TPC Benchmark™ E

Full Disclosure Report for

FUJITSU Server PRIMEQUEST 2800E

Using

Microsoft SQL Server 2014
Enterprise Edition

Using

Microsoft Windows Server 2012 R2
Standard Edition

TPC-E Version 1.12.0

Submitted for Review

April 14, 2014

First Edition April 2014

Fujitsu believes that the information in this document is accurate as of the publication date. The information in this document is subject to change without notice. We assume no responsibility for any errors that may appear in this document. The pricing information in this document is believed to accurately reflect the current prices as of the publication date. However, we provide no warranty of the pricing information in this document.

Benchmark results are highly dependent upon workload, specific application requirements, system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, TPC Benchmark™ E should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

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

Abstract

This report documents the TPC Benchmark™ E results achieved by Fujitsu using Microsoft SQL Server 2014 Enterprise Edition.

The TPC Benchmark™ E tests were run on a FUJITSU Server PRIMEQUEST 2800E system using the Microsoft Windows Server 2012 R2 Standard Edition operating system.

The results, summarized below, show the number of TPC Benchmark™ E transactions per second (tpsE) and the price per tpsE ($/tpsE).

Hardware	Software	Total System Cost	tpsE	$ USD/tpsE	Availability Date
FUJITSU Server PRIMEQUEST 2800E	**Microsoft SQL Server 2014 Enterprise Edition Microsoft Windows Server 2012 R2 Standard Edition**	**$ 1,763,068 USD**	**8,582.52**	**$ 205.43 USD**	**May 1, 2014**

The benchmark implementation and results were audited by Doug Johnson for InfoSizing Inc. (www.sizing.com). The auditor's attestation letter is contained in Section 8 of this report.

	FUJITSU Server PRIMEQUEST 2800E	**TPC-E 1.12.0** **TPC Pricing 2.0.0**
		Report Date April 14, 2014

TPC-E Throughput **8,582.52 tpsE**	Price/Performance **$ 205.43 USD per tpsE**	Availability Date **May 1, 2014**	Total System Cost **$ 1,763,068 USD**

Database Server Configuration			
Operating System **Microsoft Windows Server 2012 R2 Standard Edition**	Database Manager **Microsoft SQL Server 2014 Enterprise Edition**	Processors/Cores/Threads **8/120/240**	Memory **4 TB**

Tier A
2x PRIMERGY RX200 S8 (each with)
2x Intel Xeon E5-2667 v2 3.30 GHz
64 GB Memory
2x 250 GB 7.2k rpm SATA Drive
2x onboard LAN 1 Gb/s
1x Dual Port LAN 1 Gb/s

Tier B
PRIMEQUEST 2800E
8x Intel Xeon E7-8890 v2 2.80 GHz
4 TB Memory
2x 300 GB 10k rpm SAS Drives
2x 400 GB SSD Drives
4x onboard LAN 1 Gb/s
14x SAS RAID Controller

Storage
1x PRIMECENTER Rack
13x ETERNUS JX40
166x 400 GB SSD Drives
12x 300 GB 15k rpm SAS Drives

Initial Database Size **36,951 GB**	Redundancy Level 1 **RAID-5 data and RAID-10 log** **RAID-1 tempdb**	Storage **166 x 400 GB SSD** **12 x 300 GB 15k rpm HDD** **2 x 400 GB SSD tempdb**

FUJITSU Server PRIMEQUEST 2800E

TPC-E 1.12.0
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Description	Part Number	Price Source	Unit Price	Qty	Extended Price	3-yr. Maint. Price
Database Server (Tier B) Hardware			$		$	$
PRIMEQUEST 2800E						
Base Unit PQ2800E	MCF3AC111	1	47,900.00	1	47,900.00	
PQ 2x00E Management Board_1	MC-5HMM21	1	4,270.00	2	8,540.00	
Power Supply 2.880W platinum hp	MC-5HPS41	1	1,240.00	4	4,960.00	
Power Cord IEC320 C19 -> US NEMA L6-20p	S26361-F3151-E500	1	60.00	4	240.00	
Fan Unit	MC-5HFA41	1	325.00	2	650.00	
System Board PQ2800E	MC-3HSB51	1	43,000.00	4	172,000.00	
Memory Extention Board PQ2800E	MC-3HMB11	1	1,400.00	4	5,600.00	
Intel Xeon E7-8890 v2 15C/30T 2.80 GHz 37MB	MC-3BCA11	1	15,370.00	8	122,960.00	
64GB (2x32GB) 4Rx4 L DDR3-1600 LR ECC	MC-3CC711	1	2,600.00	64	166,400.00	
Memory Mode standard Installation	MC-0PMM1	1	7.00	4	28.00	
RAID Ctrl SAS 6G 1GB (D3116C)	MC-0JSR31	1	520.00	1	520.00	
HD SAS 6G 300GB 10K HOT PL 2.5' EP	MC-5DS741	1	310.00	2	620.00	
I/O Unit (1GbE) PQ2800E	MC-3HUX31	1	5,610.00	4	22,440.00	
RAID Ctrl SAS 6G 8Port ex 1GB LP LSI V3	MC-0JSR41	1	950.00	13	12,350.00	
JX40 SSD SAS 12G 400GB MLC 2.5" (tempdb)	FTS:JX40-SSD400	1	3,706.00	2	7,412.00	
Rack Mount Kit F1-C S7 LV	S26361-F2735-E175	1	144.00	1	144.00	
Rack Cable Arm 2U	S26361-F2735-E82	1	40.00	1	40.00	
Mounting in symmetrical Racks	S26361-F4530-E10	1	126.00	1	126.00	
Region-Kit APAC/America/EMEA/Indien	S26361-F1452-E100	1	13.00	1	13.00	
PRIMEQUEST PQ2800E Installation, normal business hours	PQ280B-N046005-000	1	2,800.00	1		2,800.00
PQ2800E Series Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing	PQ280B-U004361-001	1	6,048.00	1		6,048.00
				Subtotal (*)	572,943.00	8,848.00
Storage						
PRIMECENTER RACK						
PRIMECENTER M1 Rack 724S 24U-1050x700	S26361-K827-V220	1	2,400.00	1	2,400.00	
Dummy panel, plastics, 1U + assembly	S26361-F4530-L131	1	12.00	4	48.00	
Dummy panel, plastics, 2U + assembly	S26361-F4530-L132	1	12	2	24.00	
Socket strip 3phase 3x 8 sockets	S26361-F2262-L31	1	240.00	2	480.00	
PY PRIMECENTER during normal business hours, PRIMERGY Installation, Racks, One Time billing	PY PCTR-N076005-0NA	1	280.00	1		280.00
PY PRIMECENTER Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing (PY PCTR-U004361-0NA)	PY PCTR-U004361-0NA	1	750.00	1		750.00
ETERNUS JX40		1				
ETERNUS JX40	FTS:ETJXS11BG		3,232.00	13	42,016.00	
JX40 SAS 6G Disk 300GB 15k 2.5"	FTS:ETJSA3HBG	1	372.00	12	4,464.00	
JX40 SSD SAS 12G 400GB MLC 2.5" (configured)	FTS:JX40-SSD400	1	3,706.00	120	444,720.00	
JX40 SSD SAS 12G 400GB MLC 2.5" (priced)	FTS:JX40-SSD400	1S	3,706.00	46	170,476.00	
SAS Cable 6Gb 1x SFF 8088-1x SFF 8088 2m	D:KBSAS6G-1S-1S-2M	1	73.00	13	949.00	
PY JX40 Warranty Uplift, 12 Months, Enhanced Plus Level, 24x7x365 Phone Support (Sev1 - Live Transfer), 24x7x365 Onsite and Parts (Sev1 Resp. Time - 4 Hours), Incl. Holidays, Prepaid billing	PY JX40-U004121-0NA	1	639.00	13		8,307.00
PY JX40 Post Warranty, 24 Months, Enhanced Plus Level, 24x7x365 Phone Support (Sev1 - Live Transfer), 24x7x365 Onsite and Parts (Sev1 Resp. Time - 4 Hours), Incl. Holidays, Prepaid billing	PY JX40-P004241-0NA	1	1,218.00	13		15,834.00
PY JX40 during normal business hours, Primergy storage installation, One Time billing	PY JX40-N043005-0NA	1	450.00	13		5,850.00
				Subtotal(*)	665,577.00	31,021.00

FUJITSU Server PRIMEQUEST 2800E

TPC-E 1.12.0
TPC Pricing 2.0.0
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April 14, 2014
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May 1, 2014

Description	Part Number		Unit Price	Qty	Extended Price	3-yr. Maint.
Database Server (Tier B) Software						
SQL Server 2014 Enterprise Edition 2 Core License	7JQ-00750	2	13,472.50	60	808,350.00	
Microsoft Windows Server 2012 R2 Standard Edition 2 Processor License	P72-06284	2	735.00	4	2,940.00	
Microsoft Problem Resolution Services	n/a	2	259.00	1		259.00
				Subtotal	811,290.00	259.00
Application Server (Tier A) Hardware						
PRIMERGY RX200 S8		1				
PY RX200 S8, 4x2.5	S26361-K1455-V101	1	1,100.00	2	2,200.00	
Modulare SV 450W platin hp	S26113-F575-E12	1	275.00	2	550.00	
Power Supply Dummy	S26113-F574-E99	1	4.00	2	8.00	
Intel Xeon E5-2667v2 8C/16T 3.30GHz 25MB	S26361-F3803-E300	1	3,490.00	4	13,960.00	
Fan upgrade kit 2nd CPU	S26361-F1386-E120	1	61.00	2	122.00	
8GB (1x8GB) 2Rx8 DDR3-1866 R ECC	S26361-F3793-E515	1	237.00	16	3,792.00	
Independent Mode Installation	S26361-F3694-E10	1	7.00	4	28.00	
DVD-RW supermulti slimline SATA	S26361-F3269-E2	1	106.00	2	212.00	
HD SATA 6G 250GB 7.2K HOT PL 2.5" BC	S26361-F3708-E250	1	280.00	4	1,120.00	
PLAN CP 2x1Gbit Cu Intel I350-T2 LP	S26361-F4610-E202	1	225.00	2	450.00	
Rack Mount Kit F1-C S7 LV	S26361-F2735-E175	1	145.00	2	290.00	
Cable powercord rack, 4m, grey	T26139-Y1968-E100	1	12.00	2	24.00	
Mounting in symmetrical Racks	S26361-F4530-E10	1	7.00	2	14.00	
Region-Kit APAC/America/EMEA/Indien	S26361-F1452-E100	1	7.00	2	14.00	
PRIMERGY RX200S8 Installation, normal business hours	PYR200-N038005-0NA	1	200.00	2		400.00
PYRX200 Series Warranty Uplift, 36 Months, Enhanced Plus Level, 24x7 4hr Onsite, Prepaid billing (PYR200-U004361-0NA)	PYR200-U004361-0NA	1	600.00	2		1,200.00
				Subtotal(*)	22,784.00	1,600.00
Application Server (Tier A) Software						
Microsoft Windows Server 2012 Standard Edition 2 Processor License	P73-05761	2	735.00	2	1,470.00	
				Subtotal	1,470.00	
Miscellaneous						
DISPLAY E20T-6 LED (incl 2spares)	S26361-K1432-V160	1	165.00	3	495.00	
Infrastructure or Connectivity						
KB410 USB Black US English 104 key (incl 2 spares)	S26381-K511-L410	1	16.00	3	48.00	
MouseM510 Black (incl 2 spares)	S26381-K457-L100	1	13.00	3	39.00	
LAN-CAT 5 Enhanced, l=3m (incl 2 spares)	T26139-Y2425-M3	1	5.00	6	30.00	
				Subtotal(*)	612.00	0.00
				Total	2,074,676.00	41,728.00
Dollar Volume Discount (see Notes)	28%	1			353,336.48	
					1,721,339.52	

Three-Year Cost of Ownership USD	$1,763,068
TPC-E Throughput	8,582.52
$ USD/tpsE	$205.43

Notes:
Price Source: 1=Fujitsu, 2=Microsoft Corporation, 1S=Component of the measured configuration that has been substituted in the priced configuration. See the FDR for details.
Discount applies to all subtotal marked with(*) .
Pricing is for these or similar quantities.Discounts for similarly sized configurations will be similar to what is quoted here, but may vary based on the specific components priced.

The benchmark results and test methodology were audited by Doug Johnson for InfoSizing Inc. (www.sizing.com)

	FUJITSU Server PRIMEQUEST 2800E	TPC-E 1.12.0 TPC Pricing 2.0.0
FUJITSU		Report Date April 14, 2014
		Availability Date May 1, 2014

Numerical Quantities Summary			
Reported Throughput:	8,582.52 tpsE	**Configured Customers:**	4,500,000
Response Times (in seconds)	**Minimum**	**Average**	**90th%tile**	**Maximum**
Broker Volume	0.00	0.02	0.03	0.16
Customer Position	0.00	0.01	0.02	4.42
Market Feed	0.00	0.01	0.02	4.40
Market Watch	0.00	0.01	0.02	0.37
Security Detail	0.00	0.00	0.01	0.36
Trade Lookup	0.00	0.05	0.09	0.42
Trade Order	0.00	0.04	0.14	0.61
Trade Result	0.00	0.02	0.04	0.47
Trade Status	0.00	0.01	0.01	0.34
Trade Update	0.01	0.06	0.09	0.56
Data Maintenance	0.00	0.01	N/A	0.06
Transaction Mix		**Transaction Count**	**Mix %**
Broker Volume		30,281,445	4.900%
Customer Position		80,338,437	13.000%
Market Feed		6,179,428	1.000%
Market Watch		111,237,696	18.000%
Security Detail		86,518,430	14.000%
Trade Lookup		49,438,616	8.000%
Trade Order		62,416,756	10.100%
Trade Result		61,794,211	9.999%
Trade Status		117,418,204	19.000%
Trade Update		12,359,532	2.000%
Data Maintenance		120	N/A
Test Duration and Timings			
Ramp-up Time (hh:mm:ss)		00:20:32	
Measurement Interval (hh:mm:ss)		02:00:00	
Business Recovery Time (hh:mm:ss)		00:38:08	
Total Number of Transactions Completed		617,982,755	

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Clause 0: Preamble

Introduction

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 modelled 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 modelled by the TPC-E benchmark, any of the transactions may be executed against the database at any time, especially in relation to each other.

Goal of the TPC-E Benchmark

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.

The benchmark defines:

- Two types of transactions to simulate Consumer-to-Business as well as Business-to-Business activities
- Several transactions for each transaction type
- Different execution profiles for each transaction type
- A specific run-time mix for all defined transactions

For example, the database will simultaneously execute transactions generated by systems that interact with customers along with transactions that are generated by systems that interact with financial markets as well as administrative systems. The benchmark system will interact with a set of driver systems that simulate the various sources of transactions without requiring the benchmark to implement the complex environment.

The Performance Metric reported by TPC-E is a "business throughput" measure of the number of completed Trade-Result transactions processed per second (see Clause 6.7.1). Multiple Transactions are used to simulate the business activity of processing a trade, and each Transaction is subject to a Response Time constraint. The Performance Metric for the benchmark is expressed in transactions-per-second-E (tpsE). To be compliant with the TPC-E standard, all references to tpsE Results must include the tpsE rate, the associated price-per-tpsE, and the Availability Date of the Priced Configuration (See Clause 6.7.3 for more detail).

Although this specification defines the implementation in terms of a relational data model, the database may be implemented using any commercially available Database Management System (DBMS), Database Server, file

system, or other data repository that provides a functionally equivalent implementation. The terms "table", "row", and "column" are used in this document only as examples of logical data structures.

TPC-E uses terminology and metrics that are similar to other benchmarks, originated by the TPC and others. Such similarity in terminology does not imply that TPC-E Results are comparable to other benchmarks. The only benchmark Results comparable to TPC-E are other TPC-E Results that conform to a comparable version of the TPC-E specification.

Restrictions and Limitations

Despite the fact that this benchmark offers a rich environment that represents many OLTP applications, this benchmark does not reflect the entire range of OLTP requirements. In addition, the extent to which a customer can achieve the Results reported by a vendor is highly dependent on how closely TPC-E approximates the customer application. The relative performance of systems derived from this benchmark does not necessarily hold for other workloads or environments. Extrapolations to any other environment are not recommended.
Benchmark Results are highly dependent upon workload, specific application requirements, and systems design and implementation. Relative system performance will vary because of these and other factors. Therefore, TPC-E should not be used as a substitute for specific customer application benchmarking when critical capacity planning and/or product evaluation decisions are contemplated.
Benchmark Sponsors are permitted various possible implementation designs, insofar as they adhere to the model described and pictorially illustrated in this specification. A Full Disclosure Report (FDR) of the implementation details, as specified in Clause 9.1, must be made available along with the reported Results.

Clause 1: Overview

Order 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 in this report correspond to those in the TPC-E specification.

Executive Summary Statement

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

The Executive summary has been included near the beginning of this FDR.

Benchmark Sponsor

A statement identifying the benchmark sponsor(s) and other participating companies must be provided (9.3.1.1).

Fujitsu is the sponsor of this TPC Benchmark™ E result.

Configuration Diagram

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

The measured and priced configurations are shown in the following figures. There is additional storage in the measured configuration for database backup only. This storage is not used during the benchmark runs and is not required for pricing.

Figure 1-1: Priced Configuration

Tier A
2x PRIMERGY RX200 S8 (each with)
2x Intel Xeon E5-2667 v2 3.30 GHz
64 GB Memory
2x 250 GB 7.2k rpm SATA Drive
2x onboard LAN 1 Gb/s
1x Dual Port LAN 1 Gb/s

Tier B
PRIMEQUEST 2800E
8x Intel Xeon E7-8890 v2 2.80 GHz
4 TB Memory
2x 300 GB 10k rpm SAS Drives
2x 400 GB SSD Drives
4x onboard LAN 1 Gb/s
14x SAS RAID Controller

Storage
1x PRIMECENTER Rack
13x ETERNUS JX40
166x 400 GB SSD Drives
12x 300 GB 15k rpm SAS Drives

Figure 1-2: Measured Configuration

Tier A
2x PRIMERGY RX200 S8 (each with)
2x Intel Xeon E5-2667 v2 3.30 GHz
64 GB Memory
2x 250 GB 7.2k rpm SATA Drive
2x onboard LAN 1 Gb/s
1x Dual Port LAN 1 Gb/s

Tier B
PRIMEQUEST 2800E
8x Intel Xeon E7-8890 v2 2.80 GHz
4 TB Memory
2x 300 GB 10k rpm SAS Drives
2x 400 GB SSD Drives
4x onboard LAN 1 Gb/s
14x SAS RAID Controller

Storage
1x PRIMECENTER Rack
13x ETERNUS JX40
120x 400 GB SSD Drives
46x 200 GB SSD Drives
12x 300 GB 15k rpm SAS Drives
Backup:
72x 146 GB 15k rpm SAS Drives
24x 450 GB 15k rpm SAS Drives
Misc:
7x 1200GB 10k rpm SAS Drives

There are twelve RAID-5 arrays containing database data. Each of these arrays held the same type and amount of database data and did the same amount of work. Ten of these arrays use 12 SSDs (400GB) each during the benchmark runs and were priced. The other two arrays use 23 SSDs (200GB) each during the benchmark runs. These older SSDs were priced one-for-one by newer SSDs. This substitution was allowed because newer SSDs are faster than the older SSDs. This could be demonstrated by datasheets and performance measurements taken while tests were running.

Table 1-1: SSD Substitution

	23-Drive Array (Old SSDs)	**12-Drive Array (New SSDs)**
Capacity	200 GB	400 GB
Type and Speed	SAS 6G	SAS 6G
Read average response times per array (ms)	0.43	0.21
Write average response times per array (ms)	0.88	0.50
Drive per Array	23	12
Priced	23 new SSDs	12 new SSDs

Hardware Configuration

A description of the steps taken to configure all the hardware must be reported in the Report (9.3.1.4).

Driver
The two driver systems are not part of the System Under Test (SUT) and priced configuration. Each system was connected with one Tier A systems, using onboard LAN with 2 x 1 Gb/s Ethernet. Overall there are 2 x 2 LAN segments for connecting Driver systems and Tier A systems.

Tier A
The two Tier A servers are Fujitsu PRIMERGY RX200 S8, each with two Intel Xeon E5-2667 v2 Eight-Core Processor and 64 GB of memory. Two SATA 250 GB 7.2k rpm disk drives are connected to the onboard controller using RAID1. One 1 Gb/s dual port Ethernet LAN card is plugged in the PCI-E slot. Each of the two ports is directly connected with one of the 1 Gb/s Ethernet onboard LAN ports of Tier B using a LAN crossover cable. There are overall four LAN segments for connecting the two Tier A servers with Tier B. The two onboard 1 Gb/s LAN ports are used for driver connection.

Tier B
The Tier B or database server is a Fujitsu PRIMEQUEST 2800E with eight Intel Xeon E7-8890 v2 15-Core Processors and 4 TB memory. The four onboard 2.5" disk bays of system board 0 are used with 2x SAS 300 GB 10k rpm 2.5" and 2x SAS 400 GB SSD 2.5" disk drives connected with RAID controller SAS 6G 1GB (D3116C). The first pair of drives is configured with RAID1 for OS and database. The second pair of drives is configured with RAID1 for database tempdb. Thirteen RAID controllers SAS 6G 8Port ex 1GB LP LSI V3 are used to connect the external disk drives to the server. The controller cache of all 14 RAID controllers is configured with Write Through. Four of the eight onboard 1 Gb/s Ethernet LAN ports are connected to the Tier A systems as described above.

Storage
10 Fujitsu ETERNUS JX40 are used for data, each with 12x 400GB SSD 2.5" RAID5. Two Fujitsu ETERNUS JX40 are used for data, each with 23x 200GB SSD 2.5" RAID5, which are substituted with 23x 400GB SSD 2.5". One Fujitsu ETERNUS JX40 is used for log with 12x 300GB 15k rpm 2.5" RAID10. The enclosures are connected to the controllers SAS 6G 8Port ex 1GB LP LSI V3. For details see table 2-2 Disk Configuration. The disk configuration can be done with the ServerView RAID Manager, which is shipped on ServerStart DVD together with the Server.

Software Configuration

A description of the steps taken to configure all the software must be reported in the Report (9.3.1.5).

The default installation of the operating system was executed on Tier A and B as well as the installation of the database SW on Tier B and the database client connectivity on Tier A. Information about changes to the software, settings and BenchCraft can be found in the SupportingFiles directory Introduction - Software.

Clause 2: Database Design, Scaling and Population

Database Creation

A description of the steps taken to create the database for the Reported Throughput must be reported in the Report (9.3.2).
The physical organization of tables and indices, within the database, must be reported in the Report. (9.3.2.1)

The database has been created for 4,500,000 customers. The SQL Server scripts and setup command files are included in the SupportingFiles\Clause2 folder. Two file groups are used for the tables and indices. The distribution is shown in table 2-1.

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)

There is no partitioning implemented in this configuration.

Replication and Duplicated Attributes

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

There is no replication implemented in this configuration.
No duplications or additional attributes were used.

Cardinality of Tables

The cardinality (e.g. the number of rows) of each table, as it existed after database load (see Clause 2.6), must be reported in the Report (9.3.2.5).

The database was configured for 4,500,000 customers. The cardinality of the tables after database load is as shown in the following table 2-1.

Table 2-1: Table Cardinality and File Groups

Table	Cardinality after database load	File Group
ACCOUNT_PERMISSION	31951708	1
ADDRESS	6750004	1
BROKER	45000	1
CASH_TRANSACTION	71539158008	2
CHARGE	15	1
COMMISSION_RATE	240	1
COMPANY	2250000	1
COMPANY_COMPETITOR	6750000	1
CUSTOMER	4500000	1
CUSTOMER_ACCOUNT	22500000	1
CUSTOMER_TAXRATE	9000000	1
DAILY_MARKET	4022662500	1
EXCHANGE	4	1
FINANCIAL	45000000	1
HOLDING	3980979421	2
HOLDING_HISTORY	104211690668	2
HOLDING_SUMMARY	223801057	2
INDUSTRY	102	1
LAST_TRADE	3082500	1
NEWS_ITEM	4500000	1
NEWS_XREF	4500000	1
SECTOR	12	1
SECURITY	3082500	1
SETTLEMENT	77760000000	2
STATUS_TYPE	5	1
TAXRATE	320	1
TRADE	77760000000	2
TRADE_HISTORY	186624107089	2
TRADE_REQUEST	0	2
TRADE_TYPE	5	1
WATCH_ITEM	450064676	1
WATCH_LIST	4500000	1
ZIP_CODE	14741	1

Distribution of Tables, Partitions and Logs

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 2-2: Disk Configuration

HBA Port Enclosure	Disk#	Drives	Partition	Size	Use
Crtl 0 Port 0 JX40	0/0	12x300GB SAS HDD, RAID10	L:\	1673 GB	DB Log
Crtl 0 Port 1 JX40	1/-	21x200GB SAS SSD, RAID0	C:\jp\addon	3901 GB	tempdb
Crtl 0 Port 0 JX40	2/-	4x 1200GB SAS HDD, RAID0	C:\help01	4469 GB	tempdb
Crtl 1 Port 0 JX40	3/1	12x400GB SAS SSD, RAID5	C:\jp\tpce011 C:\jp\tpce012	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 1 Port 1 SX40	4/2	6x450GB, 15K SAS, RAID5	C:\jp\backup01	2093 GB	DB backup
Crtl 1 Port 0 JX40	5/-	4x 1200GB SAS HDD, RAID0	C:\help02	4469 GB	tempdb
Crtl 2 Port 0 JX40	6/3	12x400GB SAS SSD, RAID5	C:\jp\tpce021 C:\jp\tpce022	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 2 Port 0 JX40	7/-	4x 1200GB SAS HDD, RAID0	C:\help03	4469 GB	tempdb
Crtl 3 Port 0 JJX40	8/4	12x400GB SAS SSD, RAID5	C:\jp\tpce031 C:\jp\tpce032	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 3 Port 1 SX40	9/5	6x450GB, 15K SAS, RAID5	C:\jp\backup02	2093 GB	DB backup
Crtl 3 Port 0 JX40	10/-	4x 1200GB SAS HDD, RAID0	C:\help04	4469 GB	tempdb
Crtl 4 Port 0 JX40	11/6	12x400GB SAS SSD, RAID5	C:\jp\tpce041 C:\jp\tpce042	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 4 Port 0 JX40	12/-	4x 1200GB SAS HDD, RAID0	C:\help05	4469 GB	tempdb
Crtl 5 Port 0 JX40	13/7	12x400GB SAS SSD, RAID5	C:\jp\tpce051 C:\jp\tpce052	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 5 Port 1 SX40	14/8	6x450GB, 15K SAS, RAID5	C:\jp\backup03	2093 GB	DB backup
Crtl 5 Port 0 JX40	15/-	4x 1200GB SAS HDD, RAID0	C:\help06	4469 GB	tempdb
Crtl 6 Port 0 JX40	16/9	12x400GB SAS SSD, RAID5	C:\jp\tpce061 C:\jp\tpce062	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 6 Port 0 JX40	17/-	4x 1200GB SAS HDD, RAID0	C:\help07	4469 GB	tempdb
Crtl 7 Port 0 JX40	18/10	12x400GB SAS SSD, RAID5	C:\jp\tpce071 C:\jp\tpce072	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 7 Port 1 SX40	19/11	6x450GB, 15K SAS, RAID5	C:\jp\backup04	2093 GB	DB backup
Crtl 7 Port 0 JX40	20/-	4x 1200GB SAS HDD, RAID0	C:\help08	4469 GB	tempdb
Crtl 8 Port 0 JX40	21/12	12x400GB SAS SSD, RAID5	C:\jp\tpce081 C:\jp\tpce082	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 8 Port 0 JX40	22/-	4x 1200GB SAS HDD, RAID0	C:\help09	4469 GB	tempdb
Crtl 9 Port 0 JX40	23/13	12x400GB SAS SSD, RAID5	C:\jp\tpce091 C:\jp\tpce092	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 9 Port 0 JX40	24/-	4x 1200GB SAS HDD, RAID0	C:\help10	4469 GB	tempdb
Crtl 9 Port 1 SX40	26/15	12x146GB, 15K SAS, RAID5	C:\jp\backup06	1498 GB	DB backup

Crtl 10 Port 0 JX40	27/-	23x200GB SAS SSD, RAID5	C:\jp\tpce101 C:\jp\tpce102	86 GB 4007 GB	Filegroup1 Filegroup2
Crtl 10 Port 0 JX40	-/16	12x400GB SAS SSD, RAID5	C:\jp\tpce101 C:\jp\tpce102	86 GB 4001 GB	Filegroup1 Filegroup2
Crtl 11 Port 0 JX40	-/17	7x1200GB SAS HDD, RAID5	Z:\	6704 GB	misc
Crtl 11 Port 0 JX40	28/18	23x200GB SAS SSD, RAID5	C:\jp\tpce111 C:\jp\tpce112	86 GB 4001 GB	Filegroup1 Filegroup2
Crtl 11 Port 1 SX40	29/19	12x146GB, 15K SAS, RAID5	C:\jp\backup07	1498 GB	DB backup
Crtl 11 Port 1 Sx40	30/20	12x146GB, 15K SAS, RAID5	C:\jp\backup08	1498 GB	DB backup
Crtl 12 Port 0 JX40	31/21	23x200GB SAS SSD, RAID5	C:\jp\tpce121 C:\jp\tpce122	86 GB 4001 GB	Filegroup1 Filegroup2
Crtl 12 Port 1 SX40	32/22	12x146GB, 15K SAS, RAID5	C:\jp\backup09	1498 GB	DB backup
Crtl 12 Port 1 SX40	33/23	12x146GB, 15K SAS, RAID5	C:\jp\backup10	1498 GB	DB backup
Crtl 13 Port 0 SB#0	34/24	2x300GB 10K SAS, RAID1	C:\	278 GB	OS, DB
Crtl 13 Port 0 SB#0	35/25	2x400GB SAS SSD, RAID1	T:\	372 GB	DB temp

Note: Disk# is the Windows disk number during setup / measurement
      Disk#17 is not used during measurement

Database Interface, Data Model and Load Methodology

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.
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).

Microsoft SQL Server 2014 Enterprise Edition is a relational database. The interface used was Microsoft SQL Server stored procedures accessed with Remote Procedure Calls embedded in C++ code using the Microsoft ODBC interface.
The methodology used to load the database is described in Clause2 of the SupportingFiles directory.

Clause 3: Transactions

Vendor-Supplied Code

A statement that vendor-supplied code is functionally equivalent to Pseudo-code in the specification (see Clause 3.2.1.6) must be reported in the Report (9.3.3.1).

The vendor supplied code is functionally equivalent to the pseudo-code.

Database Footprint Requirements

A statement that the database footprint requirements (as described in Clause 3.3) were met must be reported in the Report (9.3.3.2).

Database footprint requirements were met as described in the specification.

Clause 4: SUT, Driver and Network

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 (see Clause 4.2.2) and any optional Database Server interface networks (9.3.4.2):

Figures 1-1 and 1-2 show the configuration of the measured and priced configurations. Both are identical in case of the network configuration. Tier B system PRIMEQUEST 2800E has onboard Ethernet controllers with eight 1Gb/s ports, but only four have been used. Each Tier A system PRIMERGY RX200 S8 has an onboard Ethernet controller with two 1Gb/s ports used for driver system connection. Each Tier A system was extended with one dual-port 1Gb/s Ethernet controller card. These 2 x 2 ports were directly connected with the four onboard ports of Tier B using different LAN segments.

Clause 5: EGen

EGen Version

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

The EGen version used was 1.12.0.

EGen Code

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

All the required TPC-provided code was used in the benchmark.

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 (see Clause 5.3.7.1). If any of the changes to EGen do not have a formal waiver that must also be reported (9.3.5.3).
If the Test Sponsor extended EGenLoader (as described in Appendix A.6), the use of the extended EGenLoader and the audit of the extension code by an Auditor must be reported (9.3.5.4).

EGen was not modified for this benchmark. EGenLoader was not extended for this benchmark.

Clause 6: Performance Metrics and Response time

EGen Driver

The number of EGenDriverMEE and EGenDriverCE instances used in the benchmark must be reported in the Report (see Clause 6.2.5) (9.3.1.1).

There were total 32 EGenDriverCE drivers with 1236 EGenDriverCE instances.
There were total 32 EGenDriverMEE drivers with a dynamic number of instances

Measured Throughput

The Measured Throughput must be reported in the Report (see Clause 6.7.1.2) (9.3.6.2).

The measured throughput was 8,582.52 tpsE.

Test Run Graph

A Test Run Graph of throughput versus elapsed wall clock time must be reported in the Report for the Trade-Result Transaction (see Clause 6.7.2) (9.3.6.3).

Figure 6-1: Test Run Graph

Steady State

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).

During the run the tpsE throughput was observed to determine steady state. After the run steady state was confirmed by:
1. Looked at the Test Run Graph and verified that tpsE was steady prior to commencing the Measurement Interval.
2. Calculated 60 minute average tpsE during the Steady State moving the time window 10 minutes each time. Then confirmed that the minimum 60 minute average tpsE was not less than 98% of the Reported Throughput, and that the maximum 60 minute average tpsE was not greater than 102% of the Reported Throughput.
3. Calculated 10 minute average tpsE during the Steady State moving the window 1 minute each time. Then confirmed that the minimum 10 minute average tpsE was not less than 80% of the Reported Throughput, and that the maximum 10 minute average tpsE was not greater than 120% of the Reported Throughput.

Work Performed During Steady State

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).

The Microsoft SQL Server recovery interval parameter was set to the maximum allowable value to perform checkpoint at specific intervals. Checkpoints were automatically issued at specified intervals (449 seconds) and specified duration (440 seconds). SQL Server was started with trace flag 3502, which caused it to log the occurrence of the checkpoints. This information was used to verify that the checkpoints occurred at the appropriate times and duration during steady state.

Transaction Input Parameter Averages

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

Table 6-2: Transaction Input Parameter Averages.

Transaction	Parameter	Range Min	Range Max	Value	Check
Customer Position	By Tax ID	48.00%	52.00%	50.00%	Ok
	Get History	48.00%	52.00%	50.00%	Ok
	Overall				Ok
Market Watch	By Watch List	57.00%	63.00%	59.99%	Ok
	By Customer Account	33.00%	37.00%	35.00%	Ok
	By Industry	4.50%	5.50%	5.00%	Ok
	Overall				Ok
Security Detail	Access LOB	0.90%	1.10%	1.00%	Ok
	Overall				Ok
Trade Lookup	Frame 1	28.50%	31.50%	30.00%	Ok
	Frame 2	28.50%	31.50%	29.99%	Ok
	Frame 3	28.50%	31.50%	30.01%	Ok
	Frame 4	9.50%	10.50%	10.00%	Ok
	Overall				Ok
Trade Update	Frame 1	31.00%	35.00%	33.00%	Ok
	Frame 2	31.00%	35.00%	33.01%	Ok
	Frame 3	32.00%	36.00%	33.99%	Ok
	Overall				Ok
Trade Order	By Non-Owner	9.50%	10.50%	10.01%	Ok
	By Company Name	38.00%	42.00%	40.00%	Ok
	Buy On Margin	7.50%	8.50%	8.00%	Ok
	Rollback	0.94%	1.04%	0.99%	Ok
	LIFO	33.00%	37.00%	35.00%	Ok
	Trade Qty 100	24.00%	26.00%	25.00%	Ok
	Trade Qty 200	24.00%	26.00%	24.99%	Ok
	Trade Qty 400	24.00%	26.00%	25.00%	Ok
	Trade Qty 800	24.00%	26.00%	25.01%	Ok
	Market Buy	29.70%	30.30%	29.99%	Ok
	Market Sell	29.70%	30.30%	30.00%	Ok
	Limit Buy	19.80%	20.20%	20.00%	Ok
	Limit Sell	9.90%	10.10%	10.00%	Ok
	Stop Loss	9.90%	10.10%	10.00%	Ok
	Overall				Ok

Clause 7: Transaction and System Properties

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 TPC Benchmark™ E Standard Specification defines a set of transaction processing system properties that a system under test (SUT) must support during the execution of the benchmark. Those properties are Atomicity, Consistency, Isolation and Durability (ACID). This section quotes the specification definition of each of those properties and describes the tests done as specified and monitored by the auditor, to demonstrate compliance. See also file MSTPCE ACID Procedures.pdf in the SupportingFiles directory.

Redundancy Level and Data Accessibility

The Test Sponsor must report in the Report the Redundancy Level (see Clause 7.5.7.1) and describe the Data Accessibility test(s) used to demonstrate compliance (9.3.7.2).
*A Data Accessibility Graph for each run demonstrating a Redundancy Level must be reported in the Report (see Clause 7.5.7.2) (9.3.7.3).*

Redundancy Level 1 was used for the storage system. To prove Redundancy Level 1, the following steps were successfully performed on a database data, log disk and tempdb disk. The test for Redundancy Level 1 is the test for Permanent Irrecoverable Failure of any single Durable Medium. The different steps and the various states of the three disks are reported by ServerView RAID and written to the system event (see SupportingFiles).

1. Determine the current number of completed trades in the database by counting the rows in SETTLEMENT.
2. Start submitting Transactions and ramp up to the Durability Throughput Requirements (as defined in Clause 7.5.3) and satisfy those requirements for at least 5 minutes with a throughput above 95% of reported throughput.
3. Induce the failure described for the redundancy level being demonstrated. In this case fail a disk in the database tempdb array. Since RAID1 is used, the transactions continue. Run for at least 5 minutes with a throughput above 95% of reported throughput.
4. Induce the failure described for the redundancy level being demonstrated. In this case fail a disk in the database log array. Since RAID10 is used, the transactions continue. Run for at least 5 minutes with a throughput above 95% of reported throughput.
5. Induce the failure described for the redundancy level being demonstrated. In this case fail a disk in a database data array. Since RAID5 is used, the transactions continue. Run for at least 5 minutes.
6. Begin the necessary recovery process, by replacing the failed drive in the tempdb array and start the rebuild process.
7. Begin the necessary recovery process, by replacing the failed drive in the database log array and start the rebuild process.
8. Begin the necessary recovery process, by replacing the failed drive in the database data array and start the rebuild.
9. Continue running the Drivers for at least 20 minutes.
10. Terminate the run gracefully from the Driver.
11. Wait until rebuild process has finished.
12. Determine the current number of completed trades in the database by counting the rows in SETTLEMENT.
13. Run the evaluation of Trade-Result Transactions executed and compare it with the difference of the SETTLEMENT rows counted.

The Graph in Figure 7-1 show the measured throughput versus time and the different test stated.

Figure 7-1: Redundancy Level and Data Accessibility Graph
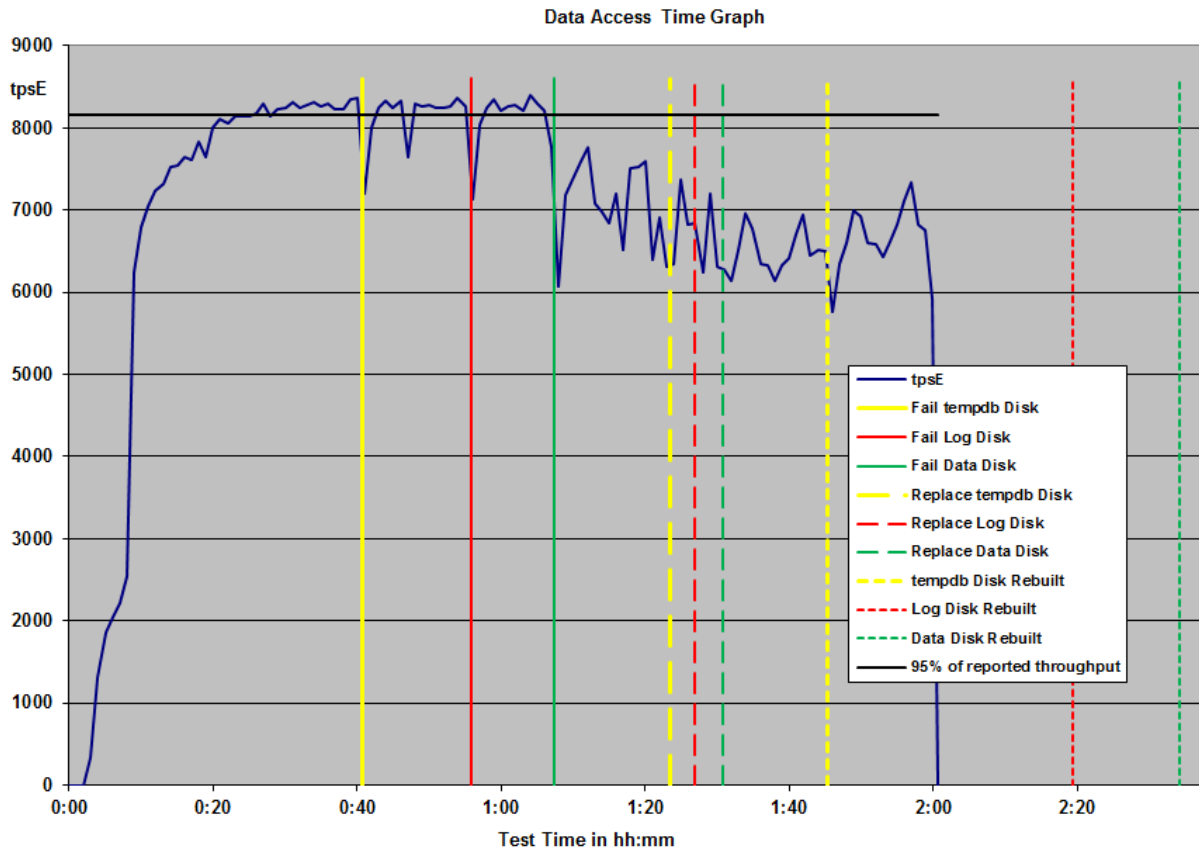
Business Recovery

The Test Sponsor must describe in the Report the test(s) used to demonstrate Business Recovery (9.3.4.7).
The Business Recovery Time must be reported on the Executive Summary Statement and in the Report. If the
failures described in Clauses 7.5.2.2, 7.5.2.3 and 7.5.2.4 were not combined into one Durability test (usually powering
off the Database Server during the run), then the Business Recovery Time for the failure described for instantaneous
interruption is the Business Recovery Time that must be reported in the Executive Summary Statement. All the
Business Recovery Times for each test requiring Business Recovery must be reported in the Report (9.3.7.6).
9.3.7.6 The Business Recovery Time Graph (see Clause 7.5.7.4) must be reported in the Report for all Business
Recovery tests (9.3.7.7).

The tests for "Instantaneous interrupt," "Failure of all or part of memory," and "Loss of external power to the SUT"
were combined by power off Tier A and B.

1. Determine the current number of completed trades in the database by counting the rows in SETTLEMENT.
2. Start submitting transactions and ramp up to the Durability Throughput Requirements (as defined in Clause 7.5.3) and satisfy those requirements for at least 20 minutes.
3. Induce the failures by power off Tier B.
4. On the driver side the number of MEE connections is captured and after transaction failures is noted by the drivers, terminate the run and collect the data for Pre-Failure Run.
5. Re-power and restart Tier B.
6. When restarting the database on Tier B, it automatically starts the recovery and records timestamps. The Database Recovery Time was 00:18:19 (hh:mm.ss).

7. After recovery has completed Trade-Cleanup has been executed. A new run started again submitting transactions and ramp up to the Durability Throughput Requirements (as defined in Clause 7.5.3) and satisfy those requirements for at least 20 minutes. The Application Recovery Time was 00:19:49 (hh:mm:ss).
8. Terminate the run gracefully from the Driver and collect the data for Post-Failure Run.
9. Verify that there are no errors in the Post-Failure run and check the consistency of the database as specified in Clause 7.3.1.1.
10. Determine the current number of completed trades in the database by counting the rows in SETTLEMENT.
11. Run the evaluation of Trade-Result Transactions executed in both runs and compare it with the difference of the SETTLEMENT rows counted. The difference must be less than or equal to the maximum number of Transactions which can be simultaneously in-flight from the Driver to the SUT.

The Business Recovery Time (per Clause 7.5.7 Step15) was 00:38:08 (hh:mm:ss).

The Graph in Figure 7-2 shows the measured throughput versus time and the Business Recovery.

Figure 7-2: Business Recovery Graph
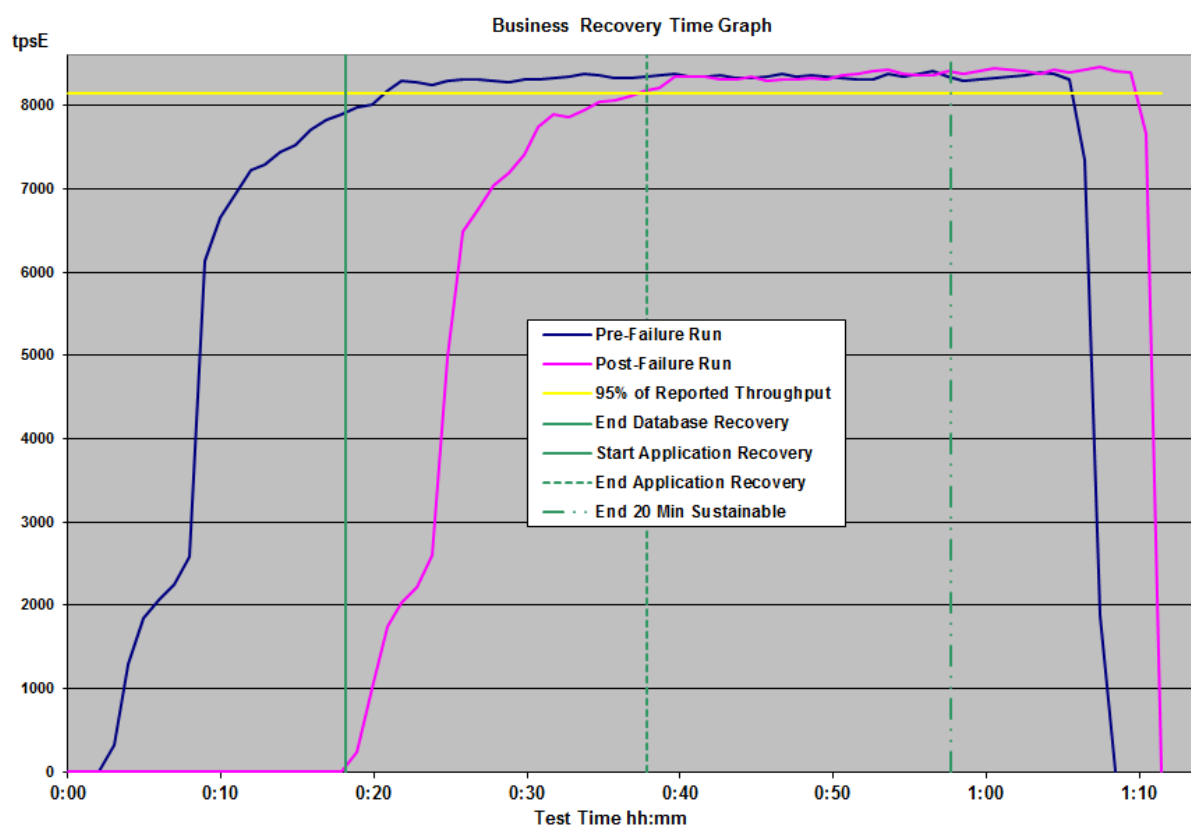
Clause 8: Pricing Related Items

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 (9.3.8.1).

Table 8-1: Space Requirements

					initinal size	grow size			
TPC-E Disk Space Requirements									
Customers Used	4,500,000								
Performance	**8582.52** TpsE		settlements after 8 hours (Busines Day)			247,176,576			
Table	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)
ACCOUNT_PERMISSION	31,951,708	1,759,520	11,512	88,552	1,859,584	1,771,072	40	106	88,552
ADDRESS	6,750,004	389,448	3,184	19,632	412,264	392,680	48	127	19,632
BROKER	45,000	4,616	9,896	726	15,238	14,512	0	0	726
CASH_TRANSACTION	71,539,158,008	7,447,480,512	15,707,200	373,159,386	7,836,347,098	7,479,604,768	16,417,056	43,132,718	43,132,718
CHARGE	15	8	8	1	17	16	0	0	1
COMMISSION_RATE	240	16	16	2	34	32	0	0	2
COMPANY	2,250,000	480,600	146,112	31,336	658,048	626,736	24	64	31,336
COMPANY_COMPETITOR	6,750,000	181,392	167,680	17,454	366,526	349,072	0	0	17,454
CUSTOMER	4,500,000	737,528	221,616	47,957	1,007,101	959,176	32	85	47,957
CUSTOMER_ACCOUNT	22,500,000	2,039,000	502,616	127,081	2,668,697	2,541,616	0	0	127,081
CUSTOMER_TAXRATE	9,000,000	187,840	3,184	9,551	200,575	191,168	144	379	9,551
DAILY_MARKET	4,022,662,500	188,818,496	553,912	9,468,620	198,841,028	189,373,776	1,368	3,595	9,468,620
EXCHANGE	4	8	8	1	17	16	0	0	1
FINANCIAL	45,000,000	5,071,192	16,520	254,386	5,342,098	5,088,024	312	820	254,386
HOLDING	3,980,979,421	266,469,160	182,175,496	22,432,233	471,076,889	454,221,136	5,576,480	14,651,150	14,651,150
HOLDING_HISTORY	104,211,690,668	3,789,516,864	2,531,570,024	316,054,344	6,637,141,232	6,339,893,528	18,806,640	49,410,899	49,410,899
HOLDING_SUMMARY	223,801,057	9,825,312	38,608	493,196	10,357,116	9,863,920	0	0	0
INDUSTRY	102	8	24	2	34	32	0	0	2
LAST_TRADE	3,082,500	192,304	2,800	9,755	204,859	195,104	0	0	9,755
NEWS_ITEM	4,500,000	487,882,216	7,880	24,394,505	512,284,601	487,890,136	40	106	24,394,505
NEWS_XREF	4,500,000	112,208	3,184	5,770	121,162	115,392	0	0	5,770
SECTOR	12	8	24	2	34	32	0	0	2
SECURITY	3,082,500	427,848	121,472	27,466	576,786	549,336	16	43	27,466
SETTLEMENT	77,760,000,000	3,707,897,792	7,818,576	185,785,818	3,901,502,186	3,724,840,488	9,124,120	23,971,904	23,971,904
STATUS_TYPE	5	8	8	1	17	16	0	0	1
TAXRATE	320	24	16	2	42	56	16	43	43
TRADE	77,760,000,000	9,284,003,784	5,173,279,280	722,864,153	15,180,147,217	14,506,189,448	48,906,384	128,492,298	128,492,298
TRADE_HISTORY	186,624,107,089	5,612,755,840	14,644,744	281,370,029	5,908,770,613	5,643,694,568	16,293,984	42,809,369	42,809,369
TRADE_REQUEST	0	0	0	0	0	1,493,176	1,493,176	3,923,039	3,923,039
TRADE_TYPE	5	8	1,032	52	1,092	1,040	0	0	52
WATCH_ITEM	450,064,676	12,653,760	48,608	635,118	13,337,486	12,702,648	280	736	635,118
WATCH_LIST	4,500,000	112,200	104,992	10,860	228,052	217,192	0	0	10,860
ZIP_CODE	14,741	488	96	29	613	584	0	0	29

Growing Tables			Initial Database Size			Settlements	94,079,667		
			37,838,047 (MB)			**Grown Database Size**			
			36,951 (GB)			37,951,934 (MB)			

	number	partition size (MB)	file size (MB)	alloc total (MB)	loaded (MB)	required (MB)		
filegroup1	12	88,003	983,040	1,056,031	686,501	720,826		space OK
filegroup2	12	4,099,932	48,967,680	49,199,186	37,151,546	37,450,756		space OK

		Number of disks	120				
		Disk Capacity (MB)	381,024				
		RAID5 Overhead	8%				
Initial Growing Space (MB)	37,151,546	Total Space-1 (MB)	41,912,640				
Final Growing Space (MB)	37,265,431	Number of disks	46	Initial Log Size (MB)	10,290	Log units	1
Delta (MB)	113,885	Disk Capacity (MB)	381,024	Final Log Size (MB)	644,863	Disks per unit	12
Data Space per Trade (MB	0.001211	RAID5 Overhead	4%	Log Growth (MB)	634,572	Disk Capacity (MB)	285,568
1 Day Data Growth (MB)	299,210	Total Space-2 (MB)	16,765,056	Log Space per Trade	0.006745	RAID10 Overhead	50.0%
60 Day Space (MB)	55,790,667	Total Space (MB)	58,677,696	1 Day Log Space (MB	1,667,219	Log Space (MB)	1,713,408

Attestation Letter

The Auditor's Attestation Letter, which indicates compliance, must be included in the Report (9.3.8.2).

InfoSizing
The Right Metric For Sizing IT

TPC Transaction Processing Performance Council
Certified Auditors

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Fujitsu Technology Solutions
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33106 Paderborn, Germany

April 11, 2014

I verified the TPC Benchmark™ E v1.12.0 performance of the following configuration:

Platform:	PRIMEQUEST 2800E
Operating System:	Microsoft Windows Server 2012 R2 Standard Edition
Database Manager:	Microsoft SQL Server 2014 Enterprise Edition

The results were:

Performance Metric	**8,582.52 tpsE**
Trade-Result 90th %-tile	0.04 Seconds

Tier B (Server)	**PRIMEQUEST 2800E**		
CPUs	8 x Intel Xeon E7-8890 v2 (2.80 GHz, 15-core, 37 MB L3)		
Memory	4 TB		
Storage	**Qty**	**Size**	**Type**
	2	300 GB	10K rpm SAS HDD
	2	400 GB	SAS SSD
	166	400 GB	SAS SSD
	12	300 GB	15K rpm SAS HDD

Tier A (Client)	**2x PRIMERGY RX200 S8 (each with)**
CPUs	2 x Intel Xeon E5-2667 v2 (3.30 GHz, 8-core, 25 MB L3)
Memory	64 GB
Storage	2 x 250 GB 7.2K rpm SATA HDD

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 transaction were correctly implemented
- The database was properly scaled and populated for 4,500,000 customers

- The mandatory network between the driver and the SUT was configured
- The ACID properties were met
- 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 120 minutes
- The implementation used Redundancy Level 1
- The Business Recovery Time of 00:38:08 was correctly measured
- The 60-day storage requirement was correctly computed
- The system pricing was verified for major components and maintenance

Additional Audit Notes:

The measured system included (46) Seagate Pulsar.2 SAS SSD disks that were substituted by (46) Toshiba PX02SMF040 SAS SSD disks in the priced configuration. Based on the specifications of these disks and on I/O data collected during testing, it is my opinion that this substitution has no significant effect on performance.

Respectfully Yours,

Doug Johnson, Auditor

François Raab, President

Clause 9: Supporting Files

Supporting Files Index table

An index for all files required by Clause 9.4 Supporting Files must be provided in the Report. The Supporting Files index is presented in a tabular format where the columns specify the following:
• The first column denotes the clause in the TPC Specification
• The second column provides a short description of the file contents
• The third column contains the path name for the file starting at the SupportingFiles directory.
If there are no Supporting Files provided then the description column must indicate that there is no supporting file and the path name column must be left blank (9.3.9.1).

Clause	Description	Path	Filename
	overview	SupportingFiles	SupportingFiles.doc
Introduction	System Configuration	SupportingFiles/Introduction/	SysInfo_TierA1.txt SysInfo_TierA2.txt SysInfo_TierB.txt
	Disk Configuration	SupportingFiles/Introduction/Hardware/	DiskConfiguration.docx flatfilelocations.txt makehelpdirff.cmd Readme.txt tempdb22.sql
	Parameter OS Tunables Database Setup	SupportingFiles/Introduction/Software/	CountOperations.reg MemoryManagement.reg MSTPCE Database Setup Reference.doc NUMA_Nodes.reg SQL_IP.reg SQL_LargePages.req SQL_Nodes.reg SQL_Server_Configuration.ver TierA1_MSSQLServer_client_connection_all.reg TierA1_W32Time.reg TierA2_MSSQLServer_client_connection_all.reg TierA2_W32Time.reg
	Startup Scripts Tier A	SupportingFiles/Introduction/Software/	start_spidera_PQ2800-16DR-affinity.cmd start_spiderb_PQ2800-16DR-affinity.cmd
	Startup Scripts Tier B	SupportingFiles/Introduction/Software/	Sqlstart2014.cmd
Clause 2	Create Database	SupportingFiles/Clause2	Backup_Database.sql Checkpoint_TPCE_Database.SQL Count_Customers.sql Create_Database.sql Create_DM_Audit_Table.sql Create_TID_Ranges_Table.sql Create_Timer_Table.sql Create_TL_TU_Warnings_Table.sql Create_TPCE_VERSIONS_Table.sql Database_Options_1.sql Database_Options_2.sql Drop_and_Create_TPCE_INFO.sql End_Load_Timer.sql Get_Next_T_ID.sql Install_Load_Timer_Proc.sql Load_TPCE_Info.sql Output_TPCE_VERSIONS_Table.SQL Remove_Database.sql Restore_Database.sql SQL_Server_Configuration.sql TPCE_Setup.cmd Trade_Cleanup.sql Version.sql
	Create Database output	SupportingFiles/Clause2/DB_setup	4500000Customers_Load_Timer.log Backup_Database.log BrokerVolume.log

| | | | Build_Steps.log
BulkInsert_1.out
…
BulkInsert_80.out
Check_Constraints_Fixed.log
Check_Constraints_Growing.log
Check_Constraints_Scaling.log
Convert_NI_ITEM_Data.log
Create_DB_Audit_Tables.log
Create_DM_Audit_Tables.log
Create_Indexes_Fixed_Tables.log
Create_Indexes_Growing_Tables.log
Create_Indexes_Scaling_Tables.log
Create_TID_Ranges_Table.log
Create_TL_TU_Warnings_Table.log
Create_TPCE_VERSIONS_Table.log
CreateDB.log
CustomerPosition.log
Database_Options_1.log
Database_Options_2.log
DataMaintenance.log
DB_Check.log
DB_FK_Constraints.log
DB_Primary_Key_Check.log
DB_Tables.log
Drop_DB_Audit_Tables.log
Drop_Fixed_Tables.log
Drop_FK_Constraints.log
Drop_Growing_Tables.log
Drop_Scaling_Tables.log
EGenLoaderFrom1To56000.log
EGenLoaderFrom56001To113000.log
….
EGenLoaderFrom 4444001To4500000.log
ERRORLOG1.txt
ERRORLOG2.txt
FK_Constraints.log
Get_Next_T_ID.log
Insert_Duplicates_Tests.log
Load_Timer.log
Load_Timer_Proc.log
Load_TPCE_Info.log
MarketFeed.log
MarketWatch.log
Referential_Integrity_Tests.log
RemoveDB.log
SecurityDetail.log
spfiles.ver
splog.ver
spused.ver
SQL_Server_Configuration.log
Tables_Fixed.log
Tables_Growing.log
Tables_Scaling.log
TPCE_VERSIONS.log
TradeLookup.log
TradeOrder.log
TradeResult.log
TradeStatus.log
TradeUpdate.log
Version.log |
| | Index Creation Scripts | SupportingFiles/Clause2/DDL | BulkInsert_<1..80>.sql
Convert_NI_ITEM_Data.SQL
Create_Check_Constraints_Fixed.sql
Create_Check_Constraints_Growing.sql
Create_Check_Constraints_Scaling.sql
Create_FK_Constraints.sql
Create_Indexes_Fixed_Tables.sql
Create_Indexes_Growing_Tables.sql
Create_Indexes_Scaling_Tables.sql
Create_Tables_Fixed.sql
Create_Tables_Growing.sql |

			Create_Tables_Scaling.sql Drop_FK_Constraints.sql Drop_Tables_Fixed.sql Drop_Tables_Growing.sql Drop_Tables_Scaling.sql
	Database Audit Scripts	SupportingFiles/Clause2/Audit_Scripts/ Database	Create_DB_Audit_Tables.SQL DB_Check.sql DB_FK_Constraints.sql DB_Primary_Key_Check.SQL DB_Tables.sql Drop_DB_Audit_Tables.SQL Insert_Duplicates_Tests.sql Referential_Integrity_Tests.sql
	Database Space Scripts	SupportingFiles/Clause2/Audit_Scripts/ Space	SPFiles.sql SPLog.sql SPUsed.sql
Clause3	Transaction Frames	SupportingFiles/Clause3	BrokerVolume.sql CustomerPosition.sql DataMaintenance.sql MarketFeed.sql MarketWatch.sql SecurityDetail.sql TradeLookup.sql TradeOrder.sql TradeResult.sql TradeStatus.sql TradeUpdate.sql
	BaseServer	SupportingFiles/Clause3/BaseServer	BaseServer.cpp BaseServer.h BaseServer.vcproj BaseServer.vcxproj stdafx.cpp stdafx.h SUTServersLocals.h
	SUT_CE_Server	SupportingFiles/Clause3/SUT_CE_Server	Release\SUT_CE_Server.exe CEServer.cpp CEServer.h CEServerMain.cpp PortDefinitions.h stdafx.cpp stdafx.h SUT_CE_Server.vcproj SUT_CE_Server.vcxproj SUTServer.sln SUTStructs.h
	SUT_MEE_Server	SupportingFiles/Clause3/SUT_MEE_Server	Release\SUT_MEE_Server.exe MEEServer.cpp MEEServer.h MEEServerMain.cpp stdafx.cpp stdafx.h SUT_MEE_Server.vcproj SUT_MEE_Server.vcxproj
	TransactionsSP	SupportingFiles/Clause3/TransactionsSP	BrokerVolumeDB_SP.cpp BrokerVolumeDB_SP.h CheckpointDB_SP.cpp CheckpointDB_SP.h CustomerPositionDB_SP.cpp CustomerPositionDB_SP.h DataMaintenanceDB_SP.cpp DataMaintenanceDB_SP.h MarketFeedDB_SP.cpp MarketFeedDB_SP.h MarketWatchDB_SP.cpp MarketWatchDB_SP.h SecurityDetailDB_SP.cpp SecurityDetailDB_SP.h stdafx.cpp stdafx.h TradeLookupDB_SP.cpp TradeLookupDB_SP.h

			TradeOrderDB_SP.cpp
			TradeOrderDB_SP.h
			TradeResultDB_SP.cpp
			TradeResultDB_SP.h
			TradeStatusDB_SP.cpp
			TradeStatusDB_SP.h
			TradeUpdateDB_SP.cpp
			TradeUpdateDB_SP.h
			TransactionsSP.vcproj
			TransactionsSP.vcxproj
			TxnHarnessDBBase.cpp
			TxnHarnessDBBase.h
			TxnHarnessDBConn.cpp
			TxnHarnessDBConn.h
	TxnHarness	SupportingFiles/Clause3/TxnHarnes	TxnHarness.vcproj
			TxnHarness.vcxproj
			TxnHarness_stdafx.cpp
			TxnHarness_stdafx.h
			TxnHarnessSendToMarket.cpp
			TxnHarnessSendToMarket.h
Clause4			
Clause5	EGen Driver Configuration	SupportingFiles/Clause5	PQ2800_4500KCus_4x36-28x39_spidera_b_RTE01.xml
	EGenLoader Parameter	SupportingFiles/Clause5	BuildSteps.log
			EGenLoaderFrom1To56000.log
			EGenLoaderFrom56001To113000.log
			….
			EGenLoaderFrom 4444001To4500000.log
	EGenLogger Output	SupportingFiles/Clause5	TxnReportE-MI.xls
Clause6	EGenValidate	SupportingFiles/Clause6	EGenValidate.txt
Clause7	ACID	SupportingFiles/Clause7	MSTPCE ACID Procedures.doc
	ACID Procedures	SupportingFiles/Clause7/AcidProcs	AcidProc.cmd
			AcidProc.out
			Remove_AcidProcs.cmd
	ACID Scripts	SupportingFiles/Clause7/AcidProcs/Scripts	AcidProc.vbs
			CustomerPosition_Iso3.sql
			CustomerPosition_Iso4.sql
			Drop_SPROC.sql
			Remove_AcidProcs.vbs
			TradeOrder_C.sql
			TradeOrder_Iso1_1.sql
			TradeOrder_Iso1_2.sql
			TradeOrder_Iso2.sql
			TradeOrder_Iso3.sql
			TradeOrder_Iso4.sql
			TradeOrder_RB.sql
			TradeResult_Iso1_1.sql
			TradeResult_Iso1_2.sql
			TradeResult_Iso2_1.sql
			TradeResult_Iso2_2.sql
			TradeResult_Iso3.sql
			TradeResult_Iso4.sql
	Atomicity	SupportingFiles/Clause7/Atomicity	Atomicity.cmd
			Atomicity_C.out
			Atomicity_RB.out
		SupportingFiles/Clause7/Atomicity/Scripts	atom.vbs
			Atomicity_C.sql
			Atomicity_RB.sql
	Consistency	SupportingFiles/Clause7/Consistency	Consistency.cmd
			Consistency.out
		SupportingFiles/Clause7/Consistency/Scripts	Consistency.sql
			Consistency.vbs
	Durability Business Recovery	SupportingFiles/Clause7/Durability/BusinessRecovery	BR_BenchCraft_Config.xml
			BR_Consistency.out
			BR_Count_Settlement1.ver
			BR_Count_Settlement2.ver

			BR_ERRORLOG1.txt
			BR_ERRORLOG2.txt
			BR_ERRORLOG3.txt
			BR_SystemEvents_TierB.txt
			BusinessRecov_Part1_step60.xlt
			BusinessRecov_Part1_TxnReportE_20.xls
			BusinessRecov_Part1_TxnReportE_all.xls
			BusinessRecov_Part2_step60.xlt
			BusinessRecov_Part2_TxnReportE_20.xls
			BusinessRecov_Part2_TxnReportE_all.xls
			BusinessRecov_TimeGraph.xls
	Durability Data Accessibility	SupportingFiles/Clause7/Durability/Data Accessibility	DA_BenchCraft_Config.xml
			DA_Count_Settlement1.ver
			DA_Count_Settlement2.ver
			DA_ERRORLOG.txt
			DataAccess_TimeGraph.xls
			DataAccess_TxnReportE_5min1.xls
			DataAccess_TxnReportE_5min2.xls
			DataAccess_TxnReportE_5min3.xls
			DataAccess_TxnReportE_20min.xls
			DataAccess_TxnReportE_all.xls
			SystemEvents_Application.txt
	Isolation	SupportingFiles/Clause7/Isolation	Isolation1_S1.rpt
			Isolation1_S2.rpt
			Isolation1_S3.rpt
			Isolation1_S4.rpt
			Isolation2_S1.rpt
			Isolation2_S2.rpt
			Isolation2_S3.rpt
			Isolation2_S4.rpt
			Isolation3_S1.rpt
			Isolation3_S2.rpt
			Isolation3_S3.rpt
			Isolation4_S1.rpt
			Isolation4_S2.rpt
			Isolation4_S3.rpt
		SupportingFiles/Clause7/Isolation/Scripts	Isolation1_S1.sql
			Isolation1_S2.sql
			Isolation1_S3.sql
			Isolation1_S4.sql
			Isolation2_S1.sql
			Isolation2_S2.sql
			Isolation2_S3.sql
			Isolation2_S4.sql
			Isolation3_S1.sql
			Isolation3_S2.sql
			Isolation3_S3.sql
			Isolation4_S1.sql
			Isolation4_S2.sql
			Isolation4_S3.sql
Clause8	60-Day Space Calculations	SupportingFiles/Clause8	tpce_space.xls

Appendix: Third Party Price Quotations

Microsoft Corporation
One Microsoft Way
Redmond, WA   98052-6399

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

Microsoft

April 2, 2014

Fujitsu
Detlev Seidel
Heinz-Nixdorf-Ring 1
Paderborn, Germany 33106

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-00750	**SQL Server 2014 Enterprise Edition** *2 Core License* *Open Program - Level C*	$13,472.50	60	$808,350.00
Database Server Operating System				
P72-06284	**Windows Server 2012 R2 Standard Edition** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 17% discount from the retail unit price of $882.*	$735.00	4	$2,940.00
Tier-A Operating System(s)				
P73-05761	**Windows Server 2012 Standard Edition** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 17% discount from the retail unit price of $882.*	$735.00	2	$1,470.00
Support				
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259.00	1	$259.00

SQL Server 2014 Enterprise Edition, Windows Server 2012 R2 Standard Edition, and Windows Server 2012 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_qhtplylGYLKTVUKf95957fiii_2014_dsrywf.