TPC Benchmark® VMS
Full Disclosure Report

HP ProLiant DL380p Gen8
Using Microsoft SQL Server 2014 Enterprise Edition
On Microsoft Windows Server 2012 Standard Edition
With VMware vSphere 5.5

First Edition
April 14, 2014

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Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, TPC Benchmark® E should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

All performance data contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly. Hewlett-Packard Company does not warrant or represent that a user can or will achieve similar performance expressed in transactions per second (VMStpsE ®) or normalized price/performance ($/VMStpsE ®). No warranty of system performance or price/performance is expressed or implied in this report.

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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 DL380p Gen8. The operating system used for the benchmark was Microsoft Windows Server 2012 Standard Edition running as a guest. The VMMS used was VMware vSphere 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 HP ProLiant DL380p Gen8 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 DL380p Gen8 using Microsoft SQL Server 2014 Enterprise Edition. It meets the requirements of the TPC Benchmark ® VMS Standard Specification, Revision 1.2.0 dated Nov. 2013. 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 DL380p Gen8 **Intel® Xeon® E5-2697v2** **C/S with 1 Proliant DL360 G7**	**TPC-VMS: 1.2.0** **TPC-E: 1.12.0** **TPC Pricing: 1.7.0** **Report Date:** **April 14, 2014**

TPC-VMS Throughput	Price/Performance	Availability Date	Total System Cost
718.12 VMStpsE	$648 USD/VMStpsE	April 14, 2014	$465,256 USD

Virtual System Under Test Configuration

VMMS	Processor/Cores/Thread	Memory
VMware vSphere 5.5	2/24/48 Intel® Xeon® E5-2697v2 2.7GHz GHz 30 MB L3	256 Gbyte

Tier B: Server
HP ProLiant DL380p Gen8

2 x Intel® Xeon® Processor E5-2697 v2 (2.7GHz/12-core) Processor (2/24/48)
256 GB Memory
6 x HP Smart Array P421/2GB
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 300GB 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

6 x HP StorageWorks D2700 Disk Enclosure, two per each VM
24 X HP 800GB 6G SATA MLC SFF (2.5-inch) SSD 4 per enclosure, 8 per VM.

Priced Only
6 x 500GB 6G SAS 7.2K SFF DP ENT HDD (60 Day Space)

	HP ProLiant DL380p Gen8 Intel® Xeon® E5-2697v2 C/S with 1 Proliant DL360 G7		TPC-VMS: 1.2.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date: April 14, 2014
	VM1	**VM2**	**VM3**
Performance	718.12 tpsE	737.08 tpsE	723.91 tpsE
Maximum Number of Virtual Processors	15	15	15
VM Memory	80GB	80GB	80GB
Maximum Capacity of Virtual Storage	4786GB	4786GB	4786GB
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 2014 Enterprise Edition	Microsoft SQL Server 2014 Enterprise Edition	Microsoft SQL Server 2014 Enterprise Edition
Scaling Component	375,000	375,000	375,000
Initial Number of Row Per VM	43,893,444,123	43,893,444,123	43,893,444,123
Initial Database Size Per VM	3063GB	3063GB	3063GB

	HP ProLiant DL380p Gen8 TPC-VMS 1.2.0				TPC-E	1.12.0
					TPC-Pricing	1.7.0
					Report date	14-Apr-14
					Availability Date	14-Apr-14
Description	**Part Number**	**Brand**	**Unit Price**	**Qty.**	**Extended Price**	**3 Yr Maint Price**
Server Hardware (Tier B)						
HP ProLiant DL380p Gen8 8 SFF Configure-to-order Server	653200-B21	1	2,803	1	2,803	
HP DL380p Gen8 Intel® Xeon® E5-2697v2 (2.7GHz/12-core/30MB/130W) FIO Processor	715224-B21	1	3,749	2	7,498	
HP 16GB (1x16GB) Dual Rank x4 PC3-14900R (DDR3-1866) Registered CAS-13 Memory	708641-B21	1	375	16	6,000	
HP 146GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise	652605-B21	1	355	2	710	
HP 300GB 6G SAS 15K rpm SFF (2.5-inch) SC Enterprise	652611-B21	1	545	6	3,270	
HP Smart Array P421/2GB FBWC 6Gb 2-ports Ext SAS Controller	631674-B21	1	899	6	5,394	
HP 3 year 4 hour 24x7 ProLiant DL38x(p) Proactive Care Service	U2Z50E	1	2,587	1		$2,587
			Subtotal		**$25,675**	**$2,587**
Server Software						
SQL Server 2014 Enterprise Edition, 2 Core License	7JQ-00750	2	13,472.50	23	309,868	
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		**$320,694**	**259**
Storage						
HP D2700 Disk Enclosure	AJ941A	1	3,399	6	20,394	
HP 3 year 4 hour 24x7 D2000 Enclosure Hardware Support	UQ540E	1	1,980	6		11,880
HP 800GB 6G SATA SFF 2.5-in Enterprise Mainstream 3yr Wty Solid State Drive	730065-B21	1	5,319	24	127,656	
HP 500GB 6G SAS 7.2K rpm SFF DP Midline Hard Drive (60 Day)	507610-B21	1	369	6	2,214	
			Subtotal		**150,264**	**11,880**
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	2,624	2	5,248	
HP 8GB (1x8GB) Dual Rank x8 PC3-10600 Memory Kit	500662-B21	1	219	2	438	
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		**8,145**	**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	789	1	789	
HP W2072a 20-inch Diagonal LED Backlit LCD Monitor	A3M50AA#ABA	1	119	3	357	
HP Wireless Classic Desktop Mouse and Keyboard	LV290AA#ABA	1	30	3	90	
			Subtotal		**1,256**	**0**
		Total Extended Price			**$508,313**	**$15,812**
Large Purchase and Net 30 discount (See Note 1)	28.0%	**Total Discounts**			**$54,515**	**$4,355**
		Grand Total			**$453,799**	**$11,457**

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	**$465,256**
tpsE	**718.12**
$ USD/VMStpsE	**$648**

	HP ProLiant DL380p Gen8 Intel® Xeon® E5-2697v2 C/S with 1 DL360 G7	TPC-VMS: 1.2.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date April 14, 2014

VM1 Numerical Quantities Summary					
Reported Throughput	718.12 tpsE	Configured Customers:			375,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.02	0.03	0.29
Customer Position		0.00	0.01	0.02	2.99
Market Feed		0.00	0.02	0.05	2.98
Market Watch		0.00	0.01	0.02	0.22
Security Detail		0.00	0.01	0.02	0.20
Trade Lookup		0.00	0.10	0.14	0.45
Trade Order		0.00	0.04	0.06	0.95
Trade Result		0.01	0.04	0.06	1.30
Trade Status		0.00	0.01	0.02	0.21
Trade Update		0.01	0.12	0.16	0.45
Data Maintenance		0.01	0.03		0.09

Transaction Mix	Transaction Count	Mix %
Broker Volume	2,533,306	4.900%
Customer Position	6,721,003	13.000%
Market Feed	517,050	1.000%
Market Watch	9,305,815	17.999%
Security Detail	7,237,992	14.000%
Trade Lookup	4,135,976	8.000%
Trade Order	5,221,688	10.100%
Trade Result	5,170,487	10.001%
Trade Status	9,823,143	19.000%
Trade Update	1,034,010	2.000%
Data Maintenance	120	

Ramp-up Time	15:00
Measurement Interval	2:00:00
Business Recovery Time	25:52
Total Number of Transactions Completed in Measurement Interval	51,700,470

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 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 hardware environment*

The HP ProLiant DL380p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 Intel® Xeon® E5-2697v2 processor installed, the system is also populated 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 two of the six 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 16-23 on server socket 0, numa node 0, and physical CPUs 24-30 on server socket 1, numa node 1. 1/2 of the memory for VM1 was allocated from server socket 0, numa node 0, the rest from server socket 1, numa node 1.

- VM2 was bound to physical CPUs 0-14 on server socket 0, numa node 0. All of the memory for VM2 was allocated from server socket 0.

- VM3 was bound to physical CPUs 32-46 on server socket 1, numa node 1. All of the memory for VM3 was allocated from server socket 1.

- Physical CPU 15 on server socket 0, numa node0 and physical CPU 31 and 47 on server socket 1, numa node 1 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 **SQL2014Setup.pdf** 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 VMMS. 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: 3/19/14 21:18:18
End Time: 3/19/14 23:18:18

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	375,000	Performance	718.12 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	3,750	280	344	31	655	624	-	-	31
CASH_TRANSACTION	5,961,564,448	613,895,656	1,294,104	30,759,488	645,949,248	616,465,240	1,275,480	3,627,001	3,627,001
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	6,480,000,000	308,991,304	651,632	15,482,147	325,125,083	310,357,552	714,616	2,032,108	2,032,108
TRADE	6,480,000,000	768,834,176	426,384,496	59,760,934	1,254,979,606	1,199,164,536	3,945,864	11,220,600	11,220,600
TRADE_HISTORY	15,552,015,041	467,729,848	1,219,448	23,447,465	492,396,761	470,230,192	1,280,896	3,642,402	3,642,402
TRADE_REQUEST	-	-	-	-	-	105,872	105,872	301,062	301,062
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	2,662,406	146,632	1,056	7,384	155,072	147,696	8	23	7,384
CUSTOMER	375,000	61,472	18,552	4,001	84,025	80,024	-	-	4,001
CUSTOMER_ACCOUNT	1,875,000	169,920	41,968	10,594	222,482	211,888	-	-	10,594
CUSTOMER_TAXRATE	750,000	15,640	344	799	16,783	16,104	120	342	799
HOLDING	331,695,554	21,919,664	14,918,592	1,841,913	38,680,169	37,269,240	430,984	1,225,562	1,225,562
HOLDING_HISTORY	8,684,413,283	315,796,928	210,964,936	26,338,093	553,099,957	528,207,776	1,445,912	4,111,647	4,111,647
HOLDING_SUMMARY	18,656,383	801,736	3,176	40,246	845,158	804,912	-	-	-
WATCH_ITEM	37,494,685	1,027,856	3,976	51,592	1,083,424	1,032,064	232	660	51,592
WATCH_LIST	375,000	9,360	8,944	915	19,219	18,304	-	-	915
Market File Group									
COMPANY	187,500	39,872	12,456	2,616	54,944	52,344	16	46	2,616
COMPANY_COMPETITOR	562,500	15,128	14,128	1,463	30,719	29,256	-	-	1,463
DAILY_MARKET	335,221,875	15,495,136	44,136	776,964	16,316,236	15,540,296	1,024	2,912	776,964
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	3,750,000	422,616	1,480	21,205	445,301	424,336	240	683	21,205
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	256,875	15,816	344	808	16,968	16,160	-	-	808
NEWS_ITEM	375,000	40,656,872	776	2,032,882	42,690,530	40,657,728	80	228	2,032,882
NEWS_XREF	375,000	9,360	344	485	10,189	9,704	-	-	485
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	256,875	35,224	10,104	2,266	47,594	45,328	-	-	2,266
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	562,504	32,488	344	1,642	34,474	32,864	32	91	1,642
TAXRATE	320	24	16	2	42	56	16	46	46
ZIP_CODE	14,741	488	24	26	538	512	-	-	26
TOTALS (KB)		**2,556,123,560**	**655,596,840**	**160,586,020**	**3,372,306,420**				
Initial Database Size (MB)		**3,136,446**	**3,063 GB**						

Db/Filegroups	LUN Count	Partition Size(KB)	MB allocated	MB Loaded	MB Required	
fixed_fg	2	46,137,344	90,112	56,948	59,795	OK
growing_fg	2	2,193,007,616	4,283,218	3,079,498	3,105,045	OK
					MB Available	
Settlements	**7,273,033**				1,208,490	

			Database	60 Day Space				
Initial Growing Space (MB)	3,079,498							
Final Growing Space (MB)	3,088,482	**LUNS**	2	1	**Initial Log size (MB)**	9,416	**Log LUNS**	1
Delta (MB)	8,984	**Disks per LUN**	4	2	**Final Log size (MB)**	59,057	**Log Disks**	2
Data Space per Trade (MB)	0.00123525	**Disk Capacity (MB)**	763,063.97	476,938	**Log Growth (MB)**	49,640	**Disk Capacity (MB)**	286,063.68
1 Day Data Growth (MB)	25,547	**RAID5 Overhead**	25.0%	50.0%	**Log Growth/trade (MB)**	0.00682527	**RAID10 Overhead**	50.0%
60-Day Overflow (MB)	**1,507,287**	**Total Space (MB)**	**4,578,383.80**	**476,938**	**1 Day log space (MB)**	**141.159**	**Log Space (MB)**	**286,063.68**

Total Space Required	**4,672,127.85**	
Total Space Priced	5,055,322	
TempDB used	42,407	
Total Minus TempDB used	5,012,915	OK

Space calculations for VM2:

TPC-E Disk Space Requirements

Customers Used	375,000	Performance	737.08	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	3,750	280	344	31	655	624	-	-	31
CASH_TRANSACTION	5,961,564,448	613,895,656	1,294,104	30,759,488	645,949,248	616,498,976	1,309,216	3,718,061	3,718,061
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	6,480,000,000	308,991,304	651,632	15,482,147	325,125,083	310,376,832	733,896	2,084,202	2,084,202
TRADE	6,480,000,000	768,834,176	426,384,496	59,760,934	1,254,979,606	1,199,194,880	3,976,208	11,292,088	11,292,088
TRADE_HISTORY	15,552,015,041	467,729,848	1,219,448	23,447,465	492,396,761	470,265,264	1,315,968	3,737,236	3,737,236
TRADE_REQUEST	-	-	-	-	-	109,440	109,440	310,801	310,801
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	2,662,406	146,632	1,056	7,384	155,072	147,736	48	137	7,384
CUSTOMER	375,000	61,472	18,552	4,001	84,025	80,032	8	23	4,001
CUSTOMER_ACCOUNT	1,875,000	169,920	41,968	10,594	222,482	211,888	-	-	10,594
CUSTOMER_TAXRATE	750,000	15,640	344	799	16,783	16,096	112	319	799
HOLDING	331,695,554	21,919,664	14,918,592	1,841,913	38,680,169	37,280,912	442,656	1,257,105	1,257,105
HOLDING_HISTORY	8,684,413,283	315,796,928	210,964,936	26,338,093	553,099,957	528,252,160	1,490,296	4,232,313	4,232,313
HOLDING_SUMMARY	18,656,383	801,736	3,176	40,246	845,158	804,912	-	-	-
WATCH_ITEM	37,494,685	1,027,856	3,976	51,592	1,083,424	1,032,064	232	659	51,592
WATCH_LIST	375,000	9,360	8,944	915	19,219	18,304	-	-	915
Market File Group									
COMPANY	187,500	39,872	12,456	2,616	54,944	52,344	16	46	2,616
COMPANY_COMPETITOR	562,500	15,128	14,128	1,463	30,719	29,256	-	-	1,463
DAILY_MARKET	335,221,875	15,495,136	44,136	776,964	16,316,236	15,540,328	1,056	2,999	776,964
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	3,750,000	422,616	1,480	21,205	445,301	424,360	264	750	21,205
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	256,875	15,816	344	808	16,968	16,160	-	-	808
NEWS_ITEM	375,000	40,656,872	776	2,032,882	42,690,530	40,657,680	32	91	2,032,882
NEWS_XREF	375,000	9,360	344	485	10,189	9,704	-	-	485
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	256,875	35,224	10,104	2,266	47,594	45,336	8	23	2,266
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	562,504	32,488	344	1,642	34,474	32,872	40	114	1,642
TAXRATE	320	24	16	2	42	56	16	46	46
ZIP_CODE	14,741	488	24	26	538	512	-	-	26
TOTALS (KB)		**2,556,123,560**	**655,596,840**	**160,586,020**	**3,372,306,420**				
Initial Database Size (MB)		**3,136,446**	**3,063 GB**						

Db/Filegroups	LUN Count	Partition Size(KB)	MB allocated	MB Loaded	MB Required	
fixed_fg	2	46,137,344	90,112	56,948	59,795	OK
growing_fg	2	2,193,007,616	4,283,218	3,079,498	3,105,505	OK
					MB Available	
Settlements	**7,474,841**				1,208,029	

			Database	60 Day Space				
Initial Growing Space (MB)	3,079,498							
Final Growing Space (MB)	3,088,656	**LUNS**	2	1	**Initial Log size (MB)**	9,416	**Log LUNS**	1
Delta (MB)	9,158	**Disks per LUN**	4	2	**Final Log size (MB)**	60,865	**Log Disks**	2
Data Space per Trade (MB)	0.00122516	**Disk Capacity (MB)**	763,063.97	476,938	**Log Growth (MB)**	51,449	**Disk Capacity (MB)**	286,063.68
1 Day Data Growth (MB)	26,008	**RAID5 Overhead**	25.0%	50.0%	**Log Growth/trade (MB)**	0.00688290	**RAID10 Overhead**	50.0%
60-Day Overflow (MB)	**1,534,450**	**Total Space (MB)**	**4,578,383.80**	**476,938**	**1 Day log space (MB)**	**146,109**	**Log Space (MB)**	**286,063.68**

Total Space Required	**4,699,750.34**	
Total Space Priced	5,055,322	
TempDB used	42,407	
Total Minus TempDB used	5,012,915	OK

Space calculations for VM3:

TPC-E Disk Space Requirements

Customers Used	**375,000**	**Performance**	**723.91**	**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	3,750	280	344	31	655	624	-	-	31
CASH_TRANSACTION	5,961,564,448	613,895,656	1,294,104	30,759,488	645,949,248	616,475,944	1,286,184	3,657,855	3,657,855
CHARGE	15	8	8	1	17	16	-	-	1
COMMISSION_RATE	240	16	16	2	34	32	-	-	2
SETTLEMENT	6,480,000,000	308,991,304	651,632	15,482,147	325,125,083	310,361,760	718,824	2,044,306	2,044,306
TRADE	6,480,000,000	768,834,176	426,384,496	59,760,934	1,254,979,606	1,199,173,312	3,954,640	11,246,834	11,246,834
TRADE_HISTORY	15,552,015,041	467,729,848	1,219,448	23,447,465	492,396,761	470,241,328	1,292,032	3,674,486	3,674,486
TRADE_REQUEST	-	-	-	-	-	106,560	106,560	303,053	303,053
TRADE_TYPE	5	8	1,032	52	1,092	1,040	-	-	52
Customer File Group									-
ACCOUNT_PERMISSION	2,662,406	146,632	1,056	7,384	155,072	147,808	120	342	7,384
CUSTOMER	375,000	61,472	18,552	4,001	84,025	80,040	16	46	4,001
CUSTOMER_ACCOUNT	1,875,000	169,920	41,968	10,594	222,482	211,888	-	-	10,594
CUSTOMER_TAXRATE	750,000	15,640	344	799	16,783	16,104	120	342	799
HOLDING	331,695,554	21,919,664	14,918,592	1,841,913	38,680,169	37,272,496	434,240	1,234,961	1,234,961
HOLDING_HISTORY	8,684,413,283	315,796,928	210,964,936	26,338,093	553,099,957	528,220,032	1,458,168	4,146,970	4,146,970
HOLDING_SUMMARY	18,656,383	801,736	3,176	40,246	845,158	804,912	-	-	-
WATCH_ITEM	37,494,685	1,027,856	3,976	51,592	1,083,424	1,032,064	232	660	51,592
WATCH_LIST	375,000	9,360	8,944	915	19,219	18,304	-	-	915
Market File Group									
COMPANY	187,500	39,872	12,456	2,616	54,944	52,344	16	46	2,616
COMPANY_COMPETITOR	562,500	15,128	14,128	1,463	30,719	29,256	-	-	1,463
DAILY_MARKET	335,221,875	15,495,136	44,136	776,964	16,316,236	15,540,328	1,056	3,004	776,964
EXCHANGE	4	8	8	1	17	16	-	-	1
FINANCIAL	3,750,000	422,616	1,480	21,205	445,301	424,312	216	615	21,205
INDUSTRY	102	8	24	2	34	32	-	-	2
LAST_TRADE	256,875	15,816	344	808	16,968	16,160	-	-	808
NEWS_ITEM	375,000	40,656,872	776	2,032,882	42,690,530	40,657,704	56	160	2,032,882
NEWS_XREF	375,000	9,360	344	485	10,189	9,704	-	-	485
SECTOR	12	8	24	2	34	32	-	-	2
SECURITY	256,875	35,224	10,104	2,266	47,594	45,336	8	23	2,266
STATUS_TYPE	5	8	8	1	17	16	-	-	1
Misc File Group									
ADDRESS	562,504	32,488	344	1,642	34,474	32,832	-	-	1,642
TAXRATE	320	24	16	2	42	56	16	46	46
ZIP_CODE	14,741	488	24	26	538	512	-	-	26
TOTALS (KB)		**2,556,123,560**	**655,596,840**	**160,586,020**	**3,372,306,420**				
Initial Database Size (MB)		**3,136,446**	**3,063 GB**						

Db/Filegroups	LUN Count	Partition Size(KB)	MB allocated	MB Loaded	MB Required	
fixed_fg	2	46,137,344	90,112	56,948	59,795	OK
growing_fg	2	2,193,007,616	4,283,218	3,079,498	3,105,190	OK
					MB Available	
Settlements	**7,330,840**				1,208,345	

Initial Growing Space (MB)	3,079,498		Database	60 Day Space					
Final Growing Space (MB)	3,088,532	**LUNS**	2	1	**Initial Log size (MB)**	9,416	**Log LUNS**	1	
Delta (MB)	9,034	**Disks per LUN**	4	2	**Final Log size (MB)**	60,442	**Log Disks**	2	
Data Space per Trade (MB)	0.00123231	**Disk Capacity (MB)**	763,063.97	476,938	**Log Growth (MB)**	51,025	**Disk Capacity (MB)**	286,063.68	
1 Day Data Growth (MB)	25,692	**RAID5 Overhead**	25.0%	50.0%	**Log Growth/trade (MB)**	0.00696036	**RAID10 Overhead**	50.0%	
60-Day Overflow (MB)	**1,515,820**	**Total Space (MB)**	**4,578,383.80**	**476,938**	**1 Day log space (MB)**	**145,114**	**Log Space (MB)**	**286,063.68**	

Total Space Required	**4,680,804.66**	
Total Space Priced	5,055,322	
TempDB used	42,407	
Total Minus TempDB used	5,012,915	OK

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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

Microsoft

April 7, 2014

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-00750	**SQL Server 2014 Enterprise Edition** *2 Core License* *Open Program - Level C*	$13,472.50	23	$309,867.50
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 2014 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_qhtplylGYLKTVUKf95957fiiiL_2014_edblx

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 April 14, 2014.

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 DL380p Gen8 Intel® Xeon® E5-2697v2 C/S with 1 DL360 G7	TPC-VMS: 1.2.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date April 14, 2014

VM2 Numerical Quantities Summary					
Reported Throughput	737.08 tpsE	Configured Customers:			375,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.01	0.03	0.08
Customer Position		0.00	0.01	0.02	0.70
Market Feed		0.00	0.02	0.04	1.01
Market Watch		0.00	0.01	0.02	0.27
Security Detail		0.00	0.01	0.01	0.14
Trade Lookup		0.00	0.11	0.15	0.29
Trade Order		0.00	0.03	0.05	0.78
Trade Result		0.00	0.03	0.05	1.28
Trade Status		0.00	0.01	0.02	0.12
Trade Update		0.01	0.13	0.16	0.30
Data Maintenance		0.01	0.02		0.09
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			2,600,444		4.900%
Customer Position			6,899,469		13.000%
Market Feed			530,705		1.000%
Market Watch			9,553,001		18.000%
Security Detail			7,430,016		14.000%
Trade Lookup			4,245,672		8.000%
Trade Order			5,360,296		10.100%
Trade Result			5,307,031		10.000%
Trade Status			10,083,638		19.000%
Trade Update			1,061,443		2.000%
Data Maintenance			120		
Ramp-up Time				15:00	
Measurement Interval				2:00:00	
Business Recovery Time				25:38	
Total Number of Transactions Completed in Measurement Interval				53,071,715	

VM3 Numerical Quantities:

	HP ProLiant DL380p Gen8 Intel® Xeon® E5-2697v2 C/S with 1 DL360 G7	TPC-VMS: 1.2.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 Report Date April 14, 2014

VM3 Numerical Quantities Summary					
Reported Throughput	723.91 tpsE	Configured Customers:			375,000
Response Times (in seconds)		Minimum	Average	90th %tile	Maximum
Broker Volume		0.00	0.01	0.02	0.16
Customer Position		0.00	0.01	0.02	2.12
Market Feed		0.00	0.02	0.04	2.11
Market Watch		0.00	0.01	0.02	0.24
Security Detail		0.00	0.01	0.01	0.16
Trade Lookup		0.00	0.12	0.17	0.33
Trade Order		0.00	0.03	0.05	0.26
Trade Result		0.00	0.03	0.04	1.42
Trade Status		0.00	0.01	0.02	0.16
Trade Update		0.01	0.14	0.18	0.36
Data Maintenance		0.01	0.02		0.07
Transaction Mix			**Transaction Count**		**Mix %**
Broker Volume			2,553,516		4.900%
Customer Position			6,774,624		13.000%
Market Feed			521,218		1.000%
Market Watch			9,380,250		18.000%
Security Detail			7,295,699		14.000%
Trade Lookup			4,168,951		8.000%
Trade Order			5,263,349		10.100%
Trade Result			5,212,172		10.002%
Trade Status			9,901,513		19.000%
Trade Update			1,042,248		2.000%
Data Maintenance			120		
Ramp-up Time					15:00
Measurement Interval					2:00:00
Business Recovery Time					24:34
Total Number of Transactions Completed in Measurement Interval					52,113,540

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 DL380p Gen8 using Microsoft SQL Server 2014 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 DL380p Gen8
2 x Intel® Xeon® Processor E5-2697 v2 (2.7GHz/12-core) Processor (2/24/48)
256 GB Memory
6 x HP Smart Array P421/2GB
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 300GB 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
6 x HP StorageWorks D2700 Disk Enclosure, two per each VM
24 X HP 800GB 6G SATA MLC SFF (2.5-inch) SSD 4 per enclosure, 8 per VM.

Priced Only
6 x 500GB 6G SAS 7.2K SFF DP ENT HDD (60 Day Space)

Figure 1.2 Measured Configuration

Tier B: Server
HP ProLiant DL380p Gen8
2 x Intel® Xeon® Processor E5-2697 v2 (2.7GHz/12-core) Processor (2/24/48)
256 GB Memory
6 x HP Smart Array P421/2GB
2 x HP 146GB SAS 15K SFF DP ENT HDD (Boot)
6 x HP 300GB 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
6 x HP StorageWorks D2700 Disk Enclosure, two per each VM
24 X HP 800GB 6G SATA MLC SFF (2.5-inch) SSD 4 per enclosure, 8 per VM.

Measured Only
24 x 500GB 6G SAS 7.2K SFF DP ENT HDD (Database Backup)
8 drives per each VM

Note: The 24 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 DL380p Gen8, in the benchmarked configuration, consists of a single cabinet with 2 sockets. Each socket has 1 Intel® Xeon® E5-2697v2 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

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\ALL_VMs\Introduction\TierB* directory outlines the steps taken to configure the guest OS and DBMS. The file **SQL2014Setup.pdf** in *SupportingFiles\ALL_VMs\Introduction\TierB* likewise outlines the steps taken to setup the DBMS. The files **VirtualMachines_and_VirtualDiskConfig.pdf** and **vSphere5.5Setup.pdf** in *SupportingFiles\ALL_VMs\Introduction\VSUT* likewise outlines the steps taken to setup the VMMS. 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 375,000 customers. Table 2.2 below shows the cardinality of each table for **All_VMs**.

Table	Rows
BROKER	3750
CASH_TRANSACTION	5961564448
CHARGE	15
COMMISSION_RATE	240
SETTLEMENT	6480000000
TRADE	6480000000
TRADE_HISTORY	15552015041
TRADE_REQUEST	0
TRADE_TYPE	5
ACCOUNT_PERMISSION	2662406
CUSTOMER	375000
CUSTOMER_ACCOUNT	1875000
CUSTOMER_TAXRATE	750000
HOLDING	331695554
HOLDING_HISTORY	8684413283
HOLDING_SUMMARY	18656383
WATCH_ITEM	37494685
WATCH_LIST	375000
COMPANY	187500
COMPANY_COMPETITOR	562500
DAILY_MARKET	335221875
EXCHANGE	4
FINANCIAL	3750000
INDUSTRY	102
LAST_TRADE	256875
NEWS_ITEM	375000
NEWS_XREF	375000
SECTOR	12
SECURITY	256875
STATUS_TYPE	5
ADDRESS	562504
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 6 HP SmartArray controllers, configured for database storage. It also shows the 6 X HP 300GB 6G SAS 15K RPM SF Hard Drives configured for the transaction log of each VM, which was connected to the 1 P420i controller in the internal bay. The database logical volumes were configured in RAID 5, and the log disks were configured as three RAID1 volumes.

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	2x300GB SAS, Internal RAID1	E:, RAW	279.24GB	Database log **VM1**
	3	2x300GB SAS, Internal RAID1	E:, RAW	279.24GB	Database log **VM2**
	4	2x300GB SAS, Internal RAID1	E:, RAW	279.24GB	Database log **VM3**
P421 SmartArray Adapter **VM1**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2091.42GB 44 GB 100 GB	Growing FG Fixed FG TempDB files **VM1**
P421 SmartArray Adapter **VM1**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) g:\mnt\temp\2\(NTFS)	2091.42GB 44 GB 100 GB	Growing FG Fixed FG TempDB files **VM1**
P421 SmartArray Adapter **VM2**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2091.42GB 44 GB 100 GB	Growing FG Fixed FG TempDB files **VM2**
P421 SmartArray Adapter **VM2**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) g:\mnt\temp\2\(NTFS)	2091.42GB 44 GB 100 GB	Growing FG Fixed FG TempDB files **VM2**

P421 SmartArray Adapter **VM3**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\1\ (RAW) g:\mnt\fixed\1\ (RAW) g:\mnt\temp\1\(NTFS)	2091.42GB 44 GB 100 GB	Growing FG Fixed FG TempDB files **VM3**
P421 SmartArray Adapter **VM3**	1	4 X 800GB 6G SATA MLC SFF	g:\mnt\growing\2\ (RAW) g:\mnt\fixed\2\ (RAW) g:\mnt\temp\2\(NTFS)	2091.42GB 44 GB 100 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 6 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 2014 Enterprise Edition 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 flexible LOM 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 NICs on the SUT and client were 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: There were 8 Driver CEs with a total of 153 EGenDriverCE instances used in the benchmark.
There were 8 Driver MEEs with a dynamic number of EGenDriverMEE instances used during the benchmark.

6.2 Measured Throughput

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

VM1: The measured throughput was 718.12 VMStpsE.

VM2: The measured throughput was 737.08 VMStpsE.

VM3: The measured throughput was 723.91 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.

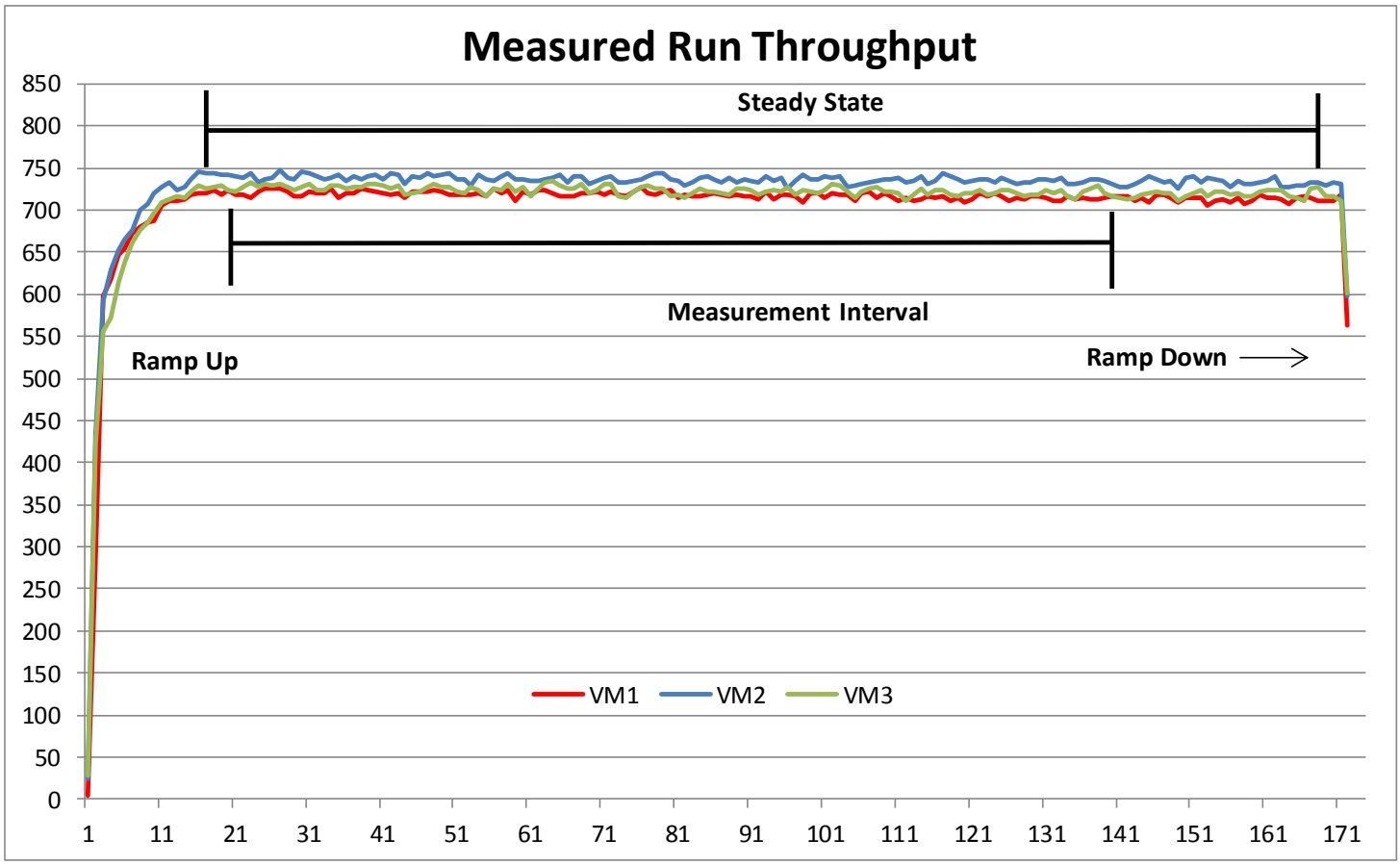


Figure 6.1 Test Run Time/Steady State Measurement Run Data

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 2014 Enterprise Edition. 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	49.99%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.98%	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	10.01%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	59.99%	Ok	57.00%	63.00%
		By Customer Acct	35.01%	Ok	33.00%	37.00%
		By Industry	5.00%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	33.04%	Ok	31.00%	35.00%
		Frame 2	32.98%	Ok	31.00%	35.00%
		Frame 3	33.97%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.00%	Ok	9.50%	10.50%
		By Company Name	40.00%	Ok	38.00%	42.00%
		Buy on Margin	8.00%	Ok	7.50%	8.50%
		Rollback	0.98%	Ok	0.94%	1.04%
		LIFO	34.95%	Ok	33.00%	37.00%
		Trade by Qty 100	25.01%	Ok	24.00%	26.00%
		Trade by Qty 200	25.01%	Ok	24.00%	26.00%
		Trade by Qty 400	24.99%	Ok	24.00%	26.00%
		Trade by Qty 800	24.99%	Ok	24.00%	26.00%
		Market Buy	29.98%	Ok	29.70%	30.30%
		Market Sell	30.00%	Ok	29.70%	30.30%
		Limit Buy	20.00%	Ok	19.80%	20.20%
		Limit Sell	10.01%	Ok	9.90%	10.10%
		Stop Loss	10.01%	Ok	9.90%	10.10%

VM2:

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.99%	Ok	48.00%	52.00%
		Get History	50.00%	Ok	48.00%	52.00%
Trade Lookup	OK	Frame 1	29.99%	Ok	28.50%	31.50%
		Frame 2	30.01%	Ok	28.50%	31.50%
		Frame 3	30.02%	Ok	28.50%	31.50%
		Frame 4	9.99%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	59.99%	Ok	57.00%	63.00%
		By Customer Acct	35.01%	Ok	33.00%	37.00%
		By Industry	5.01%	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	33.94%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.01%	Ok	9.50%	10.50%
		By Company Name	40.04%	Ok	38.00%	42.00%
		Buy on Margin	8.00%	Ok	7.50%	8.50%
		Rollback	1.00%	Ok	0.94%	1.04%
		LIFO	35.05%	Ok	33.00%	37.00%
		Trade by Qty 100	24.99%	Ok	24.00%	26.00%
		Trade by Qty 200	25.00%	Ok	24.00%	26.00%
		Trade by Qty 400	25.01%	Ok	24.00%	26.00%
		Trade by Qty 800	24.99%	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	20.01%	Ok	19.80%	20.20%
		Limit Sell	10.00%	Ok	9.90%	10.10%
		Stop Loss	9.98%	Ok	9.90%	10.10%

VM3:

Transaction	Over-all	Parameter	Value	Range Check	Acceptable Range	
					Min	Max
Customer Position	OK	By Tax ID	49.96%	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	29.97%	Ok	28.50%	31.50%
		Frame 3	30.01%	Ok	28.50%	31.50%
		Frame 4	10.01%	Ok	9.50%	10.50%
Market Watch	OK	By Watch List	59.99%	Ok	57.00%	63.00%
		By Customer Acct	34.99%	Ok	33.00%	37.00%
		By Industry	5.01%	Ok	4.50%	5.50%
Trade Update	OK	Frame 1	33.03%	Ok	31.00%	35.00%
		Frame 2	33.01%	Ok	31.00%	35.00%
		Frame 3	33.96%	Ok	32.00%	36.00%
Security Detail	OK	Access LOB	1.00%	Ok	0.90%	1.10%
Trade Order	OK	By Non-Owner	10.01%	Ok	9.50%	10.50%
		By Company Name	40.00%	Ok	38.00%	42.00%
		Buy on Margin	8.00%	Ok	7.50%	8.50%
		Rollback	0.99%	Ok	0.94%	1.04%
		LIFO	35.01%	Ok	33.00%	37.00%
		Trade by Qty 100	25.02%	Ok	24.00%	26.00%
		Trade by Qty 200	24.99%	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	29.98%	Ok	29.70%	30.30%
		Market Sell	29.99%	Ok	29.70%	30.30%
		Limit Buy	20.01%	Ok	19.80%	20.20%
		Limit Sell	9.99%	Ok	9.90%	10.10%
		Stop Loss	10.02%	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)*

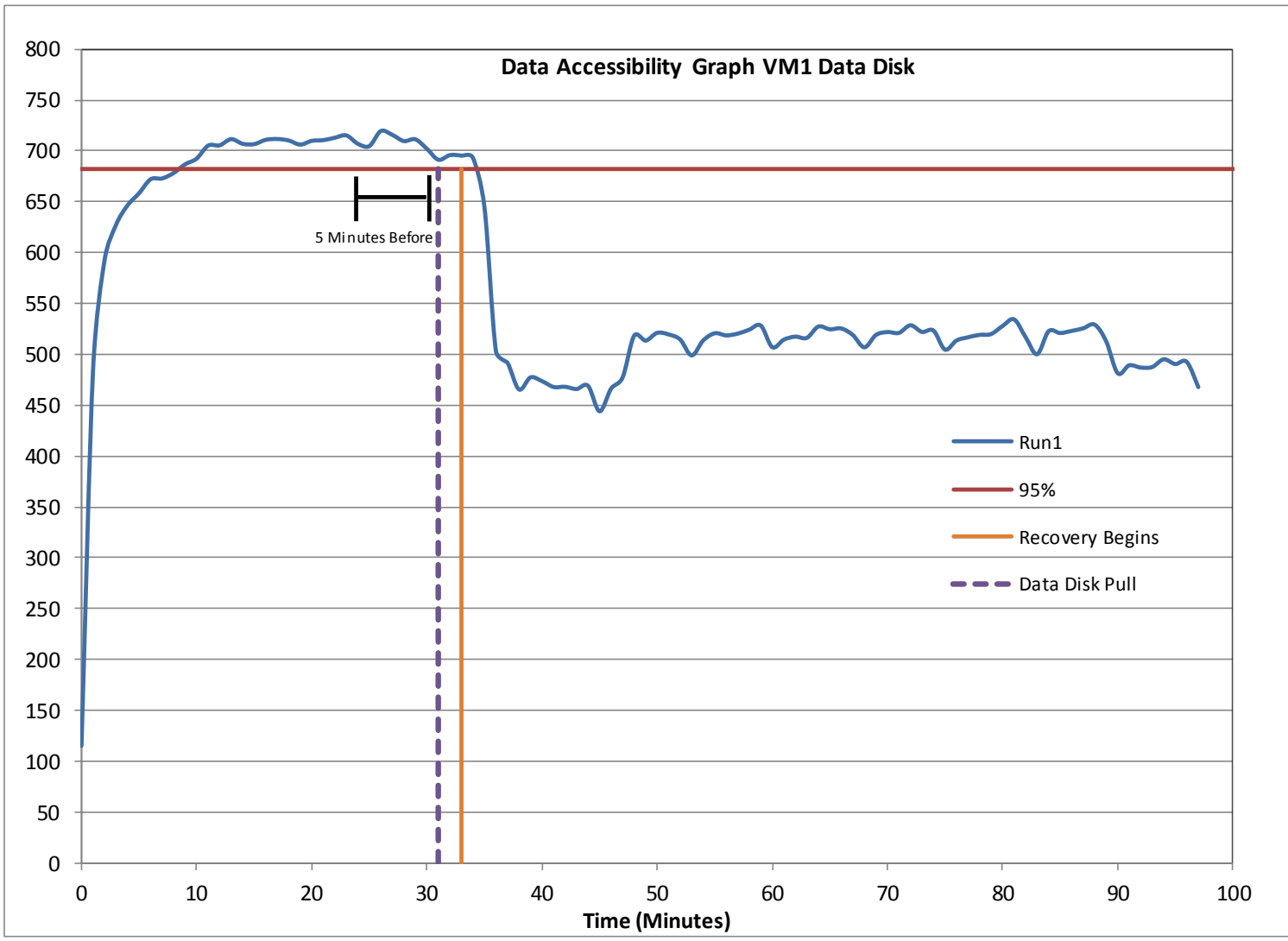
All VMs: Redundancy level 1 was used for all tests and the measured run.

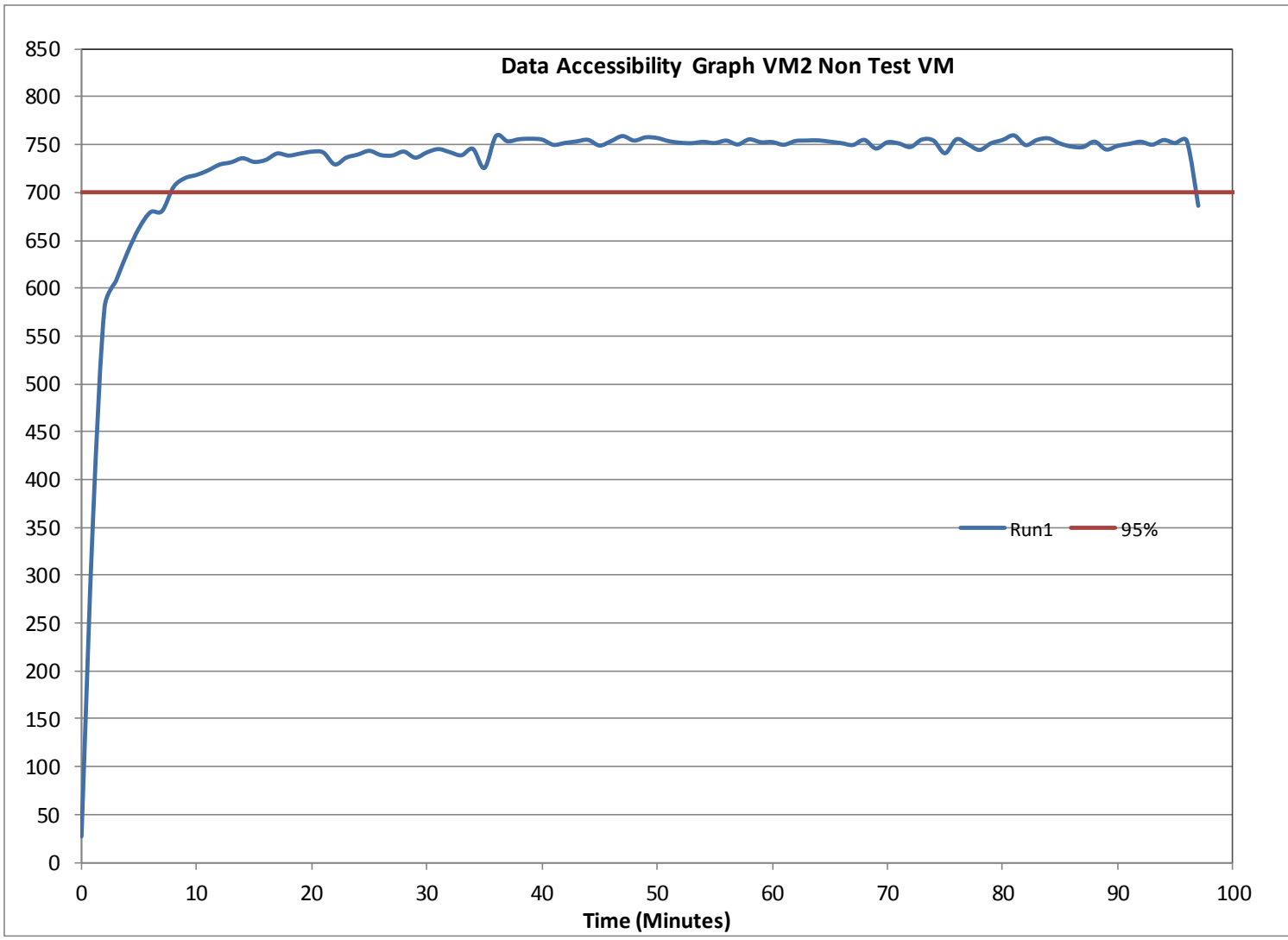
The Data Accessibility Test for the data disk, and the database transaction log was performed according to the following steps:

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)***




Data Accessibility Graph VM2 Non Test VM
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
Time (Minutes)
Run1
95%

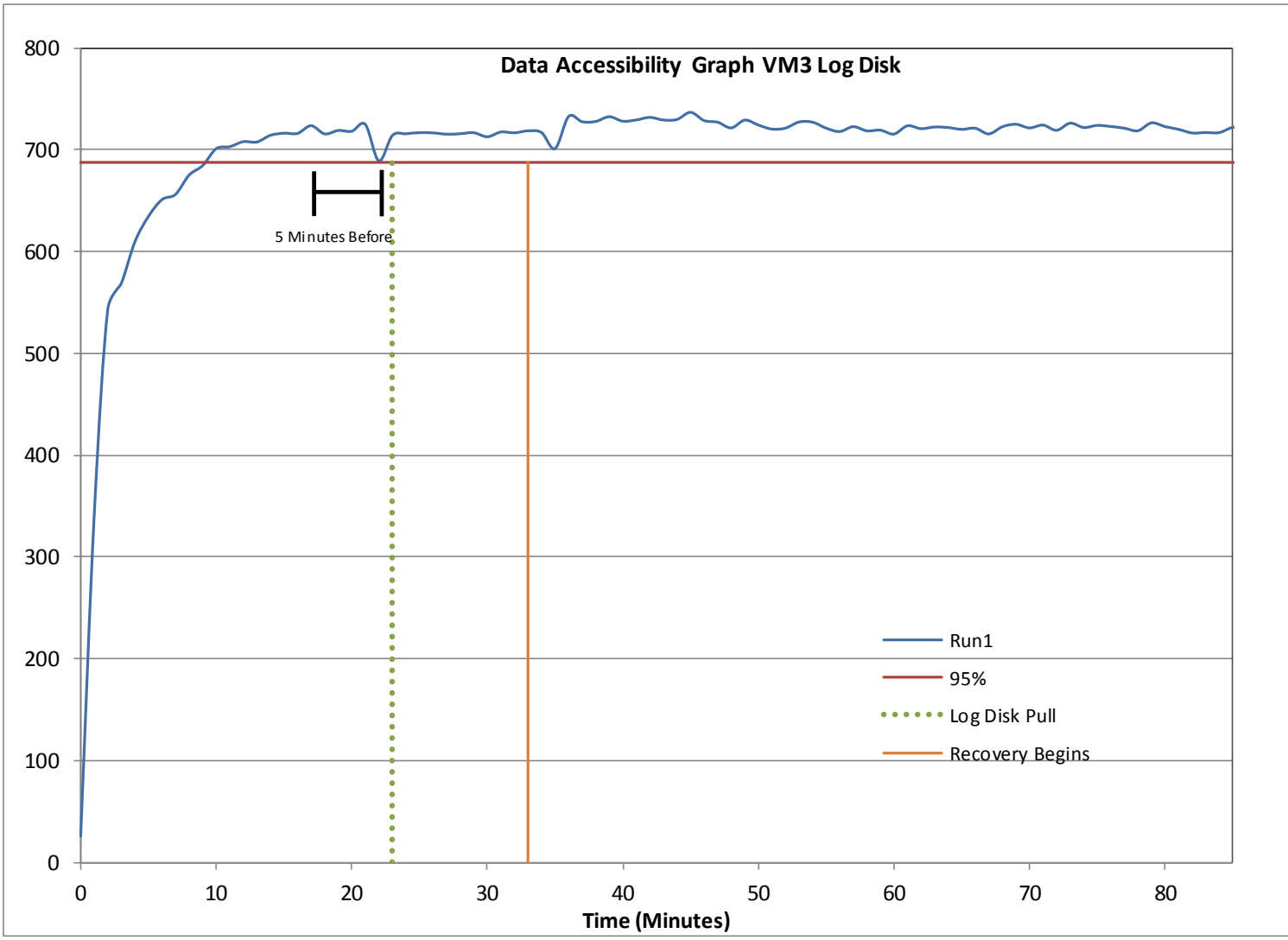


Figure 7.1 Data Accessibility Test Run Graphs

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 on each VM, 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 2014 Enterprise Edition.
8. After SQL finished recovery of the TPC-E databases and reported that the data base was available, the Trade-Cleanup Transaction were executed on each VM.
9. The benchmark was started and ramped up as before to >95% of the Reported Throughput on each VM.
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 each 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 VM1 is shown below, which was the slowest to recover and chosen as the single test VM, as all VMs were considered identical.

Business Recovery Time was: **VM1:** 25:52 **VM2:** 25:38 **VM3:** 24:34 This is also reported in the Executive Summary and TPC-VMS Appendix A.

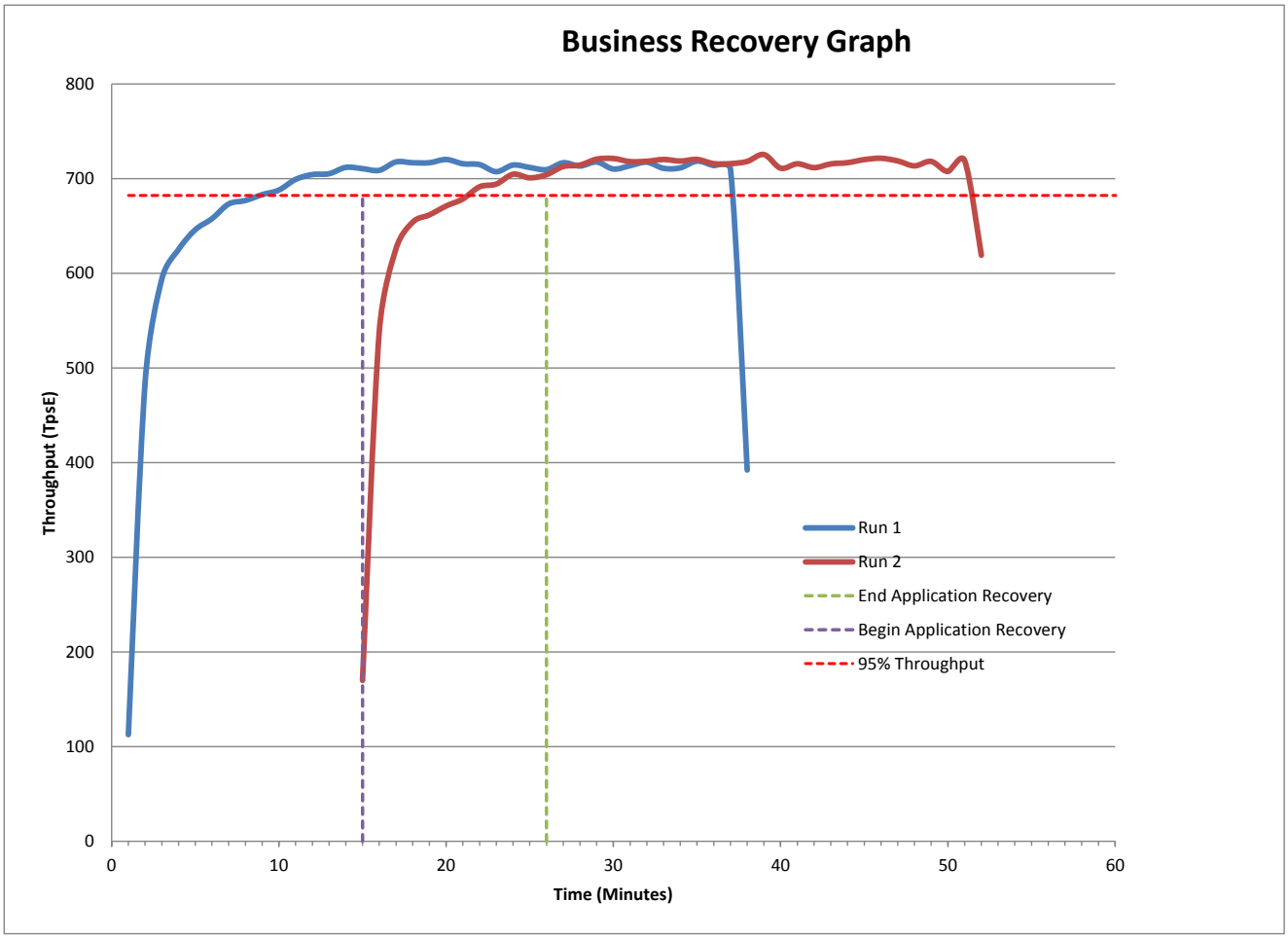


Figure 7.2 Business Recovery Tests Graph

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

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April 11, 2014

I verified the TPC Virtual Measurement Single System TPC-VMS™ v1.2.0 performance of the following configuration:

Platform:	HP ProLiant DL380p Gen8
Virtualization Manager:	VMware vSphere 5.5 Enterprise
Operating System:	Microsoft Windows Server 2012 Standard Edition
Database Manager:	Microsoft SQL Server 2014 Enterprise Edition
Base Benchmark:	TPC Benchmark™ E v1.12.0

The results were:

Performance Metric	**718.12 tpsE**
Trade-Result 90th %-tile	0.06 Seconds

Tier B (Server)	**HP ProLiant DL380p Gen8**		
CPUs	2 x Intel Xeon E5-2697 (2.7 GHz, 12-core, 30MB L3)		
Memory	256 GB		
Storage	***Qty***	***Size***	***Type***
	2	146 GB	15K rpm SAS HDD
	6	300 GB	15K rpm SAS HDD
	24	800 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, 12MB L3)
Memory	16 GB
Storage	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
- 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:

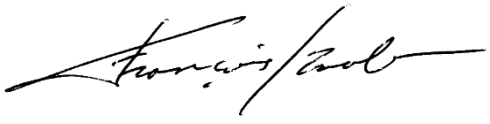
- All EGen components were verified to be v1.12.0
- The transaction were correctly implemented
- The database was properly scaled and populated for 375,000 customers
- The mandatory network between the driver and the SUT was configured
- The ACID properties were met
- Input data was generated according 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 00:25:52 was correctly measured
- The 60-day storage requirement was correctly computed

Additional Audit Notes:

None.

Respectfully Yours,

Doug Johnson, Auditor



François Raab, President