



Red Hat – Industry Standard Benchmarks

Leadership TPC-H Benchmark™ Performance & Price/Performance using Red Hat Enterprise Linux 6

**Non-Clustered TPC-H
Benchmark™**

VectorWise Database

Red Hat Enterprise Linux 6

Intel Xeon based Server

Version 5.0

June 2012





**Leadership TPC-H Benchmark™
Performance & Price/Performance
using Red Hat Enterprise Linux 6**

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1. Executive Summary

The recently published TPC-H benchmark results using a VectorWise database provide Red Hat Enterprise Linux 6 with leadership performance and price/performance in the following non-clustered TPC-H scale factor categories:

1. 100 GB
2. 300 GB
3. 1 TB

The results presented in Tables 1 through 6 and Figures 3 through 8 may be found at <http://www.tpc.org/tpch/> . All results and claims are as of June 5th, 2012.

Leadership TPC-H Performance using Red Hat Enterprise Linux (RHEL) as of June 5th, 2012:

- top 4 non-clustered 100GB performance results,
- the top 3 non-clustered 300GB performance results, and
- the top 2 non-clustered 1,000GB performance result

http://www.tpc.org/tpch/results/tpch_perf_results.asp?resulttype=noncluster

Leadership TPC-H Price/Performance using Red Hat Enterprise Linux (RHEL) as of June 5th, 2012:

- top 4 non-clustered 100GB price/performance results,
- the top 3 non-clustered 300GB price/performance results, and
- the top 2 non-clustered 1,000GB price/performance result

http://www.tpc.org/tpch/results/tpch_price_perf_results.asp?resulttype=noncluster

As described in the rest of this paper, RHEL is the best platform for running Decision Support applications from a performance as well as a price/performance perspective.



2. Overview of the TPC Benchmark H: The Decision Support Benchmark

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.

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 updates 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 updates 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 updates may be executed against the database at any time, especially in relation to each other. In addition, this mix of queries and updates is subject to specific ACID (Atomicity, Consistency, Isolation, Durability) requirements, since queries and updates 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 updates.
- The minimum database required to run the benchmark holds business data from 10,000 suppliers. It contains almost ten million rows representing a raw storage capacity of about 1 GB. Compliant benchmark implementations may also use one of the larger permissible database populations (e.g. 1000 GB).
- The performance metrics reported by TPC-H measure multiple aspects of the capability of the system to process queries. The TPC-H metric at the selected size (QphH@Size) is the performance metric. 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-D 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.

2.1 The TPC-H Business Environment

Figure 7 illustrates the TPC-H business environment and highlights the basic differences between TPC-H and other TPC benchmarks.



Other TPC benchmarks model the operational end of the business environment where transactions are executed on a real time basis. The TPC-H benchmark, however, models the analysis end of the business environment where trends are computed and refined data are produced to support the making of sound business decisions. In OLTP benchmarks the raw data flow into the OLTP database from various sources where it is maintained for some period of time. In TPC-H, periodic refresh functions are performed against a DSS database whose content is queried on behalf of or by various decision makers.

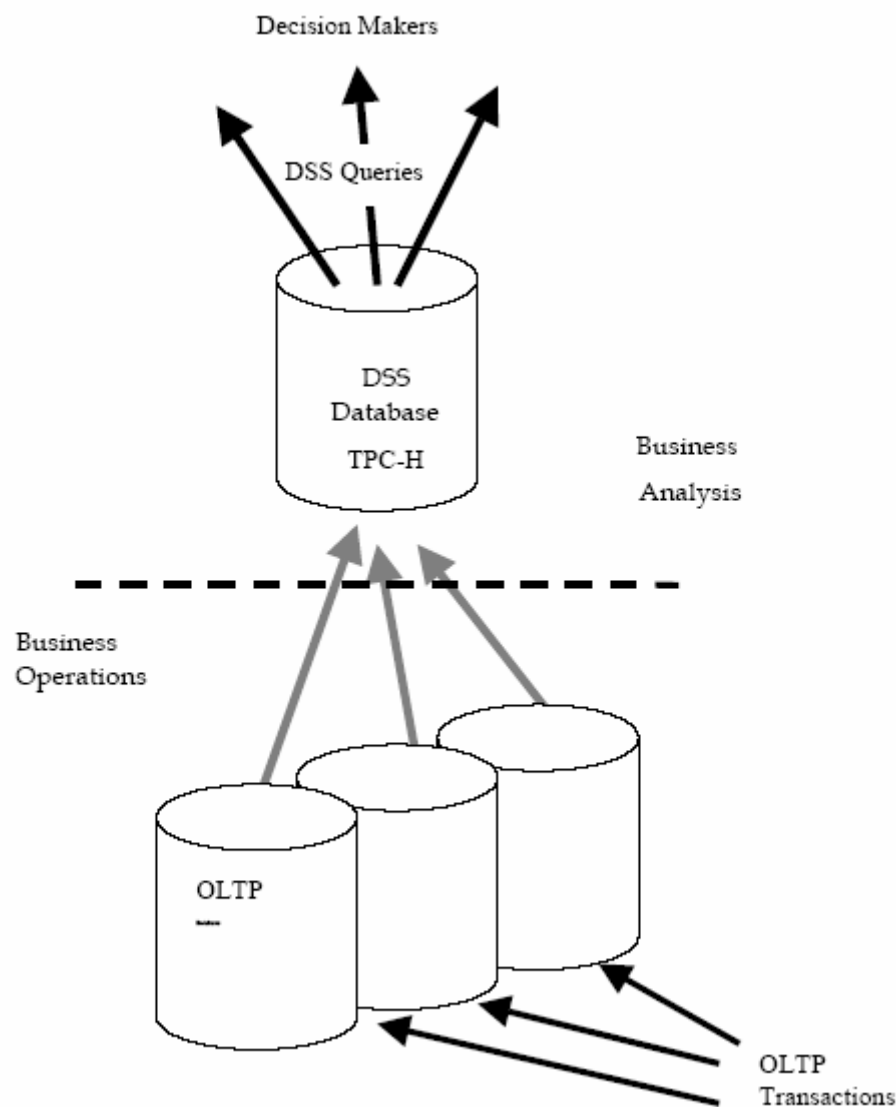


Figure 1: The TPC-H Business Environment



2.2 The TPC-H Schema

The components of the TPC-H database are defined to consist of eight separate and individual tables (the Base Tables). The relationships between columns of these tables are illustrated in Figure 8: The TPC-H Schema.

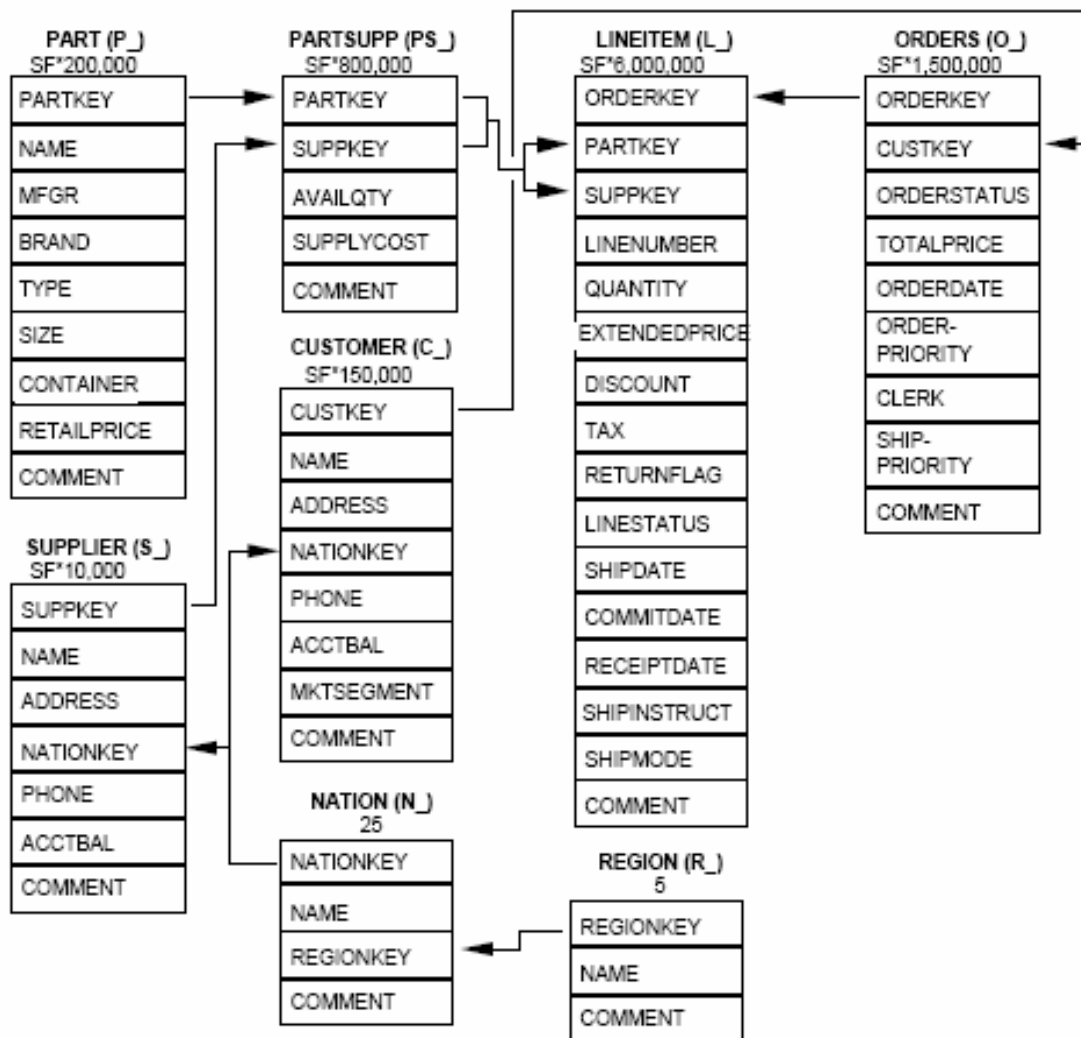


Figure 2: The TPC-H Schema



2.3 TPC-H Queries

There are 22 TPC-H 'Queries' plus 2 'Refresh Functions':

1. Pricing Summary Report Query (Q1)
This query reports the amount of business that was billed, shipped, and returned.
2. Minimum Cost Supplier Query (Q2)
This query finds which supplier should be selected to place an order for a given part in a given region.
3. Shipping Priority Query (Q3)
This query retrieves the 10 unshipped orders with the highest value.
4. Order Priority Checking Query (Q4)
This query determines how well the order priority system is working and gives an assessment of customer satisfaction.
5. Local Supplier Volume Query (Q5)
This query lists the revenue volume done through local suppliers.
6. Forecasting Revenue Change Query (Q6)
This query quantifies the amount of revenue increase that would have resulted from eliminating certain company-wide discounts in a given percentage range in a given year. Asking this type of "what if" query can be used to look for ways to increase revenues.
7. Volume Shipping Query (Q7)
This query determines the value of goods shipped between certain nations to help in the re-negotiation of shipping contracts.
8. National Market Share Query (Q8)
This query determines how the market share of a given nation within a given region has changed over two years for a given part type.
9. Product Type Profit Measure Query (Q9)
This query determines how much profit is made on a given line of parts, broken out by supplier nation and year.
10. Returned Item Reporting Query (Q10)
The query identifies customers who might be having problems with the parts that are shipped to them.
11. Important Stock Identification Query (Q11)
This query finds the most important subset of suppliers' stock in a given nation.



12. Shipping Modes and Order Priority Query (Q12)

This query determines whether selecting less expensive modes of shipping is negatively affecting the critical-priority orders by causing more parts to be received by customers after the committed date.

13. Customer Distribution Query (Q13)

This query seeks relationships between customers and the size of their orders.

14. Promotion Effect Query (Q14)

This query monitors the market response to a promotion such as TV advertisements or a special campaign.

15. Parts/Supplier Relationship Query (Q16)

This query finds out how many suppliers can supply parts with given attributes. It might be used, for example, to determine whether there is a sufficient number of suppliers for heavily ordered parts.

16. Small-Quantity-Order Revenue Query (Q17)

This query determines how much average yearly revenue would be lost if orders were no longer filled for small quantities of certain parts. This may reduce overhead expenses by concentrating sales on larger shipments.

17. Large Volume Customer Query (Q18)

The Large Volume Customer Query ranks customers based on their having placed a large quantity order. Large quantity orders are defined as those orders whose total quantity is above a certain level.

18. Discounted Revenue Query (Q19)

The Discounted Revenue Query reports the gross discounted revenue attributed to the sale of selected parts handled in a particular manner. This query is an example of code such as might be produced programmatically by a data mining tool.

19. Potential Part Promotion Query (Q20)

The Potential Part Promotion Query identifies suppliers in a particular nation having selected parts that may be candidates for a promotional offer.

20. Suppliers Who Kept Orders Waiting Query (Q21)

This query identifies certain suppliers who were not able to ship required parts in a timely manner.

21. Global Sales Opportunity Query (Q22)

The Global Sales Opportunity Query identifies geographies where there are customers who may be likely to make a purchase.

22. New Sales Refresh Function (RF1)

This refresh function adds new sales information to the database.



23. Old Sales Refresh Function (RF2)

This refresh function removes old sales information from the database.



3. TPC-H Methodology & Metrics

TPC-H is a benchmark that simulates a Decision Support System or Business Intelligence database environment. The performance of a system is measured when the system is tasked with providing answers for business analyses on a dataset. These analyses include:

- Pricing & Promotions Analysis
- Supply & Demand Management Analysis
- Profit & Revenue Management Analysis
- Customer Satisfaction Studies
- Market Share Studies
- Shipping Management Analysis

The server system runs a read-intensive Decision Support System (DSS) style database to provide the results for the business analyses. The DSS database is designed to mimic a repository of commercial order-processing Online Transaction Processing Databases. The analyses are performed on 100GB, 300GB, 1000GB, 10,000GB, 30,000GB or even 100,000GB scale factor (=size) datasets.

3.1 TPC-H Runs

The business analysis workload of the TPC-H consists of “ad-hoc” database queries with a high degree of complexity. The intention is that the exact queries are not known beforehand, which is often the case for DSS databases.

The TPC-H benchmark runs the business analyses in two different ways – it performs a Power Test and a Throughput Test.

3.1.1 TPC-H Power Test

The **TPC-H Power Test** workload performs significant sequential disk I/O as the single user’s queries perform index and table scans over the substantial datasets. The DSS database’s query optimizer typically splits the query into a number of parts and runs them in parallel, distributing the data retrieval across the disk arrays attached to the server system. The workload generally consists of read activity, though there are bursts of database inserts and updates performed during queries called “refresh functions”, which simulate OLTP databases periodically feeding data into the DSS system. There is typically a considerable amount of tempdb activity as the results of complex joins, aggregations and interim results are stored for the business analyses.

The TPC-H Power Test measures the query execution power of the system when connected with a single user. It runs the analyses in a serial manner – the queries and update functions



run one at a time and the elapsed time is measured. This test yields the **TPC-H Power @ Size metric**.

3.1.2 TPC-H Throughput Test

The **TPC-H Throughput Test** is essentially several instances of the Power Test being run simultaneously using different query parameters. This results in database buffer cache contention in system memory as the various streams compete for buffer space. The sequential read activity tends to become more random as the multiple streams access the disk drives simultaneously. The processors on the system also become busier from running more processes and switching tasks.

The TPC-H Throughput Test measures the ability of the system to process the most queries (and update functions) in the least amount of time in a multi-user environment. Each simulated user runs its own version of the TPC-H Power Test simultaneously. The number of simulated users for this test is selectable with a minimum number of users or “streams” detailed by the TPC-H specification for each scale factor. This test yields the **TPC-H Throughput @ Size metric**.

3.2 TPC-H Performance Metric

The primary performance metric for the TPC-H benchmark is the Composite Queries-Per-Hour (QphH). Composite Queries Per Hour (QphH) is calculated as a geometric mean from the results from the TPC-H Power Test and the TPC-H Throughput Test. The more QphH, the better the benchmark result. As per TPC rules, QphH is always represented as TPC-H **QphH @ Size**.

$$QphH@Size = \sqrt{Power@Size * Throughput@Size}$$

3.3 TPC-H Price/Performance Metric

TPC-H also has a pricing component, which is the total cost of the benchmark system (hardware and software) including 3 years worth of 24x7 4-hour response time support, divided by the Composite Queries Per Hour (ie price/performance). This is represented as **TPC-H \$(currency) / QphH @ Size**. The lower the price/performance, the more cost effective the system.



3.4 Comparing TPC-H Results

When comparing TPC-H results, be sure to compare results of the same scale factor. For example, comparing a system that ran 19323QphH@100GB with a system that ran 12,225QphH@300GB is not a fair comparison, whereas comparing a system that ran 102,375 QphH@1TB with a system that ran 81,515 QphH@1TB is.







- The overall TPC-H performance of a group of systems may be compared using the TPC-H Composite Queries-Per-Hour (QphH) metric.
- The price/performance of a group of systems may be compared using the \$/QphH metric.
- The system power of a single user may be compared using the TPC-H Power metric.
- The throughput and ability to process the most queries in the shortest amount of time may be compared using the TPC-H Throughput metric.

All published TPC-H results are stored on the TPC website at <http://www.tpc.org>. When making comparisons, it is useful to download the 3-4 page benchmark Executive Summary rather than try to wade through the more detailed Full Disclosure Report. The Executive Summary will include the price/performance, QphH, TPC-H Power, and TPC-H Throughput metrics, along with a full price sheet including all of the hardware and software used in the benchmark.



4. RHEL: Top Non-Clustered TPC-H Performance

4.1 100 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R720	403,230	.12 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	05/13/12
2		Cisco UCS C250 M2 Extended-Memory Server	332,481	.15 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.0	02/14/12
3		Dell PowerEdge R610 using VectorWise	303,289	.16 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/23/11
4		HP ProLiant DL380 G7	251,561	.38 USD	VectorWise 1.5	RedHat Enterprise Linux.6.0	02/09/11
5		HP ProLiant DL380 G7	73,974	.58 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	07/02/10
6		HP ProLiant DL385 G7	71,438	.51 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	07/14/10
7		Sun Fire X4270	53,501	1.14 USD	Sybase IQ Single Application Server Edition v.15.1 ESD #1	Sun Solaris 10	12/04/09
8		HP ProLiant DL380 G6	51,422	1.07 USD	Microsoft SQL Server 2008	Microsoft Windows Server 2008	08/27/09





					Enterprise x64 Edt SP1	Enterprise x64 Edt SP2	
9		HP ProLiant DL380 G6	51,085	1.09 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP2	09/04/09
10		HP ProLiant DL380 G6	50,738	1.79 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP2	10/07/09

Table 1: TPC-H (100GB) Top Ten in Performance

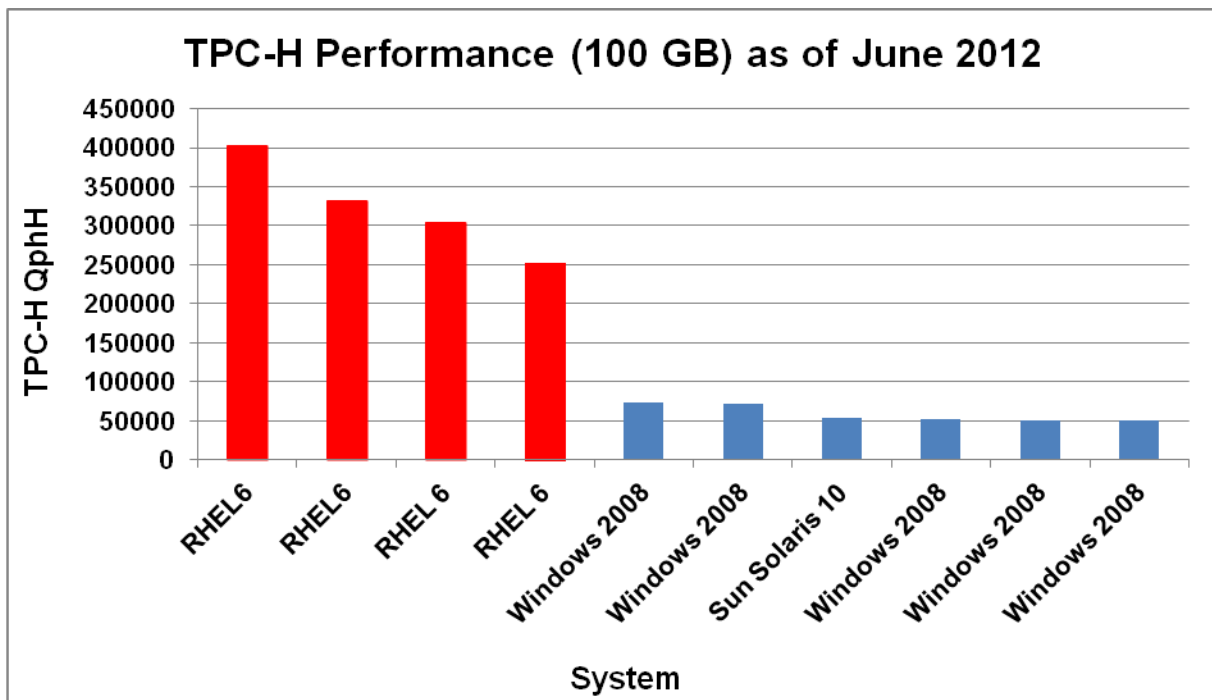










Figure 3: TPC-H (100 GB) Top Ten in Performance



4.2 300 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R720	410,594	.28 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	05/13/12
2		Dell PowerEdge R910 using VectorWise 1.6	400,931	.35 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/03/11
3		Cisco UCS C250 M2 Extended-Memory Server	331,658	.34 USD	VectorWise	RedHat Enterprise Linux.6.0	02/13/12
4		HP ProLiant DL580 G7	121,345	.65 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	09/14/10
5		HP ProLiant DL585 G7	107,561	1.08 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	06/21/10
6		HP ProLiant DL785 G6	91,558	1.94 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP1	07/31/09
7		HP ProLiant DL785	57,684	3.24 USD	Microsoft SQL Server 2008 Enterprise x64 Edition	Microsoft Windows Server 2008 Enterprise x64 Edition	11/17/08
8		IBM System x3950 M2	46,034	5.40 USD	Microsoft SQL Server	Microsoft Windows Server	11/28/07





					2005 Enterprise Edt (x64)	2003 Enterprise x64 Ent. R2	
9		HP ProLiant DL585 G2	18,298	13.67 USD	Microsoft SQL Server 2005 Enterprise Edt (x64)	Microsoft Windows Server 2003 Enterprise x64 Edition	10/31/06
10		HP ProLiant DL585 G1 4P	12,225	11.71 USD	Microsoft SQL Server 2005 Enterprise Edt (x64)	Microsoft Windows Server 2003 Enterprise x64 Edition	01/26/06

Table 2: TPC-H (300GB) Top Ten in Performance

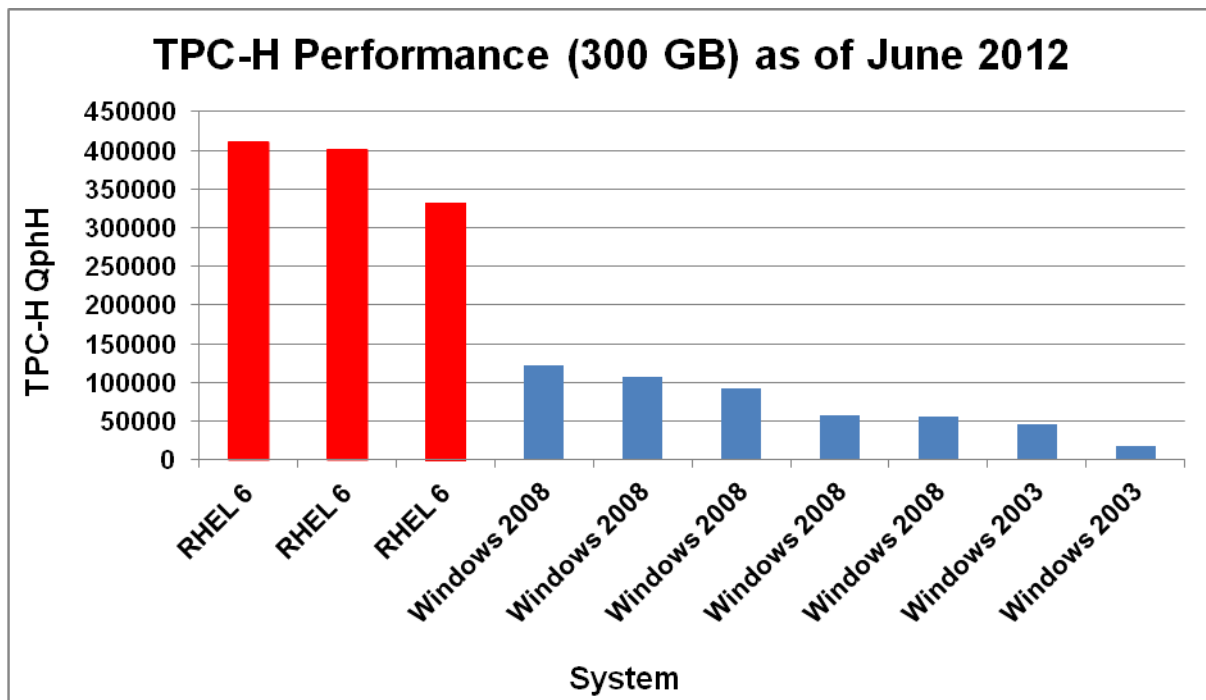









Figure 4: TPC-H (300 GB) Top Ten in Performance



4.3 1,000 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R820	445,529	.75 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	06/01/12
2		Dell PowerEdge R910 using VectorWise 1.6	436,788	.88 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/03/11
3		HP ProLiant DL980 G7	219,887	1.86 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	08/30/11
4		SPARC Enterprise M8000 Server	209,533	9.53 USD	Oracle Database 11g R2 Enterprise Edition with Partitioning	Oracle Solaris 10	06/03/11
5		SPARC T4-4 Server	201,487	4.60 USD	Oracle Database 11g Release 2 Enterprise Edition with Partitioning	Oracle Solaris 10 8/11	09/26/11
6		IBM System x3850 X5 8P	173,961	1.37 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	04/05/11
7		IBM Power 780 Model 9179-MHB	164,747	6.85 USD	Sybase IQ Single Application Server v.15.2 ESD#2	Red Hat Enterprise Linux 6 for Power	12/15/10






8		HP Integrity Superdome 2	140,181	12.15 USD	Oracle Database 11g Release 2 Enterprise Edt.	HP-UX 11i v3	04/26/10
9		Cisco UCS C460 M2 Server	134,117	1.30 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	12/07/11
10		HP Integrity Superdome-Dual-Core Itanium	123,323	20.54 USD	Oracle Database 11g Enterprise Edition	HP-UX 11.i v3 64 bit	04/29/09

Table 3: TPC-H (1,000GB) Top Ten in Performance

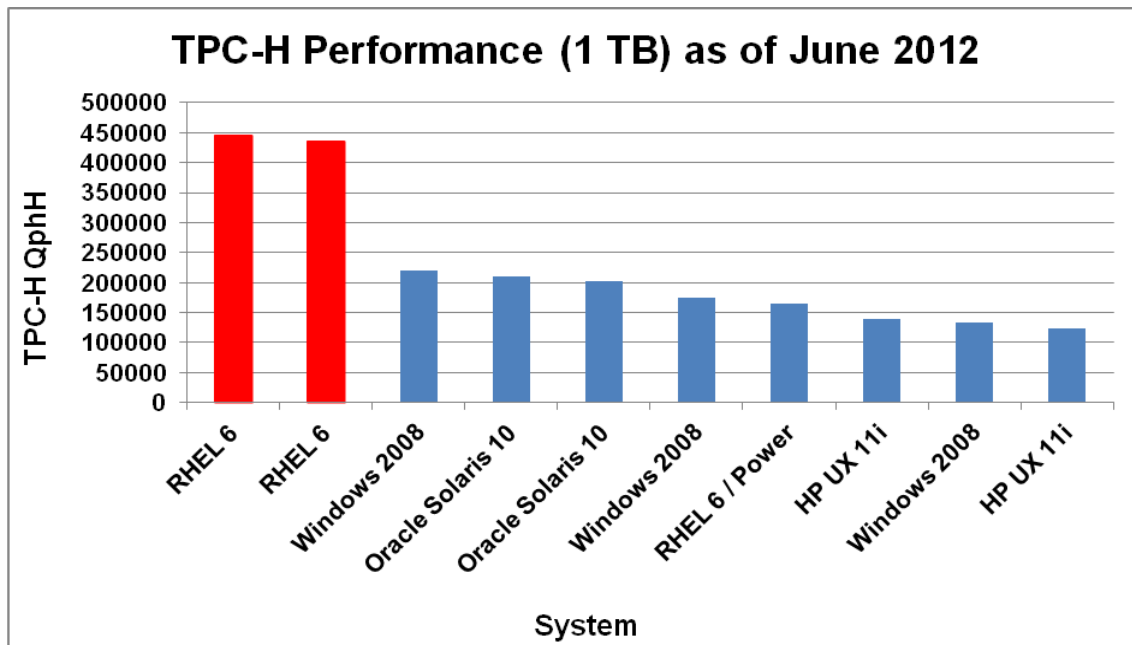









Figure 5: TPC-H (1,000 GB) Top Ten in Performance



5. RHEL: Top TPC-H Non-Clustered Price/Performance

5.1 100 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R720	403,230	.12 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	05/13/12
2		Cisco UCS C250 M2 Extended-Memory Server	332,481	0.15 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.0	02/14/12
3		Dell PowerEdge R610 using VectorWise	303,289	0.16 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/23/11
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7		HP ProLiant DL380 G6	51,422	1.07 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP2	08/27/09






8		HP ProLiant DL380 G6	51,085	1.09 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP2	09/04/09
9		Sun Fire X4270	53,501	1.14 USD	Sybase IQ Single Application Server Edition v.15.1 ESD #1	Sun Solaris 10	12/04/09
10		PowerEdge T610	28,772	1.46 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP1	06/02/09

Table 4: TPC-H (100GB) Top Ten in Price/Performance

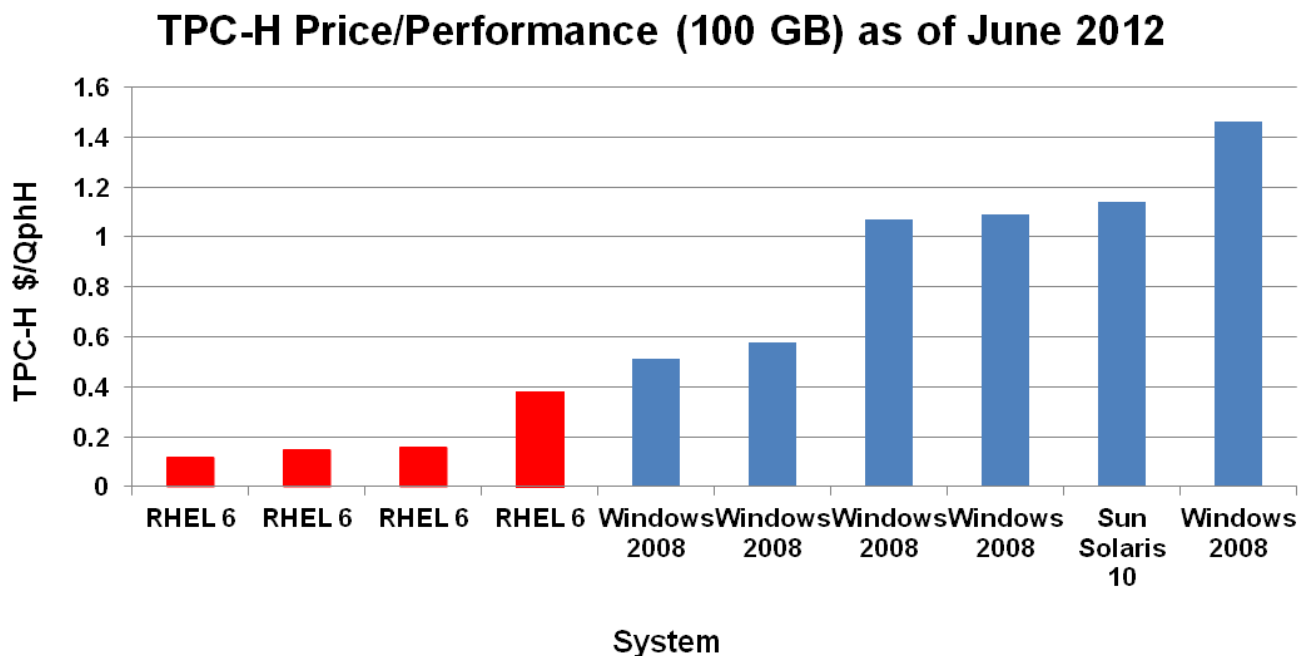










Figure 6: TPC-H (100 GB) Top Ten in Price/Performance



5.2 300 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R720	410,594	.28 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	05/13/12
2		Cisco UCS C250 M2 Extended-Memory Server	331,658	0.34 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.0	02/13/12
3		Dell PowerEdge R910 using VectorWise 1.6	400,931	0.35 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/03/11
4		HP ProLiant DL580 G7	121,345	0.65 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	09/14/10
5		HP ProLiant DL585 G7	107,561	1.08 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	06/21/10
6		HP ProLiant DL785 G6	91,558	1.94 USD	Microsoft SQL Server 2008 Enterprise x64 Edt SP1	Microsoft Windows Server 2008 Enterprise x64 Edt SP1	07/31/09
7		HP ProLiant DL785	57,684	3.24 USD	Microsoft SQL Server 2008 Enterprise x64 Edition	Microsoft Windows Server 2008 Enterprise x64 Edition	11/17/08
8		IBM System x3950 M2	46,034	5.40 USD	Microsoft SQL Server	Microsoft Windows Server	11/28/07





					2005 Enterprise Edt (x64)	2003 Enterprise x64 Ent. R2	
9		HP ProLiant DL585 G1 4P	12,225	11.71 USD	Microsoft SQL Server 2005 Enterprise Edt (x64)	Microsoft Windows Server 2003 Enterprise x64 Edition	01/26/06
10		HP ProLiant DL585 G2	18,298	13.67 USD	Microsoft SQL Server 2005 Enterprise Edt (x64)	Microsoft Windows Server 2003 Enterprise x64 Edition	10/31/06

Table 5: TPC-H (300GB) Top Ten in Price/Performance

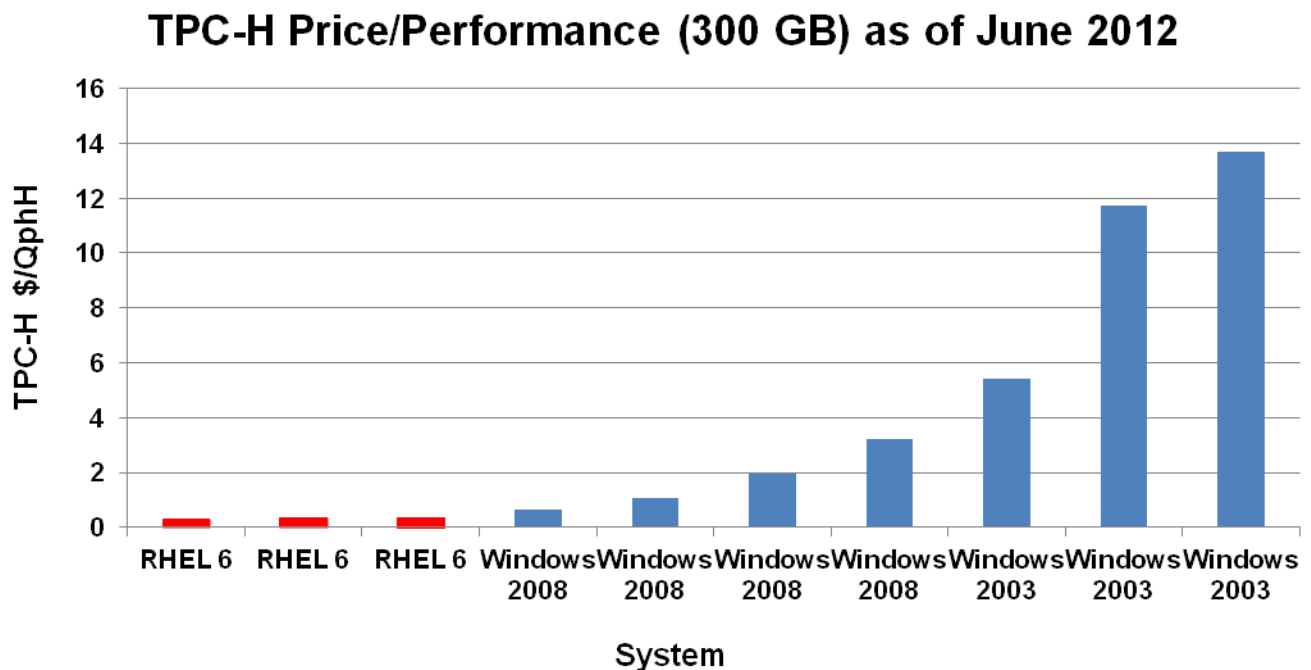










Figure 7: TPC-H (300 GB) Top Ten in Price/Performance



5.3 1,000 GB Results

Rank	Company	System	QphH	Price/QphH	Database	Operating System	Date Submitted
1		Dell PowerEdge R820	445,529	0.75 USD	VectorWise 2.0.1	RedHat Enterprise Linux.6.1	06/01/12
2		Dell PowerEdge R910 using VectorWise 1.6	436,788	0.88 USD	VectorWise 1.6	RedHat Enterprise Linux.6.0	05/03/11
3		Cisco UCS C460 M2 Server	134,117	1.30 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	12/07/11
4		IBM System x3850 X5 8P	173,961	1.37 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	04/05/11
5		IBM System x3850 X5 with IBM MAX5 for System x	101,719	1.76 USD	Microsoft SQL Server 2008 R2 Enterprise x64 Edition	Microsoft Windows Server 2008 Enterprise Ed x64 R2	03/03/11
6		HP ProLiant DL980 G7	219,887	1.86 USD	Microsoft SQL Server 2008 R2 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	08/30/11
7		HP ProLiant DL785 G6	81,514	2.90 USD	Microsoft SQL Server 2008 Enterprise Edition	Microsoft Windows Server 2008 R2 Enterprise Edition	11/09/09
8		HP ProLiant DL785 G6	102,375	3.63 USD	Sybase IQ Single Application	Red Hat Enterprise Linux 5.3	02/01/10



					Server Edition v.15.1 ESD #1		
9	ORACLE	SPARC T4-4 Server	201,487	4.60 USD	Oracle Database 11g Release 2 Enterprise Edition with Partitioning	Oracle Solaris 10 8/11	09/26/11
10	IBM	IBM Power 780 Model 9179-MHB	164,747	6.85 USD	Sybase IQ Single Application Server v.15.2 ESD#2	Red Hat Enterprise Linux 6 for Power	12/15/10

Table 6: TPC-H (1,000GB) Top Ten in Price/Performance

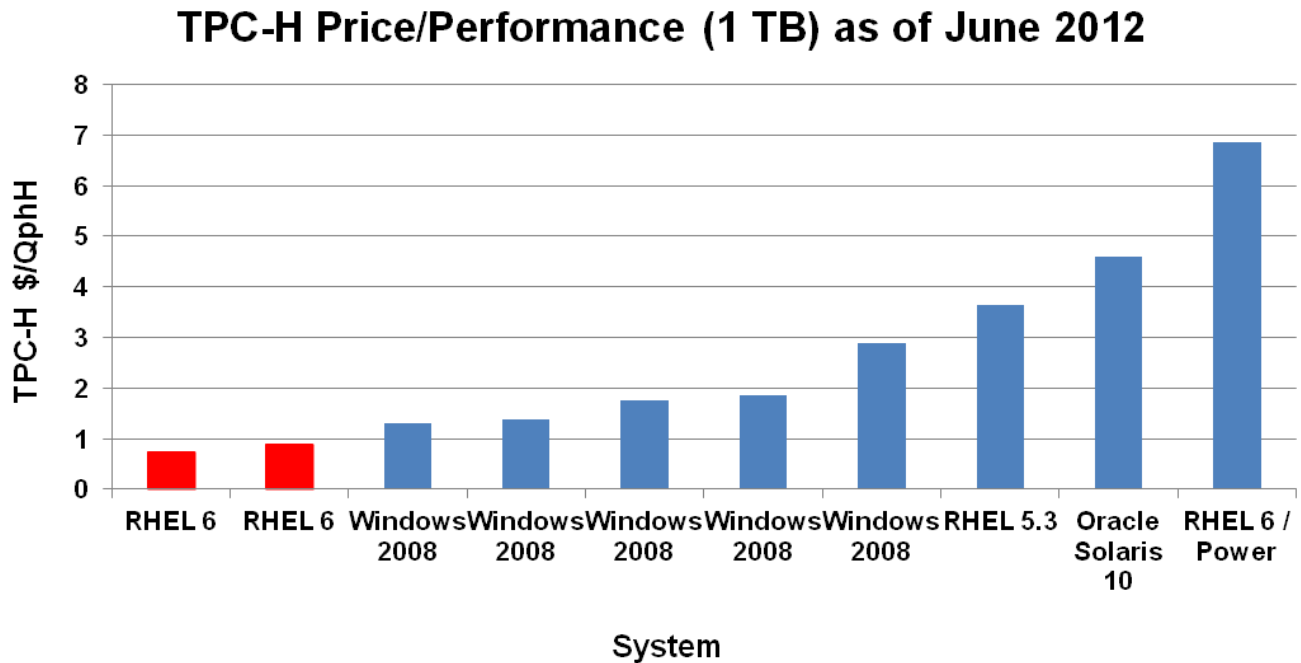


Figure 8: TPC-H (1,000 GB) Top Ten in Price/Performance



6. 100 GB TPC-H Performance-Leadership Run

6.1 System Configuration

Number of Nodes	1 x Dell PowerEdge R720
Processors/Cores/Threads/Type	2/16/16/Intel Xeon Processor E5-2690 2.90GHz
Memory	192 GB
Disk Controller	PERC H710P integrated RAID controller with 1GB NVRAM
Disk Drives	16 x 146GB 15K RPM SAS 6G
Total Disk Storage	2.336 TB
LAN Controller	Intel Ethernet I350 QP 1Gb Network Daughter Card
Database	VectorWise 2.0.1
Operating System	RedHat Enterprise Linux 6.1

6.2 Parameter Settings

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

1. Database Tuning Options
2. Optimizer/Query execution options
3. Query processing tool/language configuration parameters
4. Recovery/commit options
5. Consistency/locking options
6. Operating system and configuration parameters
7. Configuration parameters and options for any other software component incorporated into the pricing structure
8. Compiler optimization options

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

Refer to:

http://www.tpc.org/tpch/results/tpch_result_detail.asp?id=112051301

http://www.tpc.org/results/individual_results/Dell/DELL-R720-TPCH-100GB-051312-ES.pdf

<http://www.tpc.org/results/fdr/tpch/DELL-R720-TPCH-100GB-051312-FDR.pdf>

for detailed settings.



6.3 Benchmark Results

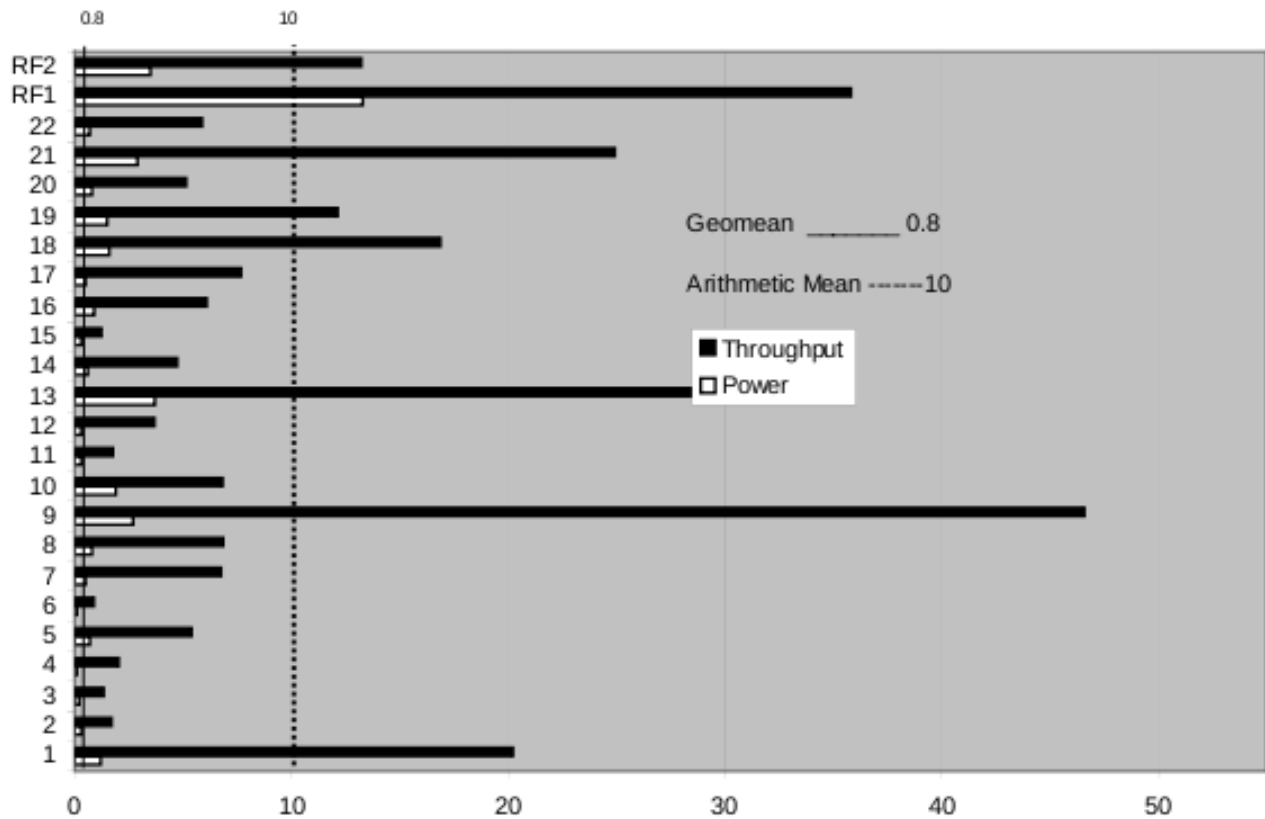


Figure 9: Query Time (Seconds) – Power & Throughput Tests (100 GB Run)



Measurement Results

Database Scaling (SF/size)	100 GB
Total Data Storage/Database Size	23.36
Memory/Database Size Percentage	192.00%
Start of Database Load Time	4/5/12 0:10:23
End of Database Load Time	4/5/12 2:21:56
Database Load Time	2:11:33
Query Streams for Throughput Test (S)	11
TPC-H Power	448,702.6
TPC-H Throughput	362,365.9
TPC-H Composite Query-per-Hour Metric (QphH@100GB)	403,230.1
Total System Price Over 3 Years (\$)	\$48,381 USD
TPC-H Price/Performance Metric (\$/QphH@100GB)	\$0.12 USD

Measurement Intervals

Measurement Interval in Throughput Test (Ts)	240.42
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7. 300 GB TPC-H Performance-Leadership Run

7.1 System Configuration

Number of Nodes	1 x Dell PowerEdge R720
Processors/Cores/Threads/Type	2/16/16/Intel Xeon Processor E5-2690 2.90GHz
Memory	384 GB
Disk Controller	PERC H710P integrated RAID controller with 1GB NVRAM
Disk Drives	16 x 146GB 15K RPM SAS 6G
Total Disk Storage	2336 GB
LAN Controllers	Intel Ethernet I350 QP 1Gb Network Daughter Card
Database	VectorWise 2.0.1
Operating System	RedHat Enterprise Linux 6.1

7.2 Parameter Settings

Settings must be provided for all customer-tunable parameters and options which have been changed

from the defaults found in actual products, including but not limited to:

1. Database Tuning Options
2. Optimizer/Query execution options
3. Query processing tool/language configuration parameters
4. Recovery/commit options
5. Consistency/locking options
6. Operating system and configuration parameters
7. Configuration parameters and options for any other software component incorporated into the pricing structure
8. Compiler optimization options

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

Refer to:

http://www.tpc.org/tpch/results/tpch_result_detail.asp?id=112051302

http://www.tpc.org/results/individual_results/Dell/DELL-R720-TPCH-300GB-051312-ES.pdf

<http://www.tpc.org/results/fdr/tpch/DELL-R720-TPCH-300GB-051312-FDR.pdf>

for detailed settings.



7.3 Benchmark Results

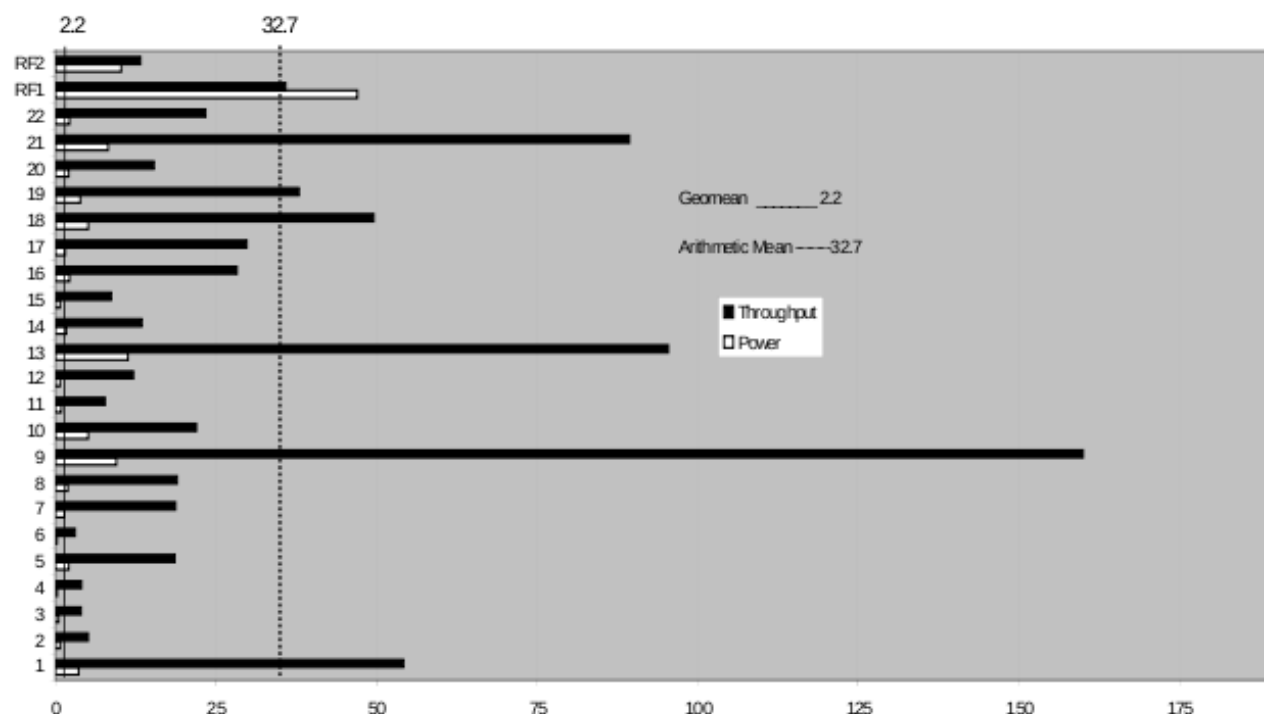


Figure 10: Query Time (Seconds) – Power & Throughput Tests (300 GB Run)



Measurement Results

Database Scaling (SF/size)	300 GB
Total Data Storage/Database Size	7.78
Memory/Database Size Percentage	128%
Start of Database Load Time	4/14/12 20:09:25
End of Database Load Time	4/15/12 2:26:45
Database Load Time	6:17:20
Query Streams for Throughput Test (S)	11
TPC-H Power	486,359.8
TPC-H Throughput	346,631.3
TPC-H Composite Query-per-Hour Metric (QphH@100GB)	410,594.1
Total System Price Over 3 Years (\$)	\$111,904
TPC-H Price/Performance Metric (\$/QphH@100GB)	\$0.28

Measurement Intervals

Measurement Interval in Throughput Test (Ts)	754
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8. 1 TB TPC-H Performance-Leadership Run

8.1 System Configuration

Number of Nodes	1 x Dell PowerEdge R820
Processors/Cores/Threads/Type	4/32/32/Intel Xeon E5-4650 2.70 GHz, 24 MB L3 Cache
Memory	768 GB
Disk Controller	PERC H710 Adapter RAID controller with 512MB NVRAM
Disk Drives	8 x 300GB 15K RPM SAS 6G
Total Disk Storage	2400 GB
LAN Controllers	Intel Ethernet I350 QP 1Gb Network Daughter Card
Database	VectorWise 2.0.1
Operating System	RedHat Enterprise Linux 6.1

8.2 Parameter Settings

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

1. Database Tuning Options
2. Optimizer/Query execution options
3. Query processing tool/language configuration parameters
4. Recovery/commit options
5. Consistency/locking options
6. Operating system and configuration parameters
7. Configuration parameters and options for any other software component
8. incorporated into the pricing structure
9. Compiler optimization options.

Refer to:

http://www.tpc.org/tpch/results/tpch_result_detail.asp?id=112060401

http://www.tpc.org/results/individual_results/Dell/DELL-R820-TPCH-1000GB-060112-ES.pdf

<http://www.tpc.org/results/fdr/tpch/DELL-R820-TPCH-1000GB-060112-FDR.pdf>

for detailed settings.



8.3 Benchmark Results

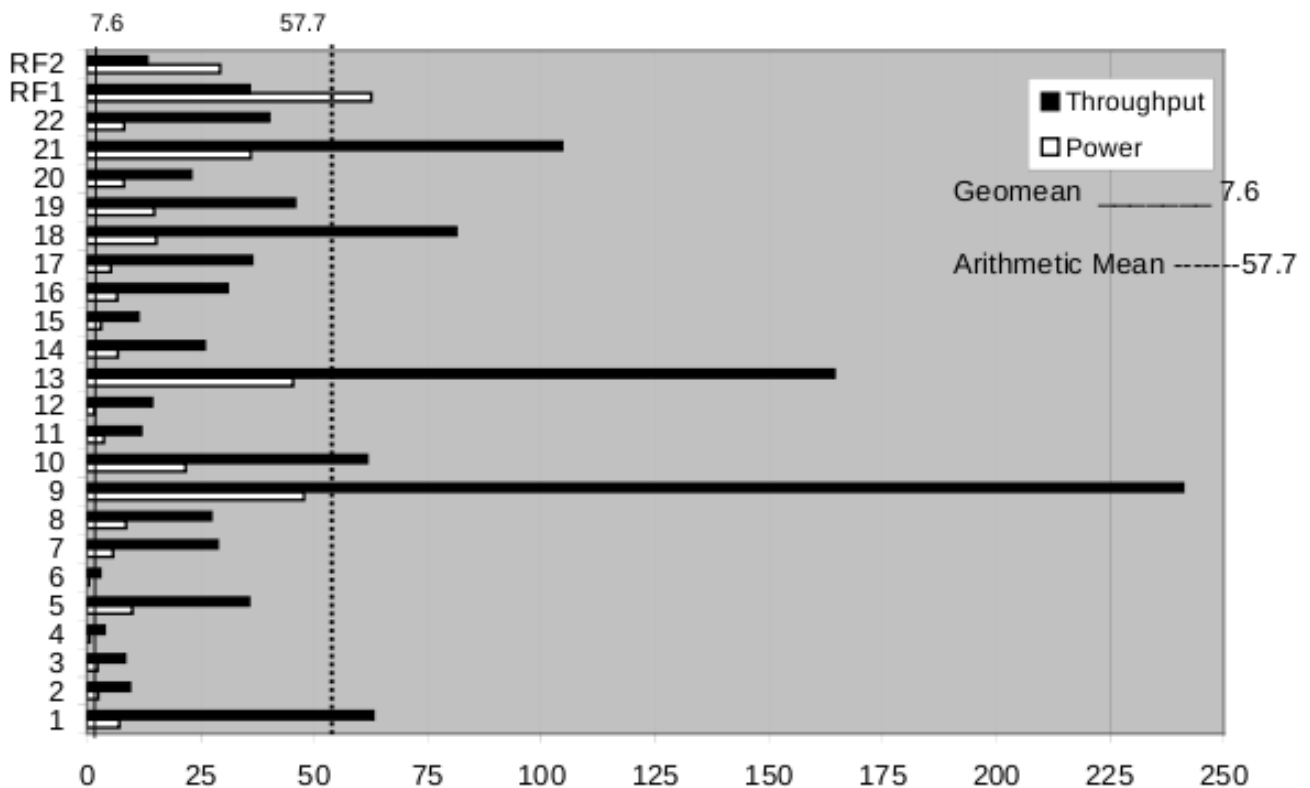


Figure 11: Query Time (Seconds) – Power & Throughput Tests (1 TB Run)



Measurement Results

Database Scaling (SF/size)	1000 GB
Total Data Storage/Database Size	2.40
Memory/Database Size Percentage	77 %
Start of Database Load Time	05/24/12 13:23:11
End of Database Load Time	05/25/12 03:50:01
Database Load Time	14:26:50
Query Streams for Throughput Test (S)	7
TPC-H Power	475,833.4
TPC-H Throughput	417,155.8
TPC-H Composite Query-per-Hour Metric (QphH@100GB)	445,529.6
Total System Price Over 3 Years (\$)	333,237
TPC-H Price/Performance Metric (\$/QphH@100GB)	0.75

Measurement Intervals

Measurement Interval in Throughput Test (Ts)	1,329
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9. References

1. TPC BENCHMARK™ H (Decision Support) - Standard Specification Revision 2.9.0
<http://www.tpc.org/tpch/spec/tpch2.9.0.doc>
2. TPC-H 100GB Benchmark Executive Summary by Dell
http://www.tpc.org/results/individual_results/Dell/DELL-R720-TPCH-100GB-051312-ES.pdf
3. TPC-H 100GB Benchmark Full Disclosure by Dell
<http://www.tpc.org/results/fdr/tpch/DELL-R720-TPCH-100GB-051312-FDR.pdf>
4. TPC-H 300GB Benchmark Executive Summary by Dell
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5. TPC-H 300GB Benchmark Full Disclosure by Dell
<http://www.tpc.org/results/fdr/tpch/DELL-R720-TPCH-300GB-051312-FDR.pdf>
6. TPC-H 1TB Benchmark Executive Summary by Dell
http://www.tpc.org/results/individual_results/Dell/DELL-R820-TPCH-1000GB-060112-ES.pdf
7. TPC-H 1TB Benchmark Full Disclosure by Dell
<http://www.tpc.org/results/fdr/tpch/DELL-R820-TPCH-1000GB-060112-FDR.pdf>