANGE	12096000000
INDUSTRY	29030418536
SECTOR	0
STATUS_TYPE	5
TAXRATE	70007791
TRADE_TYPE	700000
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 2 Violin Memory System arrays, configured for data direct connected to the HP ProLiant DL380 G7. It also shows the 4 X HP 500GB 6G SAS 7.2K rpm SFF Dual Port Midline Hard Drives configured for the log, connected to 1 x HP Smart Array P410i controller in the internal bay. The Violin units were configured in the proprietary Violin RAID 3 configuration (default) and the log disks were configured as a RAID1+0 volume.

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

Controller Type	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
P410i Internal SmartArray	1	2x72GB SAS, Internal RAID1	C:, NTFS	72GB	Win2008 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
	2	4x500GB SAS, Internal RAID1+0	L:, RAW	800GB	Database log
PCI Bridge Card	1	42 X 128GB Violin intelligent memory modules	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) t:\ (NTFS) (striped)	3100 GB 100 GB 255.9 GB	Growing FG Fixed FG TempDB files
PCI Bridge Card	1	42 X 128GB Violin intelligent memory modules	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) t:\ (NTFS) (striped)	3100 GB 100 GB 255.9 GB	Growing FG Fixed FG TempDB files

Table 2.3 Disk/Partition Configuration

The measured configuration also included four SmartArray P411 cards for database backup. Two cards were attached to 2 MSA70 enclosures, the other two were attached to three MSA70 enclosures. Each enclosure contained 24 drives configured as RAID5. This 10 volumes held backups of the database, and were also used during building of the database. This storage was not an active part of the performance run.

2.6 Database Interface

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

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

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

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

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

The data model implemented by Microsoft SQL Server 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)*

1 internal NIC of the HP Proliant DL360 G7 client was direct connected to an internal NIC in the HP ProLiant DL380 G7. No networking switches or other equipment was used. The other client NIC was used to access the system by the benchmark driver system, management, etc.

Clause 5: Egen Related Items

5.1 Egen Version

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

Egen Version used for this test was 1.12.0

5.2 Egen Code

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

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

5.3 Egen Modifications

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

No modifications to Egen were done for this report.

5.4 Egen Loader Extensions

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

Egen Loader was not extended for this report.

5.5 Egen Loader Make Files

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

The Visual C++ project files are 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 1,284.14 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.

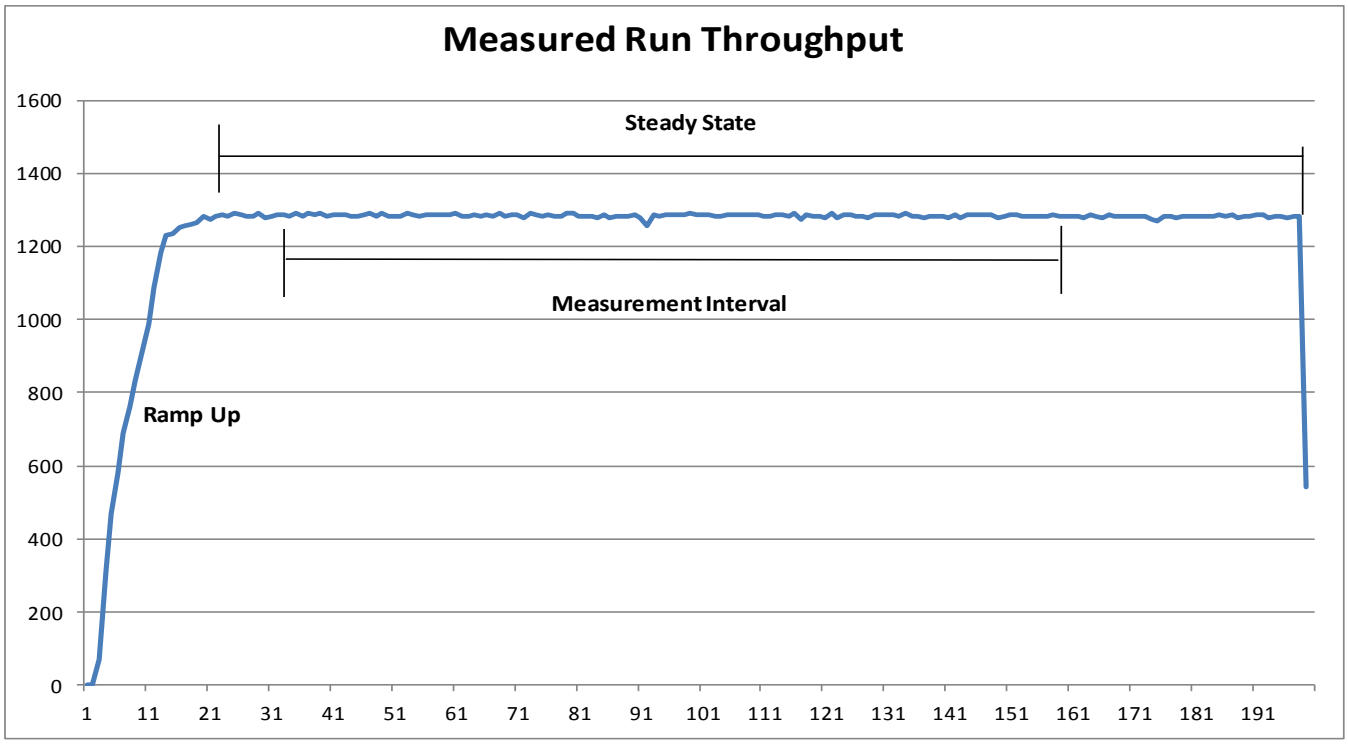

Figure 6.1 Test Run Time/Steady State Measurement Run Data

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	49.97%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	30.01%	Ok	28.50%	31.50%
		Frame 2	29.96%	Ok	28.50%	31.50%
		Frame 3	30.03%	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	34.99%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	32.98%	Ok	31.00%	35.00%
		Frame 2	33.00%	Ok	31.00%	35.00%
		Frame 3	34.02%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	0.99%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.01%	Ok	9.50%	10.50%
		By Company Name	39.97%	Ok	38.00%	42.00%
		Buy on Margin	8.01%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	35.00%	Ok	33.00%	37.00%
		Trade by Qty 100	25.01%	Ok	24.00%	26.00%
		Trade by Qty 200	25.00%	Ok	24.00%	26.00%
		Trade by Qty 400	24.99%	Ok	24.00%	26.00%
		Trade by Qty 800	25.00%	Ok	24.00%	26.00%
		Market Buy	30.00%	Ok	29.70%	30.30%
		Market Sell	30.02%	Ok	29.70%	30.30%
		Limit Buy	19.99%	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 is contained in the *Supporting Files* directory under ***Clause7***.

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

7.2 Redundancy Level and Data Accessibility Tests

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

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

The Data Accessibility Test for the Violin Memory Appliance and the database transaction log was performed according to the following steps

1. The rows in the Settlement table were counted to establish the initial count of trades present.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to at least 95% of the Reported Throughput.
3. After >=5 minutes of running at at least 95% of the Reported Throughput, a log disk in the RAID10 log array was pulled. Shortly thereafter, a command was issued to remove power from a Violin Intelligent Memory Module (VIMM). The use of this command was to prevent damage to the VIMM. The auditor verified that the effect of the command meets the requirement for instantaneous failure of the component.
4. The benchmark was allowed to run for over 5 more minutes at steady state with the RAID group degraded, all at >= 95% of Reported Throughput.
5. The Chassis Spare VIMMs were Downed so they would not be used for an automatic rebuild when the VIMM was failed in the next two steps.
6. A VIMM was chosen and downed, to prevent physical damage when pulled. Since the Spares were offline (Step 5), the RAID group was then unprotected.
7. The VIMM was then physically removed from the Violin array, and re-inserted to trigger recovery of the failed VIMM.
8. The VIMM processor automatically booted, and recovery of the RAID Group was started automatically.
9. The log disk was re-inserted to allow recovery procedure to begin.
10. The run continued for 20 minutes at a reduced throughput due to the RAID rebuild.
11. The benchmark was terminated gracefully, and the various reports were run. No errors were reported at any time in this process.
12. The rows in the Settlement table were counted again to establish the final number of trades present in the data base.
13. The initial count was subtracted from the final count and was verified against the reported number of Trade-Result transactions
14. After the VIMM RAID Group finished rebuilding, and the log array finished rebuilding, the recovery was considered complete.
15. The Consistency scripts were run to verify the data base was logically consistent.

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)***

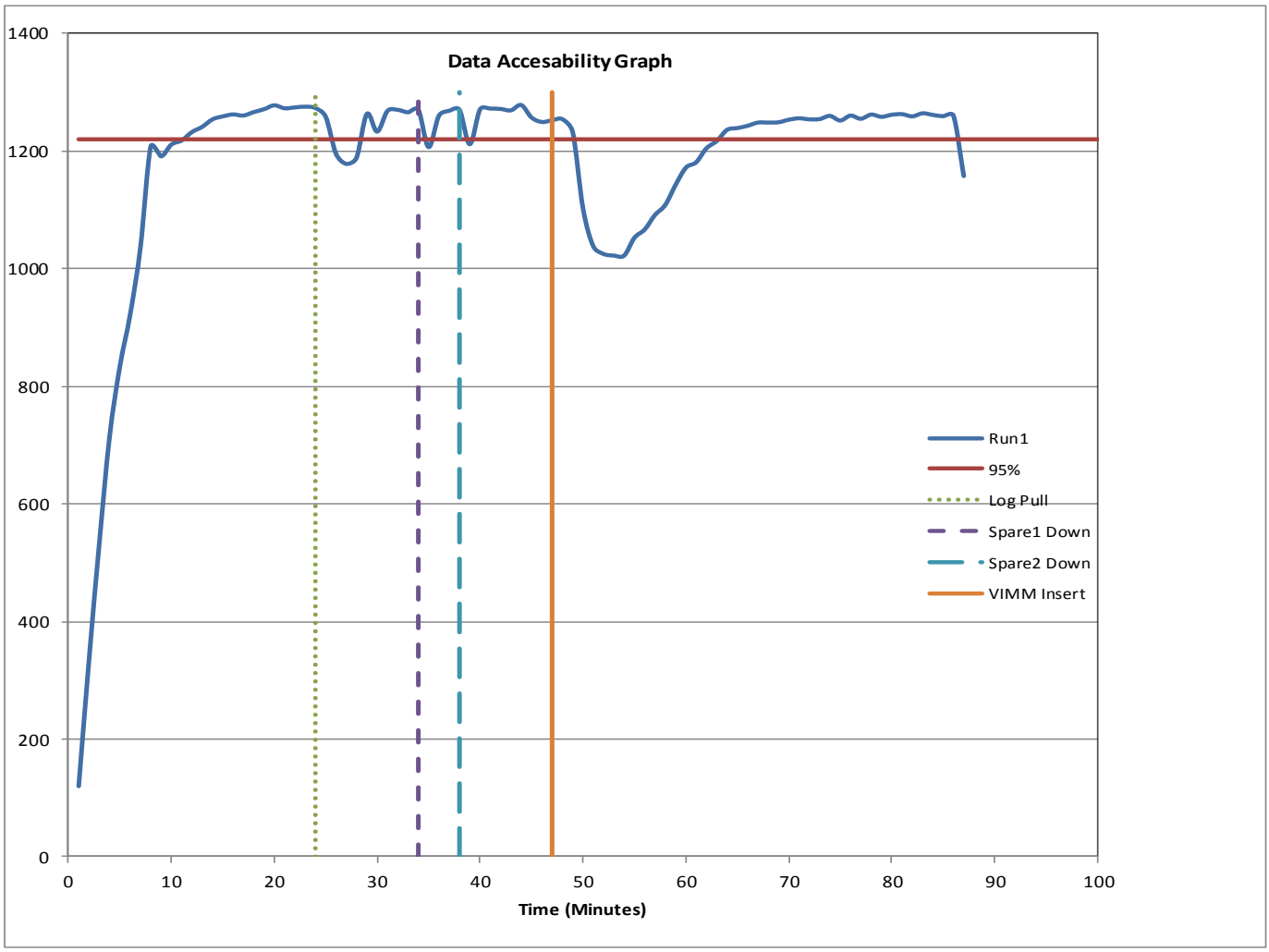

Figure 7.1 Data Accessibility Test Run Graph

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 server was booting back up.
5. Power was restored to Tier B server, and the machine 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 the TPC-E database and reported that the data base was available, the Trade-Cleanup Transaction was executed.
9. The benchmark was started and ramped up as before to >95% of the Reported Throughput.
10. The benchmark was allowed to run at >=95% for 20 minutes.
11. The driver environment was terminated gracefully. No errors were reported.
12. The rows in the Settlement table were counted again to determine the final number of trades present.
13. The initial count was subtracted from the final count, and this number was verified to be greater than or equal to the number of Trade-Result transacts as logged during the run.
14. The Consistency scripts were run to verify the data base was logically consistent.
15. The beginning of the first window of time where >=95% for 20 minutes was noted, which marked the end of the Business Recovery interval.

Business Recovery Time was 31 minutes and 20 seconds. This is also reported in the Executive Summary.

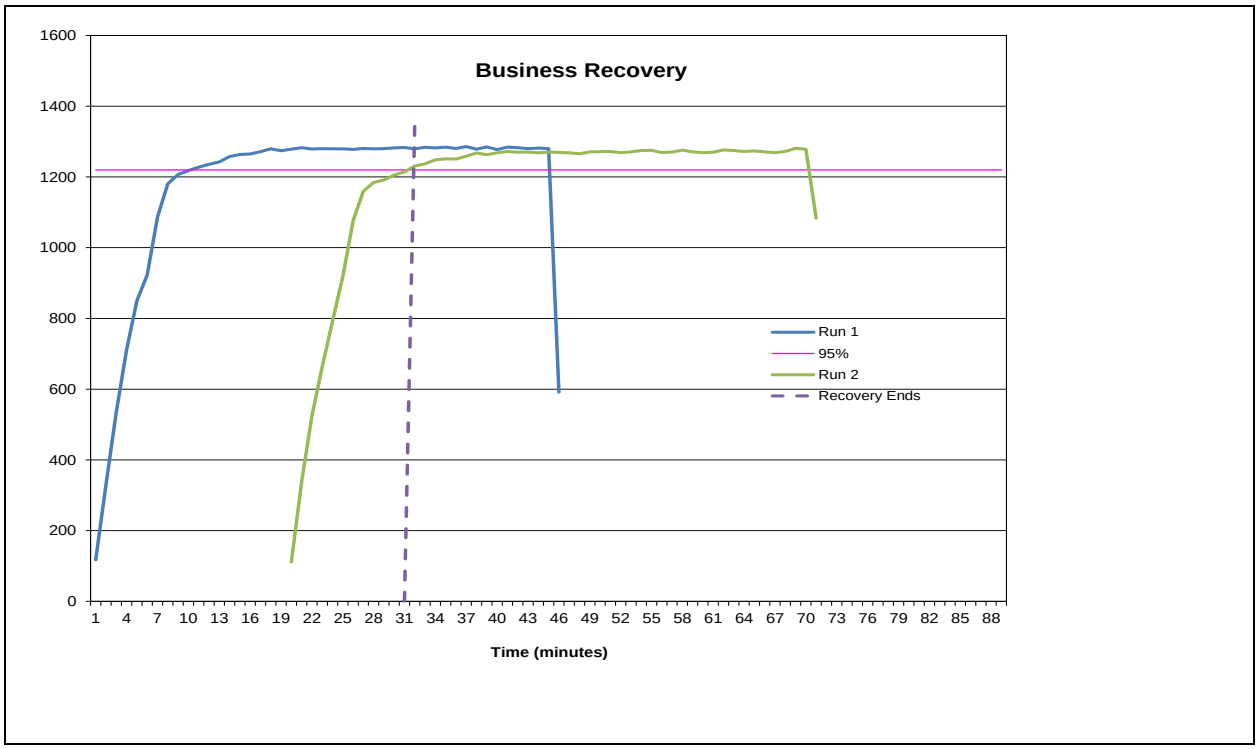

Figure 7.2 Business Recovery Tests Graph

Clause 8: Pricing Related Items

8.1 60-Day Space

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

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

TPC-E Disk Space Requirements

Customers Used	**700,000**	**Performance**	**1,284.14 TpsE**						
Broker File Group	**Initial Rows**	**Data (KB)**	**Index size (KB)**	**Extra 5% (KB)**	**Total + 5% (KB)**	**After run (KB)**	**Growth (KB)**	**1 Day Growth (KB)**	**Req. Add. (KB)**
BROKER	7,000	512	520	52	1,084	1,032	-	-	52
CASH_TRANSACTION	11,128,313,461	1,147,781,808	2,419,208	57,510,051	1,207,711,067	1,152,807,600	2,606,584	6,551,825	6,551,825
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	12,096,000,000	576,784,136	1,216,032	28,900,008	606,900,176	579,454,496	1,454,328	3,655,552	3,655,552
TRADE	12,096,000,000	1,442,021,760	724,409,144	108,321,545	2,274,752,449	2,173,819,728	7,388,824	18,572,308	18,572,308
TRADE_HISTORY	29,030,418,536	873,095,392	2,276,016	43,768,570	919,139,978	877,982,624	2,611,216	6,563,468	6,563,468
TRADE_REQUEST	-	-	-	-	-	219,696	219,696	552,221	552,221
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	4,970,435	273,696	1,688	13,769	289,153	275,416	32	81	13,769
CUSTOMER	700,000	114,704	30,248	7,248	152,200	144,976	24	61	7,248
CUSTOMER_ACCOUNT	3,500,000	317,160	67,696	19,243	404,099	384,856	-	-	19,243
CUSTOMER_TAXRATE	1,400,000	29,184	416	1,480	31,080	29,752	152	383	1,480
HOLDING	619,323,786	41,206,192	26,058,488	3,363,234	70,627,914	68,144,560	879,880	2,211,638	2,211,638
HOLDING_HISTORY	16,210,715,451	589,480,664	340,717,576	46,509,912	976,708,152	933,052,576	2,854,336	7,174,567	7,174,567
HOLDING_SUMMARY	34,817,571	1,512,576	5,776	75,918	1,594,270	1,518,352	-	-	-
WATCH_ITEM	70,007,791	1,944,008	7,280	97,564	2,048,852	1,951,544	256	644	97,564
WATCH_LIST	700,000	17,448	14,064	1,576	33,088	31,512	-	-	1,576
Market File Group									
COMPANY	350,000	74,384	20,448	4,742	99,574	94,840	8	21	4,742
COMPANY_COMPETITOR	1,050,000	28,216	22,720	2,547	53,483	50,936	-	-	2,547
DAILY_MARKET	625,747,500	29,150,896	84,336	1,461,762	30,696,994	29,236,608	1,376	3,459	1,461,762
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	7,000,000	788,832	2,480	39,566	830,878	791,608	296	745	39,566
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	479,500	29,712	416	1,506	31,634	30,128	-	-	1,506
NEWS_ITEM	700,000	92,677,344	1,136	4,633,924	97,312,404	92,678,480	-	-	4,633,924
NEWS_XREF	700,000	17,440	416	893	18,749	17,856	-	-	893
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	479,500	65,920	17,136	4,153	87,209	83,096	40	101	4,153
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	1,050,004	60,560	416	3,049	64,025	61,000	24	61	3,049
TAXRATE	320	24	16	2	42	56	16	41	41
ZIP_CODE	14,741	488	24	26	538	512	-	-	26
TOTALS (KB)		**4,797,473,120**	**1,097,374,816**	**294,742,397**	**6,189,590,333**				
Initial Database Size (MB)		**5,756,687**	**5,622 GB**						

Db/Filegroups	**LUN Count**	**Partition Size(KB)**	**MB allocated**	**MB Loaded**	**MB Required**	
fixed_fg	2	104,857,600	204,800	122,913	129,059	OK
growing_fg	2	3,250,585,600	6,348,800	5,633,774	5,677,994	OK
					MB Available	
Settlements	**14,713,443**				746,547	

Initial Growing Space (MB)	5,633,774								
Final Growing Space (MB)	5,651,367	**Data LUNS**	1	-	**Initial Log size (MB)**	4,788	**Log LUNS**	1	
Delta (MB)	17,593	**Disks per LUN**	5	-	**Final Log size (MB)**	103,686	**Log Disks**	4	
Data Space per Trade (MB)	0.00119568	**Disk Capacity (MB)**	476,160	-	**Log Growth (MB)**	98,898	**Disk Capacity (MB)**	476,160	
1 Day Data Growth (MB)	44,220	**RAID5 Overhead**	20.0%	0.0%	**Log Growth/trade (MB)**	0.00672162	**RAID10 Overhead**	50%	
60-Day Overflow (MB)	**1,862,451**	**Total Space (MB)**	**1,904,640**	-	**1 Day log space (MB)**	**248,587**	**Log Space (MB)**	**902,328**	
			1,904,640	OK					

8.2 Attestation Letter

INFO SIZING

TPC TRANSACTION PROCESSING PERFORMANCE COUNCIL CERTIFIED AUDITOR

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

May 03, 2011

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

Platform: HP ProLiant DL380 G7
Operating System: Microsoft Windows Server 2008 R2 Enterprise Edition
Database Manager: Microsoft SQL Server 2008 R2 Enterprise Edition

The results were:

CPU's Speed	Memory	Disks	Trade-Result 90% Response Time	tpsE
Tier B, Server: HP ProLiant DL380 G7				
2 x Intel Xeon X5690 (3.46GHz)	192 GB (12MB L3)	9 x 500 GB 7.2K HDD 2 x 3205 Violin Array SSD	0.08 Seconds	1284.14
Tier A, One Client: HP ProLiant DL360 G7				
1 x Intel Xeon X5630 (2.53 GHz)	6 GB (12MB L3)	2 x 146 GB 10K SAS	n/a	n/a

In my opinion, these performance results were produced in compliance with the TPC requirements for the benchmark.

The following verification items were given special attention:

- All EGen components were verified to be v1.12.0.
- The transactions were correctly implemented.
- The database was properly scaled and populated for 700,000 customers.
- The mandatory network between the driver and the SUT was configured.
- The ACID properties were met.

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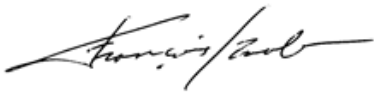
- Input data was generated according to the specified percentages.
- The reported response times were correctly measured.
- All 90% response times were under the specified maximums.
- The measurement interval was representative of steady state conditions.
- The reported measurement interval was 120 minutes.
- The implementation used Redundancy Level 1.
- The Business Recovery Time of 0:31:20 was correctly measured.
- The 60 day storage requirement was correctly computed.
- The system pricing was verified for major components and maintenance.

Additional Audit Notes:

None.

Respectfully Yours,



Doug Johnson, Auditor

François Raab, President

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Clause 9: Supporting Files

9.1 Supporting Files

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

Appendix A: Third Party Pricing Quotes/Pricing

Microsoft

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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

Microsoft

May 2, 2011

Hewlett-Packard Co.
Eric Deehr
3000 Hanover Street
Palo Alto, CA 94304-1185

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
810-08529	**SQL Server 2008 R2 Enterprise Edition** *Per Processor License* *Open Program - No Level* *Unit Price reflects a 2% discount from the retail unit price of $23,848.*	$23,370	2	$46,740
P72-04219	**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
P73-00352	**Windows Server 2008 R2 Standard Edition** *Server License with 10 CALs* *Open Program - No Level* *Unit Price reflects a 15% discount from the retail unit price of $1,029.*	$870	1	$870
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 qhtplylGYLKTVUKfhmhJjhiIiohJmof85757.

Violin Memory

Sales Quote

Violin Memory, Inc.
2700 Garcia Ave
Mountain View, CA 94043
E. Casey Roche III
Ph: 1-888-9VIOLIN (984-6546) x10
Fax: 1 732-218-6077
Email: casey@violin-memory.com
www.violin-memory.com

To: Eric Deehr
HP
One Microsoft Way
Redmond, WA
425-703-9215
eric_deehr@hp.com

Date: May 2, 2011
Quote #: 042111HP-MSFT
Expiration Date: Valid for 30 days

Project: TPC-E Benchmark for DL380 G7

Payment Terms: Net 30 days

Qty	Prod Code		List Price	Discount	Extended Price
		Violin Memory Array			
2	V-3205	V-3200 Memory Array with 5.2TB Flash Redundant AC supplies - C19 connectors PCIex8 Interface, Card and Cable	$ 150,000.00	33%	$ 201,000.00
		Storage Interface			
		Maintenance & Warranty			
3	VS-PM1Y	Violin Premium Maintenance - 1 year Refer to www.violin-memory.com/legal	4%	0%	$ 36,000.00
		No specific software version requirements		Subtotal	$ 237,000.00
				Shipping & Handling	$ -
				Sales Tax 0.000%	-
				Total	**$ 237,000.00**

Availability: Within 8 weeks after receipt of order.
Shipping: FOB Origin, Shipping by 5 day ground within USA

Shipping Details	Eric Deehr
	HP
	One Microsoft Way
	Redmond, WA
	425-703-9215
	eric_deehr@hp.com

Thank You For Your Business!

Special Requirements: None

Standard terms of sale and service policies are posted at www.violin-memory/legal

2700 Garcia Ave, Mountain View, CA 94043 Ph: 1-888-9VIOLIN (984-6546) Email: sales@violin-memory.com www.violin-memory.com