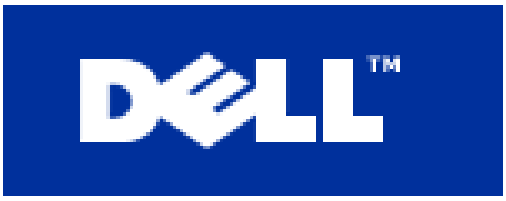

TPC Benchmark ™ E
Full Disclosure Report
DELL PowerEdge R900
Using
Microsoft SQL Server 2008 Enterprise Edition x64
On
Microsoft Windows Server 2008 Enterprise x64

First Edition

Submitted for Review

July 8, 2008

Dell, Inc. PowerEdge R900 Server with Microsoft SQL Server 2008 Enterprise Edition x64 on Microsoft Windows Server 2008 Enterprise x64

First Printing July 2008

Printed in U.S.A.

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Abstract

This report documents the methodology and results of the TPC Benchmark E test conducted on a PowerEdge R900 Server using SQL Server 2008 database in conformance with the requirements of the TPC-E Benchmark Specification. The operating system used for the server was Microsoft Windows Server 2008 Enterprise Edition x64. The operating system on the client was Microsoft Windows Server 2003 Enterprise Edition x64 SP2.
All tests were done in compliance with Revision 1.5.0 of the Transaction Processing Council's TPC Benchmark™ E Standard Specification. The standard TPC Benchmark™ E metrics, transactions per second (tpsE), price per tpsE ($/tpsE) and the availability date are reported and referred to in this document.

The results from the tests are summarized below:

Hardware	Software	Total System Cost	tpsE	$/tpsE	Availability Date
Dell PowerEdge R900	Microsoft Windows 2008 Enterprise Ed. x64 SQL Server 2008 Enterprise Ed. x64	$331,357	451.29	$734.25	August 31, 2008

Additional copies of this Full Disclosure Report can be obtained from either the Transaction Processing Performance Council or Dell at the following address:

Transaction Processing Performance Council (TPC)
c/o Adminstrator, TPC
Presidio of San Francisco
Bldg 572B Ruger St.
San Francisco, CA 94129-0920
Phone: (415) 561-6272, fax 415-561 6120
www.tpc.org

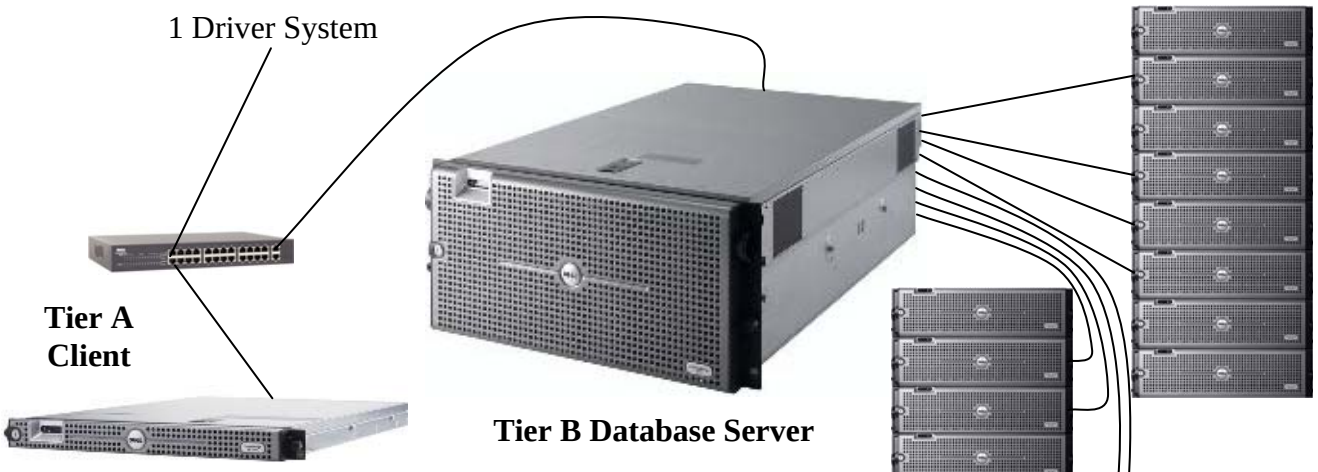
or

Dell
One Dell Way
Round Rock, TX 78682
Attention: Mike Molloy

Auditor

In order to verify compliance to the TPC-E benchmark specification, Lorna Livingtree, Performance Metrics, Inc., audited the benchmark configuration, environment and methodology used to produce and validate the test results, and the pricing model used to calculate the price/performance.

DELL™	**PowerEdge™ R900 Server**		**TPC-E 1.5.1** **TPC Pricing 1.3** Report Date: July 8, 2008
TPC-E Throughput	Price/Performance	Availability Date	Total System Cost
451.29 tpsE	**$734.25 USD per tpsE**	**August 31, 2008**	**$331,357 USD**
Database Server Configuration			
Operating System **Microsoft Windows Server 2008 Enterprise x64 Edition™**	Database Manager **SQL Server 2008 Enterprise x64 Edition™**	Processors/Cores/ Threads **4/16/16**	Memory **64GB**



Client
1 PowerEdge SC 1430
2 Quad Core Intel E5345 2x4MB/2.33GHz,1333FSB
2GB Memory
2 Broadcom Ethernet
1 80GB SATA 7.2K Disk

Server
1 PowerEdge R900
4 X7350 Quad Core Intel Xeon 2x4MB cache, 2.93GHz, 1066MHz FSB
64GB 667MHz(16x4GB), Dual Ranked Fully Buffered DIMM
2 Broadcom NetExtreme II Gigabit Ethernet
1 PERC6i SAS RAID Controller
6 MegaRAID SAS 8888ELP Cntrs
8 73GB 15k 2.5" SAS Disks

Storage
24 PowerVault MD1000 SAS Enclosures
336 73GB 15k 3.5" 3GBPS SAS Disks

Initial Database Size	Redundancy Level:	Storage
1,666GB	**One**	**8 x 73GB** **336 x 73GB**

	PowerEdge R900	TPC-E 1.5.1 TPC Pricing 1.3 Report Date July 8, 2008 Revision Date July 8, 2008 Availability Date August 31, 2008

Description	Part Number	Price Source	Unit Price	Qty	Extended Price	3 yr. Maint. Price
Server Hardware						
PER900,DUAL X7350,2.93GHz,130W	223-4229	1	9,395.00	1	$9,395.00	$540.00
& 2 Broadcom NICs						
Upgrade to Quad X7350, 2.93GHz	310-9825	1	5,599.00	1	$5,599.00	
64GB,667MHZ, 16X4GB	311-7857	1	5,241.00	1	$5,241.00	
PERC6i SAS RAID, Internal, Bat	341-5699	1	$299.00	1	$299.00	
MegaRAID SAS 8888ELP, 2X4 EXTERNAL	LS-8888ELP	6	$790.00	8	$6,320.00	
73GB,SAS,2.5-inch,15K RPM HD	341-4727	1	$339.00	8	$2,712.00	
DELL E157FP,15 IN,15.0 VIS	320-5090	1	$189.00	1	$189.00	
				Subtotal	$29,755.00	$540.00
Server Storage						
PV MD1000,RACK,3U,15 BAY,LBZL	222-2299	1	2,480.00	24	$59,520.00	$39,792.00
SINGLE ENCL MGT MODULE, SAS ONLY	420-5927	1	$345.83	24	$8,299.92	
73GB,3GBPS,SAS,3.5IN,15K	341-2818	1	$299.00	336	$100,464.00	
RACK-42U, CUST	340-4896	1	$239.99	2	$479.98	
				Subtotal	$168,763.90	$39,792.00
Server Software						
SQL Server 2008 Enterprise x64 Edition **		2	$23,432.00	4	$93,728.00	
Windows Server 2008 Enterprise Edition (x64) **	P72-03168	2	$2,310.00	1	$2,310.00	
Professional Support (1 Incident)			$245.00	1		$245.00
				Subtotal	$96,038.00	$245.00
Client Hardware						
Dell PowerEdge SC 1430, 2.33GHZ/4MB,1333 FSB	223-3196	1	910.00	1	$910.00	$492.00
Additional processor, E5345,2X4MB,2.33GHz,1333FSB	311-7774	1	749.00	1	$749.00	
2GB,667MHz,(2X2GB),2R,FBD	311-6152	1	$368.00	1	$368.00	
80GB,SATA,1IN,7.2K RPM,HD ,7.2K	341-3757	1	$99.00	1	$99.00	
BCOM NetX 5721,Gb,ETHERNET,NIC	430-1496	1	$59.00	1	$59.00	
				Subtotal	$2,185.00	$492.00
Client Software						
Windows Server 2003 Enterprise x64 Server **	P72-01684	2	$2,334.00	1	$2,334.00	
				Subtotal	$2,334.00	$0.00
Infastructure						
PowerConnect 2216, 16port Switch	222-2259	1	$69.00	1	$69.00	
1M SAS Cable MegaRAID SAS 8888ELP	HI-MS-1MSB	3	$34.10	12	$409.20	
2M SAS Cable, MD1000	310-7083	1	$40.00	12	$480.00	
				Subtotal	$958.20	$0.00
				Other Discounts*	($9,746.65)	
				Total	$290,287.46	$41,069.00

Notes:

No components of the measured configuration have been substituted in the Priced Configuration. See the FDR for details.

*All hardware from Dell(1) is discounted 5% based on total dollar volume of this config.

** All Microsoft maintenance is covered by the maint. costs of Microsoft SQL Server

Price Source: 1=Dell, 2=Microsoft, 3=eWiz, NIO = Not Immediately Orderable

Pricing may be verified by calling 1-800-BUY-DELL and referencing quote # 438230115 as a complex quote.

Audited by Lorna Livingtree, Performance Metrics Inc.

Three-Year Cost of Ownership:	**$331,357**	**USD**
TPC-E Throughput:	**451.29**	**tpsE**
Price/Performance:	**$734.25**	**tpsE/USD**

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed components. For complete details, see the pricing sections of the TPC benchmark specifications. If you find that the stated prices are not available according to these items, please inform the TPC at pricing@tpc.org.

Numerical Quantities Summary				
Reported Throughput: 451.29 tpsE	**Configured Customers: 240,000**			
Response Times (in seconds)	**Minimum**	**Average**	**90th%tile**	**Maximum**
Broker-Volume	0.00	0.04	0.07	1.37
Customer-Position	0.00	0.03	0.06	2.92
Market-Feed	0.00	0.04	0.10	2.88
Market-Watch	0.00	0.03	0.06	0.89
Security-Detail	0.00	0.02	0.03	0.97
Trade-Lookup	0.00	0.52	0.67	1.57
Trade-Order	0.00	0.10	0.15	4.16
Trade-Result	0.00	0.09	0.15	4.02
Trade-Status	0.00	0.03	0.05	1.07
Trade-Update	0.02	0.61	0.72	1.56
Data-Maintenance	0.00	0.19		5.02
Transaction Mix		**Transaction Count**		**Mix %**
Broker-Volume		1,592,293		4.900%
Customer-Position		4,224,342		13.000%
Market-Feed		324,934		1.000%
Market-Watch		5,849,159		18.000%
Security-Detail		4,549,451		14.000%
Trade-Lookup		2,599,510		8.000%
Trade-Order		3,282,166		10.100%
Trade-Result		3,249,328		9.999%
Trade-Status		6,174,213		19.000%
Trade-Update		649,812		2.000%
Data-Maintenance		120		
Test Duration and Timings				
Ramp-up Time (hh:mm:ss)		00:22:00		
Measurement Interval (hh:mm:ss)		02:00:00		
Business Recovery Time (hh:mm:ss)		00:48:04		
Total number of Transactions Completed in Measurement Interval		32,495,208		

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Introduction

Document Structure

The TPC Benchmark™ E Standard Specification requires test sponsors to publish, submit to the TPC, and make available to the public, a full disclosure report (FDR) for any result to be considered compliant with the specification. The required contents of the full disclosure report are specified in Clause 9. This report is submitted to satisfy the specification's requirement for full disclosure. It documents the compliance of the benchmark implementation and execution reported for the Dell PE2900 server using Microsoft SQL Server 2008 Enterprise Edition (x64) on Microsoft Windows Server 2008 Enterprise Edition (x64).

Benchmark Overview

The Transaction Processing Performance Council (TPC) developed The TPC Benchmark™ E Standard Specification Revision 1.5.0.
TPC Benchmark™ E (TPC-E) is an Online 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 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 benchmark simulates the OLTP workload of a brokerage firm. The focus of the benchmark is the central database that exercises transactions related to the firm’s customer accounts. In keeping with the goal of measuring the performance characteristics of the database system, the benchmark does not attempt to measure the complex flow of data between multiple application systems that would exist in a real environment.

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

Clause 1: General Items

1.1: Order and Titles

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

The order and titles in this report correspond to those in the specification.

1.2: Executive Summary Statement

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

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

1.3: Test Sponsor

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

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

1.4: Configuration Diagram

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

The System Under Test (SUT) is depicted in the next diagram. The difference between the priced and measured system was as shown in Table 1

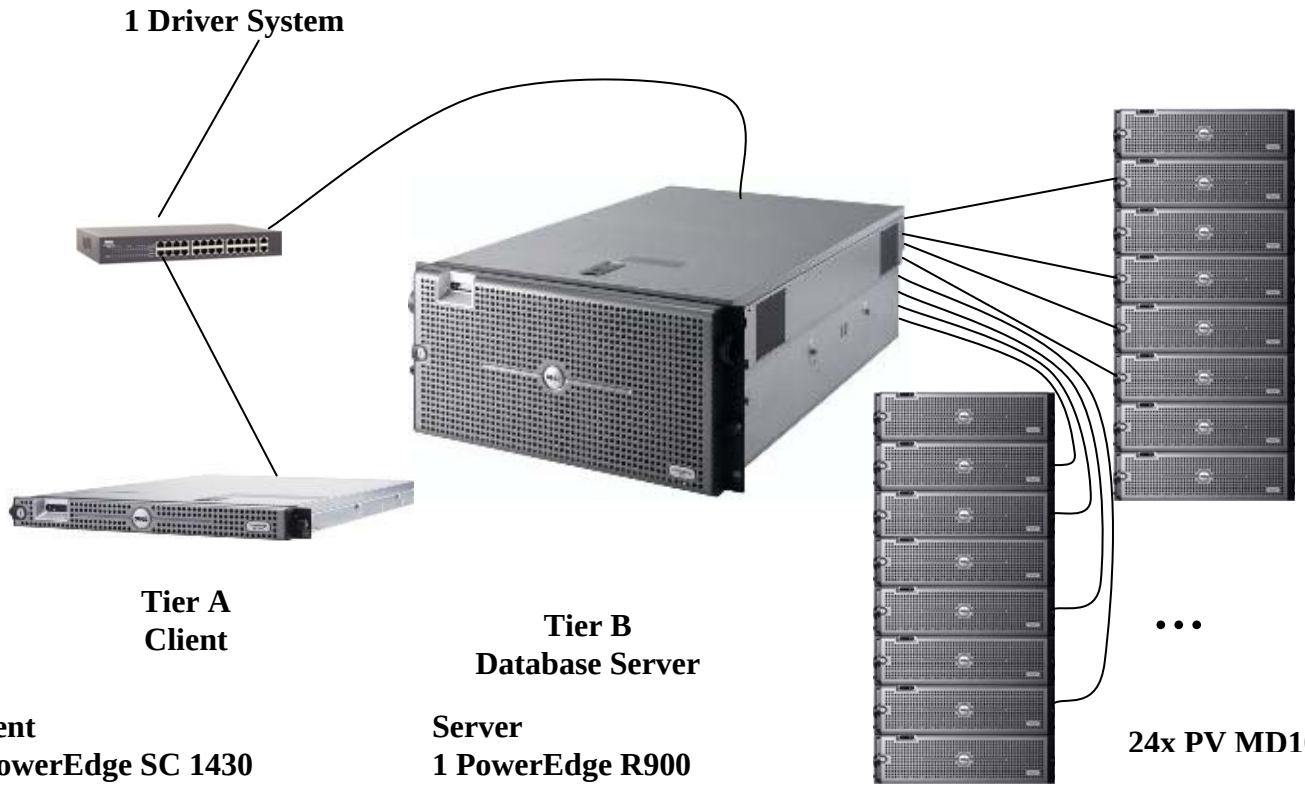
Table 1: *Difference between priced and measured configuration*

	Priced	**Measured**
Client Server - FSB - Processors - Memory - OS drives	PE SC 1430 1333MHz Intel Quad-core Xeon 2.33 GHz/2x4MB-L2 2GB 1x80GB	No difference

Measured Configuration

The measured and priced configurations are identical.

Figure 1: Measured Configuration



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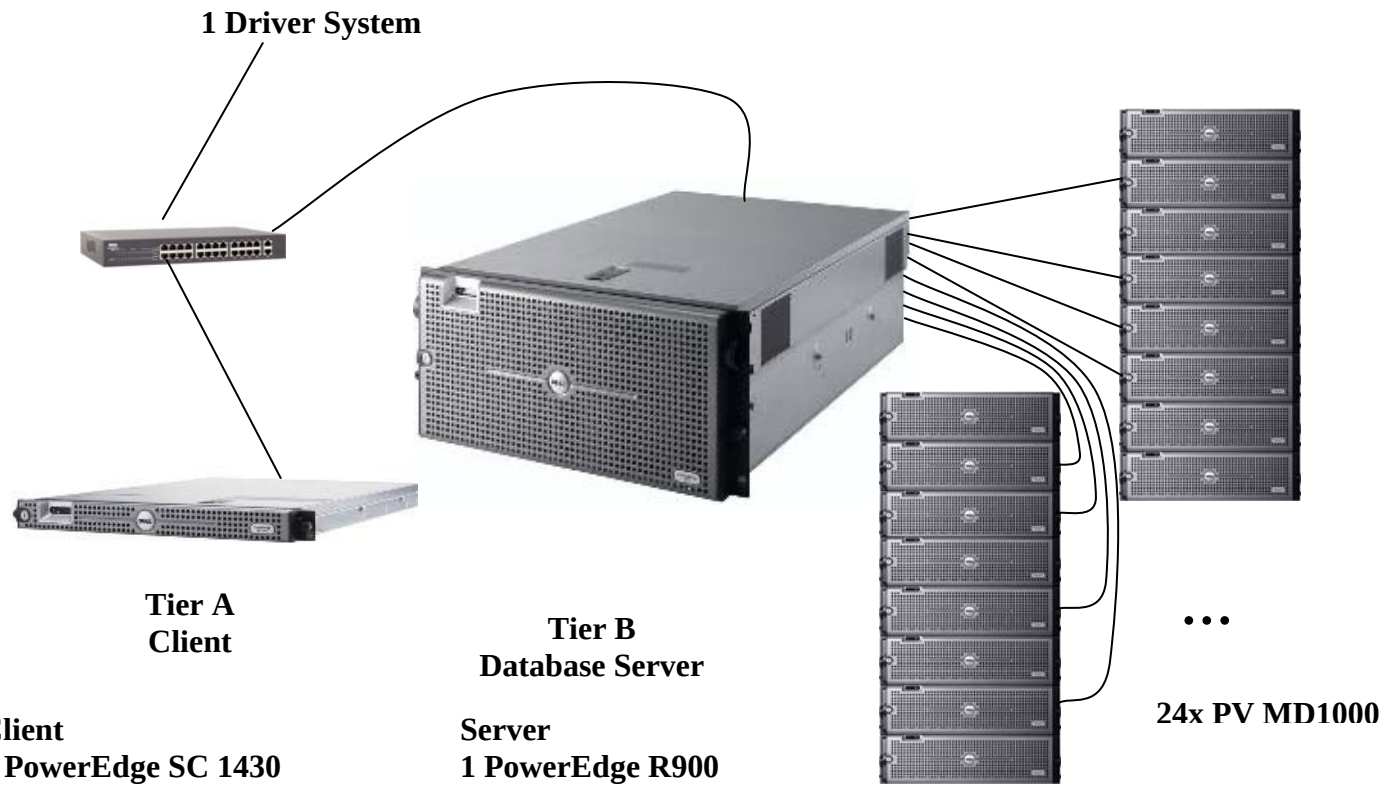
1 PERC6i SAS RAID Controller
6 MegaRAID SAS 8888ELP Cntrs
8 73GB 15k 2.5" SAS Disks

Storage

24 PowerVault MD1000
336 73GB 15k SAS Disks

Priced Configuration

Figure 2: *Priced Configuration*



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8 73GB 15k 2.5” SAS Disks

Storage

24 PowerVault MD1000
336 73GB 15k 3.5” SAS Disks

1.5: Hardware configuration

A description of the steps taken to configure all of the hardware must be reported in the Report. Any and all configuration scripts or step by step GUI instructions are reported in the Supporting Files (see Clause 9.4.1.1). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the hardware environment. (9.3.1.4)

The file ***PEr900_HardwareConfiguration.pdf*** in the *SupportingFiles* Directory ("Introduction") contains the hardware configuration used in running these TPC-E tests. The directory also contains the storage subsystem configuration in the file ***Storage_Hardware_config.pdf*** in the DiskSubsystem directory.

The hardware configuration used in this TPC-E test is a Dell PowerEdge R900 server (tier B) driven by one Dell PowerEdge SC 1430 (tierA) client. The clients and server are networked together via a Dell PowerConnect 2216 10/100/1000 BaseT switch. One Dell PowerEdge 1600 server was the driver system that emulated 375 users executing the standard TPC-E workload. The driver system is connected to the client via the Dell Powerconnect network switch. Microsoft Windows 2008 Enterprise Server x64 was the operating system used on the server. Microsoft Windows 2003 Enterprise Server x64 SP2 was the operating system used on the client system. Microsoft SQL Server 2008 Enterprise Edition x64 was the database management system on the server machine.

The PowerEdge R900 motherboard uses the Intel 7300 chipset and can hold up to four quad-core Intel Xeon MP processors (2.93 GHz with 8MB L2 cache each). The system has 7 PCI-e I/O slots. The measured configuration used 64Gbytes of DDR RAM, which was achieved by using 16 4096Mbyte DIMMs.

The PowerEdge R900 has an integrated PERC SAS controller to which was attached eight 73GB disk drives containing the operating system and databse logs. In addition, 6 MegaRAID SAS 8888ELP controllers were installed in 6 PCI-e slots and connected to 24 MD 1000 disk pods, which can hold 15 disks each. Each of the 4 controllers managed 4 RAID 10 LUNs. Each LUN had 14 physical drives. The total number of physical drives used for the database was 336 SAS disks. There were 1 empty PCI-e slots. Hyperthreading was not enabled on this server.

The PE sc 1430 client server has two Intel Quad-core Xeon processor with 2x4MB of L2 cache and a FSB rated at 1333MHz. The system had 2 Gbytes of RAM, two 73 GB hard disk, 2 intergrated Ethernet ports. The client connected to the driver machine and the DB server through a powerconnect switch. Hyperthreading was not enabled on this client.

1.6: Software Configuration

A description of the steps taken to configure all software must be reported in the Report. Any and all configuration scripts or step by step GUI instructions are reported in the Supporting Files (see Clause 9.4.1.2). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the software environment. (9.3.1.5)

The file ***SoftwareConfiguration.pdf*** in the *SupportingFiles* Directory (“Introduction”) contains the configuration and system parameters used in running these tests.

Clause 2: Database Design Scaling and Population

2.1: Physical Database Organization

The physical organization of tables and indices, within the database, must be reported in the Report. (9.3.2.1)

The **SupportingFiles/Clause2** folder contains the SQL definitions of all the required filegroups, tables and indexes.
The database tables and their indexes were divided into 3 file groups : Broker, Customer, market as shown in the table below :

***Table 2**: Physical database organization*

Broker File Group	Customer File Group	Market File Group
BROKER	ACCOUNT_PERMISSION	COMPANY
CASH_TRANSACTION	CUSTOMER	COMPANY_COMPETITOR
CHARGE	CUSTOMER_ACCOUNT	DAILY_MARKET
COMMISSION_RATE	CUSTOMER_TAXRATE	EXCHANGE
SETTLEMENT	HOLDING	FINANCIAL
TRADE	HOLDING_HISTORY	INDUSTRY
TRADE_HISTORY	HOLDING_SUMMARY	LAST_TRADE
TRADE_REQUEST	WATCH_ITEM	NEWS_ITEM
TRADE_TYPE	WATCH_LIST	NEWS_XREF
ADDRESS		SECTOR
TAXRATE		SECURITY
ZIP_CODE		STATUS_TYPE

2.2: Table and Row Partitioning

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

No partitioning implemented in this configuration.

2.3: Replications, Duplications and Additions

Replication of tables, if used, must be reported in the Report (9.3.2.3)

No replication implemented in this configuration.

Additional and/or duplicated attributes in any table must be reported in the Report along with a statement on the impact on performance (9.3.2.4)

No additional or duplicated attributes.

2.4: Initial Cardinality of Tables

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

The database was configured for 150,000 customers. The cardinality of the tables is as shown in table 2.2 below:

***Table 3*: Table Cardinality**

Table	Cardinality after database load
Account_Permission	1704196
Address	360004
Broker	2400
Cash_Transaction	3815424420
Charge	15
Commission_Rate	240
Company	120000
Company_Competitor	360000
Customer	240000
Customer_Account	1200000
Customer_Taxrate	480000
Daily_Market	214542000
Exchange	4
Financial	2400000
Holding	212296374
Holding_History	5557982603
Holding_Summary	11942250
Industry	102
Last_Trade	164400
News_Item	240000
News_Xref	240000
Sector	12
Security	164400
Settlement	4147200000
Status_Type	5
Taxrate	320
Trade	4147200000
Trade_History	9953295159
Trade_Request	0
Trade_Type	5
Watch_Item	24003797
Watch_List	240000
Zip_Code	14741

2.5: Disk Configuration Data

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

The Storage subsystem was configured as shown in Table 4. All database files were located on NTFS file systems. Backup devices were setup up on NTFS filesystems. Junction points were used to map to the NTFS partitions that contained the backup devices. The OS (C:\)drive was formatted for NTFS.

***Table 4**: Disk Configuration*

HBA#	Slot#	Disk#	Drives Enclosure model RAID level	OS Partition	Size	Use
0	internal	0	8x73GB,15K,SAS onboard RAID10	C:\	40GB	OS
		1	8x73GB,15K,SAS onboard RAID10	E:\	200GB	Logs
1	1	2	14x73GB,15K,SAS MD1000 RAID10	C:\A\A	118GB	Broker1
				C:\B\A	5GB	Customer1
				C:\C\A	24GB	Market1
				C:\D\A	327.25GB	Backup1
		3	14x73GB,15K,SAS MD1000 RAID10	C:\A\B	118GB	Broker2
				C:\B\B	5GB	Customer2
				C:\C\B	24GB	Market2
				C:\D\B	327.25GB	Backup2
		4	14x73GB,15K,SAS MD1000 RAID10	C:\A\C	118GB	Broker3
				C:\B\C	5GB	Customer3
				C:\C\C	24GB	Market3
				C:\D\C	327.25GB	Backup3
		5	14x73GB,15K,SAS MD1000 RAID10	C:\A\D	118GB	Broker4
				C:\B\D	5GB	Customer4
				C:\C\D	24GB	Market4
				C:\D\D	327.25GB	Backup4
2	2	6	14x73GB,15K,SAS MD1000 RAID10	C:\A\E	118GB	Broker5
				C:\B\E	5GB	Customer5
				C:\C\E	24GB	Market5
				C:\D\E	327.25GB	Backup5
		7	14x73GB,15K,SAS MD1000 RAID10	C:\A\F	118GB	Broker6
				C:\B\F	5GB	Customer6
				C:\C\F	24GB	Market6
				C:\D\F	327.25GB	Backup6

		8	14x73GB,15K,SAS MD1000 RAID10	C:\A\G	118GB	Broker7
				C:\B\G	5GB	Customer7
				C:\C\G	24GB	Market7
				C:\D\G	327.25GB	Backup7
		9	14x73GB,15K,SAS MD1000 RAID10	C:\A\H	118GB	Broker8
				C:\B\H	5GB	Customer8
				C:\C\H	24GB	Market8
				C:\D\H	327.25GB	Backup8
3	3	10	14x73GB,15K,SAS MD1000 RAID10	C:\A\I	118GB	Broker9
				C:\B\I	5GB	Customer9
				C:\C\I	24GB	Market9
				C:\D\I	327.25GB	Backup9
		11	14x73GB,15K,SAS MD1000 RAID10	C:\A\J	118GB	Broker10
				C:\B\J	5GB	Customer10
				C:\C\J	24GB	Market10
				C:\D\J	327.25GB	Backup10
		12	14x73GB,15K,SAS MD1000 RAID10	C:\A\K	118GB	Broker11
				C:\B\K	5GB	Customer11
				C:\C\K	24GB	Market11
				C:\D\K	327.25GB	Backup11
		13	14x73GB,15K,SAS MD1000 RAID10	C:\A\L	118GB	Broker12
				C:\B\L	5GB	Customer12
				C:\C\L	24GB	Market12
				C:\D\L	327.25GB	Backup12
4	4	14	14x73GB,15K,SAS MD1000 RAID10	C:\A\M	118GB	Broker13
				C:\B\M	5GB	Customer13
				C:\C\M	24GB	Market13
				C:\D\M	327.25GB	Backup13
		15	14x73GB,15K,SAS MD1000 RAID10	C:\A\O	118GB	Broker14
				C:\B\O	5GB	Customer14
				C:\C\O	24GB	Market14
				C:\D\O	327.25GB	Backup14
		16	14x73GB,15K,SAS MD1000 RAID10	C:\A\P	118GB	Broker15
				C:\B\P	5GB	Customer15
				C:\C\P	24GB	Market15
				C:\D\P	327.25GB	Backup15
		17	14x73GB,15K,SAS MD1000 RAID10	C:\A\Q	118GB	Broker16
				C:\B\Q	5GB	Customer16
				C:\C\Q	24GB	Market16
				C:\D\Q	327.25GB	Backup16

5	5	18	14x73GB,15K,SAS MD1000 RAID10	C:\A\R	118GB	Broker17
				C:\B\R	5GB	Customer17
				C:\C\R	24GB	Market17
				C:\D\R	327.25GB	Backup17
		19	14x73GB,15K,SAS MD1000 RAID10	C:\A\S	118GB	Broker18
				C:\B\S	5GB	Customer18
				C:\C\S	24GB	Market18
				C:\D\S	327.25GB	Backup18
		20	14x73GB,15K,SAS MD1000 RAID10	C:\A\T	118GB	Broker19
				C:\B\T	5GB	Customer19
				C:\C\T	24GB	Market19
				C:\D\T	327.25GB	Backup19
		21	14x73GB,15K,SAS MD1000 RAID10	C:\A\U	118GB	Broker20
				C:\B\U	5GB	Customer20
				C:\C\U	24GB	Market20
				C:\D\U	327.25GB	Backup20
6	6	22	14x73GB,15K,SAS MD1000 RAID10	C:\A\V	118GB	Broker21
				C:\B\V	5GB	Customer21
				C:\C\V	24GB	Market21
				C:\D\V	327.25GB	Backup21
		23	14x73GB,15K,SAS MD1000 RAID10	C:\A\W	118GB	Broker22
				C:\B\W	5GB	Customer22
				C:\C\W	24GB	Market22
				C:\D\W	327.25GB	Backup22
		24	14x73GB,15K,SAS MD1000 RAID10	C:\A\X	118GB	Broker23
				C:\B\X	5GB	Customer23
				C:\C\X	24GB	Market23
				C:\D\X	327.25GB	Backup23
		25	14x73GB,15K,SAS MD1000 RAID10	C:\A\N	118GB	Broker24
				C:\B\N	5GB	Customer24
				C:\C\N	24GB	Market24
				C:\D\N	327.25GB	Backup24

C:\..\back1[2] - C:\backup\back1
C:\..\back2[2] - C:\backup\back2
C:\..\back3[2] - C:\backup\back3
C:\..\back4[2] - C:\backup\back4
C:\..\back5[2] - C:\backup\back5
C:\..\back6[2] - C:\backup\back6
C:\..\back7[2] - C:\backup\back7
C:\..\back8[2] - C:\backup\back8
C:\..\back9[2] - C:\backup\back9
C:\..\back10[2] - C:\backup\back10
C:\..\back10[2] - C:\backup\back11
C:\..\back10[2] - C:\backup\back12
C:\..\back10[2] - C:\backup\back13
C:\..\back10[2] - C:\backup\back14
C:\..\back10[2] - C:\backup\back15

2.6: Database Interface

A statement must be provided in the Report that describes:
The Database Interface (e.g., embedded, call level) and access language (e.g., SQL, COBOL read/write) used to implement the TPC-E Transactions. If more than one interface / access language is used to implement TPC-E, each interface / access language must be described and a list of which interface /access language is used with which Transaction type must be reported. The data model implemented by the DBMS (e.g., relational, network, hierarchical). (9.3.2.7)
The methodology used to load the database must be reported in the Report. (9.3.2.8)

This test deployed Microsft SQL Server 2008 which is a relational database.
The client software interfaced to SQL Server via Stored Procedures invoked through ODBC calls driven by the C++ application code.
The methodology used to load the database is described in **Clause2** of the *SupportingFiles* directory (***MSTPCE Database Setup Reference.pdf***)

Clause 3: Transaction Items

3.1: Code Functionality

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

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

3.2: Database Requirements

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

Database footprint requirements were met as described in the specification.

Clause 4: SUT, Driver and Network

4.1: EGenDriver Items

The number of EGenDriverMEE and EGenDriverCE instances used in the benchmark must be reported in the Report (9.3.4.1)

There was 1 instance of EGenDriverMEE and 1 instance of EGenDriverCE

4.2: Network Configuration

The Network configurations of both the measured and Priced Configurations must be described and reported in the Report. This includes the mandatory Network between the Driver and Tier A (see Clause 4.2.2) and any optional Database Server interface networks (9.3.4.2)

Figure 1 and Figure 2 show the network connections of the configuration. The PE R900 server has an inbuilt network Ethernet controller with 2 1000MB/s ports. One of the ports is used to connect to the client (tier A) system via a Dell PowerConnect switch. The Client system also has an inbuilt network controller with 2 1000MB/s ports. One of these ports is connected to the driver system via the PowerConnect switch and satisfies the requirement for a mandatory network between tier A and the driver system.

Clause 5: EGen Items

5.1: EGen Version

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

The EGen version used was 1.5.0

5.2: EGen Code

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

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

5.3: EGen Modifications

If the Test Sponsor modified EGen, a statement EGen has been modified must be reported in the Report. All formal waivers from the TPC documenting the allowed changes to EGen must also be reported in the Report (see Clause 5.3.7.1). If any of the changes to EGen do not have a formal waiver that must also be reported (9.3.5.3)

There were no modifications to the EGen other than the fix required by version 1.5.0.

5.4: EGen Loader Extension Code

If the Test Sponsor extended EGenLoader (as described in Appendix A.6), the use of the extended EGenLoader and the audit of the extension code by an Auditor must be reported (9.3.5.4)

There was no use and no implementation of the EGenloader extension code.

Clause 6: Performance Metrics and Response time

6.1: Measured Throughput (tpsE)

The Measured Throughput must be reported (9.3.6.1)

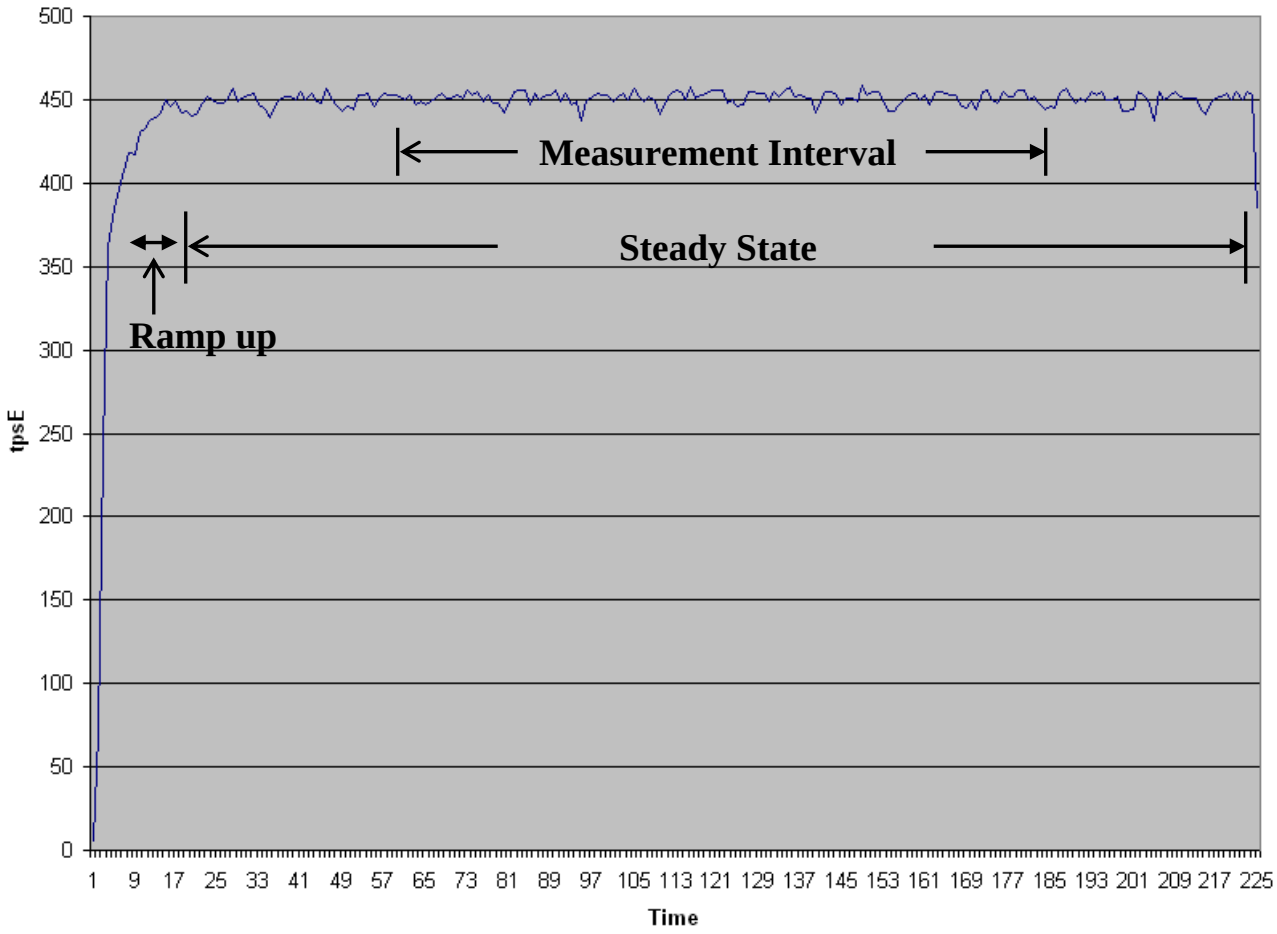
The measured tpsE was 451.29

6.2: Test Run times

A Test Run Graph of throughput versus elapsed wall clock time must be reported in the Report for the Trade-Result Transaction (see Clause 6.7.2). (9.3.6.2)

The transaction step report for the performance run was evaluated and drawn as shown in Figure 3.

***Figure 3**: Steady State graph*



6.3: Steady State Measurement

The method used to determine that the SUT had reached a Steady State prior to commencing the Measurement Interval must be reported. (9.3.6.3)

It can be seen that after ramp-up a steady state was maintained through outt the measurement interval and until the run was stopped.
A 1 hour window sliding by 10 mins in steady state was evaluated and was found to vary by 0.30%. A 10 min window sliding by 1 min was found to vary by 2.00%.

6.4: Work Measurements during Test Run

A description of how the work normally performed during a Test Run, actually occurred during the Measurement Interval must be reported in the Report (for example checkpointing, writing Undo/Redo Log records, etc.). (9.3.6.4)

The driver generated the required transactions and their input data. This data was timestamped. Response for the requested transaction was verified and time-stamped in the driver log files. Log file contents are consolidated for the reports.
The driver engine accessed the application processes running on the client system via an Ethernet network connection. The client application processes handled all requests to the database on the server. The applications communicated with the database server over an Ethernet connection using SQL Server ODBC library and RPC calls.
To perform checkpoints at specific intervals, the SQL Server recovery interval was set to 32767. Continuous checkpoints every 7.5 minutes were performed during steady state before and during the measurement interval by the driver engine. SQL Server was started with trace flag 3502, which caused it to log the occurrence of the checkpoints. This information was used to verify that the checkpoints occurred at the appropriate times during the test run.

6.5: Transaction Averages

The recorded averages over the Measurement Interval for each of the Transaction input parameters specified by clause 6.4.1 must be reported. (9.3.6.5)

The transaction averages were recorded as shown in Table 5.

***Table 5**: Transaction Averages*

Transaction	Overall	Parameter	Value	Range Check	Acceptable Range Min	Max
Customer Position	Ok	By Tax ID	50.01%	**Ok**	48.00%	52.00%
		Get history	49.96%	**Ok**	48.00%	52.00%
Trade Lookup	Ok	Frame 1	30.00%	**Ok**	28.50%	31.50%
		Frame 2	30.03%	**Ok**	28.50%	31.50%
		Frame 3	29.98%	**Ok**	28.50%	31.50%
		Frame 4	9.99%	**Ok**	9.50%	10.50%
Market Watch	Ok	By Watch List	60.01%	**Ok**	57.00%	63.00%

		By Customer Account	35.00%	**Ok**	33.00%	37.00%
		By Industry	4.99%	**Ok**	4.50%	5.50%
Trade Update	Ok	Frame 1	33.06%	**Ok**	31.00%	35.00%
		Frame 2	32.95%	**Ok**	31.00%	35.00%
		Frame 3	33.99%	**Ok**	32.00%	36.00%
Security Detail	Ok	Access LOB	1.00%	**Ok**	0.90%	1.10%
Trade Order	Ok	By Non-Owner	10.02%	**Ok**	9.50%	10.50%
		By Company Name	39.99%	**Ok**	38.00%	42.00%
		Buy on Margin	8.02%	**Ok**	7.50%	8.50%
		Rollback	0.99%	**Ok**	0.94%	1.04%
		LIFO	35.00%	**Ok**	33.00%	37.00%
		Trade Quantity 100	25.03%	**Ok**	24.00%	26.00%
		Trade Quantity 200	24.99%	**Ok**	24.00%	26.00%
		Trade Quantity 400	25.00%	**Ok**	24.00%	26.00%
		Trade Quantity 800	24.98%	**Ok**	24.00%	26.00%
		Market Buy	30.01%	**Ok**	29.70%	30.30%
		Market Sell	29.96%	**Ok**	29.70%	30.30%
		Limit buy	20.03%	**Ok**	19.80%	20.20%
		Limit sell	9.99%	**Ok**	9.90%	10.10%
		Stop Loss	10.01%	**Ok**	9.90%	10.10%

Clause 7: Transaction and System Properties

7.1 : Transaction Properties (ACID)

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

The benchmark specification requires that a system under test (SUT) must support a set of properties during the execution of the benchmark. Those properties are ACID and Redundancy.
This section defines each of these properties, describes the steps taken to ensure that they were present during the test and describes a series of tests done to demonstrate compliance with the specification. See file ***MSTPCE ACID Procedures.pdf*** in the *SupportingFiles* directory (Clause 7).

7.2: Redundancy Level

The Test Sponsor must report in the Report the Redundancy Level (see Clause 7.5.7.1) and describe the test(s) used to demonstrate compliance. (9.3.7.2)

Redundancy level 1 was used for all storage systems.

7.3: Data Accessibility Tests

A description of the Data Accessibility tests run and the Redundancy Level they were demonstrating must be reported. (9.3.7.3)

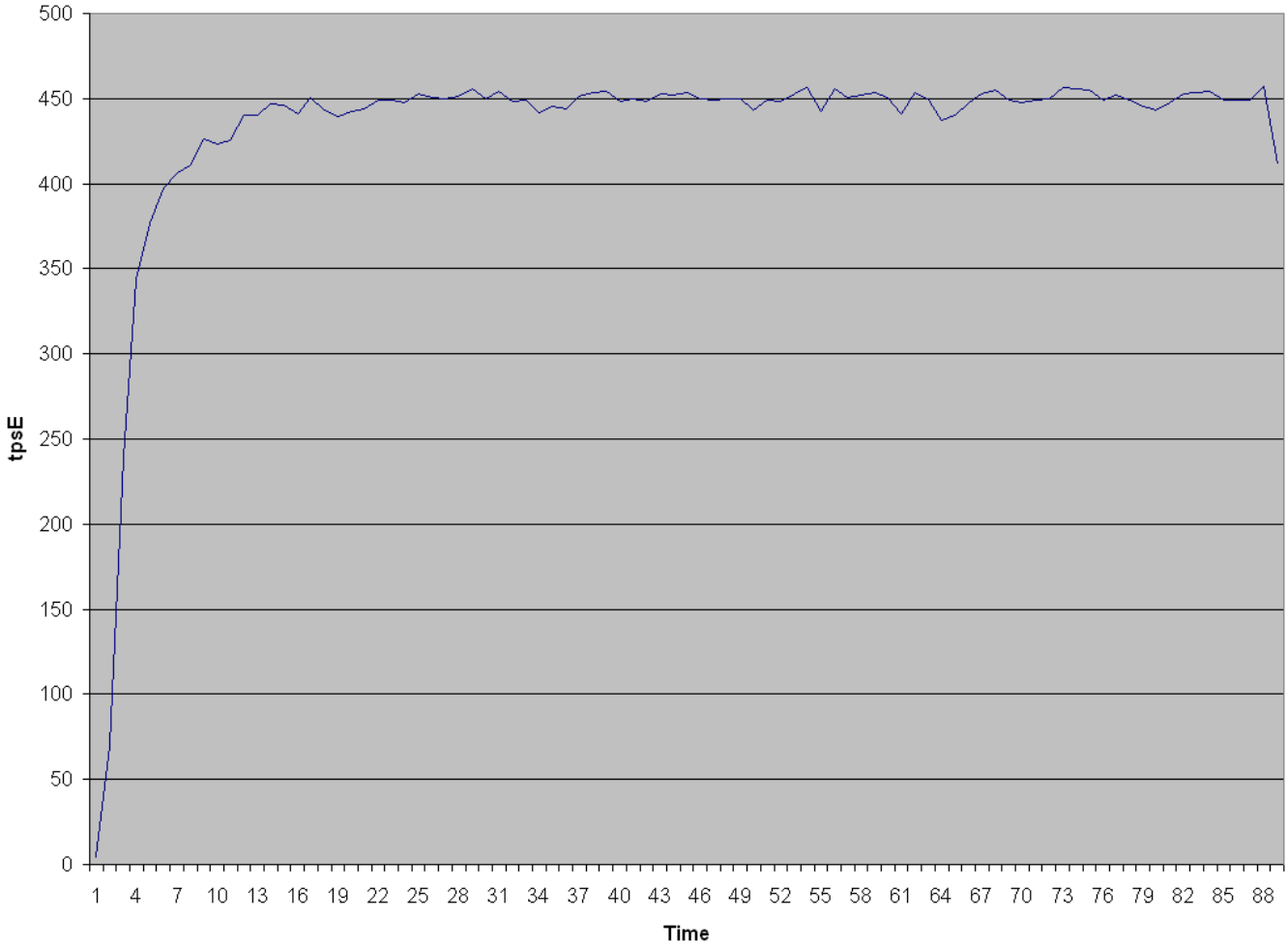
1. A restore was executed to yield a fresh database.
2. The rows in the Settlement table were counted to determine the initial count of completed trades present in the database (count-before).
3. A performance run was started with the same number of configured customers and driver load used for the measurement interval.
4. The test ramped up, and executed at or above 95% of the Reported Throughput for 30 mins.
5. After 30mins, a log disk drive was pulled from the disk pod.
6. The driver continued running normally for 5 mins.
7. After an additional 5mins, a data disk drive was pulled from the disk pod.
8. The drivers continued running normally with no errors logged in the SQL errorlog and OS logs.
9. After an additional 30mins the driver was stopped gracefully.
10. A transaction report for the test was generated and the number of Trade_Result transactions recorded during the run was noted.
11. The faulty log and data disk drives were replaced by spare disks of similar characteristics.
12. The Database was allowed to recover normally

13. Step 2 was repeated to determine the total number of completed trades present in the database (count-after)
14. count-after minus count-before was verified to be equal to the number of successful Trade-Result transaction records in the driver log file.
15. Consistency tests were run to ensure that the database was in a consistent state.

7.4: Data Accessibility Test Graph

A Data Accessibility Graph for each run demonstrating a Redundancy Level must be reported (9.3.7.4)

Figure 4: Data Accessibility Graph



7.5: Business Recovery Tests

The Test Sponsor must describe in the Report the test(s) used to demonstrate Business Recovery. (9.3.7.5)

Power to the SUT was removed as a way of demonstrating recovery from a system crash:

1. A restore was executed to yield a fresh database.
2. The rows in the Settlement table were counted to determine the initial count of completed trades present in the database (count-before).
3. A performance run (Run1) with the same number of configured customers and driver load was started and ramped up to steady state.
4. The test ran at 95% and above of reported throughput for 30mins.
5. Power to tier A and tier B systems was pulled.
6. After transaction failures were noted by the drivers, the drivers were stopped
7. Power to the SUT was returned.
8. Database recovery started. That marked the beginning of business recovery.
9. Database recovery was completed successfully
10. Transaction cleanup was executed on the database.
11. A performance run (Run2) was started.
12. The test ramped-up to steady state.
13. Business recovery ends when the test attains at least 95% of reported throughput and maintains that rate or above thereafter.
14. The test was allowed to run in steady-state for 2hrs 30mins.
15. The drivers were stopped gracefully.
16. Transaction reports for Run1 and Run2 were generated and the count of Trade_Results transactions for both runs were noted and summed.
17. Step 2 was repeated to determine the total number of completed trades present in the database (count-after)
18. count-after minus count-before was verified to be equal to the number of successful Trade-Result transaction (sum of Run1 and Run2) records in the driver log file.
19. Consistency tests were run to ensure that the database was in a consistent state.

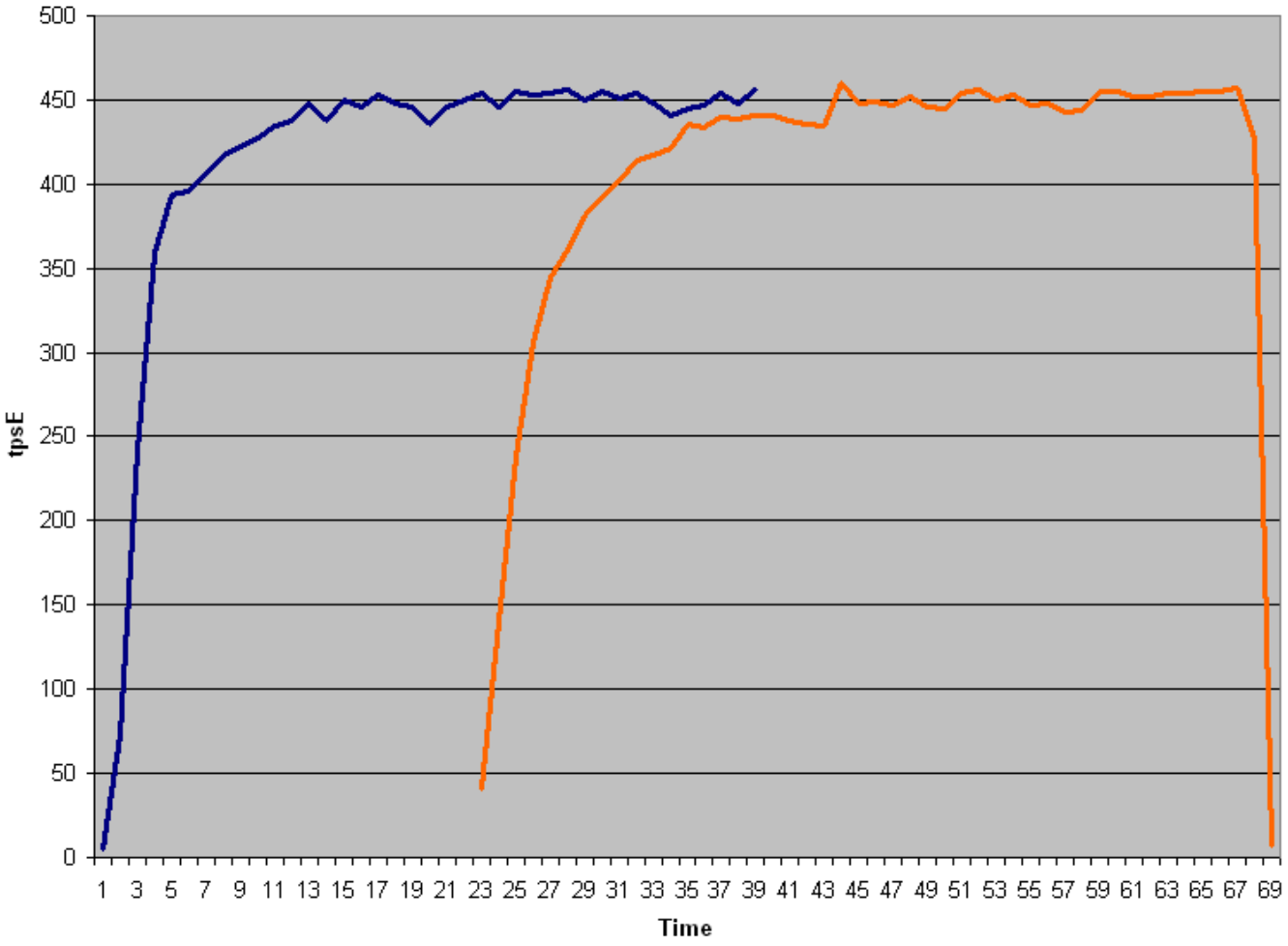
7.6: Business Recovery Time

The Business Recovery Time must be reported on the Executive Summary Statement and in the report.If the failures described in clauses 7.5.2.2, 7.5.2.3, and 7.5.2.4 were not combined into one Durability Test (Usually powering off the database during the run), then the Business Recovery Time for the failure described for instantaneous interruption is the Business Recovery Time that must be reported in the Executive Summary Statement. All the Business Recovery Times for each test requiring Business Recovery must be reported in the Report. (9.3.7.6)

A Business Recovery Graph (see clause 7.5.7.4) must be reported in the Report for all Business Recovery Tests. (9.3.7.7)

The Business Recovery Time was determined to be 48mins 4s. This is also recorded in the Executive Summary.

***Figure 5**: Business Recovery Tests Graph*



Clause 8: Pricing

8.1: 60-day space

Details of the 60-Day Space computations (see Clause 8.2.2) along with proof that the database is configured to sustain a Business Day of growth (see Clause 6.6.6.1) must be reported. (9.3.8.1)

***Table 6:** Space Requirements*

Space calulcations for TPC-E		Customers:	240,000						
		TpsE:	451.29						
		TradeResult count:	5,981,736						
Table	**Rows**	**Data(KB)**	**Index(KB)**	**Total**	**Total + 5%**	**Rows After**	**Data After(KB)**	**Index After(KB)**	**Growth**
ACCOUNT_PERMISSION	1704196	170448	1144	171,592	180,172	1704196	170448	1144	0
ADDRESS	360004	20760	328	21,088	22,142	360004	20800	328	40
BROKER	2400	192	1256	1,448	1,520	2400	320	1272	144
CASH_TRANSACTION	3815424420	377192408	796976	377,989,384	396,888,853	3820928255	386780976	1571576	10363168
CHARGE	15	8	8	16	17	15	8	8	0
COMMISSION_RATE	240	16	16	32	34	240	16	16	0
COMPANY	120000	26072	7512	33,584	35,263	120000	26072	7512	0
COMPANY_COMPETITOR	360000	9664	8144	17,808	18,698	360000	9664	8144	0
CUSTOMER	240000	40640	10928	51,568	54,146	240000	40656	10936	24
CUSTOMER_ACCOUNT	1200000	111448	133048	244,496	256,721	1200000	111448	133048	0
CUSTOMER_TAXRATE	480000	10016	336	10,352	10,870	480000	10168	352	168
DAILY_MARKET	214542000	10948016	4592616	15,540,632	16,317,664	214542000	10949248	4592824	1440
EXCHANGE	4	8	8	16	17	4	8	8	0
FINANCIAL	2400000	282392	1064	283,456	297,629	2400000	282568	1168	280
HOLDING	212296374	11237208	8308144	19,545,352	20,522,620	212449759	18825480	8660960	7941088
HOLDING_HISTORY	5557982603	202108488	105329240	307,437,728	322,809,614	5566045516	202827992	105814408	1204672
HOLDING_SUMMARY	11942250	401544	1728	403,272	423,436	11942320	803032	4640	404400
INDUSTRY	102	8	40	48	50	102	8	40	0
LAST_TRADE	164400	7584	328	7,912	8,308	164400	15112	336	7536
NEWS_ITEM	240000	26433328	584	26,433,912	27,755,608	240000	26433352	608	48
NEWS_XREF	240000	5968	328	6,296	6,611	240000	5968	328	0
SECTOR	12	8	24	32	34	12	8	24	0
SECURITY	164400	25752	11440	37,192	39,052	164400	25760	11440	8
SETTLEMENT	4147200000	203520864	429248	203,950,112	214,147,618	4153181736	212648096	858248	9556232
STATUS_TYPE	5	8	8	16	17	5	8	8	0
TAXRATE	320	64	88	152	160	320	72	88	8
TRADE	4147200000	457532528	244901408	702,433,936	737,555,633	4153206624	470089704	248688176	16343944
TRADE_HISTORY	9953295159	285399176	744208	286,143,384	300,450,553	9967663752	286512496	748832	1117944
TRADE_REQUEST	0	0	0	-	-	24888	3456	5736	9192
TRADE_TYPE	5	8	1032	1,040	1,092	5	8	1032	0
WATCH_ITEM	24003797	650632	2600	653,232	685,894	24003797	650776	2792	336
WATCH_LIST	240000	5968	5216	11,184	11,743	240000	5968	5216	0
ZIP_CODE	14741	512	336	848	890	14741	512	336	0
Totals in KB	28091817447	1576141736	365289384	1941431120	2038502676		1617250208	371131584	46950672

						file size
Database File Groups	**Allocated size MB**	**Required size MB**	**Diff**			# of files
Customer_fg	525,504	344,046	181,458	OK		total in KB (*8)
Broker_fg	2,625,168	1,610,428	1,014,740	OK		
Market_fg	99,120	43,443	55,677	OK		
Total	3,249,792					
Total in GB	3,173.6					

Growing Space	46,940,640	KB	
per Trade Results	7.85	KB	
Data Growth	101,992,905	KB	
60 Day Space	8,061,005,435	KB	
60 Day Space	7,688	GB	
		%	size
Log space before in MB	4,737	204000	2.321898
Log space after in MB	69,366	204000	34.002872
per Trade Results	0.011		
Log Growth	140,427	MB	
Total 8 hours log space	145,163	MB	
Total 8 hours log space	141.76	GB	

	Count	Formatted size GB	Total GB Configured	Total Needed
Data Disks configured	0	33.37	-	
	336	67.75	22,764	
	0	135.49	-	
RAID 10 overhead 50%			(11,382)	
Data Disks space total			**11,382**	7,688
Log Disks configured	8	67.75	542	
RAID 10 overhead 50%			(271)	
Log Disk space total			271	142

8.2: Attestation Letter

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

This configuration and benchmark test was audited by a TPC certified auditor Lorna Livingtree as shown by the attestation letter shown below:

July 7, 2008

Mr. Gene Purdy
Dell, Inc.
One Dell Way
Round Rock, TX 78682

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

Platform: Dell R900
Database Manager: Microsoft SQL Server 2008 Enterprise x64 Edition
Operating System: Microsoft Windows Sever 2008 Enterprise x64 Edition

Server (Tier B): R900			
CPU's	Memory	Disks (total)	tpsE
1 Intel Xeon quad core @ 2.93 Ghz	64 GB	344 @ 73 GB	**451.29**
Clients (Tier A): 1 PE SC 1430			
2 Intel quad core @ 1.59 Ghz	2 GB	1 @ 80 GB	Na

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

- All EGen components were verified to be version 1.5.0.
- The database files were properly sized and populated for 240,000 customers.
- The transaction components were properly implemented.
- The required network between the driver and the transaction harness was configured.

- The ACID properties were successfully demonstrated.
- The database was verified to have no Trade-Request rows prior to the start of the test run.
- The test run met all the requirements for timing, mix, and response times.
- Input data was generated according to the specified percentages.
- One and only one Data-Maintenance process was running during the test run.
- There were no inactive load units during the test run.
- Eight hours of mirrored log space was present on the measured system.
- Eight hours of growth space was present on the measured system.
- The data for the 60 day space calculation was verified.
- There were 375 user contexts present on the system.
- The steady state portion of the test was 120 minutes.
- One checkpoint was taken after steady state and before the measured interval.
- Checkpoint interval was verified to be equal to or less than 7.5 minutes.
- The system pricing was checked for major components and maintenance.
- Third party quotes were verified for compliance.
- The FDR was reviewed and verified as required.

Auditor Notes:
None.

Sincerely,

Lorna Livingtree
Auditor

Clause 9: Supporting Files

9.1: Supporting Files

An index for all files required by Clause 9.4 Supporting Files must be provided in the Report. The Supporting Files index is presented in a tabular format where the columns specify the following:

- *The first column denotes the clause in the TPC Specification*
- *The second column provides a short description of the file contents*
- *The third column contains the path name for the file starting at the SupportingFiles directory.*

If there are no Supporting Files provided then the description column must indicate that there is no supporting file and the path name column must be left blank. (9.3.9.1)

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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

Microsoft

June 27, 2008

Dell
Gene Purdy
1 Dell Way
Round Rock, TX 78664

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
	SQL Server 2008 Enterprise x64 Edition *Per Processor License* *Discount Schedule: Open Program - Level C* *Unit Price reflects a 6% discount from the retail unit price of $24,999.*	$23,432	4	$93,728
P72-03168	**Windows Server 2008 Enterprise Edition (x64)** *Server License with 25 CALs* *Discount Schedule: Open Program - Level C* *Unit Price reflects a 42% discount from the retail unit price of $3,999.*	$2,310	1	$2,310
P72-01684	**Windows Server 2003 R2 Enterprise x64 Edition** *Server License Only - No CALs* *Discount Schedule: Open Program - No Level* *Unit Price reflects a 42% discount from the retail unit price of $3,999.*	$2,334	1	$2,334
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident)*	$245	1	$245

Windows Server 2008 and Windows Server 2003 are currently orderable through Microsoft's normal distribution channels. A list of Microsoft's resellers can be found at **http://www.microsoft.com/products/info/render.aspx?view=22&type=mnp&content=22/licensing**

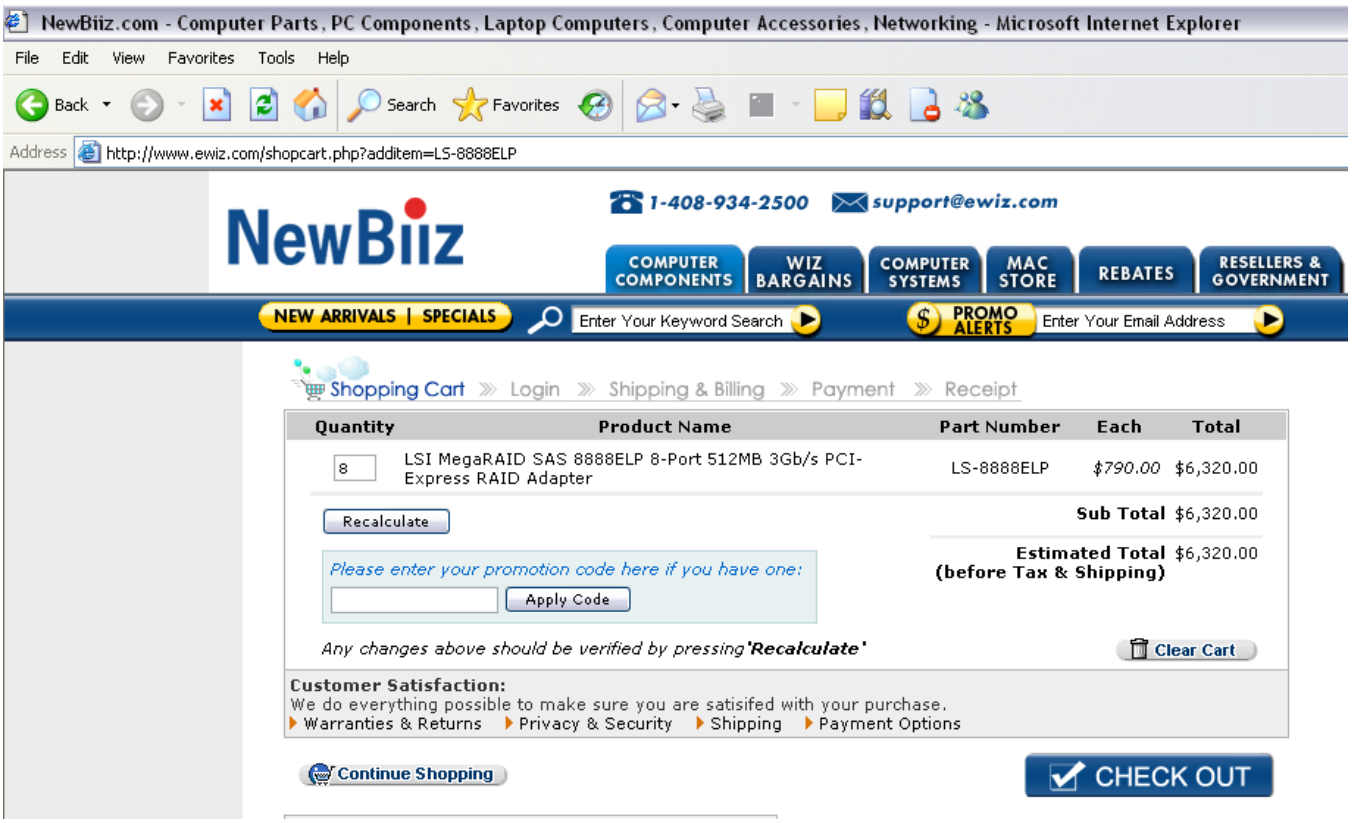
SQL Server 2008 will be orderable and available by August 30, 2008.

Defect support is included in the purchase price. Additional support is available from Microsoft PSS on an incident by incident basis at $245 per call.

This quote is valid for the next 90 days.

If we can be of any further assistance, please contact Jamie Reding at (425) 703-0510 or jamiere@microsoft.com.

Reference ID: PEgepu0806270000000143.
Please include this Reference ID in any correspondence regarding this price quote.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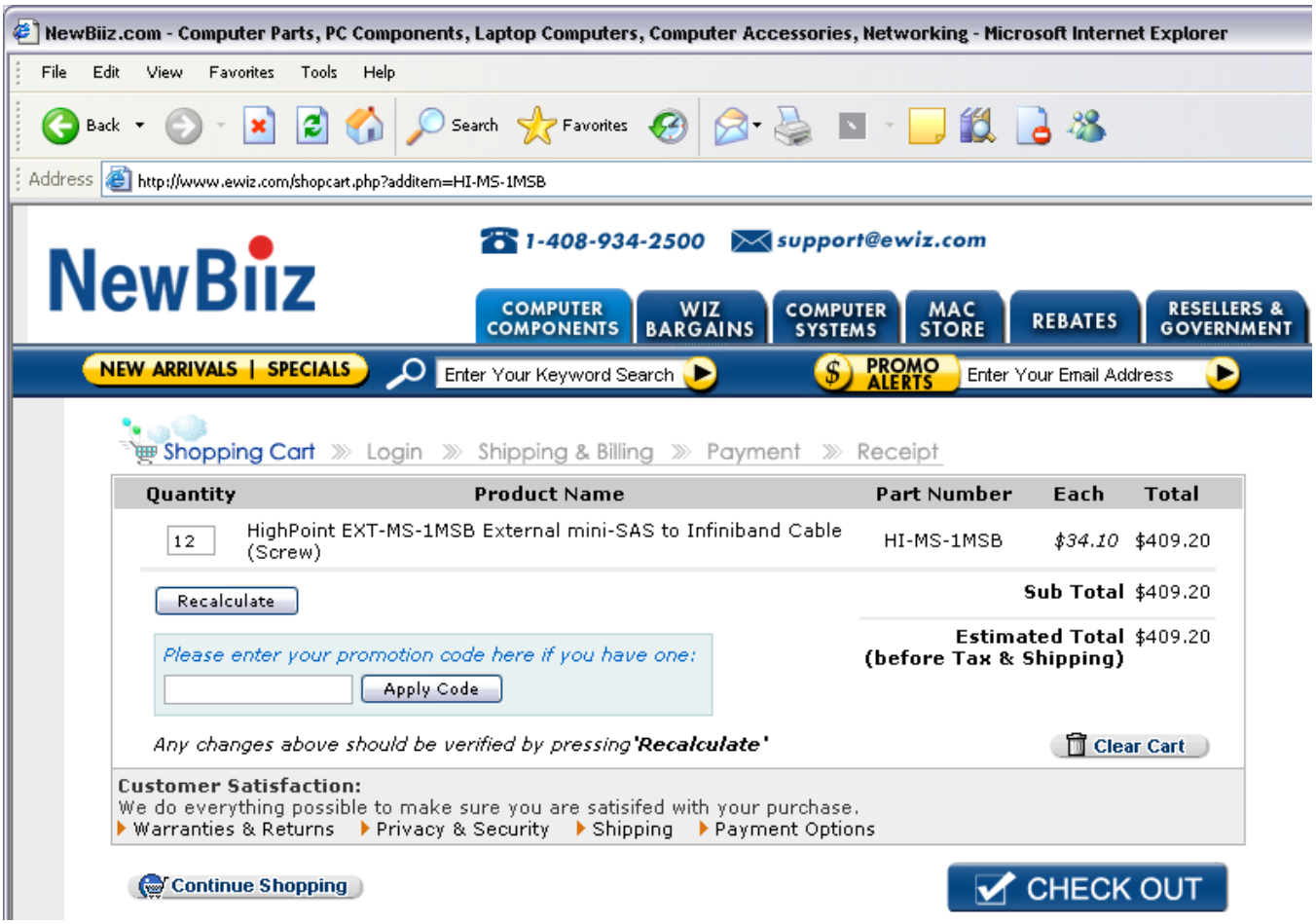
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