TPC Benchmark® E
Full Disclosure Report

HP ProLiant DL380p Gen8

Using Microsoft SQL Server 2012 Enterprise Edition SP1

On Microsoft Windows Server 2012 Standard Edition

First Edition

Nov. 20, 2012

First Edition Nov. 20, 2012

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Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® E (TPC-E) test conducted on the HP ProLiant DL380p Gen8. The operating system used for the benchmark was Microsoft Windows Server 2012 Standard Edition.

TPC Benchmark® E Metrics

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

TPC Benchmark® Energy Metrics

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

Standard and Executive Summary Statements

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

Auditor

The benchmark configuration, environment and methodology used to produce and validate the test results, and the pricing model used to calculate the cost per tpsE®, were audited by Lorna Livingtree of PerfMetrics to verify compliance with the relevant TPC specifications.

HP ProLiant DL380p Gen8
Intel Xeon CPU E5-2690
C/S with 1 Proliant DL360 G7

TPC-E Rev 1.12.0

TPC Pricing 1.7.0

Report Date
Nov. 20, 2012

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
1881.76 tpsE	$173 USD/tpsE	Nov. 20, 2012	$325,268 USD

Database Server Configuration

Operating System	Database Manager	Processor/Cores/Thread	Memory
Microsoft Windows Server 2012 Standard Edition	Microsoft SQL Server 2012 Enterprise Edition SP1	2/16/32 Intel Xeon CPU E5-2690 2.9 GHz 20 MB L3	256 Gbyte

Tier B: Server
HP ProLiant DL380p Gen8

2 x Intel Xeon Processor E5-2690 2.90 GHZ
256 GB Memory
2 x HP 146GB SAS 15K SFF DP ENT HDD
6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)

Tier A: Client

1 x ProLiant DL360 G7
2x Quad-Core Intel Xeon X5670 Processor 2.93Ghz
3 x 4GB PC3-10600 Memory
2 x 300GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet

Storage

4 x HP Smart Array P421/1GB
4 x HP StorageWorks D2700 Disk Enclosure
32 X HP 400GB 6G SAS SLC SFF (2.5-inch) SSD

Priced Only
2 x 500GB 6G SAS 15K SFF DP ENT HDD 60 Day Space

Initial Database Size	Redundancy Level: 1	Storage
7,792 GB	RAID10:Log/RAID5:Data	32x 400GB SSD (data), 6x300GB HDD (log), 2x500GB HDD(60Day)

	HP ProLiant DL380p Gen8				TPC-E	1.12.0
					TPC-Pricing	1.7.0
					Report date	20-Nov-12
					Availability Date	20-Nov-12
Description	**Part Number**	**Brand**	**Unit Price**	**Qty.**	**Extended Price**	**3 Yr Maint Price**
Server Hardware (Tier B)						
HP ProLiant DL380p Gen8 8 SFF CTO Chassis	653200-B21	1	2,668	1	2,668	
HP DL380p Gen8 Intel® Xeon® E5-2690 (2.9GHz/8-core/20MB/135W) Processor	662226-B21	1	2,849	2	5,698	
HP 16GB (1x16GB) Dual Rank x4 PC3-12800R (DDR3-1600) Memory Kit	672631-B21	1	439	16	7,024	
HP 146GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise	652605-B21	1	389	2	778	
HP 300GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise (Log)	652611-B21	1	699	6	4,194	
HP Ethernet 10Gb 2-port 560SFP+ Adapter	665249-B21	1	699	1	699	
HP Smart Array P421/2GB FBWC 6Gb 2-ports Ext SAS Controller	631674-B21	1	899	4	3,596	
HP 3 year 4 hour 24x7 ProLiant DL38x(p) Hardware Support	U4545E	1	1,061	1		$1,061
			Subtotal		**$24,657**	**$1,061**
Server Software						
SQL Server 2012 Enterprise Edition SP1, 2 Core License	7JQ-00256	2	13,473	8	107,780	
Windows Server 2012 Standard Edition	P73-05761	2	735	1	735	
Microsoft Problem Resolution Services	N/A	2	259	1		259
			Subtotal		**$108,515**	**259**
Storage						
HP D2700 Disk Enclosure	AJ941A	1	3,399	4	13,596	
HP 3 year 4 hour 24x7 D2000 Enclosure Hardware Support	UQ540E	1	1,980	4		7,920
HP 400GB 6G SAS SLC SFF (2.5-inch) 3yr Warranty Solid State Drive	632494-B21	1	7,399	32	236,768	
HP 500GB 6G SAS 7.2K rpm SFF DP Midline Hard Drive (60 Day)	507610-B21	1	349	2	698	
			Subtotal		**251,062**	**7,920**
Client Hardware (Tier A)						
HP ProLiant DL360 G7 CTO Server	579237-B21	1	2,098	1	2,098	
HP DL380 G7 Intel® Xeon® X5670 (2.93GHz/6-core/12MB/95W) Processor	587493-B21	1	2,099	2	4,198	
HP 2GB (1x2GB) Dual Rank x8 PC3-10600 Memory Kit	500656-B21	1	110	6	660	
HP 300GB 6G SAS 10K rpm SFF (2.5-inch) Enterprise 3yr Warranty Hard Drive	507127-B21	1	309	2	618	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	828	1		828
			Subtotal		**7,574**	**828**
Client Software						
Microsoft Windows Server 2008 R2 Enterprise Edition	P72-04217	2	2,280	1	2,280	
			Subtotal		**2,280**	**0**
Infrastructure						
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4	4	15	
HP Networking 2910al-24G Switch	J9145A	1	2,113	1	2,113	
3-year, 4-hour onsite, 24x7 coverage for hardware	U2856E	1	998	1		998
HP X242 SFP+ SFp+ 1 m Direct Attach Cable	J9281B	1	157	2	314	
HP V142 1075mm deep Pallet 100 series Rack	AF046S	1	789	1	789	
HP LE1901wm 19-inch Widescreen LCD Monitor	NP446A8#ABA	1	149	1	149	
HP PS/2 Keyboard And Mouse Bundle	RC464AA#ABA	1	39	1	39	
			Subtotal		**3,419**	**998**
		Total Extended Price			**$397,507**	**$11,066**
Large Purchase and Net 30 discount (See Note 1)	28.0%	**Total Discounts**			**$80,279**	**$3,026**
		Grand Total			**$317,228**	**$8,040**

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

Three-year Cost of Ownership: USD	**$325,268**
tpsE	**1,881.76**
$ USD/tpsE	**$173**

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 DL380p Gen8
Intel Xeon CPU E5-2690
C/S with 1 DL360 G7

TPC-E Rev 1.12.0
TPC Pricing 1.7.0

Report Date
Nov. 20, 2012

Availability Date
Nov. 20, 2012

Numerical Quantities Summary

Reported Throughput	1881.76 tpsE	Configured Customers:	950,000

Response Times (in seconds)	Minimum	Average	90th %tile	Maximum
Broker Volume	0.00	0.01	0.03	0.61
Customer Position	0.00	0.01	0.02	1.05
Market Feed	0.00	0.02	0.04	1.01
Market Watch	0.00	0.01	0.02	0.95
Security Detail	0.00	0.01	0.01	0.35
Trade Lookup	0.00	0.08	0.11	1.00
Trade Order	0.00	0.03	0.05	1.14
Trade Result	0.00	0.03	0.05	1.64
Trade Status	0.00	0.01	0.02	0.47
Trade Update	0.01	0.09	0.12	0.55
Data Maintenance	0.01	0.02		0.07

Transaction Mix	Transaction Count	Mix %
Broker Volume	6,639,298	4.900%
Customer Position	17,614,001	13.000%
Market Feed	1,354,873	1.000%
Market Watch	24,389,010	18.000%
Security Detail	18,969,036	14.000%
Trade Lookup	10,839,347	8.000%
Trade Order	13,684,799	10.100%
Trade Result	13,548,699	10.000%
Trade Status	25,743,564	19.000%
Trade Update	2,709,818	2.000%
Data Maintenance	120	

Ramp-up Time	0:15:00
Measurement Interval	2:00:00
Business Recovery Time	0:41:30
Total Number of Transactions Completed in Measurement Interval	135,492,445

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Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL380p Gen8 using Microsoft SQL Server 2012 Enterprise Edition SP1. It meets the requirements of the TPC Benchmark ® E Standard Specification, Revision 1.12.0 dated June 2010. TPC Benchmark® E was developed by the **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 any time, especially in relation to each other.

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

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

Clause 1: General Items

1.1 Orders and Titles

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

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

1.2 Pricing

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

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

1.3 Executive Summary Statement

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

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

1.4 Supporting Files

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

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

1.5 Auditor

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

This Benchmark, Executive Summary, and Full Disclosure Report were audited by Lorna Livingtree of Perfmetrics. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

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

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

Figure 1.1 Priced Configuration

Tier B: Server
HP ProLiant DL380p Gen8

2 x Intel Xeon Processor E5-2690 2.90 GHZ
256 GB Memory
2 x HP 146GB SAS 15K SFF DP ENT HDD
6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)

Tier A: Client

1 x ProLiant DL360 G7
2x Quad-Core Intel Xeon X5670 Processor 2.93Ghz
3 x 4GB PC3-10600 Memory
2 x 300GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet

Storage

4 x HP Smart Array P421/1GB
4 x HP StorageWorks D2700 Disk Enclosure
32 X HP 400GB 6G SAS SLC SFF (2.5-inch) SSD

Priced Only
2 x 500GB 6G SAS 15K SFF DP ENT HDD (60 Day Space)

Figure 1.2 Measured Configuration

Tier B: Server
HP ProLiant DL380p Gen8

2 x Intel Xeon Processor E5-2690 2.90 GHZ
256 GB Memory
2 x HP 146GB SAS 15K SFF DP ENT HDD
6 x HP 300GB SAS 15K SFF DP ENT HDD (Database Log)

Tier A: Client

1 x ProLiant DL360 G7
2x Quad-Core Intel Xeon X5670 Processor 2.93Ghz
3 x 4GB PC3-10600 Memory
2 x 300GB 6G SAS 10K SFF DP
4 x Onboard 1Gbps Ethernet

Storage

4 x HP Smart Array P421/1GB
4 x HP StorageWorks D2700 Disk Enclosure
32 X HP 400GB 6G SAS SLC SFF (2.5-inch) SSD

Measured Only
48 x 500GB 6G SAS 15K SFF DP ENT HDD (Database Backup)
8 X HP 400GB 6G SAS SLC SFF (2.5-inch) SSD (unused)

Note: The 48 x 500GB 6G SAS and 8 X HP 400GB 6G SAS present during the measured run were for data backup only, or unused, and were not active during the actual performance measurement or durability runs.

1.7 Hardware Configuration

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

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

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

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

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

The HP ProLiant DL390p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 processor installed, along with 16 x 16 GB DIMMs. The various HBA's, NICS, and other IO cards are installed in the various chassis as defined in the file **HWConfig.pdf** in the *\Supporting Files\Introduction\TierB* "Introduction" directory. Additionally, the **DiskConfig.pdf** file in the *Supporting Files* directory shows how the SmartArray storage subsystem 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 **Win2012Setup.pdf** in the *\SupportingFiles\Introduction\TierB* directory outlines the steps taken to configure the OS and DBMS. The file **SQL2012Setup.doc** in *\SupportingFiles\Introduction\TierB* likewise outlines the steps taken to setup the DBMS. Other supporting files (registry, configuration) are also included in the respective directories.

Clause 2: Database Design, Scaling & Population Items

2.1 Physical Database Organization

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

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

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

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

Table 2.1 – FileGroup Table Assignments

2.2 Table and Row Partitioning

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

No partitioning was done for this benchmark.

2.3 Replication, Duplication

*Replication of tables, if used, must be **reported** in the **Report. (9.3.2.3).***
*Additional and/or duplicated columns in any table must **be** reported in the Report along with a statement on the impact on performance. (9.3.2.4)*

No replication or duplication was done for this benchmark.

2.4 Cardinality of Tables

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

The TPC-E database was configured using 950,000 customers. Table 2.2 below shows the cardinality of each table.

Table	Rows
BROKER	9500
CASH_TRANSACTION	15106858947
CHARGE	15
COMMISSION_RATE	240
SETTLEMENT	16420519946
TRADE	16420630686
TRADE_HISTORY	39409426952
TRADE_REQUEST	0
TRADE_TYPE	5
ACCOUNT_PERMISSION	6744962
CUSTOMER	950000
CUSTOMER_ACCOUNT	4750000
CUSTOMER_TAXRATE	1900000
HOLDING	840561937
HOLDING_HISTORY	22006345805
HOLDING_SUMMARY	47248629
WATCH_ITEM	95001161
WATCH_LIST	950000
COMPANY	475000
COMPANY_COMPETITOR	1425000
DAILY_MARKET	849228750
EXCHANGE	4
FINANCIAL	9500000
INDUSTRY	102
LAST_TRADE	650750
NEWS_ITEM	950000
NEWS_XREF	950000
SECTOR	12
SECURITY	650750
STATUS_TYPE	5
ADDRESS	1425004
TAXRATE	320
ZIP_CODE	14741

Table 2.2 Initial Cardinality of Tables

2.5 Disk Configuration

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

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

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

Controller Type	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
P420i Internal SmartArray	1	2x146GB SAS, Internal RAID1	C:, NTFS	136.7GB	Win2012 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
	2	6x000GB SAS, Internal RAID1+0	L:, RAW	838GB	Database log
P421 SmartArray Adapter	1	8 X 400GB 6G SAS SLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1(NTFS)	2051 GB 46.1 GB 511 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	8 X 400GB 6G SAS SLC SFF	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) g:\mnt\temp\2(NTFS)	2051 GB 46.1 GB 511 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	8 X 400GB 6G SAS SLC SFF	g:\mnt\growing\3\ (RAW) g:\mnt\fixed\3\ (RAW) g:\mnt\temp\3(NTFS)	2051 GB 46.1 GB 511 GB	Growing FG Fixed FG TempDB files
P421 SmartArray Adapter	1	8 X 400GB 6G SAS SLC SFF	g:\mnt\growing\4\ (RAW) g:\mnt\fixed\4\ (RAW) g:\mnt\temp\4(NTFS)	2051 GB 46.1 GB 511 GB	Growing FG Fixed FG TempDB files

Table 2.3 Disk/Partition Configuration

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

2.6 Database Interface

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

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

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

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

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

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

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

Clause 3: Transaction Related Items

3.1 Code Functionality

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

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

3.2 Database Footprint

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

Database footprint requirements were met.

Clause 4: SUT, Driver and Network Related Items

4.1 Network Configuration

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

The two ports of the HP 560SFP+ NIC card in the SUT were connected to the 2910-al-24g network switch. Two ports of the HP Proliant DL360 G7 client were also connected to this switch. These connections were used for database traffic. The other built in NICs on the SUT and client were used to access the system by the benchmark driver system, management, etc.

Clause 5: EGen Related Items

5.1 EGen Version

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

EGen Version used for this test was 1.12.0

5.2 EGen Code

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

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

5.3 EGen Modifications

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

No modifications to EGen were done for this report.

5.4 EGen Loader Extensions

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

EGen Loader was not extended for this report.

5.5 EGen Loader Make Files

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

The Visual C++ project files are in the **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)***

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

6.2 Measured Throughput

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

Measured tpsE for this run was 1,881.76 tpsE.

Test Run Graph and Steady State Measurement

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

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

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

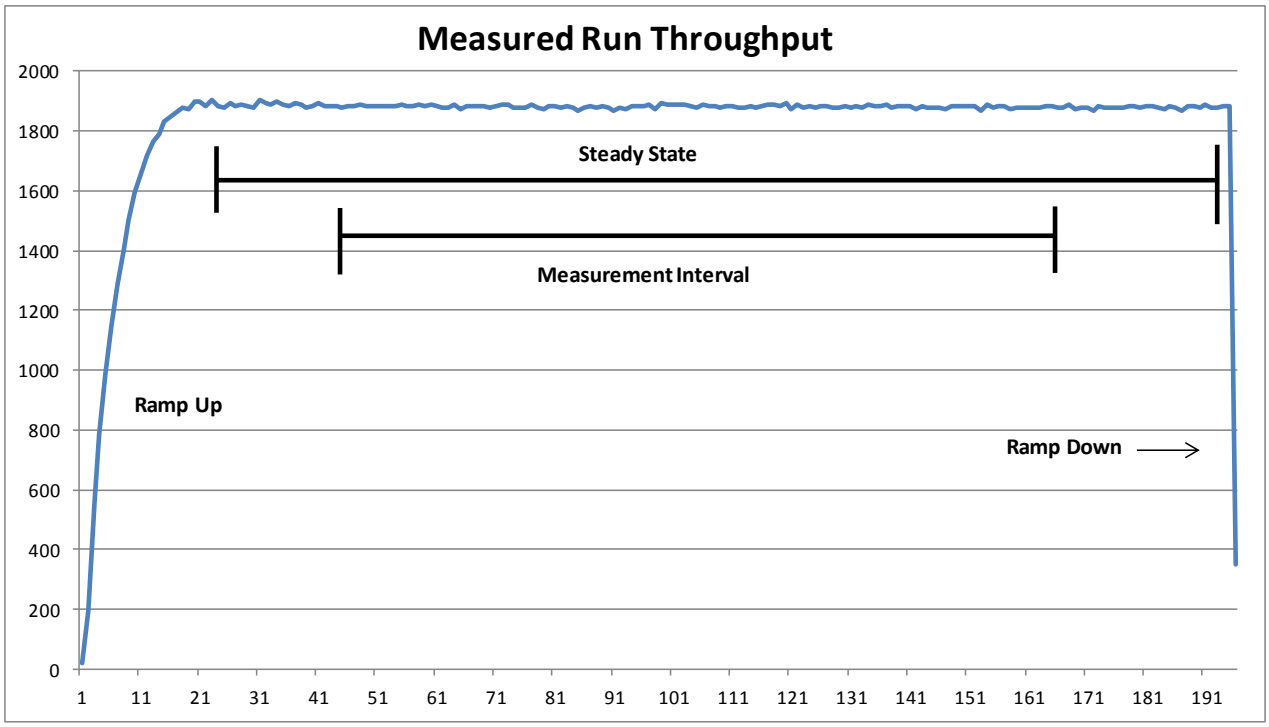

Figure 6.1 Test Run Time/Steady State Measurement Run Data

6.4 Work Measurement

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

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

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

6.5 Transaction Reporting

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

Table 6.2 shows the Averages for the Test Run.

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.98%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	30.00%	Ok	28.50%	31.50%
		Frame 2	29.99%	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	34.99%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	33.04%	Ok	31.00%	35.00%
		Frame 2	33.02%	Ok	31.00%	35.00%
		Frame 3	33.94%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	9.99%	Ok	9.50%	10.50%
		By Company Name	40.02%	Ok	38.00%	42.00%
		Buy on Margin	8.00%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	35.01%	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	25.00%	Ok	24.00%	26.00%
		Trade by Qty 800	24.99%	Ok	24.00%	26.00%
		Market Buy	29.99%	Ok	29.70%	30.30%
		Market Sell	30.02%	Ok	29.70%	30.30%
		Limit Buy	20.00%	Ok	19.80%	20.20%
		Limit Sell	10.01%	Ok	9.90%	10.10%
		Stop Loss	9.99%	Ok	9.90%	10.10%

Table 6.2 Average Transaction Parameters

Clause 7: Transaction and System Properties

7.1 ACID Tests

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

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

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

7.2 Redundancy Level and Data Accessibility Tests

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

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

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

7.3 Data Accessibility Graph

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

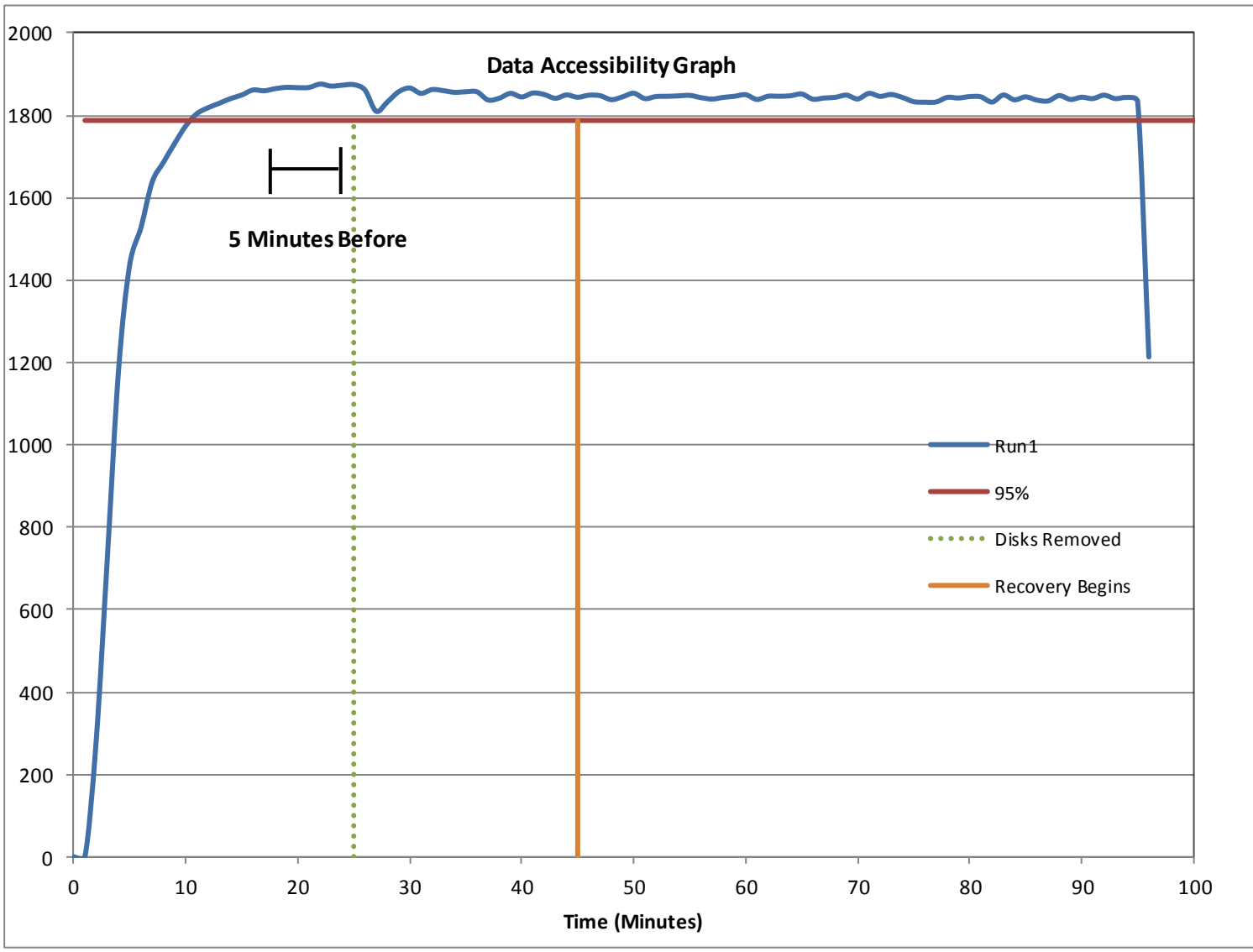

Figure 7.1 Data Accessibility Test Run Graph

7.4 Business Recovery Tests

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

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

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

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

Business Recovery Time was 41 minutes and 30 seconds. This is also reported in the Executive Summary.

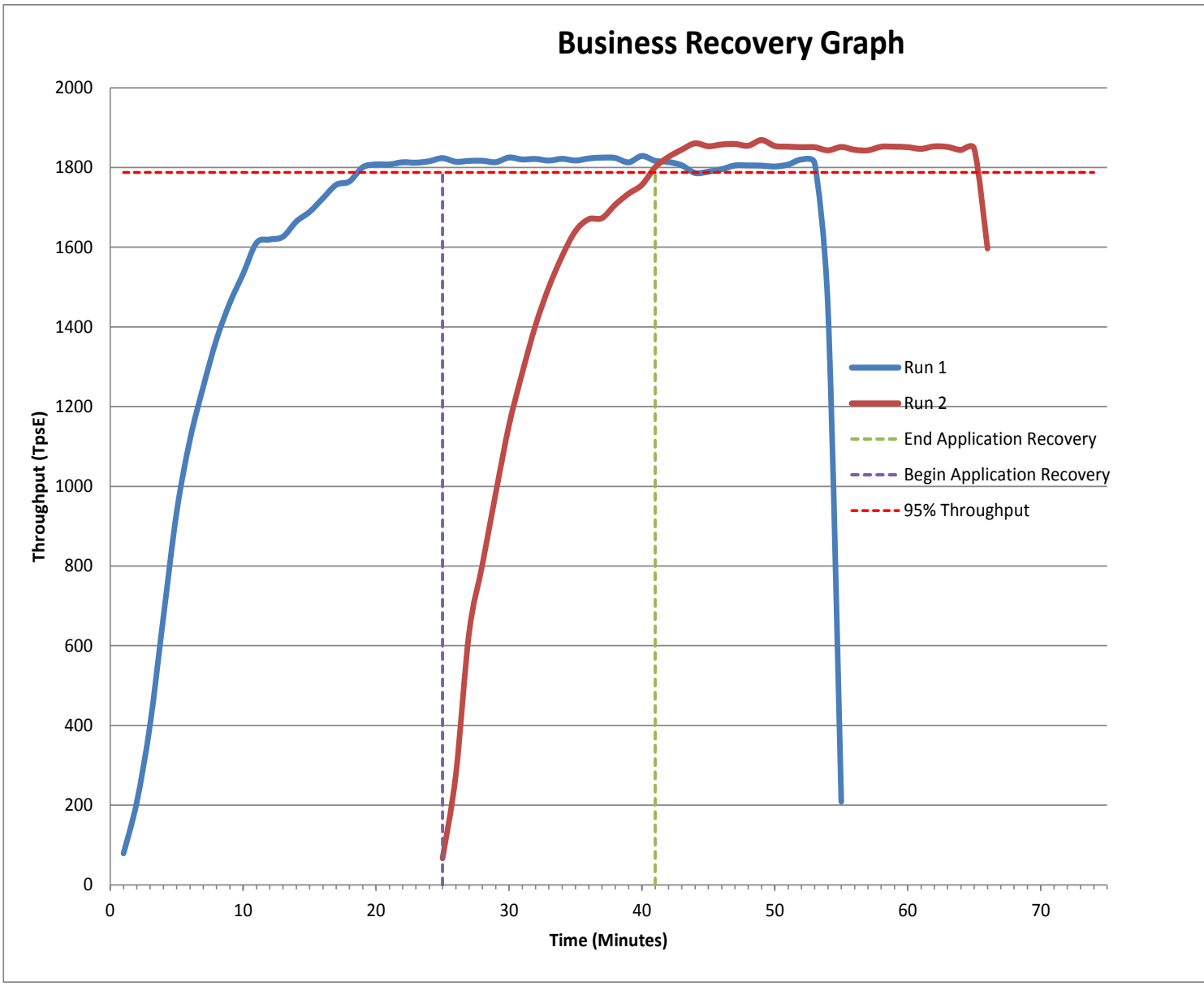

Figure 7.2 Business Recovery Tests Graph

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.

Space calulcations for TPC-E		Customers:	950,000								
		TpsE:	1,881.76								
		TradeResult count:	21,421,293							Database File Groups	
Table	**Rows**	**Data(KB)**	**Index(KB)**	**Total**	**Total + 5%**	**Rows After**	**Data After(KB)**	**Index After(KB)**	**Growth**	**Fixed**	**Growing**
ACCOUNT_PERMISSION	6744962	371416	2304	373,720	392,406	6744962	371432	2320	32	373,752	
ADDRESS	1425004	82184	576	82,760	86,898	1425004	82216	576	32	82,792	
BROKER	9500	696	776	1,472	1,546	9500	696	776	0	1,472	
CASH_TRANSACTION	15106858947	1559328880	3287336	1,562,616,216	1,640,747,027	15126567222	1563043496	3304368	3731648		1,566,347,864
CHARGE	15	8	8	16	17	15	8	8	0	16	
COMMISSION_RATE	240	16	16	32	34	240	16	16	0	32	
COMPANY	475000	100984	30576	131,560	138,138	475000	100984	30576	0	131,560	
COMPANY_COMPETITOR	1425000	38272	35168	73,440	77,112	1425000	38272	35168	0	73,440	
CUSTOMER	950000	155672	46664	202,336	212,453	950000	155680	46672	16	202,352	
CUSTOMER_ACCOUNT	4750000	430440	106032	536,472	563,296	4750000	430440	106032	0	536,472	
CUSTOMER_TAXRATE	1900000	39616	560	40,176	42,185	1900000	39728	576	128	40,304	
DAILY_MARKET	849228750	39655488	115264	39,770,752	41,759,290	849228750	39656456	115488	1192	39,771,944	
EXCHANGE	4	8	8	16	17	4	8	8	0	16	
FINANCIAL	9500000	1070576	3344	1,073,920	1,127,616	9500000	1070720	3480	280	1,074,200	
HOLDING	840561937	56289456	38236256	94,525,712	99,251,998	841098150	57554936	38244720	1273944		95,799,656
HOLDING_HISTORY	22006345805	800230184	534838744	1,335,068,928	1,401,822,374	22035234512	803134520	53667476	4740368		1,339,809,296
HOLDING_SUMMARY	47248629	2059352	7880	2,067,232	2,170,594	47248699	2059352	7880	0		2,067,232
INDUSTRY	102	8	24	32	34	102	8	24	0	32	
LAST_TRADE	650750	40408	560	40,968	43,016	650750	40408	560	0	40,968	
NEWS_ITEM	950000	102997344	1520	102,998,864	108,148,807	950000	102997368	1544	48	102,998,912	
NEWS_XREF	950000	23640	560	24,200	25,410	950000	23640	560	0	24,200	
SECTOR	12	8	24	32	34	12	8	24	0	32	
SECURITY	650750	89592	25344	114,936	120,683	650750	89624	25360	48	114,984	
SETTLEMENT	16420519946	783224688	1651720	784,876,408	824,120,228	16441941239	785304424	1660424	2088440		786,964,848
STATUS_TYPE	5	8	8	16	17	5	8	8	0	16	
TAXRATE	320	32	16	48	50	320	40	16	8	56	
TRADE	16420630686	1959066352	1095717096	3,054,783,448	3,207,522,620	16442164370	1961782376	1096166800	3165728		3,057,949,176
TRADE_HISTORY	39409426952	1185708560	3091984	1,188,800,544	1,248,240,571	39460880951	1189418320	3112848	3730624		1,192,531,168
TRADE_REQUEST	0	0	0	-	-	112391	299360	24416	323776		323,776
TRADE_TYPE	5	8	1032	1,040	1,092	5	8	1032	0	1,040	
WATCH_ITEM	95001161	2648184	9968	2,658,152	2,791,060	95001161	2648296	10096	240	2,658,392	
WATCH_LIST	950000	23648	21904	45,552	47,830	950000	23648	21904	0	45,552	
ZIP_CODE	14741	488	40	528	554	14741	488	40	0	528	
Totals in KB		6493676216	1677233312	8170909528	8579455004		6510366984	1679599096	19056552	148173064	8041793016
									file size	6048000	268800000
									# of files	4	4
									total in KB (*8)	193536000	8601600000

Database File Groups	**Allocated size MB**	**Required size MB**	**Diff**
Fixed_FG	189,000	144,700	44,300
Growing_FG	8,400,000	7,853,313	546,687

Growing Space	19,054,528	KB
per Trade Results	0.89	KB
Data Growth	48,206,903	KB
60 Day Space	11,063,323,725	KB
60 Day Space	10,551	GB

Log space before in MB	35,550	14.21995	250000
Log space after in MB	174,751	69.9002	250000
per Trade Results	0.006		
Log Growth	352,170	MB	
Total 8 hours log space	387,720	MB	
Total 8 hours log space	378.63	GB	

	Count	Formatted size GB	Total GB Configured	Total Needed
Data Disks configured	32	372.56	11,922	
RAID 5 overhead 12.5%			(1,490)	
60 Day Space Disks priced	2	465.718	931	
RAID 10 overhead 50%			(466)	
Data Disks space total			**10,897**	10,551
Log Disks configured	6	279.37	1,676	
RAID 10 overhead 50%			(838)	
Log Disk space total			838	379

8.2 Attestation Letter

PERFORMANCE METRICS INC.
TPC Certified Auditors

November 14, 2012

Mr. Eric Deehr
Performance Engineer
Hewlett-Packard Company
14475 NE 24th St.
Bellevue, WA 98007

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

Platform: HP ProLiant DL380p G8
Database Manager: Microsoft SQL Server 2012 Enterprise Edition SP1
Operating System: Microsoft Windows Sever 2012 Standard Edition

Server (Tier B): DL380p G8			
CPU's	Memory	Disks (total)	TpsE
2 Intel Xeon 8 core @ 2.90 Ghz	256 GB	40 @ 400GB SSD 2 @ 500 GB 2 @ 146 GB 6 @ 300 GB	**1,881.76**
Clients (Tier A): ProLiant DL360 G7			
2 Intel Xeon 6 core @ 2.93 Ghz	12 GB	2 @ 300 GB	Na

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

- All EGen components were verified to be version 1.12.0
- The database files were properly sized and populated for 950,000 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.

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(707) 954-7757 fax: (707) 482-0575 email: LornaL@PerfMetrics.com

- The test run met all the requirements for timing, mix, and response times.
- Input data was generated according to the specified percentages.
- One and only one Data-Maintenance process was running during the test run.
- There were no inactive load units during the test run.
- Eight hours of mirrored log space was present on the measured system.
- Eight hours of growth space was present on the measured system.
- The data for the 60 day space calculation was verified.
- The steady state portion of the test was 120 minutes.
- One checkpoint was taken after steady state and before the measured interval.
- Checkpoint interval was verified to be equal to or less than 7.5 minutes.
- The system pricing was checked for major components and maintenance.
- Third party quotes were verified for compliance.
- The FDR was reviewed and verified as required.

Auditor Notes: There were more SSD disks configured than actually measured. I verified that 8 SSD were unused by reviewing the RAID controller configurations showing only 8 out of 10 disks were configured.

Sincerely,

Lorna Livingtree

Lorna Livingtree
TPC Certified Auditor

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(707) 954-7757 fax: (707) 482-0575 email: LornaL@PerfMetrics.com

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

October 29, 2012

Hewlett-Packard
Eric Deehr
One Microsoft Way
Redmond, Washington 98052

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

All pricing shown is in US Dollars ($).

Part Number	Description	Unit Price	Quantity	Price
Database Management System				
7JQ-00256	**SQL Server 2012 Enterprise Edition** *2 Core License* *Open Program - Level C*	$13,472.50	8	$107,780.00
Database Server Operating System				
P73-05761	**Windows Server 2012 Standard** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 17% discount from the retail unit price of $882.*	$735.00	1	$735.00
Tier-A Operating System(s)				
P72-04217	**Windows Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - Level C* *Unit Price reflects a 43% discount from the retail unit price of $3,999.*	$2,280.00	1	$2,280.00
Support				
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259.00	1	$259.00

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

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

This quote is valid for the next 90 days.

Reference ID: TPCE_qhtplylGYLKTVUKf85757fihjQjhiJikhLll.