**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**

redhat.

**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.
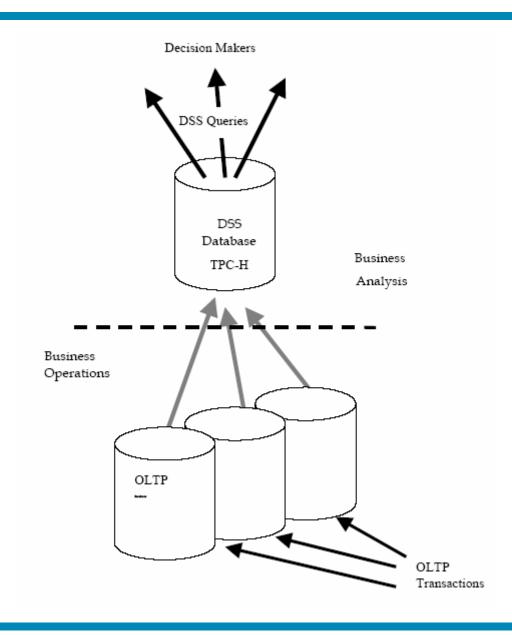


*Figure 1: The TPC-H Business Environment*

## 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.
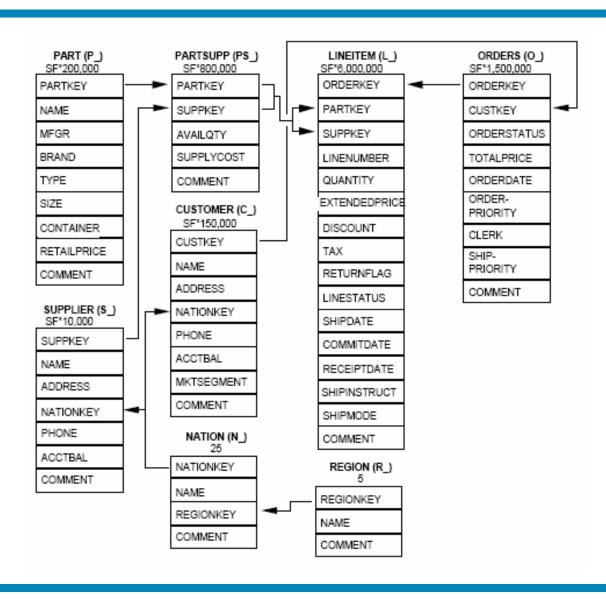


**Figure 2: The TPC-H Schema**

## 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 satisfac-tion.

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-prior-ity 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 can-didates 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 are 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 | Dell PowerEdge R720 | 403,230 | .12 USD | VectorWise 2.0.1 | RedHat Enterprise Linux.6.1 | 05/13/12 |
| 2 | CISCO | 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 | Dell PowerEdge R610 using VectorWise | 303,289 | .16 USD | VectorWise 1.6 | RedHat Enterprise Linux.6.0 | 05/23/11 |
| 4 | INGRES | HP ProLiant DL380 G7 | 251,561 | .38 USD | VectorWise 1.5 | RedHat Enterprise Linux.6.0 | 02/09/11 |
| 5 | hp invent | 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 invent | 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 | SYBASE An SAP Company | 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 invent | 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 invent | 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 invent | 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 |

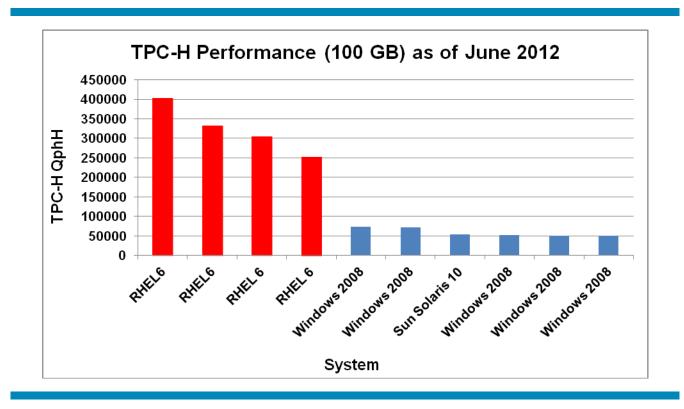*Table 1: TPC-H (100GB) Top Ten in Performance*



*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 | Dell PowerEdge R720 | 410,594 | .28 USD | VectorWise 2.0.1 | RedHat Enterprise Linux.6.1 | 05/13/12 |
| 2 | DELL | Dell PowerEdge R910 using VectorWise 1.6 | 400,931 | .35 USD | VectorWise 1.6 | RedHat Enterprise Linux.6.0 | 05/03/11 |
| 3 | CISCO | Cisco UCS C250 M2 Extended-Memory Server | 331,658 | .34 USD | VectorWise | RedHat Enterprise Linux.6.0 | 02/13/12 |
| 4 | hp invent | 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 invent | 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 invent | 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 invent | 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 | 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 |

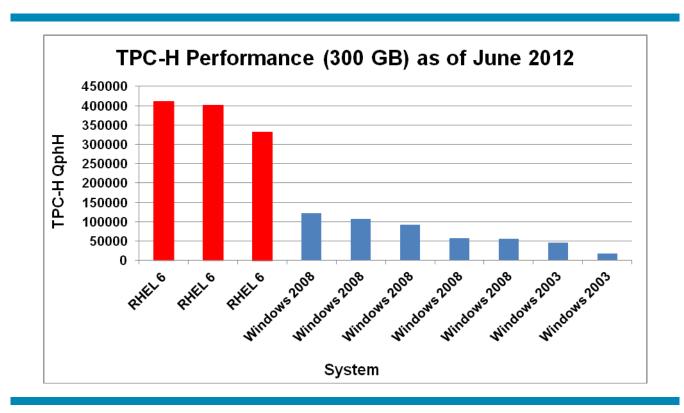*Table 2: TPC-H (300GB) Top Ten in Performance*



*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 | Dell PowerEdge R820 | **445,529** | .75 USD | VectorWise 2.0.1 | **RedHat Enterprise Linux.6.1** | 06/01/12 |
| 2 | DELL | Dell PowerEdge R910 using VectorWise 1.6 | **436,788** | .88 USD | VectorWise 1.6 | **RedHat Enterprise Linux.6.0** | 05/03/11 |
| 3 | hp invent | 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 | ORACLE | SPARC Enterprise M8000 Server | 209,533 | 9.53 USD | Oracle Database 11g R2 Enterprise Edition with Partitioning | Oracle Solaris 10 | 06/03/11 |
| 5 | 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 |
| 6 | IBM | 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 | 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 invent | 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 | 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 invent | 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*
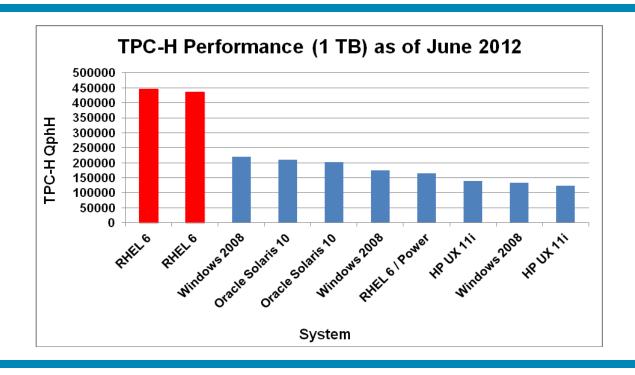


*Figure 5: TPC-H (1,000 GB) Top Ten in Performance*

# 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 | Dell PowerEdge R720 | 403,230 | .12 USD | VectorWise 2.0.1 | **RedHat Enterprise Linux.6.1** | 05/13/12 |
| 2 | CISCO | 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 | 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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| 5 | hp invent | HP ProLiant DL385 G7 | 71,438 | 0.51 USD | Microsoft SQL Server 2008 R2 Enterprise Edition | Microsoft Windows Server 2008 R2 Enterprise Edition | 07/14/10 |
| 6 | hp invent | HP ProLiant DL380 G7 | 73,974 | 0.58 USD | Microsoft SQL Server 2008 R2 Enterprise Edition | Microsoft Windows Server 2008 R2 Enterprise Edition | 07/02/10 |
| 7 | hp invent | 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 | 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 | SYBASE An SAP Company | 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 | DELL | 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 |

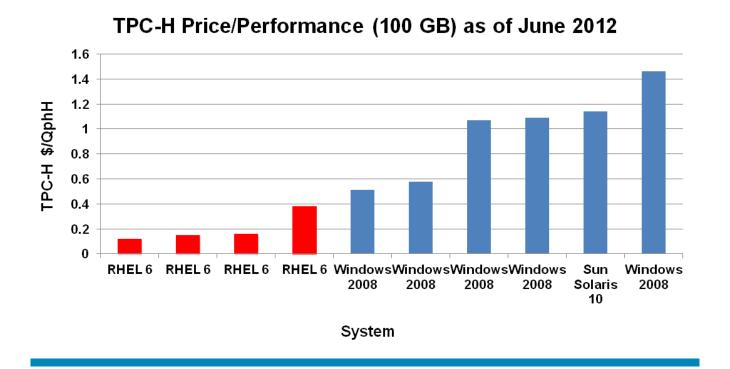*Table 4: TPC-H (100GB) Top Ten in Price/Performance*



*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 | Dell PowerEdge R720 | 410,594 | .28 USD | VectorWise 2.0.1 | **RedHat Enterprise Linux.6.1** | 05/13/12 |
| 2 | CISCO | Cisco UCS C250 M2 Extended-Memory Server | 331,658 | **0.34 USD** | VectorWise 2.0.1 | **RedHat Enterprise Linux.6.0** | 02/13/12 |
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| 6 | hp invent | 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 invent | 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 | IBM System x3950 M2 | 46,034 | 5.40 USD | Microsoft SQL Server | Microsoft Windows Server | 11/28/07 |

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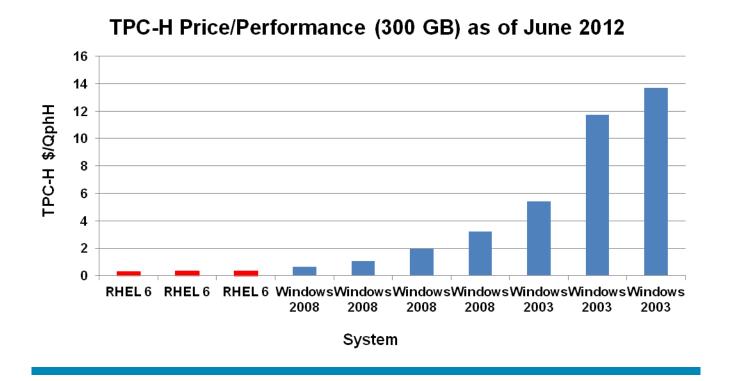*Table 5: TPC-H (300GB) Top Ten in Price/Performance*



*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 |
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| 2 | DELL | 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 | 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 | 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 | 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 invent | 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 invent | 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 invent | HP Proliant DL785 G6 | 102,375 | 3.63 USD | Sybase IQ Single Application | Red Hat Enterprise Linux 5.3 | 02/01/10 |

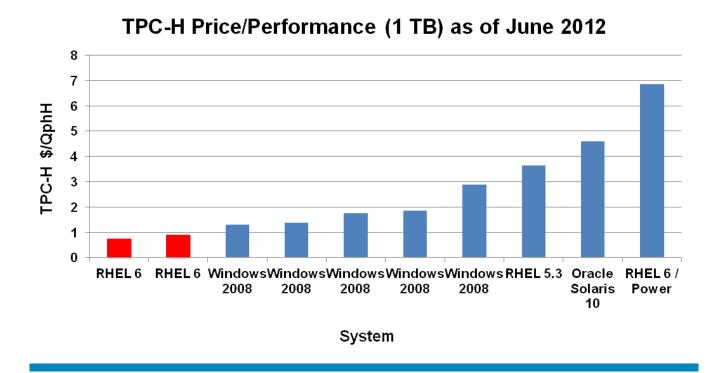| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Server Edition v.15.1 ESD #1 | | |
| 9 | ORACLE | SPARC T4-4 Server | 201,487 | 4.60 USD | Oracle Database 11g Release 2 Enterprise Edition with Partitioning | Oracle Solaris 10 8/11 | 09/26/11 |
| 10 | IBM | IBM Power 780 Model 9179-MHB | 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
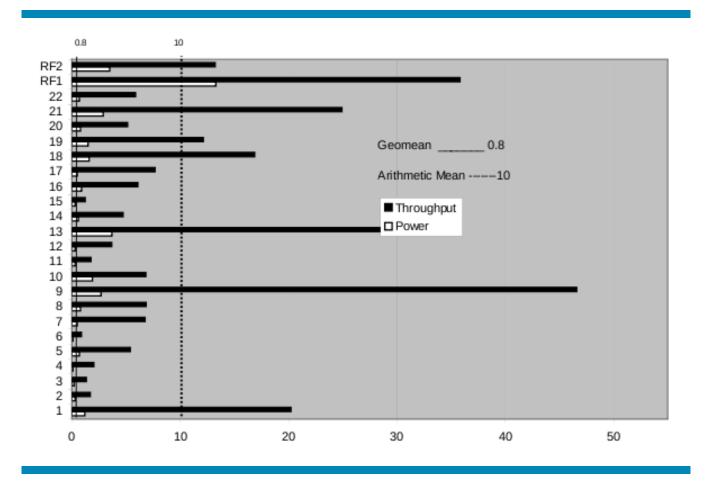for detailed settings.

## 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 |

# 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
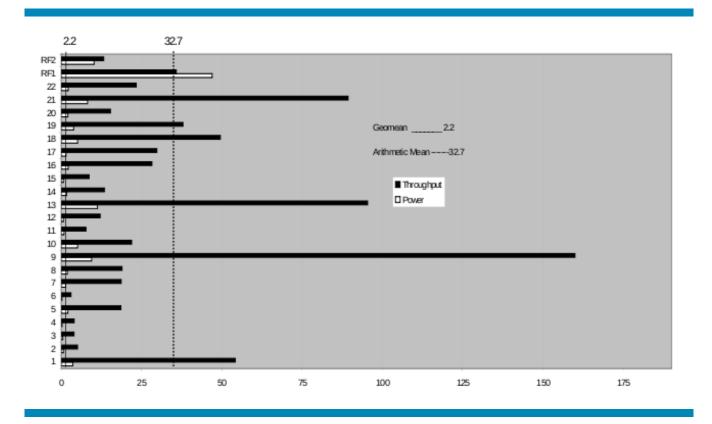for detailed settings.

# 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 |

# 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.
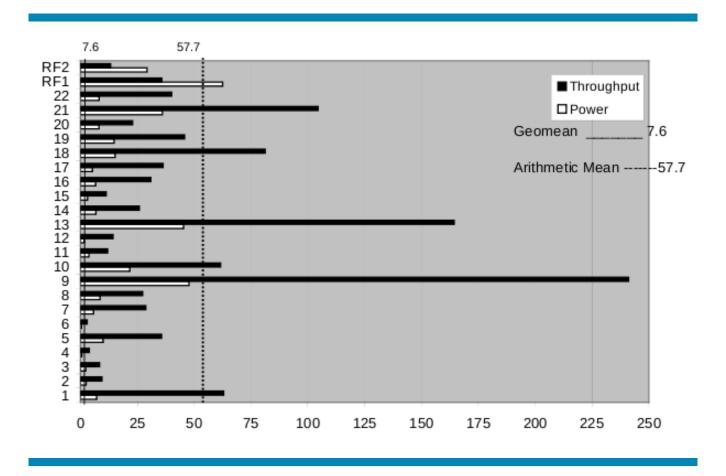
## 8.3 Benchmark Results



*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 |

# 9. References

1. TPC BENCHMARK<sup>TM</sup> 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
   http://www.tpc.org/results/individual_results/Dell/DELL-R720-TPCH-300GB-051312-ES.pdf

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