



Dell Inc.

TPC Benchmark™ H Full Disclosure Report

PowerEdge R720

using

VectorWise 2.0.1

and

RedHat Enterprise Linux 6.1

First Edition

May 2012

First Edition – May, 2012

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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 H 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. No warranty of system performance or price/performance is expressed or implied in this report.

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Abstract

This report documents the methodology and results of the TPC Benchmark© H test conducted on the Dell PowerEdge R720 using RedHat Enterprise Linux 6.1 and Actian VectorWise 2.0.1

Dell PowerEdge R720

Company Name	System Name	Database Software	Operating System
Dell, Inc.	Dell PowerEdge R720	VectorWise 2.0.1	RedHat Enterprise Linux 6.1
TPC Benchmark© H Metrics			
Total System Cost	TPC-H Throughput	Price/Performance	Availability Date
\$48,381 USD	403,230.1 QphH@100GB	\$0.12 USD \$/QphH@100GB	May 8, 2012

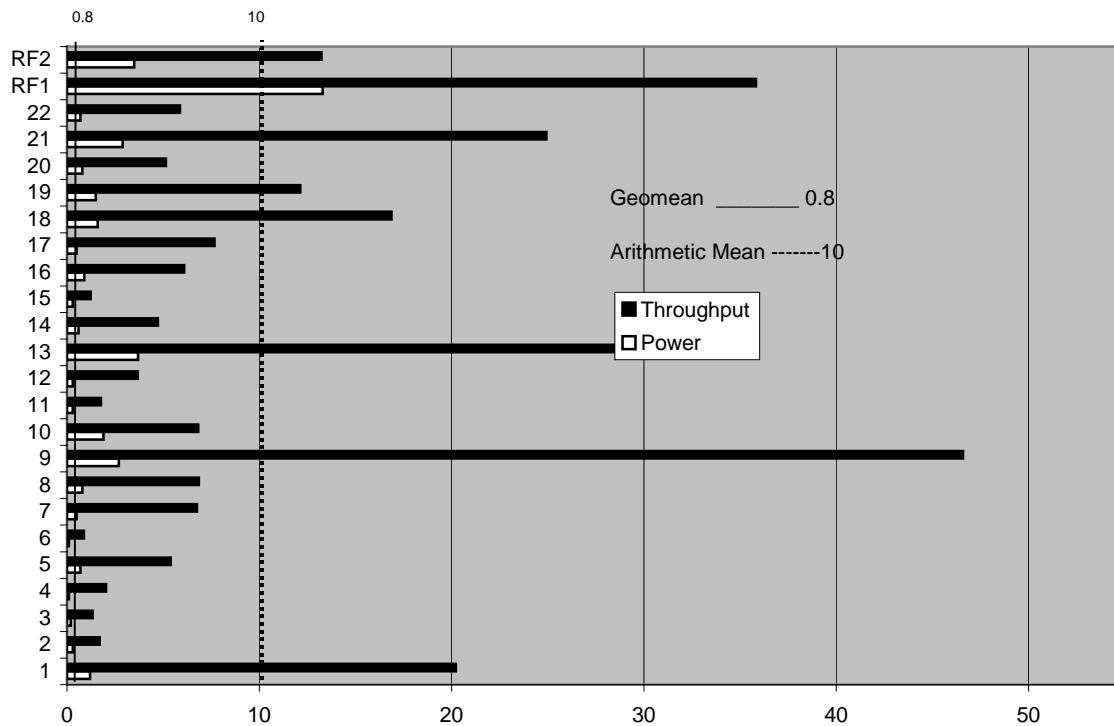


Dell PowerEdge R720

TPC-H Rev. 2.14.0
 TPC-Pricing Rev. 1.6.0

Report Date:
 May 8, 2012

Total System Cost		Composite Query per Hour Metric		Price / Performance	
\$48,381 USD		403,230.1 QphH@100GB		\$0.12 USD \$/QphH@100GB	
Database Size		Database Manager	Operating System	Other Software	Availability Date
100GB		VectorWise 2.0.1	RedHat Enterprise Linux 6.1		May 8, 2012



Database Load Time = 2:11:33	Storage Redundancy Level	
Load Includes Backup: N	Base Tables and Auxiliary Data Structures	5
Total Data Storage / Database Size = 23.36	DBMS Temporary Space	5
Percentage Memory / Database Size = 192%	OS and DBMS Software	5

System Configuration: Dell PowerEdge R720
 Memory: 192 GB
 Disk Controller: PERC H710P integrated RAID controller with 1GB NVRAM
 Storage: 16 x 146GB 15K RPM SAS 6G
 Total Storage: 2336 GB
 LAN Controller: Intel Ethernet I350 QP 1Gb Network Daughter Card



Dell PowerEdge R720

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Description	Part Number	Pricing Source	Unit Price	Qty	Extended Price	3 yr. Maint. Price
Server Hardware						
PowerEdge R720	225-2133	1	\$1,342.00	1	\$1,342.00	
2.5" Chassis with up to 16 Hard Drives	317-8474	1	\$650.00	1	\$650.00	
PowerEdge R720 Shipping	331-4437	1	\$0.00	1	\$0.00	
Performance Optimized	331-4428	1	\$0.00	1	\$0.00	
VFlash,8GB SD Card,iDRAC Ent	342-1413	1	\$49.00	1	\$49.00	
iDRAC7 Enterprise	421-5339	1	\$399.00	1	\$399.00	
POWER CORD, 10F, NEMA5-15P-C13	310-8509	1	\$0.00	2	\$0.00	
Power Saving Dell Active Power Controlle	330-5116	1	\$0.00	1	\$0.00	
DVD+/-RW, SATA	313-9090	1	\$99.00	1	\$99.00	
NO DOCUMENTATION	310-5171	1	\$0.00	1	\$0.00	
No Media Required	421-5736	1	\$0.00	1	\$0.00	
ONSITE INSTL DECLINED	900-9997	1	\$0.00	1	\$0.00	
E5-2690 2.90GHz,20M Cache,135W	317-9600	1	\$2,999.00	1	\$2,999.00	
Heat Sink,PowerEdge R720 and R720xd	331-4508	1	\$0.00	1	\$0.00	
DIMM Blanks for Systems with 2 Processor	317-8688	1	\$0.00	1	\$0.00	
E5-2690 2.90GHz,20M Cache,135W	317-9614	1	\$2,999.00	1	\$2,999.00	
Heat Sink,PowerEdge R720 and R720xd	331-4508	1	\$0.00	1	\$0.00	
1600 MHz RDIMMS	331-4424	1	\$0.00	1	\$0.00	
8GB RDIMM,1600MHz,SV,DR,x4	317-9648	1	\$180.00	24	\$4,320.00	
R5,H710p,H710,H310 CTL	331-4382	1	\$0.00	1	\$0.00	
146GB 15K SAS,6G,2.5,HP	342-0427	1	\$389.00	16	\$6,224.00	
Dual Redundant Power Supply, 1100W	331-4607	1	\$490.00	1	\$490.00	
No Bezel	313-0869	1	\$0.00	1	\$0.00	
Enet I350 QP 1Gb NW DC	430-4447	1	\$349.00	1	\$349.00	
Risers,6,x8PCIe+1,x16 PCIe	331-4440	1	\$0.00	1	\$0.00	
RHEL6.1,Flx64,No Lic or Media	421-7141	1	\$0.00	1	\$0.00	
RHEL, 1-2 SKT,3yr Sub and Lic,1VT Guest	421-5721	1	\$3,595.00	1	\$3,595.00	
PH710P Intg RD CTL,1GB NV	342-3531	1	\$799.00	1	\$799.00	
PSMC 4H7X24 OS,PE R720,UNY,2YR EXT	936-4573	1	\$654.00	1	\$654.00	\$654.00
PSMC TECH SPT,PE R720,3 YR	936-4613	1	\$1,203.00	1	\$1,203.00	\$1,203.00
HW WRTY + SVC,PE R720,UNY,2YR EXT	939-2678	1	\$126.00	1	\$126.00	\$126.00
HW WRTY + SVC,PE R720,UNY,INIT	939-2768	1	\$74.00	1	\$74.00	\$74.00
PSMC 4H7X24 OS,PE R720,UNY,INIT	988-9221	1	\$156.00	1	\$156.00	\$156.00
INFO,PS TECH SPT CONTACT,ENTERPRISE	989-3439	1	\$0.00	1	\$0.00	\$0.00
PSMC MISSION CRIT SVC,PE R720,3YR	996-8019	1	\$486.00	1	\$486.00	\$486.00
RdyRI Sldng RI,No CMA	331-4434	1	\$149.00	1	\$149.00	\$149.00
Dell E170S,17VIS,VGA Only,CLIENT/ENT	320-8083	1	\$149.00	1	\$149.00	\$149.00
OPTICAL MOUSE, TWO BUTTONS, USB, BLACK	331-0846	1	\$9.00	1	\$9.00	\$9.00
Dell USB KB,ENG, No Palmrest, ESG	331-2254	1	\$10.00	1	\$10.00	\$10.00
Dell Discount (30%)		1		1	-\$7,389.30	-\$809.70
Subtotal					\$17,241.70	\$1,889.30
No external storage						
Software						
VectorWise 2.0 3-year license Dell server**	ING-VW-3Y-GB-DELL	2	\$250.00	100	\$25,000.00	
VectorWise 1-year maintenance bug fixes**	ING-VW-3Y-GB-DELL-MNT	2	\$25.00	300	\$750.00	\$7,500.00
VectorWise discount	10%	2			-\$2,500.00	-\$750.00
Subtotal					\$22,500.00	\$6,750.00
Total					\$39,741.70	\$8,639.30
Audited by: Lorna Livingtree for Performance Metrics, Inc.						
Price Key: 1-Dell: Pricing may be verified by calling 1-800-BUY-DELL contact: Gregory Olsen, Greg_Olsen@dell.com and referencing quote # 619930776 2-Actian Pricing may be verified by calling 1-650-587-5500 contact: Mark Van de Wiel, mark.vandewiel@Actian.com All discounts are based on list prices and for similar quantities and configurations.					Cost of Ownership: \$48,381 USD QpH@100GB: 403,230.1 \$/QpH@100GB: \$0.12 USD	
<i>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 from their respective vendors. For complete details, see the pricing sections of the TPC benchmark specifications.</i> <i>If you find that the stated prices are not available according to these items, please inform the TPC at pricing@tpc.org. Thank you.</i>						



Dell PowerEdge R720

TPC-H Rev.2.14.0

TPC-Pricing 1.6.0

Report Date

8-May-12

Measurement Results

Database Scaling (SF/Size)	100
Total Data Storage/Database Size	23.36
Percentage Memory/Database Size	192%
Start of Database Load Time	4/5/12 0:10:23
End of Database Load Time	4/5/12 2:21:56
Database Load Time	2:11:33
Query Streams for Throughput Test (S)	11
TPC-H Power @100GB	448,702.6
TPC-H Throughput @100GB	362,365.9
TPC-H Composite @100GB	403,230.1
Total System Price Over 3 Years	\$48,381
TPC-H Price/Performance Metrics (\$/QpH@100GB)	\$0.12

Measurement Interval in Throughput Test (Ts)

240.42

Power Run	Seed	Query Start Time Query End Time	Duration(sec)	RF1 Start Time RF1 End Time	RF 2 Start Time RF 2 End Time
	405022156	4/5/2012 03:15:54 4/5/2012 03:16:17		22.8	4/5/2012 03:15:41 4/5/2012 03:15:54
Throughput Streams	Seed	Query Start Time Query End Time	Duration(sec)	RF1 Start Time RF1 End Time	RF 2 Start Time RF 2 End Time
1	405022157	4/5/2012 03:16:22 4/5/2012 03:19:42		200.7	4/5/2012 03:16:22 4/5/2012 03:16:38
2	405022158	4/5/2012 03:16:22 4/5/2012 03:20:09	227.3	4/5/2012 03:16:43 4/5/2012 03:16:59	4/5/2012 03:16:59 4/5/2012 03:17:04
3	405022159	4/5/2012 03:16:22 4/5/2012 03:20:01	219.1	4/5/2012 03:17:04 4/5/2012 03:17:20	4/5/2012 03:17:20 4/5/2012 03:17:24
4	405022160	4/5/2012 03:16:22 4/5/2012 03:20:05	223.0	4/5/2012 03:17:24 4/5/2012 03:17:40	4/5/2012 03:17:40 4/5/2012 03:17:45
5	405022161	4/5/2012 03:16:22 4/5/2012 03:19:56	214.1	4/5/2012 03:17:45 4/5/2012 03:18:02	4/5/2012 03:18:02 4/5/2012 03:18:07
6	405022162	4/5/2012 03:16:22 4/5/2012 03:20:08	225.9	4/5/2012 03:18:07 4/5/2012 03:18:31	4/5/2012 03:18:31 4/5/2012 03:18:36
7	405022163	4/5/2012 03:16:22 4/5/2012 03:20:00	218.7	4/5/2012 03:18:36 4/5/2012 03:18:53	4/5/2012 03:18:53 4/5/2012 03:18:58
8	405022164	4/5/2012 03:16:22 4/5/2012 03:19:58	216.1	4/5/2012 03:18:58 4/5/2012 03:19:14	4/5/2012 03:19:14 4/5/2012 03:19:19
9	405022165	4/5/2012 03:16:22 4/5/2012 03:20:01	219.0	4/5/2012 03:19:19 4/5/2012 03:19:36	4/5/2012 03:19:36 4/5/2012 03:19:41
10	405022166	4/5/2012 03:16:22 4/5/2012 03:20:05	222.8	4/5/2012 03:19:41 4/5/2012 03:19:57	4/5/2012 03:19:58 4/5/2012 03:20:03
11	405022167	4/5/2012 03:16:22 4/5/2012 03:20:03	220.8	4/5/2012 03:20:03 4/5/2012 03:20:18	4/5/2012 03:20:18 4/5/2012 03:20:21



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Stream ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
0	1.2	0.3	0.2	0.1	0.7	0.1	0.5	0.8	2.7	1.9	0.3	0.3
1	19.2	1.3	3.3	0.9	4.9	1.1	5.8	5.5	46.4	6.3	1.6	3.6
2	21.8	1.4	1.1	0.8	6.2	0.6	6.2	5.7	46.4	6.8	1.7	3.4
3	19.3	2.0	1.4	0.8	9.0	1.0	6.2	6.4	50.9	7.9	1.6	1.3
4	19.1	1.9	0.8	1.2	6.6	1.0	8.7	15.1	46.6	6.8	2.0	3.9
5	28.4	0.7	1.0	3.3	5.2	1.0	6.2	5.8	50.1	6.2	1.9	5.0
6	18.8	1.5	1.3	0.4	5.9	1.2	9.5	5.8	44.9	5.5	1.5	3.9
7	19.3	1.3	1.1	0.8	6.3	1.0	6.4	5.8	43.6	7.3	2.5	3.9
8	19.3	1.3	1.1	0.9	5.9	0.4	6.3	5.8	45.6	6.5	1.8	3.9
9	18.9	1.3	1.0	11.5	2.4	1.2	6.2	6.4	46.4	7.3	2.3	3.7
10	19.3	1.3	1.5	0.9	1.1	0.1	6.6	5.8	47.2	7.8	1.0	3.9
11	19.0	4.7	1.1	0.8	5.9	1.1	6.2	7.4	44.4	6.6	1.5	4.0
Minimum	1.2	0.3	0.2	0.1	0.7	0.1	0.5	0.8	2.7	1.9	0.3	0.3
Maximum	28.4	4.7	3.3	11.5	9.0	1.2	9.5	15.1	50.9	7.9	2.5	5.0
Average	18.6	1.6	1.2	1.9	5.0	0.8	6.2	6.4	42.9	6.4	1.6	3.4
Stream ID	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	RF1	RF2
0	3.7	0.6	0.3	0.9	0.5	1.6	1.5	0.8	2.9	0.7	13.3	3.5
1	30.4	3.4	1.5	6.3	7.9	15.7	13.1	4.4	12.2	6.0	54.4	12.6
2	38.6	4.6	1.2	6.7	7.4	17.5	12.0	5.4	25.7	6.1	28.1	11.9
3	30.3	6.0	1.2	2.2	7.5	15.9	12.9	4.6	25.6	5.2	27.9	16.1
4	29.6	3.2	1.5	2.0	7.5	15.9	12.3	4.7	29.4	3.3	30.2	11.7
5	30.4	3.3	1.3	5.9	8.1	15.1	13.2	4.7	11.7	5.5	28.3	13.0
6	29.1	6.1	1.4	6.3	8.1	21.9	12.9	8.9	25.3	5.8	27.9	13.3
7	28.9	6.3	0.7	6.2	7.9	18.1	12.4	4.3	28.6	6.1	29.8	14.2
8	28.4	5.1	1.3	16.9	8.0	15.3	3.9	4.4	26.5	7.7	47.0	14.0
9	29.6	4.1	1.4	2.4	7.2	15.3	12.9	4.9	25.9	6.8	30.7	13.6
10	28.4	3.0	1.4	6.1	7.2	18.3	15.0	5.4	35.9	5.7	29.8	13.5
11	28.7	6.8	0.7	6.0	7.5	16.7	12.8	4.8	27.5	6.5	30.0	14.1
Minimum	3.7	0.6	0.3	0.9	0.5	1.6	1.5	0.8	2.9	0.7	13.3	3.5
Maximum	38.6	6.8	1.5	16.9	8.1	21.9	15.0	8.9	35.9	7.7	54.4	16.1
Average	28.0	4.4	1.2	5.7	7.1	15.6	11.2	4.8	23.1	5.5	31.4	12.6

Preface

The Transaction Processing Performance Council (TPC) is a non-profit corporation founded to define transaction processing and database benchmarks and to disseminate objective, verifiable TPC performance data to the industry. The TPC Benchmark© H (TPC-H) is a decision support benchmark.

TPC Benchmark© H Overview

The TPC Benchmark© H (TPC-H) consists of a suite of business oriented ad-hoc queries and concurrent data modifications. The queries and the data populating the database have been chosen to have broad industry-wide relevance while maintaining a sufficient degree of ease of implementation. This benchmark illustrates decision support systems that

- Examine large volumes of data;
- Execute queries with a high degree of complexity;
- Give answers to critical business questions.

TPC-H evaluates the performance of various decision support systems by the execution of sets of queries against a standard database under controlled conditions. The TPC-H queries:

- Give answers to real-world business questions;
- Simulate generated ad-hoc queries (e.g., via a point and click GUI interface);
- Are far more complex than most OLTP transactions;
- Include a rich breadth of operators and selectivity constraints;
- Generate intensive activity on the part of the database server component of the system under test;
- Are executed against a database complying to specific population and scaling requirements;
- Are implemented with constraints derived from staying closely synchronized with an on-line production database.

The TPC-H operations are modeled as follows:

- The database is continuously available 24 hours a day, 7 days a week, for ad-hoc queries from multiple end users and data modifications against all tables, except possibly during infrequent (e.g., once a month) maintenance sessions;
- The TPC-H database tracks, possibly with some delay, the state of the OLTP database through on-going refresh functions which batch together a number of modifications impacting some part of the decision support database;
- Due to the world-wide nature of the business data stored in the TPC-H database, the queries and the refresh functions may be executed against the database at any time, especially in relation to each other. In addition, this mix of queries and refresh functions is subject to specific ACIDity requirements, since queries and refresh functions may execute concurrently;

- To achieve the optimal compromise between performance and operational requirements, the database administrator can set, once and for all, the locking levels and the concurrent scheduling rules for queries and refresh functions.

The performance metric reported by TPC-H is called the TPC-H Composite Query-per-Hour Performance Metric (QphH@Size), and reflects multiple aspects of the capability of the system to process queries. These aspects include the selected database size against which the queries are executed, the query processing power when queries are submitted by a single stream and the query throughput when queries are submitted by multiple concurrent users. The TPC-H Price/Performance metric is expressed as \$/QphH@Size. To be compliant with the TPC-H standard, all references to TPC-H results for a given configuration must include all required reporting components. The TPC believes that comparisons of TPC-H results measured against different database sizes are misleading and discourages such comparisons.

The TPC-H database must be implemented using a commercially available database management system (DBMS) and the queries executed via an interface using dynamic SQL. The specification provides for variants of SQL, as implementers are not required to have implemented a specific SQL standard in full.

TPC-H uses terminology and metrics that are similar to other benchmarks, originated by the TPC and others. Such similarity in terminology does not in any way imply that TPC-H results are comparable to other benchmarks. The only benchmark results comparable to TPC-H are other TPC-H results compliant with the same revision.

Despite the fact that this benchmark offers a rich environment representative of many decision support systems, this benchmark does not reflect the entire range of decision support requirements. In addition, the extent to which a customer can achieve the results reported by a vendor is highly dependent on how closely TPC-H approximates the customer application. The relative performance of systems derived from this benchmark does not necessarily hold for other workloads or environments. Extrapolations to any other environment are not recommended.

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

Further information is available at www.tpc.org

General Items

0.1 Test Sponsor

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

This benchmark was sponsored by Dell Inc.. and developed and engineered in partnership with Actian Corporation.

0.2 Parameter Settings

Settings must be provided for all customer-tunable parameters and options which have been changed from the defaults found in actual products, including but not limited to:

- *Database Tuning Options*
- *Optimizer/Query execution options*
- *Query processing tool/language configuration parameters*
- *Recovery/commit options*
- *Consistency/locking options*
- *Operating system and configuration parameters*
- *Configuration parameters and options for any other software component incorporated into the pricing structure*
- *Compiler optimization options*

This requirement can be satisfied by providing a full list of all parameters and options, as long as all those which have been modified from their default values have been clearly identified and these parameters and options are only set once.

The Supporting File Archive contains the Operating System and DBMS parameters used in this benchmark.

0.3 Configuration Diagrams

Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences. This includes, but is not limited to:

- *Number and type of processors*
- *Size of allocated memory, and any specific mapping/partitioning of memory unique to the test.*
- *Number and type of disk units (and controllers, if applicable).*
- *Number of channels or bus connections to disk units, including their protocol type.*
- *Number of LAN (e.g. Ethernet) Connections, including routers, workstations, terminals, etc., that were physically used in the test or are incorporated into the pricing structure.*
- *Type and the run-time execution location of software components (e.g., DBMS, query processing tools/languages, middle-ware components, software drivers, etc.).*

The Dell PowerEdge R720 features:

- Up to two Intel Xeon E5-2600 Series processors
- Up to 768GB (24 DIMM Slots): 2GB/4GB/8GB/16GB/32GB DDR3 up to 1600MHz
- Up to eight 3.5" drives or up to sixteen 2.5" drives:
- 2.5" PCIe SSD, SAS SSD, SATA SSD, SAS (15K, 10K), nearline SAS (7.2K), SATA (7.2K)
- 3.5" SAS (15K), nearline SAS (7.2K), SATA (7.2K)
- RAID 0, 1, 5, 6, 10, 50, and 60 support for up to 16 SAS drives with PERC H710p HW RAID controller
- 7 PCIe slots: One x16 full-length, full-height; Three x8 full-length, full-height; Three x8 half-length, half-height
- Platinum efficiency 495W, 750W or Platinum+ efficiency 1100W power supplies
- Network Connectivity: Broadcom Quad Port 1Gb, Intel Quad Port 1GbE, Intel Dual Port 10GbE + 2 x 1GbE, Broadcom Dual Port 10GbE + 2 x 1GbE
- Remote Management: iDRAC7 with Lifecycle Controller; iDRAC7 Express (default), iDRAC7 Enterprise (upgrade option); 8GB vFlash media (upgrade option), 16GB vFlash media (upgrade optional)
- Availability: High-efficiency, hot-plug, redundant power supplies; hot-plug drive bays; TPM; dual internal SD support; hot-plug
- redundant fan; optional bezel; luggage-tag; ECC memory, interactive LCD screen; extended thermal support; ENERGY STAR(r) compliant, extended power range; switch agnostic partitioning (SWAP)



Both the measured and priced configurations are same and consist of a Dell PowerEdge R720 with:

- Two Intel Xeon E5-2690 processors running at 2.90Ghz
- 192 GB 1600MHz memory
- One PERC H710p RAID integrated controller
- 16 internal 2.5" 146GB 15K RPM 6G SAS drives (RAID-5)
- Dual redundant 1100W power supplies
- Intel Ethernet I350 QP 1Gb Network Daughter Card
- iDRAC7 Enterprise

Clause 1: Logical Database Design

1.1 Database Definition Statements

Listings must be provided for all table definition statements and all other statements used to set up the test and qualification databases

The Supporting File Archive contains the table definitions and all other statements used to set up the test and qualification databases.

1.2 Physical Organization

The physical organization of tables and indices, within the test and qualification databases, must be disclosed. If the column ordering of any table is different from that specified in Clause 1.4, it must be noted.

No record clustering or index clustering was used. No column reordering was used.

1.3 Horizontal Partitioning

Horizontal partitioning of tables and rows in the test and qualification databases (see Clause 1.5.4) must be disclosed.

No horizontal partitioning was used.

1.4 Replication

Any replication of physical objects must be disclosed and must conform to the requirements of Clause 1.5.6.

No replication was used.

Clause 2: Queries and Refresh Functions

2.1 Query Language

The query language used to implement the queries must be identified.

SQL was the query language used to implement the queries.

2.2 Verifying Method of Random Number Generation

The method of verification for the random number generation must be described unless the supplied DBGEN and QGEN were used.

TPC-supplied DBGEN version 2.14.0 and QGEN version 2.14.0 were used.

2.3 Generating Values for Substitution Parameters

The method used to generate values for substitution parameters must be disclosed. If QGEN is not used for this purpose, then the source code of any non-commercial tool used must be disclosed. If QGEN is used, the version number, release number, modification number and patch level of QGEN must be disclosed.

TPC supplied QGEN version 2.14.0 was used to generate the substitution parameters.

2.4 Query Text and Output Data from Qualification Database

The executable query text used for query validation must be disclosed along with the corresponding output data generated during the execution of the query text against the qualification database. If minor modifications (see Clause 2.2.3) have been applied to any functional query definitions or approved variants in order to obtain executable query text, these modifications must be disclosed and justified. The justification for a particular minor query modification can apply collectively to all queries for which it has been used. The output data for the power and throughput tests must be made available electronically upon request.

Supporting Files Archive contains the actual query text and query output. Following are the modifications to the query.

- In Q1, Q4, Q5, Q6, Q10, Q12, Q14, Q15 and Q20, the “dateadd” function is used to perform date arithmetic.
- In Q7, Q8 and Q9, the “datepart” function is used to extract part of a date (e.g., datepart(yy,...)).
- In Q2, Q3, Q10, Q18 and Q21, the “top” function is used to restrict the number of output rows.
- The word GO is used as a command delimiter.

2.5 Query Substitution Parameters and Seeds Used

All the query substitution parameters used during the performance test must be disclosed in tabular format, along with the seeds used to generate these parameters.

Supporting Files Archive contains the query substitution parameters and seed used.

2.6 Isolation Level

The isolation level used to run the queries must be disclosed. If the isolation level does not map closely to one of the isolation levels defined in Clause 3.4, additional descriptive detail must be provided.

The queries and transactions were run with “Snapshot Isolation”.

2.7 Source Code of Refresh Functions

The details of how the refresh functions were implemented must be disclosed (including source code of any non-commercial program used).

Supporting Files Archive contains the Source Code of refresh functions.

Clause 3: Database System Properties

3.1 ACID Properties

The ACID (Atomicity, Consistency, Isolation, and Durability) properties of transaction processing systems must be supported by the system under test during the timed portion of this benchmark. Since TPC-H is not a transaction processing benchmark, the ACID properties must be evaluated outside the timed portion of the test.

All ACID tests were conducted according to specification. The Supporting Files Archive contains the source code of the ACID test scripts.

3.2 Atomicity Requirements

The results of the ACID tests must be disclosed along with a description of how the ACID requirements were met. This includes disclosing the code written to implement the ACID Transaction and Query.

3.2.1 Atomicity of the Completed Transactions

Perform the ACID Transaction for a randomly selected set of input data and verify that the appropriate rows have been changed in the ORDER, LINEITEM, and HISTORY tables.

The following steps were performed to verify the Atomicity of completed transactions:

1. The total price from the ORDER table and the extended price from the LINEITEM table were retrieved for a randomly selected order key.
2. The ACID Transaction was performed using the order key from step 1.
3. The ACID Transaction was committed.
4. The total price from the ORDER table and the extended price from the LINEITEM table were retrieved for the same order key. It was verified that the appropriate rows had been changed.

3.2.2 Atomicity of Aborted Transactions

Perform the ACID transaction for a randomly selected set of input data, submitting a ROLLBACK of the transaction for the COMMIT of the transaction. Verify that the appropriate rows have not been changed in the ORDER, LINEITEM, and HISTORY tables.

The following steps were performed to verify the Atomicity of the aborted ACID transaction:

1. The total price from the ORDER table and the extended price from the LINEITEM table were retrieved for a randomly selected order key.
2. The ACID Transaction was performed using the order key from step 1. The transaction was stopped prior to the commit.
3. The ACID Transaction was ROLLED BACK. .
4. The total price from the ORDER table and the extended price from the LINEITEM table were retrieved for the same order key used in steps 1 and 2. It was verified that the appropriate rows had not been changed.

3.3 Consistency Requirements

Consistency is the property of the application that requires any execution of transactions to take the database from one consistent state to another.

A consistent state for the TPC-H database is defined to exist when:

$O_TOTALPRICE = SUM(L_EXTENDEDPRICE - L_DISCOUNT) * (1 + L_TAX)$
For each ORDER and LINEITEM defined by (O_ORDERKEY = L_ORDERKEY)

3.3.1 Consistency Test

Verify that ORDER and LINEITEM tables are initially consistent as defined in Clause 3.3.2.1, based upon a random sample of at least 10 distinct values of O_ORDERKEY.

The following steps were performed to verify consistency:

1. The consistency of the ORDER and LINEITEM tables was verified based on a sample of O_ORDERKEYs.
2. One hundred ACID Transactions were submitted from each of twelve execution streams.
3. The consistency of the ORDER and LINEITEM tables was re-verified.

3.4 Isolation Requirements

Operations of concurrent transactions must yield results which are indistinguishable from the results which would be obtained by forcing each transaction to be serially executed to completion in some order.

3.4.1 Isolation Test 1 - Read-Write Conflict with Commit

Demonstrate isolation for the read-write conflict of a read-write transaction and a read-only transaction when the read-write transaction is committed.

The following steps were performed to satisfy the test of isolation for a read-only and a read-write committed transaction:

1. An ACID query was run with randomly selected values for O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID Transaction was started using O_KEY, L_KEY and DELTA from step 1. The ACID Transaction was suspended prior to Commit.
3. An ACID query was started for the same O_KEY used in step 1. The ACID query ran to completion and did not see any uncommitted changes made by the ACID Transaction.
4. The ACID Transaction was resumed and committed.
5. The ACID query completed. It returned the data as committed by the ACID Transaction.

3.4.2 Isolation Test 2 - Read-Write Conflict with Rollback

Demonstrate isolation for the read-write conflict of a read-write transaction and a read-only transaction when the read-write transaction is rolled back.

The following steps were performed to satisfy the test of isolation for read-only and a rolled back read-write transaction:

1. An ACID query was run with randomly selected values for O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID transaction was started using O_KEY, L_KEY and DELTA from step 1. The ACID Transaction was suspended prior to Rollback.
3. An ACID query was started for the same O_KEY used in step 1. The ACID query did not see any uncommitted changes made by the ACID Transaction.
4. The ACID Transaction was ROLLED BACK.

5. The ACID query completed.

3.4.3 Isolation Test 3 - Write-Write Conflict with Commit

Demonstrate isolation for the write-write conflict of two update transactions when the first transaction is committed.

Two tests were run, the first with a transaction that COMMITS and the second with a transaction that ROLLS BACK. Results from the first test were as follows:

1. An ACID query was run with randomly selected values for O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID Transaction T1 was started using the same O_KEY, L_KEY and DELTA as step 1. The ACID transaction T1 was suspended prior to Commit.
3. Another ACID Transaction T2 was started using the same O_KEY and L_KEY and a randomly selected DELTA.
4. T2 committed and completed normally.
5. The ACID transaction T1 was allowed to Commit and received an error. This was expected due to the “Snapshot Isolation” in use by the DBMS. This is also known as “First Committer Wins”.
6. The ACID Query was run again to verify that the O_TOTALPRICE was the value from T2.

Results from the second test were as follows:

1. An ACID Query was run for a randomly selected O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID Transaction, T1, was started with the values used in step 1. The ACID transaction T1 was suspended prior to COMMIT.
3. A Second ACID transaction, T2, was started with the same O_KEY and L_KEY as step 1 and a different value for DELTA.
4. T2 ROLLED BACK and completed.
5. T1 resumed and completed normally.
6. The ACID Query was run to verify the database was updated with the values from T1 and not T2.

3.4.4 Isolation Test 4 - Write-Write Conflict with Rollback

Demonstrate isolation for the write-write conflict of two update transactions when the first transaction is rolled back.

Two tests were run, the first with a transaction that COMMITS and the second with a transaction that ROLLS BACK

The results from the first test were as follows:

1. An ACID Query was run for a randomly selected O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE
2. An ACID Transaction, T1, was started using the values from step 1. The ACID transaction T1 was suspended prior to ROLLBACK.
3. Another ACID Transaction, T2, was started using the same O_KEY and L_KEY and a randomly selected DELTA.
4. T2 completed normally.
5. T1 was allowed to ROLLBACK.
6. It was verified that O_TOTALPRICE was from T2.

The results from the second test were as follows

1. An ACID Query was run for a randomly selected O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID Transaction, T1, was started with the same values as from step 1. T1 suspended prior to COMMIT.
3. Another ACID Transaction, T2, was started and it ROLLED BACK its updates and completed normally.
4. T1 resumed and COMMITTED its updates.
5. An ACID Query was run to verify that O_TOTALPRICE was the value from T1 and not T2.

3.4.5 Isolation Test 5 – Concurrent Read and Write Transactions on Different Tables

Demonstrate the ability of read and write transactions affecting different database tables to make progress concurrently.

The following steps were performed to verify isolation of concurrent read and write transactions on different tables:

1. An ACID Query was run for a randomly selected O_KEY, L_KEY and DELTA to get the initial value for O_TOTALPRICE.
2. An ACID Transaction, T1, was started with the values from step 1. T1 was suspended prior to COMMIT.
3. A query was started using random values for PS_PARTKEY and PS_SUPPKEY, all columns of the PARTSUPP table for which PS_PARTKEY and PS_SUPPKEY are equal are returned. The query completed normally.
4. T1 was allowed to COMMIT.
5. It was verified that O_TOTALPRICE had been changed by T1

3.4.6 Isolation Test 6 – Update Transactions during Continuous Read-Only Query Stream

Demonstrate the continuous submission of arbitrary (read-only) queries against one or more tables of the database does not indefinitely delay update transactions affecting those tables from making progress.

The following steps were performed to verify isolation of update transaction during continuous read-only query:

1. A Stream was submitted that executed Q1 ten times in a row with a delta of 0 to ensure that each query ran as long as possible.
2. An ACID Transaction, T1, was started for a randomly selected O_KEY, L_KEY and DELTA.
3. T1 completed and it was verified that O_TOTALPRICE was updated correctly.
4. The stream submitting Q1 finished.

3.5 Durability Requirements

The tested system must guarantee durability: the ability to preserve the effects of committed transactions and insure database consistency after recovery from any one of the failures listed in Clause 3.5.2.

3.5.1 Permanent Unrecoverable Failure of Any Durable Medium

Guarantee the database and committed updates are preserved across a permanent irrecoverable failure of any single durable medium containing TPC-H database tables or recovery log tables.

The database files including the logs were distributed across 16 disk drives in a RAID 5 configuration. The tests were conducted on the qualification database. These steps were performed to demonstrate that committed updates are preserved across a permanent irrecoverable failure of a disk drive:

1. The consistency of the ORDERS and LINEITEM tables was verified using 120 randomly chosen values for O_ORDERKEY.
2. Exactly 12 streams of ACID transactions were started.
3. When the driver script indicated that at least 100 transactions had completed in each stream, a randomly selected disk drive was removed from the SUT and the SUT continued to process work until all streams had completed 200 transactions.
4. An analysis of the transaction start and end times from each stream showed that there was at least 1 transaction in-flight at all times.
5. An analysis of the HISTORY table showed that all of the values used for O_ORDERKEY in step 1 were used by some transaction in step 2.
6. An analysis of the success file and the HISTORY table showed that all entries in the HISTORY table had a corresponding entry in the success file and that every entry in the success file had a corresponding entry in the HISTORY table.
7. The consistency of the database was re-verified.

3.5.2 System Crash

Guarantee the database and committed updates are preserved across an instantaneous interruption (system crash/system hang) in processing which requires the system to reboot to recover.

1. The system crash and memory failure tests were combined. First the consistency of the ORDER and LINEITEM tables was verified.
2. Then transactions were submitted from 12 streams.
3. Once the driver script indicated that 100 transactions had been submitted from each stream, power to the SUT was removed by using the Power Off System feature of the Integrated Dell Remote Access Controller 7 (iDRAC7).
4. When power was restored to the SUT, the system rebooted and the database was restarted.
5. The HISTORY table and success files were compared to verify that every record in the HISTORY table had a corresponding record in the success file and that each record in the success file had a corresponding entry in the HISTORY table. The consistency of the ORDERS and LINEITEM tables was then verified again.

3.5.3 Memory Failure

Guarantee the database and committed updates are preserved across failure of all or part of memory (loss of contents).

See section 3.5.2

Clause 4: Scaling and Database Population

4.1 Initial Cardinality of Tables

The cardinality (e.g., the number of rows) of each table of the test database, as it existed at the completion of the database load (see clause 4.2.5) must be disclosed.

Table 4.1 lists the TPC Benchmark H defined tables and the row count for each table as they existed upon completion of the build.

Table 4. 1: Initial Number of Rows

Table Name	Row Count
Region	5
Nation	25
Supplier	1,000,000
Customer	15,000,000
Part	20,000,000
Partsupp	80,000,000
Orders	150,000,000
Lineitem	600,037,902

4.2 Distribution of Tables and Logs Across Media

The distribution of tables and logs across all media must be explicitly described for the tested and priced systems.

The storage system consisted of:

- 1 x PERC H710P integrated RAID controller
- 16 x 146 GB 6Gb SAS 15K RPM

The database tables and the temporary files were distributed on a RAID 5 volume created across sixteen 146 GB 15K RPM SAS 6G disk drives.

4.3 Mapping of Database Partitions/Replications

The mapping of database partitions/replications must be explicitly described.

Database partitioning/replication were not used.

4.4 Implementation of RAID

Implementations may use some form of RAID to ensure high availability. If used for data, auxiliary storage (e.g. indexes) or temporary space, the level of RAID used must be disclosed for each device.

The database tables and the temporary files were distributed on a RAID 5 volume created across sixteen 146 GB 15K RPM SAS 6G disk drives.

4.5 DBGEN Modifications

The version number, release number, modification number, and patch level of DBGEN must be disclosed. Any modifications to the DBGEN (see Clause 4.2.1) source code must be disclosed. In the event that a program other than DBGEN was used to populate the database, it must be disclosed in its entirety.

DBGEN version 2.14.0 was used, no modifications were made.

4.6 Database Load time

The database load time for the test database (see clause 4.3) must be disclosed.

The database load time was 2 hours 11 minutes and 33 seconds

4.7 Data Storage Ratio

The data storage ratio must be disclosed. It is computed by dividing the total data storage of the priced configuration (expressed in GB) by the size chosen for the test database as defined in 4.1.3.1. The ratio must be reported to the nearest 1/100th, rounded up.

The database storage ratio can be found in Table 4.7

Table 4.7: Data Storage Ratio

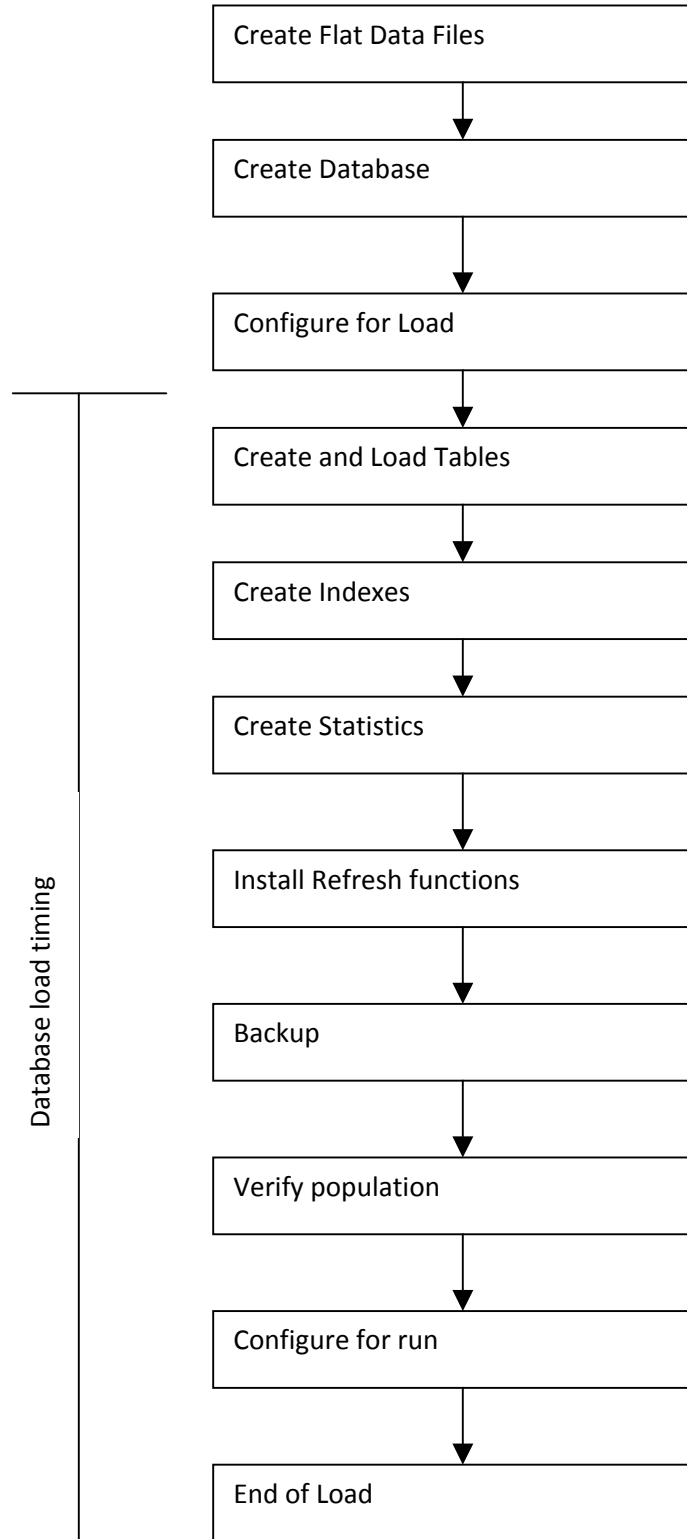
Storage Devices	Total Storage Capacity	Scale factor	Data Storage Ratio
16 x 146 GB 15K SAS 6G disk drives	2,336 GB	100	23.36

4.8 Database Load Mechanism Details and Illustration

The details of the database load must be disclosed, including a block diagram illustrating the overall process. Disclosure of the load procedure includes all steps, scripts, input and configuration files required to completely reproduce the test and qualification databases.

Flat files were created using DBGEN. The tables were loaded as shown in Figure 4.8.

Figure 4.8: Block Diagram of Database Load Process



4.9 Qualification Database Configuration

Any differences between the configuration of the qualification database and the test database must be disclosed.

The qualification database used identical scripts to create and load the data with changes to adjust for the database scale factor.

4.10 Memory to Database Size Percentage

The memory to database size percentage must be disclosed.

The memory to database size percentage is 192%

Clause 5: Performance Metrics and Execution Rules

5.1 System Activity Between Load and Performance Tests

Any system activity on the SUT that takes place between the conclusion of the load test and the beginning of the performance test must be fully disclosed.

Auditor requested script was run to display the indices that had been created on the database and the row counts at the end of the load. All scripts and queries used are included in the Supporting Files Archive.

5.2 Steps in the Power Test

The details of the steps followed to implement the power test (e.g., system boot, database restart, etc.) must be disclosed.

The following steps were used to implement the power test:

1. RF1 Refresh Transaction
2. Stream 00 Execution
3. RF2 Refresh Transaction.

5.3 Timing Intervals for Each Query and Refresh Function

The timing intervals (see Clause 5.3.6) for each query of the measured set and for both refresh functions must be reported for the power test.

The timing intervals for each query and both refresh functions are given in the Numerical Quantities Summary earlier in the executive summary.

5.4 Number of Streams for The Throughput Test

The number of execution streams used for the throughput test must be disclosed.

Eleven streams were used for the Throughput Test.

5.5 Start and End Date/Times for Each Query Stream

The start time and finish time for each query execution stream must be reported for the throughput test.

The Numerical Quantities Summary contains the start and stop times for the query execution streams run on the system reported.

5.6 Total Elapsed Time for the Measurement Interval

The total elapsed time of the measurement interval (see Clause 5.3.5) must be reported for the throughput test.

The Numerical Quantities Summary contains the timing intervals for the throughput test run on the system reported.

5.7 Refresh Function Start Date/Time and Finish Date/Time

Start and finish time for each update function in the update stream must be reported for the throughput test.

Start and finish time for each update function in the update stream are included in the Numerical Quantities Summary earlier in the Executive Summary.

5.8 Timing Intervals for Each Query and Each Refresh Function for Each Stream

The timing intervals (see Clause 5.3.6) for each query of each stream and for each update function must be reported for the throughput test.

The timing intervals for each query and each update function are included in the Numerical Quantities Summary earlier in the Executive Summary.

5.9 Performance Metrics

The computed performance metrics, related numerical quantities and the price performance metric must be reported.

The Numerical Quantities Summary contains the performance metrics, related numerical quantities, and the price/performance metric for the system reported.

5.10 The Performance Metric and Numerical Quantities from Both Runs

A description of the method used to determine the reproducibility of the measurement results must be reported. This must include the performance metrics (QppH and QthH) from the reproducibility runs.

Performance results from the first two executions of the TPC-H benchmark indicated the following difference for the metric points:

Table 5.10: Performance Metric

Run	QppH @ 100GB	QthH @ 100GB	QphH @ 100GB
Run 1	424,373.0	390,462.5	407,064.8
Run 2	448,702.6	362,365.9	403,230.1

5.11 System Activity Between Tests

Any activity on the SUT that takes place between the conclusion of Run1 and the beginning of Run2 must be disclosed.

There was no activity between Run1 and Run2.

5.12 Dataset Verification

Verify that the rows in the loaded database after the performance test are correct by comparing some small number of rows extracted at random from any two files of the corresponding Base, Insert and Delete reference data set files for each table and the corresponding rows of the database

Verified according to specification.

5.13 Referential Integrity

Verify referential integrity in the database after the initial load.

An auditor supplied script was used to verify referential integrity.

Clause 6: SUT and Driver Implementation

6.1 Driver

A detailed description of how the driver performs its functions must be supplied, including any related source code or scripts. This description should allow an independent reconstruction of the driver.

The supporting files archive contains the scripts that were used to implement the driver.

The power test is invoked through the script power_test.sh. It starts the stream 0 SQL script along with the refresh functions such that:

- The SQL for RF1 is submitted and executed by the database
- Then the queries as generated by QGEN are submitted in the order defined by Clause 5.3.5.4
- The SQL for RF2 is then submitted from the same connection used for RF1 and executed by database

The Throughput test is invoked through the script throughput_test.sh. This script then initiates all of the SQL streams and the refresh stream.

6.2 Implementation Specific Layer

If an implementation-specific layer is used, then a detailed description of how it performs its functions must be supplied, including any related source code or scripts. This description should allow an independent reconstruction of the implementation-specific layer.

There was no Implementation Specific Layer, only native scripts and SQL.

6.3 Profile-Directed Optimization

If profile-directed optimization as described in Clause 5.2.9 is used, such used must be disclosed.

Profile-directed optimization was not used.

Clause 7: Pricing

7.1 Hardware and Software Pricing

A detailed list of hardware and software used in the priced system must be reported. Each item must have vendor part number, description, and release/revision level, and either general availability status or committed delivery date. If package-pricing is used, contents of the package must be disclosed. Pricing source(s) and effective date(s) of price(s) must also be reported.

A detailed list of all hardware and software, including the 3-year support, is provided in the Executive Summary in the Abstract section of this report. The price quotations are included in Appendix A.

7.2 Three Year Price

The total 3-year price of the entire configuration must be reported including: hardware, software, and maintenance charges. Separate component pricing is recommended. The basis of all discounts used must be disclosed.

The pricing details for this disclosure are contained in the executive summary pages.

7.3 Availability Dates

The committed delivery date for general availability of products used in the price calculations must be reported. When the priced system includes products with different availability dates, the availability date reported on the executive summary must be the date by which all components are committed to being available. The full disclosure report must report availability dates individually for at least each of the categories for which a pricing subtotal must be provided.

All components of the SUT will be available on the date of publication.

Supporting File Index

An index for all files included in the supporting files archive as required by Clause 8.3.2 through 8.3.8 must be provided in the report.

Table 8.0: Supporting File Index

Clause	Description	Archive File	Pathname
Clause 1	Device setup	benchmark_scripts.zip	/sysinfo/mount.out /sysinfo/mount-l.out /sysinfo/df_h.out
	Installation and configuration	benchmark_scripts.zip	/sysinfo/vectorwise.conf
	OS Tunable Parameters	benchmark_scripts.zip	/sysinfo/sysctl-A.out
	DB creation scripts	benchmark_scripts.zip	/ddl/create_index.sql /ddl/create_tables.sql /ddl/grant.sql /scripts/create_db.sh
Clause 2	QGen Modifications	benchmark_scripts.zip	None
Clause 3	ACID Test scripts	benchmark_scripts.zip	acid/Makefile acid/acidkeys.sc acid/acidquery.sh acid/acidtrans.sc acid/acidtrans_rb.sc acid/create_history.sql acid/get_iisysdepvar.sh acid/pskeys.sc acid/run_aci.sh acid/atom/atom1.sh acid/atom/atom2.sh acid/cons/Makefile acid/cons/consist.sh acid/cons/consist_condition.sc acid/dur/Makefile acid/dur/acidtrans_dur.sc acid/dur/dur.sh acid/dur/post-failure.sh acid/iso/iso*.sh acid/iso/iso_q1.sql acid/iso/iso6_txn.sh

	ACID Test Results	benchmark_scripts.zip	acid/atom/output:/atom*_output acid/cons/output/consist_output acid/cons/output/step*_stream*_output acid/cons/output/stream*_rnd acid/dur/output.diskf/dur.out acid/dur/output.diskf/POST_FAILURE_HISTORY_TABLE acid/dur/output.diskf/SUCCESS_FILE acid/dur/output.diskf/step*_stream*_output acid/dur/output.diskf/stream*_rnd acid/dur/output.pwrf/dur.out acid/dur/output.pwrf/post.out acid/dur/output.pwrf/POST_FAILURE_HISTORY_TABLE acid/dur/output.pwrf/SUCCESS_FILE acid/dur/output.pwrf/step*_stream*_output acid/dur/output.pwrf/stream*_rnd acid/iso/output/iso*_output acid/iso/output/output_iso*_Txn*
Clause 4	Qualification db load results	benchmark_scripts.zip	1/console.out 1/customer.count 1/lineitem.count 1/load_report.txt 1/nation.count 1/orders.count 1/part.count 1/partsupp.count 1/region.count 1/supplier.count
	Qualification db validation results	benchmark_scripts.zip	1G/output/q*.output 1G/EQT/*_q*.sql 1G/params/q*_params
	DBGEN Modifications	benchmark_scripts.zip	None
	Database Load Scripts	benchmark_scripts.zip	/scripts/load_test.sh
	Test db Load results	benchmark_scripts.zip	7/console.out 7/customer.count 7/lineitem.count 7/load_report.txt 7/nation.count 7/orders.count 7/part.count 7/partsupp.count 7/region.count 7/supplier.count
Clause 5	Run 1	run1results.zip	9/power_test_report.txt 9/results/rf1/setnum1_output 9/results/rf1/times1 9/results/rf2/setnum1_output 9/results/rf2/times1 9/stream0/q*.output 9/stream0/timing_intervals 10/tput_test_report.txt 10/results/rf1/setnum*_output 10/results/rf1/times* 10/results/rf2/setnum*_output 10/results/rf2/times* 10/results/stream[1-11]/q*.output 10/results/stream[1-11]/timing_intervals

	Run 2	run1results.zip	11/power_test_report.txt 11/results/rf1/setnum*_output 11/results/rf1/times* 11/results/rf2/setnum*_output 11/results/rf2/times* 11/stream0/q*.output 11/stream0/timing_intervals 12/tput_test_report.txt 12/results/rf1/setnum*_output 12/results/rf1/times* 12/results/rf2/setnum*_output 12/results/rf2/times* 12/results/stream[1-11]/q*.output 12/results/stream[1-11]/timing_intervals
Clause 6	implementation scripts	benchmark_scripts.zip	/scripts/performance_test.sh /scripts/power_test.sh /scripts/tput_test.sh
Clause 7	n/a	n/a	n/a
Clause 8	Query substitution parameters	benchmark_scripts.zip	9/queries/stream0/q*_param 10/queries/stream*/q*_param
	RF function source code	benchmark_scripts.zip	/scripts/*rf*

Auditors' Information and Attestation Letter

The auditor's agency name, address, phone number, and Attestation letter with a brief audit summary report indicating compliance must be included in the full disclosure report. A statement should be included specifying who to contact in order to obtain further information regarding the audit process.

The auditor's letter is included in the following section.

This benchmark was audited by:

Lorna Livingtree
Performance Metrics, Inc.
PO Box 984
Klamath, CA 95548
Phone: 707-954-7757



PERFORMANCE METRICS INC.
TPC Certified Auditors

May 11, 2012

Mr. David Morse
Dell, Inc.
One Dell Way
Round Rock, TX 78682

I have verified by remote the TPC Benchmark™ H for the following configuration:

Platform: Dell PowerEdge R720
Database Manager: VectorWise 2.0.1
Operating System: Red Hat Enterprise Linux 6.1

CPU's	Memory	Total Disks	Qpph@ 100GB	QthH @100GB	QphH@100GB
2 Intel Xeon @ 2.90 Ghz 8 core	192 GB	16 @ 146 GB	448,702.6	362,365.9	403,230.1

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

- The database tables were defined with the proper columns, layout and sizes.
- The tested database was correctly scaled and populated for 100GB using DBGEN. The version of DBGEN was 2.14.0.
- The data generated by DBGEN was successfully compared to reference data.
- The qualification database layout was identical to the tested database except for the size of the files.
- The query text was verified to use only compliant variants and minor modifications.
- The executable query text was generated by QGEN and submitted through a standard interactive interface. The version of QGEN was 2.14.0.
- The validation of the query text against the qualification database produced compliant results.

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(707) 954-7757 fax: (707) 482-0575

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email: LornaL@PerfMetrics.com

PERFORMANCE METRICS INC.
TPC Certified Auditors

- The refresh functions were properly implemented and executed the correct number of inserts and deletes.
- The load timing was properly measured and reported.
- The execution times were correctly measured and reported.
- The performance metrics were correctly computed and reported.
- The repeatability of the measurement was verified.
- The ACID properties were successfully demonstrated and verified.
- The system pricing was checked for major components and maintenance.
- The executive summary pages of the FDR were verified for accuracy.

Auditor's Notes: None.

Sincerely,



Lorna Livingtree
Auditor



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email: LornaL@PerfMetrics.com

Appendix A

ACTIAN Order Confirmation

Actian Corporation
500 Arguello Street Suite 200
Redwood City, CA 94063
United States

Phone: (650) 587-5500
Fax: (650) 649-2358

Order Number: 04-12805
Account Number: 123456
Agreement ID:
Payment Terms: Net 30
Partner:

Prepared by:
 Mark Van de Wiel
 (650) 587-5538
 mark.vandewiel@actian.com

Message:

PREPARED FOR (BILL TO)	SHIP TO
David J. Morse Director, Systems Performance Analysis Dell Enterprise Product Group office + 1 512 723 2758	Dell Enterprise Product Group Attn. David J. Morse Mail Stop: RR5-18 200 Dell Way Round Rock, TX, 78682

Product item	Memo	Contract Start	Contract End	Unit	Qty	Price	Discount %	Extended Price
ING-VW-3Y-GB-DELL	3 year license, 1 GB source data, Dell server	01-April-2012	31-March-2015	GB	100	USD 250	10	USD 22,500
ING-VW-3Y-GB-DELL-MNT	1 year professional support, bug fixes only, 1 GB source data, Dell server	01-April-2012	31-March-2015	GB	300	USD 25	10	USD 6,750

Grand Total:	USD 29,250
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**Fees herein are exclusive of taxes, withholding, levies, imposts, and duties ("Taxes"), and Customer, not Actian, is responsible for any such Taxes.*