TPC Benchmark™ E
Full Disclosure Report
for
IBM® System x® 3850 X5
using
Microsoft® SQL Server 2008 R2
Enterprise Edition
and
Microsoft Windows® Server 2008 R2
Enterprise Edition

TPC-E Version 1.12.0

First Edition
Submitted for Review
June 27, 2011

IBM Corporation

First Edition – June 2011

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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 2008 R2 Enterprise Edition and Microsoft SQL Server 2008 R2 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 2008 R2 Enterprise Edition Microsoft Windows Server 2008 R2 Enterprise Edition	$371,142 USD	2862.61	$129.66 USD	June 27, 2011

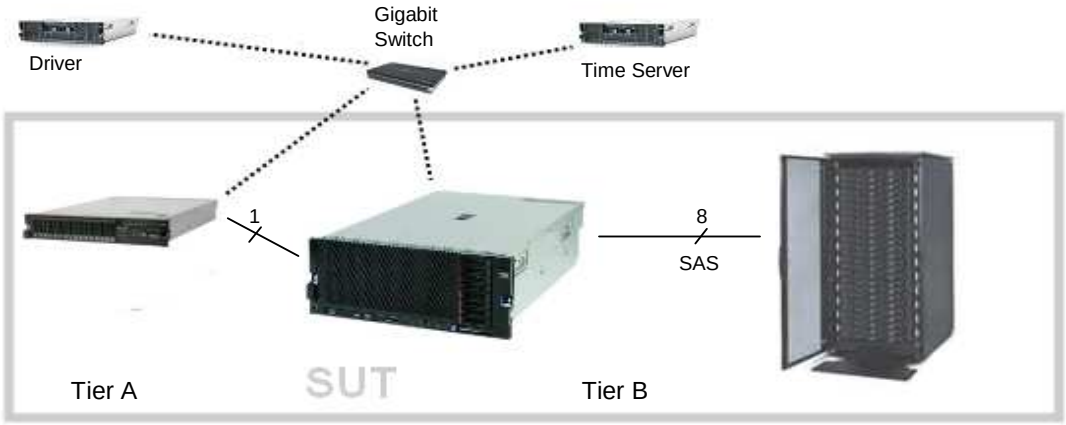
The benchmark implementation and results were audited by Doug Johnson for InfoSizing (www.sizing.com). The auditor's attestation letter is contained in this report.

	IBM® System x® 3850 X5 **Microsoft® SQL Server 2008 R2**	**TPC-E 1.12.0** **TPC Pricing 1.6.0** Report Date: June 27, 2011 Revision Date: June 27, 2011

TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
2862.61 tpsE	**$129.66** **USD per tpsE**	**June 27, 2011**	**$371,142 USD**

Database Server Configuration

Operating System	Database Manager	Processors/Cores/ Threads	Memory
Microsoft Windows Server 2008 R2 Enterprise Edition	**Microsoft SQL Server 2008 R2 Enterprise Edition**	**4/40/80**	**1024GB**



IBM x3650 M3, with:
- 2 x Intel Xeon Processor X5650 2.66GHz (2 Procs/12 Cores/24 Threads)
- 8GB Memory
- 2 x 250GB SFF SATA (RAID-1)
- 1 x IBM ServeRAID M1015
- Onboard Quad Gb Ethernet

IBM System x3850 X5, with:
- 4 x Intel Xeon Processor E7-4870 2.40GHz (4 Procs/40 Cores/80 Threads)
- 1024GB Memory
- 2 x 250GB SFF SATA (RAID-1)
- 6 x 300GB 10K SAS (RAID-10)
- 1 x IBM ServeRAID M5015
- 6 x IBM ServeRAID M5025
- Onboard Dual Gb Ethernet
- NetXtreme Dual Gb Ethernet

6 x LSI 620J JBOD Enclosures, with:
- 90 x 200GB 2.5" SAS SSD (6 x 15-drive RAID-5 DB data)
- 7 x 600GB 10K 2.5" SAS (RAID-5 60-Day space)

97 Total External Drives

Initial Database Size	Redundancy Level: **1**	Storage
11,631 GB	**RAID-10 Log** **RAID-5 Data**	**2 x 250 GB** **90 x 200 GB** **6 x 300 GB** **7 x 600 GB**

IBM System x3850 X5
Microsoft SQL Server 2008 R2

TPC-E 1.12.0

TPC Pricing 1.6.0

Report Date:
June 27, 2011

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June 27, 2011

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June 27, 2011

Description	Part Number	Price Source	Unit Price	Quantity	Extended Price	3-Yr. Maint. Price
Server Hardware						
x3850 X5 with 2 x Intel Xeon Processor E7-4870 (10C 2.40GHz / 2.5MB L2 Cache / 30MB L3 Cache) 4 x 4GB Memory, 2 memory cards	7143B7U	1	20,775	1	20,775	
Intel Xeon Processor E7-4870	69Y1893	1	5,909	2	11,818	
16GB (1x16GB) QuadRank PC3-8500 1066MHz LP RDIMM	46C7483	1	899	64	57,536	
IBM x3850 X5 MB2 Memory Expansion Card	69Y1888	1	299	6	1,794	
IBM ServeRAID-M5015 SAS/SATA Controller	46M0829	1	449	1	449	
IBM 250GB 7200 NL SATA 2.5" SFF HS HDD	81Y9722	1	289	2	578	
IBM 300GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD	42D0637	1	409	6	2,454	
IBM ServeRAID-M5025 SAS/SATA Controller	46M0830	1	649	6	3,894	
ServeRAID M5000 Series Performance Accelerator Key	81Y4426	1	399	6	2,394	
IBM Preferred Pro USB Keyboard	40K9584	1	29	1	29	
IBM 2-Button Optical Mouse - Black - USB	40K9200	1	19	1	19	
NetXtreme II 1000 Express Ethernet Adapter	39Y6066	1	139	1	139	
ServicePac for 3-Year 24x7x4 Support (x3690 X5)	84Y2233	1	1,250	1		1,250
Hanns-G 17" 5ms Widescreen LCD Monitor (2 spares)	HW-173ABB	3	120	3	360	
				Subtotal	102,239	1,250
Server Storage						
IBM S2 42U Standard Rack	93074RX	1	1,299	1	1,299	
LSI 620J JBOD Enclosure	LSI00217	5 - S	2,042	6	12,252	
LSI 620J JBOD Enclosure (10% spares)	LSI00217	5 - S	2,042	2		4,084
IBM 1M SAS cable	39R6529	1	119	12	1,428	
IBM 600GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD	49Y2003	1	799	7	5,593	
IBM 600GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD (spares)	49Y2003	1	799	2		1,598
200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC	SG9XCA2E200GE01	4	1,800	90	162,000	
200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC (spares)	SG9XCA2E200GE01	4	1,800	9		16,200
				Subtotal	182,572	21,882
Server Software						
SQL Server 2008 R2 Enterprise Edition	810-08527	2	23,848	4	95,392	
Windows Server 2008 R2 Enterprise Edition	P72-04217	2	3,999	1	3,999	
Microsoft Problem Resolution Services	N/A	2a	259	1		259
				Subtotal	99,391	259
Client Hardware						
IBM System x3650 M3 Configure-To-Order, includes:	7945AC1	1	5,362	1	5,362	
System Common Planar for 1U/2U	5663			1		
IBM System x3650 M3 Base with 675W AC power supply	5694			1		
Intel Xeon Processor X5650 6C 2.66GHz 12MB 1333MHz 95w	4589, 7709			2		
IBM System x3650 M3 8 HDD Kit	1745			1		
2GB PC3-10600 CL9 ECC DDR3 1333MHz LP RDIMM	8934			4		
PCI-Express (2 x8 slots) Riser Card	3734, 5086			2		
ServeRAID M1015 SAS/SATA Controller	0095			1		
IBM UltraSlim Enhanced SATA DVD-ROM	4161			1		
Dual port 1Gb Ethernet daughter card	3585			1		
IBM 250GB 7200 NL SATA 2.5" SFF HS HDD	81Y9722	1	289	2	578	
ServicePac for 3-Year 24x7x4 Support (x3650 M3)	21P2078	1	660	1		660
				Subtotal	5,940	660
Client Software						
Microsoft Windows Server 2008 R2 Standard Edition	P73-04980	2	1,029	1	1,029	
				Subtotal	1,029	0
Infrastructure						
Ethernet Cables (2 spares)	24501	3	4	4	16	
				Subtotal	16	0
				Total	391,187	24,051
Dollar Volume Discount (See Note 1)	19.57%	1			23,419	
Microsoft Open Program Discount Schedule	20.54%	2			20,677	

Pricing: 1 - IBM - 1-800-656-0833, x35330; 2 - Microsoft; 3 - newegg.com; 4 - ClearComm; 5 - Avnet
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.
S: One or more components of the measured configuration have been substituted in the priced configuration. See the FDR for details.

Three-Year Cost of Ownership USD:	$371,142
TPC-E Throughput:	2,862.61
$ USD/tpsE:	$129.66

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 2008 R2

TPC-E 1.12.0
TPC Pricing 1.6.0

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Numerical Quantities Summary				
Reported Throughput: 2862.61 tpsE	**Configured Customers: 1,450,000**			
Response Time (in seconds)	**Minimum**	**Average**	**90Th Percentile**	**Maximum**
Broker-Volume	0.01	0.02	0.04	0.34
Customer-Position	0.01	0.01	0.03	2.22
Market-Feed	0.01	0.01	0.04	0.86
Market-Watch	0.01	0.02	0.04	0.34
Security-Detail	0.01	0.01	0.02	0.75
Trade-Lookup	0.01	0.10	0.18	1.16
Trade-Order	0.01	0.03	0.06	2.31
Trade-Result	0.01	0.04	0.07	3.37
Trade-Status	0.01	0.01	0.02	2.27
Trade-Update	0.01	0.12	0.19	1.00
Data-Maintenance	0.01	0.02	N/A	0.10

Transaction Mix	Transaction Count	Mix %
Broker-Volume	10,098,758	4.900%
Customer-Position	26,792,317	13.000%
Market-Feed	2,061,091	1.000%
Market-Watch	37,096,795	18.000%
Security-Detail	28,853,316	14.000%
Trade-Lookup	16,487,432	8.000%
Trade-Order	20,815,601	10.100%
Trade-Result	20,610,853	10.001%
Trade-Status	39,158,079	19.000%
Trade-Update	4,121,743	2.000%
Data-Maintenance	120	N/A

Test Duration and Timings	
Ramp-up Time (hh:mm:ss)	00:28:58
Measurement Interval (hh:mm:ss)	02:00:00
Business Recovery Time (hh:mm:ss)	01:09:57
Total Number of Transactions Completed in Measurement Interval	206,095,985

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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

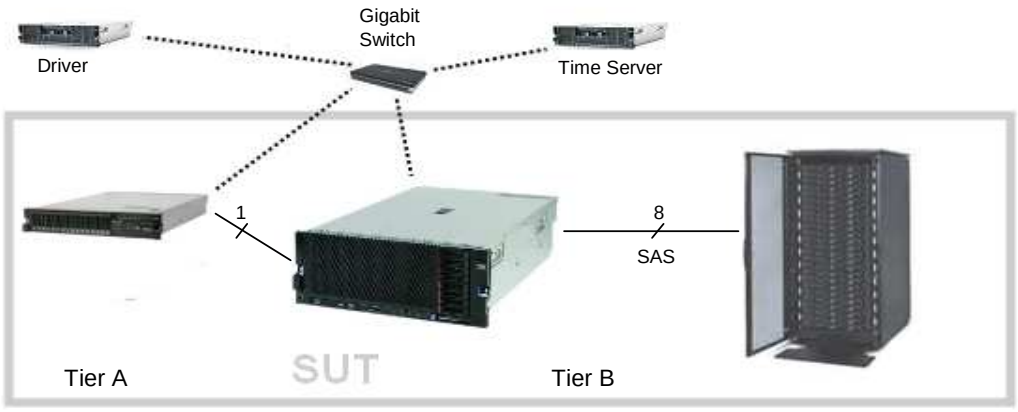
Diagrams of both the Measured and Priced Configurations must be reported, accompanied by a description of the differences.

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



IBM x3650 M3, with:
- 2 x Intel Xeon Processor X5650 2.66GHz (2 Procs/12 Cores/24 Threads)
- 8GB Memory
- 2 x 250GB SFF SATA (RAID-1)
- 1 x IBM ServeRAID M1015
- Onboard Quad Gb Ethernet

IBM System x3850 X5, with:
- 4 x Intel Xeon Processor E7-4870 2.40GHz (4 Procs/40 Cores/80 Threads)
- 1024GB Memory
- 2 x 250GB SFF SATA (RAID-1)
- 6 x 300GB 10K SAS (RAID-10)
- 1 x IBM ServeRAID M5015
- 6 x IBM ServeRAID M5025
- Onboard Dual Gb Ethernet
- NetXtreme Dual Gb Ethernet

11 x IBM EXP2524 JBOD Enclosures, with:
- 90 x 200GB 2.5" SAS SSD (5 x 15-drive RAID-5 DB data)
- 7 x 600GB 10K 2.5" SAS (RAID-5 60-Day space)
- 120 x 600GB 2.5" SAS HDD (5 x 24-drive RAID-10 backup and temp space)

217 Total External Drives

The measured and priced configurations differed in the model of the external SAS enclosures used. The measured configuration used IBM System Storage™ EXP2524 enclosures. The priced configuration

contains LSI 620J JBOD storage enclosures. Both are 6Gbps JBOD SAS enclosures that hold twenty-four 2.5" drives.

Additionally, compared to the priced configuration, the measured configuration contained extra external enclosures and drives used strictly for database backup files and temporary 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_x3650M3_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
- DDL\ Create_Tables_Scaling_Flat.sql

The files that were customized for this specific SUT hardware are included in the folder SupportingFiles\Clause2\1450000.Cust\Database:

- Tempdb.sql creates a larger temporary database for SQL Server
- Shrinktempdb.sql shrinks it back down
- 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 1,450,000 customers. The cardinality is shown in Table 2-1.

Table 2-1. Initial Cardinality of Tables

Table Name	Rows
ACCOUNT_PERMISSION	10,294,373
ADDRESS	2,175,004
BROKER	14,500
CASH_TRANSACTION	23,051,548,065
CHARGE	15
COMMISSION_RATE	240
COMPANY	725,000
COMPANY_COMPETITOR	2,175,000
CUSTOMER	1,450,000
CUSTOMER_ACCOUNT	7,250,000
CUSTOMER_TAXRATE	2,900,000
DAILY_MARKET	1,296,191,250
EXCHANGE	4
FINANCIAL	14,500,000
HOLDING	1,282,640,932
HOLDING_HISTORY	33,579,405,772
HOLDING_SUMMARY	72,109,536
INDUSTRY	102
LAST_TRADE	993,250
NEWS_ITEM	1,450,000
NEWS_XREF	1,450,000
SECTOR	12
SECURITY	993,250
SETTLEMENT	25,056,000,000
STATUS_TYPE	5
TAXRATE	320
TRADE	25,056,000,000
TRADE_HISTORY	60,134,542,362
TRADE_REQUEST	0
TRADE_TYPE	5
WATCH_ITEM	145,033,663
WATCH_LIST	1,450,000
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 log was stored on a RAID-10 array located on six 300GB 2.5" 10K SAS drives. These drives were in the server and were accessed by the internal ServeRAID M5015 SAS/SATA controller.

The database data was stored on external SAS SSD storage. This storage was accessed by six IBM ServeRAID M5025 SAS/SATA controllers. Each of these controllers was connected to one external 6Gbps SAS JBOD storage enclosure [IBM System Storage EXP2524 (measured); LSI 620J JBOD (priced)], each holding fifteen 200GB SAS SSDs. In total, for database data, six enclosures and 90 external SSDs were connected to the server. Six data arrays were each configured as 15-drive RAID-5. Each data array was broken into two partitions: one for fixed_fg (RAW) and one for growing_fg (RAW).

Additionally, one of those six enclosures contained seven 600GB 2.5" 10K SAS drives. These drives were configured as a RAID-5 array and formatted as NTFS. This storage space was added to meet the 60-Day space requirement.

In addition to the priced configuration described above, the measured configuration included five additional external 6Gbps SAS JBOD 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 five enclosures were attached, one each, to five of the six priced enclosures. Four 24-drive RAID-10 arrays and one 24-drive RAID-6 array were created using this hardware and formatted as NTFS.

Adapter write caching was disabled for all controllers and arrays.

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	Partition (File System)	Size	Use
0	Internal M5015	2x250GB SATA HDD internal RAID-1	C: (NTFS)	231.67GB	OS
1	Internal M5015	6x300GB SAS HDD internal RAID-10	E: (RAW) F: (NTFS)	639.96GB 195.31GB	LOG and MDF
2	M5025 #1	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx1 (RAW) c:\mp\gw1 (RAW)	52.25GB 2542.29GB	Fixed_fg growing_fg
3	M5025 #1	24x600GB SAS HDD EXP2524 RAID-6 (Measured)	c:\mp\bk1 (NTFS)	12272.82 GB	Backup, flatfiles, & tempDB

Disk #	Controller	Drives Enclosure RAID level	Partition (File System)	Size	Use
4	M5025 #2	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx2 (RAW) c:\mp\gw2 (RAW)	52.25GB 2542.29GB	Fixed_fg growing_fg
5	M5025 #2	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk2 (NTFS)	6694.21 GB	Backup, flatfiles, & tempDB
6	M5025 #3	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx3 (RAW) c:\mp\gw3 (RAW)	52.25GB 2542.29GB	Fixed_fg growing_fg
7	M5025 #3	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk3 (NTFS)	6694.21 GB	Backup, flatfiles, & tempDB
8	M5025 #4	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx4 (RAW) c:\mp\gw4 (RAW)	52.25GB 2542.29GB	Fixed_fg growing_fg
9	M5025 #4	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk4 (NTFS)	6694.21 GB	Backup, flatfiles, & tempDB
10	M5025 #5	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx5 (RAW) c:\mp\gw5 (RAW)	52.25GB 2542.29GB	fixed_fg growing_fg
11	M5025 #5	24x600GB SAS HDD EXP2524 RAID-10 (Measured)	c:\mp\bk5 (NTFS)	6694.21 GB	Backup, flatfiles, & tempDB
12	M5025 #5	7x600GB SAS HDD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	S: (NTFS)	3347.04GB	60-Day Space
13	M5025 #6	15x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx6 (RAW) c:\mp\gw6 (RAW)	52.25GB 2542.29GB	fixed_fg growing_fg

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 2008 R2 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 two Gb Ethernet crossover cables. These cables were connected to onboard Gb Ethernet ports in the client and a combination of onboard and add-in Gb Ethernet ports in the 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 20 EGenDriverCEs with a total of 655 EGenDriverCE instances used in the benchmark.

There were 20 EGenDriverMEEs with a dynamic number of instances used in the benchmark.

Measured Throughput

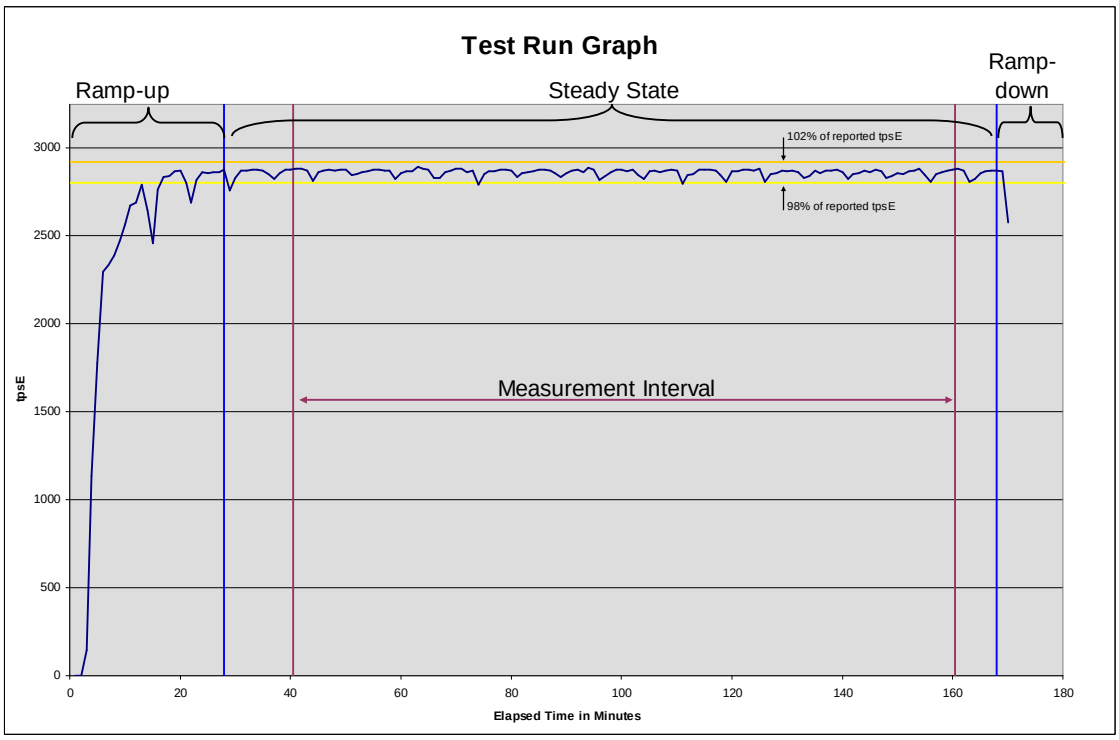
The Measured Throughput must be reported (see Clause 6.7.1.2).

The Measured Throughput was 2,862.61 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	50.00%	48% to 52%
Get History	1	50.02%	48% to 52%
Market-Watch			
Securities chosen by	Watch List	59.98%	57% to 63%
	Account ID	35.01%	33% to 37%
	Industry	5.01%	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	30.00%	28.5% to 31.5%
	3	29.99%	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		40.00%	38% to 42%
Buy On Margin	1	8.00%	7.5% to 8.5%
Rollback	1	0.99%	0.94% to 1.04%
LIFO	1	35.01%	33% to 37%
Trade Quantity	100	25.00%	24% to 26%
	200	24.99%	24% to 26%
	400	25.00%	24% to 26%
	800	25.00%	24% to 26%
Trade Type	Market Buy	30.00%	29.7% to 30.3%
	Market Sell	30.01%	29.7% to 30.3%
	Limit Buy	20.00%	19.8% to 20.2%
	Limit Sell	9.99%	9.9% to 10.1%
	Stop Loss	9.99%	9.9% to 10.1%
Trade-Update			
Frame to execute	1	33.01%	31% to 35%
	2	33.03%	31% to 35%
	3	33.96%	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.

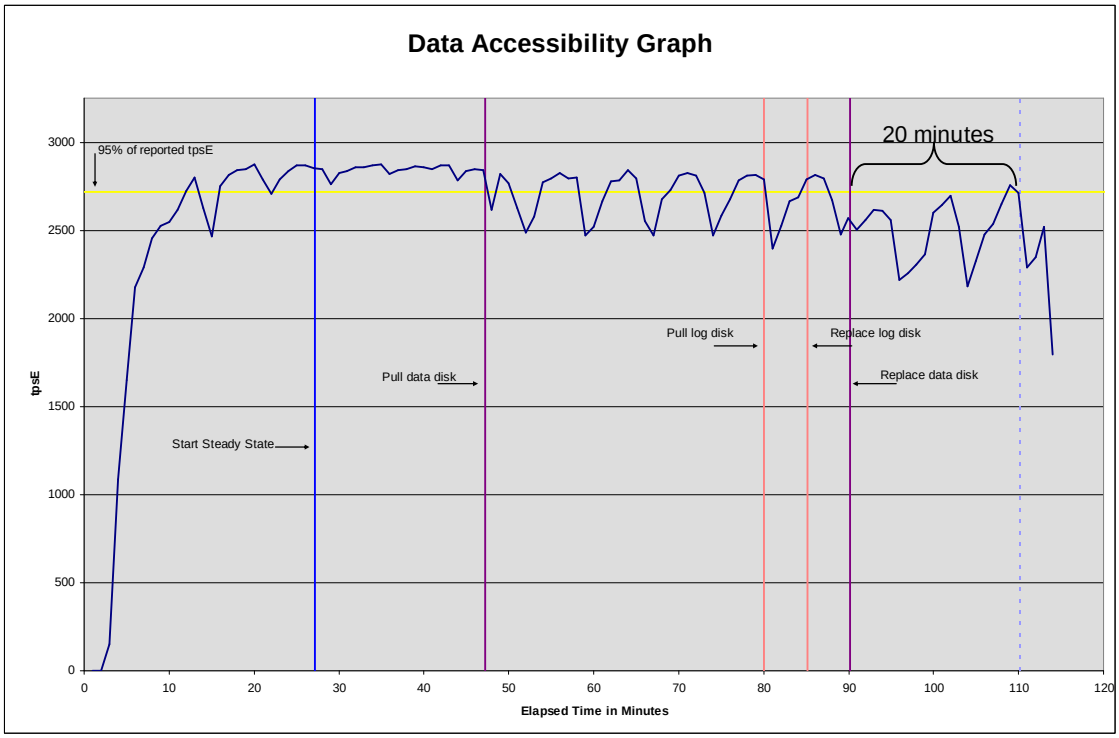
To prove Redundancy Level 1, the following steps were successfully performed:

1. Restored the database to its freshly-loaded, proven-consistent state.
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 a database data array by physically removing it from its enclosure. Since the database data arrays are 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 the database log array by physically removing it from its enclosure. Since the database log array is RAID protected, transaction processing continued.
7. 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.

8. 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.
9. Continued running the benchmark for at least 20 minutes.
10. Terminated the run gracefully.
11. Retrieved the new number of completed trades in the database by running *select count(*) as count2 from SETTLEMENT.*
12. 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.
13. 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.

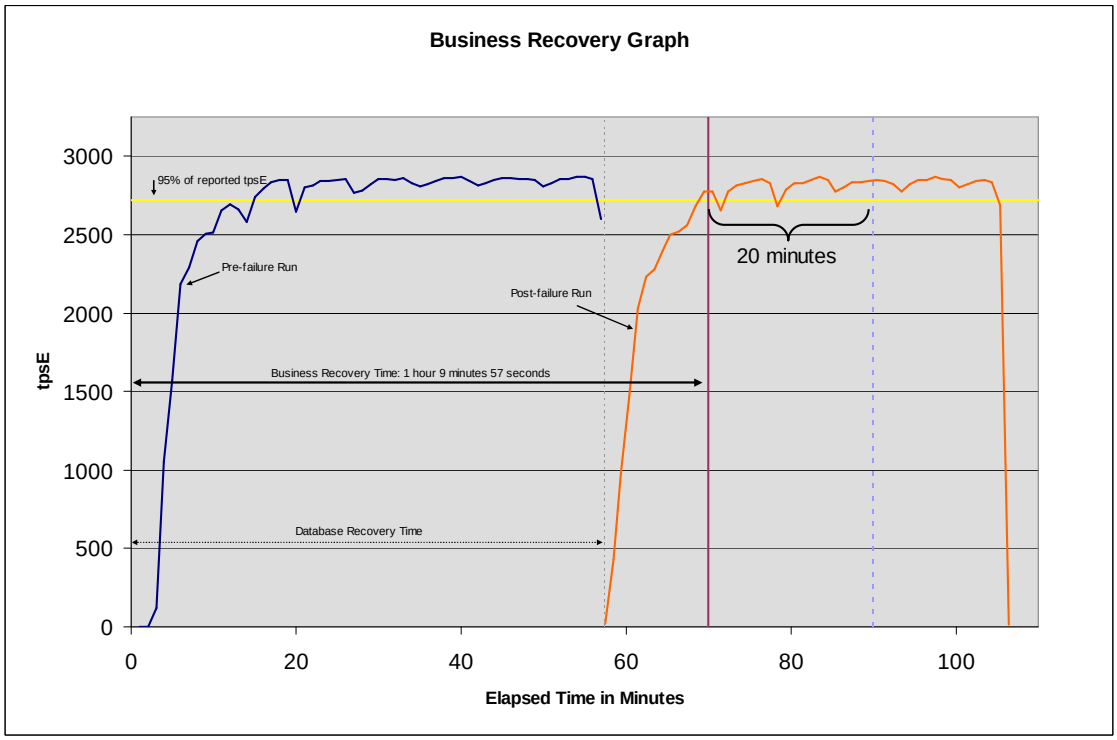
The following steps were successfully performed to test Business Recovery:

1. Restored the database to its freshly-loaded, proven-consistent state.
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.
5. Stopped submitting Transactions.
6. Plugged in and restarted the database server.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. Terminated the run gracefully.
13. Verified that no errors were reported during steps 8 through 12.
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 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.
16. Verified database consistency.

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

The Database Recovery Time was 00:57:27. The Application Recovery Time was 00:12:30. The Business Recovery Time, which is the sum of the Database Recovery Time and the Application Recovery Time, was 01:09:57.

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 1,450,000 **Performance** 2862.61 TpsE **Reported** 2862.61 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	14,500	1,064	1,080	107	2,251	14,500	2,144	-	-	107
CASH_TRANSACTION	23,051,548,065	2,387,250,144	5,032,392	119,614,127	2,511,896,663	23,077,551,634	2,397,299,912	5,017,376	14,634,325	14,634,325
CHARGE	15	8	8	1	17	15	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	240	32	-	-	2
SETTLEMENT	25,056,000,000	1,194,767,496	2,520,480	59,864,399	1,257,152,375	25,084,265,628	1,200,075,688	2,787,712	8,131,000	8,131,000
TRADE	25,056,000,000	2,990,571,872	1,506,127,840	224,834,986	4,721,534,698	25,084,437,341	4,511,737,096	15,037,384	43,859,970	43,859,970
TRADE_HISTORY	60,134,542,362	1,808,558,000	4,717,408	90,663,770	1,903,939,178	60,202,445,190	1,818,270,976	4,995,568	14,570,717	14,570,717
TRADE_REQUEST	-	-	-	-	-	171,706	433,560	433,560	1,264,577	1,264,577
TRADE_TYPE	5	8	1,032	52	1,092	5	1,040	-	-	52
ACCOUNT_PERMISSION	10,294,373	566,960	4,128	28,554	599,642	10,294,373	571,160	72	211	28,554
CUSTOMER	1,450,000	237,752	63,616	15,068	316,436	1,450,000	301,376	8	24	15,068
CUSTOMER_ACCOUNT	7,250,000	657,064	140,944	39,900	837,908	7,250,000	798,008	-	-	39,900
CUSTOMER_TAXRATE	2,900,000	60,592	1,344	3,097	65,033	2,900,000	62,056	120	351	3,097
HOLDING	1,282,640,932	85,612,736	54,274,616	6,994,368	146,881,720	1,283,338,518	141,582,080	1,694,728	4,943,062	4,943,062
HOLDING_HISTORY	33,579,405,772	1,221,069,648	705,775,392	96,342,252	2,023,187,292	33,617,529,015	1,932,273,464	5,428,424	15,833,240	15,833,240
HOLDING_SUMMARY	72,109,536	3,153,024	12,704	158,286	3,324,014	72,109,009	3,165,728	-	-	-
WATCH_ITEM	145,033,663	4,058,216	15,920	203,707	4,277,843	145,033,663	4,074,376	240	701	203,707
WATCH_LIST	1,450,000	36,224	30,240	3,323	69,787	1,450,000	66,464	-	-	3,323
COMPANY	725,000	154,472	44,240	9,936	208,648	725,000	198,712	-	-	9,936
COMPANY_COMPETITOR	2,175,000	58,544	48,128	5,334	112,006	2,175,000	106,672	-	-	5,334
DAILY_MARKET	1,296,191,250	60,664,344	177,088	3,042,072	63,883,504	1,296,191,250	60,842,512	1,080	3,151	3,042,072
EXCHANGE	4	8	8	1	17	4	16	-	-	1
FINANCIAL	14,500,000	1,634,072	5,720	81,990	1,721,782	14,500,000	1,640,080	288	841	81,990
INDUSTRY	102	8	24	2	34	102	32	-	-	2
LAST_TRADE	993,250	61,976	1,344	3,166	66,486	993,250	63,320	-	-	3,166
NEWS_ITEM	1,450,000	157,206,600	2,944	7,860,477	165,070,021	1,450,000	157,209,544	-	-	7,860,477
NEWS_XREF	1,450,000	36,224	1,344	1,878	39,446	1,450,000	37,568	-	-	1,878
SECTOR	12	8	24	2	34	12	32	-	-	2
SECURITY	993,250	137,312	36,704	8,701	182,717	993,250	174,032	16	47	8,701
STATUS_TYPE	5	8	8	1	17	5	16	-	-	1
ADDRESS	2,175,004	125,560	1,344	6,345	133,249	2,175,004	126,920	16	47	6,345
TAXRATE	320	24	16	2	42	320	56	16	47	47
ZIP_CODE	14,741	488	56	27	571	14,741	544	-	-	27
TOTALS (KB)		**9,916,680,472**	**2,279,038,152**	**609,785,931**	**12,805,504,555**		**12,231,115,232**	**35,396,608**	**103,242,311**	**114,550,680**

Initial Database Size (MB) **11,909,881** **11,631 GB**

Database Filegroups	LUN Count	Partition Size (MB)	MB Allocated	MB Loaded	MB Required	
	0	-	-	-	-	OK
growing_fg	6	2,603,305	15,619,830	11,688,910	11,789,727	OK
	0	-	-	-	-	OK
fixed_fg	6	53,504	321,024	220,972	232,020	OK

Settlements **28,265,628**

Data Space Required (MB)		Data Space Configured (MB)					Log Space Required (MB)		Log Space Configured (MB)	
Initial Growing Space	11,688,910									
Final Growing Space	11,723,475	Data LUNS	6	1	-	-	Initial Log Size	26,457	Log LUNS	1
Delta	34,565	Disks per LUN	15	7	-	-	Final Log Size	215,401	Log Disks	6
Data Space per Trade	0.00122287	Disk Capacity	189,781	571,250	-	-	Log Growth	188,945	Disk Capacity	285,148
1 Day Data Growth	100,817	RAID Overhead	93%	86%	0%	0%	Log Growth/Trade	0.006684605	RAID Overhead	50%
60 Day Space	17,958,918	Total Space				19,369,101	1 Day Log Space	577,557	Log Space	855,444
						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 June 27, 2011.

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

June 21, 2011

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

Platform: IBM System x3850 X5
Operating System: Microsoft Windows Server 2008 R2 Enterprise Edition
Database Manager: Microsoft SQL Server 2008 R2 Enterprise Edition

The results were:

CPU's Speed	Memory	Disks	Trade-Result 90% Response Time	tpsE
Tier B, Server: IBM System x3850 X5				
4 x Intel Xeon E7-4870 (2.40GHz)	1024 GB (4 x 2.5 MB L2) (4 x 30 MB L3)	2 x 250GB 7.2K SATA 90 x 200GB SSD SAS 6 x 300 GB 10K SAS 7 x 600 GB 10K SAS	0.07 Seconds	2862.61
Tier A, One Client: IBM System x3650 M3				
2 x Intel Xeon X5650 (2.66 GHz)	8 GB (2 x 1.5 MB L2) (2 x 12 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:

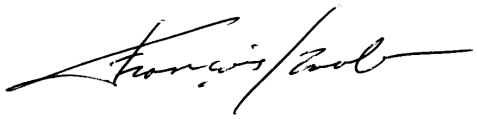
- All EGen components were verified to be v1.12.0.
- The transactions were correctly implemented.
- The database was properly scaled and populated for 1,450,000 customers.
- The mandatory network between the driver and the SUT was configured.
- The ACID properties were met.

- 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 01:09:57 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

June 15, 2011

IBM
Ray Engler
3039 Cornwallis Road
Raleigh, 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
810-08527	**SQL Server 2008 R2 Enterprise Edition** *Per Processor License* *Open Program - Level C* *Unit Price reflects a 20% discount from the retail unit price of $23,848.*	$19,188	4	$76,752
P72-04217	**Windows Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - Level C* *Unit Price reflects a 43% discount from the retail unit price of $3,999.*	$2,280	1	$2,280
P73-04980	**Windows Server 2008 R2 Standard Edition** *Server License with 10 CALs* *Open Program - Level C* *Unit Price reflects a 31% discount from the retail unit price of $1,029.*	$711	1	$711
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259	1	$259

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

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

This quote is valid for the next 90 days.

Reference ID: TPCE_qhtplylGYLKTVUKfhniMjhiIihhHjlf85757.DOC.

CLEARCOMM
TECHNICAL SALES, INC.

SMART®
Modular Technologies

IBM Corporation
Joe Herman
3039 Cornwallis Road
Research Triangle Park, NC 27709

June 14, 2011

Dear Joe,

Noted below is the information you requested regarding pricing for the SMART Modular 2.5" SAS Solid State Drive (SSD) to be used in conjunction with your TPC benchmark testing.

All prices shown are in US Dollars ($). Pricing does not include applicable taxes or shipping charges, which may vary.

Part Number	Description	Unit Price [1]	Quantity [2]	Extended Price
SG9XCA2E200GE01	200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC	$1,800.00	99	$178,200.00

[1] Unit price includes special product replacement support (7 day replacement TAT). Certain restrictions apply.
[2] The minimum order quantity on this part number is 10 units.

The SMART SG9XCA2E200GE01 is currently available. For price confirmation and order assistance, please contact Ray Eustace at ClearComm Technical Sales at (919) 859-4400, or via email at smart@clearcommsales.com.

Notes:
1. This pricing is valid for thirty (30) days from the date of quotation.
2. All units are covered by a 5 year warranty from the date of shipment from SMART, subject to usage conditions defined in the product data sheet.

Sincerely,

Raymond Eustace

Raymond Eustace
ClearComm Technical Sales (representative of SMART Modular Technologies, Inc.)
919-859-4400
reustace@clearcommsales.com

Ref quote ID: SMART ClearComm 20110614JH SG9XCA2E200GE01

cc: B. Heinze / SMART Modular

400 Riverpark Drive Suite 300
North Reading, MA 01864
PHONE: 1-800-332-8638
FAX: 1-800-257-0568
www.avnetexpress.com

DATE: 6-14-2011
PAGES: 1

ATTENTION: Joe Herman
COMPANY: IBM
FROM: Sandra Nocivelli

PLEASE REFER TO QUOTE #:H255 5457560

QTY	*PART #*	*MFG*	*QTD PRICE*	*DELIVERY*	*COMMENTS*
8	LSI00217	LSI	$2041.17/ea	2wks	non cancelable non returnable

Avnet Terms & Conditions

- PRICE AND DELIVERY ARE SUBJECT TO CHANGE
- ALL ORDERS ARE SUBJECT TO AVNET STANDARD TERMS AND CONDITIONS.
- Quote valid for Thirty(30)Days

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Qty.	Product Description	Savings	Total Price
3	 Hanns-G HW-173ABB Black 17" 5ms Widescreen LCD Monitor Item #: N82E16824254037 Return Policy: Monitor Standard Return Policy	-$40.00 Instant	~~$359.97~~ $239.97 ($79.99 each)
4	 CABLES TO GO 24501 5 ft. Cat 5E Black Cat5E 350 MHz Crossover Patch Cable Item #: N82E16812196824 Return Policy: Standard Return Policy		$15.96 ($3.99 each)
		Subtotal:	$255.93

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Zip Code: UPS Guaranteed 3 Day

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Card Number: Security Code:

Apply Promo Code(s):

Promo Code: $0.00

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Subject to credit approval. See Terms

Grand Total:* $255.93

* Above total does not include shipping or taxes. Please input zip code to calculate your grand total.

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