TPC-H Benchmark™ Full Disclosure Report

Hitachi BladeSymphony BS2000
using
Hitachi Advanced Data Binder 01-02

Submitted for Review
October 19, 2013

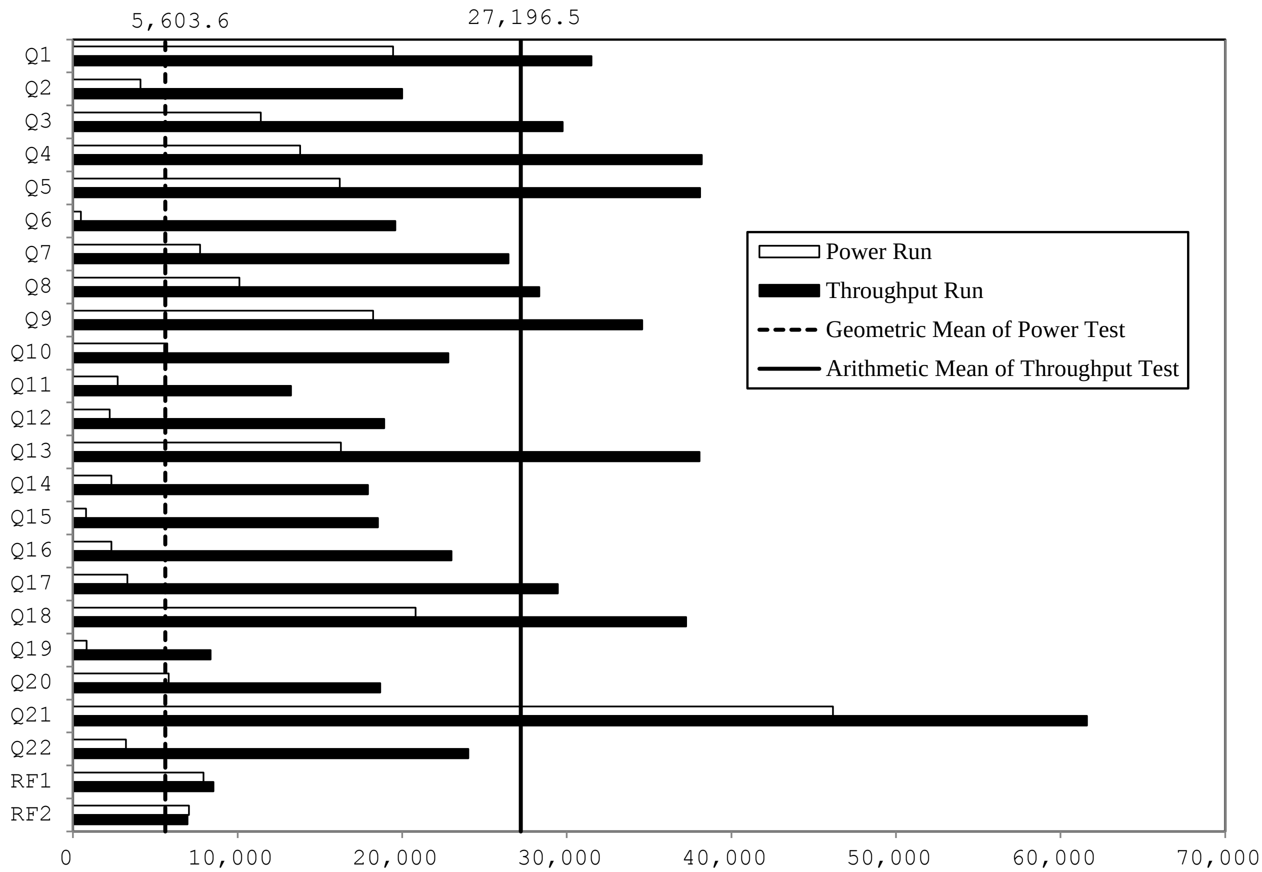
First Edition - October, 2013

Hitachi, Ltd. (HITACHI), the Sponsor of this benchmark test, believes that the technical, pricing and discounting information in this document is accurate as of its publication date. The performance information in this document is for guidance only. System performance is highly dependent on many factors including system hardware, system and user software, and user-application characteristics. Customer applications must be carefully evaluated before estimating performance. HITACHI does not warrant or represent that a user can or will achieve similar performance as expressed in this document.

HITACHI Inspire the Next	Hitachi BladeSymphony BS2000 using Hitachi Advanced Data Binder 01-02	TPC-H Rev. 2.16.0 TPC-Pricing Rev. 1.7.0 Report Date: Oct 19, 2013

Total System Cost	Composite Query per Hour Metric	Price/Performance
¥1,563,605,024 JPY	**82,678.0** **QphH@100000GB**	**¥ 18,911.98 JPY** **¥ / QphH@100000GB**

Database Size (*)	Database Manager	Operating System	Other Software	Availability Date
100,000GB	**Hitachi Advanced Data Binder 01-02**	**Red Hat® Enterprise Linux® 6.2**	**None**	**Oct 19, 2013**



Database Load Time =139:53:08
Load Includes Backup: N
Total Data Storage / Database Size (*) = 14.76
Memory / Database Size = 8.0%

Storage Redundancy Levels:

Base Tables:	Level One
Auxiliary Data Structures:	Level One
DBMS Temporary Space:	Level One
OS and DBMS Software:	Level One

System Configuration

Number of Nodes:	4
Processors/Cores/Threads/Type:	32/320/640 Intel® Xeon® Processor E7-8870 (24M Cache, 2.40 GHz, 6.40 GT/s Intel® QPI)
Memory:	8TB
Storage Controllers:	128 x 8Gbps PCI Express FC Dual-port HBA, 4 x 8Gbps PCI Express Mezzanine FC Dual-port HBA
Storage Subsystem Disk Drives:	16 x Hitachi Unified Storage 150 (Dual 8-port controller) each with 100 x 900GB 10Krpm SAS Disks 4 x Hitachi BR1600E each with 15 x 600GB 10Krpm SAS Disks
Total Disk Storage:	1,476,000GB

* Database Size includes only raw data (e.g., no temp, index, redundant storage space, etc.)

Description	Key	Product Code	Unit Price	Qty	Exit. Price	3 Yr. Maint.
Server Hardware						
BS2000 Server chassis	1	GV-SRE2A172NN1	1,800,000	2	3,600,000	
BS2000 ACElectric power input module	1	GV-BE2ACM1N1BX	50,000	4	200,000	
BS2000 Brocade 8Gb Fiber channel switch module	1	GV-BE2FSW2N1BX	1,800,000	4	7,200,000	
BS2000 SFP+module for Brocade 8Gb	1	GV-BE2SFP1N1BX	35,000	8	280,000	
BS2000 Power supply module for chassis	1	GV-BP2PWM1N1BX	180,000	6	1,080,000	
BS2000 Highly efficient server blade	1	GVAE57A2-5NNN14X	2,450,000	16	39,200,000	
BS2000 I/O slot extension equipment Connection board	1	GV-CB2NPT1N1BX	75,000	32	2,400,000	
BS2000 Hitachi 8Gb 2-ports Fiber channel extension card	1	GV-CC2M8G1N1EX	120,000	4	480,000	
BS2000 Extension processor Xeon E7-8870	1	GV-EC22401N4EX	1,350,000	16	21,600,000	
BS2000 4-braids SMP connection board	1	GV-EZ2SMP2N1BX	600,000	4	2,400,000	
BS2000 16GB memory	1	GV-MJ216H1N1EX	104,000	512	53,248,000	
BS2000 I/O slot extension equipment	1	GV0EDW11-224N11N	1,500,000	16	24,000,000	
BS2000 Hitachi 8Gb 2-ports Fiber channel board	1	GV-CC2D8G2N1EX	400,000	128	51,200,000	
BS2000 Connection metal cable	1	GV-SLT2DPE2N1	90,000	32	2,880,000	
HA8000/RS210AL Base model	1	GQU210AL-A6NNKN2	794000	1	794,000	
HA8000/RS210 Xeon X5675 3.06GHz（6-core）/L3 Cache	1	GQ-ECDPH3P0BEX	264000	1	264,000	
HA8000/RS210 200V Accable	1	GQ-LG2252	2,000	1	2,000	
HA8000/RS210 Memory board 4GB	1	GQ-MJ704G2WEEX	36,000	6	216,000	
HA8000/RS210 Internal hard disk SAS 600GB 2.5type	1	GQ-UH7600NVLEX	108,000	5	540,000	
HA8000/RS210 Reserve disk SAS 600GB 2.5type	1	GQ-UH7600NVLRX	108,000	1	108,000	
HA8000/RS210 Display/Keyboard unit	1	GQ-SRLK72406A	385,000	1	385,000	
HA8000/RS210 USB keyboard/Mouse/Display cable	1	GQ-LUB7113A	6,000	2	12,000	
Support Fee (Standard support of Server Hardware)	1		50,979,024	1		50,979,024
			Server Hardware Subtotal		212,089,000	50,979,024
Storage						
BR1600E Basic case	1	GV0BR162-D48NNNN	3,821,600	4	15,286,400	
BR1600E BladeSymphony License for connection	1	GV-AR9BBDSN1	1,000	4	4,000	
BR1600E SAS HDD 600GB	1	GV-UH9F6001EEX	380,000	60	22,800,000	
BR1600E Performance Monitor	1	GVS-ESU9PPM1A	80,000	4	320,000	
HUS150 24-ports 8Gbps Fiber switch	1	HT-4990-SW360H	3,040,000	4	12,160,000	
HUS150 Basic case	1	HT-4066-RMHY	5,160,000	16	82,560,000	
HUS150 Cache memory	1	HT-F4066-32GBY	6,834,000	16	109,344,000	
HUS150 2.5type SAS 900GB HDD	1	HT-F4066-9HGSSY	307,000	1,600	491,200,000	
HUS150 8GbpsFC 4ports module	1	HT-F4066-HF8GY	654,000	64	41,856,000	
HUS150 BladeSymphony Server connection license	1	HT-F4066-LBS	0	16	0	
HUS150 2.5type Drive loading extension case	1	HT-F4066-DBSY	700,000	80	56,000,000	
Support Fee (Standard support of Storage Hardware)	1		49,309,800	1		49,309,800
			Storage Subtotal		831,530,400	49,309,800

HITACHI Inspire the Next	Hitachi BladeSymphony BS2000 using Hitachi Advanced Data Binder 01-02	TPC-H Rev. 2.16.0 TPC-Pricing Rev. 1.7.0 Report Date: Oct 19, 2013

Description	Key	Product Code	Unit Price	Qty	Exit. Price	3 Yr. Maint.
Other Hardware						
PDU for BS2000	1	GV-AG9PDU200V4	40,000	8	320,000	
200V PDB for rack	1	A-F6516-PDU6	150,000	16	2,400,000	
Electric socket box metal fittings	1	GV-AU9PDUBKT1	16,000	8	128,000	
Electric socket box unit	1	GV-AG1207	40,000	6	240,000	
Electric socket box unit	1	GH-AG7107	17,000	1	17,000	
Power cable	1	GV-LG1045N	18,000	6	108,000	
Power cable for PDU	1	A-F6516-P620	16,000	16	256,000	
FC cable	1	A-6515-HM20L	75,000	288	21,600,000	
HA8500 common use Rack cabinet	1	GH-RK7386	157,000	5	785,000	
HA8500 common use Punching metal specification front door	1	GH-RD7386	53,000	5	265,000	
Blank panel	1	GH-RP7012	800	86	68,800	
HA8500 common use Rack side panel	1	GH-RS7386	17,000	5	85,000	
40U 19-inch rack	1	A-6516-RK40	1,100,000	16	17,600,000	
HUS100/HUS VM Rack decoration panel	1	A-F6516-FP1U	6,000	224	1,344,000	
			Other Hardware Subtotal		45,216,800	
Software						
Hitachi Advanced Data Binder 01-02 +4-license	1	P-9W62-C111&V3	5,760,000	40	230,400,000	
Hitachi Advanced Data Binder 01-02 Master +1-license	1	P-9W62-C111&VW	3,600,000	4	14,400,000	
Hitachi Device Manager MASTER	1	P-2Z13-3574	0	1	0	
Hitachi Device Manager for BR1600	1	P-9Z13-3571&D3CF	80,000	1	80,000	
Support Fee (Standard support of Software)	1		43,200,000	3		129,600,000
			Software Subtotal		244,880,000	129,600,000
			Total		¥1,333,716,200	¥229,888,824
			Three-Year Cost of Ownership:			**¥1,563,605,024 JPY**
			QphH@100000GB:			**82,678**
			¥/QphH@100000GB:			**¥18,911.98 JPY**

Key: 1 – Hitachi, Ltd.

Audited by Francois Raab of InfoSizing (sizing.com)

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

Numerical Quantities

Measurement Results:

Database Scale Factor	100,000
Total Data Storage / Database Size	14.76
Start of Database Load	2013-08-29 19:07:31
Shutdown	2013-09-04 06:43:11
Restart	2013-09-04 08:05:31
End of Database Load	2013-09-04 16:22:59
Database Load Time	139:53:08
Query Streams for Throughput Test	11
TPC-H Power	64,244.1
TPC-H Throughput	106,401.3
TPC-H Composite Query-per-Hour (QphH@100000GB)	82,678.0
Total System Price over 3 Years	¥1,563,605,024 JPY
TPC-H Price / Performance Metric (¥ JPY / QphH@100000GB)	¥18,911.98 JPY

Measurement Interval:

Measurement Interval in Throughput Test (Ts)	818,787

Duration of Stream Execution

Power Run	Seed	Query Start Time / Query End Time	Duration (sec)	RF1 Start Time / RF1 End Time	RF2 Start Time / RF2 End Time
	904162259	09/28/2013 18:21:13	214,037	09/28/2013 16:08:59	10/01/2013 05:48:30
		10/01/2013 05:48:30		09/28/2013 18:21:12	10/01/2013 07:45:58

Throughput Stream	Seed	Query Start Time / Query End Time	Duration (sec)	RF1 Start Time / RF1 End Time	RF2 Start Time / RF2 End Time
1	904162260	10/01/2013 07:45:58	567,020	10/08/2013 19:53:41	10/08/2013 22:11:49
		10/07/2013 21:16:19		10/08/2013 22:11:49	10/09/2013 00:08:15
2	904162261	10/01/2013 07:45:59	639,299	10/09/2013 00:08:15	10/09/2013 02:34:23
		10/08/2013 17:20:58		10/09/2013 02:34:23	10/09/2013 04:31:12
3	904162262	10/01/2013 07:45:59	608,302	10/09/2013 04:31:12	10/09/2013 06:55:04
		10/08/2013 08:44:21		10/09/2013 06:55:04	10/09/2013 08:51:12
4	904162263	10/01/2013 08:03:58	596,191	10/09/2013 08:51:12	10/09/2013 11:16:10
		10/08/2013 05:40:29		10/09/2013 11:16:10	10/09/2013 13:12:33
5	904162264	10/01/2013 07:45:58	574,892	10/09/2013 13:12:33	10/09/2013 15:38:43
		10/07/2013 23:27:30		10/09/2013 15:38:43	10/09/2013 17:34:25

Throughput Stream	Seed	Query Start Time / Query End Time	Duration (sec)	RF1 Start Time / RF1 End Time	RF2 Start Time / RF2 End Time
6	904162265	10/01/2013 07:45:59	639,886	10/09/2013 17:34:25	10/09/2013 19:58:50
		10/08/2013 17:30:45		10/09/2013 19:58:50	10/09/2013 21:54:30
7	904162266	10/01/2013 08:04:01	563,092	10/09/2013 21:54:30	10/10/2013 00:16:48
		10/07/2013 20:28:53		10/10/2013 00:16:48	10/10/2013 02:11:43
8	904162267	10/01/2013 07:45:59	521,121	10/10/2013 02:11:43	10/10/2013 04:36:54
		10/07/2013 08:31:20		10/10/2013 04:36:54	10/10/2013 06:32:38
9	904162268	10/01/2013 08:03:58	620,831	10/10/2013 06:32:38	10/10/2013 08:50:11
		10/08/2013 12:31:09		10/10/2013 08:50:11	10/10/2013 10:46:10
10	904162269	10/01/2013 07:45:59	602,456	10/10/2013 10:46:10	10/10/2013 13:03:21
		10/08/2013 07:06:55		10/10/2013 13:03:21	10/10/2013 14:59:00
11	904162270	10/01/2013 07:45:59	648,462	10/10/2013 14:59:01	10/10/2013 17:15:52
		10/08/2013 19:53:41		10/10/2013 17:15:52	10/10/2013 19:12:25

TPC-H Timing Intervals (in seconds)

Stream ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
0	19,448.8	4,089.4	11,412.4	13,793.6	16,201.3	477.8	7,712.7	10,114.9	18,239.3	5,723.7	2,717.9	2,228.5
1	24,717.4	4,447.7	34,545.3	26,180.1	30,166.6	15,117.2	22,568.1	16,174.8	56,080.6	10,114.7	6,871.4	10,038.6
2	34,996.9	45,407.7	24,131.4	34,408.6	57,891.2	2,030.3	33,730.0	11,834.6	72,834.2	54,809.5	6,477.8	10,365.4
3	23,911.6	33,291.6	17,607.2	45,313.1	64,002.6	40,515.3	26,223.4	14,715.6	19,058.1	33,246.6	20,050.5	2,378.7
4	46,651.9	30,559.5	11,576.3	38,522.9	68,312.0	4,463.8	8,531.9	34,358.9	22,349.1	23,050.4	9,916.5	16,457.3
5	22,785.5	20,183.7	18,066.2	84,488.3	34,962.8	7,975.0	55,083.6	37,193.3	31,892.7	8,613.6	5,028.8	9,107.1
6	33,932.0	26,349.5	52,321.5	18,507.8	33,810.2	31,297.3	16,275.0	20,827.9	25,660.4	6,333.2	7,150.9	29,276.6
7	20,192.3	10,068.8	27,225.2	14,821.7	21,243.3	30,501.6	15,928.4	51,340.2	21,659.3	13,392.1	24,942.8	8,589.0
8	44,605.6	15,980.1	48,135.6	16,393.6	36,751.3	8,919.0	34,459.3	57,893.3	34,182.3	17,478.6	7,460.8	12,089.2
9	38,605.2	15,283.8	27,007.0	82,415.2	16,374.8	27,071.8	50,381.1	24,036.9	32,718.7	16,692.4	26,191.4	61,787.2
10	33,363.6	6,293.9	49,250.0	19,728.1	28,112.5	919.4	20,023.5	17,466.8	22,489.1	22,248.6	7,042.3	26,632.0
11	22,808.2	12,171.4	17,375.9	39,411.2	27,512.8	46,674.1	7,853.6	25,757.0	41,452.1	44,780.4	24,587.9	21,232.0
Minimum	19,448.8	4,089.4	11,412.4	13,793.6	16,201.3	477.8	7,712.7	10,114.9	18,239.3	5,723.7	2,717.9	2,228.5
Average	30,501.6	18,677.3	28,221.2	36,165.4	36,278.5	17,996.9	24,897.6	26,809.5	33,218.0	21,373.7	12,369.9	17,515.1
Maximum	46,651.9	45,407.7	52,321.5	84,488.3	68,312.0	46,674.1	55,083.6	57,893.3	72,834.2	54,809.5	26,191.4	61,787.2

Stream ID	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	RF1	RF2
0	16,274.7	2,322.6	787.1	2,334.4	3,308.2	20,820.2	832.6	5,806.5	46,171.2	3,219.6	7,933.0	7,047.5
1	43,200.6	28,789.0	19,987.5	19,685.0	27,383.1	40,647.2	4,803.9	12,500.0	56,346.6	56,654.7	8,287.5	6,986.0
2	23,847.0	17,023.9	3,427.3	8,281.2	60,368.6	38,797.5	21,548.4	7,060.8	46,860.0	23,166.9	8,768.0	7,009.0
3	33,915.9	21,495.9	21,214.8	15,463.0	16,243.1	23,755.1	26,063.6	26,154.5	64,807.5	18,874.0	8,632.4	6,967.6
4	47,399.5	24,950.7	22,547.8	21,013.9	20,559.6	30,846.3	3,636.7	7,566.2	71,428.0	31,492.0	8,698.2	6,983.4
5	24,283.1	21,755.5	18,379.9	43,372.6	5,105.8	42,884.6	3,632.5	19,224.2	51,820.8	9,051.9	8,769.9	6,941.5
6	28,916.4	12,679.9	5,646.0	11,345.3	59,584.8	41,603.3	21,626.4	43,961.8	88,939.1	23,840.8	8,665.3	6,940.0
7	69,297.4	6,755.7	34,677.1	49,164.8	8,480.8	27,067.2	1,854.8	14,265.9	64,628.4	26,994.6	8,538.5	6,894.9
8	34,743.2	8,177.7	11,615.5	5,491.9	10,922.2	32,329.8	3,235.0	16,778.2	56,255.7	7,222.8	8,711.0	6,943.9
9	23,092.4	17,156.1	12,168.6	2,335.2	22,676.7	48,945.3	1,628.1	21,936.9	47,615.3	4,710.8	8,252.7	6,958.7
10	47,433.9	14,896.9	51,719.4	47,376.1	54,582.1	39,417.7	3,107.5	8,559.0	56,827.1	24,966.7	8,231.5	6,939.5
11	42,575.5	23,448.2	2,396.6	29,481.4	38,076.4	43,517.5	831.9	27,252.5	72,083.1	37,182.9	8,211.3	6,993.1
Minimum	16,274.7	2,322.6	787.1	2,334.4	3,308.2	20,820.2	831.9	5,806.5	46,171.2	3,219.6	7,933.0	6,894.9
Average	36,248.3	16,621.0	17,047.3	21,278.7	27,274.3	35,886.0	7,733.5	17,588.9	60,315.2	22,281.5	8,474.9	6,967.1
Maximum	69,297.4	28,789.0	51,719.4	49,164.8	60,368.6	48,945.3	26,063.6	43,961.8	88,939.1	56,654.7	8,769.9	7,047.5

Table of Contents

TPC Benchmark H Overview

The TPC Benchmark™ H (TPC-H) is a decision support benchmark. It 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

0. 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 Hitachi, Ltd.

0.2. Parameter Settings

Settings must be provided for all customer-tunable parameters and options that 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.*

The Supporting Files Archive contains all the parameters and options for Hitachi Advanced Data Binder and operating system.

0.3. Configuration Diagram

Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences.

The System Under Test (SUT), which is depicted in Figure 0.1, consists of the following components:

4 x Hitachi BladeSymphony BS2000
  4 x Hitachi BS2000 High-performance Server Blade
    2 x Intel® Xeon® Processor E7-8870 (24M Cache, 2.40GHz, 6.40 GT/s Intel® QPI)
    512 GB memory
  4 x PCI I/O slots expansion unit
    8 x 8Gbps PCI Express FC Dual-port HBA
  1 x 8Gbps PCI Express Mezzanine FC Dual-port HBA
16 x Hitachi Unified Storage 150
  1 x Dual 8-port controller with 32GB Cache (16GB mirrored)
  100 x 900GB 10Krpm SAS Disks
4 x Hitachi BR1600E
  15 x 600GB 10Krpm SAS Disks

Four 2-socket blade servers are interconnected via SMP connector and combined into one 8-socket SMP server.

Priced configuration and measured configuration are identical.

System Under Test

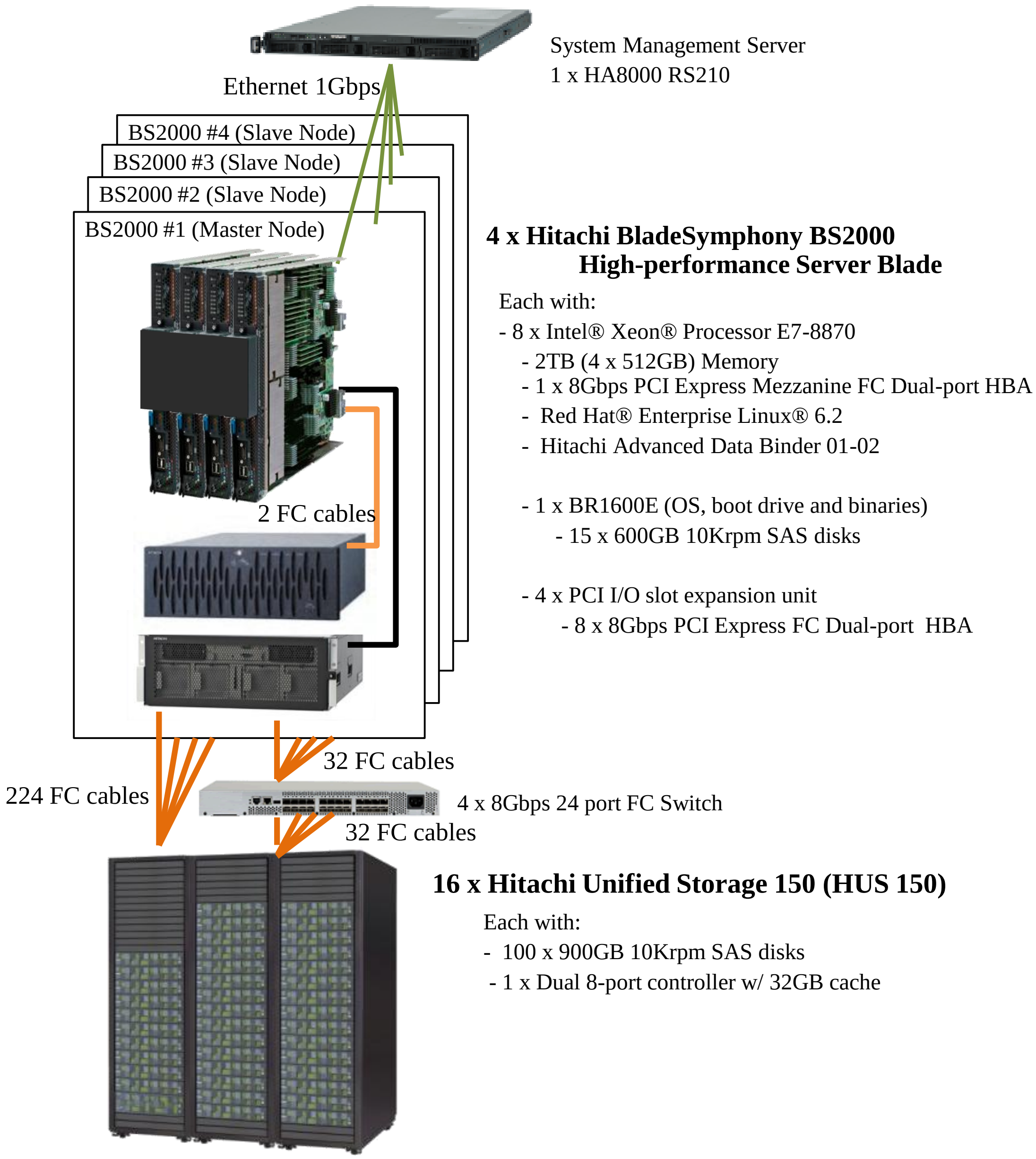


Figure 0.1: Measured and Priced System Configuration

1. 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. All listings must be reported in the supporting files archive.

The Supporting Files Archive contains the scripts which define the tables and indexes for TPC-H database.

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. The physical organization of tables must be reported in the supporting files archive.

The column ordering was changed for customer, orders and lineitem tables. The Supporting Files Archive contains the definitions of these tables.

1.3. Horizontal Partitioning

Horizontal partitioning of tables and rows in the test and qualification databases (see Clause 1.5.4) must be disclosed. Scripts to perform horizontal partitioning must be reported in the supporting files archive.

Horizontal partitioning was not used.

1.4. Replication

Any replication of physical objects must be disclosed and must conform to the requirements of Clause 1.5.7. Scripts to perform any replication must be reported in the supporting files archive.

The physical objects stored the TPC-H database are shared among all the server nodes. No replication was used.

1.5. Tunable Parameters

Script or text for all hardware and software tunable parameters must be reported in the supporting files archive.

All software parameters changed from their defaults are reported in the Supporting Files Archive.

2. Clause 2 – Queries and Refresh Function-Related Items

2.1. Query Language

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

SQL was the query language used to implement all queries.

2.2. QGen Version Verification

*The version number, release number, modification number, and patch level of **QGen** must be disclosed. Any modifications to the **QGen** (see Clause 2.1.4) source code (see Appendix D) must be reported in the supporting files archive.*

Version 2.16.0 of the DBGen package was not available at the time of testing. QGen 2.15.0 was used with the modifications approved by the TPC for release 2.16.0. These approved modifications were detailed in the FDR of the TPC-H result published by Oracle on June 7, 2013 for the SPARC T5-4 Server. In addition, the reference dataset for the query substitution parameters could not be verified since the 2.16.0 dataset is not available.

2.3. Query Text and Output Data from Database

The executable query text used for query validation must be reported in the supporting files archive 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 Supporting Files Archive contains the executable query text and output data. The following modifications were used:

- The "limit" function is used to restrict the number of output rows in Q2, Q3, Q10, Q18, and Q21.
- The "interval" function doesn't use to perform date arithmetic in Q1, Q4, Q5, Q6, Q10, Q12, Q14, Q15, and Q20, e.g. "l_shipdate <= date '1998-12-01' - :1 DAY".
- The "substr" function is used to extract a part of string in Q22.
- The ";" is used to insert comment line in ALL queries.
- Q15 Variant A is used.

2.4. 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.

The Supporting Files Archive contains the query substitution parameters and the seeds used.

2.5. Query 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 were run with isolation Level 1 (READ COMMITED of Hitachi Advanced Data Binder). The refresh functions were run with Level 3 (REPEATABLE READ of Hitachi Advanced Data Binder).

2.6. Source Code of Refresh Functions

The details of how the refresh functions were implemented must be reported in the supporting files archive (including source code of any non-commercial program used).

The Supporting Files Archive contains the source codes of the refresh functions.

3. Clause 3 – Database System Properties Related Items

3.1. ACID Properties

The results of the ACID tests must be disclosed along with a description of how the ACID requirements were met. All code (including queries, stored procedures etc.) used to test the ACID requirements and their entire output must be reported in the supporting files archive.

All the ACID tests are conducted according to the specification. The steps performed are outlined in the following sections. The Supporting Files Archive contains all the source codes, the scripts, and their output files.

3.2. Atomicity Requirements

The system under test must guarantee that transactions are atomic; the system will either perform all individual operations on the data, or will assure that no partially-completed operations leave any effects on the data.

3.2.1. Atomicity of 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 ORDERS, LINEITEM, and HISTORY tables.

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

1. The total price from the ORDERS 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 ORDERS table and the extended price from the LINEITEM table were retrieved for the same order key used in Step 1. 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, substituting a ROLLBACK of the transaction for the COMMIT of the transaction. Verify that the appropriate rows have not been changed in the ORDERS, LINEITEM, and HISTORY tables.

The following steps were performed to verify the atomicity of the aborted transactions:

1. The total price from the ORDERS 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 is stopped prior to the commit.
3. The ACID transaction was ROLLED BACK.
4. The total price from the ORDERS table and the extended price from the LINEITEM table were retrieved for the same order key used in Step 1. 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.

3.3.1. Consistency Test

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

*O_TOTALPRICE =SUM(trunc(trunc(L_EXTENDEDPRICE *(1 - L_DISCOUNT),2) * (1+L_TAX),2))*

for each ORDERS and LINEITEM defined by (O_ORDERKEY = L_ORDERKEY)

The following three queries were executed before and after executing ACID transactions in order to verify that ORDERS table and LINEITEM table were in consistent state. The program source codes to execute the queries are included in the Supporting Files Archive.

```
INSERT INTO temp_con_output
  SELECT o.O_ORDERKEY, o.O_TOTALPRICE, l.L_ORDERKEY,
        SUM(trunc((trunc((L_EXTENDEDPRICE * ( 1 - L_DISCOUNT )),2) * ( 1 + L_TAX )),2)),
        a.SEQ_NUM
    FROM ACID_VALUES_LIST a
    INNER JOIN ORDERS o ON a.ACID_O_KEY = o.O_ORDERKEY JOIN LINEITEM l
    ON o.O_ORDERKEY = l.L_ORDERKEY WHERE a.ACID_TEST_NAME = 'Consistency_Durability'
      GROUP BY o.O_ORDERKEY, o.O_TOTALPRICE, l.L_ORDERKEY, a.SEQ_NUM;
```

```
SELECT * FROM temp_con_output WHERE O_TOTALPRICE <> LINEITEM_SUM;
```

```
SELECT O_ORDERKEY, O_TOTALPRICE, L_ORDERKEY, LINEITEM_SUM, O_TOTALPRICE - LINEITEM_SUM FROM temp_con_output;
```

To verify the consistency between the ORDERS, and LINEITEM tables, perform the following steps:

1. The consistency of the ORDERS and LINEITEM tables was verified.
2. One hundred ACID Transactions were submitted from each of 12 streams.
3. The consistency of the ORDERS 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 the proper 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 Transaction was started for a randomly selected O_KEY, L_KEY, and DELTA. The ACID Transaction suspended prior to COMMIT.
2. An ACID Query was started for the same O_KEY as in Step 1. The ACID Query did not see the uncommitted changes made by the ACID Transaction.
3. The ACID Query completed.
4. The ACID Transaction was resumed and COMMITTED.

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 a read-only and a rolled back read-write transaction:

1. An ACID Transaction was started for a randomly selected O_KEY, L_KEY, and DELTA. The ACID Transaction suspended

prior to COMMIT.
2. An ACID Query was started for the same O_KEY as in Step 1. The ACID Query did not see the uncommitted changes made by the ACID Transaction.
3. The ACID Query completed.
4. The ACID Transaction was resumed and ROLLED BACK.

3.4.3. Isolation Test3 - Write-Write Conflict with Commit

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

The following steps were performed to verify isolation of two update transactions:

1. An ACID Transaction, T1, was started for a randomly selected O_KEY, L_KEY, and DELTA1. The ACID Transaction was stopped prior to COMMIT.
2. Another ACID Transaction, T2, was started using the same O_KEY, L_KEY and a randomly selected DELTA2.
3. T2 updates returned an error. T2 was aborted (ROLLED BACK) and restarted. (Step3 was repeated until T1 was COMMITTED.)
4. T1 was allowed to COMMIT and T2 completed.
5. It was verified that: T2.L_EXTENDEDPRICE = T1.L_EXTENDEDPRICE+(DELTA1 * (T1.L_EXTENDEDPRICE / T1.L_QUANTITY)).

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.

The following steps were performed to verify isolation of two update transactions:

1. An ACID Transaction, T1, was started for a randomly selected O_KEY, L_KEY, and DELTA1. The ACID Transaction was stopped prior to ROLLBACK.
2. Another ACID Transaction, T2, was started using the same O_KEY, L_KEY and a randomly selected DELTA2.
3. T2 updates returned an error. T2 was aborted (ROLLED BACK) and restarted. (Step3 was repeated until T1 was ROLLED BACK.)
4. T1 was allowed to ROLLBACK and T2 completed.
5. It was verified that: T2.L_EXTENDEDPRICE = T1.L_EXTENDEDPRICE.

3.4.5. Isolation Test 5 - Concurrent Progress of Read and Write Transactions

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

The following steps were performed to verify the ability of read and write transactions affecting different database tables to make progress concurrently.

1. An ACID Transaction, T1, with randomly selected values of O_KEY, L_KEY and DELTA. T1 was suspended prior to COMMIT.
2. Another transaction, T2, was starting using random values of PS_PARTKEY and PS_SUPPKEY.
3. T2 completed.
4. T1 was allowed to COMMIT.
5. It was verified that the appropriate rows in the ORDERS, LINEITEM and HISTORY tables were changed.

3.4.6. Isolation Test 6 – Read-Only Query Conflict with Update Transaction

Demonstrate that 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 an update transaction during a continuous read-only query:

1. An ACID Transaction, T1, was started, executing Q1 against the qualification database. The substitution parameter was chosen to be 0 so that the query ran for a sufficient length of time.
2. Before T1 completed, an ACID Transaction, T2, was started using randomly selected values of O_KEY, L_KEY and DELTA.
3. T2 completed before T1 completed.
4. It was verified that the appropriate rows in the ORDERS, LINEITEM and HISTORY tables were changed.

3.5. Durability Requirements

The SUT must guarantee durability: the ability to preserve the effects of committed transactions and ensure database consistency after recovery from any one of the failures listed in Clause 3.5.3.

3.5.1. System Crash / Memory Failure

System Crash: Guarantee the database and the effects of committed updates are preserved across an instantaneous interruption (system crash/system hang) in processing which requires system re-boot to recover.

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

Each of these requirements was satisfied in the following two tests: (A) the first test was the single system crash (master node); (B) the second test was the single system crash (slave node).

3.5.1.1. (A) The Single System Crash on Master Node

The following steps were performed to test a system crash or memory failure:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running, the master node was powered off by using SVP.
4. When power was restored, the system rebooted and the database was restarted.
5. The ORDERS and LINITEM tables were verified to be consistent.
6. The contents of the success files and the HISTORY table were compared and found to match.

3.5.1.2. (B) The Single System Crash on Slave Node

The following steps were performed to test a system crash or memory failure:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running, one of the slave nodes was powered off by using SVP.
4. When power was restored, the system rebooted and the database was restarted.
5. The ORDERS and LINITEM tables were verified to be consistent.
6. The contents of the success files and the HISTORY table were compared and found to match.

3.5.2. Loss of External Power

Loss of External Power: Guarantee the database and the effects of committed updates are preserved during the loss of all external power to the SUT for an indefinite time period.

The following steps were performed to test the loss of all external power to the SUT:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running, all servers were powered off by using SVP.
4. When power was restored, the system rebooted and the database was restarted.
5. The ORDERS and LINITEM tables were verified to be consistent.
6. The contents of the success files and the HISTORY table were compared and found to match.

3.5.3. Failure of a Durable Medium

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

TPC-H database tables, indexes, and log files are striped over 128 RAID-10 arrays using Logical Volume Manager (LVM). Each RAID-10 array is composed of 12 physical hard disk drives. Therefore all tables, indexes, and log files are striped over all the physical hard disk drives of the 128 RAID-10 arrays and a failure of one physical hard disk drive affects all tables, indexes, and log files at the same time.

The following steps were performed to test the failure of a single disk drive in an array:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running, one of the disk drives in an RAID-10 array was removed. The transactions continued without any interruptions.
4. After each streams completed 200 ACID transactions, the ORDERS and LINITEM tables were verified to be consistent.
5. The contents of the success files and the HISTORY table were compared and found to match.

3.5.4. Failure of Write-Back Cache on a Storage Controller

The following steps were performed to test the failure of a single controller in a storage subsystem:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running.
4. A hardware failure was injected into one of the storage controllers.
5. When the storage controller was restored and the storage subsystem with the storage controller was restored, the system reboots and the database was restarted.
6. The ORDERS and LINITEM tables were verified to be consistent.
7. The contents of the success files and the HISTORY table were compared and found to match.

3.5.5. Power Failure on a Storage Controller

The following steps were performed to test the loss of power to a single controller in a storage subsystem:

1. The ORDERS and LINITEM tables were verified to be consistent.
2. Twelve streams of ACID transactions were started.
3. After at least 100 transactions have occurred on each stream and the streams of ACID transactions were still running.
4. The power was removed from one of the storage controllers.
5. When the power was restored and the storage subsystem with the storage controller was restored, the system reboots and the

database was restarted.

6. The ORDERS and LINITEM tables were verified to be consistent.
7. The contents of the success files and the HISTORY table were compared and found to match.

4. Clause 4 – Scaling and Database Population Related Items

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.

The tables defined by TPC-H Benchmark and the row count for each table as they existed at the completion of the database load are listed in Table 4.1.

Table 4.1: Initial Cardinality of Tables

Table	Cardinality
Lineitem	599,999,969,200
Orders	150,000,000,000
Partsupp	80,000,000,000
Part	20,000,000,000
Customer	15,000,000,000
Supplier	1,000,000,000
Nation	25
Region	5

4.2. Distribution of Tables and Logs Across Media

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

TPC-H database tables and log files are stripped over 128 RAID-10 arrays using Logical Volume Manager (LVM). Each RAID-10 arrays (Raid Groups) is composed of 12 900GB physical disk drives. Each Logical Units (LUs) which allocated from the Raid Group. The Logical Volumes (LVs) created by LVM are allocated from the LUs and are assigned to the TPC-H tables and Log files.

Table 4.2 and Table 4.3 list the allocation of the physical disk drives to RAID-10 arrays and LUs. Table 4.4 lists allocation of LVMs from LUs. Table 4.5 lists the assignment of LVs to TPC-H Tables and Log Files.

Table 4.2: Allocation of LUs from Raid Groups (1/2)

LU	Size (in GB)	Storage	Raid Group	# of Disks	RAID	LU	Size (in GB)	Storage	Raid Group	# of Disks	RAID
LU_0_0_[0-7]	600	Storage#0 : HUS150	RG00	12	10	LU_5_0_[0-7]	600	Storage#5 : HUS150	RG00	12	10
LU_0_1_[0-7]	600		RG01	12	10	LU_5_1_[0-7]	600		RG01	12	10
LU_0_2_[0-7]	600		RG02	12	10	LU_5_2_[0-7]	600		RG02	12	10
LU_0_3_[0-7]	600		RG03	12	10	LU_5_3_[0-7]	600		RG03	12	10
LU_0_4_[0-7]	600		RG04	12	10	LU_5_4_[0-7]	600		RG04	12	10
LU_0_5_[0-7]	600		RG05	12	10	LU_5_5_[0-7]	600		RG05	12	10
LU_0_6_[0-7]	600		RG06	12	10	LU_5_6_[0-7]	600		RG06	12	10
LU_0_7_[0-7]	600		RG07	12	10	LU_5_7_[0-7]	600		RG07	12	10
LU_0_10_[0-9a-f] *	680		RG10	5	5	LU_5_10_[0-9a-f] *	680		RG10	5	5
LU_0_11_[0-9a-f] *	680		RG11	5	5	LU_5_11_[0-9a-f] *	680		RG11	5	5
LU_0_12_[0-9a-f] *	680		RG12	5	5	LU_5_12_[0-9a-f] *	680		RG12	5	5
LU_0_13_[0-9a-f] *	680		RG13	5	5	LU_5_13_[0-9a-f] *	680		RG13	5	5
LU_1_0_[0-7]	600	Storage#1 : HUS150	RG00	12	10	LU_6_0_[0-7]	600	Storage#6 : HUS150	RG00	12	10
LU_1_1_[0-7]	600		RG01	12	10	LU_6_1_[0-7]	600		RG01	12	10
LU_1_2_[0-7]	600		RG02	12	10	LU_6_2_[0-7]	600		RG02	12	10
LU_1_3_[0-7]	600		RG03	12	10	LU_6_3_[0-7]	600		RG03	12	10
LU_1_4_[0-7]	600		RG04	12	10	LU_6_4_[0-7]	600		RG04	12	10
LU_1_5_[0-7]	600		RG05	12	10	LU_6_5_[0-7]	600		RG05	12	10
LU_1_6_[0-7]	600		RG06	12	10	LU_6_6_[0-7]	600		RG06	12	10
LU_1_7_[0-7]	600		RG07	12	10	LU_6_7_[0-7]	600		RG07	12	10
LU_1_10_[0-9a-f] *	680		RG10	5	5	LU_6_10_[0-9a-f] *	680		RG10	5	5
LU_1_11_[0-9a-f] *	680		RG11	5	5	LU_6_11_[0-9a-f] *	680		RG11	5	5
LU_1_12_[0-9a-f] *	680		RG12	5	5	LU_6_12_[0-9a-f] *	680		RG12	5	5
LU_1_13_[0-9a-f] *	680		RG13	5	5	LU_6_13_[0-9a-f] *	680		RG13	5	5
LU_2_0_[0-7]	600	Storage#2 : HUS150	RG00	12	10	LU_7_0_[0-7]	600	Storage#7 : HUS150	RG00	12	10
LU_2_1_[0-7]	600		RG01	12	10	LU_7_1_[0-7]	600		RG01	12	10
LU_2_2_[0-7]	600		RG02	12	10	LU_7_2_[0-7]	600		RG02	12	10
LU_2_3_[0-7]	600		RG03	12	10	LU_7_3_[0-7]	600		RG03	12	10
LU_2_4_[0-7]	600		RG04	12	10	LU_7_4_[0-7]	600		RG04	12	10
LU_2_5_[0-7]	600		RG05	12	10	LU_7_5_[0-7]	600		RG05	12	10
LU_2_6_[0-7]	600		RG06	12	10	LU_7_6_[0-7]	600		RG06	12	10
LU_2_7_[0-7]	600		RG07	12	10	LU_7_7_[0-7]	600		RG07	12	10
LU_2_10_[0-9a-f] *	680		RG10	5	5	LU_7_10_[0-9a-f] *	680		RG10	5	5
LU_2_11_[0-9a-f] *	680		RG11	5	5	LU_7_11_[0-9a-f] *	680		RG11	5	5
LU_2_12_[0-9a-f] *	680		RG12	5	5	LU_7_12_[0-9a-f] *	680		RG12	5	5
LU_2_13_[0-9a-f] *	680		RG13	5	5	LU_7_13_[0-9a-f] *	680		RG13	5	5
LU_3_0_[0-7]	600	Storage#3 : HUS150	RG00	12	10	LU_8_0_[0-7]	600	Storage#8 : HUS150	RG00	12	10
LU_3_1_[0-7]	600		RG01	12	10	LU_8_1_[0-7]	600		RG01	12	10
LU_3_2_[0-7]	600		RG02	12	10	LU_8_2_[0-7]	600		RG02	12	10
LU_3_3_[0-7]	600		RG03	12	10	LU_8_3_[0-7]	600		RG03	12	10
LU_3_4_[0-7]	600		RG04	12	10	LU_8_4_[0-7]	600		RG04	12	10
LU_3_5_[0-7]	600		RG05	12	10	LU_8_5_[0-7]	600		RG05	12	10
LU_3_6_[0-7]	600		RG06	12	10	LU_8_6_[0-7]	600		RG06	12	10
LU_3_7_[0-7]	600		RG07	12	10	LU_8_7_[0-7]	600		RG07	12	10
LU_3_10_[0-9a-f] *	680		RG10	5	5	LU_8_10_[0-9a-f] *	680		RG10	5	5
LU_3_11_[0-9a-f] *	680		RG11	5	5	LU_8_11_[0-9a-f] *	680		RG11	5	5
LU_3_12_[0-9a-f] *	680		RG12	5	5	LU_8_12_[0-9a-f] *	680		RG12	5	5
LU_3_13_[0-9a-f] *	680		RG13	5	5	LU_8_13_[0-9a-f] *	680		RG13	5	5
LU_4_0_[0-7]	600	Storage#4 : HUS150	RG00	12	10	LU_9_0_[0-7]	600	Storage#9 : HUS150	RG00	12	10
LU_4_1_[0-7]	600		RG01	12	10	LU_9_1_[0-7]	600		RG01	12	10
LU_4_2_[0-7]	600		RG02	12	10	LU_9_2_[0-7]	600		RG02	12	10
LU_4_3_[0-7]	600		RG03	12	10	LU_9_3_[0-7]	600		RG03	12	10
LU_4_4_[0-7]	600		RG04	12	10	LU_9_4_[0-7]	600		RG04	12	10
LU_4_5_[0-7]	600		RG05	12	10	LU_9_5_[0-7]	600		RG05	12	10
LU_4_6_[0-7]	600		RG06	12	10	LU_9_6_[0-7]	600		RG06	12	10
LU_4_7_[0-7]	600		RG07	12	10	LU_9_7_[0-7]	600		RG07	12	10
LU_4_10_[0-9a-f] *	680		RG10	5	5	LU_9_10_[0-9a-f] *	680		RG10	5	5
LU_4_11_[0-9a-f] *	680		RG11	5	5	LU_9_11_[0-9a-f] *	680		RG11	5	5
LU_4_12_[0-9a-f] *	680		RG12	5	5	LU_9_12_[0-9a-f] *	680		RG12	5	5
LU_4_13_[0-9a-f] *	680		RG13	5	5	LU_9_13_[0-9a-f] *	680		RG13	5	5

* LUs were mounted during database load only.

Table 4.3: Allocation of LUs from Raid Groups (2/2)

LU	Size (in GB)	Storage	Raid Group	# of Disks	RAID
LU_a_0_[0-7]	600	Storage#a : HUS150	RG00	12	10
LU_a_1_[0-7]	600		RG01	12	10
LU_a_2_[0-7]	600		RG02	12	10
LU_a_3_[0-7]	600		RG03	12	10
LU_a_4_[0-7]	600		RG04	12	10
LU_a_5_[0-7]	600		RG05	12	10
LU_a_6_[0-7]	600		RG06	12	10
LU_a_7_[0-7]	600		RG07	12	10
LU_a_10_[0-9a-f] *	680		RG10	5	5
LU_a_11_[0-9a-f] *	680		RG11	5	5
LU_a_12_[0-9a-f] *	680		RG12	5	5
LU_a_13_[0-9a-f] *	680		RG13	5	5
LU_b_0_[0-7]	600	Storage#b : HUS150	RG00	12	10
LU_b_1_[0-7]	600		RG01	12	10
LU_b_2_[0-7]	600		RG02	12	10
LU_b_3_[0-7]	600		RG03	12	10
LU_b_4_[0-7]	600		RG04	12	10
LU_b_5_[0-7]	600		RG05	12	10
LU_b_6_[0-7]	600		RG06	12	10
LU_b_7_[0-7]	600		RG07	12	10
LU_b_10_[0-9a-f] *	680		RG10	5	5
LU_b_11_[0-9a-f] *	680		RG11	5	5
LU_b_12_[0-9a-f] *	680		RG12	5	5
LU_b_13_[0-9a-f] *	680		RG13	5	5
LU_c_0_[0-7]	600	Storage#c : HUS150	RG00	12	10
LU_c_1_[0-7]	600		RG01	12	10
LU_c_2_[0-7]	600		RG02	12	10
LU_c_3_[0-7]	600		RG03	12	10
LU_c_4_[0-7]	600		RG04	12	10
LU_c_5_[0-7]	600		RG05	12	10
LU_c_6_[0-7]	600		RG06	12	10
LU_c_7_[0-7]	600		RG07	12	10
LU_c_10_[0-9a-f] *	680		RG10	5	5
LU_c_11_[0-9a-f] *	680		RG11	5	5
LU_c_12_[0-9a-f] *	680		RG12	5	5
LU_c_13_[0-9a-f] *	680		RG13	5	5
LU_d_0_[0-7]	600	Storage#d : HUS150	RG00	12	10
LU_d_1_[0-7]	600		RG01	12	10
LU_d_2_[0-7]	600		RG02	12	10
LU_d_3_[0-7]	600		RG03	12	10
LU_d_4_[0-7]	600		RG04	12	10
LU_d_5_[0-7]	600		RG05	12	10
LU_d_6_[0-7]	600		RG06	12	10
LU_d_7_[0-7]	600		RG07	12	10
LU_d_10_[0-9a-f] *	680		RG10	5	5
LU_d_11_[0-9a-f] *	680		RG11	5	5
LU_d_12_[0-9a-f] *	680		RG12	5	5
LU_d_13_[0-9a-f] *	680		RG13	5	5
LU_e_0_[0-7]	600	Storage#e : HUS150	RG00	12	10
LU_e_1_[0-7]	600		RG01	12	10
LU_e_2_[0-7]	600		RG02	12	10
LU_e_3_[0-7]	600		RG03	12	10
LU_e_4_[0-7]	600		RG04	12	10
LU_e_5_[0-7]	600		RG05	12	10
LU_e_6_[0-7]	600		RG06	12	10
LU_e_7_[0-7]	600		RG07	12	10
LU_e_10_[0-9a-f] *	680		RG10	5	5
LU_e_11_[0-9a-f] *	680		RG11	5	5
LU_e_12_[0-9a-f] *	680		RG12	5	5
LU_e_13_[0-9a-f] *	680		RG13	5	5

LU	Size (in GB)	Storage	Raid Group	# of Disks	RAID
LU_f_0_[0-7]	600	Storage#f : HUS150	RG00	12	10
LU_f_1_[0-7]	600		RG01	12	10
LU_f_2_[0-7]	600		RG02	12	10
LU_f_3_[0-7]	600		RG03	12	10
LU_f_4_[0-7]	600		RG04	12	10
LU_f_5_[0-7]	600		RG05	12	10
LU_f_6_[0-7]	600		RG06	12	10
LU_f_7_[0-7]	600		RG07	12	10
LU_f_10_[0-9a-f] *	680		RG10	5	5
LU_f_11_[0-9a-f] *	680		RG11	5	5
LU_f_12_[0-9a-f] *	680		RG12	5	5
LU_f_13_[0-9a-f] *	680		RG13	5	5
LU_10_0_0	50	Storage#10 : BR1600E	RG00	14	5
LU_10_0_1	2,048				
LU_11_0_0	50	Storage#11 : BR1600E	RG00	14	5
LU_11_0_1	2,048				
LU_12_0_0	50	Storage#12 : BR1600E	RG00	14	5
LU_12_0_1	2,048				
LU_13_0_0	50	Storage#13 : BR1600E	RG00	14	5
LU_13_0_1	2,048				

* LUs were mounted during database load only.

Table 4.4: Allocation of LVMs from LUs

LV	Size (in GB)	VG	LU
lvm_vgh00_index_L_O_[0-7][0-9	200	VGH00	LU_[0-9a-f]_[0-7]_0
lvm_vgh00_index_L_P_[0-7][0-9	95		
lvm_vgh00_index_O_O_[0-7][0-9	120		
lvm_vgh00_index_ps_[0-7][0-9]	38		
lvm_vgh00_index_P_[0-7][0-9]	9		
lvm_vgh00_index_C_[0-7][0-9]	7		
lvm_vgh00_index_S_[0-7][0-9]	1		
lvm_vgh00_index_NR	0.5		
lvm_vgh00_100K_RangeIndex	20		
lvm_vgh00_L_table_0[0-9] lvm_vgh00_L_table_1[0-3]	2,396		
lvm_vgh01_L_table_1[4-9] lvm_vgh01_L_table_[2-3][0-9] lvm_vgh01_L_table_4[0-2]	2,396	VGH01	LU_[0-9a-f]_[0-7]_1
lvm_vgh01_O_table_0[0-8]	500		
lvm_vgh02_L_table_4[3-9] lvm_vgh02_L_table_5[0-7]	2,396	VGH02	LU_[0-9a-f]_[0-7]_2
lvm_vgh02_O_table_09 lvm_vgh02_O_table_[1-6][0-9] lvm_vgh02_O_table_7[0-6]	500		
lvm_vgh02_P_table_[0-7][0-9]	50		
lvm_vgh03_L_table_5[8-9] lvm_vgh03_L_table_6[0-2]	2,396	VGH03	LU_[0-9a-f]_[0-7]_3
lvm_vgh03_O_table_7[7-9]	500		
lvm_vgh03_PS_table[0-7][0-9]	213		
lvm_vgh03_C_table[0-7][0-9]	44		
lvm_vgh03_S_table[0-7][0-9]	4		
lvm_vgh03_NR_table	0.5		
lvm_vgh03_100K_ADBDIC	10		
lvm_vgh03_100K_ADBMST	10		
lvm_vgh03_work	39,997		
lvm_vgh04_L_table_6[3-8]	2,396	VGH04	LU_[0-9a-f]_[0-7]_4
lvm_vgh04_work	39,997		
lvm_vgh04_importi_0[0-9] * lvm_vgh04_importi_1[0-1] *	1,700		

LV	Size (in GB)	VG	LU
lvm_vgh05_L_table_69 lvm_vgh05_L_table_7[0-4]	2,396	VGH05	LU_[0-9a-f]_[0-7]_5
lvm_vgh05_work	39,997		
lvm_vgh05_importi_0[0-9] * lvm_vgh05_importi_1[0-1] *	1,700		
lvm_vgh05_L_table_7[5-9]	2,396	VGH06	LU_[0-9a-f]_[0-7]_6
lvm_vgh06_work	39,997		
lvm_vgh06_adbsys	500		
lvm_vgh06_adbsys2	500		
lvm_vgh06_adbsys3	500		
lvm_vgh06_adbsys4	500		
lvm_vgh06_importi_0[0-9] * lvm_vgh06_importi_1[0-1] *	1,700		
lvm_vgh07_verification[0-7][0-9]	1.5	VGH07	LU_[0-9a-f]_[0-7]_7
lvm_vgh07_importi_[0-3][0-9] * lvm_vgh07_importi_4[0-3] *	1,700		
lvm_vgn00_dbgen_0[0-9] * lvm_vgn00_dbgen_1[0-1] *	3,604	VGN00	LU_[0-9a-f]_1[0-3]_0
lvm_vgn01_dbgen_1[2-9] * lvm_vgn01_dbgen_2[0-3] *	3,604	VGN01	LU_[0-9a-f]_1[0-3]_1
lvm_vgn02_dbgen_2[4-9] * lvm_vgn02_dbgen_3[0-5] *	3,604	VGN02	LU_[0-9a-f]_1[0-3]_2
lvm_vgn03_dbgen_3[6-9] * lvm_vgn03_dbgen_4[0-6] *	3,604	VGN03	LU_[0-9a-f]_1[0-3]_3
lvm_vgn04_dbgen_4[7-9] * lvm_vgn04_dbgen_5[0-7] *	3,604	VGN04	LU_[0-9a-f]_1[0-3]_4
lvm_vgn05_dbgen_5[8-9] * lvm_vgn05_dbgen_6[0-8] *	3,604	VGN05	LU_[0-9a-f]_1[0-3]_5
lvm_vgn06_dbgen_69 * lvm_vgn06_dbgen_7[0-9] *	3,604	VGN06	LU_[0-9a-f]_1[0-3]_6

* LVs were mounted during database load only.

Table 4.5: Assignment of LVs to TPC-H Tables and Log Files

Contents		LV/LU
OS and DBMS Software		LU_10_0_[01] (for BS2000 #1) LU_11_0_[01] (for BS2000 #2) LU_12_0_[01] (for BS2000 #3) LU_13_0_[01] (for BS2000 #4)
DB	MASTER DIRECTORY	lvm_vgh03_100K_ADBMST
	DICTIONARY	lvm_vgh03_100K_ADBDIC
	SYSTEM LOG FILE	lvm_vgh06_adbsys (for BS2000 #1) lvm_vgh06_adbsys2 (for BS2000 #2) lvm_vgh06_adbsys3 (for BS2000 #3) lvm_vgh06_adbsys4 (for BS2000 #3)
	WORK	lvm_vgh03_work (for BS2000 #1) lvm_vgh04_work (for BS2000 #2) lvm_vgh05_work (for BS2000 #3) lvm_vgh06_work (for BS2000 #4)
	LINEITEM TABLE	lvm_vgh00_L_table_0[0-9] lvm_vgh00_L_table_1[0-3] lvm_vgh01_L_table_1[4-9] lvm_vgh01_L_table_[2-3][0-9] lvm_vgh01_L_table_4[0-2] lvm_vgh02_L_table_4[3-9] lvm_vgh02_L_table_5[0-7] lvm_vgh03_L_table_5[8-9] lvm_vgh03_L_table_6[0-2] lvm_vgh04_L_table_6[3-8] lvm_vgh05_L_table_69 lvm_vgh05_L_table_7[0-4] lvm_vgh05_L_table_7[5-9]
	ORDERS TABLE	lvm_vgh01_O_table_0[0-8] lvm_vgh02_O_table_09 lvm_vgh02_O_table_[1-6][0-9] lvm_vgh02_O_table_7[0-6] lvm_vgh03_O_table_7[7-9]
	CUSTOMER TABLE	lvm_vgh03_C_table[0-7][0-9]
	PART TABLE	lvm_vgh02_P_table_[0-7][0-9]
	SUPPLIER TABLE	lvm_vgh03_S_table[0-7][0-9]
	PARTSUPP TABLE	lvm_vgh03_PS_table[0-7][0-9]
	NATION TABLE RETION TABLE	lvm_vgh03_NR_table
	LINEITEM INDEX	lvm_vgh00_index_L_O_[0-7][0-9] lvm_vgh00_index_L_P_[0-7][0-9]
	ORDERS INDEX	lvm_vgh00_index_O_O_[0-7][0-9]
	CUSTOMER INDEX	lvm_vgh00_index_C_[0-7][0-9]
	PART INDEX	lvm_vgh00_index_P_[0-7][0-9]
	SUPPLIER INDEX	lvm_vgh00_index_S_[0-7][0-9]
	PARTSUPP INDEX	lvm_vgh00_index_ps_[0-7][0-9]
	NATION INDEX RETION INDEX	lvm_vgh00_index_NR
	RANGE INDEX	lvm_vgh00_100K_RangeIndex
	TABLES for Verification	lvm_vgh07_verification[0-7][0-9]
Flat Files (input files for database load)		lvm_vgn00_dbgen_0[0-9] lvm_vgn00_dbgen_1[0-1] lvm_vgn01_dbgen_1[2-9] lvm_vgn01_dbgen_2[0-3] lvm_vgn02_dbgen_2[4-9] lvm_vgn02_dbgen_3[0-5] lvm_vgn03_dbgen_3[6-9] lvm_vgn03_dbgen_4[0-6] lvm_vgn04_dbgen_4[7-9] lvm_vgn04_dbgen_5[0-7] lvm_vgn05_dbgen_5[8-9] lvm_vgn05_dbgen_6[0-8] lvm_vgn06_dbgen_69 lvm_vgn06_dbgen_7[0-9]
Load Work (areas to put tempolary files in the loading phase only)		lvm_vgh04_importi_0[0-9] lvm_vgh04_importi_1[0-1] lvm_vgh05_importi_0[0-9] lvm_vgh05_importi_1[0-1] lvm_vgh06_importi_0[0-9] lvm_vgh06_importi_1[0-1] lvm_vgh07_importi_[0-3][0-9] lvm_vgh07_importi_4[0-3]

Note: Flat Files and Load Work were mounted during database load.

4.3. Mapping of Database Partitions/Replications

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

Neither database partitions nor replications are used.

4.4. Implementation of Data Redundancy Mechanism

Implementations may use data redundancy mechanism(s). The type of data redundancy mechanism(s) and any configuration parameters (e.g., RAID level used must be disclosed for each device).

Table 4.6 lists the storage redundancy level.

Table 4.6: Storage Redundancy Level

Items	Storage Redundancy Levels
Base Tables	Level One (RAID-10)
Auxiliary Data Structure	Level One (RAID-10)
DBMS Temporary Space	Level One (RAID-10)
OS and DBMS Software	Level One (RAID-5)
Database Log files	Level One (RAID-10)

4.5. Modifications to the DBGen

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 (see Appendix D) must be reported in the supporting files archive.

Version 2.16.0 of the DBGen package was not available at the time of testing. DBGen version 2.15.0 was used instead. The TPC did not make any modifications between the two versions. Aside from the release number, the two versions are identical.

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 139:53:08.

4.7. Database 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 Clause 4.1.3.1.

Table 4.7 lists the database storage ratio.

Table 4.7: Database Storage Ratio

Disk Type	# of Disks	Total (GB)
900GB 10Krpm SAS	1,600	1,440,000
600GB 10Krpm SAS	60	36,000
Total Space		1,476,000
Data Storage Ratio		14.76

4.8. Database Load Mechanism Detail and Illustration

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

Figure 4.1 shows the block diagram illustrating the overall process. All scripts and configurations for all the steps are included in the Supporting Files.

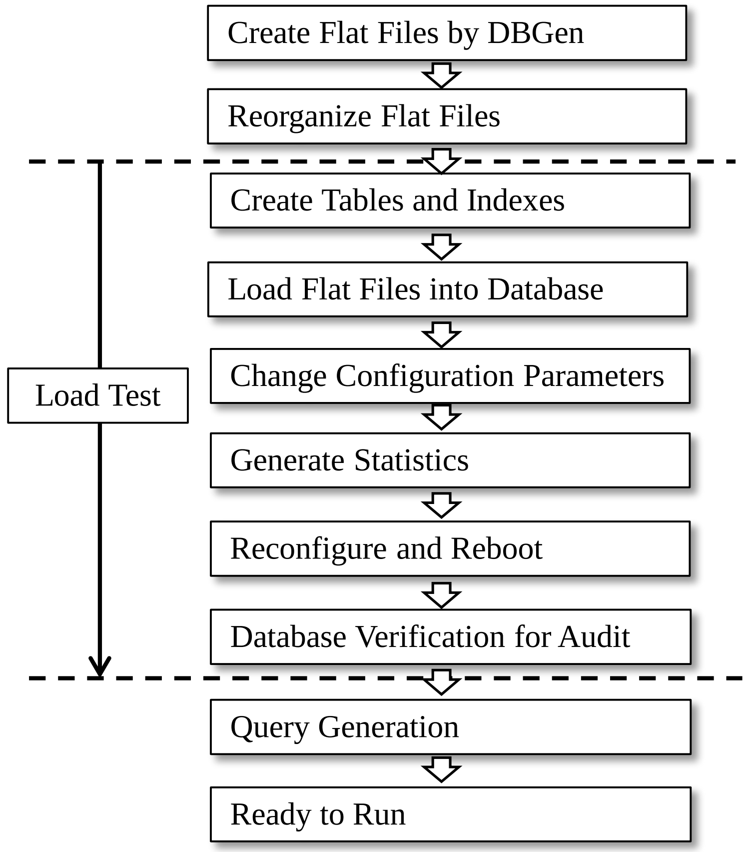


Figure 4.1: Block Diagram of Database Load Process

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 the same scripts to create and load the data with adjustments for the size difference between the test database and the qualification database.

4.10. Memory to Database Size Ratio

The memory to database size percentage must be disclosed.

The memory to database size percentage is 8.0%.

5. Clause 5 – Performance Metrics and Execution Rules Related Items

5.1. System Activity between Load and Performance Test

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 reported in the supporting files archive including listings of scripts, command logs and system activity.

TPC-H queries created during the Load Test were copied from master-node server to the client because the benchmark driver of the Performance Test was executed on the client and that of the Load Test was executed on the master-node server.

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 reported in the supporting files archive.

The following steps were used to implement power test:

1. Execution of the refresh function RF1 from the refresh stream
2. Execution of the full query set from the query stream
3. Execution of the refresh function RF2 from the refresh stream

5.3. Timing Intervals for Each Query and Refresh Functions

The timing intervals (see Clause 5.3.7) for each query and for both refresh functions must be reported for the power test. The output for each query and for both refresh functions must be reported in the supporting files archive.

The timing intervals for each query and for both refresh functions are contained in the Numerical Quantities Summary of the Executive Summary, which is located at the beginning of this document.

5.4. Number of Streams for Throughput Test

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

Eleven query 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 stream for the throughput test must be disclosed. The output for each query stream for the throughput test must be reported in the supporting files archive.

The start time and finish time for each query stream for the throughput test are contained in the Numerical Quantities Summary of Executive Summary, which is located at the beginning of this document.

5.6. Total Elapsed Time of the Measurement Interval

The total elapsed time of the measurement interval (see Clause 5.3.6) must be disclosed for the throughput test.

The total elapsed time of the measurement interval for the throughput test is contained in the Numerical Quantities Summary of Executive Summary, which is located at the beginning of this document.

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

The start time and, finish time for each refresh function in the refresh stream for the throughput test must be disclosed. The output of each refresh function in the refresh stream for the throughput test must be reported in the supporting files archive.

The start time and finish time for each refresh function in the refresh stream are contained in the Numerical Quantities Summary of the Executive Summary, which is located at the beginning of this document.

5.8. Performance Metrics

The computed performance metric, related numerical quantities and the price/performance metric must be disclosed.

The performance metric, related numerical quantities and the price/performance are contained in the Numerical Quantities Summary of the Executive Summary, which is located at the beginning of this document.

5.9. The Performance Metric and Numerical Quantities from Both Runs

The performance metric (QphH@Size) and the numerical quantities (TPC-H Power@Size and TPC-H Throughput@ Size) from both of the runs must be disclosed (see Clause 5.4).

Table 5.1 lists the performance metric and the numerical quantities from both of the runs.

Table 5.1: Performance Metric and Numerical Quantities

Run ID	TPC-H Power@100000GB	TPC-H Throughput@100000GB	QphH@100000GB
Run 1	68,301.4	106,916.4	85,454.9
Run 2	64,244.1	106,401.3	82,678.0

5.10. System Activity Between Performance Test

Any activity on the SUT that takes place between the conclusion of Run1 and the beginning of Run2 must be fully disclosed including system activity, listings of scripts or command logs along with any system reboots or database restarts.

After a successful execution of Run1, system and memory failures occurred during the execution of Run2. The first attempts at Run2 were aborted and Run2 was restarted until it completed successfully. The following activity took place between the end of Run1 and the beginning of the successful Run2:

- The execution of RF1/RF2 pairs from failed Run2 were checked to make sure that complete pairs had been fully executed.
- Failed memory boards were replaced.
- The system was rebooted and the database was restarted.

The logs for the RF1/RF2 pairs from the failed Run2 are included in the Supporting Files archive.

5.11. Documentation to satisfy Clause 5.2.7

All documentation necessary to satisfy Clause 5.2.7 must be made available upon request.

The Supporting Files archive contains the documentation.

5.12. Query Output Validation

The output of the Query Output Validation Test must be reported in the supporting files archive.

The Supporting Files archive contains the documentation.

6. Clause 6 – SUT and Driver Implementation Related Items

6.1. Driver

A detailed textual description of how the driver performs its functions, how its various components interact and any product functionalities or environmental settings on which it relies and all related source code, scripts and configuration files must be reported in the supporting files archive. The information provided should be sufficient for an independent reconstruction of the driver.

QGen is used for creating executable queries for all query streams. All queries are created in Load Test. Each query text is executed by the C program called Exec_sql (source code: Exec_sql.c) using the APIs which Hitachi Advanced Data Binder offers. The Exec_sql issues TPC-H query text to Hitachi Advanced Data Binder and receives output data from Hitachi Advanced Data Binder.

The Refresh Function 1 (RF1) is implemented as the C programs called RF_INSER_bulk (source code: RF_INSERT_bulk.c) and the Refresh Function 2 (RF2) is implemented as the C programs called RF_DELETE_bulk (source code: RF_DELETE_bulk.c). These programs use the APIs of Hitachi Advanced Data Binder.

The Power Test and The Throughput are executed from a shell script, Run_Performance.sh. The Power test operation is performed as the following steps:

1. Run_PerformceTest.sh runs another script, Run_PWT_RF.sh.
2. Run_PWT_RF.sh executes the Refresh Function 1 (RF1) program RF_INSERT_bulk.
3. When RF1 completes, Run_PerformceTest.sh runs the query execution program (Exec_sql.c), which runs 22 queries of stream 0.
4. When stream 0 completes, Run_PWT_RF.sh executes RF2 program, RF_DELETE_bulk

The Throughput Test is performed as the following steps:

1. When RF2 completes, Run_PerformceTest.sh executes Run_TPT_RF.sh.
2. Run_PerformceTest.sh runs 11 query streams concurrently.
3. When all the streams completes, Run_TPT_RF.sh run RF stream. The combination of RF1 and Rf2 is repeated 11 times.

The Supporting Files Archive contains all the scripts and the source codes.

6.2. Implementation Specific Layer

If an implementation specific layer is used, then a detailed description of how it performs its functions, how its various components interact and any product functionalities or environmental setting on which it relies must be disclosed. All related source code, scripts and configuration files must be reported in the supporting files archive. The information provided should be sufficient for an independent reconstruction of the implementation specific layer.

The queries are submitted by the driver using Hitachi Advanced Data Binder standard APIs.

6.3. Profile-Directed Optimization

If profile-directed optimization as described in Clause 5.2.9 is used, such use must be disclosed. In particular, the procedure and any scripts used to perform the optimization must be reported in the supporting files archive.

Profile-directed optimization was not used.

7. Clause 7 – Pricing

7.1. Hardware and Software Used

A detailed list of hardware and software used in the Priced Configuration must be reported. The listing for each separately Orderable item must have vendor Part Number, description and applicable release/revision level, price source, unit price, quantity, extended price, applicable Discounted price and 3-year maintenance price. If package-pricing is used, the vendor Part Number of the package and a description uniquely identifying each of the Components of the package must be disclosed to a sufficient level of detail to meet the requirements of 1.4.1.1.

The Executive Summary contains a list of hardware and software, including maintenance for 3-years.

7.2. Three-Year Price

The total 3-year price of the entire Priced Configuration must be reported, including: hardware, software, and maintenance charges. The justification of any Discounts applied must be disclosed in the price sheet. Sufficient detail of what items are being discounted and by how much they are being discounted must be provided so that the Discount amount used in the computation of the total system cost can be independently reproduced.

The Executive Summary contains all details of the total 3-year price.

7.3. Availability Date

The committed Availability Date of Components used in the price calculations must be reported. The Availability Date must be reported on the first page of the Executive Summary and with a precision of one day. When the priced system includes products with different availability dates, the reported Availability Date for the priced system must be a date at which all Components are committed to be Generally Available. Each Component used in the Priced Configuration is considered to be Available on the Availability Date unless an earlier date is specified.

Availability Dates:

Server Hardware	Now (date of publication)
Server Software	Now (date of publication)
Storage	Now (date of publication)
Database Manager (Hitachi Advanced Data Binder 01-02)	Now (date of publication)

7.4. Benchmark Performance Metric

A statement of the benchmark performance metric, as well as the respective calculations for 3-year pricing, price/performance, and the availability date must be included.

Table 7.1 lists the benchmark performance metric, price/performance metric, total 3-year cost, and availability date.

Table 7.1: Benchmark Performance Metric and Pricing

Performance Metric	Price/Performance Metric	Total 3-year Cost	Availability Date
82,678.0 QphH@100000GB	¥ 18,911.98 JPY / QphH@100000GB	¥1,563,605,024 JPY	Oct 19, 2013

8. Clause 8 – Supporting Files Index Table

An index for all files and/or directories included in the Supporting Files Archive as required by Clauses 8.3.2 through 8.3.8 must be provided in the report.

Clause	Description	Archive File	Pathname
Clause 1	OS and EFI Settings	SupportingFiles.zip	Clause1/OSandEFISettings
	Scripts of setting OS Configuration		Clause1/SetOSConfig
	DB Creation Scripts		Clause1/DBCreationScripts
	System Verification		Clause1/CONFIG_HW Clause1/CONFIG_SW
	Hitachi Advanced Data Binder Configuration		Clause1/HADBConfig
	Toolkit Environment Variables		Clause1/ToolkitEnv
	Toolkit Common Scripts		Clause1/CommonScripts
Clause 2	Queries, Query Parameters, and Seeds	SupportingFiles.zip	Clause2/RUN/ST_QUERY
	Refresh Functions		Clause2/RefreshFunction
Clause 3	ACID Test Scripts	SupportingFiles.zip	Clause3/ACIDtest
	ACID Test Results		Clause3/ATOM Clause3/CONS Clause3/ISO Clause3/DUR
Clause 4	Source codes and Scripts of Flat Files Sort and Merge	SupportingFiles.zip	Clause4/Generate
	DBGen Configuration for Porting to Hitachi Advanced Data Binder		Clause4/ModifiedSourceCode
	DB Load Scripts		Clause4/DataLoad
	DB Load Results		Clause4/DB_LOAD
	Qualification Test Results		Clause4/BEFORE_AFTER_LOAD Clause4/LOAD_QUAL_DB Clause4/VRF_OUT_DIR Clause4/VA_OUTPUT Clause4/VERIFICATION
	Database Verification Scripts		Clause4/Verification
	Database Verification Results		Clause4/DB_VRF Clause4/REF_VRF
Clause 5	Query Output Results	Run1Results_[1-12].zip Run2Results_[1-12].zip	Clause5/RUN
	Refresh Functions Outputs of Failed Run	SupportingFiles.zip	Clause5/FailedRun
	Truncate tool of Query Output Results		Clause5/Report
Clause 6	Source Codes and Scripts of Driver	SupportingFiles.zip	Clause6/PerformanceTest
Clause 7	There are no files required to be included for Clause 7.	N/A	N/A
Clause 8	There are no files required to be included for Clause 8.	N/A	N/A

9. Clause 9 – Audit Related Items

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 whom to contact in order to obtain further information regarding the audit process.

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

Benchmark Sponsor: Shinji Fujiwara
Chief Engineer
Hitachi, Ltd.
292 Yoshida-cho, Totsuka-ku,
Yokohama, 244-0817, Japan

October 15, 2013

I verified the TPC Benchmark H (TPC-H™ v2.16.0) performance of the following configuration:

Platform:	Hitachi BladeSymphony BS2000 using Hitachi Advanced Data Binder
Operating System:	Red Hat® Enterprise Linux® 6.2
Database Manager:	Hitachi Advanced Data Binder 01-02
Other Software:	n/a

The results were:

Performance Metric	**82,678.0 QphH@100,000GB**
TPC-H Power	64,244.1
TPC-H Throughput	106,401.3
Database Load Time	139:53:08

Server	**4 x Hitachi BladeSymphony BS2000**		
CPUs	4 x 8 Intel Xeon Processor E7-8870 (2.40 GHz, 24MB Cache)		
Memory	4 x 2 TB		
Disks	***Qty***	***Size***	***Type***
	1600	900 GB	SAS 10K rpm HDD
	60	600 GB	SAS 10K rpm 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:

- The database records were defined with the proper layout and size
- The database population was generated using DBGen
- The database was properly scaled to 100,000GB and populated accordingly
- The compliance of the database auxiliary data structures was verified
- The database load time was correctly measured and reported
- The required ACID properties were verified and met
- The query input variables were generated by QGen

- The query text was produced using minor modifications and no query variant
- The execution of the queries against the SF1 database produced compliant answers
- A compliant implementation specific layer was used to drive the tests
- The throughput tests involved 11 query streams
- The ratio between the longest and the shortest query was such that no query timings were adjusted
- The execution times for queries and refresh functions were correctly measured and reported
- The repeatability of the measured results was verified
- The system pricing was verified for major components and maintenance
- The major pages from the FDR were verified for accuracy

Additional Audit Notes:

> Version 2.16.0 of the DBGen package was not available at the time of testing. DBGen version 2.15.0 was used instead. The TPC did not make any modifications between the two versions. Aside from the release number, the two versions are identical. QGen 2.15.0 was used with the modifications approved by the TPC for release 2.16.0. These approved modifications were detailed in the FDR of the TPC-H result published by Oracle on June 7, 2013 for the SPARC T5-4 Server. In addition, the reference dataset for the query substitution parameters could not be verified since the 2.16.0 dataset is not available.

Respectfully Yours,

François Raab, President