Cisco Systems, Inc.

TPC Benchmark™ H Full Disclosure Report

Cisco UCS C460 M2 Rack-Mount Server

using

Microsoft SQL Server 2008 R2 Enterprise Edition

and

Windows Server 2008 R2 Enterprise Edition

First Edition

December, 2011

First Edition – December, 2011

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Abstract

This report documents the methodology and results of the TPC Benchmark© H test conducted on the Cisco UCS C460 M2 Server using Microsoft Windows Server 2008 R2 Enterprise Edition and database Microsoft SQL Server 2008 R2 Enterprise Edition.

Cisco UCS C460 M2 Server

Company Name	System Name	Database Software	Opeating System
Cisco Systems, Inc	Cisco UCS C460 M2 Server	Microsoft Windows Server 2008 R2 Enterprise Edition	Microsoft SQL Server 2008 R2 Enterprise Edition.

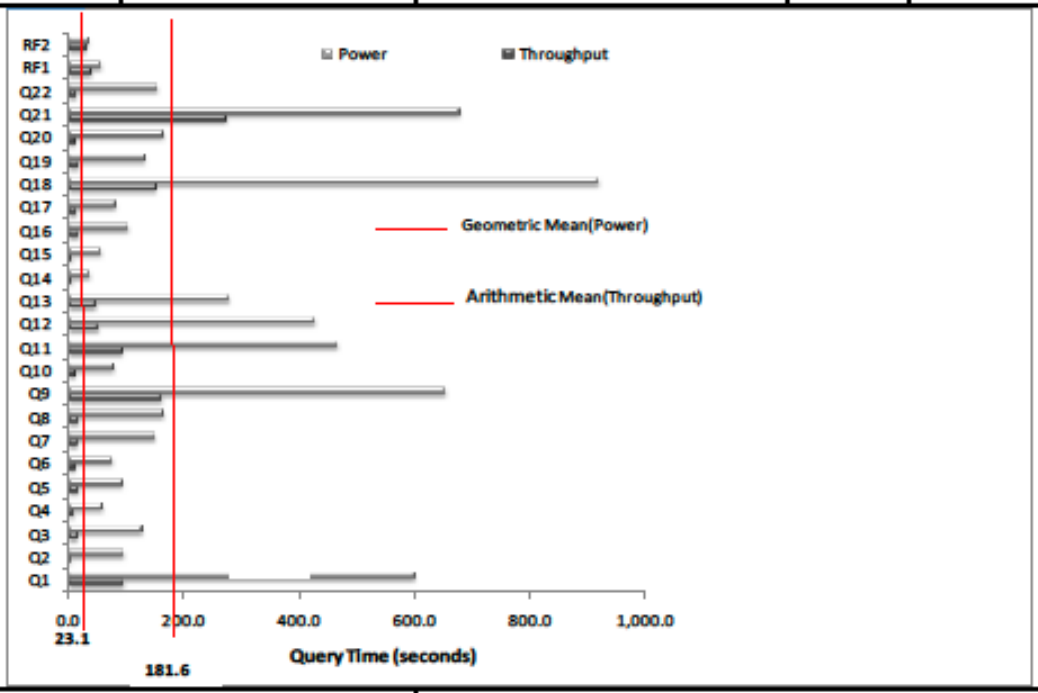
TPC Benchmark© H Metrics

Total System Cost	TPC-C Throughput	Price/Performance	Availability Date
174,325	134,117.2 QphH@1000GB	$1.30 USD $/QphH@1000GB	December 7, 2011

CISCO	**Cisco UCS C460 M2 Server**	TPC-H Rev. 2.14.2 TPC-Pricing Rev. 1.6.0 Report Date: December 7, 2011

Total System Cost	Composite Query per Hour Metric	Price / Performance
$174,325 USD	**134,117.2** QphH@1000GB	**$1.30 USD** $ / QphH@1000GB

Database Size	Database Manager	Operating System	Other Software	Availability Date
1000GB	Microsoft SQL Server 2008 R2 Enterprise Edition	Windows Server 2008 R2 Enterprise Edition		December 7, 2011



Database Load Time = 21h 04m 19s	Storage Redundancy Level	
Load Includes Backup: Y	Base Tables and Auxiliary Data Structures	0
Total Data Storage / Database Size = 8.78	DBMS Temporary Space	0
Percentage Memory / Database Size = 102 %	OS and DBMS Software	1

System Configuration:	**Cisco UCS C460 M2**
Processors:	4 x Intel Xeon E7-4870 Processor (2.4 GHz,30 MB cache, 130 W)
Memory:	1024 GB
Storage:	2 x 300GB 6 Gb SAS 10K RPM SFF HDD 10 x 600GB 6Gb SAS 10K RPM SFF HDD 10 x LSI WarpDrive SLP-300 (300GB)
Table Storage:	8.78 TB

Cisco	Cisco UCS C460 M2 Server	TPC-H Rev. 2.14.2, TPC-Pricing Rev. 1.60
		Report Date: 7-Dec-11

Description	Part Number	Brand	Source	Unit Price	Qty	Extended Price	3 yr. Maint. Price
Server Hardware							
UCS C460 M2 Rack SVR w/o CPU, Mem HDD, PCIe	UCSC-BASE-M2-C460	Cisco	1	$10,119	1	$10,119	
850W POWER SUPPLY UNIT FOR C-SERIES C460	RC460-PSU2-850W	Cisco	1	$613	2	$1,226	
2.4 GHz E7-4870 130W 10C CPU / 30M Cache	UCS-CPU-E74870	Cisco	1	$10,500	4	$42,000	
32GB DDR3-1066MHz RDIMM/PC3-8500/2x16GB 4R	A02-M332GB3-2-L	Cisco	1	$3,371	32	$107,872	
LSI CONTROLLER 9260-8i	RC460-PL001	Cisco	1	$1,113	1	$1,113	
300GB 6Gb SAS 10K RPM SFF HDD	A03-D300GA2	Cisco	1	$564	2	$1,128	
600GB 6Gb SAS 10K RPM SFF HDD	A03-D600GA2	Cisco	1	$1,367	10	$13,670	
MS Comfort Curve DT 3000 USB-EN NA Keyboard & Mouse	7ZJ-00001	Provantage	4	$25	1	$25	
V173DJb LCD Monitor	ET-BV3RP-D03	Provantage	4	$90	1	$90	
Cisco R42610 expansion rack	RACK-UCS	Cisco	1	$2,857	1	$2,857	
UCS C460 M2 Rack SVR 24x7 Hr	CON-UCWD3-C460M2	Cisco	1	$683	3		$2,049
					Subtotal	$180,100	$2,049
Storage							
LSI WarpDrive SLP-300 (10+2 spares)	LSI00263	Harwood	3	$6,565	12	$78,780	Inc.
					Subtotal	$78,780	
Hardware and Maintence Discount *							
Large Purchase discount	57.0%	Cisco	1			-$102,591	
					Hardware Subtotal	$156,289	$2,049
Software							
Microsoft SQL Server 2008 R2 Enterprise Edition w/ 25 CALs	810-08553	Microsoft	2	$8,318	1	$8,318	
SQL Server 2008 Client Access License	359-01912	Microsoft	2	$114	45	$5,130	
Microsoft Windows Server 2008 R2 Enterprise Edition	P72-03195	Microsoft	2	$2,280	1	$2,280	
Microsoft Problem Resolution Services		Microsoft	2	$259	1		259
					Subtotal	15,728	259
					Total	$172,017	$2,308

Pricing: 1=Cisco 2=Microsoft 3=Harwood 4=Provantage; *Excludes Support Services

Audited by Francois Raab of InfoSizing,Inc. www.sizing.com

All discounts are based on US list prices and for similar quantities and configurations. A 57% discount was based on the overall specific components pricing from vendor 1 in this single quotation. Discounts for similarly sized configurations will be similar to those quoted here,but may vary based on the components in the configuration.

Three-Year Cost of Ownership:	**$174,325 USD**
QphH @ 1000GB:	**134,117.2**
$ / QphH @ 1000GB:	**$1.30 USD**

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

Cisco	Cisco UCS C460 M2 Server	TPC-H Rev. 2.14.2 TPC-Pricing Rev. 1.6.0 December 7, 2011

Measurement Results

Database Scaling (SF/Size)	1,000
Total Data Storage/Database Size	8.78
Percentage Memory/Database Size	102%
Start of Database Load Time	14/08/11 19:36:22
End of Database Load Time	15/08/11 16:40:41
Database Load Time	21:04:19
Query Streams for Throughput Test (S)	7
TPC-H Power	156,157.2
TPC-H Throughput	115,188.0
TPC-H Composite	134,117.2
Total System Price Over 3 Years	174,307
TPC-H Price/Performance Metric ($/QphH@1000GB)	1.30

Measurement Interval

Measurement Interval in Throughput Test (Ts)	4,813

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
	0815164040	08/15/2011 19:43:29 08/15/2011 20:01:12	1,063	08/15/2011 19:42:48 08/15/2011 19:43:29	08/15/2011 20:01:13 08/15/2011 20:01:42

Throughput Stream	Seed	Query Start Time Query End Time	Duration (sec)	RF1 Start Time RF1 End Time	RF2 Start Time RF2 End Time
1	0815164041	08/15/2011 20:01:43 08/15/2011 21:06:47	3,905	08/15/2011 21:12:55 08/15/2011 21:13:51	08/15/2011 21:13:51 08/15/2011 21:14:22
2	0815164042	08/15/2011 20:01:43 08/15/2011 21:10:21	4,119	08/15/2011 21:14:22 08/15/2011 21:15:07	08/15/2011 21:15:08 08/15/2011 21:15:36
3	0815164043	08/15/2011 20:01:43 08/15/2011 21:06:25	3,882	08/15/2011 21:15:36 08/15/2011 21:16:18	08/15/2011 21:16:18 08/15/2011 21:16:47
4	0815164044	08/15/2011 20:01:43 08/15/2011 21:10:38	4,135	08/15/2011 21:16:48 08/15/2011 21:17:29	08/15/2011 21:17:30 08/15/2011 21:18:00
5	0815164045	08/15/2011 20:01:43 08/15/2011 21:06:07	3,864	08/15/2011 21:18:00 08/15/2011 21:18:40	08/15/2011 21:18:40 08/15/2011 21:19:12
6	0815164046	08/15/2011 20:01:43 08/15/2011 21:12:54	4,271	08/15/2011 21:19:13 08/15/2011 21:20:00	08/15/2011 21:20:00 08/15/2011 21:20:35
7	0815164047	08/15/2011 20:01:43 08/15/2011 21:04:50	3,787	08/15/2011 21:20:35 08/15/2011 21:21:22	08/15/2011 21:21:22 08/15/2011 21:21:55

TPC-H Timing Intervals (in seconds)

Duration of stream execution:

Stream ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
0	97.1	1.9	15.9	8.0	18.8	10.8	14.5	18.8	162.2	11.8	93.8	51.9
1	485.2	48.2	127.0	30.9	78.6	21.3	136.9	163.5	387.9	63.5	240.9	129.1
2	601.7	27.6	113.2	45.2	94.2	23.7	56.1	90.8	404.1	66.7	194.8	427.8
3	508.9	41.6	100.4	48.2	92.9	62.8	125.2	87.9	390.8	60.9	129.5	135.0
4	551.9	9.6	46.2	37.5	86.7	77.3	63.6	121.2	654.2	78.4	39.8	103.8
5	527.9	25.9	79.0	59.1	79.6	42.7	101.2	80.3	379.7	59.6	136.7	157.0
6	597.3	20.5	103.1	36.9	80.3	26.2	150.0	103.1	490.6	52.7	466.9	178.1
7	513.9	97.1	108.2	38.4	88.7	20.7	90.0	81.9	428.4	61.0	107.8	91.5
Minimum	97.1	1.9	15.9	8.0	18.8	10.8	14.5	18.8	162.2	11.8	39.8	51.9
Maximum	601.7	97.1	127.0	59.1	94.2	77.3	150.0	163.5	654.2	78.4	466.9	427.8
Average	485.5	34.1	86.6	38.0	77.5	35.7	92.2	93.4	412.2	56.8	176.3	159.3

Stream ID	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	RF1	RF2
0	46.7	5.2	5.2	18.5	12.0	151.7	18.5	11.9	274.3	13.4	41.2	29.6
1	119.5	23.4	28.8	76.1	39.0	780.9	133.7	79.2	636.0	75.2	56.1	30.6
2	193.9	37.2	35.1	95.0	82.1	774.6	133.4	102.9	363.2	155.4	45.0	28.4
3	206.0	22.3	38.6	93.4	64.6	708.0	68.6	164.1	674.6	57.1	41.6	28.7
4	196.3	22.0	43.4	79.8	58.2	919.7	124.7	74.7	678.6	65.1	41.7	29.9
5	213.1	26.4	34.0	86.5	40.8	759.5	98.7	104.2	639.3	132.7	39.4	32.3
6	279.5	21.4	42.0	91.7	74.5	872.6	81.4	112.4	320.6	68.8	46.8	34.9
7	224.9	17.7	56.9	102.7	44.0	887.6	97.7	108.1	464.2	55.5	46.4	33.0
Minimum	46.7	5.2	5.2	18.5	12.0	151.7	18.5	11.9	274.3	13.4	39.4	28.4
Maximum	279.5	37.2	56.9	102.7	82.1	919.7	133.7	164.1	678.6	155.4	56.1	34.9
Average	185.2	21.9	35.5	80.5	51.9	731.8	94.6	94.7	506.3	77.9	44.8	30.9

Preface

The 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 Cisco Systems, Inc. and developed and engineered in partnership with Microsoft 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 by 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

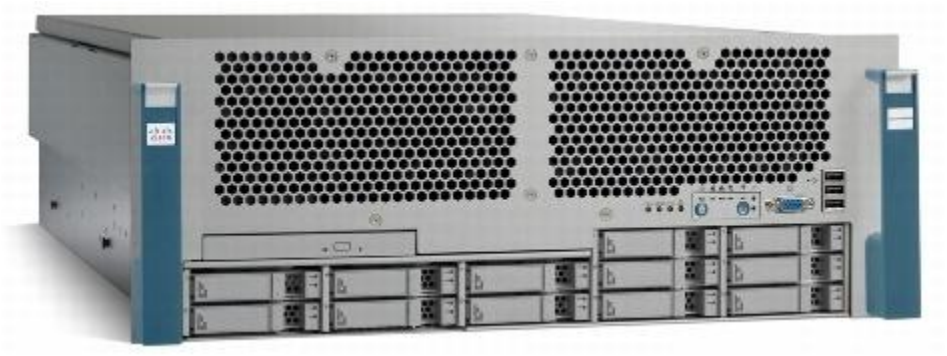
Diagrams of both measured and priced configurations must be provided, accompanied by a description of the differences. This includes, but is not limited to:

- *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 Cisco UCS C460 M2 server features:

- Intel Xeon processor E7-4800 product family
- 4-rack unit (RU) rack-mount chassis
- 64 dual in-line memory module (DIMM) slots
- Up to 12 small form-factor (SFF) optional hot-plug hard drives
- 10 x PCIe slots
- Two 1/10 Gb Ethernet LAN on Motherboard (LOM) ports, two 10/100/1000 LOM ports
- Baseboard management controller (BMC)



Both the measured and priced configurations are same and consist of a Cisco UCS C460 M2 Rack-Mount Server with:

- 4 x Intel Xeon E7-4870 Processor (2.4 GHz, 30 MB cache, 130W)
- 1024 GB of memory
- 1 x LSI MegaRAID 9260-8i RAID Controller
    - 2 x 300GB 6Gb SAS 10K RPM Small Form Factor (SFF) disk drives
    - 10 x 600GB 6Gb SAS 10K RPM Small Form Factor (SFF) disk drives
- 10 x LSI WarpDrive SLP-300 PCIe solid-state storage acceleration cards

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 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 isolation level 1.

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 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 eight 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 Transaction was started for a randomly selected O_KEY, L_KEY and DELTA. The ACID Transaction was suspended prior to Commit.
2. An ACID query was started for the same O_KEY used in step 1. The ACID query blocked and did not see any uncommitted changes made by the ACID Transaction.
3. The ACID Transaction was resumed and committed.
4. 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 transaction was started for a randomly selected O_KEY, L_KEY and DELTA. The ACID Transaction was suspended prior to Rollback.
2. 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.
3. The ACID Transaction was ROLLED BACK.

4. 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.

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 DELTA. The ACID transaction T1 was suspended prior to Commit.
2. Another ACID Transaction T2 was started using the same O_KEY and L_KEY and a randomly selected DELTA.
3. T2 waited.
4. The ACID transaction 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 the isolation of two update transactions after the first one is rolled back:

1. An ACID Transaction T1 was started for a randomly selected O_KEY, L_KEY and DELTA. The ACID Transaction T1 was suspended prior to Rollback.
2. Another ACID Transaction T2 was started using the same O_KEY and L_KEY used in step 1 and a randomly selected DELTA.
3. T2 waited.
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 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 Transaction T1 for a randomly selected O_KEY, L_KEY and DELTA. The ACID Transaction T1 was suspended prior to commit.
2. Another ACID Transaction T2 was started using random values for PS_PARTKEY and PS_SUPPKEY.
3. T2 completed.
4. T1 completed and the appropriate rows in the ORDER, LINEITEM and HISTORY tables were changed.

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. An ACID Transaction T1 was started, executing Q1 against the qualification database. The substitution parameter was chosen from the interval [0..2159] so that the query ran for a sufficient amount 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 ORDER, LINEITEM and HISTORY tables were changed.

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 were distributed across ten LSI WarpDrive SLP-300 Cards. The database log files were stored on a RAID-10 volume of ten disk drives.

A backup of the database was taken. 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 disk drive containing data tables:

1. Verified the consistency of the database and that the history table had 0 rows
2. Started 8 ACID transaction streams
3. Waited until each of the streams completed at least 100 transactions.
4. A data disk failure was by induced using a ddcli low-level utility command to format one of the WarpDrive Cards holding the database tables.
5. SQL server error log showed that one of the disks had i/o errors.
6. Streams were stopped as the transactions were failing and not able to continue.
7. The database Transaction Log was backed up.
8. SQL server was shutdown.
9. Partitions were re-created on the card which was re-formatted.
10. SQL server was restarted.
11. The database was restored from a previous backup.
12. After restoring the database backup, the Transaction Log was rolled forward.
13. Once the database was fully recovered, the count of history rows was collected and it was verified that it matched the number of transactions reported as successful by the streams.
14. The consistency of the database was verified.

These steps were performed to demonstrate that committed updates are preserved across a permanent irrecoverable failure of disk drive containing database log file:

1. Verified the consistency of the database and that the history table had 0 rows.
2. Started 8 ACID transaction streams.
3. Waited until each of the streams completed at least 100 transactions.
4. Physically pulled out one of the log disks from the RAID 10 group.

5. SQL server error log showed no i/o errors as RAID 10 is resilient to one disk failure.
6. Let each of the 8 streams complete 200 transactions.
7. Collected the count of history rows and verified that it matched the number of transactions reported as successful by the streams.
8. Verified the consistency of the database.

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.

These steps were performed to demonstrate that committed updates are preserved across a loss of all external power:

1. Verified the consistency of the database and that the history table had 0 rows.
2. Started 8 ACID transaction streams.
3. Waited until each of the streams completed at least 100 transactions.
4. Power cable was pulled out of the server's socket.
5. Machine was powered up again and power on button was pressed.
6. Operating system was rebooted.
7. As part of the boot process, SQL server process was also rebooted.
8. After the reboot, SQL server log was checked to ensure that it showed rollbacks and roll forwards of transactions.
9. After SQL server reboot is complete, post-durability step was executed.
10. Collected the count of history rows and verified that it matched the number of transactions reported as successful by the streams.
11. Verified the consistency of the database.

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	10,000,000
Customer	150,000,000
Part	200,000,000
Partsupp	800,000,000
Orders	1,500,000,000
Lineitem	5,999,989,709

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 LSI MegaRAID 9260-8i RAID Controller
  - 2 x 300GB 6Gb SAS 10K RPM SFF disk drives
  - 10 x 600GB 6Gb SAS 10K RPM SFF disk drives
- 10 x LSI WarpDrive SLP-300

The database tables and the temporary files were distributed across ten LSI WarpDrive SLP-300 Cards. Each LSI WarpDrive SLP-300 Card had twenty partitions, ten for database tables and ten for temporary files. The database log files resided on a RAID-10 array of ten 600GB 6Gb SAS 10K RPM disk drives. A detailed description of distribution of database filegroups and log can be found in Table 4.2.

Table 4.2: Disk Array to Logical Drive Mapping

Disk Drive	Storage Capacity (GB)	Interface	RAID	Type	Drive Letter	Comments
1	300	SAS	RAID-10	NTFS	C:	Operating System and database distribution
2	300	SAS				
3	600	SAS	RAID-10	NTFS	H:	Database Backup, Staging Files, Flat Files, Log Files
4	600	SAS				
5	600	SAS				
6	600	SAS				
7	600	SAS				
8	600	SAS				
9	600	SAS				
10	600	SAS				
11	600	SAS				
12	600	SAS				
PCIe Solid State Card	Storage Capacity (GB)	Interface	RAID	Type	Drive Letter	Comments
1	300	PCIe	N.A.	RAW	c:\dev \tpch1	1/8 of lineitem and order tables, 1/10 of tempdb
2	300	PCIe	N.A.	RAW	c:\dev \tpch2	1/8 of lineitem and order tables, 1/10 of tempdb
3	300	PCIe	N.A.	RAW	c:\dev \tpch3	1/8 of lineitem and order tables, 1/10 of tempdb
4	300	PCIe	N.A.	RAW	c:\dev \tpch4	1/8 of lineitem and order tables, 1/10 of tempdb
5	300	PCIe	N.A.	RAW	c:\dev \tpch5	1/8 of lineitem and order tables, 1/10 of tempdb
6	300	PCIe	N.A.	RAW	c:\dev	1/8 of lineitem

					\tpch6	and order tables, 1/10 of tempdb
7	300	PCIe	N.A.	RAW	c:\dev \tpch7	1/8 of lineitem and order tables, 1/10 of tempdb
8	300	PCIe	N.A.	RAW	c:\dev \tpch8	11/8 of lineitem and order tables, 1/10 of tempdb
9	300	PCIe	N.A.	RAW	c:\dev \tpch9	1/2 of other tables, 1/10 of tempdb
10	300	PCIe	N.A.	RAW	c:\dev \tpch10	1/2 of other tables, 1/10 of tempdb

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 database files were distributed across ten LSI WarpDrive SLP-300 Cards. The database log files resided on a RAID-10 array of ten 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 1 hours 20 minutes and 13 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

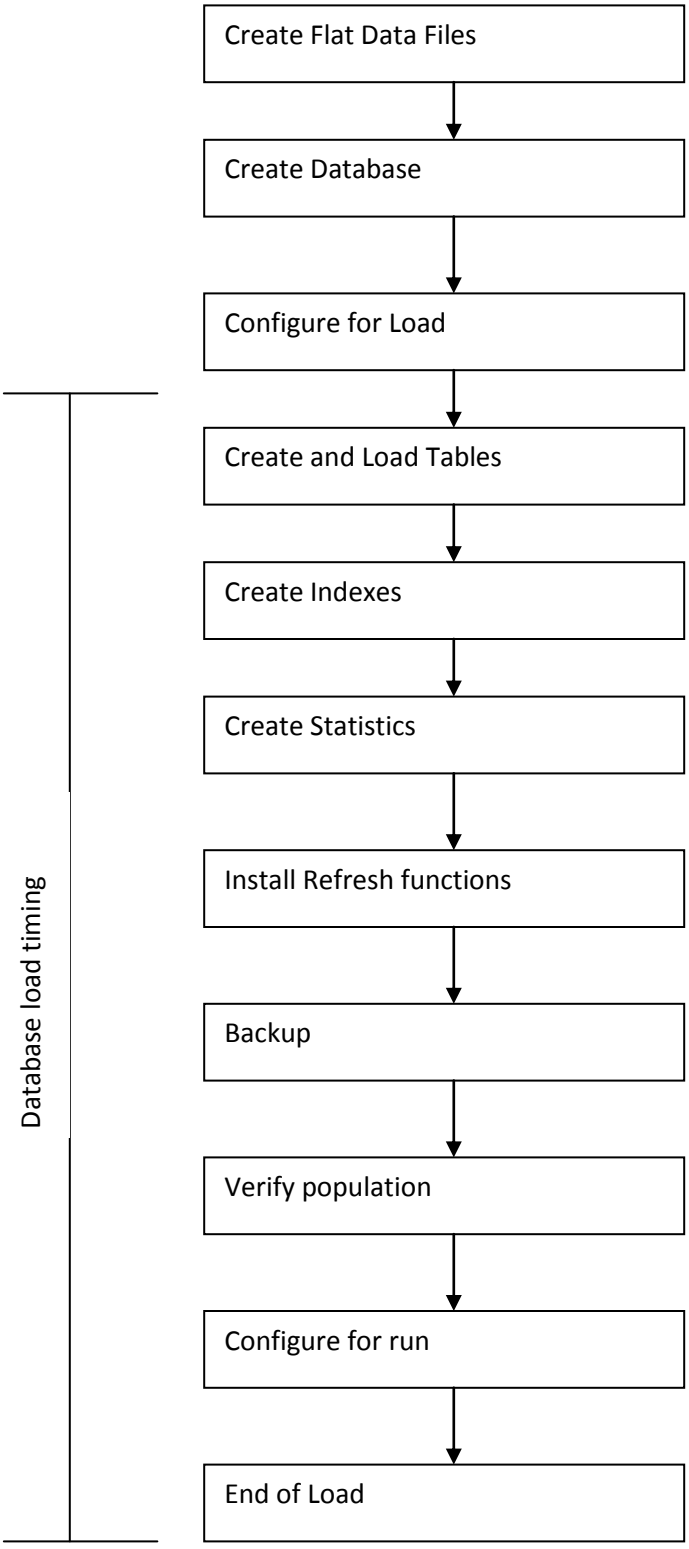
Storage Devices	Storage Capacity	Total Storage Capacity	Scale factor	Data Storage Ratio
2 x 300 GB (SAS disk drives)	600 GB	8,400 GB	1000	8.4
8 x 600 GB (SAS disk drives)	4,800 GB			
10 x 300 GB (PCIe Solid State Card)	3,000 GB			

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 102%

Clause 5: Performance Metrics and Execution Rules

5.1 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.

5.2 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.

5.3 Number of Streams for The Throughput Test

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

Seven streams were used for the Throughput Test.

5.4 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.

5.5 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.

5.6 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.

5.7 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.

5.8 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.

5.9 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 5.9: Performance Metric

Run	QppH @ 1000GB	QthH @ 1000GB	QphH @ 1000GB
Run 1	154,297.3	120,758.0	136,501.4
Run 2	156,157.2	115,188.0	134,117.2

5.10 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.

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.

Two scripts were used. The first one was used to create and load the database, while the second was used to run the Power and Throughput tests. These scripts are in Supporting files.. A C program, semaphore.c, was used for coordination of parallel processes.

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.

A command script was used to control and track the execution of queries. The scripts are contained in Supporting Files. Qgen was used to generate the query streams, along with the appropriate substitution values.
The following steps are performed, to accomplish the Power and Throughput Runs:
1. Power Run
   - Execute 40 concurrent RF1 processes, each of which will apply a segment of an update set generated by dbgen.
   - Each process submits multiple transactions, where a transaction spans a set of orders and their associated line items.
   - Execute the Stream0 queries, in the prescribed order.
   - Execute 40 concurrent RF2 processes, each of which will apply a segment of an update set generated by dbgen. Each thread submits multiple transactions, where a transaction spans a set of orders and their associated line items.
2. Throughput Run
   - Execute Seven concurrent query streams. Each stream executes queries in the prescribed order for the appropriate Stream Id (1-5). Upon completion of each stream, a semaphore is set to indicate completion.
   - Execute five consecutive RF1/RF2 transactions, against ascending Update sets produced by dbgen. The first RF1 waits on a semaphore prior to beginning its insert operations.

Each step is timed by the script. The timing information is stored in the database for later analysis. The inputs and outputs of steps are stored in text files for later analysis.

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
Clause 1	Operating System and Database settings	Clause1.zip
Clause 2	Qualification Queries and Output	Clause2.zip
Clause 3	ACID scripts and output	Clause3.zip
Clause 4	Database load scripts	Clause4.zip
Clause 5	Queries and output	Clause5.zip
Clause 6	Implementation code for measured runs	Clause6.zip
Clause 8	RFs source and parameters	Clause8.zip

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:

Francois Raab
InfoSizing, Inc.
531 Crystal Hills Blvd
Manitou Springs, CO 80829
Phone: 719-473-7555.

INFO SIZING

TPC TRANSACTION PROCESSING PERFORMANCE COUNCIL CERTIFIED AUDITOR

Benchmark Sponsor: Raghunath Nambiar
Cisco Systems Inc.
3800 Zanker Road
San Jose, CA 95134

October 24, 2011

I verified the TPC Benchmark™ H performance of the following configuration:

Platform: **Cisco UCS C460 M2**
Database Manager: **Microsoft SQL Server 2008 R2 Enterprise Edition**
Operating System: **Windows Server 2008 R2 Enterprise Edition**

The results were:

CPU (Speed)	Memory	Disks	**QphH@1000GB**
Cisco UCS C460 M2			
4 x Intel Xeon E7 4870 (2.4GHz, 10-core)	1024GB	10 x 600GB 10Krpm 10 x 300GB LSI WarpDrive 2 x 300GB 10Krpm	**134,117.2**

In my opinion, this performance result was produced in compliance with the TPC's 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 1,000GB and populated accordingly
- The compliance of the database auxiliary data structures was verified

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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 7 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:

None.

Respectfully Yours,

François Raab
President

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Microsoft

December 2, 2011

Cisco Systems, Inc.
Raghunath Nambiar
3800 Zanker Road
San Jose, CA 95134

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

All pricing shown is in US Dollars ($).

Part Number	Description	Unit Price	Quantity	Price
810-08553	**SQL Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - Level C* *Unit Price reflects a 23% discount from the retail unit price of $3,999.*	$8,318	1	$8,318
359-05354	**SQL Server Client Access License** *Open Program - Level C* *Unit Price reflects a 30% discount from the retail unit price of $114.*	$114	45	$5,130
P72-04217	**Windows Server 2008 R2 Enterprise Edition** *Server License with 25 CALs* *Open Program - Level C* *Unit Price reflects a 43% discount from the retail unit price of $3,999.*	$2,280	1	$2,280
N/A	**Microsoft Problem Resolution Services** *Professional Support* *(1 Incident).*	$259	1	$259

SQL Server 2008 R2 Enterprise Edition and Windows Server 2008 R2 Enterprise Edition are currently orderable and available through Microsoft's normal distribution channels. A list of Microsoft's resellers can be found in the Microsoft Product Information Center at **http://www.microsoft.com/products/info/render.aspx?view=22&type=how**

Defect support is included in the purchase price. Additional support is available from Microsoft PSS on an incident by incident basis at $259 call.

This quote is valid for the next 90 days.

Reference ID: TPCH_qhtplylGYLKTVUKfijhJjhiIihiKhof85757.DOC.

QUOTE

Harwood International Corporation
100 Northshore Office Park
Chattanooga, TN 37343
Ph: 423-870-5500
Ph: 800-390-2567

QUOTE NUMBER	TK-120511-1
DATE	12/5/2011
CUSTOMER ID	
EXPIRATION DATE	**2/15/2011**

TO	QUOTE PROVIDED BY
Raghunath Nambiar	Thomas Kosik
Cisco	Harwood International Corporation
rnambiar@cisco.com	tkosik@harwood-intl.com

HARWOOD CONTACT	SYSTEM	DESCRIPTION		ESTIMATED SHIP DATE	PAYMENT TERMS
Thomas Kosik	LSI WarpDrive	12x LSI00263 LSI WarpDrive 300GB		TBD	TBD

QTY	PRODUCT NUMBER	DESCRIPTION	LIST PRICE	EXT LIST	VOLUME DISCOUNT PRICE EACH	LINE TOTAL
12	LSI00263	LSI WarpDrive - 300GB	$ 13,795.00	$ 165,540.00	$ 6,565.00	$ 78,780.00

List Price Per Configuration Above	$ 165,540.00
Sale Price Per Configuration Above	**$ 78,780.00**
Quantity Required (per configuration above)	**1**
Shipping	
***Total**	**$ 78,780.00**

Quote Accepted by: _____

Date: _____

THANK YOU FOR YOUR BUSINESS!

*Unless specified above, shipping costs are not included in the final sales price.

*This quotation does not include GST/VAT/TAX. The applicable rate of GST/VAT/TAX will be applied at the time of invoicing.

*Please see terms and conditions page for further information.