TPC Benchmark™ E
Full Disclosure Report
for
IBM® System x® 3850 X5
using
Microsoft® SQL Server 2012
Enterprise Edition
and
Microsoft Windows® Server 2012
Standard Edition

TPC-E Version 1.12.0

First Edition
Submitted for Review
March 8, 2013

First Edition – March 2013

Trademarks

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Notes

[1] GHz and MHz only measures microprocessor internal clock speed, not application performance. Many factors affect application performance.

[2] When referring to hard disk capacity, GB, or gigabyte, means one thousand million bytes. Total user-accessible capacity may be less.

Abstract

IBM Corporation conducted the TPC Benchmark™ E on the IBM® System x®3850 X5 configured as a client/server system. This report documents the full disclosure information required by the TPC Benchmark E Standard Specification, Revision 1.12.0, including the methodology used to achieve the reported results. All testing fully complied with this revision level.

The software used on the IBM System x3850 X5 system included Microsoft® Windows® Server 2012 Standard Edition and Microsoft SQL Server 2012 Enterprise Edition.

Standard metrics, transactions per second-E (tpsE), price per tpsE ($/tpsE) and Availability Date, are reported as required by the TPC Benchmark E Standard Specification.

The benchmark results are summarized in the following table:

Hardware	Software	Total System Cost	tpsE	$ USD /tpsE	Total Solution Availability Date
IBM System x3850 X5	Microsoft SQL Server 2012 Enterprise Edition Microsoft Windows Server 2012 Standard Edition	$1,362,006 USD	5457.20	$249.58 USD	March 8, 2013

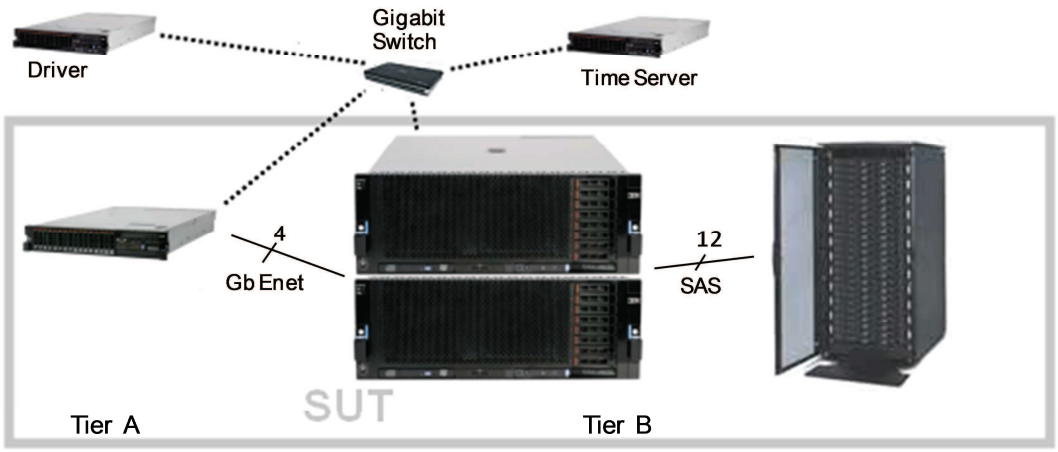
The benchmark implementation and results were audited by Doug Johnson for InfoSizing (www.sizing.com). The auditor's attestation letter is contained in this report.

	IBM® System x® 3850 X5 **Microsoft® SQL Server 2012**	**TPC-E 1.12.0** **TPC Pricing 1.7.0** Report Date: March 8, 2013 Revision Date: March 8, 2013

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
5457.20 tpsE	**$249.58** **USD per tpsE**	**March 8, 2013**	**$1,362,006 USD**

Database Server Configuration

Operating System	Database Manager	Processors/Cores/ Threads	Memory
Microsoft Windows Server 2012 Standard Edition	**Microsoft SQL Server 2012 Enterprise Edition**	**8/80/160**	**4096GB**



IBM x3650 M4, with:
- 2 x Intel Xeon Processor E5-2690 2.90GHz (2 Procs/16 Cores/32 Threads)
- 16GB Memory
- 2 x 250GB SFF SATA (RAID-1)
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- 2 x 250GB SFF SATA (RAID-1)
- 1 x IBM ServeRAID M5015
- 11 x IBM ServeRAID M5025
- Onboard Quad Gb Ethernet
- NetXtreme Dual Gb Ethernet

12 x IBM EXP2524 JBOD Enclosures, with:
- 220 x 200GB 2.5" SAS SSD (11 x 20-drive RAID-5 DB data)
- 2 x 600GB 2.5" SAS HDD (1 x 2-drive RAID-1 temp space)
- 16 x 200GB 2.5" SAS SSD (1 x 16-drive RAID-10 DB log)

238 Total External Drives

Initial Database Size	Redundancy Level: **1**	Storage
22,572 GB	**RAID-10 Log** **RAID-5 Data**	**2 x 250GB 2.5" 7.2K SATA** **236 x 200GB 2.5" SAS SSD** **2 x 600GB 2.5" 10K SAS**

IBM System x3850 X5
Microsoft SQL Server 2012

TPC-E 1.12.0

TPC Pricing 1.7.0

Report Date:
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March 8, 2013

Description	Part Number		Price Source	Unit Price	Quantity	Extended Price	3-Yr. Maint. Price
Server Hardware							
IBM System x3850 X5 Configure-To-Order, includes:	7143AC1		1	250,700	1	250,700	
x3850 X5/x3950 X5 Base + Planar	7626, A14C				2		
Intel Xeon Processor E7-8870	A14L, A14Y				8		
32GB PC3L-8500 1066MHz LP RDIMM	A1CP				128		
IBM 1975W Power Supply	2111				4		
IBM x3850 X5 MB2 Memory Expansion Card	A14D				16		
IBM x3850 X5 QPI Scalability Kit	5103				1		
IBM Hot Swap SAS Hard Disk Drive Backplane	3873				2		
IBM UltraSlim Enhanced SATA DVD-ROM	4161				1		
IBM ServeRAID-M5015 SAS/SATA Controller	0093				1		
IBM 250GB 7200 NL SATA 2.5" SFF HS HDD	A1NX				2		
NetXtreme II 1000 Express Ethernet Adapter	2995				1		
Power Cable	6311				4		
IBM ServeRAID-M5025 SAS/SATA Controller	46M0830		1	649	11	7,139	
ServeRAID M5000 Series Performance Accelerator Key	81Y4426		1	399	11	4,389	
IBM Preferred Pro Keyboard USB - US English 103P RoHS	94Y6138		1	29	1	29	
IBM 2-Button Optical Mouse - Black - USB	40K9200		1	19	1	19	
ServicePac for 3-Year 24x7x4 Support (x3850 X5)	67567CG		1	1,250	2		2500
Hanns-G 18.5" 5ms LED LCD Monitor (2 spares)	HL193ABB		3	130	3	390	
					Subtotal	262,666	2,500
Server Storage							
IBM S2 42U Standard Rack	93074RX		1	1,459	1	1,459	
IBM System Storage EXP2524 Storage Enclosure	174724X		1	3,999	12	47,988	
IBM 1M SAS cable	39R6529		1	119	12	1,428	
200GB 2.5" SAS SSD	81Y9956		1	4,099	236	967,364	
IBM 600GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD	49Y2003		1	559	2	1,118	
ServicePac for 3-Year 24x7x4 Support (EXP2524)	91Y5785		1	1,200	12		14,400
ServicePac for 3-Year 24x7x4 Support (Rack)	41L2760		1	315	1		315
					Subtotal	1,019,357	14,715
Server Software							
SQL Server 2012 Enterprise Edition	7JQ-00256		2a	13,473	40	538,900	
Windows Server 2012 Standard Edition	P73-05762		2	1,216	4	4,864	
Microsoft Problem Resolution Services	N/A		2a	259	1		259
					Subtotal	543,764	259
Client Hardware							
IBM System x3650 M4 Configure-To-Order, includes:	7915AC1		1	10,623	1	10,623	
x3650 M4 Base + Planar	A1KF, A1KH				1		
900W High Efficiency Platinum AC Power Supply	A2EB				2		
Intel Xeon Processor E5-2690 8C 2.9GHz 20MB 135W	A2VN, A2QL				2		
IBM UltraSlim Enhanced SATA DVD-ROM + cable	4161, A22N				1		
x3650 M4 PCIe Riser Card 1 (1 x8 FH/FL + 2 x8 FH/HL Slots)	A1JT				1		
IBM System x Gen-III Slides Kit + CMA	A228, A229				1		
IBM 250GB 7.2K 6Gbps NL SATA 2.5" SFF HS HDD	A1NX				2		
IBM System x Lightpath Kit	A1LF				1		
x3650 M4 8x 2.5" HS HDD Assembly Kit	A1JX				1		
4GB PC3L-10600 CL9 ECC DDR3 1333MHz LP RDIMM	8941				4		
Power Cable	6263				2		
ServeRAID M5100 Series 512MB Cache/RAID 5 Upgrade	A1J3				1		
NetXtreme II 1000 Express Ethernet Adapter	2995				1		
ServicePac for 3-Year 24x7x4 Support (x3650 M4)	67567XR		1	790	1		790
					Subtotal	10,623	790
Client Software							
Windows Server 2012 Standard Edition	P73-05761		2	1,216	1	1,216	
					Subtotal	1,216	0
Infrastructure							
Ethernet Cables (2 spares)	RCW-720		3	3	6	18	
					Subtotal	18	0
					Total	1,837,644	18,264
Dollar Volume Discount (See Note 1)		37.51%	1			491,497	
Microsoft Open Program Discount Schedule		39.56%	2			2,405	

Pricing: 1 - IBM - 1-800-656-0833, x35330; 2 - Microsoft; 3 - newegg.com

Note 1: Discount applies to all line items where Pricing=1; 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.

Three-Year Cost of Ownership USD:	$1,362,006
TPC-E Throughput:	5,457.20
$ USD/tpsE:	$249.58

Benchmark results and test methodology audited by Doug Johnson for InfoSizing, Inc. (www.sizing.com)

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 section of the TPC benchmark specifications. If you find that stated prices are not available according to these terms, please inform the TPC at pricing@tpc.org. Thank you.

IBM System x3850 X5
Microsoft SQL Server 2012

TPC-E 1.12.0
TPC Pricing 1.7.0

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Numerical Quantities Summary				
Reported Throughput: 5457.20 tpsE	**Configured Customers: 2,750,000**			
Response Time (in seconds)	**Minimum**	**Average**	**90Th Percentile**	**Maximum**
Broker-Volume	0.00	0.02	0.03	0.22
Customer-Position	0.00	0.01	0.02	0.72
Market-Feed	0.00	0.01	0.02	1.11
Market-Watch	0.00	0.01	0.02	0.36
Security-Detail	0.00	0.00	0.01	5.21
Trade-Lookup	0.00	0.07	0.12	0.53
Trade-Order	0.00	0.04	0.12	1.11
Trade-Result	0.00	0.02	0.04	1.53
Trade-Status	0.00	0.01	0.02	0.64
Trade-Update	0.01	0.08	0.12	0.83
Data-Maintenance	0.00	0.01	N/A	0.07

Transaction Mix	**Transaction Count**	**Mix %**
Broker-Volume	19,251,698	4.900%
Customer-Position	51,076,427	13.000%
Market-Feed	3,929,197	1.000%
Market-Watch	70,721,416	18.000%
Security-Detail	55,005,582	14.000%
Trade-Lookup	31,431,313	8.000%
Trade-Order	39,682,225	10.100%
Trade-Result	39,291,900	10.001%
Trade-Status	74,650,360	19.000%
Trade-Update	7,857,898	2.000%
Data-Maintenance	120	N/A

Test Duration and Timings	
Ramp-up Time (hh:mm:ss)	00:27:10
Measurement Interval (hh:mm:ss)	02:00:00
Business Recovery Time (hh:mm:ss)	00:34:56
Total Number of Transactions Completed in Measurement Interval	392,898,016

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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 modeled as follows: The database is continuously available 24 hours a day, 7 days a week, for data processing from multiple sessions and data modifications against all tables, except possibly during infrequent (e.g., once a month) maintenance sessions. Due to the worldwide nature of the application modeled by the TPC-E benchmark, any of the transactions may be executed against the database at anytime, especially in relation to each other.

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. 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.

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.

Clause 1 – Introduction

Benchmark Sponsor

A statement identifying the benchmark Sponsor(s) and other participating companies must be reported.

This benchmark was sponsored by IBM Corporation.

Configuration Diagrams

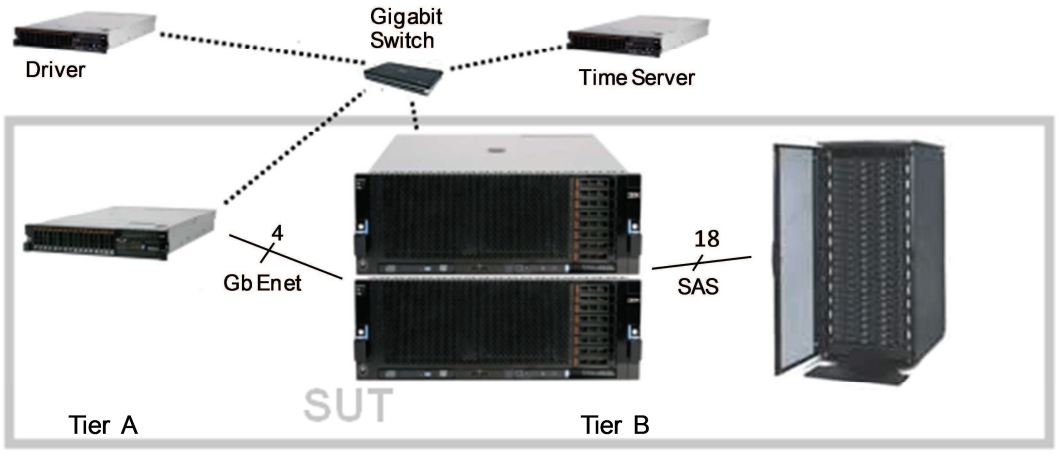
Diagrams of both the Measured and Priced Configurations must be reported, accompanied by a description of the differences.

Any information and/or measurement results used to prove the validity of a Component substitution must be included in the FDR. Original and substituted Components must be clearly identified. Proof of comparable performance for substitution without a full benchmark run must be cited in the FDR.

Measured and Priced Configurations

The measured configuration is shown in Figure 1-1. The priced configuration is shown above in the executive summary.

Figure 1-1. Measured Configuration



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- 2 x 250GB SFF SATA (RAID-1)
- 1 x IBM ServeRAID M5015
- 11 x IBM ServeRAID M5025
- Onboard Quad Gb Ethernet
- NetXtreme Dual Gb Ethernet

18 x IBM EXP2524 JBOD Enclosures, with:
- 220 x 200GB 2.5" SAS SSD (11 x 20-drive RAID-5 DB data)
- 2 x 600GB 2.5" SAS HDD (1 x 2-drive RAID-1 temp space)
- 16 x 200GB 2.5" SAS SSD (1 x 16-drive RAID-10 DB log)
- 144 x 600GB 2.5" SAS HDD (6 x 24-drive RAID-10 backup)

382 Total External Drives

Compared to the priced configuration, the measured configuration contained extra external enclosures and drives used strictly for database backup files and flat file space used during the benchmark database load process. These extra enclosures and drives were not used at all during the benchmark runs.

Hardware and Software Configuration Steps

A description of the steps taken to configure all the hardware must be reported in the Report.
A description of the steps taken to configure all the 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 Clauses 9.4.1.1 and 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 hardware and software environments.

Detailed instructions for installing and configuring the SUT hardware and software are included in the supporting files:

- Information specific to the Tier A client can be found in:
  SupportingFiles\Introduction\TierA\TierA_x3650M4_Setup.pdf
- Information specific to the Tier B database server and storage can be found in:
  SupportingFiles\Introduction\TierB\TierB_x3850X5_Setup.pdf

Clause 2- Database Design, Scaling, and Population

Database Creation and Table Definitions

A description of the steps taken to create the database for the Reported Throughput must be reported in the Report. Any and all scripts or step by step GUI instructions are reported in the Supporting Files (see Clause 9.4.2). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of database software environments and the TPC-E specification could recreate the database.

The database was created and populated using the Microsoft TPC-E benchmark kit. Instructions for doing so are included in the supporting files. See SupportingFiles\Clause2\MSTPCE Database Setup Reference.pdf.

Changes and customizations were made to some of the kit files. First, the filegroups the database was loaded onto were changed in number from three filegroups to two. Second, several scripts were modified to customize the load to the specific hardware configuration of this SUT.

The default kit files create the database on three filegroups: fixed_fg, scaling_fg, and growing_fg. That was changed so that only two filegroups were used, fixed_fg and growing_fg. All of the items that would have been loaded onto scaling_fg were loaded instead onto fixed_fg.

The modified files are included as part of SupportingFiles\Clause2:

- Utility\Create_TID_Ranges_Table.sql
- DDL\ Create_Indexes_Scaling_Tables.sql
- DDL\ Create_Tables_Scaling.sql

The files that were customized for this specific SUT hardware are included in the folder SupportingFiles\Clause2\2750000.Cust\Database:

- Tempdb_load.sql specifies temporary database files to use when loading the database
- Tempdb_run.sql specifies temporary database files to use when running the database
- Shrinktempdb.sql removes extra tempdb files
- Backupdev.sql creates devices for SQL Server to backup the database to
- Dropbackupdev.sql removes those devices
- Backup_Database.sql backs up the tpce database to the specified device names
- Restore_Database.sql restores the tpce database from the specified device names
- Create_Database.sql maps the database filegroups and log to physical storage
- Flatfile.txt tells the database loader where to store the database flatfiles during the load
- Remove_Database.sql drops the current tpce database

Database Physical Organization

The physical organization of tables and User-Defined Objects, within the database, must be reported in the Report.

The following tables and related indexes were on the growing_fg filegroup:

- CASH_TRANSACTION
- SETTLEMENT
- TRADE
- TRADE_HISTORY
- TRADE_REQUEST
- HOLDING
- HOLDING_HISTORY
- HOLDING_SUMMARY

The remaining tables and their related indexes were all on the fixed_fg filegroup.

Horizontal/Vertical 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.

Partitioning was not used for this benchmark.

Replication

Replication of tables, if used, must be reported in the Report.

Replication was not used for this benchmark.

Table Attributes

Additional and/or duplicated columns in any table must be reported in the Report along with a statement on the impact on performance (see Clause 2.3.5).

No additional attributes were used for this benchmark.

Cardinality of Tables

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

The database was built with 2,750,000 customers. The cardinality is shown in Table 2-1.

Table 2-1. Initial Cardinality of Tables

Table Name	Rows
ACCOUNT_PERMISSION	19,525,677
ADDRESS	4,125,004
BROKER	27,500
CASH_TRANSACTION	43,718,468,517
CHARGE	15
COMMISSION_RATE	240
COMPANY	1,375,000
COMPANY_COMPETITOR	4,125,000
CUSTOMER	2,750,000
CUSTOMER_ACCOUNT	13,750,000
CUSTOMER_TAXRATE	5,500,000
DAILY_MARKET	2,458,293,750
EXCHANGE	4
FINANCIAL	27,500,000
HOLDING	2,432,976,985
HOLDING_HISTORY	63,684,926,128
HOLDING_SUMMARY	136,764,742
INDUSTRY	102
LAST_TRADE	1,883,750
NEWS_ITEM	2,750,000
NEWS_XREF	2,750,000
SECTOR	12
SECURITY	1,883,750
SETTLEMENT	47,520,000,000
STATUS_TYPE	5
TAXRATE	320
TRADE	47,520,000,000
TRADE_HISTORY	114,047,833,613
TRADE_REQUEST	0
TRADE_TYPE	5
WATCH_ITEM	275,022,696
WATCH_LIST	2,750,000
ZIP_CODE	14,741

Distribution of Tables and Logs

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

There were two 250GB 2.5" SFF 7.2K SATA drives in the server accessed by the internal ServeRAID M5015 SAS/SATA controller. The OS was loaded onto a RAID-1 array located on these two drives.

The database data was stored on external SAS SSD storage. This storage was accessed by eleven IBM ServeRAID M5025 SAS/SATA controllers. Each of these controllers was connected to one external IBM System Storage® EXP2524 enclosure, each holding twenty 200GB SAS SSDs. In total, for database data, eleven enclosures and 220 external SSDs were connected to the database server. Eleven data arrays were each configured as 20-drive RAID-5. Each data array was broken into three partitions: one for fixed_fg (RAW), one for growing_fg (RAW), and one for load-time tempdb (NTFS).

Additionally, one of those eleven enclosures contained two 600GB 2.5" 10K SAS drives. These drives were configured as a RAID-1 array and formatted as NTFS. This storage space was used to hold tempdb while the benchmark was running.

The database log was stored on external SAS SSD storage. This storage was accessed by one of the eleven IBM ServeRAID M5025 SAS/SATA controllers mentioned above for database data. The database log was stored on a RAID-10 array located on sixteen 200GB 2.5" SAS SSDs. These drives were located in an external EXP2524 enclosure.

In addition to the priced configuration described above, the measured configuration included six additional external EXP2524 enclosures, each filled with twenty-four 600GB SAS HDDs. This space was used to generate and load the TPC-E benchmark database, and during database backup and restore operations. This hardware performed no function during benchmark runs. These additional six enclosures were attached directly to the previously mentioned ServeRAID M5025 SAS/SATA controllers. Six 24-drive RAID-10 arrays were created using this hardware and formatted as NTFS.

Adapter write caching was disabled for all controllers and arrays, except for the 600GB RAID-1 array.

Further details on the storage configuration are available in the supporting files. See the files in the directory SupportingFiles\Introduction\TierB.

Table 2-2 depicts the database configuration of the measured and priced systems to meet the 8-hour steady state requirement.

Table 2-2. Data Distribution for the Measured and Priced Configuration

Disk #	Controller	Drives Enclosure RAID Level (Pricing)	Partition (File System)	Size	Use
0	Internal M5015	2x250GB SATA HDD internal RAID-1	C: (NTFS)	231.38GB	OS
1	M5025 #1	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx1 (RAW) c:\mp\gw1 (RAW) c:\mp\xt1 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
2	M5025 #1	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk3 (NTFS)	6694.21GB	backup & flatfiles

Disk #	Controller	Drives Enclosure RAID Level (Pricing)	Partition (File System)	Size	Use
3	M5025 #2	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx2 (RAW) c:\mp\gw2 (RAW) c:\mp\xt2 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
4	M5025 #2	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk5 (NTFS)	6694.21GB	backup & flatfiles
5	M5025 #3	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx3 (RAW) c:\mp\gw3 (RAW) c:\mp\xt3 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
6	M5025 #3	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk2 (NTFS)	6694.21GB	backup & flatfiles
7	M5025 #3	2x600GB SAS HDD EXP2524 RAID-1	K: (NTFS)	557.74GB	tempdb
8	M5025 #4	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx4 (RAW) c:\mp\gw4 (RAW) c:\mp\xt4 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
9	M5025 #4	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk4 (NTFS)	6694.21GB	backup & flatfiles
10	M5025 #5	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx5 (RAW) c:\mp\gw5 (RAW) c:\mp\xt5 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
11	M5025 #5	16x200GB SAS SSD EXP2524 RAID-10	E: (RAW) F: (NTFS)	1220.70GB 261.83GB	tpce log MDF
12	M5025 #6	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx6 (RAW) c:\mp\gw6 (RAW) c:\mp\xt6 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
13	M5025 #6	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk1 (NTFS)	6694.21GB	backup & flatfiles
14	M5025 #7	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx7 (RAW) c:\mp\gw7 (RAW) c:\mp\xt7 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
15	M5025 #8	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx8 (RAW) c:\mp\gw8 (RAW) c:\mp\xt8 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb

Disk #	Controller	Drives Enclosure RAID Level (Pricing)	Partition (File System)	Size	Use
16	M5025 #9	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx9 (RAW) c:\mp\gw9 (RAW) c:\mp\xt9 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
17	M5025 #9	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk6 (NTFS)	6694.21GB	backup & flatfiles
18	M5025 #10	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx10 (RAW) c:\mp\gw10 (RAW) c:\mp\xt10 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb
19	M5025 #11	20x200GB SAS SSD EXP2524 RAID-5	c:\mp\fx11 (RAW) c:\mp\gw11 (RAW) c:\mp\xt11 (NTFS)	53.91GB 2563.67GB 903.62GB	fixed_fg growing_fg tempdb

Database Interface and Model Implemented

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).*

Microsoft SQL Server 2012 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.

Database Load Methodology

The methodology used to load the database must be reported in the Report.

The database was loaded using the flat files option on the EGenLoader command line. This will generate flat files first, then bulk insert the data into the tables. A further description is provided in SupportingFiles\Clause2\MSTPCE Database Setup Reference.pdf.

Clause 3 – Transaction Related Items

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.

The stored procedure code for the transactions was functionally equivalent to the pseudo-code. The stored procedures can be seen in SupportingFiles\Clause3\StoredProcedures.

The code to interface the stored procedures can be found in:

- SupportingFiles\Clause3\BaseServer
- SupportingFiles\Clause3\TransactionsSP
- SupportingFiles\Clause3\TxnHarness

Database Footprint of Transactions

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

The database footprint requirements were met.

Clause 4 – SUT, Driver, and Network

Network Configuration

The Network configurations of both the Measured and Priced Configurations must be described and reported. This includes the mandatory Network between the Driver and Tier A (see Clause 4.2.2) and any optional Database Server interface networks (see Clause 4.1.3.12).

The network configurations of the measured and priced configurations were the same. Refer to Figure 1-1 for a diagram of the network connections.

The Tier A client and Tier B database server were connected by four Gb Ethernet crossover cables. These cables were connected to two of the client's onboard Gb Ethernet ports, both ports of a dual-port Ethernet adapter in the client, two of the database server's onboard Gb Ethernet ports, and both ports of a dual-port Ethernet adapter in the database server. These crossover networks handled all of the network traffic between Tier A and Tier B while a measurement was underway.

Another network connected the driver, the database server, the client, and a time server. This network, which was connected via a gigabit Ethernet switch, used one of the onboard Ethernet ports on the client and database server. This network fulfills the mandatory network between the driver and Tier A. It also allows the driver, client, and database server to synchronize and verify their times with the time server.

Clause 5 – EGen

EGen Version

The version of EGen used in the benchmark must be reported (see Clause 5.3.1).

EGen v1.12.0 was used in the benchmark.

EGen Code and Modifications

A statement that all required TPC-provided EGen code was used in the benchmark must be reported. 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 (see Clause 5.3.7.1). If any of the changes to EGen do not have a formal waiver, that must also be reported. 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 (see Clause 5.7.4).

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

EGen was not modified for use in this benchmark.

EGenLoader was not extended for this benchmark.

EGen 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.

See the supporting files directory SupportingFiles\Clause3\prj for the files related to EGenLoader and EGenValidate.

See the supporting files directory SupportingFiles\Clause3\SUT_CE_Server for the files related to the SUT_CE_Server.

See the supporting files directory SupportingFiles\Clause3\SUT_MEE_Server for the files related to the SUT_MEE_Server.

Clause 6 – Performance Metrics and Response Time

EGen Instances

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

There were 16 EGenDriverCEs with a total of 880 EGenDriverCE instances used in the benchmark.

There were 16 EGenDriverMEEs with a dynamic number of instances used in the benchmark.

Measured Throughput

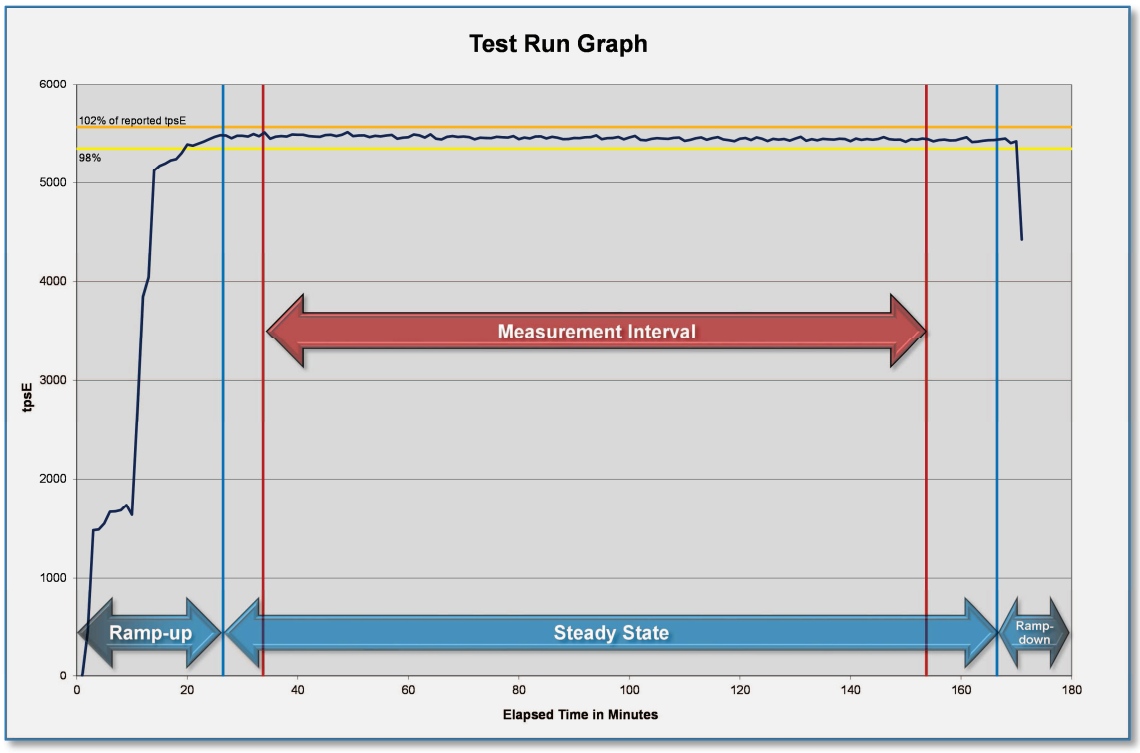
The Measured Throughput must be reported (see Clause 6.7.1.2).

The Measured Throughput was 5,457.20 tpsE.

Throughput vs. Elapsed Time for Trade-Result Transaction

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

Figure 6-1. Test Run Graph



Steady State Methodology

The method used to determine that the SUT had reached a Steady State prior to commencing the Measurement Interval must be reported.

During the run, observation of the tpsE as the benchmark ran was used to determine Steady State. After the run, Steady State was confirmed by:

1. Looking at the Test Run Graph and verifying that tpsE was steady prior to commencing the Measurement Interval.
2. Calculating the average tpsE over 60-minute windows during Steady State, with the start of each window 10 minutes apart. Then it was 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. Calculating the average tpsE over 10-minute windows during Steady State, with the start of each window 1 minute apart. Then it was confirmed that the minimum 10-minute average tpsE was not less than 80% of the Reported Throughput, and 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 (e.g., checkpointing, writing Undo/Redo Log records).

Checkpoints had a duration of 430 seconds and were scheduled to run every 447 seconds.

Data-Maintenance was run every 60 seconds.

Transaction Statistics

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

Table 6-1 contains the transaction statistics.

Table 6-1. Transaction Statistics

Input Parameter	Value	Actual Percentage	Required Range
Customer-Position			
By Tax ID	1	49.99%	48% to 52%
Get History	1	49.99%	48% to 52%
Market-Watch			
Securities chosen by	Watch List	60.00%	57% to 63%
	Account ID	35.00%	33% to 37%
	Industry	5.00%	4.5% to 5.5%
Security-Detail			
Access LOB	1	1.00%	0.9% to 1.1%
Trade-Lookup			
Frame to execute	1	30.01%	28.5% to 31.5%
	2	29.99%	28.5% to 31.5%
	3	30.00%	28.5% to 31.5%
	4	10.00%	9.5% to 10.5%
Trade-Order			
Transactions requested by a third party		9.99%	9.5% to 10.5%
By Company Name		39.99%	38% to 42%
Buy On Margin	1	7.99%	7.5% to 8.5%
Rollback	1	0.99%	0.94% to 1.04%
LIFO	1	35.00%	33% to 37%
Trade Quantity	100	25.00%	24% to 26%
	200	24.99%	24% to 26%
	400	25.01%	24% to 26%
	800	25.00%	24% to 26%
Trade Type	Market Buy	30.00%	29.7% to 30.3%
	Market Sell	30.00%	29.7% to 30.3%
	Limit Buy	20.00%	19.8% to 20.2%
	Limit Sell	10.00%	9.9% to 10.1%
	Stop Loss	10.00%	9.9% to 10.1%
Trade-Update			
Frame to execute	1	33.01%	31% to 35%
	2	32.99%	31% to 35%
	3	34.00%	32% to 36%

Clause 7 – Transaction and System Properties

The ACID (Atomicity, Consistency, Isolation, and Durability) properties of transaction processing systems must be supported by the System Under Test during the running of this benchmark. It is the intent of this section to define the ACID properties informally and to specify a series of tests that must be performed to demonstrate that these properties are met.

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.

Atomicity Requirements

The System Under Test must guarantee that Database Transactions are atomic; the system will either perform all individual operations on the data, or will ensure that no partially completed operations leave any effects on the data..

All ACID tests were conducted according to specification. The following steps were performed to verify the Atomicity of the Trade-Order transactions:

- *Perform a market Trade-Order Transaction with the roll_it_back flag set to false. Verify that the appropriate rows have been inserted in the TRADE and TRADE_HISTORY tables.*
- *Perform a market Trade-Order Transaction with the roll_it_back flag set to true. Verify that no rows associated with the rolled back Trade-Order have been added to the TRADE and TRADE_HISTORY tables.*

The procedure for running the atomicity tests is documented in the file SupportingFiles\Clause7\MSTPCE ACID Procedures.pdf.

The atomicity scripts and outputs are located in the directory SupportingFiles\Clause7\Atomicity.

Consistency Requirements

Consistency is the property of the Application that requires any execution of a Database Transaction to take the database from one consistent state to another. A TPC-E database when first populated by EGenLoader must meet these consistency conditions. The three consistency conditions must be tested after initial database population and after any Business Recovery tests.

Consistency condition 1:
Entries in the BROKER and TRADE tables must satisfy the relationship:
B_NUM_TRADES = count(*)
For each broker defined by:
(B_ID = CA_B_ID) and (CA_ID = T_CA_ID) and (T_ST_ID = ―CMPT‘).

Consistency condition 2:
Entries in the BROKER and TRADE tables must satisfy the relationship:
B_COMM_TOTAL = sum(T_COMM)
For each broker defined by:
(B_ID = CA_B_ID) and (CA_ID = T_CA_ID) and (T_ST_ID = ―CMPT‘).

Consistency condition 3:
Entries in the HOLDING_SUMMARY and HOLDING tables must satisfy the relationship:
HS_QTY = sum(H_QTY)
For each holding summary defined by:
(HS_CA_ID = H_CA_ID) and (HS_S_SYMB = H_S_SYMB).

Consistency conditions 1, 2, and 3 were tested using a batch file to issue queries to the database after the database was loaded and after the Business Recovery Test. The results of the queries demonstrated that the database was consistent for all three tests.

The procedure for running the consistency tests is documented in the file SupportingFiles\Clause7\MSTPCE ACID Procedures.pdf.

The consistency scripts and outputs are located in the directory SupportingFiles\Clause7\Consistency.

Isolation Requirements

The isolation property of a Transaction is the level to which it is isolated from the actions of other concurrently executing Transactions. Systems that implement Transaction isolation using a locking and/or versioning scheme must demonstrate compliance with the isolation requirements by executing the tests described in Clause 7.4.2.

Isolation tests 1 through 4 were successfully done following the procedure documented in the file SupportingFiles\Clause7\MSTPCE ACID Procedures.pdf.

The isolation scripts and outputs are located in the directory SupportingFiles\Clause7\Isolation.

Durability Requirements

The SUT must provide Durability. In general, state that persists across failures is said to be Durable and an implementation that ensures state persists across failures is said to provide Durability. In the context of the benchmark, Durability is more tightly defined as the SUT's ability to ensure all Committed data persist across a Single Point of Failure.

Durability Test for Data Accessibility

The Test Sponsor must report in the Report the Redundancy Level (see Clause 7.6.7.1) and describe the Data Accessibility test(s) used to demonstrate compliance.

A Data Accessibility Graph for each run demonstrating a Redundancy Level must be reported in the Report (see Clause 7.6.7.2).

This benchmark result used Redundancy Level 1. The test for Redundancy Level 1 is the test for permanent irrecoverable failure of any single Durable Medium.

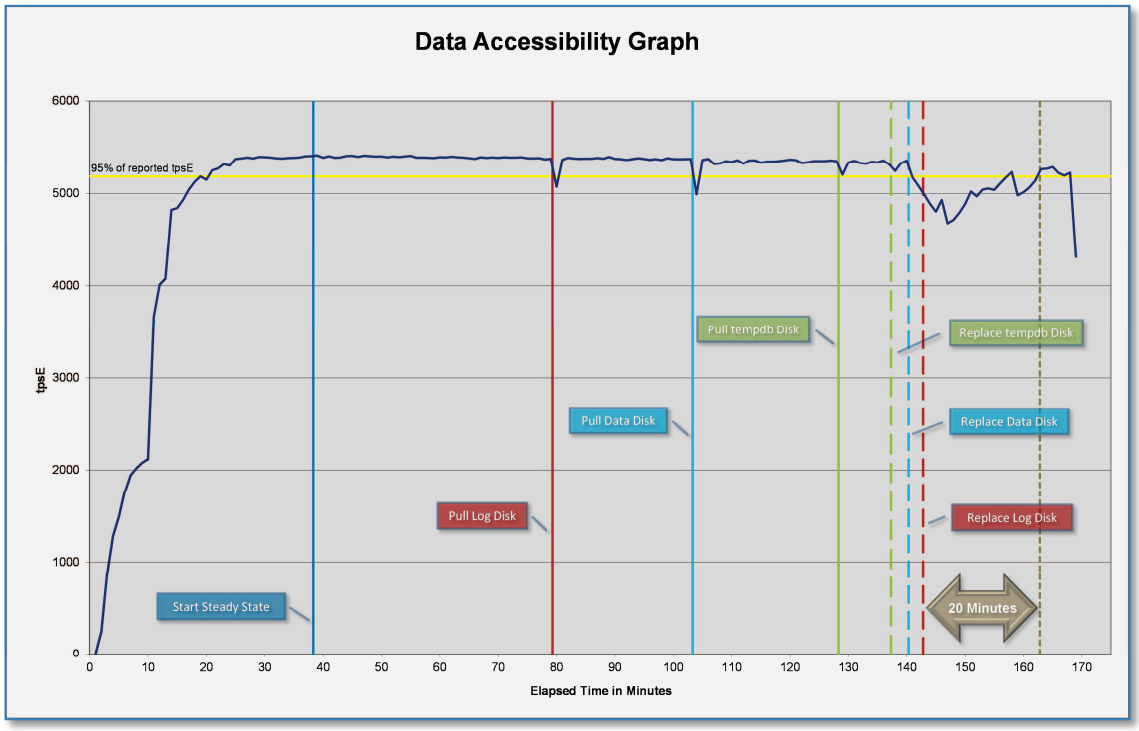
To prove Redundancy Level 1, the following steps were successfully performed:

1. Performed Trade-Cleanup to remove remnants of previous benchmark runs from the database.
2. Determined the current number of completed trades in the database, *count1*.
3. Started a run, using the profile from the measured run, with checkpoints, and met the Durability Throughput Requirements for at least 5 minutes.
4. Induced the first failure, which in this case was failing a drive in the database log array by physically removing it from its enclosure. Since the database log array is RAID protected, transaction processing continued.
5. Waited until the Durability Throughput Requirements were met again for at least 5 minutes.
6. Induced the second failure, which in this case was failing a drive in a database data array by physically removing it from its enclosure. Since the database data arrays are RAID protected, transaction processing continued.
7. Waited until the Durability Throughput Requirements were met again for at least 5 minutes.

8. Induced the third failure, which in this case was failing a drive in the database tempdb array by physically removing it from its enclosure. Since the database tempdb array is RAID protected, transaction processing continued.
9. After a few minutes passed, a new drive was inserted into the tempdb enclosure to replace the failed tempdb drive. The tempdb array rebuilding process was started.
10. After a few minutes passed, a new drive was inserted into the data enclosure to replace the failed data drive. The data array rebuilding process was started.
11. After a few minutes passed, a new drive was inserted into the log enclosure to replace the failed log drive. The log array rebuilding process was started.
12. Continued running the benchmark for at least 20 minutes.
13. Terminated the run gracefully.
14. Retrieved the new number of completed trades in the database by running *select count(*) as count2 from SETTLEMENT*.
15. Verified that (*count2 – count1*), which is the number of actual completed Trade-Result Transactions done during the run, equaled the number of successful Trade-Result transactions reported by the Driver.
16. Allowed the recovery process to complete.

Figure 7-1 is a graph of the measured throughput versus elapsed time for the data accessibility run. The timings of the induced failures as well as the recovery process are indicated.

Figure 7-1. Data Accessibility Graph



The files related to this data accessibility test are located in SupportingFiles\Clause7\Durability\DataAccessibility.

Durability Test for Business Recovery

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

The Business Recovery Time must be reported on the Executive Summary Statement and in the Report. If the failures described in Clauses 7.6.2.2, 7.6.2.3 and 7.6.2.4 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.

The Business Recovery Time Graph (see Clause 7.6.7.4) must be reported in the Report for all Business Recovery tests.

The tests for "Loss of Processing," "Loss of Vulnerable Storage Component," and "Loss of all External Power to the SUT" were combined.

The following steps were successfully performed to test Business Recovery:

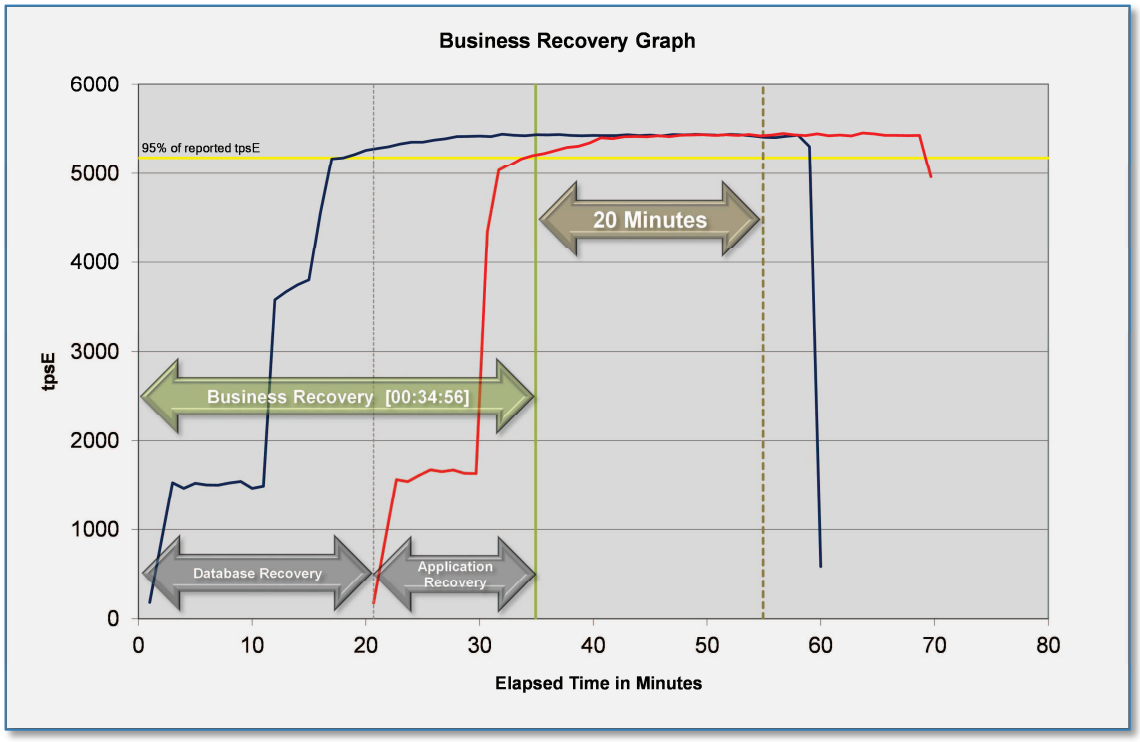
1. Performed Trade-Cleanup to remove remnants of previous benchmark runs from the database.
2. Determined the current number of completed trades in the database, *count1*.
3. Started a run, using the profile from the measured run, with checkpoints, and met the Durability Throughput Requirements for at least 20 minutes.
4. Pulled the power cords from the database server, causing it to immediately cease functioning. All the contents of the server's main memory and caches were lost. All the disk controllers were inside the server, and all of their batteries were not present, so all disk controller cache contents were lost.
5. Stopped submitting Transactions.
6. Plugged in and restarted the database server. It booted a fresh copy of the OS from the OS array.
7. Deleted the data file and log file for tempdb.
8. Started SQL Server on the database server. It automatically began recovery of the tpce database. The timestamp in the SQL Server ERRORLOG of the first message related to database tpce is considered the start of Database Recovery.
9. Waited for SQL Server to finish recovering the database. The timestamp in the SQL Server ERRORLOG of the message indicating that the recovery of database tpce is complete is considered the end of Database Recovery.
10. Since there was a time gap between the end of Database Recovery and the start of Application Recovery, and the Drivers and Transactions needed to be started again (not just continued), the Trade-Cleanup Transaction was executed during this time gap.
11. Started a run, using the profile from the measured run, with checkpoints. The time when the first transaction is submitted to the database is considered the start of Application Recovery.
12. Let the run proceed until a 20 minute window existed such that the first minute of the window and the entire window both scored at least 95% of the Reported Throughput. The time of the beginning of that 20-minute window is considered the end of Application Recovery.
13. Terminated the run gracefully.
14. Verified that no errors were reported during steps 8 through 13.
15. Retrieved the new number of completed trades in the database by running *select count(*) as count2 from SETTLEMENT.*
16. Verified that (*count2 – count1*), which is the number of actual completed Trade-Result Transactions done during the two runs, was greater than or equal to the combined number of successful Trade-Result Transactions reported by the Driver for both runs. In the case of an inequality, verified that the difference was less than or equal to the maximum number of transactions that could be simultaneously in-flight from the Driver to the SUT.

17. Verified database consistency.

Figure 7-2 is a graph of the measured throughput versus elapsed time for Business Recovery.

The Database Recovery Time was 00:20:41. The Application Recovery Time was 00:14:15. The Business Recovery Time, which is the sum of the Database Recovery Time and the Application Recovery Time, was 00:34:56.

Figure 7-2. Business Recovery Time Graph



The files related to this business recovery test are located in SupportingFiles\Clause7\Durability\BusinessRecovery.

Clause 8 – Pricing

60-Day Space

Details of the 60-Day Space computations (see Clause 6.6.6.6) along with proof that the database is configured to sustain a Business Day of growth (see Clause 6.6.6.1) must be reported in the Report.

The 60-day space calculations shown in Table 8-1 are included in SupportingFiles\Clause8\ tpce_space.xls.

Table 8-1. Disk Space Requirements

TPC-E Disk Space Requirements

Customers: 2,750,000 Performance: 5457.20 TpsE Reported: 5457.20 TpsE

Table	Initial Rows	Data Size (KB)	Index Size (KB)	Extra 5% (KB)	Total + 5% (KB)	Rows After	After Run (KB)	Growth (KB)	Bus. Day Growth (KB)	Req. Add. (KB)
BROKER	27,500	2,008	2,168	209	4,385	27,500	4,176	-	-	209
CASH_TRANSACTION	43,718,468,517	4,544,057,552	9,579,880	227,681,872	4,781,319,304	43,781,123,000	4,565,604,664	11,967,232	27,619,197	27,619,197
CHARGE	15	8	8	1	17	15	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	240	32	-	-	2
SETTLEMENT	47,520,000,000	2,265,938,504	4,783,200	113,536,085	2,384,257,789	47,588,099,674	2,277,379,776	6,658,072	15,366,177	15,366,177
TRADE	47,520,000,000	5,673,134,280	3,159,457,216	441,629,575	9,274,221,071	47,588,747,983	8,864,335,952	31,744,456	73,263,088	73,263,088
TRADE_HISTORY	114,047,833,613	3,430,010,680	8,947,344	171,947,901	3,610,905,925	114,212,175,286	3,450,857,880	11,899,856	27,463,700	27,463,700
TRADE_REQUEST	-	-	-	-	-	325,144	830,440	830,440	1,916,574	1,916,574
TRADE_TYPE	5	8	1,032	52	1,092	5	1,040	-	-	52
ACCOUNT_PERMISSION	19,525,677	1,075,440	7,952	54,170	1,137,562	19,525,677	1,083,464	72	167	54,170
CUSTOMER	2,750,000	450,856	137,512	29,418	617,786	2,750,000	588,368	-	-	29,418
CUSTOMER_ACCOUNT	13,750,000	1,246,176	308,616	77,740	1,632,532	13,750,000	1,554,792	-	-	77,740
CUSTOMER_TAXRATE	5,500,000	114,880	2,664	5,877	123,421	5,500,000	117,704	160	370	5,877
HOLDING	2,432,976,985	162,692,472	111,227,160	13,695,982	287,615,614	2,434,726,237	277,986,448	4,066,816	9,385,812	9,385,812
HOLDING_HISTORY	63,684,926,128	2,315,816,112	1,547,058,488	193,143,730	4,056,018,330	63,776,744,228	3,876,824,896	13,950,296	32,195,914	32,195,914
HOLDING_SUMMARY	136,764,742	5,997,016	24,360	301,069	6,322,445	136,765,338	6,021,376	-	-	-
WATCH_ITEM	275,022,696	7,721,376	30,592	387,598	8,139,566	275,022,696	7,752,272	304	702	387,598
WATCH_LIST	2,750,000	68,784	65,736	6,726	141,246	2,750,000	134,520	-	-	6,726
COMPANY	1,375,000	293,592	91,552	19,257	404,401	1,375,000	385,144	-	-	19,257
COMPANY_COMPETITOR	4,125,000	110,984	103,632	10,731	225,347	4,125,000	214,616	-	-	10,731
DAILY_MARKET	2,458,293,750	115,287,576	338,088	5,781,283	121,406,947	2,458,293,750	115,627,168	1,504	3,472	5,781,283
EXCHANGE	4	8	8	1	17	4	16	-	-	1
FINANCIAL	27,500,000	3,099,280	10,976	155,513	3,265,769	27,500,000	3,110,592	336	776	155,513
INDUSTRY	102	8	24	2	34	102	32	-	-	2
LAST_TRADE	1,883,750	117,680	2,656	6,017	126,353	1,883,750	120,336	-	-	6,017
NEWS_ITEM	2,750,000	298,150,432	5,696	14,907,806	313,063,934	2,750,000	298,156,224	96	222	14,907,806
NEWS_XREF	2,750,000	68,712	2,664	3,569	74,945	2,750,000	71,376	-	-	3,569
SECTOR	12	8	24	2	34	12	32	-	-	2
SECURITY	1,883,750	261,376	75,704	16,854	353,934	1,883,750	337,096	16	37	16,854
STATUS_TYPE	5	8	8	1	17	5	16	-	-	1
ADDRESS	4,125,004	238,144	2,696	12,042	252,882	4,125,004	240,944	104	241	12,042
TAXRATE	320	24	16	2	42	320	56	16	37	37
ZIP_CODE	14,741	488	88	29	605	14,741	576	-	-	29
TOTALS (KB)		**18,825,954,488**	**4,842,267,776**	**1,183,411,113**	**24,851,633,377**		**23,749,342,040**	**81,119,776**	**187,216,486**	**208,685,397**

Initial Database Size (MB) 23,113,498 22,572 GB

Database Filegroups	LUN Count	Partition Size (MB)	MB Allocated	MB Loaded	MB Required	
	0	-	-	-	-	OK
growing_fg	11	2,625,100	28,876,100	22,694,067	22,876,889	OK
	0	-	-	-	-	OK
fixed_fg	11	55,100	606,100	419,432	440,403	OK

Settlements 68,099,674

Data Space Required (MB)		Data Space Configured (MB)					Log Space Required (MB)		Log Space Configured (MB)	
Initial Growing Space	22,694,067									
Final Growing Space	22,773,283	Data LUNS	11	-	-	-	Initial Log Size	10,060	Log LUNS	1
Delta	79,216	Disks per LUN	20	-	-	-	Final Log Size	469,182	Log Disks	16
Data Space per Trade	0.001163236	Disk Capacity	189,781	-	-	-	Log Growth	459,122	Disk Capacity	189,781
1 Day Data Growth	182,823	RAID Overhead	95%	0%	0%	0%	Log Growth/Trade	0.006741905	RAID Overhead	50%
60 Day Space	34,082,861	Total Space				39,664,227	1 Day Log Space	1,069,668	Log Space	1,518,248
						OK				OK

Availability Date

The committed Availability Date of Components used in the price calculations must be reported with a precision of one day. All hardware, software and support used in the calculations must be Orderable by Any Customer on the Availability Date. For each of the Components that are not Orderable on the report date of the FDR, the following information must be included in the FDR:

- *Name and Part Number of the item that is not Orderable*
- *The date when the Component can be ordered (on or before the Availability Date)*
- *The method to be used to order the Component (at or below the quoted price) when the order date arrives*
- *The method for verifying the price*

The total solution as priced will be generally available March 8, 2013.

Supporting Files Index

An index for all files required by Clause 9.4 Supporting Files must be provided.

An index of the files contained in the supporting files is here: SupportingFiles\SupportingFilesIndex.pdf

Auditor's Attestation Letter

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

The auditor's Attestation Letter is on the next two pages.

INFO SIZING

TPC TRANSACTION PROCESSING PERFORMANCE COUNCIL CERTIFIED AUDITOR

Joe Herman, Manager
System x Server Performance
IBM Systems and Technology Group
3039 Cornwallis Road
RTP, NC 27709

March 1, 2013

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

Platform: IBM System x3850 X5
Operating System: Microsoft Windows Server 2012 Standard Edition
Database Manager: Microsoft SQL Server 2012 Enterprise Edition

The results were:

CPU's Speed	Memory	Disks	Trade-Result 90% Response Time	tpsE
Tier B, Server: IBM System x3850 X5				
8 x Intel Xeon E7-8870 (2.40GHz)	4096 GB (8 x 30 MB L3)	236 x 200GB SSD SAS 2 x 600 GB 10K SAS	0.04 Seconds	5,457.20
Tier A, One Client: IBM System x3650 M4				
2 x Intel Xeon E5-2690 (2.90 GHz)	16 GB (2 x 20 MB L3)	2 x 250 GB 7.2K SATA	n/a	n/a

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

The following verification items were given special attention:

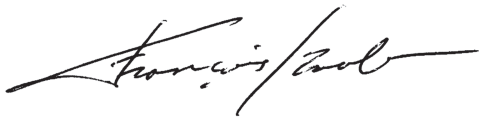
- All EGen components were verified to be v1.12.0.
- The transactions were correctly implemented.
- The database was properly scaled and populated for 2,750,000 customers.
- The mandatory network between the driver and the SUT was configured.
- The ACID properties were met.

- 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 representative of steady state conditions.
- The reported measurement interval was 120 minutes.
- The implementation used Redundancy Level 1.
- The Business Recovery Time of 00:34:56 was correctly measured.
- The 60 day storage requirement was correctly computed.
- The system pricing was verified for major components and maintenance.

Additional Audit Notes:

None.

Respectfully Yours,



Doug Johnson, Auditor

François Raab, President

Appendix A – Price Quotes

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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

Microsoft

February 20, 2013

IBM Corporation
Ray Engler
3039 Cornwallis Road
RTP, NC 27709

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	40	$538,900.00
Database Server Operating System				
P73-05762	**Windows Server 2012 Standard Edition** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 39% discount from the retail unit price of $1,216.*	$735.00	4	$2,940.00
Tier-A Operating System(s)				
P73-05761	**Windows Server 2012 Standard** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 39% discount from the retail unit price of $1,216.*	$735.00	1	$735.00
Support				
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259.00	1	$259.00

SQL Server 2012 Enterprise Edition and Windows Server 2012 Standard 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://pinpoint.microsoft.com/en-US/home.

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_qhtplylGYMMRGUKf85757fiiiLjhiJihjHmh.

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Shopping Cart

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Qty.	Product Description	Savings	Total Price
1	 Hanns-G HL193ABB Black 18.5" 5ms LED Backlight Widescreen LCD Monitor Item #: N82E16824254061 Return Policy: Monitor Standard Return Policy	-$50.00 Instant	~~$129.99~~ $79.99
1	 Rosewill RCW-720 14ft. /Network Cable Cat 6 (Crossover) Yellow Item #: N82E16812119156 Return Policy: Standard Return Policy		$2.99
		Subtotal:	$82.98
Calculate Shipping Zip Code: 27709 Choose a delivery method (•) *FREE* Newegg 3 Business Days ( ) *$35.79* Newegg 2 Business Days ( ) *$54.00* Newegg Next Business Day		Shipping:	$0.00
Redeem Newegg Gift Cards / Google Offer Code Card Number: Security Code:			
Apply Promo Code(s):		Promo Code:	$0.00
Apply Promo Codes Promo codes have usage limitations that require you to enter your email address to enable Promo Codes. E-Mail Address: Enter We value your privacy. You wont get any emails from us unless you place an order or sign up for our newsletter.			
		Grand Total:	$82.98

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