

**TPC Benchmark™ E**  
**Full Disclosure Report**  
**for**  
**IBM® System x® 3690 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**  
**May 27, 2011**

**IBM Corporation**

## **First Edition – May 2011**

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## **Notes**

<sup>1</sup> GHz and MHz only measures microprocessor internal clock speed, not application performance. Many factors affect application performance.

<sup>2</sup> 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®3690 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.


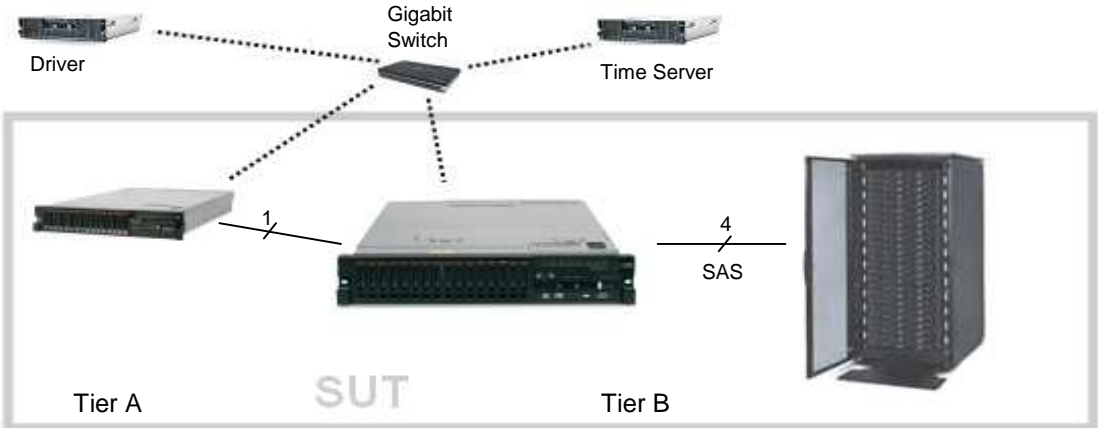
The software used on the IBM System x3690 X5 system included Microsoft® Windows® Server 2008 R2 Enterprise Edition and Microsoft SQL Server 2008 R2 Enterprise Edition.

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:

<b>Hardware</b>	<b>Software</b>	<b>Total System Cost</b>	<b>tpsE</b>	<b>\$ USD /tpsE</b>	<b>Total Solution Availability Date</b>
IBM System x3690 X5	Microsoft SQL Server 2008 R2 Enterprise Edition Microsoft Windows Server 2008 R2 Enterprise Edition	\$223,664 USD	1560.70	\$143.32 USD	May 27, 2011

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

	<b>IBM® System x® 3690 X5</b> <b>Microsoft® SQL Server 2008 R2</b>		<b>TPC-E 1.12.0</b> <b>TPC Pricing 1.6.0</b>
			Report Date: May 27, 2011
			Revision Date: May 27, 2011
TPC-E Throughput <b>1560.70 tpsE</b>	Price/Performance <b>\$143.32</b> <b>USD per tpsE</b>	Availability Date <b>May 27, 2011</b>	Total System Cost <b>\$223,664 USD</b>
<b>Database Server Configuration</b>			
Operating System <b>Microsoft Windows Server 2008 R2 Enterprise Edition</b>	Database Manager <b>Microsoft SQL Server 2008 R2 Enterprise Edition</b>	Processors/Cores/Threads <b>2/20/40</b>	Memory <b>512GB</b>
			
1 x 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 Dual Gb Ethernet	IBM System x3690 X5, with: - 2 x Intel Xeon Processor E7-2870 2.40GHz (2 Procs/20 Cores/40 Threads) - 512GB Memory - 2 x 250GB SFF SATA (RAID-1) - 6 x 300GB 10K SAS (RAID-10) - 1 x IBM ServeRAID M5015 - 4 x IBM ServeRAID M5025 - Onboard Dual Gb Ethernet	4 x LSI 620J JBOD Enclosures, with: - 52 x 200GB 2.5" SAS SSD (4 x 13-drive RAID-5 DB data) - 6 x 300GB 10K 2.5" SAS (RAID-5 60-Day space)  58 Total External Drives	
Initial Database Size <b>6,408 GB</b>	Redundancy Level: <b>1</b> <b>RAID-10 Log</b> <b>RAID-5 Data</b>	Storage <b>2 x 250 GB</b> <b>52 x 200 GB</b> <b>12 x 300 GB</b>	



# IBM System x3690 X5 Microsoft SQL Server 2008 R2

**TPC-E 1.12.0**  
**TPC Pricing 1.6.0**

Report Date:  
May 27, 2011

Revision Date:  
May 27, 2011

Availability Date:  
May 27, 2011

Description	Part Number	Price Source	Unit Price	Quantity	Extended Price	3-Yr. Maint. Price
<b>Server Hardware</b>						
x3690 X5 with 1 x Intel Xeon Processor E7-2870 (2.40GHz / 2.5MB L2 Cache / 30MB L3 Cache) 2x4GB Memory; ServRAID M1015; 2x675W PS	7147A7U	1	11,555	1	11,555	
Intel Xeon Processor E7-2870 (2.40GHz/2.5MB L2/30MB L3)	88Y5663	1	6,465	1	6,465	
16GB (1x16GB) QuadRank PC3-8500 1066MHz LP RDIMM	46C7483	1	899	32	28,768	
IBM x3690 X5 16-DIMM Internal Memory Expansion	81Y8926	1	475	1	475	
IBM 4x 2.5" HS SAS HDD Backplane	60Y0339	1	89	1	89	
IBM UltraSlim Enhanced SATA DVD-ROM	46M0901	1	89	1	89	
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	4	2,596	
ServeRAID M5000 Series Performance Accelerator Key	81Y4426	1	399	4	1,596	
IBM Preferred Pro USB Keyboard	40K9584	1	29	1	29	
IBM 2-Button Optical Mouse - Black - USB	40K9200	1	19	1	19	
ServicePac for 3-Year 24x7x4 Support (x3690 X5)	88Y8307	1	660	1	660	660
Hanns-G 17" 5ms Widescreen LCD Monitor (2 spares)	HW-173ABB	3	120	3	360	
<b>Subtotal</b>					55,522	660
<b>Server Storage</b>						
IBM S2 42U Standard Rack	93074RX	1	1,299	1	1,299	
LSI 620J JBOD Enclosure	LSI00217	5 - S	2,042	4	8,168	
LSI 620J JBOD Enclosure (10% spares)	LSI00217	5 - S	2,042	2	2,042	4,084
IBM 1M SAS cable	39R6529	1	119	4	476	
IBM 300GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD	42D0637	1	409	6	2,454	
IBM 300GB 10K 6Gbps SAS 2.5" SFF Slim-HS HDD (spares)	42D0637	1	409	2	818	818
200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC	SG9XCA2E200GE01	4	1,800	52	93,600	
200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC (spares)	SG9XCA2E200GE01	4	1,800	6	7,200	10,800
<b>Subtotal</b>					105,997	15,702
<b>Server Software</b>						
SQL Server 2008 R2 Enterprise Edition	810-08529	2	23,848	2	47,696	
Windows Server 2008 R2 Enterprise Edition	P72-04219	2	3,999	1	3,999	
Microsoft Problem Resolution Services	N/A	2a	259	1	259	259
<b>Subtotal</b>					51,695	259
<b>Client Hardware</b>						
IBM System x3650 M3 Configure-To-Order, includes: System Common Planar for 1U/2U	7945AC1	1	5,273	1	5,273	
IBM System x3650 M3 Base with 675W AC power supply	5663	1	5663	1	5,663	
IBM System x3650 M3 Base with 675W AC power supply	5694	1	5694	1	5,694	
Intel Xeon Processor X5650 6C 2.66GHz 12MB 1333MHz 95W	4589, 7709	2	4,589	2	9,178	
IBM System x3650 M3 8 HDD Kit	1745	1	1,745	1	1,745	
2GB PC3-10600 CL9 ECC DDR3 1333MHz LP RDIMM	8934	4	8934	4	35,736	
PCI-Express (2 x8 slots) Riser Card	3734	1	3,734	1	3,734	
ServeRAID M1015 SAS/SATA Controller	0095	1	609	1	609	
IBM UltraSlim Enhanced SATA DVD-ROM	4161	1	416	1	416	
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	660
<b>Subtotal</b>					5,851	660
<b>Client Software</b>						
Microsoft Windows Server 2008 R2 Standard Edition	P73-00352	2	1,029	1	1,029	
<b>Subtotal</b>					1,029	0
<b>Infrastructure</b>						
Ethernet Cables (2 spares)	24501	3	4	3	12	
<b>Subtotal</b>					12	0
<b>Total</b>					220,106	17,281
Dollar Volume Discount (See Note 1)	16.22%	1			10,929	
Microsoft Open Program Discount Schedule	5.27%	2			2,794	

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.

<b>Three-Year Cost of Ownership USD:</b>	\$223,664
<b>TPC-E Throughput:</b>	1,560.70
<b>\$ USD/tpsE:</b>	\$143.32

Benchmark results and test methodology audited by Doug Johnson for InfoSizing, Inc. ([www.sizing.com](http://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](mailto:pricing@tpc.org). Thank you.



**IBM System x3690 X5  
Microsoft SQL Server 2008 R2**

**TPC-E 1.12.0  
TPC Pricing 1.6.0**

Report Date:  
May 27, 2011

Revision Date:  
May 27, 2011

Availability Date:  
May 27, 2011

Numerical Quantities Summary				
<b>Reported Throughput: 1560.70 tpsE</b>		<b>Configured Customers: 800,000</b>		
Response Time (in seconds)	Minimum	Average	90 <sup>th</sup> Percentile	Maximum
Broker-Volume	0.01	0.03	0.05	0.35
Customer-Position	0.01	0.03	0.05	1.67
Market-Feed	0.01	0.02	0.04	1.42
Market-Watch	0.01	0.03	0.05	0.39
Security-Detail	0.01	0.01	0.03	0.59
Trade-Lookup	0.01	0.11	0.17	0.84
Trade-Order	0.01	0.06	0.09	1.04
Trade-Result	0.01	0.08	0.11	2.34
Trade-Status	0.01	0.02	0.03	0.53
Trade-Update	0.01	0.12	0.18	0.90
Data-Maintenance	0.01	0.03	N/A	0.13
Transaction Mix		Transaction Count	Mix %	
Broker-Volume		5,505,975	4.900%	
Customer-Position		14,607,357	13.000%	
Market-Feed		1,123,712	1.000%	
Market-Watch		20,225,939	18.000%	
Security-Detail		15,731,473	14.000%	
Trade-Lookup		8,989,120	8.000%	
Trade-Order		11,349,063	10.100%	
Trade-Result		11,237,044	10.000%	
Trade-Status		21,349,265	19.000%	
Trade-Update		2,247,273	2.000%	
Data-Maintenance		120	N/A	
Test Duration and Timings				
Ramp-up Time (hh:mm:ss)				00:21:25
Measurement Interval (hh:mm:ss)				02:00:00
Business Recovery Time (hh:mm:ss)				00:29:10
Total Number of Transactions Completed in Measurement Interval				112,366,221

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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

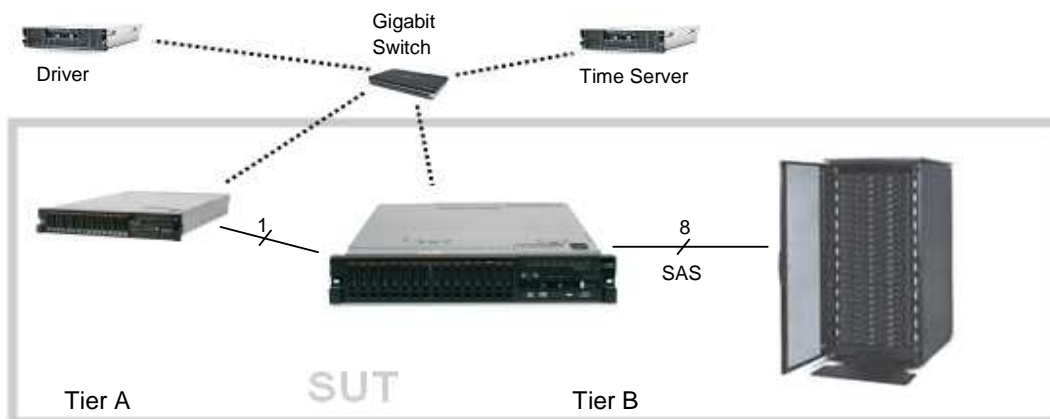
Diagrams of both the Measured and Priced Configurations must be reported, accompanied by a description of the differences.

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**



1 x 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 Dual Gb Ethernet

IBM System x3690 X5, with:  
- 2 x Intel Xeon Processor E7-2870 2.40GHz (2 Procs/20 Cores/40 Threads)  
- 512GB Memory  
- 2 x 250GB SFF SATA (RAID-1)  
- 6 x 300GB 10K SAS (RAID-10)  
- 1 x IBM ServeRAID M5015  
- 4 x IBM ServeRAID M5025  
- Onboard Dual Gb Ethernet

8 x IBM EXP2524 JBOD Enclosures, with:  
- 52 x 200GB 2.5" SAS SSD (4 x 13-drive RAID-5 DB data)  
- 6 x 300GB 10K 2.5" SAS (RAID-5 60-Day space)  
- 96 x 200GB 2.5" SAS SSD (4 x 24-drive RAID-6 backup and temp space)  
154 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\_x3690X5\_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\800000.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 800,000 customers. The cardinality is shown in Table 2-1.

**Table 2-1. Initial Cardinality of Tables**

Table Name	Rows
ACCOUNT_PERMISSION	5,679,775
ADDRESS	1,200,004
BROKER	8,000
CASH_TRANSACTION	12,718,084,996
CHARGE	15
COMMISSION_RATE	240
COMPANY	400,000
COMPANY_COMPETITOR	1,200,000
CUSTOMER	800,000
CUSTOMER_ACCOUNT	4,000,000
CUSTOMER_TAXRATE	1,600,000
DAILY_MARKET	715,140,000
EXCHANGE	4
FINANCIAL	8,000,000
HOLDING	707,739,258
HOLDING_HISTORY	18,526,540,227
HOLDING_SUMMARY	39,788,095
INDUSTRY	102
LAST_TRADE	548,000
NEWS_ITEM	800,000
NEWS_XREF	800,000
SECTOR	12
SECURITY	548,000
SETTLEMENT	13,824,000,000
STATUS_TYPE	5
TAXRATE	320
TRADE	13,824,000,000
TRADE_HISTORY	33,177,541,373
TRADE_REQUEST	0
TRADE_TYPE	5
WATCH_ITEM	80,054,495
WATCH_LIST	800,000
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 four 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 thirteen 200GB SAS SSDs. In total, for database data, four enclosures and 52 external SSDs were connected to the server. Four data arrays were each configured as 13-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 four enclosures contained six 300GB 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 four additional external 6Gbps SAS JBOD enclosures, each filled with twenty-four 200GB SAS SSDs. 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 four enclosures were attached to the existing (priced) four ServeRAID M5025 RAID controllers. Four 24-drive RAID-6 arrays 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)	147.96GB	OS
1	Internal M5015	6x300GB SAS HDD internal RAID-10	E: (RAW) F: (NTFS)	390.63GB 444.64GB	LOG and MDF
2	M5025 #1	13x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx1 (RAW) c:\mp\gw1 (RAW)	43.46GB 2180.41GB	fixed_fg growing_fg
3	M5025 #1	6x300GB SAS HDD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	S: (NTFS)	1392.2GB	60-Day Space



Disk #	Controller	Drives Enclosure RAID level	Partition (File System)	Size	Use
4	M5025 #1	24x200GB SAS SSD EXP2524 RAID-6 (Measured)	c:\mp\bk1 (NTFS)	4077.20GB	Backup, flatfiles, & tempDB
5	M5025 #2	13x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx2 (RAW) c:\mp\gw2 (RAW)	43.46GB 2180.41GB	fixed_fg growing_fg
6	M5025 #2	24x200GB SAS SSD EXP2524 RAID-6 (Measured)	c:\mp\bk2 (NTFS)	4077.20GB	Backup, flatfiles, & tempDB
7	M5025 #3	13x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx3 (RAW) c:\mp\gw3 (RAW)	43.46GB 2180.41GB	fixed_fg growing_fg
8	M5025 #3	24x200GB SAS SSD EXP2524 RAID-6 (Measured)	c:\mp\bk3 (NTFS)	4077.20GB	Backup, flatfiles, & tempDB
9	M5025 #4	13x200GB SAS SSD EXP2524 (measured) LSI 620J JBOD (priced) RAID-5	c:\mp\fx4 (RAW) c:\mp\gw4 (RAW)	43.46GB 2180.41GB	fixed_fg growing_fg
10	M5025 #4	24x200GB SAS SSD EXP2524 RAID-6 (Measured)	c:\mp\bk4 (NTFS)	4077.20GB	Backup, flatfiles, & 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 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 one Gb Ethernet crossover cable. This cable was connected to an onboard Gb Ethernet port in both tiers. This crossover network 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 500 EGenDriverCE instances used in the benchmark.

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

### Measured Throughput

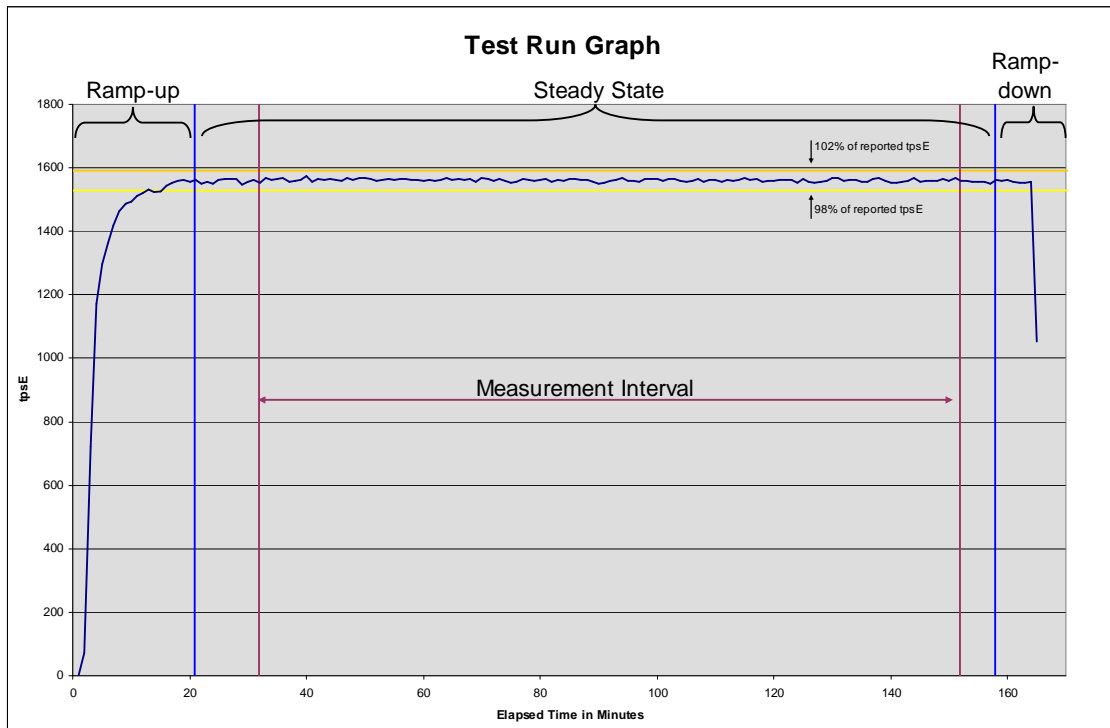
The Measured Throughput must be reported (see Clause 6.7.1.2).

The Measured Throughput was 1,560.70 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
<b>Customer-Position</b>			
By Tax ID	1	49.99%	48% to 52%
Get History	1	49.99%	48% to 52%
<b>Market-Watch</b>			
Securities chosen by	Watch List	59.99%	57% to 63%
	Account ID	35.01%	33% to 37%
	Industry	5.00%	4.5% to 5.5%
<b>Security-Detail</b>			
Access LOB	1	1.00%	0.9% to 1.1%
<b>Trade-Lookup</b>			
Frame to execute	1	30.00%	28.5% to 31.5%
	2	29.99%	28.5% to 31.5%
	3	30.00%	28.5% to 31.5%
	4	10.01%	9.5% to 10.5%
<b>Trade-Order</b>			
Transactions requested by a third party		10.00%	9.5% to 10.5%
By Company Name		40.03%	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	34.98%	33% to 37%
Trade Quantity	100	25.01%	24% to 26%
	200	25.00%	24% to 26%
	400	24.98%	24% to 26%
	800	25.01%	24% to 26%
Trade Type	Market Buy	30.00%	29.7% to 30.3%
	Market Sell	29.99%	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%
<b>Trade-Update</b>			
Frame to execute	1	33.01%	31% to 35%
	2	33.01%	31% to 35%
	3	33.98%	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  $(T\_ST\_ID = \text{---CMPT'}$ ).*

*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  $(T\_ST\_ID = \text{---CMPT'}$ ).*

*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.

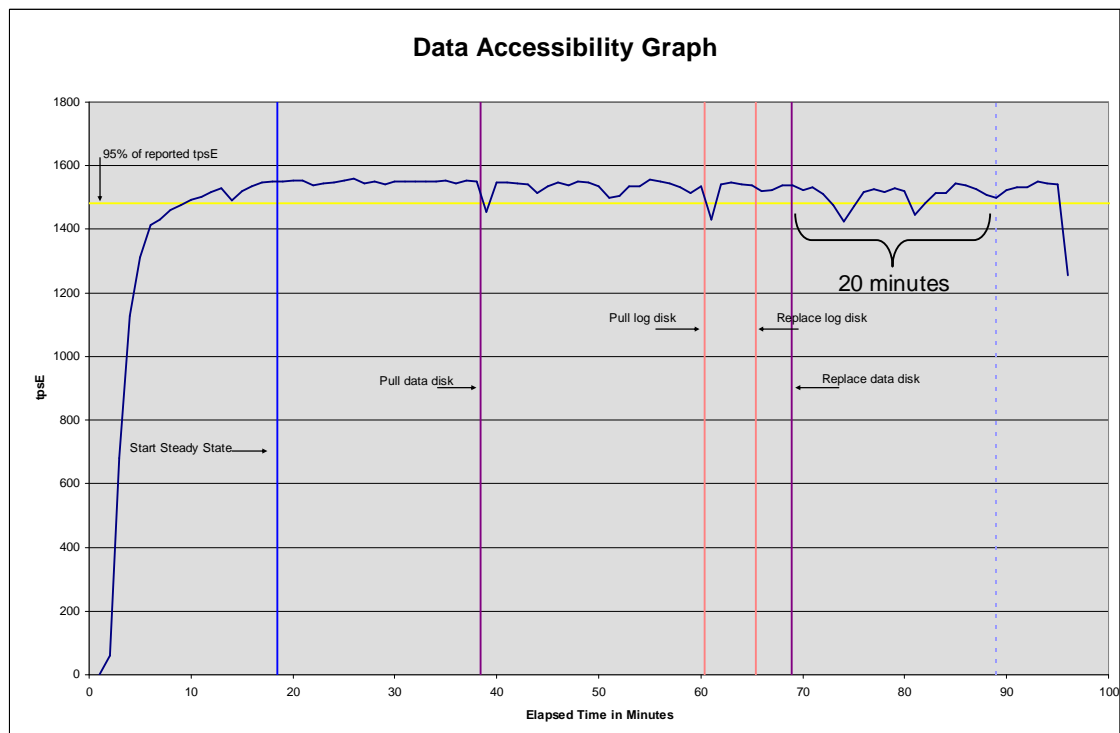
To prove Redundancy Level 1, the following steps were successfully performed:

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.

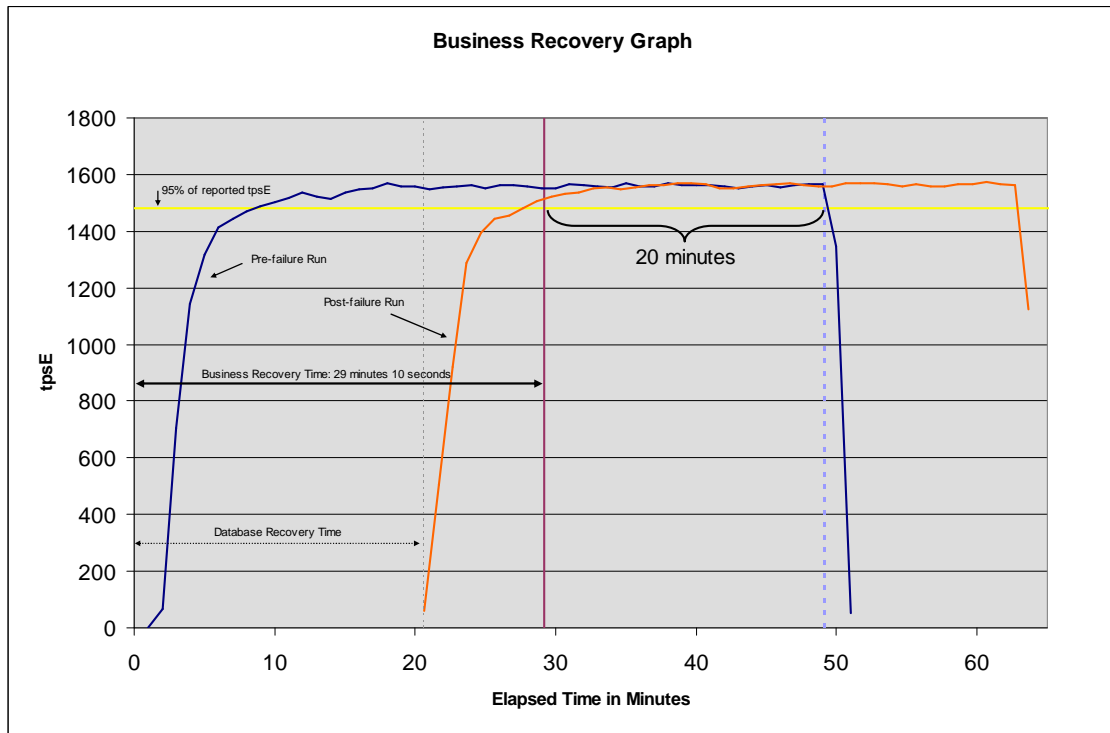
The following steps were successfully performed to test Business Recovery:

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 00:20:40. The Application Recovery Time was 00:08:30. The Business Recovery Time, which is the sum of the Database Recovery Time and the Application Recovery Time, was 00:29:10.

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\ tpc\_e\_space.xls.

**Table 8-1. Disk Space Requirements**

TPC-E Disk Space Requirements											
Customers	800,000		Performance			1560.70 TpsE		Reported			1560.70 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	8,000	584	632	61	1,277	8,000	1,216	-	-	61	
CASH_TRANSACTION	12,718,084,996	1,312,120,416	2,765,960	65,744,319	1,380,630,695	12,731,928,164	1,317,567,096	2,680,720	8,008,010	8,008,010	
CHARGE	15	8	8	1	17	15	16	-	-	1	
COMMISSION_RATE	240	16	16	2	34	240	32	-	-	2	
SETTLEMENT	13,824,000,000	659,181,712	1,390,216	33,028,596	693,600,524	13,839,046,615	662,068,992	1,497,064	4,472,121	4,472,121	
TRADE	13,824,000,000	1,648,679,112	828,640,176	123,865,964	2,601,185,252	13,839,140,506	2,485,517,128	8,197,840	24,489,085	24,489,085	
TRADE_HISTORY	33,177,541,373	997,820,936	2,601,632	50,021,128	1,050,443,696	33,213,692,142	1,003,110,072	2,687,504	8,028,275	8,028,275	
TRADE_REQUEST	-	-	-	-	-	93,891	206,976	206,976	618,292	618,292	
TRADE_TYPE	5	8	1,032	52	1,092	5	1,040	-	-	52	
ACCOUNT_PERMISSION	5,679,775	312,808	2,200	15,750	330,758	5,679,775	315,080	72	216	15,750	
CUSTOMER	800,000	131,144	34,848	8,300	174,292	800,000	165,992	-	-	8,300	
CUSTOMER_ACCOUNT	4,000,000	362,496	77,584	22,004	462,084	4,000,000	440,080	-	-	22,004	
CUSTOMER_TAXRATE	1,600,000	33,408	688	1,705	35,801	1,600,000	34,216	120	359	1,705	
HOLDING	707,739,258	47,133,000	29,820,008	3,847,650	80,800,658	708,129,146	77,857,992	904,984	2,703,424	2,703,424	
HOLDING_HISTORY	18,526,540,227	673,692,536	389,392,360	53,154,245	1,116,239,141	18,546,823,441	1,065,964,376	2,879,480	8,601,758	8,601,758	
HOLDING_SUMMARY	39,788,095	1,731,208	6,912	86,906	1,825,026	39,788,424	1,738,120	-	-	-	
WATCH_ITEM	80,054,495	2,227,192	8,640	111,792	2,347,624	80,054,495	2,236,032	200	598	111,792	
WATCH_LIST	800,000	19,960	16,560	1,826	38,346	800,000	36,520	-	-	1,826	
COMPANY	400,000	85,088	24,088	5,459	114,635	400,000	109,200	24	72	5,459	
COMPANY_COMPETITOR	1,200,000	32,264	26,336	2,930	61,530	1,200,000	58,600	-	-	2,930	
DAILY_MARKET	715,140,000	33,352,824	96,584	1,672,470	35,121,878	715,140,000	33,450,416	1,008	3,012	1,672,470	
EXCHANGE	4	8	8	1	17	4	16	-	-	1	
FINANCIAL	8,000,000	901,584	3,096	45,234	949,914	8,000,000	904,944	264	789	45,234	
INDUSTRY	102	8	24	2	34	102	32	-	-	2	
LAST_TRADE	548,000	34,040	688	1,736	36,464	548,000	34,728	-	-	1,736	
NEWS_ITEM	800,000	86,734,656	1,576	4,336,812	91,073,044	800,000	86,736,248	16	48	4,336,812	
NEWS_XREF	800,000	19,992	688	1,034	21,714	800,000	20,680	-	-	1,034	
SECTOR	12	8	24	2	34	12	32	-	-	2	
SECURITY	548,000	75,464	20,072	4,777	100,313	548,000	95,544	8	24	4,777	
STATUS_TYPE	5	8	8	1	17	5	16	-	-	1	
ADDRESS	1,200,004	69,248	688	3,497	73,433	1,200,004	70,008	72	216	3,497	
TAXRATE	320	24	16	2	42	320	56	16	48	48	
ZIP_CODE	14,741	488	40	26	554	14,741	528	-	-	26	
<b>TOTALS (KB)</b>		<b>5,464,752,248</b>	<b>1,254,933,408</b>	<b>335,984,283</b>	<b>7,055,669,939</b>		<b>6,738,742,024</b>	<b>19,056,368</b>	<b>56,926,347</b>	<b>63,156,485</b>	
Initial Database Size (MB)		6,562,193	6,408 GB								
Database Filegroups	LUN Count	Partition Size (MB)	MB Allocated	MB Loaded	MB Required						
	0	-	-	-	-					OK	
growing_fg	4	2,232,740	8,930,959	6,440,406	6,495,993					OK	
	0	-	-	-	-					OK	
fixed_fg	4	44,503	178,012	121,787	127,876					OK	
Settlements	15,046,615										
Data Space Required (MB)	Data Space Configured (MB)	Log Space Required (MB)	Log Space Configured (MB)								
Initial Growing Space	6,440,406										
Final Growing Space	6,459,014	Data LUNS	4	1	-	Initial Log Size	2,831	Log LUNS	1		
Delta	18,608	Disks per LUN	13	6	-	Final Log Size	103,711	Log Disks	6		
Data Space per Trade	0.001236689	Disk Capacity	189,781	285,148	-	Log Growth	100,879	Disk Capacity	285,148		
1 Day Data Growth	55,587	RAID Overhead	92%	83%	0%	Log Growth/Trade	0.00670453	RAID Overhead	50%		
60 Day Space	9,897,406	Total Space				1 Day Log Space	304,184	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 May 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.

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

May 23, 2011

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

Platform: IBM System x3690 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
<b>Tier B, Server: IBM System x3690 X5</b>				
2 x Intel Xeon E7-2870 (2.40GHz)	512 GB (2 x 2.5 MB L2) (2 x 30 MB L3)	2 x 250GB 7.2K SATA 52 x 200GB SSD SAS 12 x 300 GB 10K SAS	0.11 Seconds	1560.70
<b>Tier A, One Client: IBM System x3650 M3</b>				
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 800,000 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 00:29:10 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**

May 13, 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
810-08529	<b>SQL Server 2008 R2 Enterprise Edition</b> <i>Per Processor License Open Program - No Level Unit Price reflects a 2% discount from the retail unit price of \$23,848.</i>	\$23,370	2	\$46,740
P72-04219	<b>Windows Server 2008 R2 Enterprise Edition</b> <i>Server License with 25 CALs Open Program - No Level Unit Price reflects a 42% discount from the retail unit price of \$3,999.</i>	\$2,320	1	\$2,320
P73-00352	<b>Windows Server 2008 R2 Standard Edition</b> <i>Server License with 10 CALs Open Program - No Level Unit Price reflects a 15% discount from the retail unit price of \$1,029.</i>	\$870	1	\$870
N/A	<b>Microsoft Problem Resolution Services</b> <i>Professional Support (1 Incident).</i>	\$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\_qhtplylGYLKTUVKfhmiKjhiIiikPlpf85757.

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

May 04, 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 <sup>1</sup>	Quantity <sup>2</sup>	Extended Price
SG9XCA2E200GE01	200GB, 2.5" XceedIOPS SAS Solid-State Drive, eMLC	\$1,800.00	58	\$104,400.00

<sup>1</sup> Unit price includes special product replacement support (7 day replacement TAT). Certain restrictions apply.


<sup>2</sup> 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](mailto: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  
ClearComm Technical Sales (representative of SMART Modular Technologies, Inc.)  
919-859-4400  
[reustace@clearcommsales.com](mailto:reustace@clearcommsales.com)

Ref quote ID: SMART ClearComm 20110504JH 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](http://www.avnetexpress.com)

DATE: 5-12-2011  
PAGES: 1

ATTENTION: Joe Herman  
COMPANY: IBM  
FROM: Sandra Nocivelli

PLEASE REFER TO QUOTE #:H255 5457560

<u>QTY</u>	<u>PART #</u>	<u>MFG</u>	<u>QTD PRICE</u>	<u>DELIVERY</u>	<u>COMMENTS</u>
6	LSI00217	LSI	\$2041.17/ea	2wks	<b><u>Avnet Terms &amp; Conditions</u></b>

- 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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## Shopping Cart

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Qty.	Product Description	Savings	Total Price
3	<a href="#">Hanns-G HW-173 ABB Black 17" 5ms Widescreen LCD Monitor</a> Item #: N82E16824254037 Return Policy: <a href="#">Monitor Standard Return Policy</a>	-\$40.00 Instant	\$359.97 \$239.97 (\$79.99 each)
3	<a href="#">CABLES TO GO 24501 5 ft. Cat 5E Black Cat5E 350 MHz Crossover Patch Cable</a> Item #: N82E16812196824 Return Policy: <a href="#">Standard Return Policy</a>		\$11.97 (\$3.99 each)
Subtotal:			\$251.94
<p>Would you like to use our Will-Call Service? _____</p> <p>Some of your products can be picked up at our warehouse in City Of Industry, CA.</p> <p>Use Will-Call</p> <p>Exact address and full instructions will be provided upon order completion.</p>			
<p>Calculate Shipping _____</p> <p>Zip Code: <input type="text" value="UPS Guaranteed 3 Day"/></p>		Shipping:	\$0.00
<p><b>Redeem Newegg Gift Cards</b></p> <p>Card Number: <input type="text"/> Security Code: <input type="text"/></p>			
<p><b>Apply Promo Code(s):</b></p>		Promo Code:	\$0.00
<p><a href="#">No Payments + No Interest if paid in full in 6 Months on order over \$250.</a>  <a href="#">Subject to credit approval. See Terms</a></p>			
Grand Total:*			\$251.94

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

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