TPC Benchmark® VMS
Full Disclosure Report

HP ProLiant DL385p Gen8

Using Microsoft SQL Server 2012 Enterprise Edition SP1
On Microsoft Windows Server 2012 Standard Edition
With VMware vSphere 5.5

First Edition
August 26, 2013

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Abstract

Overview

This report documents the methodology and results of the TPC Benchmark® VMS (TPC-VMS) test conducted on the HP ProLiant DL385p Gen8. The operating system used for the benchmark was Microsoft Windows Server 2012 Standard Edition running as a guest. The Hypervisor used was VMware ESX 5.5.

TPC Benchmark® VMS Metrics

The standard TPC Benchmark ® VMS metrics, VMStpsE® (transactions per second), price per VMStpsE ® (three year capital cost per measured VMStpsE ®) and the availability date are reported as required by the benchmark specification.

TPC Benchmark® Energy Metrics

The standard TPC Benchmark ® Energy metrics, watts per tpsE is optionally reported by the benchmark specification.

Standard and Executive Summary Statements

The following pages contain the Executive Summary of the benchmark results for the system.

Auditor

The benchmark configuration, environment and methodology used to produce and validate the test results, and the pricing model used to calculate the cost per tpsE®, were audited by Doug Johnson for InfoSizing to verify compliance with the relevant TPC specifications.

Introduction

This is the full disclosure report for a benchmark test of the HP ProLiant DL385p Gen8 using Microsoft SQL Server 2012 Enterprise Edition SP1. It meets the requirements of the TPC Benchmark ® VMS Standard Specification, Revision 1.1.0 dated November 2012. TPC Benchmark® VMS was developed by the **T**ransaction Processing **P**erformance **C**ouncil (TPC). It is the intent of this group to develop a suite of benchmarks to measure the performance of computer systems executing a wide range of applications. Hewlett-Packard Company, Microsoft, Inc. and VMware are active participants in the TPC.

The requirements for this Full Disclosure Report are in Clause 7 of TPC Benchmark ® VMS Specification.

TPC Benchmark® VMS Overview

The TPC-VMS Specification leverages existing **TPC Benchmarks**, namely; TPC-C, TPC-E, TPC-DS and TPC-H. Each of these benchmarks represents a specific set of customer environments and details can be found in the relevant benchmark specification. For example, TPC-E exercises database server transaction functionality for a financial environment that receives work requests from multiple sources. TPC-VMS defines four new benchmarks that are neither comparable to each other nor to the base benchmarks from which they are derived.

From a market sizing standpoint, the **TPC Benchmarks** span diverse end-customer business environments ranging from small-sized business to large-sized corporate IT datacenters. The TPC-VMS Specification defines methodologies to determine virtualization efficiency for data processing servers deployed in these diverse customer environments.

The primary metric reported as defined by TPC-VMS is in the form of VMS "performance" where the performance units are specific by each TPC Benchmark, e.g. VMStpmC, VMStpsE, VMSQphH or VMSQphDS.

Goals

The goals for measuring **TPC Benchmarks** in a virtualized environment are as follows:

- Provide a consolidated system workload for three database environments running in a **Virtualization Environment**.
- Provide virtualization metrics that are based on existing **TPC Benchmark Standards**.
- Provide for repeatable measurements.
- Provide requirements for disclosure and documentation of the measurements to ensure compliance with this specification.
- Leverage existing **TPC Benchmark Standards** without requiring any implementation changes.

Restrictions and Limitations

Despite the fact that **TPC benchmarks** offer a rich environment that represents many typical IT applications, these benchmarks do not reflect the entire range of customer IT requirements. In addition, the extent to which a customer can achieve the **Results** reported by a vendor is highly dependent on how closely the TPC-VMS measurements and configuration approximates the customer application. The relative performance of systems derived from these benchmarks does not necessarily hold for other workloads or environments. Extrapolations to any other environments are not recommended.

Benchmark **Results** are highly dependent upon workload, specific application requirements, and systems design and implementation. Relative system performance and virtualized environments will vary because of these and other factors. Therefore, **TPC-VMS Results** should not be used as a substitute for specific customer application benchmarking when critical capacity planning and/or product evaluation decisions are contemplated.

HP ProLiant DL385p Gen8
AMD Opteron™ 6386SE Processor
C/S with 1 Proliant DL360 G7

TPC-VMS: 1.1.0
TPC-E: 1.12.0
TPC Pricing: 1.7.0
Report Date: August 26, 2013

TPC-VMS Throughput	Price/Performance	Availability Date	Total System Cost
457.55 VMStpsE	$571 USD/VMStpsE	September 30, 2013	$261,121 USD

Virtual System Under Test Configuration

VMMS	Processor/Cores/Thread	Memory
VMware vSphere 5.5	2/32/32 AMD Opteron™ 6386SE Processor 2.8GHz GHz 16 MB L3	256 Gbyte

Tier B: Server
HP ProLiant DL385p Gen8

2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor (2/32/32)
256 GB Memory
3 x HP Smart Array P421/2GB, One per each VM
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 146GB SAS 15K SFF DP ENT HDD 2 Drives for each VM (Database Log)

Tier A: Client

1 x ProLiant DL360 G7
2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz
2 x 8GB PC3-10600 Memory
2 x 146GB 6G SAS 15K SFF DP
4 x Onboard 1Gbps Ethernet

Storage

3 x HP StorageWorks D2700 Disk Enclosure, one per each VM
24 X HP 400GB 6G SATA MLC SFF (2.5-inch) SSD 8 per enclosure, per VM.

Priced Only
6 x 500GB 6G SAS 15K SFF DP ENT HDD (60 Day Space)

	HP ProLiant DL385p Gen8 AMD Opteron™ 6386SE Processor C/S with 1 Proliant DL360 G7		TPC-VMS: 1.1.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date: August 26, 2013
	VM1	VM2	VM3
Performance	457.55 tpsE	468.11 tpsE	470.31 tpsE
Maximum Number of Virtual Processors	10	10	10
VM Memory	80GB	80GB	80GB
Maximum Capacity of Virtual Storage	4173GB	4173GB	4173GB
Operating System	Microsoft Windows Server 2012 Standard Edition	Microsoft Windows Server 2012 Standard Edition	Microsoft Windows Server 2012 Standard Edition
Database Manager	Microsoft SQL Server 2012 Enterprise Edition SP1	Microsoft SQL Server 2012 Enterprise Edition SP1	Microsoft SQL Server 2012 Enterprise Edition SP1
Scaling Component	240,000	240,000	240,000
Initial Number of Row Per VM	28,091,588,432	28,091,588,432	28,091,588,432
Initial Database Size Per VM	1961GB	1961GB	1961GB

	HP ProLiant DL385p Gen8 TPC-VMS 1.1.0				TPC-E	1.12.0
					TPC-Pricing	1.7.0
					Report date	26-Aug-13
					Availability Date	30-Sep-13
Description	**Part Number**	**Brand**	**Unit Price**	**Qty.**	**Extended Price**	**3 Yr Maint Price**
Server Hardware (Tier B)						
HP ProLiant DL385p Gen8 8 SFF Configure-to-order Server	653203-B21	1	2,563	1	2,563	
Gen8 AMD Opteron™ 6386SE (2.8GHz/16-core/16MB/140W) Processor	703939-B21	1	1,799	2	3,598	
16GB (1x16GB) Dual Rank x4 PC3-12800R (DDR3-1600) Registered Memory	672633-B21	1	319	16	5,104	
HP 146GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise	652605-B21	1	339	8	2,712	
HP Smart Array P421/2GB FBWC 6Gb 2-ports Ext SAS Controller	631674-B21	1	899	3	2,697	
HP 3 year 4 hour 24x7 ProLiant DL38x(p) Hardware Support	U4545E	1	1,371	1		$1,371
			Subtotal		**$16,674**	**$1,371**
Server Software						
SQL Server 2012 Enterprise Edition SP1, 2 Core License	7JQ-00256	2	13,472.50	12	161,670	
Windows Server 2012 Standard Edition	P73-05761	2	735	2	1,470	
Microsoft Problem Resolution Services	N/A	2	259	1		259
VMware VSphere 5.5 Enterprise 1 Processor	BD713AAE	1	$4,678	2	9,356	
			Subtotal		**$172,496**	**259**
Storage						
HP D2700 Disk Enclosure	AJ941A	1	3,399	4	13,596	
HP 3 year 4 hour 24x7 D2000 Enclosure Hardware Support	UQ540E	1	1,980	4		7,920
HP 400GB 3G SATA MLC SFF (2.5-inch) SC Enterprise Mainstream	653120-B21	1	3,019	24	72,456	
HP 500GB 6G SAS 7.2K rpm SFF DP Midline Hard Drive (60 Day)	507610-B21	1	369	6	2,214	
			Subtotal		**88,266**	**7,920**
Client Hardware (Tier A)						
HP ProLiant DL360 G7 CTO Server	579237-B21	1	1,721	1	1,721	
HP DL360 G7 Intel® Xeon® X5670 (2.93GHz/6-core/12MB/95W) Processor	588062-B21	1	2,099	2	4,198	
HP 8GB (1x8GB) Dual Rank x8 PC3-10600 Memory Kit	500662-B21	1	169	2	338	
HP 146GB 6G SAS 15K rpm SFF (2.5-inch) Enterprise 3yr Warranty Hard Drive	512547-B21	1	369	2	738	
HP 3y 4h 24x7 ProLiant DL36x HW Support ,ProLiant DL36x	U4497E	1	1,086	1		1,086
			Subtotal		**6,995**	**1,086**
Client Software						
Microsoft Windows Server 2008 R2 Enterprise Edition	P72-04217	2	2,280	1	2,280	
			Subtotal		**2,280**	**0**
Infrastructure						
HP 1.2m/4ft CAT5 RJ45 M/M Ethernet Cable	C7533A	1	4.00	5	20	
HP V142 1075mm deep Pallet 100 series Rack	AF046S	1	709	1	709	
HP W2072a 20-inch Diagonal LED Backlit LCD Monitor	A3M50AA#ABA	1	143	1	143	
HP Keyboard And Mouse Bundle	LV290AA#ABL	1	18	1	18	
			Subtotal		**890**	**0**
		Total Extended Price			**$287,601**	**$10,636**
Large Purchase and Net 30 discount (See Note 1)	28.0%	**Total Discounts**			**$34,211**	**$2,906**
		Grand Total			**$253,390**	**$7,730**

Pricing: 1=HP Direct 800-203-6748 2= Microsoft. Note 1: Discount based on HP Direct guidance applies to all lines where pricing = 1. Note 2: All the hardware are available to order. Note 3: The benchmark results were audited by Doug Johnson for InfoSizing. www.infosizing.com.

Three-year Cost of Ownership: USD	**$261,121**
tpsE	**457.55**
$ USD/VMStpsE	**$571**

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 terms, please inform at pricing@tpc.org. Thank you.

	HP ProLiant DL385p Gen8 AMD Opteron™ 6386SE Processor C/S with 1 DL360 G7	TPC-VMS: 1.1.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date August 26, 2013

VM1 Numerical Quantities Summary					
Reported Throughput	457.55 tpsE	Configured Customers:			240,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.01	0.03	0.11
Customer Position		0.00	0.01	0.02	0.64
Market Feed		0.00	0.02	0.04	0.22
Market Watch		0.00	0.01	0.02	0.12
Security Detail		0.00	0.01	0.01	0.40
Trade Lookup		0.00	0.13	0.18	0.67
Trade Order		0.00	0.03	0.05	0.82
Trade Result		0.00	0.03	0.05	1.11
Trade Status		0.00	0.01	0.02	0.42
Trade Update		0.01	0.15	0.19	0.66
Data Maintenance		0.01	0.02		0.05
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			1,614,276		4.900%
Customer Position			4,282,587		13.000%
Market Feed			329,440		1.000%
Market Watch			5,929,880		18.000%
Security Detail			4,612,270		14.000%
Trade Lookup			2,635,504		8.000%
Trade Order			3,327,366		10.100%
Trade Result			3,294,404		10.000%
Trade Status			6,259,229		19.000%
Trade Update			658,863		2.000%
Data Maintenance			120		
Ramp-up Time				0:22:00	
Measurement Interval				2:00:00	
Business Recovery Time				0:38:27	
Total Number of Transactions Completed in Measurement Interval				32,943,819	

Table of Contents

Clause 0 -- Preamble

Copies of the following TPC-VMS's clauses are to be placed at the beginning of the ***Report****.*

- *Clause 0.1 Introduction*
- *Clause 0.1.1 Goal of the TPC Virtual Measurement Single System Specification*
- *Clause 0.1.2 Limitations and Restrictions*

A statement identifying the benchmark ***Test Sponsor***(s) *and other participating companies must be* ***reported*** *at the beginning of the* ***Report****.*

This benchmark was sponsored by Hewlett-Packard Corporation.

Clause 1 -- Overview

There are no reporting requirements for TPC-VMS Clause 1.

Clause 2 -- Virtualization Environment

Diagrams of both VSUT ***Measured*** *and* ***Priced Configuration****s must be* ***reported*** *in the* ***Report****, accompanied by a description of the differences.*

See Appendix B- 1.6 for measured and priced configuration diagrams.

A description of the steps taken to configure all of the **VSUT** *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* ***Error! Reference source not found.****) The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-VMS specification could recreate the hardware environment*

The HP ProLiant DL385p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 processor installed, along with 16 x 16 GB DIMMs. The various HBAs and cards are installed in the chassis as defined in the file **HWConfig.pdf** in the *\Supporting Files\Introduction\TierB* "Introduction" directory. Additionally, the **DiskConfig.pdf** file in the *Supporting Files* directory shows how the SmartArray storage subsystem was configured. Each **VM** was presented a virtualized 1GB NIC that was directly connected to the client system. Also, each **VM** utilized the storage subsystem attached to one of the three SmartArray P421 controllers, thus making the storage configuration identical for each **VM**.

*A description of the steps taken to configure the VMMS 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 7.4). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-VMS specification could recreate the software environment.*

In general, vSphere allows each VM to request the number of virtual CPUs and the amount of memory it requires, and declare the virtual disk drives it will attach to. The VMMS then arbitrates among the many VMs, and allocates the physical resources to each VM depending on its needs and other system settings. In the case of the tests used in this benchmark report, we used various vSphere facilities to bind the virtual CPUs to specific set of physical CPUs and sockets to achieve optimum performance. In particular:

- VM1 was bound to physical CPUs 0-7 on server socket 0, numa node 0, and physical CPUs 18-19 on server socket 1, numa node 2. 4/5th of the memory for VM1 was allocated from server socket 0, numa node 0, the rest from server socket 1, numa node 2.

- VM2 was bound to physical CPUs 8-15 on server socket 0, numa node 1, and physical CPUs 20-21 on server socket 1, numa node 2. 4/5th of the memory for VM2 was allocated from server socket 0, numa node 1, the rest from server socket 1, numa node 2.

- VM3 was bound to physical CPUs 24-31 on server socket 1, numa node 3, and physical CPUs 22-23 on server socket 1, numa node 2. 4/5th of the memory for VM3 was allocated from server socket 1, numa node 3, the rest from server socket 1, numa node 2.

- Physical CPUs 16-17 on server socket 1, numa node 2 ran the auxiliary vSphere worldlets

For each VM, a description of the configuration parameters for resources available to the VM 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 7.4). The description, scripts and/or GUI instructions must be sufficient such that a reader knowledgeable of the VMMS could recreate the virtual environment.*

Any tuning options (Clause 2.4.2.2) used for any of the software (**Operating System**, *device drivers,* **DBMS**, *transaction monitor, and any other software programs) that run in the* **VM**s *must be* **reported** *in the* **Report**.

The file **Win2012Setup.pdf** in the *\SupportingFiles\Introduction\TierB* directory outlines the steps taken to configure the guest OS. The file **SQL2012Setup.doc** in *\SupportingFiles\Introduction\TierB* likewise outlines the steps taken to setup the DBMS. The files

VirtualMachines_and_VirtualDiskConfig.pdf and **vSphere5.5Setup.pdf** in *\SupportingFiles\Introduction\TierB* likewise outlines the steps taken to setup the Hypervisor. Other supporting files (registry, configuration) are also included in the respective directories.

*For software that was optimized (Clause 2.4.2.2) for the **Virtualization Environment**, the **Test Sponsor** must attest in the **Report** that the same **Software Version** will meet the requirements of Clause 2.4.2.1.*

All software used in the VMs is able to run without user intervention in a non-virtualized environment.

Clause 3 -- Metrics

There are no reporting requirements for TPC-VMS Clause 3.

Clause 4 -- Driver/Controller Software

Describe any modifications to the **TPC Benchmark** driver or controller software for ease of benchmarking the TPC-VMS Benchmark (Clause 4.1)

No modifications were made.

Describe any modifications to the **TPC Benchmark** driver or controller software for the synchronization of TPC-VMS Benchmark execution to be complaint with Clause 5.3.

No modifications were made.

Clause 5 -- Rules and Procedures

Describe any changes to the random number seeds used for data generation that were made to meet the requirements of Clause 5.2.1.

No Changes were made to the seeds because they are managed by EGen..

Describe any changes to the random number seeds used in the test runs that were made to meet the requirements of Clause 5.2.2.

No Changes were made to the seeds because they are managed by EGen.

*For **TPC Benchmarks** that compute their primary metric from a measured time interval, report the measurement intervals for all VMs. Use **VM Identifications** to identify the **VM** measurement intervals.*

All VMs:
Start time: 8/19/13 23:12:00
End Time: 8/20/13 01:12:00

Clause 6 -- Pricing

*Report any additional pricing related information required by the **TPC Benchmark FDR** but not reported in the **Executive Summary**. For example, the TPC-C or TPC-E 60-Day Space calculations would be reported here.*

Space calculations for VM1:

TPC-E Disk Space Requirements

Customers Used	**240,000**	**Performance**	**457.55**	**TpsE**	

Broker File Group	Initial Rows	Data (KB)	Index size (KB)	Extra 5% (KB)	Total + 5% (KB)	After run (KB)	Growth (KB)	1 Day Growth (KB)	Req. Add. (KB)
BROKER	2,400	176	248	21	445	424	-	-	21
CASH_TRANSACTION	3,819,890,130	393,002,840	830,040	19,691,644	413,524,524	394,586,152	753,272	2,313,691	2,313,691
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	4,152,061,976	198,231,888	418,656	9,932,527	208,583,071	199,072,736	422,192	1,296,772	1,296,772
TRADE	4,152,092,566	490,226,320	273,491,424	38,185,887	801,903,631	764,659,904	942,160	2,893,864	2,893,864
TRADE_HISTORY	9,965,018,425	300,200,968	784,672	15,049,282	316,034,922	301,741,968	756,328	2,323,077	2,323,077
TRADE_REQUEST	-	-	-	-	-	62,104	62,104	190,754	190,754
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	1,704,196	93,888	656	4,727	99,271	94,608	64	197	4,727
CUSTOMER	240,000	39,328	11,880	2,560	53,768	51,224	16	50	2,560
CUSTOMER_ACCOUNT	1,200,000	108,744	26,832	6,779	142,355	135,576	-	-	6,779
CUSTOMER_TAXRATE	480,000	10,136	192	516	10,844	10,440	112	345	516
HOLDING	212,473,747	14,229,992	9,478,688	1,185,434	24,894,114	23,970,168	261,488	803,166	803,166
HOLDING_HISTORY	5,564,523,982	202,660,760	135,436,656	16,904,871	355,002,287	339,067,464	970,048	2,979,523	2,979,523
HOLDING_SUMMARY	11,941,789	508,304	1,944	25,512	535,760	510,248	-	-	-
WATCH_ITEM	24,003,797	650,752	2,592	32,667	686,011	653,544	200	615	32,667
WATCH_LIST	240,000	5,984	5,648	582	12,214	11,632	-	-	582
Market File Group									
COMPANY	120,000	25,480	7,808	1,664	34,952	33,304	16	50	1,664
COMPANY_COMPETITOR	360,000	9,680	8,928	930	19,538	18,608	-	-	930
DAILY_MARKET	214,542,000	9,850,808	27,800	493,930	10,372,538	9,879,560	952	2,925	493,930
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	2,400,000	270,616	1,040	13,583	285,239	271,880	224	689	13,583
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	164,400	10,056	184	512	10,752	10,240	-	-	512
NEWS_ITEM	240,000	26,020,448	440	1,301,044	27,321,932	26,020,904	16	50	1,301,044
NEWS_XREF	240,000	5,992	184	309	6,485	6,176	-	-	309
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	164,400	22,472	6,328	1,440	30,240	28,824	24	74	1,440
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	360,004	20,808	184	1,050	22,042	21,048	56	173	1,050
TAXRATE	320	40	16	3	59	56	-	-	3
ZIP_CODE	14,741	488	16	25	529	504	-	-	25
TOTALS (KB)		**1,636,207,032**	**420,544,176**	**102,837,560**	**2,159,588,768**				
Initial Database Size (MB)		**2,008,546**	**1,961 GB**						

Db/Filegroups	LUN Count	Partition Size(KB)	MB allocated	MB Loaded	MB Required	
fixed_fg	1	48,381,297	47,247	36,375	38,194	OK
growing_fg	1	2,560,003,932	2,500,004	1,972,171	1,984,672	OK
					MB Available	
Settlements	**4,290,201**				524,386	

			Database	60 Day Space				
Initial Growing Space (MB)	1,972,171							
Final Growing Space (MB)	1,976,241	**LUNS**	1	1	**Initial Log size (MB)**	38,062	**Log LUNS**	1
Delta (MB)	4,070	**Disks per LUN**	8	2	**Final Log size (MB)**	67,349	**Log Disks**	2
Data Space per Trade (MB)	0.00094865	**Disk Capacity (MB)**	381,501	476,160	**Log Growth (MB)**	29,286	**Disk Capacity (MB)**	139,981
1 Day Data Growth (MB)	12,501	**RAID5 Overhead**	12.5%	50.0%	**Log Growth/trade (MB)**	0.00682635	**RAID10 Overhead**	50%
60-Day Overflow (MB)	**737,549**	**Total Space (MB)**	**2,670,510**	**476,160**	**1 Day log space (MB)**	**89,954**	**Log Space (MB)**	**139,981**

Total Space Required	**2,760,414.31**	
Total Space Priced	3,146,670	
Total Minus TempDB used	3,118,612	OK

Space calculations for VM2:

TPC-E Disk Space Requirements

Customers Used	240,000	Performance	468.11 TpsE							
Broker File Group	**Initial Rows**	**Data (KB)**	**Index size (KB)**	**Extra 5% (KB)**	**Total + 5% (KB)**		**After run (KB)**	**Growth (KB)**	**1 Day Growth (KB)**	**Req. Add. (KB)**
BROKER	2,400	176	248	21	445		424	-	-	21
CASH_TRANSACTION	3,819,900,896	393,004,288	830,080	19,691,718	413,526,086		394,604,080	769,712	2,355,679	2,355,679
CHARGE	15	8	8	1	17		16	-	-	1
COMMISSION_RATE	240	16	16	2	34		32	-	-	2
SETTLEMENT	4,152,073,117	198,231,440	418,656	9,932,505	208,582,601		199,082,944	432,848	1,324,718	1,324,718
TRADE	4,152,103,598	490,227,840	273,492,048	38,185,994	801,905,882		764,700,624	980,736	3,001,511	3,001,511
TRADE_HISTORY	9,965,044,085	300,200,976	784,752	15,049,286	316,035,014		301,759,896	774,168	2,369,317	2,369,317
TRADE_REQUEST	-	-	-	-	-		65,104	65,104	199,249	199,249
TRADE_TYPE	5	8	1,032	52	1,092		1,040	-	-	52
Customer File Group										-
ACCOUNT_PERMISSION	1,704,196	93,888	648	4,727	99,263		94,616	80	245	4,727
CUSTOMER	240,000	39,328	11,880	2,560	53,768		51,240	32	98	2,560
CUSTOMER_ACCOUNT	1,200,000	108,744	26,832	6,779	142,355		135,576	-	-	6,779
CUSTOMER_TAXRATE	480,000	10,144	192	517	10,853		10,440	104	319	517
HOLDING	212,470,774	14,230,224	9,478,704	1,185,446	24,894,374		23,977,864	268,936	823,070	823,070
HOLDING_HISTORY	5,564,539,816	202,661,696	135,437,624	16,904,966	355,004,286		339,095,696	996,376	3,049,377	3,049,377
HOLDING_SUMMARY	11,941,854	508,304	1,944	25,512	535,760		510,280	32	98	98
WATCH_ITEM	24,003,797	650,752	2,576	32,666	685,994		653,536	208	637	32,666
WATCH_LIST	240,000	5,984	5,648	582	12,214		11,632	-	-	582
Market File Group										
COMPANY	120,000	25,464	7,808	1,664	34,936		33,272	-	-	1,664
COMPANY_COMPETITOR	360,000	9,680	8,928	930	19,538		18,608	-	-	930
DAILY_MARKET	214,542,000	9,850,800	27,808	493,930	10,372,538		9,879,568	960	2,939	493,930
EXCHANGE	4	8	8	1	17		16	-	-	1
FINANCIAL	2,400,000	270,632	1,032	13,583	285,247		271,864	200	613	13,583
INDUSTRY	102	8	24	2	34		32	-	-	2
LAST_TRADE	164,400	10,056	184	512	10,752		10,240	-	-	512
NEWS_ITEM	240,000	26,020,480	496	1,301,049	27,322,025		26,020,992	16	49	1,301,049
NEWS_XREF	240,000	5,992	184	309	6,485		6,176	-	-	309
SECTOR	12	8	24	2	34		32	-	-	2
SECURITY	164,400	22,472	6,328	1,440	30,240		28,800	-	-	1,440
STATUS_TYPE	5	8	8	1	17		16	-	-	1
Misc File Group										
ADDRESS	360,004	20,824	184	1,050	22,058		21,056	48	147	1,050
TAXRATE	320	40	16	3	59		56	-	-	3
ZIP_CODE	14,741	488	16	25	529		504	-	-	25
TOTALS (KB)		**1,636,210,776**	**420,545,936**	**102,837,836**	**2,159,594,548**					
Initial Database Size (MB)		**2,008,551**	**1,961 GB**							

Db/Filegroups	**LUN Count**	**Partition Size(KB)**	**MB allocated**	**MB Loaded**	**MB Required**	
fixed_fg	1	48,381,297	47,247	36,375	38,194	OK
growing_fg	1	2,560,003,932	2,500,004	1,972,176	1,984,992	OK
					MB Available	
Settlements	**4,405,068**				524,066	

Initial Growing Space (MB)	1,972,176		Database	60 Day Space				
Final Growing Space (MB)	1,976,364	**LUNS**	1	1	**Initial Log size (MB)**	38,031	**Log LUNS**	1
Delta (MB)	4,187	**Disks per LUN**	8	2	**Final Log size (MB)**	68,035	**Log Disks**	2
Data Space per Trade (MB)	0.00095059	**Disk Capacity (MB)**	381,501	476,160	**Log Growth (MB)**	30,004	**Disk Capacity (MB)**	139,981
1 Day Data Growth (MB)	12,815	**RAID5 Overhead**	12.5%	50.0%	**Log Growth/trade (MB)**	0.00681125	**RAID10 Overhead**	50%
60-Day Overflow (MB)	**756,111**	**Total Space (MB)**	**2,670,510**	**476,160**	**1 Day log space (MB)**	**91,826**	**Log Space (MB)**	**139,981**

Total Space Required	**2,779,296.95**	
Total Space Priced	3,146,670	
Total Minus TempDB used	3,118,612	OK

Space calculations for VM3:

TPC-E Disk Space Requirements

Customers Used	**240,000**	**Performance**	**470.31**	**TpsE**	

Broker File Group	Initial Rows	Data (KB)	Index size (KB)	Extra 5% (KB)	Total + 5% (KB)	After run (KB)	Growth (KB)	1 Day Growth (KB)	Req. Add. (KB)
BROKER	2,400	176	248	21	445	424	-	-	21
CASH_TRANSACTION	3,819,915,529	393,005,904	830,088	19,691,800	413,527,792	394,607,056	771,064	2,367,381	2,367,381
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	4,152,090,134	198,233,200	418,664	9,932,593	208,584,457	199,084,968	433,104	1,329,750	1,329,750
TRADE	4,152,120,838	490,229,992	273,493,008	38,186,150	801,909,150	764,706,808	983,808	3,020,565	3,020,565
TRADE_HISTORY	9,965,087,890	300,203,904	784,784	15,049,434	316,038,122	301,764,216	775,528	2,381,087	2,381,087
TRADE_REQUEST	-	-	-	-	-	65,624	65,624	201,484	201,484
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	1,704,196	93,912	680	4,730	99,322	94,664	72	222	4,730
CUSTOMER	240,000	39,336	11,880	2,561	53,777	51,232	16	50	2,561
CUSTOMER_ACCOUNT	1,200,000	108,744	26,832	6,779	142,355	135,576	-	-	6,779
CUSTOMER_TAXRATE	480,000	10,144	192	517	10,853	10,440	104	320	517
HOLDING	212,476,263	14,231,624	9,478,656	1,185,514	24,895,794	23,981,232	270,952	831,898	831,898
HOLDING_HISTORY	5,564,560,004	202,663,752	135,439,440	16,905,160	355,008,352	339,097,448	994,256	3,052,643	3,052,643
HOLDING_SUMMARY	11,941,637	508,304	1,944	25,512	535,760	510,248	-	-	-
WATCH_ITEM	24,003,797	650,752	2,592	32,667	686,011	653,552	208	639	32,667
WATCH_LIST	240,000	5,984	5,648	582	12,214	11,632	-	-	582
Market File Group									
COMPANY	120,000	25,472	7,808	1,664	34,944	33,280	-	-	1,664
COMPANY_COMPETITOR	360,000	9,680	8,928	930	19,538	18,608	-	-	930
DAILY_MARKET	214,542,000	9,850,784	27,800	493,929	10,372,513	9,879,536	952	2,923	493,929
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	2,400,000	270,624	1,016	13,582	285,222	271,832	192	590	13,582
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	164,400	10,056	184	512	10,752	10,240	-	-	512
NEWS_ITEM	240,000	26,020,432	440	1,301,044	27,321,916	26,020,896	24	74	1,301,044
NEWS_XREF	240,000	5,992	184	309	6,485	6,176	-	-	309
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	164,400	22,464	6,328	1,440	30,232	28,816	24	74	1,440
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	360,004	20,808	184	1,050	22,042	21,040	48	148	1,050
TAXRATE	320	40	16	3	59	56	-	-	3
ZIP_CODE	14,741	488	16	25	529	504	-	-	25
TOTALS (KB)		**1,636,222,632**	**420,548,680**	**102,838,566**	**2,159,609,878**				
Initial Database Size (MB)		**2,008,566**	**1,961 GB**						

Db/Filegroups	LUN Count	Partition Size(KB)	MB allocated	MB Loaded	MB Required	
fixed_fg	1	48,381,297	47,247	36,375	38,194	OK
growing_fg	1	2,560,003,932	2,500,004	1,972,191	1,985,066	OK
					MB Available	
Settlements	**4,411,629**				523,991	

Initial Growing Space (MB)	1,972,191		Database	60 Day Space					
Final Growing Space (MB)	1,976,384	**LUNS**	1	1	**Initial Log size (MB)**	38,216	**Log LUNS**	1	
Delta (MB)	4,194	**Disks per LUN**	8	2	**Final Log size (MB)**	68,352	**Log Disks**	2	
Data Space per Trade (MB)	0.00095060	**Disk Capacity (MB)**	381,501	476,160	**Log Growth (MB)**	30,136	**Disk Capacity (MB)**	139,981	
1 Day Data Growth (MB)	12,876	**RAID5 Overhead**	12.5%	50.0%	**Log Growth/trade (MB)**	0.00683104	**RAID10 Overhead**	50%	
60-Day Overflow (MB)	**759,671**	**Total Space (MB)**	**2,670,510**	**476,160**	**1 Day log space (MB)**	**92,526**	**Log Space (MB)**	**139,981**	

Total Space Required	**2,782,931.71**	
Total Space Priced	3,146,670	
Total Minus TempDB used	3,118,612	OK

Third Party Pricing Quotes:

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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

Microsoft

August 21, 2013

Hewlett-Packard
Eric Deehr
One Microsoft Way
Redmond, WA 98055

Here is the information you requested regarding pricing for several Microsoft products to be used in conjunction with your TPC-E benchmark testing.

All pricing shown is in US Dollars ($).

Part Number	Description	Unit Price	Quantity	Price
Database Management System				
7JQ-00256	**SQL Server 2012 Enterprise Edition** *2 Core License* *Open Program - Level C*	$13,472.50	12	$161,670.00
Database Server Operating System				
P73-05761	**Windows Server 2012 Standard** *2 Processor License* *Open Program - Level C* *Unit Price reflects a 17% discount from the retail unit price of $882.*	$735.00	2	$1,470.00
Tier-A Operating System(s)				
P72-04217	**Windows Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - Level C* *Unit Price reflects a 43% discount from the retail unit price of $3,999.*	$2,280.00	1	$2,280.00
Support				
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259.00	1	$259.00

SQL Server 2012 Enterprise Edition, Windows Server 2012 Standard, and Windows Server 2008 R2 Enterprise 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: TPCVMS_qhtplylGYLKTVUKf95957fiiiLwdntoplsdy.

Availability Date

The committed delivery date for general availability (availability date) of products used in the price calculations must be reported. When the priced system includes products with different availability dates, the reported availability for the priced system must be the date at which all components are committed to be available.

The total solution as priced will be generally available September 30, 2013. This date reflects the software availability of VMware vSphere version update 5.5.

Clause 7 -- Full Disclosure Report

An index for all files required by Clause 7.4 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-VMS 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.*

The supporting files indexes are includes in the root directory of the files themselves.

Appendix A: TPC Benchmark Executive Summary Information

7.3.10 Appendix A of the TPC-VMS Report contains any TPC Benchmark information, graphs or tables that would be reported in the TPC Benchmark Executive Summary but are not specified by Clauses 7.2.1 – 7.2.4 to be reported in the TPC-VMS Executive Summary. VM Identifications are used to identify the specific VM data.

All Storage was configured with redundancy level 1.

VM2 Numerical Quantities:

HP ProLiant DL385p Gen8 AMD Opteron™ 6386SE Processor C/S with 1 DL360 G7	TPC-VMS: 1.1.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date August 26, 2013

VM2 Numerical Quantities Summary					
Reported Throughput	468.11 tpsE	Configured Customers:			240,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.01	0.03	0.24
Customer Position		0.00	0.01	0.02	0.64
Market Feed		0.00	0.02	0.04	0.55
Market Watch		0.00	0.01	0.02	0.10
Security Detail		0.00	0.00	0.01	0.37
Trade Lookup		0.00	0.12	0.16	0.90
Trade Order		0.00	0.03	0.05	0.66
Trade Result		0.00	0.03	0.05	0.47
Trade Status		0.00	0.01	0.02	0.61
Trade Update		0.01	0.14	0.18	0.93
Data Maintenance		0.01	0.02		0.06
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			1,651,511		4.900%
Customer Position			4,381,514		13.000%
Market Feed			337,043		1.000%
Market Watch			6,066,564		18.000%
Security Detail			4,718,520		14.000%
Trade Lookup			2,696,319		8.000%
Trade Order			3,404,199		10.100%
Trade Result			3,370,422		10.000%
Trade Status			6,403,763		19.000%
Trade Update			674,069		2.000%
Data Maintenance			120		
Ramp-up Time				0:22:00	
Measurement Interval				2:00:00	
Business Recovery Time				0:38:07	
Total Number of Transactions Completed in Measurement Interval				33,703,924	

VM3 Numerical Quantities:

	HP ProLiant DL385p Gen8 AMD Opteron™ 6386SE Processor C/S with 1 DL360 G7	TPC-VMS: 1.1.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date August 26, 2013

VM3 Numerical Quantities Summary					
Reported Throughput	470.31 tpsE	Configured Customers:			240,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.01	0.03	0.09
Customer Position		0.00	0.01	0.02	0.14
Market Feed		0.00	0.02	0.04	0.20
Market Watch		0.00	0.01	0.02	0.11
Security Detail		0.00	0.00	0.01	0.41
Trade Lookup		0.00	0.12	0.16	1.19
Trade Order		0.00	0.03	0.05	0.22
Trade Result		0.00	0.03	0.05	1.14
Trade Status		0.00	0.01	0.02	0.43
Trade Update		0.01	0.14	0.18	1.18
Data Maintenance		0.00	0.02		0.06
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			1,659,227		4.900%
Customer Position			4,402,226		13.000%
Market Feed			338,629		1.000%
Market Watch			6,095,144		18.000%
Security Detail			4,740,714		14.000%
Trade Lookup			2,708,943		8.000%
Trade Order			3,420,130		10.100%
Trade Result			3,386,285		10.000%
Trade Status			6,433,857		19.000%
Trade Update			677,243		2.000%
Data Maintenance			120		
Ramp-up Time				0:22:00	
Measurement Interval				2:00:00	
Business Recovery Time				0:44:16	
Total Number of Transactions Completed in Measurement Interval				33,862,398	

Appendix B: TPC Benchmark Reporting Requirements

7.3.11 Appendix B of the TPC-VMS Report contains the TPC Benchmark Reporting Requirements, i.e. a TPC Benchmark Report. The clauses numbering follows the TPC Benchmark requirements but with the prefix of "B" denoting Appendix B.

Preface

Document Structure

This is the full disclosure report for a benchmark test of the HP ProLiant DL385p Gen8 using Microsoft SQL Server 2012 Enterprise Edition SP1. It meets the requirements of the TPC Benchmark ® E Standard Specification, Revision 1.12.0 dated June 2010. TPC Benchmark® E was developed by the **T**ransaction Processing **P**erformance **C**ouncil (TPC). It is the intent of this group to develop a suite of benchmarks to measure the performance of computer systems executing a wide range of applications. Hewlett-Packard Company and Microsoft, Inc. are active participants in the TPC.

The requirements for this Full Disclosure Report are in Clause 9 of TPC Benchmark ® E Specification.

TPC Benchmark® E Overview

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 any time, especially in relation to each other.

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.

Clause B1: General Items

1.1 Orders 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 of the sections in this report correspond with those specified in the TPC-E specification.

1.2 Pricing

*The **FDR** must follow all reporting rules specified in the effective version of the TPC Pricing Specification, located at www.tpc.org. (9.1.1.2)*

The pricing rules for this FDR follow the current standard at the time of publication, TPC Pricing Specification 1.7.0.

1.3 Executive Summary Statement

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

The Executive Summary statement is included after the preamble of this Full Disclosure Report, as well as a separate document.

1.4 Supporting Files

A directory structure for the supporting files must be followed. (9.1.1.3)

The accompanying support files are in the proper structure as defined by the specification.

1.5 Auditor

*The name of the **Auditor** who certified the result must be included after the Price Spreadsheet. (9.2.2.2)*

This Benchmark, Executive Summary, and Full Disclosure Report were audited by Doug Johnson for InfoSizing. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

*Diagrams of both **Measured** and **Priced Configurations** must be **reported** in the **Report**, accompanied by a description of the differences. (9.3.1.2, 9.3.1.3)*

The Benchmarked and Priced configurations of the driver, SUT Server, and DBMS server are illustrated in Figures 1.1 and 1.2.

Figure 1.1 Priced Configuration

Tier B: Server
HP ProLiant DL385p Gen8
2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor (2/32/32)
256 GB Memory
3 x HP Smart Array P421/2GB, One per each VM
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 146GB SAS 15K SFF DP ENT HDD 2 Drives for each VM (Database Log)

Tier A: Client
1 x ProLiant DL360 G7
2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz
2 x 8GB PC3-10600 Memory
2 x 146GB 6G SAS 15K SFF DP
4 x Onboard 1Gbps Ethernet

Storage
3 x HP StorageWorks D2700 Disk Enclosure, one per each VM
24 X HP 400GB 6G SATA MLC SFF (2.5-inch) SSD 8 per enclosure, per VM.
Priced Only
6 x 500GB 6G SAS 15K SFF DP ENT HDD (60 Day Space)

Figure 1.2 Measured Configuration

Tier B: Server
HP ProLiant DL385p Gen8
2 x AMD Opteron™ 6386SE (2.8GHz/16-core) Processor (2/32/32)
256 GB Memory
3 x HP Smart Array P421/2GB, One per each VM
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 146GB SAS 15K SFF DP ENT HDD 2 Drives for each VM (Database Log)

Tier A: Client
1 x ProLiant DL360 G7
2x Hex-Core Intel Xeon X5670 Processor 2.93Ghz
2 x 8GB PC3-10600 Memory
2 x 146GB 6G SAS 15K SFF DP
4 x Onboard 1Gbps Ethernet

Storage
3 x HP StorageWorks D2700 Disk Enclosure, one per each VM
24 X HP 400GB 6G SATA MLC SFF (2.5-inch) SSD 8 per enclosure, per VM.
Measured Only
12 x 500GB 6G SAS 15K SFF DP ENT HDD (Database Backup)
4 drives per each VM

Note: The 12 x 500GB 6G SAS present during the measured run were for data backup only, and were not active during the actual performance measurement or durability runs.

1.7 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.*

A description of any firmware updates or patches to the hardware.

A description of any GUI configuration used to configure the system hardware.

*A description of exactly how the hardware is combined to create the complete system. For example, if the **SUT** description lists a base chassis with 1 processor, a processor update package of 3 processors, a NIC controller and 3 disk controllers, a description of where and how the processors, NIC and disk controllers are placed within the base chassis must be **reported** in the **Report**.*

A description of how the hardware components are connected. The description can assume the reader is knowledgeable of computer systems and the TPC-E specification. For example, only a description that Controller 1 in slot A is connected to Disk Tower 5 is required. The reader is assumed to be knowledgeable enough to determine what type of cable is required based upon the component descriptions and how to plug the cable into the components.

The HP ProLiant DL385p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 processor installed, along with 16 x 16 GB DIMMs. The various HBA's, NICS, and other IO cards are installed in the various chassis as defined in the file **HWConfig.pdf** in the *\Supporting Files\Introduction\TierB* "Introduction" directory. Additionally, the **DiskConfig.pdf** file in the *Supporting Files* directory shows how the SmartArray storage subsystem was configured.

1.8 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. This includes, but is not limited to:*

A description of any updates or patches to the software.

A description of any changes to the software.

A description of any GUI configurations used to configure the software.

The file **Win2012Setup.pdf** in the *\SupportingFiles\Introduction\TierB* directory outlines the steps taken to configure the guest OS and DBMS. The file **SQL2012Setup.doc** in *\SupportingFiles\Introduction\TierB* likewise outlines the steps taken to setup the DBMS. The files **VirtualMachines_and_VirtualDiskConfig.pdf** and **vSphere5.5Setup.pdf** in *\SupportingFiles\Introduction\TierB* likewise outlines the steps taken to setup the Hypervisor. Other supporting files (registry, configuration) are also included in the respective directories.

Clause B2: Database Design, Scaling & Population Items

2.1 Physical Database Organization

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

The database tables and indices were organized into two SQL Server filegroups as shown in Table 2.1 below. The tables that grew during the run, defined as *growing tables* in the TPC-E specification, were placed in a file group called Growing, while the tables that do not grow during the run, designated as *fixed and scaling*, and were placed in a filegroup called Fixed.

Directory **Clause2** in *Supporting Files* contains the scripts used to create the data base filegroups, tables, constraints, and indices. In addition, files to create TEMPDB files before the build and remove them after the build are included, as well as a script to remove the LOAD_FG files and filegroup after the build and before the initial backup.

Fixed		Growing
Account_Permission	Security	Cash_Transaction
Company	Watch_Item	Holding
Company_Competitor	Watch_List	Holding_History
Customer	Charge	Holding_Summary
Customer_Account	Commission_Rate	Settlement
Customer_TaxRate	Exchange	Trade
Daily_Market	Industry	Trade_History
Financial	Sector	Trade_Request
Last_Trade	Status_Type	
News_Item	TaxRate	
News_Xref	Trade_Type	
Broker	Zip_Code	
Address		

Table 2.1 – FileGroup Table Assignments

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 was done for this benchmark.

2.3 Replication, Duplication

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

No replication or duplication was done for this benchmark.

2.4 Cardinality of Tables

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

The TPC-E database was configured using 240,000 customers. Table 2.2 below shows the cardinality of each table for **All_VMs**.

Table	Rows
BROKER	2400
CASH_TRANSACTION	3815416969
CHARGE	15
COMMISSION_RATE	240
SETTLEMENT	4147200000
TRADE	4,152,092,566
TRADE_HISTORY	9953276846
TRADE_REQUEST	0
TRADE_TYPE	5
ACCOUNT_PERMISSION	1704196
CUSTOMER	240,000
CUSTOMER_ACCOUNT	1,200,000
CUSTOMER_TAXRATE	480,000
HOLDING	212350338
HOLDING_HISTORY	5557966064
HOLDING_SUMMARY	11941574
WATCH_ITEM	24,003,797
WATCH_LIST	240,000
COMPANY	120,000
COMPANY_COMPETITOR	360,000
DAILY_MARKET	214,542,000
EXCHANGE	4
FINANCIAL	2,400,000
INDUSTRY	102
LAST_TRADE	164,400
NEWS_ITEM	240,000
NEWS_XREF	240,000
SECTOR	12
SECURITY	164,400
STATUS_TYPE	5
ADDRESS	360004
TAXRATE	320
ZIP_CODE	14,741

Table 2.2 Initial Cardinality of Tables

2.5 Disk Configuration

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

Table 2.3 shows the configuration of the 3 HP SmartArray controllers, configured for database storage. It also shows the 6 X HP 146GB 6G SAS 15K RPM SF Hard Drives configured for the transaction log of each VM, which was connected to the 1 x HP Smart Array P420i controller in the internal bay. The database logical volumes were configured in RAID 5, and the log disks were configured as a RAID1+0 volume.

Each data array was partitioned with 3 partitions, one for the Growing FG, one for the Fixed FG, and one for TempDB files, for each VM. The first 2 partitions were RAW; the 3rd was configured as NTFS. Access to all the TPCE database partitions was by using mount points, no drive letters were used except for the log, and the boot/utility drives.

Controller Type	Disk #	Drives Enclosure RAID Lvl	Path Filesystem Partition	Size	Use
P420i Internal SmartArray	1	2x146GB SAS, Internal RAID1	C:, NTFS	136.7GB	Win2012 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File
	2	2x146GB SAS, Internal RAID1+0	E:, RAW	136.7GB	Database log **VM1**
	3	2x146GB SAS, Internal RAID1+0	E:, RAW	136.7GB	Database log **VM2**
	4	2x146GB SAS, Internal RAID1+0	E:, RAW	136.7GB	Database log **VM3**
P421 SmartArray Adapter **VM1**	1	8 X 400GB 6G SAS MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2441 GB 46 GB 120.5 GB	Growing FG Fixed FG TempDB files **VM1**
P421 SmartArray Adapter **VM2**	1	8 X 400GB 6G SAS MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2441 GB 46 GB 120.5 GB	Growing FG Fixed FG TempDB files **VM2**
P421 SmartArray Adapter **VM3**	1	8 X 400GB 6G SAS MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2441 GB 46 GB 120.5 GB	Growing FG Fixed FG TempDB files **VM3**

Table 2.3 Disk/Partition Configuration

The measured configuration also included 4 X HP 500GB 6G SAS 7.2K RPM hard drives attached to each P421 card. These 3 volumes held backups of the database, and were also used during building of the database. This storage was not an active part of the performance run.

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**.(9.3.2.7)*

*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)*

Client software interfaced to SQL Server through stored procedures invoked by the clients with ODBC calls. The application code was C++.

The data model implemented by Microsoft SQL Server 2012 Enterprise Edition SP1 is relational.

The methodology used to load the database is contained in the file **MSTPCE Database Setup Reference.pdf** in the CLAUSE2 directory in *SupportingFiles* directory.

Clause B3: Transaction Related Items

3.1 Code Functionality

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

Secondary sponsor-supplied code is functionally equivalent to pseudo-code in the specification.

3.2 Database Footprint

*A statement that the database footprint requirements were met must be **reported** in the **Report**. (9.3.3.2)*

Database footprint requirements were met.

Clause B4: SUT, Driver and Network Related Items

4.1 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**) and any optional **Database Server** interface networks (9.3.4.1)*

Three ports of the HP card BC5719 in the SUT were directly connected to the HP DL360 G7 client. These connections were used for database traffic. Each of the **VMs** were presented a single interface. The other built in NIC on the SUT and client was used to access the system by the benchmark driver system, management, etc.

Clause B5: EGen Related Items

5.1 EGen Version

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

EGen Version used for this test was 1.12.0

5.2 EGen Code

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

All required TPC provided EGen code was used in this 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** if any of the changes to **EGen** do not have a formal waiver that must also be **reported** in the **Report**.*

No modifications to EGen were done for this report.

5.4 EGen Loader Extensions

*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** in the **Report (9.3.5.4)***

EGen Loader was not extended for this report.

5.5 EGen Loader Make 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**.(9.3.5.5)*

The Visual C++ project files are in the **Clause3** directory in the *Supporting Files* directory.

Clause B6: Performance Metrics and Response Time Related Items

6.1 EGenDriver and MEE instances

*The number of **EGenDriverMEE** and **EGenDriverCE** instances used in the benchmark must be **reported** in the **Report (9.3.6.1)***

All_VMs: 5 instances of both the EGenDriverMEE and EGenDriverCE were used to drive each VM.

6.2 Measured Throughput

*The **Measured Throughput** must be **reported** in the **Report. (9.3.6.2)***

VM1: The measured throughput was 457.55 VMStpsE.

VM2: The measured throughput was 468.11 VMStpsE.

VM3: The measured throughput was 470.31 VMStpsE.

Test Run Graph and Steady State Measurement

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

*The method used to determine that the **SUT** had reached a **Steady State** prior to commencing the **Measurement Interval** must be **reported** in the **Report**.(9.3.6.4)*

After initial ramp-up, throughput and response time were observed until both were constant, generally to within less than a percent of the reported throughput. Throughput and response time were determined by examining the data after the run was terminated. The data was reported over every 60 second window during the test run. Ramp up and steady state can be seen from the graph below.

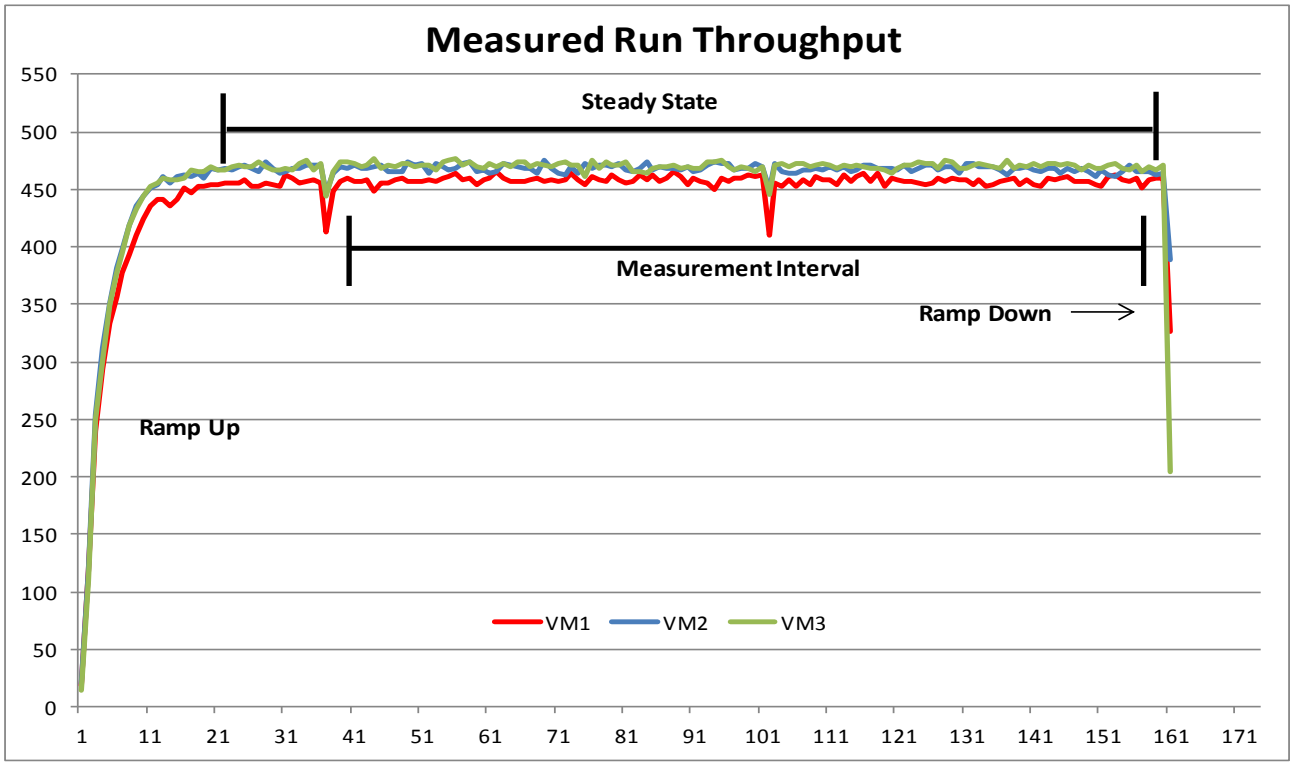


Figure 6.1 Test Run Time/Steady State Measurement Run Data

6.4 Work Measurement

*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 check-pointing, writing **Undo/Redo Log** records, etc). (9.3.6.5)*

All_VMs: During the run, the Customer Emulator engines (Driver Engines) generated transactions via the audited stored procedures as per the TPC-E specification. Each transaction was time-stamped, response time verified, and the transactions logged into individual log files. Communication was done between the Driver Engine Customer Emulators and Market Emulators to the SUT Server emulators, which in turn generated commands via ODBC connections to Microsoft SQL Server 2012 Enterprise Edition SP1. Satisfying these ODBC requests constitute the primary load on the server during the run.

Checkpoints were performed to flush all dirty pages from memory, and write a record of this fact to the transaction log. This was accomplished by setting the SQL Recovery Interval to 32767, which effectively tells SQL to not checkpoint automatically. Near the beginning of the test run, a script was started that did manual checkpoints, specifying an interval of 435 seconds. SQL Server was run with run flag 3502, which caused it to display messages when checkpoints were started and ended. This was used to verify the checkpoints were done in the time intervals as required by the TPC-E specification.

6.5 Transaction Reporting

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

Table 6.2 shows the Averages for the Test Run of each VM.

VM1:

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	50.00%	Ok	48.00%	52.00%
		Get History	49.98%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	30.03%	Ok	28.50%	31.50%
		Frame 2	29.95%	Ok	28.50%	31.50%
		Frame 3	30.03%	Ok	28.50%	31.50%
		Frame 4	10.00%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	60.01%	Ok	57.00%	63.00%
		By Customer Acct	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	33.00%	Ok	31.00%	35.00%
		Frame 3	33.95%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.01%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.01%	Ok	9.50%	10.50%
		By Company Name	40.01%	Ok	38.00%	42.00%
		Buy on Margin	8.03%	Ok	7.50%	8.50%
		Rollback	0.98%	Ok	0.94%	1.04%
		LIFO	34.99%	Ok	33.00%	37.00%
		Trade by Qty 100	25.00%	Ok	24.00%	26.00%
		Trade by Qty 200	25.00%	Ok	24.00%	26.00%
		Trade by Qty 400	24.99%	Ok	24.00%	26.00%
		Trade by Qty 800	25.01%	Ok	24.00%	26.00%
		Market Buy	30.00%	Ok	29.70%	30.30%
		Market Sell	30.01%	Ok	29.70%	30.30%
		Limit Buy	20.00%	Ok	19.80%	20.20%
		Limit Sell	10.00%	Ok	9.90%	10.10%
		Stop Loss	9.99%	Ok	9.90%	10.10%

VM2:

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.98%	Ok	48.00%	52.00%
		Get History	49.99%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.98%	Ok	28.50%	31.50%
		Frame 2	30.00%	Ok	28.50%	31.50%
		Frame 3	30.03%	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 Acct	34.99%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	32.98%	Ok	31.00%	35.00%
		Frame 2	32.95%	Ok	31.00%	35.00%
		Frame 3	34.07%	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	7.98%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	34.98%	Ok	33.00%	37.00%
		Trade by Qty 100	25.01%	Ok	24.00%	26.00%
		Trade by Qty 200	25.00%	Ok	24.00%	26.00%
		Trade by Qty 400	24.99%	Ok	24.00%	26.00%
		Trade by Qty 800	25.00%	Ok	24.00%	26.00%
		Market Buy	29.99%	Ok	29.70%	30.30%
		Market Sell	30.02%	Ok	29.70%	30.30%
		Limit Buy	19.96%	Ok	19.80%	20.20%
		Limit Sell	10.01%	Ok	9.90%	10.10%
		Stop Loss	10.01%	Ok	9.90%	10.10%

VM3:

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.97%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	30.01%	Ok	28.50%	31.50%
		Frame 2	29.98%	Ok	28.50%	31.50%
		Frame 3	30.00%	Ok	28.50%	31.50%
		Frame 4	10.00%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	60.00%	Ok	57.00%	63.00%
		By Customer Acct	35.00%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	32.95%	Ok	31.00%	35.00%
		Frame 2	33.13%	Ok	31.00%	35.00%
		Frame 3	33.92%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.03%	Ok	9.50%	10.50%
		By Company Name	40.00%	Ok	38.00%	42.00%
		Buy on Margin	7.99%	Ok	7.50%	8.50%
		Rollback	0.98%	Ok	0.94%	1.04%
		LIFO	35.03%	Ok	33.00%	37.00%
		Trade by Qty 100	24.97%	Ok	24.00%	26.00%
		Trade by Qty 200	24.99%	Ok	24.00%	26.00%
		Trade by Qty 400	25.03%	Ok	24.00%	26.00%
		Trade by Qty 800	25.02%	Ok	24.00%	26.00%
		Market Buy	29.99%	Ok	29.70%	30.30%
		Market Sell	29.98%	Ok	29.70%	30.30%
		Limit Buy	20.02%	Ok	19.80%	20.20%
		Limit Sell	10.00%	Ok	9.90%	10.10%
		Stop Loss	10.01%	Ok	9.90%	10.10%

Table 6.2 Average Transaction Parameters

Clause B7: Transaction and System Properties

7.1 ACID Tests

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

The Atomicity, Consistency, Isolation, and Durability tests are specified by the TPC-E specification. These requirements are translated into audited procedures which are executed either on a fresh database (Isolation, Atomicity, Consistency), or after a test run (Consistency). Instructions for running these tests are included in the file ***MSTPCE ACID Procedures.pdf.*** This file, along with results of these tests is contained in the *Supporting Files* directory under ***Clause7***.

Durability test consisted of Data Accessibility and Business Recovery tests. The procedures for each are outlined below.

7.2 Redundancy Level and Data Accessibility Tests

*The **Test Sponsor** must **report** in the **Report** the Redundancy Level and describe the Data **Accessibility** test(s) used to demonstrate compliance .(9.3.7.2)*

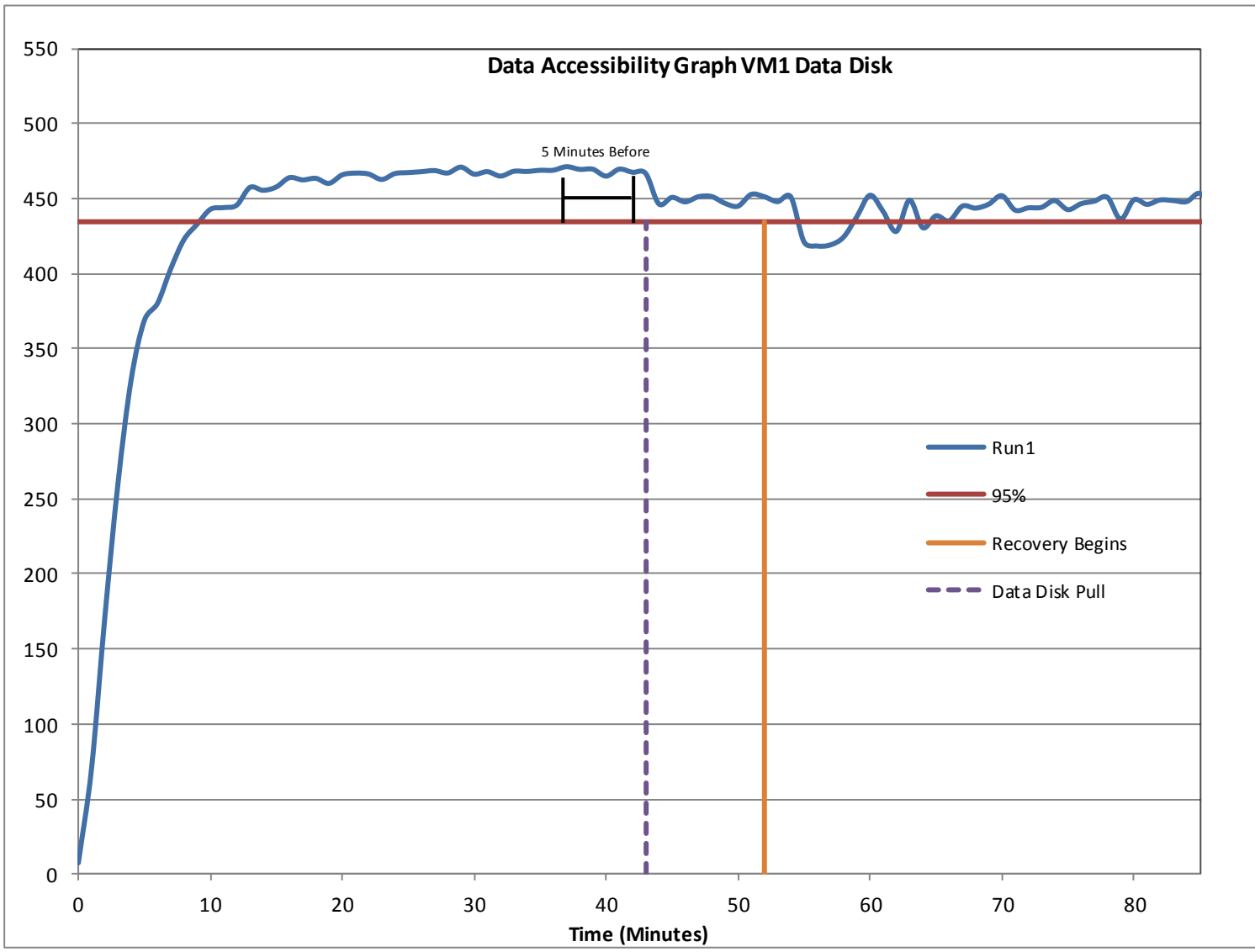
All VMs: Redundancy level 1 was used for all tests and the measured run.

The Data Accessibility Test for the data disk, and the database transaction log was performed according to the following steps:

1. The rows in the Settlement table were counted to establish the initial count of trades present.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to > 95% of the Reported Throughput for all three VMs.
3. After more 5 minutes of running at >= 95% of the Reported Throughput, log disk in the RAID10 log array for VM3 was pulled, and approximately five minutes later, a data disk in the RAID5 data arrays for **VM1** was pulled.
4. The benchmark was allowed to run for 5 more minutes at steady state, all at >= 95% of Reported Throughput.
5. After the 5 minutes, the disks were replaced by different disks of the same size and a rebuild of the volumes started automatically by the Smart Array controllers.
6. The run continued for more than 20 minutes while the disk arrays were in a rebuilding state.
7. Various reports were run. No errors were reported at any time in this process. There was no effect on **VM2**, and throughput remained at >= 95% during the entire data accessibility for this VM.
8. The rows in the Settlement table were counted again to establish the final number of trades present in the data base.
9. The initial count was subtracted from the final count and was verified against the reported number of Trade-Result transactions
10. After the two arrays finished the rebuilding process, the data accessibility test was considered complete.

7.3 Data Accessibility Graph

*A Data **Accessibility** Graph for each run demonstrating a Redundancy Level must be **reported** in the **Report. (9.3.7.3)***



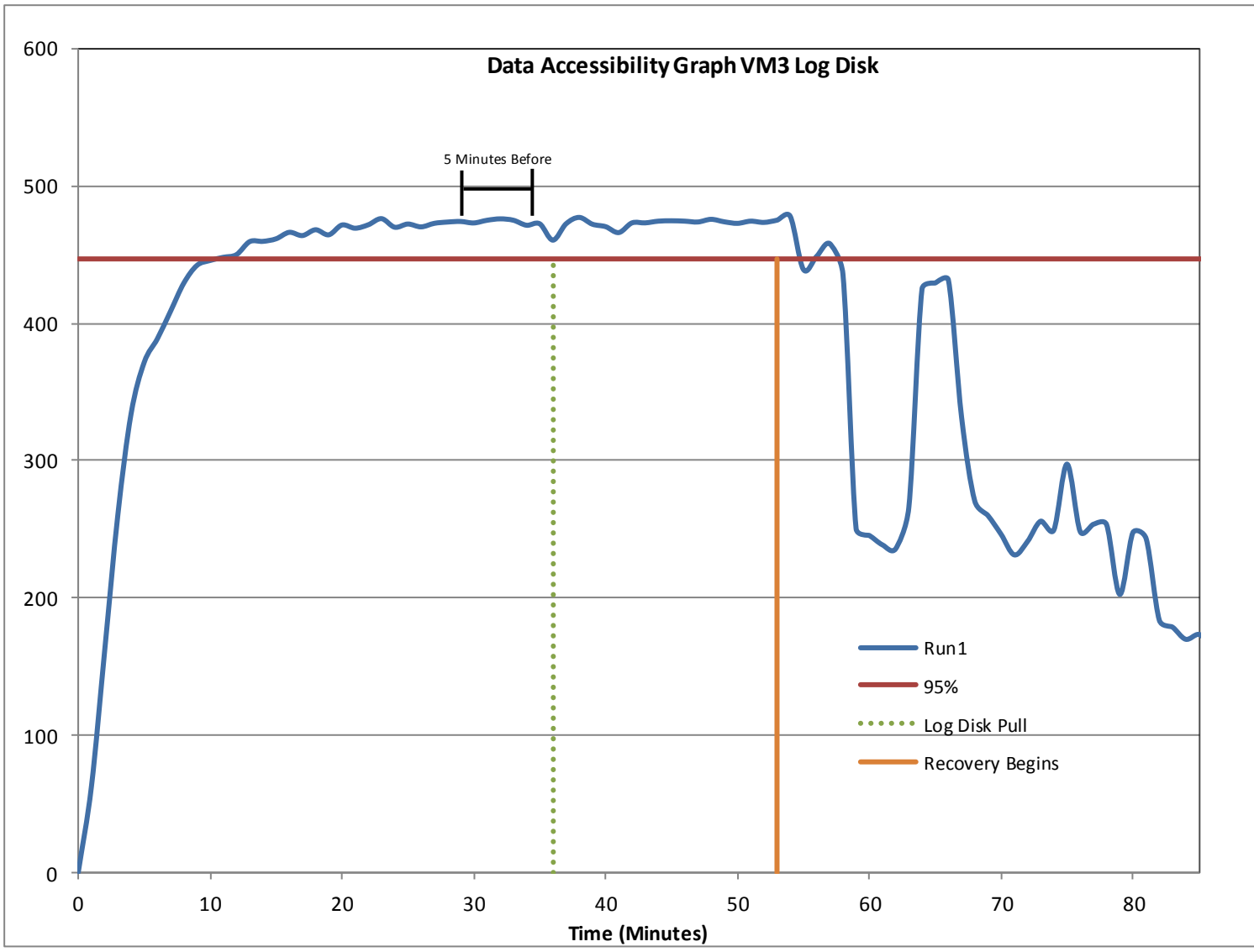


Figure 7.1 Data Accessibility Test Run Graphs

7.4 Business Recovery Tests

*The **Test Sponsor** must describe in the **Report** the test(s) used to demonstrate **Business Recovery**. (9.3.7.4)*

This test measures the time it takes to recover to 95% of the reported throughput after a system power loss.

1. The rows in the Settlement table were counted to establish the initial count of trades present for each VM.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to >95% of the Reported Throughput for all three VMs.
3. Primary power to Tier B server was removed (i.e., the plug was pulled).
4. Drivers noted transaction failures almost immediately, and the driver environment was terminated.
5. Power was restored to Tier B server, and the machine rebooted. While the machine booted and recovered (step 6), the logs for the first run were processed.

6. After the OS was running, SQL Server was started, which automatically started transaction recovery of the primary TPC-E database. This process reads the transaction log and reapplies all committed transactions and rollback any incomplete transactions. At the end of this process, the database on disk will be logically consistent.
7. Business Recovery starts with the first line of output produced by Microsoft SQL Server 2012 SP1 Enterprise Edition.
8. After SQL finished recovery of the TPC-E database and reported that the data base was available, the Trade-Cleanup Transaction was executed.
9. The benchmark was started and ramped up as before to >95% of the Reported Throughput.
10. The benchmark was allowed to run at >=95% for 20 minutes.
11. The driver environment was terminated gracefully. No errors were reported.
12. The rows in the Settlement table were counted again to determine the final number of trades present for each VM.
13. The initial count was subtracted from the final count, and this number was verified to be greater than or equal to the number of Trade-Result transacts as logged during the run.
14. The Consistency scripts were run to verify the data base was logically consistent.
15. The beginning of the first window of time where >=95% for 20 minutes was noted, which marked the end of the Business Recovery interval.
16. Although all procedures were completed and verified on each VM, only the graph of VM3 is show below, which was the slowest to recover.

Business Recovery Time was: **VM1:** 38:27 **VM2:** 38:07 **VM3:** 44:16 This is also reported in the Executive Summary and TPC-VMS Appendix A.

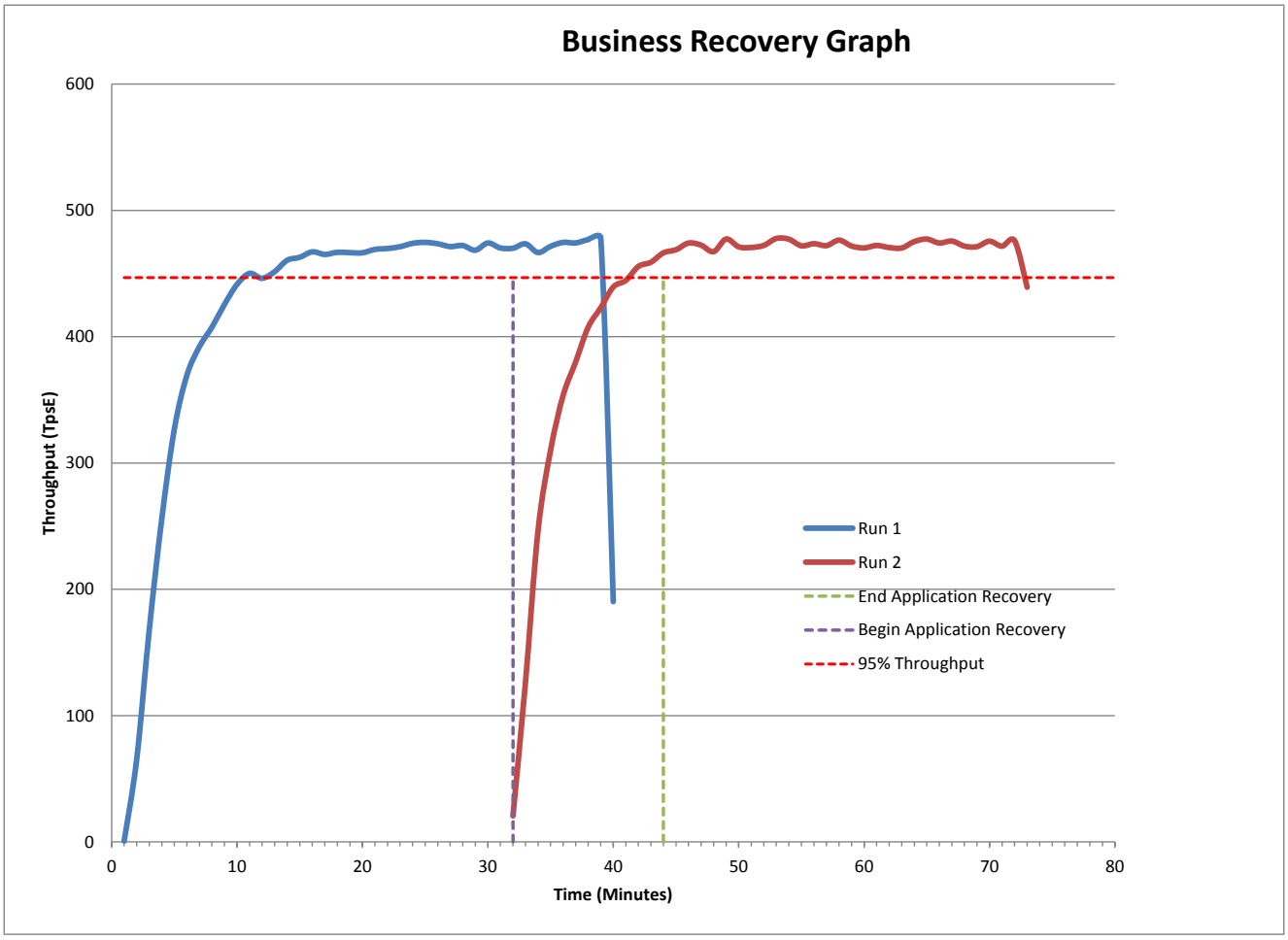


Figure 7.2 Business Recovery Tests Graph

Clause B8: Pricing Related Items

8.1 60-Day Space

*Details of the **60-Day Space** computations along with proof that the database is configured to sustain a **Business Day** of growth must be **reported** in the **Report**. (9.3.8.1)*

See TPC-VMS Clause 6- Pricing reported information.

Clause B9: Supporting Files

9.1 Supporting Files

*The **Supporting Files** contain human readable and machine executable (i.e., able to be performed by the appropriate program without modification) scripts that are required to recreate the benchmark **Result**. If there is a choice of using a GUI or a script, then the machine executable script must be provided in the **Supporting Files**. If no corresponding script is available for a GUI, then the **Supporting Files** must contain a detailed step by step description of how to manipulate the GUI.(9.4)*

Appendix C: Auditor's Attestation Letter

InfoSizing
The Right Metric For Sizing IT

TPC Transaction Processing Performance Council
Certified Auditor

Eric Deehr
Hewlett-Packard Company
14475 NE 24th Street
Bellevue, WA 98007

August 25, 2013

I verified the TPC Virtual Measurement Single System TPC-VMS™ v1.1.0 performance of the following configuration:

Platform:	HP ProLiant DL385p Gen8
Virtualization Manager:	VMware vSphere 5.5 Enterprise
Operating System:	Microsoft Windows Server 2012 Standard Edition
Database Manager:	Microsoft SQL Server 2012 Enterprise Edition SP1
Base Benchmark:	TPC Benchmark™ E v1.12.0

The results were:

Performance Metric	**457.55 tpsE**
Trade-Result 90th %-tile	0.05 Seconds

Tier B (Server)	**HP ProLiant DL385p Gen8**		
CPUs	2 x AMD Opteron 6386SE (2.8 GHz / 16-core) (2/32/32)		
Memory	256 GB (16MB L3)		
Disks	***Qty***	***Size***	***Type***
	8	146 GB	15K rpm SAS HDD
	24	400 GB	SATA SSD
	6	500 GB	7.2K rpm SAS HDD

Tier A (Client)	**HP ProLiant DL360 G7**
CPUs	2 x Hex-Core Intel Xeon X5670 (2.93 GHz)
Memory	16 GB (12MB L3)
Disks	2 x 146 GB 15K rpm SAS HDD

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

The following verification items were given special attention:

- All I/O was properly virtualized
- All VMs on the Consolidated Database Server were properly implemented

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- All base benchmarks were properly driven
- All random number seed requirements were properly met
- All measurement timings were properly implemented.
- The system pricing was verified for major components and maintenance

In addition, all base benchmarks were properly implemented. In particular:

- All EGen components were verified to be v1.12.0
- The transactions were correctly implemented
- The database was properly scaled and populated for 240,000 customers
- The mandatory network between the driver and the SUT was configured
- The ACID properties were met
- Input data was generated according to the specified percentages
- The reported response times were correctly measured
- All 90% response times were under the specified maximums
- The measurement interval was 120 minutes
- The implementation used Redundancy Level 1
- The Business Recovery Time of 00:38:27 was correctly measured
- The 60-day storage requirement was correctly computed

Additional Audit Notes:

None.

Respectfully Yours,

Doug Johnson, Auditor

François Raab, President

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