TPC Virtual Measurement Single System
TPC-VMS

Standard Specification
Version 1.2.0

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Transaction Processing Performance Council (TPC)

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Document Revision History

Date	Version	Description
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October 2, 2012	1.1.0	Incremental clarification to Clauses 2.4.* and other minor wording changes
November 7, 2013	1.2.0	Wording clarifications due to Auditor review

Typographic Conventions

The following typographic conventions are used in this specification:

Convention	Description
Bold	Bold type is used to highlight terms that are defined in this document
Italics	Italics type is used to highlight a variable that indicates some quantity whose value can be assigned in one place and referenced in many other places.
UPPERCASE	Uppercase letters names such as tables and column names. In addition, most acronyms are in uppercase.

Table of Contents

Clause 0 -- Preamble **9**

0.1 Introduction *9*
0.1.1 Goal of the TPC Virtual Measurement Single System Specification 9
0.1.2 Restrictions and Limitations 9

0.2 General Implementation Guidelines *9*
0.2.1 Benchmark Specials 9
0.2.2 Benchmark Special Characteristics 10

0.3 General Measurement Guidelines *10*

0.4 Definitions *10*

Clause 1 -- Overview **16**

1.1 Business and Application Environment *16*

Clause 2 -- Virtualization Environment **17**

2.1 Introduction *17*

2.2 Goals *17*

2.3 Relationship to other TPC Benchmark Standards *17*

2.4 VMS System Under Test (VSUT) *17*
2.4.1 Virtualization Environment 17
2.4.2 Virtual Machine Management Software (VMMS) 17
2.4.3 Virtual Machine (VM) 18

2.5 Consolidated Database Server *19*
2.5.1 Communication between the VMs running the DBMS software 20
2.5.2 Database Scaling and Database Population 20
2.5.3 TPC Benchmark SUT Components other than the Database Server 20

Clause 3 -- Metrics **21**

3.1 Introduction *21*

3.2 TPC-VMS Primary Performance Metric *21*

3.3 TPC-VMS Primary Price/Performance Metric *21*

3.4 TPC-VMS Availability Date *21*

3.5 TPC-VMS Primary Energy Metric *21*

3.6 TPC-VMS Numerical Quantities *22*

Clause 4 -- Driver / Controller Software **23**

4.1 Overview *23*
4.1.1 Communication between the TPC Benchmark drivers 23

Clause 5 -- Rules and Procedures **24**

5.1 Introduction *24*

5.2 Starting Random Number Seeds *24*
5.2.1 Load Time Data Generation 24
5.2.2 Test Run 24

5.3 Virtualization Measurement Interval *24*

5.3.1 TPC Benchmark Measurement Interval ... 24
5.3.2 TPC Benchmark Timed Measurements ... 25
5.3.3 VMMS and VM Parameters ... 25

Clause 6 -- Pricing ... 26

6.1 Priced Configuration ... 26

6.2 Substitution ... 26

Clause 7 -- Full Disclosure Report ... 27

7.1 Full Disclosure Report Requirements ... 27
7.1.1 General Items ... 27
7.1.2 VM Identification ... 27

7.2 Executive Summary Statement ... 29
7.2.1 First Page of the Executive Summary Statement ... 29
7.2.2 Second Page of the Executive Summary Statement ... 29
7.2.3 Energy Pages of Executive Summary Statement ... 30
7.2.4 Pricing Pages of Executive Summary Statement ... 30
7.2.5 TPC Benchmark Executive Summary Information Pages of Executive Summary Statement ... 30

7.3 Report Disclosure Requirements ... 30
7.3.1 Attestation Letter ... 30
7.3.2 Reporting Requirements for Clause 0 -- Preamble ... 30
7.3.3 Reporting Requirements for Clause 1 -- Overview ... 30
7.3.4 Reporting Requirements for Clause 2 -- Virtualization Environment ... 30
7.3.5 Reporting Requirements for Clause 3 -- Metrics ... 32
7.3.6 Reporting Requirements for Clause 4 -- Driver/Controller Software ... 32
7.3.7 Reporting Requirements for Clause 5 -- Rules and Procedures ... 32
7.3.8 Reporting Requirements for Clause 6 -- Pricing ... 32
7.3.9 Reporting Requirements for Clause 7 -- Full Disclosure Report ... 32
7.3.10 Reporting Requirements for Appendix A – TPC Benchmark Executive Summary Information ... 32
7.3.11 Reporting Requirements for Appendix B – TPC Benchmark Reporting Requirements ... 33

7.4 Supporting Files ... 34
7.4.1 TPC Benchmarks with Supporting Files ... 34
7.4.2 TPC Benchmarks without Supporting Files ... 34
7.4.3 Information supplied in Supporting Files at Test Sponsor's Option ... 35

Clause 8 -- Independent Audit ... 36

8.1 General Rules ... 36
8.1.1 Auditor Certification ... 36
8.1.2 Scope of Audit ... 36
8.1.3 Optional TPC-Energy Standard ... 36
8.1.4 Auditor Checklist ... 36
8.1.5 Attestation Letter ... 36

8.2 Auditor's Checklist ... 36
8.2.1 Clause 2 Virtualization Environment Related Items ... 36
8.2.2 Clause 3 Metrics Related Items ... 37
8.2.3 Clause 4 Driver/Controller Related Items ... 37
8.2.4 Clause 5 Rules and Procedures Related Items ... 37
8.2.5 Clause 6 Pricing Related Items ... 37
8.2.6 Clause 7 FDR Related Items ... 38
8.2.7 Auditing the Databases, Transactions, ACI, Drivers & TPC Provided Code ... 38
8.2.8 Auditing of Execution Rules and Metrics ... 39
8.2.9 Auditing of Durability ... 39

Appendix A. Sample Executive Summaries **40**

A.1 Template Layout for TPC-VMS TPC-E Executive Summary *41*

A.2 Sample Layout for TPC-VMS TPC-E Executive Summary *45*

A.3 Template Layout for TPC-VMS TPC-H Executive Summary *50*

A.4 Sample Layout for TPC-VMS TPC-H Executive Summary *56*

Table of Figures

FIGURE 1 - CONSOLIDATED DATABASE SERVER..... 19

CLAUSE 0 -- PREAMBLE

0.1 Introduction

The TPC Virtual Measurement Single System Specification, TPC-VMS, contains the rules and methodology for measuring and reporting TPC Benchmarks metrics running in a Virtualized Environment.

0.1.1 Goal of the TPC Virtual Measurement Single System Specification

The TPC-VMS Specification leverages the TPC-C, TPC-E, TPC-H and TPC-DS Benchmarks by adding the methodology and requirements for running and reporting virtualization metrics. TPC-VMS defines four new benchmarks that are neither comparable to each other nor to the base benchmarks from which they are derived.

The primary metric reported as defined by TPC-VMS is in the form of VMS"performance" where the performance units are specific by each TPC Benchmark, e.g. VMStpmC, VMStpsE, VMSQphH or VMSQphDS.

There is no requirement, intended or implied, to publish a **Result** of the **TPC Benchmark** used as the basis for the **TPC-VMS Result**.

0.1.2 Restrictions and Limitations

Despite the fact that **TPC benchmarks** offer a rich environment that represents many typical IT applications, these benchmarks do not reflect the entire range of customer IT requirements. In addition, the extent to which a customer can achieve the **Results** reported by a vendor is highly dependent on how closely the TPC-VMS measurements and configuration approximates the customer application. The relative performance of systems derived from these benchmarks does not necessarily hold for other workloads or environments. Extrapolations to any other environments are not recommended.

Benchmark **Results** are highly dependent upon workload, specific application requirements, and system designs and implementations. Relative system performance and virtualized environments will vary because of these and other factors. Therefore, **TPC-VMS Results** should not be used as a substitute for specific customer application benchmarking when critical capacity planning and/or product evaluation decisions are contemplated.

Test Sponsors are permitted various possible implementation designs, insofar as they adhere to the model described and pictorially illustrated in this specification and other TPC specifications. A **Full Disclosure Report (FDR)** of the implementation details, as specified in Clause 7, must be made available along with the reported TPC-VMS Metrics.

Comment: While separated from the main text for readability, comments are a part of the standard and must be enforced.

0.2 General Implementation Guidelines

The purpose of **TPC benchmarks** is to provide relevant, objective performance data to industry users. To achieve that purpose, **TPC Benchmark Specifications** require that benchmark tests be implemented with systems, products, technologies and pricing that:

- Are generally available to users.
- Are relevant to the market segment that the individual **TPC benchmark** models or represents.

0.2.1 Benchmark Specials

The use of new systems, products, technologies (hardware or software) and pricing is encouraged so long as they meet the requirements above. Specifically prohibited are benchmark systems, products, technologies, pricing (hereafter referred to as "implementations") whose primary purpose is optimization of **TPC Benchmark** results without any corresponding applicability to real-world applications and environments. The intent is to disallow "Benchmark Special" implementations that improve benchmark results but not real-world performance, pricing, or energy consumption.

The following characteristics should be used as a guide to judge whether a particular implementation is a Benchmark Special. It is not required that each point below be met, but that the cumulative weight of the evidence be considered to identify an unacceptable implementation. Absolute certainty or certainty beyond a reasonable doubt is not required to make a judgment on this complex issue. The question that must be answered is this: based on the available evidence, does the clear preponderance (the greater share or weight) of evidence indicate that this implementation is a Benchmark Special?

0.2.2 Benchmark Special Characteristics

The following characteristics should be used to judge whether a particular implementation is a Benchmark Special:

1) Is the implementation generally available, documented, and supported?
2) Does the implementation have significant restrictions on its use or applicability that limits its use beyond TPC benchmarks?
3) Is the implementation or part of the implementation poorly integrated into the larger product?
4) Does the implementation take special advantage of the limited nature of TPC benchmarks (e.g., limited duration, use of virtualized capabilities not found in the commercially available product) in a manner that would not be generally applicable to the environment the benchmark represents?
5) Is the use of the implementation discouraged by the vendor? (This includes failing to promote the implementation in a manner similar to other products and technologies.)
6) Does the implementation require uncommon sophistication on the part of the end-user, datacenter facility manager, programmer, or system administrator?
7) Does the implementation use knowledge of the variability of the possible components to enhance the result in such a way as to be significantly different from what a typical customer would experience?
8) Is the implementation being used (including beta) or purchased by end-users in the market area the benchmark represents? How many? Multiple sites? If the implementation is not currently being used by end-users, is there any evidence to indicate that it will be used by a significant number of users?

0.3 General Measurement Guidelines

TPC-VMS Results are expected to be accurate representations of system performance in a **Virtualization Environment**. Therefore there are certain requirements which must be followed. The approach and methodology are explicitly detailed in this specification and in the **TPC Benchmark Standards**.

- The approach is an accepted engineering practice or standard.
- The approach does not enhance the **Results**.
- The equipment used in measuring **Results** must conform to the requirements in Clause 6.
- Fidelity and candor is maintained in reporting any anomalies in the **Results**, even if not specified in the benchmark requirements.

The use of new methodologies and approaches is encouraged so long as they meet the requirements above.

0.4 Definitions

A _____

Application

The term **Application** or Application Program refers to a computer program or piece of software designed to perform a specific task in a TPC Benchmark. This may include both commercial and **Test Sponsor** written code. An **Application** runs within the control of an **Operating System**.

Application Server

An **Application Server** is hardware and software that provides the interface between the user and the Database Server(s).

Attestation Letter

The **TPC-Certified Auditor**'s opinion regarding the compliance of a **Result** must be consigned in an **Attestation Letter** delivered directly to the **Test Sponsor**.

Availability Date

The date when all products necessary to achieve the stated performance and energy characteristics will be available (stated as a single date on the **Executive Summary**).

B _____

Benchmark Special

Any aspect of the benchmark implementation with the primary purpose of the optimization of TPC benchmark results without any corresponding applicability to real-world applications and environments.

C _____

Consolidated Database Server

The Consolidated Database Server is the hardware and software that implements the **Virtualization Environment** which consolidates the TPC Benchmark Standard Database Server functionality.

D _____

Database Management System, DBMS

A Database Management System (DBMS) is the commercially available software that manages the database portion of the **TPC Benchmark Standard transactions**.

Database Server

The **TPC Benchmark** Database Server implements the **TPC Benchmark Standard** transactions. The Database Server includes

- Commercially available server or servers
- Commercially available storage
- Commercially available Operating System
- Commercially available DBMS

E _____

Executive Summary

The term **Executive Summary** refers to the Adobe Acrobat PDF file required by each TPC benchmark. The contents of the **Executive Summary** are defined in each of the **TPC Benchmark Standard**s.

F _____

Full Disclosure Report (FDR)

The **Full Disclosure Report** is a set of files required by the TPC Benchmarks. The purpose of the **Full Disclosure Report** is to document how a benchmark **Result** was implemented and executed in sufficient detail so that the **Result** can be reproduced given the appropriate hardware and software products.

G _____

H _____

I _____

J _____

K _____

L _____

M _____

Measurement Interval

The Measurement Interval is the period of time defined by the **TPC Benchmark Standard** used in the computation of the **TPC Benchmark** primary performance metric**.**

N _____

O _____

Operating System/OS

The term **Operating System** refers to a commercially available program that, after being initially loaded into the computer by a boot program, manages all the other programs in a computer, or in a **VM**. The **Operating System** provides a software platform on top of which all other programs run. Without the **Operating System** and the core services that it provides no other programs can run and the computer would be non-functional. Other programs make use of the **Operating System** by making requests for services through a defined application program interface (API). All major computer platforms require an **Operating System**. The functions and services supplied by an **Operating System** include but are not limited to the following:

- Manages a dedicated set of processor and memory resources.
- Maintains and manages a file system.

- Loads applications into memory.
- Ensures that the resources allocated to one application are not used by another application in an unauthorized manner.
- Determines which applications should run in what order, and how much time should be allowed to run the application before giving another application a turn to use the systems resources.
- Manages the sharing of internal memory among multiple applications.
- Handles input and output to and from attached hardware devices such as hard disks, network interface cards etc.

Some examples of **Operating Systems** are listed below:

- Windows
- Unix (Solaris, AIX)
- Linux(Red Hat, SUSE)
- Mac OS

P _____

Performance Metric

The **primary performance metric** as expressed in the units specified by each **TPC Benchmark Standard**

Priced Configuration

The **Priced Configuration** consists of all components priced in the **TPC Benchmark Standard** including all hardware, software and maintenance as required by the **TPC Benchmark Standard**.

Price/Performance Metric

The **Price/Performance Metric** is the total price of the **VSUT** divided by the **TPC-VMS Primary Performance Metric**.

Q _____

R _____

Report

The term **Report** refers to the Adobe Acrobat PDF file in the Report folder in the **FDR**. The contents of the **Report** are defined in Clause 7.

Reported

The term **Reported** refers to an item that is part of the **FDR**.

Result

A performance test, documented by an FDR and Executive Summary submitted to the TPC, claiming to meet the requirements of an official **TPC Benchmark Standard**.

S _____

Software Version

A **Software Version** uniquely identifies a software product, its release level, update level and/or patch level. It is typically a string of alphanumeric characters that allows the software manufacturer to uniquely identify the software.

Substitution

Substitution is the use of components in the **Priced Configuration** which are different than those used in the measured configuration. This also requires compliance with the TPC Pricing Specification.

Supporting Files

Supporting Files refers to the contents of the Supporting Files folder in the **FDR**. The contents of this folder, consisting of various source files, scripts, and listing files, are defined in Clause 7.

System Under Test (SUT)

System Under Test (SUT) – is defined by the **TPC Benchmark Standard**.

T _____

Test

A timed component of the **TPC Benchmark** consisting of a database load or a set of queries and/or transactions, e.g. a TPC-H Power Test is a Test.

Test Sponsor

The **Test Sponsor** is the company officially submitting the **Result** with the **FDR** and will be charged the filing fee. Although multiple companies may sponsor a **Result** together, for the purposes of the TPC's processes the **Test Sponsor** must be a single company. A **Test Sponsor** need not be a TPC member. The **Test Sponsor** is responsible for maintaining the **FDR** with any necessary updates or corrections. The **Test Sponsor** is also the name used to identify the **Result**.

TPC Benchmark, TPC Benchmark Specification or TPC Benchmark Standard

Use of the term **TPC Benchmark** represents one of the following TPC benchmarks: the TPC-C Benchmark Standard, the TPC-E Benchmark Standard, the TPC-H Benchmark Standard or the TPC-DS Benchmark Standard.

TPC-Certified Auditor (Auditor)

The term **TPC-Certified Auditor** is used to indicate that the TPC has reviewed the qualification of the **Auditor** and has certified his/her ability to verify that benchmark **Results** are in compliance with a specification. Note that an **Auditor** may be certified for either a **TPC Benchmark Standard** or the **TPC Virtual Measurement Single System Specification** or both. (Additional details regarding the **Auditor** certification process and the audit process can be found in Section 9 of the TPC Policy document.)

TPC-VMS Primary Performance Metric

This term refers to the reported metric and is the work done by the SUT in a virtualized environment. The metric is constructed by prefixing the TPC Benchmark Primary Metric with the letters "VMS", e.g. as in VMStpmC, VMStpsE, VMSQphH or VMSQphDS.

TPC-VMS Result

TPC-VMS Result is a **Result** which meets the requirements of the TPC Virtual Measurement Single System specification and reports TPC Virtual Measurement Single System Metrics.

U _____

V _____

Virtualization Environment

A Virtualization Environment provides a separate execution environment for multiple TPC Benchmarks.

Virtual Machine (VM)

A self-contained computing environment, managed by a **VMMS** and that behaves as if it were a separate computer.

Virtual Machine Management Software (VMMS)

The VMMS is a commercially available framework or methodology of dividing the resources of a Virtualization Environment into multiple computing environments called **Virtual Machines (VMs).**

VM Identification

A **VM Identification** is used in the **FDR** to identify the **VM** that the **FDR** text is describing.

VSUT – VMS System Under Test

The VSUT is composed of the hardware and software necessary to support the three **TPC Benchmark** SUTs. It includes the **Consolidated Database Server** and any additional hardware or software required by the **TPC Benchmark Standard** that is not consolidated onto the **Consolidated Database Server**, but that would be included in the **SUT** definition for the **TPC Benchmark Standard**.

W _____

X _____

Y _____

Z _____

CLAUSE 1 -- OVERVIEW

1.1 Business and Application Environment

The TPC-VMS Specification leverages existing **TPC Benchmarks**, namely; TPC-C, TPC-E, TPC-DS and TPC-H. Each of these benchmarks represents a specific set of customer environments and details can be found in the relevant benchmark specification. For example, TPC-E exercises database server transaction functionality for a financial environment that receives work requests from multiple sources.

From a market sizing standpoint, the **TPC Benchmarks** span diverse end-customer business environments ranging from small-sized business to large-sized corporate IT datacenters. The TPC-VMS Specification defines methodologies to determine virtualization efficiency for data processing servers deployed in these diverse customer environments.

CLAUSE 2 -- VIRTUALIZATION ENVIRONMENT

2.1 Introduction

The intent of this Specification is to represent a **Virtualization Environment** where three database workloads are consolidated onto one server.

2.2 Goals

The goals for measuring **TPC Benchmarks** in a virtualized environment are as follows:

- Provide a consolidated system workload for three database environments running in a **Virtualization Environment**.
- Provide virtualization metrics that are based on existing **TPC Benchmark Standards**.
- Provide for repeatable measurements.
- Provide requirements for disclosure and documentation of the measurements to ensure compliance with this specification.
- Leverage existing **TPC Benchmark Standards** without requiring any implementation changes.

2.3 Relationship to other TPC Benchmark Standards

This specification is intended to leverage existing **TPC Benchmark Standard**s by specifying the requirements to measure and report virtualization metrics. Unless otherwise specified in the TPC-VMS Specification, all rules and procedures must be followed in the **TPC Benchmark Standard** Specifications.

2.4 VMS System Under Test (VSUT)

The VSUT is composed of the hardware and software necessary to support **the three** TPC Benchmark SUTs. It **includes the Consolidated** Database Server and any additional hardware or software required **by the TPC** Benchmark Standard that is not consolidated **onto the Consolidated** Database Server, but that would be included **in** the SUT definition **for the TPC** Benchmark **Standard**.

2.4.1 Virtualization Environment

A Virtualization Environment provides a separate execution environment for multiple TPC Benchmarks. A Virtualization Environment consists of one or more physical nodes managed by one **VMMS**. If there is more than one physical node, the parameters established in the **VMMS** must allow a single **VM** to span two or more physical nodes.

2.4.2 Virtual Machine Management Software (VMMS)

The VMMS is a commercially available framework or methodology of dividing the resources of a Virtualization Environment into multiple computing environments called **Virtual Machines (VMs).** Each of these computing environments allows a software stack to run in complete isolation from each other on the system. The **VMMS** allows for the creation of multiple computing environments on the same system.

2.4.2.1 A VMMS cannot be implemented by the static partitioning of a system at boot time or by any static partitioning that may take place through operator intervention.

2.4.2.2 A VMMS cannot act as the **Operating System** that manages the **Application**(s) running inside a VM.

2.4.2.3 All I/O devices must be virtualized by the VMMS or by the I/O controller managing the I/O devices. The same I/O virtualization technology must work with a large number of VMs (number of VMs greater than number of controllers).

2.4.3 **Virtual Machine (VM)**

A self-contained computing environment, managed by a **VMMS** and that behaves as if it were a separate computer. A number of **Virtual Machine**s can be supported by the physical hardware. A **VM** includes an **Operating System** and **Application** software that runs in isolation from other **VM Operating System**s and **Application** software.

At the Test Sponsor's option, the three VMs may or may not be identical in their characteristics or configuration.

2.4.3.1 It is a requirement that for all software (**Operating System**, **DBMS**, transaction monitor, and any other software programs) that are to run in the **VM**s, the same **Software Version** can run without user intervention in a non-**Virtualization Environment**. The same **Software Version** requirement does not extend to device drivers for devices that do not have counterparts in a non-**Virtualization Environment**. It is permissible for the software (at installation time or during execution) to recognize that it is running or not running in a **Virtualization Environment** and load appropriate device drivers or execute a different code path.

Comment: This is not a requirement that the exact same software that runs on native hardware must be used in the **VM**s. The requirement is that it can be done. Since no native hardware representing servers that are consolidated onto the **Consolidated Database Server** are actually examined as part the TPCV-VMS Benchmark, it is not possible to demonstrate that the same software that would have run on that hypothetical native hardware is being used in the **Virtualization Environment**. Hence the test sponsor is asked to state that the converse is true (Clause 7.3.4.7): for all software that is to run in the VMs, the same **Software Version** can run without user intervention in a non-**Virtualization Environment**, with the exceptions noted in Clause 2.4.3.1.

2.4.3.2 Additional performance tuning options may be applied to the software running in the **VM**s. Given the requirement of Clause 2.4.3.1, the **Test Sponsor** may use the same **Software Version** optimized to run in a **Virtualized Environment**. The allowable tuning options are as follows:

- The **Test Sponsor** may use documented and supported parameters or answer installation questions such that the software binary will modify its behavior to execute a code path optimized for a **Virtualization Environment**.

- The software installation process can automatically determine the target installation environment and re-compile, re-link, rebuild or load a binary optimized for the **Virtualization Environment**.

- The Test Sponsor may use documented and supported parameters or answer installation questions such that the installation process can re-compile, re-link, rebuild or load a binary optimized for the **Virtualization Environment**.

- The optimized versions of the same **Software Versions** may either be provided in the same installation package (DVD or downloadable files) as the binaries that run on native hardware or provided in a separate installation package (DVD or downloadable files).

2.4.3.3 A **Software Version** uniquely identifies a software product, its release level, update level and/or patch level. It is typically a string of alphanumeric characters that allows the manufacturer to uniquely identify the software. For the Software Version to be the same the unique strings must match, including the update level and/or path level.

2.4.3.4 The **Test Sponsor** cannot use a different **Software Version** than the one used to satisfy the requirements of Clause 2.4.3.1.

Comment: For this specification the term **Software Version** includes an update level, thus the **Test Sponsor** cannot use a software release with an update that only runs in a **Virtualization Environment** and then claim to pass the requirements of Clause 2.4.3.1 with the software release level without the update.

2.5 Consolidated Database Server

The Consolidated Database Server is the hardware and software that implements the **Virtualization Environment** which consolidates the TPC Benchmark Standard Database Server functionality. **Virtual Machine Management Software (VMMS)** virtualizes the Consolidated Database Server hardware into **Virtual Machines** (VMs).

The TPC Benchmark Standard Database Servers are consolidated onto the **Consolidated Database Server** as depicted by Figure 1. As shown the Database Server's Operating Systems and DBMSs are consolidated onto the **Consolidated Database Server** each in a separate Virtual Machine.

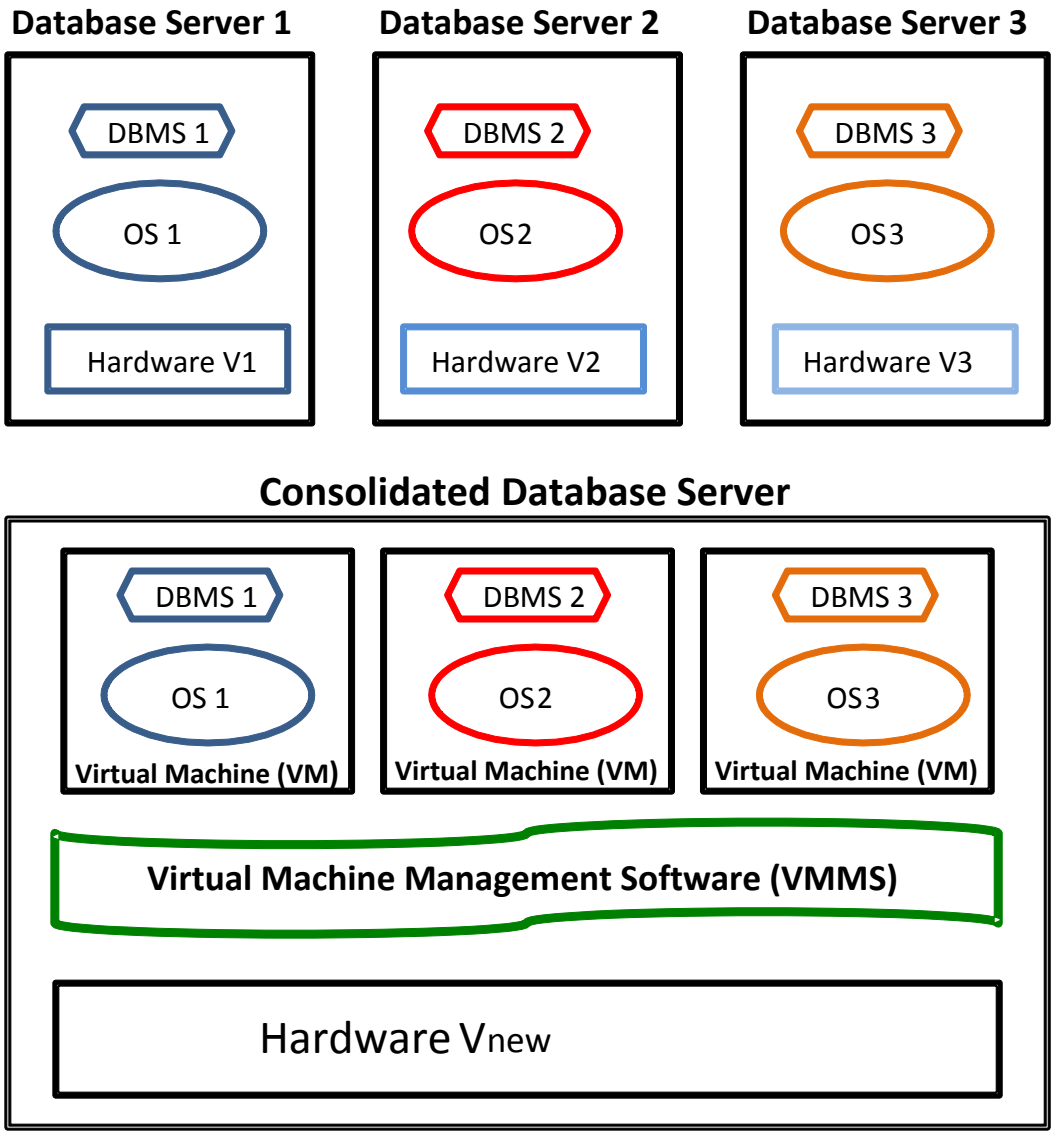


Figure 1 - Consolidated Database Server

Figure 1 shows that each VM could be running a different Operating System and DBMS, however for ease of benchmarking, the **Test Sponsor** may use the same **DBMS** and **Operating System** in all three VMs.

2.5.1 Communication between the VMs running the DBMS software

No sharing of information directly or indirectly can occur between any software running on the **Consolidated Database Server** VMs running the DBMS software.

2.5.2 Database Scaling and Database Population

Each database must follow the scaling and database population rules specified in the **TPC Benchmark Standard**.

2.5.3 TPC Benchmark SUT Components other than the Database Server

TPC Benchmark SUT components other than the **Database Server** may be replicated, consolidated onto systems with or without a **VMMS**, or consolidated onto the **Consolidated Database Server** in separate **VMs.** This requirement may disallow configurations otherwise allowed by the base benchmark, (e.g. TPC-E and TPC-C).

2.5.3.1 **Comment:** For example, if the **TPC Benchmark** SUT requires application software that typically runs on an **Application Server**, then it is the Test Sponsor's option for the application software to run on the **Consolidated Database Server** in a separate VM or on a separate client system or systems. The communication between the **Application** software in one VM with the DBMS in a separate **VM** must be through commercially available software interfaces. Neither the DBMS nor the **Application** software can execute differently if they are both located on the **Consolidated Database Server** or on separate systems.

CLAUSE 3 -- METRICS

3.1 Introduction

Multiple instances of a given **TPC Benchmark** are run in a **Virtualization Environment**. Each VM must be running the same **TPC Benchmark**; different **TPC Benchmarks** cannot be used across the VMs. Each VM must be running the given TPC Benchmark at the same scaling factor.

Comment:

Examples of compliant implementations include:

- each VM running TPC-C scaled for 10,000 warehouses
- each VM running TPC-E scaled for 42,000 customers
- each VM running TPC-H at Scale Factor 100 GB

Examples of non-compliant implementations include:

- each VM running TPC-C, with one VM scaled for 10,000 warehouses and the other VMs scaled for 20,000 warehouses
- one VM running TPC-C scaled for 10,000 warehouses, one VM running TPC-E scaled for 10,000 customers, and another VM running TPC-H at Scale Factor 1,000 GB.

3.2 TPC-VMS Primary Performance Metric

The **TPC-VMS Primary Performance Metric** is the minimum value of the **TPC Benchmark** Primary metrics for the **TPC Benchmarks** run in the **Virtualization Environment**. The TPC-VMS Primary metric is reported by prefixing a "VMS" to the **TPC Benchmark Standard** Primary Metric, e.g. VMStpmC, VMStpsE, VMSQphDS@ScaleFactor or VMSQphH@ScaleFactor.

3.3 TPC-VMS Primary Price/Performance Metric

The TPC-VMS total price divided by the **TPC-VMS Primary Performance Metric** is known as the TPC-VMS Primary **Price/Performance Metric**. Refer to Clause 6 for the detailed pricing rules. Similar to the **TPC-VMS Primary Performance Metric** the prefix "VMS" is used to denote the **TPC Benchmark Standard**, e.g. $/VMStpmC, $/VMStpsE, $/VMSQphDS@ScaleFactor or $/VMSQphH@ScaleFactor.

3.4 TPC-VMS Availability Date

The TPC-VMS Availability Date requirements are specified by the **TPC Benchmark Specification** and the **TPC Pricing Specification**.

3.5 TPC-VMS Primary Energy Metric

The TPC-Energy Primary Metric is the ratio of total energy consumed by the VSUT for all required **TPC Benchmark** measurement intervals in the numerator divided by the **TPC-VMS Primary Performance Metric**, e.g. watts/VMSKtpmC, watts/VMStpsE, watts/VMSQphDS@ScaleFactor or watts/VMSKQphH@Scalefactor. Refer to the TPC-Energy Specification for further details.

3.6 **TPC-VMS Numerical Quantities**

There are no additional TPC-VMS Numerical Quantities beyond those required by the **TPC Benchmark Standard**.

CLAUSE 4 -- DRIVER / CONTROLLER SOFTWARE

4.1 Overview

The TPC-VMS Benchmark does not require any new driver or controller software except as required to be compliant with Clause 5.3.2. Any modification made by the Test Sponsor to facilitate ease of benchmarking must adhere to all TPC-VMS Specification run rules and procedures.

4.1.1 Communication between the TPC Benchmark drivers

No sharing of information directly or indirectly can occur between the **TPC Benchmark** drivers during the **Measurement Interval** except for synchronization of **TPC Benchmark** execution as specified by Clause 5.3.

CLAUSE 5 -- RULES AND PROCEDURES

5.1 Introduction

This clause defines the run rules and procedures for implementing TPC-VMS Benchmark. Unless otherwise specified in the TPC-VMS Specification all rules and procedures of the **TPC Benchmark Standard** must be adhered to by the Test Sponsor.

5.2 Starting Random Number Seeds

If each **TPC Benchmark** used the same random number seeds for generating the benchmark data and during the test run, it is possible that the benchmarks could all perform the same operation and the same data manipulations within their respective databases. This could lead to a pulsing or lock-step behavior of the **VSUT**. In some cases this behavior is beneficial to the Test Sponsor as the overall **VSUT** performance is higher than what would be achieved if all **TPC Benchmarks** were randomly accessing their data.

In order to prevent this condition, the data generation and test run starting random seed values should be different. However, the **TPC Benchmark Standards** have differing rules on how the random seeds are chosen. The basic **TPC-VMS** rule is that if the random number seed can be changed by the **Test Sponsor**, then the seed values must be different in each of the **VSUT TPC Benchmarks**.

5.2.1 Load Time Data Generation

5.2.1.1 If the **TPC Benchmark** allows the changing of the starting random number seed values for the **TPC Benchmark** data generation scripts, then the data generation scripts for each of the **TPC Benchmark**s in the **VSUT** must start with different random number seeds. The choice of different seeds must follow the **TPC Benchmark** Specification rules.

5.2.1.2 If the **TPC Benchmark** data generation scripts automatically generate starting random number seed values, then the scripts are used as is for each of the **TPC Benchmark** databases in the VSUT.

5.2.1.3 If the **TPC Benchmark** uses fixed starting random number seed values, then the data generation scripts will generate the same database. For ease of benchmarking, the VMs may use the same source data to load all databases.

5.2.2 Test Run

If the **TPC Benchmark** allows the changing of the starting random number seed values for the **TPC Benchmark** test run, then the test run commands for the each of the **TPC Benchmarks** in the **VSUT** must start with different random number seeds. The choice of different seeds must follow the **TPC Benchmark** Specification rules.

5.3 Virtualization Measurement Interval

The Measurement Interval is the period of time defined by the **TPC Benchmark Standard** used in the computation of the **TPC Benchmark** primary performance metric**.** A **Measurement Interval** can be either a measured time or one or more timed measurements of a quantity of work.

5.3.1 The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.The Measurement Interval **is the period of time defined by the** TPC Benchmark Standard **used in the computation of the** TPC Benchmark **primary performance metric**.**TPC Benchmark Measurement Interval**

For **TPC Benchmarks** that compute their primary metric from a measured time interval (e.g. TPC-C, TPC-E), the same **Measurement Interval** must be used by the **TPC Benchmarks** in the **VSUT**. For all **TPC Benchmarks**, the **Measurement Interval** start time must be within 3 seconds of each other, i.e. the difference between the earliest start time value and the latest start time value must be less than or equal to 3 seconds. All **TPC Benchmark Measurement Intervals** must be of the same duration.

5.3.2 **TPC Benchmark Timed Measurements**

For **TPC Benchmarks** that compute their primary metric from one or more timed measurements for a quantity of work (e.g. TPC-H, TPC-DS), the start of the **Measurement Interval(s)** for all **TPC Benchmarks Tests** must occur within 3 seconds, i.e. the difference between the earliest start time value and the latest start time value must be less than or equal to 3 seconds.

Comment: In TPC-H Load Tests are not used in the computation of the primary performance metric, but in the context of **TPC-VMS** the Load Tests of each TPC Benchmark must start within 3 seconds of each other.

5.3.2.1 Initiation of each TPC Benchmark **Test** must start within the guidelines of Clause 5.3.2 for all VMs that are running a DBMS. For example, all TPC-H or TPC-DS Load tests must start at the same time, all TPC-H Power tests must start at the same time, all TPC-H or TPC-DS throughput tests must start at the same time, etc.

5.3.3 **VMMS and VM Parameters**

5.3.3.1 Any load balancing, tuning commands or directives specified to the **VM**s or **VMMS** must be documented, supported and useable by any customer running the same version of the software.

5.3.3.2 No commands or directives for load balancing or tuning of the **VM**s or **VMMS** can be introduced manually or by Test Sponsor developed code once the **TPC Benchmark Measurement Interval** begins.

CLAUSE 6 -- PRICING

Rules for pricing the **Priced Configuration** and associated software and maintenance are included TPC Pricing Specification, located at *www.tpc.org*. The following requirements are intended to supplement the TPC Pricing Specification:

6.1 Priced Configuration

The system to be priced is the aggregation of the V**SUT** and any additional component that would be required to achieve the **reported** performance level. Calculation of the priced system consists of:

- Price of the V**SUT** as tested and as defined in Clause 2.4.
- Price of any additional storage and associated infrastructure required by the **TPC Benchmark Standard**.
- Price of additional products that are required for the operation, administration or maintenance of the priced system.
- Price of additional products required for **Application** development.

Comment: Any component, for example a Network Interface Card (NIC), must be included in the price of the V**SUT** if it draws resources for its own operation from the V**SUT**. This includes, but is not limited to, power and cooling resources.

6.2 Substitution

Component substitution is as defined in the **TPC Benchmark Standard** and **TPC Pricing Specifications**.

CLAUSE 7 -- FULL DISCLOSURE REPORT

7.1 Full Disclosure Report Requirements

A **Full Disclosure Report (FDR)** is required. This section specifies the requirements of the **FDR**.

The **FDR** is a zip file of a directory structure containing the following:

- A **Report** in Adobe Acrobat PDF format,
- An **Executive Summary Statement** in Adobe Acrobat PDF format,
- The **Supporting Files** consisting of various source files, scripts, and listing files. Requirements for the **FDR** file directory structure are described below.

Comment: The purpose of the **FDR** is to document how a benchmark **Result** was implemented and executed in sufficient detail so that the **Result** can be reproduced given the appropriate hardware and software products.

7.1.1 General Items

7.1.1.1 The order and titles of sections in the **Report** and **Supporting Files** must correspond with the order and titles of sections from the TPC-VMS Benchmark Standard Specification (i.e., this document). The intent is to make it as easy as possible for readers to compare and contrast material in different **Reports**.

7.1.1.2 The **FDR** must follow all reporting rules of the TPC Pricing Specification, located at *www.tpc.org*, specified by the TPC Benchmark Standard Specification. For clarity and readability the TPC Pricing Specification requirements may be repeated in the TPC-VMS Specification.

7.1.1.3 The directory structure of the **FDR** has three folders:

- *ExecutiveSummaryStatement* - contains the **Executive Summary Statement**
- *Report* - contains the **Report**,
- *SupportingFiles* - contains the **Supporting Files**.

7.1.1.4 The **Report** contains the TPC-VMS reporting information as well as the TPC Benchmark FDR reporting information in an Appendix A and Appendix B of the **Report**. **VM Identification** is used in the **Report** to identify the reporting information for the **VSUT VMs**.

7.1.2 VM Identification

A **VM Identification** is used in the **FDR** to identify the **VM** that the **FDR** text is describing.

7.1.2.1 The general **VM Identification** syntax is the two letter acronym "VM" followed by a number where the number one represents the **VM** with the lowest reported **TPC Benchmark Result**, the number two represents the next lowest reported result, and the number three represents the highest reported result. For example, the valid **VM Identifications** are as follows:

VM 1 identifies the **VM** that achieved the lowest TPC Benchmark **Result** (the reported result)

VM 2 identifies the **VM** that achieved the next lowest TPC Benchmark **Result**

VM 3 identifies the **VM** that achieved the highest TPC Benchmark **Result**.

If two or more **TPC Benchmark Result**s are exactly the same to all significant digits specified by the **TPC Benchmark Specification**, it is the **Test Sponsor**'s option for the order of the **VM Identification** numbers. The **Test Sponsor** must use the same order throughout the **FDR**.

7.1.2.2 To identify that the **FDR** information pertains to a specific **VM**, a bolded **VM Identification** followed by a colon is placed at the beginning of the FDR information. For example in a TPC-VMS **TPC-E** Appendix A, the measured throughput would be **reported** in the FDR as follows:

> **Measured Throughput**
> *The Measured Throughput must be reported in the Report.*
>
> **VM 1:** The measured throughput was 413.21 tpsE.
>
> **VM 2:** The measured throughput was 423.51 tpsE.
>
> **VM 3:** The measured throughput was 450.70 tpsE.

7.1.2.3 To identify that the **FDR** information pertains to all **VM**s in the **VSUT**, the bolded phrase "**All VMs:"** is placed at the beginning of the **FDR** information. For example in a TPC-VMS **TPC-C** Appendix A, the Table Definitions reporting requirements would be **reported** in the **FDR** as follows:

> **Table Definitions**
> *Listing must be provided for all table definition statements and all other statements used to set up the database.*
>
> **All VMs:** Appendix B contains the code used to define and load the database tables.

7.1.2.4 To identify that the **FDR** information pertains to more than one **VM** but not all **VM**s, a list of **VM Identifications** are used separated by commas except for the last **VM Identification** which is separated from the comma list by a "&" or the word "and". The bolded list of **VM Identifications** followed by a colon is placed at the beginning of the **reported** information. For a **VSUT** with 3 **VM**s the valid **VM Identifications** are as follows:

> **VM 1 & VM 2:**
> **VM 2 & VM 3:**
> **VM 1 & VM 2:**
> **VM 1 and VM 2:**
> **VM 2 and VM 3:**
> **VM 1 and VM 2:**

7.1.2.5 To identify that the **FDR** information pertains to one **VM** but due to TPC-VMS ease of benchmarking rules the **reported** information is applicable to other **VM**s, a **VM Identification** that the reporting text pertains to is listed first followed by the phrase "applicable to" followed by a list of **VM Identifications** separated by commas except for the last **VM Identification** which is separated from the comma list by a "&" or the word "and". The bolded **VM Identifications** followed by a colon is placed at the beginning of the FDR information. For a **VSUT** with 3 **VM**s the valid **VM Identifications** are as follows:

> **VM 1 applicable to VM 2:**
> **VM 1 applicable to VM 3:**
> **VM 1 applicable to VM 2 & VM 3:**
> **VM 1 applicable to VM 2 and VM 3:**
> **VM 2 applicable to VM 1:**
> **VM 2 applicable to VM 3:**
> **VM 2 applicable to VM 1 & VM 3:**
> **VM 2 applicable to VM 1 and VM 3:**
> **VM 3 applicable to VM 1:**
> **VM 3 applicable to VM 2:**
> **VM 3 applicable to VM 1 & VM 2:**
> **VM 3 applicable to VM 1 and VM 2:**

Note: The "applicable to" **VM Identifications** will typically be found in the ACID reporting requirements (see Clause 8.2.7 and 8.2.9).

7.1.2.6 When a **VM Identification** is used in a directory name or path name, blank characters are replaced with underscores.

7.2 Executive Summary Statement

The TPC-VMS **Executive Summary Statement** must be included near the beginning of the **Report**. Examples of the **Executive Summary Statements** are presented in **Error! Reference source not found.**. The latest version of the required format is available from the TPC Administrator. When the optional TPC-Energy Standard is used, the additional requirements and formatting of TPC-Energy related items in the **Executive Summary** must be reported and used. In addition, the requirements of the TPC-Energy Specification, located at *www.tpc.org*, must be met.

7.2.1 First Page of the Executive Summary Statement

The first page of the Executive Summary Statement must include the following:

- **Test Sponsor's** name
- TPC-VMS Specification version number under which the benchmark is published
- TPC Benchmark Specification version number under which the benchmark is published
- TPC-Pricing Specification version number under which the benchmark is published
- If applicable, TPC Energy Specification version number under which the benchmark is published
- Report date and/or Revision Date
- For the VSUT the following is reported:
    - Measured server's product name
    - **TPC-VMS Primary Performance Metric** (see Clause 3.2)
    - If applicable, the TPC-VMS **Primary Energy Metric** (see Clause 3.5)
    - TPC-VMS **Primary Price/Performance Metric** (see Clause 3.3)
    - **Total** System Cost (see TPC Pricing Specification)
    - Number of **Durable Media** (disks)
    - TPC-VMS **Availability Date** (see Clause 3.4)
    - The **VMMS** name and version
    - Number of **Consolidated Database Server** Processors/Cores/Threads that were enabled for the benchmark (see TPC Policies located at *www.tpc.org*)
    - Memory in GB for the **Consolidated Database Server**
    - A diagram describing the components of the **Priced Configuration** (see TPC Pricing Specification)

7.2.2 Second Page of the Executive Summary Statement

For each VM in the VSUT the following must be reported. A column format must be used with VM Identifications (Clause 7.1.2) as the column headers.

- **TPC Benchmark Primary Performance Metric**
- Maximum number of Virtual Processors visible to **VM** during the **Measurement Interval(s)**
- Maximum memory in GB visible to the **VM** during the **Measurement Interval(s)**
- Maximum Capacity of Storage in GB visible to the **VM** during the **Measurement Interval(s)**
- Operating System name and version
- Database Manager name and version
- The TPC Benchmark scaling, i.e. number of customers, warehouses or scale factor
- Initial number of database rows
- Initial Database Size in GB

7.2.3 Energy Pages of Executive Summary Statement

If a **TPC Energy** metric is reported, then the **Executive Summary** must include any information required by the **TPC-Energy Specification.**

7.2.4 Pricing Pages of Executive Summary Statement

The Price Spreadsheet must be included in the **Executive Summary Statement** as specified by the TPC Pricing Specification.

The major categories for division of the price spreadsheet are:

- **Consolidated Database Server** Hardware
- **Consolidated Database Server** Storage
- **Consolidated Database Server** Software
- Client Hardware
- Client Software
- Infrastructure (networking, UPS, consoles, other components that do not fit into the above categories)

7.2.4.1 The name(s) of the **Auditor(s)** who certified the result must be included at the end of the Pricing Pages.

7.2.5 TPC Benchmark Executive Summary Information Pages of Executive Summary Statement

Any **TPC Benchmark** information, graphs or tables that would be reported in the **TPC Benchmark Executive Summary** but are not specified in Clauses 7.2.1 – 7.2.4 must be reported in the **Executive Summary** for VM 1. The information for all VMs can be found in Appendix A (see Clause 7.3.10).

7.3 Report Disclosure Requirements

7.3.1 Attestation Letter

The **Auditor's Attestation Letter**, which indicates compliance, must be included in the **Report**.

7.3.2 Reporting Requirements for Clause 0Preamble

Copies of the following TPC-VMS's clauses are to be placed at the beginning of the **Report**.

- Clause 0.1 Introduction
- Clause 0.1.1 Goal of the TPC Virtual Measurement Single System Specification
- Clause 0.1.2 Limitations and Restrictions

7.3.2.1 A statement identifying the benchmark **Test Sponsor**(s) and other participating companies must be **reported** at the beginning of the **Report**.

7.3.3 Reporting Requirements for Clause 1Overview

There are no reporting requirements for TPC-VMS Clause 1.

7.3.4 Reporting Requirements for Clause 2Virtualization Environment

7.3.4.1 Diagrams of both VSUT **Measured** and **Priced Configuration**s must be **reported** in the **Report**, accompanied by a description of the differences. This includes, but is not limited to:

- Number and type of processors, number of cores and number of threads.

- 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, etc., that were physically used in the test or incorporated into the pricing structure.
- Type and the run-time execution location of software components (e.g. **DBMS**, client, processes, transaction monitors, software drivers, etc.).

Comment: Detailed diagrams for system configurations and architectures can widely vary, and it is impossible to provide exact guidelines suitable for all implementations. The intent here is to describe the system components and connections in sufficient detail to allow independent reconstruction of the measurement environment.

7.3.4.2 Descriptions of which hardware is being use by each of the **VM**s must be **reported** in the **Report**. The **VM Identifications** are to be used to identify the hardware that is being used by the various **VM**s. The **VM Identification** can either be used to annotate the **Measured** and **Priced Configuration** diagrams (7.3.3.1) or be used in a separate table or list that describes which hardware is being used by the **VM**s.

7.3.4.3 A description of the steps taken to configure all of the **VSUT** hardware must be **reported** in the **Report**. Any and all configuration scripts or step by step GUI instructions are **reported** in the **Supporting Files** (see Clause 7.4) The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-VMS specification could recreate the hardware environment. This includes, but is not limited to:

- A description of any firmware updates or patches to the hardware.
- A description of any GUI configuration used to configure the system hardware.
- A description of exactly how the hardware is combined to create the complete system. For example, if the **VSUT** description lists a base chassis with 1 processor, a processor update package of 3 processors, a NIC controller and 3 disk controllers, a description of where and how the processors, NIC and disk controllers are placed within the base chassis must be **reported** in the **Report**.
- A description of how the hardware components are connected. The description can assume the reader is knowledgeable of computer systems and the TPC-VMS specification. For example, only a description that Controller 1 in slot A is connected to Disk Tower 5 is required. The reader is assumed to be knowledgeable enough to determine what type of cable is required based upon the component descriptions and how to plug the cable into the components.

7.3.4.4 A description of the steps taken to configure the VMMS software must be **reported** in the **Report**. Any and all configuration scripts or step by step GUI instructions are **reported** in the **Supporting Files** (see Clause 7.4). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-VMS specification could recreate the software environment. This includes, but is not limited to:

- A description of any updates or patches to the software.
- A description of any changes to the software.
- A description of any GUI configurations used to configure the software.

7.3.4.5 For each VM, a description of the configuration parameters for resources available to the VM must be **reported** in the **Report**. Any and all configuration scripts or step by step GUI instructions are **reported** in the **Supporting Files** (see Clause 7.4). The description, scripts and/or GUI instructions must be sufficient such that a reader knowledgeable of the VMMS could recreate the virtual environment. This includes, but is not limited to:

- A description of the minimum, maximum, initial, and target memory available to the VM
- A description of the minimum, maximum, initial, and target virtual processors available to the VM
- A description of the minimum, maximum, initial, and target processors, threads and cores available to the VM

- A description of the minimum, maximum, initial, and target virtual and physical storage available to the VM
- A description of the physical and/or virtual communications resources available to the VM

7.3.4.6 Any tuning options (Clause 2.4.3.2) used for any of the software (**Operating System**, device drivers, **DBMS**, transaction monitor, and any other software programs) that run in the **VM**s must be **reported** in the **Report**.

7.3.4.7 For software that was optimized (Clause 2.4.3.2) for the **Virtualization Environment,** the **Test Sponsor** must attest in the **Report** that the same **Software Version** will meet the requirements of Clause 2.4.3.1.

7.3.5 Reporting Requirements for Clause 3Metrics

There are no reporting requirements for TPC-VMS Clause 3.

7.3.6 Reporting Requirements for Clause 4Driver/Controller Software

7.3.6.1 Describe any modifications to the **TPC Benchmark** driver or controller software for ease of benchmarking the TPC-VMS Benchmark (Clause 4.1)

7.3.6.2 Describe any modifications to the **TPC Benchmark** driver or controller software for the synchronization of TPC-VMS Benchmark execution to be complaint with Clause 5.3.

7.3.7 Reporting Requirements for Clause 5Rules and Procedures

7.3.7.1 Describe any changes to the random number seeds used for data generation that were made to meet the requirements of Clause 5.2.1.

7.3.7.2 Describe any changes to the random number seeds used in the test runs that were made to meet the requirements of Clause 5.2.2.

7.3.7.3 For **TPC Benchmarks** that compute their primary metric from a measured time interval, report the measurement intervals for all VMs. Use **VM Identifications** to identify the **VM** measurement intervals.

7.3.7.4 For **TPC Benchmarks** that compute their primary metric from a time measure for a quantity of work, report the starting values of all tests for all **VM**s. Use **VM Identifications** to identify the **VM** measurement intervals.

7.3.8 Reporting Requirements for Clause 6 -- Pricing

Report any additional pricing related information required by the **TPC Benchmark FDR** but not reported in the **Executive Summary**. For example, the TPC-C or TPC-E 60-Day Space calculations would be reported here.

7.3.9 Reporting Requirements for Clause 7 -- Full Disclosure Report

An index for all files required by Clause 7.4 **Supporting Files** must be provided in the **Report**. The **Supporting Files** index is presented in a tabular format where the columns specify the following:

- The first column denotes the clause in the TPC-VMS Specification
- The second column provides a short description of the file contents
- The third column contains the path name for the file starting at the SupportingFiles directory.

7.3.10 Reporting Requirements for Appendix A – TPC Benchmark Executive Summary Information

Appendix A of the TPC-VMS **Report** contains any **TPC Benchmark** information, graphs or tables that would be reported in the **TPC Benchmark Executive Summary** but are not specified by Clauses 7.2.1 – 7.2.4 to be reported in the TPC-VMS **Executive Summary**. VM Identifications are used to identify the specific VM data.

7.3.10.1 The information should be organized to provide the reader an easy method of comparing the data between the VMs. Each subset of the data should be placed together with the appropriate VM Identification used to identify the VM data.

7.3.10.2 The information may be placed in **Supporting Files** if it meets Clause 7.4.3 requirements to be added to **Supporting Files**.

7.3.11 **Reporting Requirements for Appendix B – TPC Benchmark Reporting Requirements**

Appendix B of the TPC-VMS **Report** contains the **TPC Benchmark Reporting Requirements**, i.e. a **TPC Benchmark Report**. The clauses numbering follows the **TPC Benchmark** requirements but with the prefix of "B" denoting Appendix B.

7.3.11.1 **VM Identifications** are used in each of the **TPC Benchmark** reported information to clearly identify which **VM** is associated with the reported information.

7.3.11.2 For throughput vs. time graphs where the **TPC Benchmark** primary **Performance Metric** is graphed over time, the data for all **VM**s in the **VSUT** must be incorporated onto one graph. The graph lines representing the throughput for the **VM**s are to be identified using **VM Identifications**.

7.3.11.3 For all other graphs except the throughput vs. time graph, it is the **Test Sponsor**'s option to report a graph per **VM** or to consolidate the **VM** data onto one graph. If consolidated into one graph, the graph lines representing the throughput for the **VM**s are to be identified using **VM Identifications**.

7.3.11.4 In a typical **TPC Benchmark FDR** the **TPC Benchmark** clause is stated in italics followed by the **Test Sponsor**(s) reported information. In some cases the clause numbers of the TPC Benchmark are referenced. To avoid confusion with the TPC-VMS clause numbers, any **TPC Benchmark** clause numbers are to be prefixed with the **TPC Benchmark** identification as in TPC-C 9.3.1.2, TPC-H 5.1.1, TPC-DS 6.2.1 or TPC-E 3.1.

7.3.11.5 The TPC-VMS reporting requirements for the **Test Sponsor** information (clause 7.3.2.1) take precedence over any **TPC Benchmark** reporting requirements for the **Test Sponsor** information. The following sentence should be used to refer the reader to the TPC-VMS Clause 0 – Preamble reporting rules: "See the TPC-VMS Clause 0 – Preamble Test Sponsor reported information".

For example:

> **Test Sponsor**
> *A statement identifying the benchmark Test Sponsor(s) and other participating companies must be provided.*
>
> **All VMs:** See the TPC-VMS Clause 0 – Preamble Test Sponsor reported information.

7.3.11.6 The TPC-VMS reporting requirements for descriptions of the **VSUT Measured** and **Priced Configurations** (clause 7.3.4) takes precedence over any **TPC Benchmark** reporting requirements for the descriptions of the **Measured** and **Priced Configurations** of the **SUT**. The following sentence should be used to refer the reader to the TPC-VMS Clause 2 – Virtualization Environment reporting rules: "See the TPC-VMS Clause 2 – Virtualization Environment reported information".

For example:

> **Configuration Diagram**
> *Diagrams of both measured and Priced Configurations must be reported in the Report, accompanied by a description of the differences (TPC-E 9.3.1.2).*
>
> **All VMs:** See the TPC-VMS Clause 2 – Virtualization Environment reported information.

7.3.11.7 A description of the steps taken to configure the all software running inside a **VM** must follow all TPC Benchmark reporting rules.

7.3.11.8 The TPC-VMS reporting requirement for pricing takes precedence over any **TPC Benchmark** pricing reporting requirements. For pricing information that is reported in the TPC-VMS **Executive Summary**, the following sentence should be used to refer the reader to the TPC-VMS **Executive Summary**: "See the TPC-VMS Pricing information reported in the Executive Summary". For any additional pricing related information not in the TPC-VMS **Executive Summary**, the following sentence should be used to refer the reader to the TPC-VMS Clause 6 – Pricing reporting requirements: "See the TPC-VMS Clause 6 – Pricing reported information".

7.4 Supporting Files

If the **TPC Benchmark Specification** requires **Supporting Files**, then the **TPC Benchmark Specification Supporting File** directory and structure must be used with the additional directory structures specified by Clause 7.4.1. If the **TPC Benchmark Specification** does not define any **Supporting Files** directories or structures, then the Supporting Files directories and structures specified by Clause 7.4.2 must be used.

7.4.1 TPC Benchmarks with Supporting Files

The top level directories of the **TPC Benchmark Supporting File** directory structure are to be incorporated under the directories using the **VM Identification** names of ALL_VMs, VM_1, VM_2 and VM_3.

7.4.2 TPC Benchmarks without Supporting Files

The TPC-VMS **Supporting Files** directories and structures are defined in the following Clauses.

7.4.2.1 The TPC-VMS **Supporting Files** contain human readable and machine executable (i.e., able to be performed by the appropriate program without modification) scripts that are required to recreate the benchmark **Result**. If there is a choice of using a GUI or a script, then the machine executable script may be provided in the **Supporting Files**. If no corresponding script is available for a GUI, then the **Supporting Files** may contain a detailed step by step description of how to manipulate the GUI.

7.4.2.2 Directory and file names should be chosen to indicate to the casual reader what is contained within the directory or file. For example, if the requirement is to provide the scripts for all table definition statements and all other statements used to set-up the database, file names of 1, 2, 3, 4 or 5 are unacceptable. File names that include the text "tables", "index" or "frames" should be used to convey to the reader what is being created by the script.

7.4.2.3 The top level directories of the **Supporting Files** directory structure are to be incorporated under the directories using the **VM Identification** names of ALL_VMs, VM_1, VM_2 and VM_3. The directory names below the **VM Identification** directories should be descriptive of what is contained within the directory (see Clause 7.4.2.2)

For example, in a **TPC-C FDR** the source code files, database scripts and the output of software parameter settings are incorporated into an Appendix in the **FDR** pdf file. At the **Test Sponsor**'s option the information could be reported in a **Supporting Files** directory structure as follows:

SupportingFiles/All_VMs/Source/dlldata.c

SupportingFiles/All_VMs/Source/error.h

SupportingFiles/VM_1/DatabaseDesign/createdb.sql

SupportingFles/VM_2/DatabaseDesign/createdb.sql

SupportingFiles/VM_3/DatabaseDesign/createdb.sql

SupportingFiles/All_VMs/Parameters/SQL_Config.txt

SupportingFiles/All_VMs/Parameters/SQL_Super_Socket_Config.txt

SupportingFiles/All_VMs/Configuration/VMMsConfig.sh

SupportingFiles/All_VMs/Configuration/VMConfig.sh

In the TPC-VMS **TPC-C** Appendix B that describes the TPC-C reporting requirements, the **Test Sponsor** must refer the reader to the appropriate **Support Files** directory.

7.4.3 Information supplied in Supporting Files at Test Sponsor's Option

If the **TPC Benchmark Specification** does not specify the use of **Supporting Files** containing human readable and machine executable scripts, then at the **Test Sponsor**'s option the following **TPC Benchmark** information can be placed in **Support Files**:

- Any table having greater than 5 columns or 5 rows can be placed in a spreadsheet file.
- Any machine executable scripts that are required to recreate the benchmark **Result**.
- Any machine output greater than 10 lines generated by a script or GUI command.

CLAUSE 8 -- INDEPENDENT AUDIT

8.1 General Rules

8.1.1 Auditor Certification

Prior to its publication, a **TPC-VMS Result** must be reviewed by a **TPC-Certified,** independent **Auditor.**

Comment 1: The **Auditor** must be independent from the **Test Sponsor** in that the outcome of the benchmark carries no financial benefit to the **Auditor**, other than fees earned as a compensation for performing the audit. More specifically:

- The **Auditor** is not allowed to have supplied any performance consulting for the benchmark under audit.
- The **Auditor** is not allowed to be financially related to the **Test Sponsor** or to any one of the suppliers of a measured/priced component (e.g., the **Auditor** cannot be an employee of an entity owned wholly or in part by the **Test Sponsor** or by the supplier of a benchmarked component, and the **Auditor** cannot own a significant share of stocks from the **Test Sponsor** or from the supplier of any benchmarked component, etc.)

8.1.1.1 All audit requirements specified in the version of the TPC Pricing Specification, located at *www.tpc.org* must be followed.

8.1.2 Scope of Audit

The scope of the audit is limited to the functions defined in this specification in addition to the functions defined in the **TPC Benchmark Standard** used to generate the **TPC-VMS Result.**

8.1.3 Optional TPC-Energy Standard

When the optional TPC-Energy standard is used, the additional audit requirements must be followed. In addition, the requirements of the TPC-Energy Specification, located at *www.tpc.org*, must be met.

8.1.4 Auditor Checklist

A generic audit checklist is provided as part of this specification. The **generic** audit checklist specifies the TPC-VMS requirements that must be checked to ensure a **TPC-VMS Result** is compliant with the TPC-VMS Specification in addition to the **TPC Benchmark Standard** used to generate the **TPC-VMS Result**. Not only should the TPC-VMS requirements be checked for accuracy but the **Auditor** must ensure that the **FDR** accurately reflects the audited **Result**. The **Auditor** may choose to provide the **Test Sponsor** with additional details on the TPC-VMS audit process.

8.1.5 Attestation Letter

The **Auditor**'s opinion regarding the compliance of a **Result** must be consigned in an **Attestation Letter** delivered directly to the **Test Sponsor**. To document that a **Result** has been audited, the **Attestation Letter** must be included in the **Report** and made readily available to the public. Upon request, and after approval from the **Test Sponsor**, a detailed audit report may be produced by the **Auditor**.

8.2 Auditor's Checklist

8.2.1 Clause 2 Virtualization Environment Related Items

8.2.1.1 Verify that all I/O devices are virtualized (see Clause 2.4.2.3).

8.2.1.2 If an I/O controller is used to virtualize the I/O, verify that either the controller specifications state that the controller will virtualize more than 1 VM or verify that the controller can actually support more than 1 VM (see Clause 2.4.2.3).

8.2.1.3 Verify that the **Test Sponsor** has attested in the **Report** that for software that was optimized (Clause 2.4.3.2) for the **Virtualization Environment** the same **Software Version** will meet the requirements of Clause 2.4.3.1.

8.2.1.4 Verify that there is no sharing of information directly or indirectly between the **Consolidated Database Server VM**s running the **DBMS** software (see Clause 2.5.1).

8.2.1.5 If the **Application** software is implemented on the **Consolidated Database Server** in a separate VM, verify that the communication between the **Application** software and the **DBMS** is through commercially available software interfaces (see Clause 2.5.3.1).

8.2.2 **Clause 3 Metrics Related Items**

8.2.2.1 Verify that **TPC-VMS Primary Performance Metric** is the minimum value of the **TPC Benchmark** Primary metric from one of the **TPC Benchmarks** run in the **Virtualization Environment** (see Clause 3.2).

8.2.3 **Clause 4 Driver/Controller Related Items**

8.2.3.1 Verify there is no sharing of information between the **TPC Benchmark** drivers other than allowed by Clause 4.1.1.

8.2.4 **Clause 5 Rules and Procedures Related Items**

8.2.4.1 For **TPC Benchmarks** that allow the changing of the random number seeds for the data generation scripts, verify that different random number seeds are used in the data generation scripts for each **TPC Benchmark** (see Clause 5.2.1.1).

8.2.4.2 If the same set of files was used to load all databases, verify that the **TPC Benchmark** uses fixed random number seeds for the data generation scripts, (Clause 5.2.1.3).

8.2.4.3 For **TPC Benchmarks** that allow the changing of the starting random number seed values for the test run, verify that the test run commands start with different random number seeds for each **TPC Benchmark** (see Clause 5.2.2).

8.2.4.4 For **TPC Benchmarks** that use a measured time interval, verify the start times and durations of each **TPC Benchmark** (see Clause 5.3.1).

8.2.4.5 For **TPC Benchmarks** that use a time measure for a quantity of work, verify the start times of each **TPC Benchmark** and **TPC Benchmark Test** (see Clause 5.3.2).

8.2.4.6 Verify compliant use of load balancing, tuning commands or directives (see Clause 5.3.3).

8.2.5 **Clause 6 Pricing Related Items**

Rules for auditing Pricing information are specified in the effective version of the TPC Pricing Specification located at www.tpc.org.

8.2.5.1 Verify that the required components are included in the Priced Configuration (see Clause 6.1).

8.2.5.2 Verify that all component **Substitutions** are compliant with the **TPC Benchmark** and **TPC Pricing Specifications** (see Clause 6.2).

8.2.6 **Clause 7 FDR Related Items**

For the Audit requirements specified in Clauses 8.2.1 through 8.2.5, the Auditor must ensure that if required by Clause 7, the items, requirements or values are correctly reported in the **FDR**.

For those items, requirements or values that are reported in the **FDR** and not required to be audited, the Auditor need only ensure that they are in the **FDR** and appear to be reasonable. For example, the Auditor cannot be held responsible for accuracy of the Availability Date but can ensure that it is reported in the **FDR** and does not fall outside the 6 month availability window starting from the publication date.

8.2.6.1 Verify that the order and titles of sections in the Report and any Supporting Files is compliant (see Clause 7.1.1.1)

8.2.6.2 Verify that the reporting rules of the TPC Pricing Specification were followed (see Clause 7.1.1.2)

8.2.6.3 Verify that VM Identification is accurate (see Clause 7.1.2).

8.2.6.4 Verify that the **Executive Summary Statement** is accurate and is compliant (see Clause 7.2).

8.2.6.5 For those items which are required by Clause 7.3 to be reported in the Report and are also required by Clauses 8.2.2 through 8.2.5 to be verified by the **Auditor**, verify that the items are accurately **reported** in the **Report**. For those items which are required to be **reported** by Clause 7.3 but are not required to be verified by the **Auditor**, ensure that the items are reported in the **Report** and appear to be reasonable.

8.2.6.6 Verify that the following sections of the **FDR** are accurate:

- Verify that the diagram illustrating the **VSUT** is accurate (see Clause 7.3.4.1).
- Verify that the diagram illustrating the **Priced Configuration** is accurate (see Clause 7.3.4.1).

A complete review of the **Report** by the **Auditor**, beyond the sections listed above, can be requested by the **Test Sponsor**, but is not required.

8.2.6.7 Verify that the required **Supporting Files** exist and appear to be reasonable (see Clause 7.4).

8.2.7 **Auditing the Databases, Transactions, ACI, Drivers & TPC Provided Code**

For the selected **TPC Benchmark** being run in each **VM**, verify that the **TPC Benchmark Standard** Audit Requirements have been followed (see Clause 2.3) for the Database, Transactions, ACI of ACID requirements, Driver/Controlling Software and any TPC provided code.

Comment: Conceptually, each VM represents an independent audit environment for the selected **TPC Benchmark** and requires a Full Audit (see TPC Policies Clause 9.5.3). For ease of benchmarking TPC Policies allow for the work of one audit to be leveraged in another audit (Updated Audit) where appropriate. The degree to which previous audits may be leveraged is left to the discretion of the auditor. Similarly, the degree to which audit work performed in one VM may be leverage across the other VMs is left to the discretion of the auditor. In evaluating this, the following items should be carefully evaluated.

- OS version
- DBMS version
- Version of any TPC provided code
- Number of vCPUs
- Amount of memory per VM

- OS parameters
- DBMS parameters
- Database Schema
- Database initial population size
- VM parameters
- Storage Space configuration/characteristics allocated to the VM
- Virtual Durability configuration/characteristics
- Physical Storage Space configuration/characteristics to be the same (types, amounts, configuration)
- Physical Durability configuration/characteristics.

8.2.8 Auditing of Execution Rules and Metrics

Verify that each **VM** has followed the **TPC Benchmark Standard** Audit Requirements for the Execution Rules and Metrics.

8.2.9 Auditing of Durability

All implementations of the TPC Benchmarks in the **VSUT** must meet the Durability requirements as specified in their TPC Benchmark Specifications.

8.2.9.1 All VMs must meet the Durability throughput requirements of their TPC Benchmark Specifications at the time of the Durability test.

8.2.9.2 All VMs must meet the ending requirements of their TPC Benchmark Durability requirements upon completion of the Durability test.

8.2.9.3 Storage Durability tests must be applied to the physical devices, including physical devices within a virtualized subsystem.

8.2.9.4 For Durability tests that target more than one **VM**, only one test may be performed for those **VM**s. For example, a loss of power test that targets all **VM**s in the **VSUT** may only be performed once and not once for each **VM**.

8.2.9.5 For a Durability test that targets a subset of **VM**s, the induced failure of the **VM**s being tested cannot induce a failure in any untested **VM**s. The untested **VM**s must continue to accept and commit transactions as required by their respective TPC Benchmark Durability tests.

8.2.9.6 Results of a Durability test that targets a subset of **VM**s may be applied to any of the untested **VM**s if the **VM**s involved are identical (See Clause **Error! Reference source not found.**).

Comment: For example if a storage device is removed on one **VM**, the Durability results can be used to satisfy any of the other **VM**s if the exact same type of storage device and exact same versions of software to access the storage device are used. The Auditor chooses which Durability test is to be run on which of the **VM**s that use the same software versions and hardware implementation.

Appendix A. SAMPLE EXECUTIVE SUMMARIES

The following pages provide TPC-VMS **Executive Summary** templates and examples for the TPC-VMS **TPC-E** and TPC-VMS **TPC-H** publications. It is expected that a TPC-VMS **TPC-C Executive Summary** will be similar to the TPC-VMS **TPC-E Executive Summary** template (Clause A.1) and example (Clause A.1) and that the T**PC-VMS TPC-DS Executive Summary** will be similar to the TPC-VMS **TPC-H Executive Summary** template (Clause A.3) and example (Clause A.4).

A.1 Template Layout for TPC-VMS TPC-E Executive Summary

The following templates define the format, style, font and minimum font sizes to be used by the TPC-VMS **TPC-E Executive Summary**. The template for the pricing pages of the **Executive Summary** is defined by the TPC Pricing Specification.

Sponsor Name and/or Logo (3b)	**System Name** (3b)		**TPC-VMS:** x.y.z (2b) **TPC-E:** x.y.z (2b) **TPC Pricing:** x.y.z (2b) **TPC-Energy:** x.y.z (2b) **Report Date:** Month, Day, Year (2b)	
Performance (2) **xxx.xx VMStpsE** (2b)	Price/Performance (2) **$ xxx.xx USD per VMStpsE** (2b)	Availability Date (2) **Month, Day, Year** (2b)	Total System Cost (2) **$ XX,XXX USD** (2b)	TPC-Energy Metric (2) **xx.xx Watts/VMStpsE (2b)**
Virtual System Under Test Configuration (3b)				
VMMS (2) **VMMS Name** (2b)	Processors/Cores/Threads (2) **X/X/X** (2b)		Memory (2) **XX GB** (2b)	

- Place Configuration Diagram Here
- Diagram must include the following:
    - Graphic representation of the Virtual System Under Test
    - Graphic representation of the disk subsystem
    - Graphic representation of the Tier A system(s)
    - List of system components in the Virtual System Under Test
        - Processors (quantity and type), Cores, and Threads
        - Memory
        - Disk controllers (quantity and type)
        - Disk drives (quantity and type)
        - Network interface cards (quantity and type)
        - Other components
    - List of system components in the Tier A system(s)
        - Processors (quantity and type), Cores, and Threads
        - Memory
        - Disk controllers (quantity and type)
        - Disk drives (quantity and type)
        - Network interface cards (quantity and type)
- Font
    - Times New Roman or Arial
- Size
    - Minimum 12 point type, normal

Style Legend

Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)		TPC-VMS: x.y.z (2b) TPC-E: x.y.z (2b) TPC Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
	VM 1 (3b)	**VM 2** (3b)	**VM 3** (3b)
Performance (2)	xxx tpsE (2)	xxx tpsE (2)	xxx tpsE (2)
Maximum Number of Virtual Processors (2)	x (2)	x (2)	x (2)
VM Memory (2)	xx GB (2)	xx GB (2)	xx GB (2)
Maximum Capacity of Virtual Storage (2)	x,xxx GB (2)	x,xxx GB (2)	x,xxx GB (2)
Operating System (2)	(2)		
Database Manager (2)	(2)	(2)	(2)
Scaling Component (2)	xxx,xxx Customers (2)	xxx,xxx Customers (2)	xxx,xxx Customers (2)
Initial Number of Rows Per VM (2)	xxx,xxx,xxx,xxx (2)	xxx,xxx,xxx,xxx (2)	xxx,xxx,xxx,xxx (2)
Initial Database Size Per VM (2)	x,xxx GB (2)	x,xxx GB (2)	x,xxx GB (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1) Minimum 10 point type, normal
(2) Minimum 12 point type, normal
(2b) Minimum 12 point type, bold
(3) Minimum 14 point type, normal
(3b) Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)			TPC-VMS: x.y.z (2b) TPC-E: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
Total System Cost (2)	TPC-VMS Throughput (2)	Price/Performance (2)	Availability Date (2)	TPC-Energy Metric (2)
$xx,xxx USD (2b)	xxx.xx VMStpsE (2b)	$xxx.xx USD/VMtpsE (2b)	Month, Day, Year (2b)	xx.xx watts/VMStpsE (2b)

Numerical Quantities For Reported Energy Configuration (2)

REC Idle Power: x,xxx watts (2)

Average Power of REC: xx,xxx.xx watts (2)

Subsystem Reporting: (2)

Seconday (subsystem) Metrics are not reported. (2)

Comparisons to other TPC-Energy Results must nor reference subsystem energy information. (2)

Lowest ambient temperature at air inlet: xx.xx Degrees Celsius (2)

Items in Priced Configuration not in Reported Energy Configuration: (2)

Items in the Reported Energy Configuration not in the Measured Energy Configuration: (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)	TPC-VMS: x.y.z (2b) TPC-E: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)

VM 1 Numerical Quantities Summary (3b)

Reported Throughput: (2b) xxx.xx VMStpsE (2b) **Configured Customers:** (2b) xxx,xxx (2b)

Response Times (in seconds) (3b)	Minimum (2b)	Average (2b)	90th %tile (2b)	Maximum (2b)
Broker Volume	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Customer Position	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Market Feed	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Market Watch	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Security Detail	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Trade Lookup	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Trade Order	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Trade Result	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Trade Status	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Trade Update	xx.xx (2)	xx.xx (2)	xx.xx (2)	xx.xx (2)
Data Maintenance	xx.xx (2)	xx.xx (2)		xx.xx (2)

Transaction Mix (3b)	Transaction Count (2b)	Mix % (2b)
Broker Volume	xxx,xxx,xxx (2)	xx.xx% (2)
Customer	xxx,xxx,xxx (2)	xx.xx% (2)
Market Feed	xxx,xxx,xxx (2)	xx.xx% (2)
Market Watch	xxx,xxx,xxx (2)	xx.xx% (2)
Security Detail	xxx,xxx,xxx (2)	xx.xx% (2)
Trade Lookup	xxx,xxx,xxx (2)	xx.xx% (2)
Trade Order	xxx,xxx,xxx (2)	xx.xx% (2)
Trade Result	xxx,xxx,xxx (2)	xx.xx% (2)
Trade Status	xxx,xxx,xxx (2)	xx.xx% (2)
Trade Update	xxx,xxx,xxx (2)	xx.xx% (2)
Data Maintenance	xxx (2)	

Ramp-up Time	Hour:Minute:Second (2)
Measurement Interval	Hour:Minute:Second (2)
Business Recovery Time	Hour:Minute:Second (2)
Total Number of Transactions Completed in Measurement Interval	xxx,xxx,xxx (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

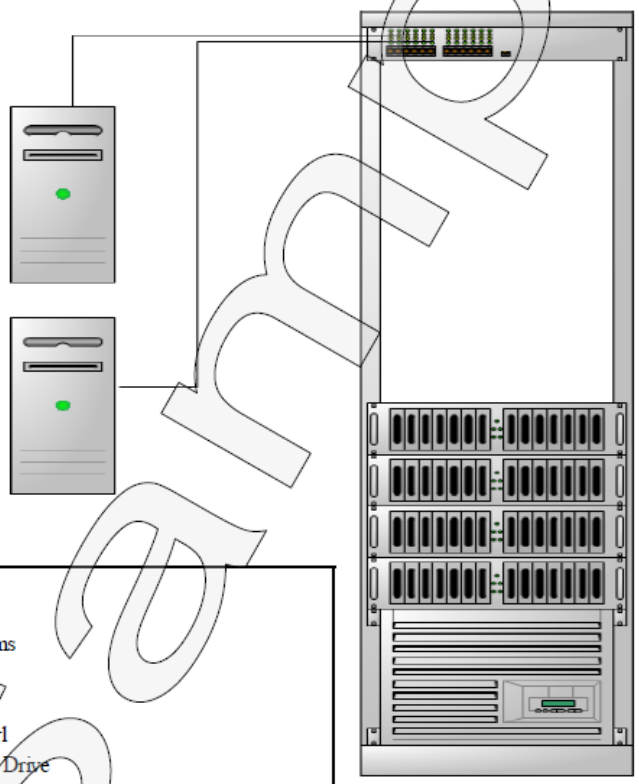
A.2 Sample Layout for TPC-VMS TPC-E Executive Summary

	Super Widget Model RV01234	TPC-VMS: 1.0.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012

Performance	Price/Performance	Availability Date	Total System Cost	TPC Energy Metric
187.00 VMStpsE	**$ 482.66 USD per VMStpsE**	**April 1, 2012**	**$ 90,258 USD**	**58.65 Watts/VMStpsE**

Virtual System Under Test Configuration

VMMS	Processors/Cores/Threads	Memory
Virtually Virtual Mangement System	**4/8/8**	**16 GB**



Tier A Clients
- 2 x Super-Duper Systems
  - 1 x Processor 2950
  - 4 x 256GB Memory
  - 1 x Internal SCSI Ctrl
  - 1 x 25GB, 10K, SAS Drive
  - 2 x 1GB Ethernet Ports

Super Widget Server
- 6 x Dual-Core Processor 995 3.0 GHz w/1MB L2
- 2 x 32GB Memory
- 1 x Internal PCI Dual-Port SAS Controller
- 2 x Gigabit Ethernet Ports
- 56 x 75GB SAS Drives

Sample

	Super Widget Model RV01234		TPC-VMS: 1.0.0 TPC-E: 1.12.0 TPC Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012
	VM 1	VM 2	VM 3
Performance	187 tpsE	191 tpsE	192 tpsE
Maximum Number of Virtual Processors	4	4	4
VM Memory	16 GB	16 GB	16 GB
Maximum Capacity of Virtual Storage	2,200 GB	2,200 GB	2,200 GB
Operating System	ACME OS V2.4 wth Some Recent Service Pack and Some Other Add-On for More Performance		
Database Manager	ACME RDBMS V5.5		
Scaling Component	100,000 Customers	100,000 Customers	100,000 Customers
Initial Number of Rows Per VM	28,903,281,948	28,903,281,948	28,903,281,948
Initial Database Size Per VM	2,040 GB	2,040 GB	2,040 GB

Sample

Super Widget Model RY01234

TPC-VMS:	1.0.0
TPC-E:	1.12.0
TPC-Pricing:	1.6.0
TPC-Energy:	1.5.0
Report Date:	April 1, 2012

Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date	TPC-Energy Metric
$90,258.00	187.00 VMStpsE	482.66 USD/VMtpsE	April 1, 2012	58.65 watts/VMStpsE

Numerical Quantities For Reported Energy Configuration

REC Idle Power: 9,945 watts

Average Power of REC: 10,968 watts

	Secondary Metrics	Additional Numerical Quantities			
	Watts / VMStpsE	Full Load Avg. Watts	Full Load % of REC	Idle Avg. Watts	Idle % of REC
Database Server	8.56	1,601.34	14.6%	1,237.84	12.4%
Storage	45.78	8,561.20	78.1%	7,944.79	79.9%
Application Server	3.71	693.29	6.3%	650.31	6.5%
Miscellaneous	0.60	112.37	1.0%	112.48	1.1%
Total REC	58.65	10,968	100%	9,945.42	100%

Lowest ambient temperature at air inlet: 20.32 °C

Items in Priced Configuration no in the Reported Energy Configuration: None

Items in Reported Energy Configuration no in the Measured Energy Configuration: None

Sample

	Super Widget Model RY01234				TPC-VMS:	1.0.0
					TPC-E:	1.12.0
					TPC-Pricing:	1.7.0
					TPC-Energy:	1.5.0
					Report Date:	April 1, 2012
Description	**Part Number**	**Price Source**	**Unit Price USD**	**Qty**	**Extended Price USD**	**3-YR Maint. Price USD**
Consolidated Database Server Hardware						
Super Widget Model RY01234	5839-001	1	3,500	1	3,500	
Super Widget Processor Kit	5827-321	1	6,000	6	36,000	
Super 32GB Memory Module	6492-294	1	8,000	2	16,000	
Super 15-in Monitor	M3849-293	1	125	1	125	
Keyboard/Mouse Bundle	K3728-289	1	25	1	25	
Super 3 Year Service Package	S4738	1	1,000	1		1,000
			Sub Total		55,650	1,000
Consolidated Database Server Storage						
Super Widget Nifty Storage Enclosure	SE37-398	1	3,000	4	12,000	
Super 75GB SAS Drive	3728-003	1	350	56	19,600	
Super Widget Rack Enclosure	R382-923	1	275	1	275	
			Sub Total		31,875	0
Consolidated Database Server Software						
ACME OS V2.4	SW65-389	2	500	1	500	
ACME OS TPC Performance Package	SW11-001	2	10	1	10	
ACME RDBMS V5.5	SW47-237	2	1,000	1	1,000	
ACME 3 Year Software Maintenance	SW99-192	2	450	1		450
			Sub Total		1,510	450
Client Hardware						
Super-Duper 2950 System	4328-091	1	450	2	900	
Super 3 Year Service Package	S4735	1	250	1		250
			Sub Total		900	250
Client Software						
ACME Desktop V10.1	SW22-039	2	150	2	300	
			Sub Total		300	0
Infrastructure						
SomeCheap 24-Port Switch	T5730-029	3	75	1	75	
SomeCheap Ethernet Cable Package	C4780-893	3	15	2	30	
SomeCheap 3-Year Hardware Coverage	W384-223	3	25	1		25
			Sub Total		105	25
		Total Extended Price			$90,340	$1,725
Super Widget 2% Discount		**Total Discounts**			$1,807	$0
		Grand Total			$88,533	$1,725
Pricing: 1=Super Direct, 2 = ACME, 3=SomeCheap		**Three-year Cost of Ownership: USD**				**$90,258**
Network Components		**VMStpsE**				**187.00**
		$ USD/VMStpsE				**$482.66**

Benchmark results and test methodology audited by [Auditor Names and Companies]

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed components. For complete details, see the pricing 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.

Sample

	Super Widget Model RY01234	TPC-VMS: 1.0.0 TPC-E: 1.12.0 TPC-Pricing: 1.6.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012

VM 1 Numerical Quantities Summary

Reported Throughput 187.00 VMStpsE **Configured Customers:** 100,000

Response Times (in seconds)	Minimum	Average	90th %tile	Maximum
Broker Volume	0.00	0.06	0.10	2.72
Customer Position	0.00	0.04	0.06	4.56
Market Feed	0.00	0.03	0.05	6.94
Market Watch	0.00	0.04	0.08	4.56
Security Detail	0.00	0.02	0.04	2.64
Trade Lookup	0.00	0.41	0.61	5.08
Trade Order	0.00	0.08	0.13	19.56
Trade Result	0.00	0.10	0.16	20.41
Trade Status	0.00	0.02	0.04	4.52
Trade Update	0.01	0.46	0.63	5.03
Data Maintenance	0.00	0.07		0.54

Transaction Mix	Transaction Count	Mix %
Broker Volume	659,736	4.904%
Customer Position	1,750,320	13.012%
Market Feed	134,640	1.001%
Market Watch	2,423,520	18.016%
Security Detail	1,884,960	14.013%
Trade Lookup	1,077,120	8.007%
Trade Order	1,347,746	10.019%
Trade Result	1,346,400	10.009%
Trade Status	2,558,160	19.017%
Trade Update	269,280	2.002%
Data Maintenance	120	

Ramp-up Time	1:08:00
Measurement Interval	2:00:00
Business Recovery Time	0:56:45
Total Number of Transactions Completed in Measurement Interval	13,451,882

Sample

A.3 Template Layout for TPC-VMS TPC-H Executive Summary

The following templates define the format, style, font and minimum font sizes to be used by the TPC-VMS **TPC-H Executive Summary**. The template for the pricing pages of the **Executive Summary** is defined by the TPC Pricing Specification.

Sponsor Name and/or Logo (3b)	**System Name** (3b)		TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)	
Performance (2) x,xxx.x VMSQphH@xGB (2b)	Price/Performance (2) $ xx.xx USD per VMSQphH@xGB (2b)	Availability Date (2) Month, Day, Year (2b)	Total System Cost (2) $ xxx,xxx USD (2b)	TPC Energy Metric (2) xx.xx Watts/VMSQphH@xGB (2b)
Virtual System Under Test Configuration (3b)				
VMMS (2) (2b)	Processors/Cores/Threads (2) x/x/x (2b)	Memory (2) xx GB (2b)		

- Place Configuration Diagram Here
- Diagram must include the following:
    - Graphic representation of the Virtual System Under Test
    - Graphic representation of the disk subsystem
    - Graphic representation of the Tier A system(s)
    - List of system components in the Virtual System Under Test
        - Processors (quantity and type), Cores, and Threads
        - Memory
        - Disk controllers (quantity and type)
        - Disk drives (quantity and type)
        - Network interface cards (quantity and type)
        - Other components
- Font
    - Times New Roman or Arial
- Size
    - Minimum 12 point type, normal

Style Legend

Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)		TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
	VM 1 (3b)	VM 2 (3b)	VM 3 (3b)
Performance (2)	xx,xxx QphH@xGB (2)	xx,xxx QphH@xGB (2)	xx,xxx QphH@xGB (2)
Maximum Number of Virtual Processors (2)	x (2)	x (2)	x (2)
VM Memory (2)	xx GB (2)	xx GB (2)	xx GB (2)
Maximum Capacity of Virtual Storage (2)	x,xxx GB (2)	x,xxx GB (2)	x,xxx GB (2)
Operating System (2)	(2)		
Database Manager (2)	(2)	(2)	(2)
Scaling Component	xxxxGB (2)		
Initial Number of Rows Per VM (2)	xxx,xxx,xxx,xxx (2)	xxx,xxx,xxx,xxx (2)	xxx,xxx,xxx,xxx (2)
Initial Database Size Per VM (2)	x,xxx GB (2)	x,xxx GB (2)	x,xxx GB (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1) Minimum 10 point type, normal
(2) Minimum 12 point type, normal
(2b) Minimum 12 point type, bold
(3) Minimum 14 point type, normal
(3b) Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)			TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
Total System Cost (2)	TPC-VMS Throughput (2)	Price/Performance (2)	Availability Date (2)	TPC-Energy Metric (2)
$xx,xxx USD (2b)	xxx.xx VMSQphh@xGB (2b)	$xxx.xx USD/VMQphH@xGB (2b)	Month, Day, Year (2b)	xx.xx watts/VMSQphH@xGB (2b)

Numerical Quantities For Reported Energy Configuration (2)

REC Idle Power: xxx.xx watts (2)

Average Power of REC: xx,xxx.xx watts (2)

Subsystem Reporting: (2)

Seconday (subsystem) Metrics are not reported. (2)

Comparisons to other TPC-Energy Results must nor reference subsystem energy information. (2)

Lowest ambient temperature at air inlet: xx.xx Degrees Celsius (2)

Items in Priced Configuration not in Reported Energy Configuration: (2)

Items in the Reported Energy Configuration not in the Measured Energy Configuration: (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1) Minimum 10 point type, normal

(2) Minimum 12 point type, normal

(2b) Minimum 12 point type, bold

(3) Minimum 14 point type, normal

(3b) Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	System Name (3b)		TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
Total System Cost (2)	TPC-VMS Throughput (2)	Price/Performance (2)	Availability Date (2)
$ xx,xxx (2b)	xxx.xx VMSQphh@xGB (2b)	$ xxx.xx USD/VMQphH@xGB (2b)	Month, Day, Year (2b)

VM 1 Implementation Overview

< Graph of Reported Query Times >

Style Legend

Font - Times New Roman or Arial

Sizes

(1) Minimum 10 point type, normal
(2) Minimum 12 point type, normal
(2b) Minimum 12 point type, bold
(3) Minimum 14 point type, normal
(3b) Minimum 14 point type, bold

Database Load Time = HH:MM:SS (2)	Storage Redundancy Levels (2)			
Load Included Backup: (2)	Base Tables (2)	x	DBMS Temporary Tables	x
Total Storage / Database Size = xx.x (2)	Auxiliary Data Structures (2)	x	OS and DBMS Software	x
Memory / Database Size = xx% (2)				

Note: Database Size includes on raw data (e.g. no temp DB, indexes, or redundant space)

Sponsor Name and/or Logo (3b)	Super Widget Model RY01234		TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date
$ xx,xxx (2b)	xxx.xx VMSQphh@xGB (2b)	$ xxx.xx USD/VMQphH@xGB (2b)	Month, Day, Year (2b)

VM 1 Numerical Quantities (3b)

Measurement Results: (3b)

<Measurement Results Data> (2)

Measurement Intervals: (3b)

<Measurement Interval Data> (2)

Duration of Stream Execution: (3b)

<Stream Duration Chart> (2)

Style Legend

Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

Sponsor Name and/or Logo (3b)	Super Widget Model RY01234		TPC-VMS: x.y.z (2b) TPC-H: x.y.z (2b) TPC-Pricing: x.y.z (2b) TPC-Energy: x.y.z (2b) Report Date: Month, Day, Year (2b)
Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date
$ xx,xxx (2b)	xxx.xx VMSQphh@xGB (2b)	$ xxx.xx USD/VMQphH@xGB (2b)	Month, Day, Year (2b)

VM 1 TPC-H Timing Interval (in seconds) (3b)

<Stream/Query Timing Chart> (2)

Style Legend

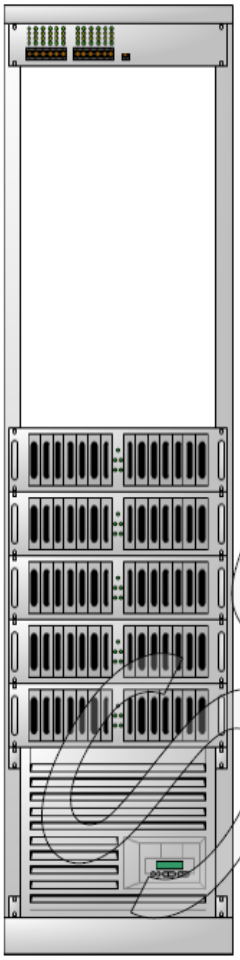
Font - Times New Roman or Arial

Sizes

(1)	Minimum 10 point type, normal
(2)	Minimum 12 point type, normal
(2b)	Minimum 12 point type, bold
(3)	Minimum 14 point type, normal
(3b)	Minimum 14 point type, bold

A.4 Sample Layout for TPC-VMS TPC-H Executive Summary

	Super Widget Model RV01234			TPC-VMS: 1.0.0 TPC-H: 2.14.3 TPC Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012	
Performance	Price/Performance	Availability Date	Total System Cost	TPC Energy Metric	
2,434.2 VMSQphH@100GB	$ 39.67 USD per VMSQphH@100GB	April 1, 2012	$ 96,574 USD	9.58 Watts/VMSQphH@100GB	
Virtual System Under Test Configuration					
VMMS	Processors/Cores/Threads	Memory			
Virtually Virtual Mangement System	4/8/8	16 GB			



Super Widget Server
- 6 x Dual-Core Processor 995 3.0 GHz w/1MB L2
- 2 x 32GB Memory
- 1 x Internal PCI Dual-Port SAS Controller
- 2 x Gigabit Ethernet Ports
- 70 x 75GB SAS Drives

Sample

	Super Widget Model RV01234		TPC-VMS: 1.0.0 TPC-H: 2.14.3 TPC-Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012
	VM 1	VM 2	VM 3
Performance	2,434.2 QphH@100GB	2,436.5 QphH@100GB	2,440.1 QphH@100GB
Maximum Number of Virtual Processors	4	4	4
VM Memory	16 GB	16 GB	16 GB
Maximum Capacity of Virtual Storage	1,700 GB	1,700 GB	1,700 GB
Operating System	ACME OS V2.4 with Some Recent Service Pack and Some Other Add-On for More Performance		
Database Manager	ACME RDBMS V5.5		
Scaling Component	100GB		
Initial Number of Rows Per VM	2,216,037,932	2,216,037,932	2,216,037,932
Initial Database Size Per VM	684 GB	684 GB	684 GB

Sample

	Super Widget Model RY01234			TPC-VMS: 1.0.0 TPC-H: 2.14.3 TPC-Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012
Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date	TPC-Energy Metric
$96,574.00	2,434.2 VMSQphH@100GB	39.67 USD/VMSQphH@100GB	April 1, 2012	9.58 watts/KVMSQphH@100GB

Numerical Quantities For Reported Energy Configuration

REC Idle Power: 703.52 watts

Average Power of REC: 1,030.57 watts

Subsystem Reporting:

Seconday (subsystem) Metrics are not reported.

Comparisons to other TPC-Energy Results must nor reference subsystem energy information.

Lowest ambient temperature at air inlet: 21.26 Degrees Celsius

Items in Priced Configuration not in Reported Energy Configuration:

Items in the Reported Energy Configuration not in the Measured Energy Configuration:

Sample

Super Widget Model RY01234

TPC-VMS:	1.0.0
TPC-H:	2.14.3
TPC-Pricing:	1.7.0
TPC-Energy:	1.5.0
Report Date:	April 1, 2012

Description	Part Number	Price Source	Unit Price USD	Qty	Extended Price USD	3-YR Maint. Price USD
Consolidated Database Server Hardware						
Super Widget Model RY01234	5839-001	1	3,500	1	3,500	
Super Widget Processor Kit	5827-321	1	6,000	6	36,000	
Super 32GB Memory Module	6492-294	1	8,000	2	16,000	
Super 15-in Monitor	M3849-293	1	125	1	125	
Keyboard/Mouse Bundle	K3728-289	1	25	1	25	
Super 3 Year Service Package	S4738	1	1,000	1		1,000
			Sub Total		55,650	1,000
Consolidated Database Server Storage						
Super Widget Nifty Storage Enclosure	SE37-398	1	3,000	5	15,000	
Super 75GB SAS Drive	3728-003	1	350	70	24,500	
Super Widget Rack Enclosure	R382-923	1	275	1	275	
			Sub Total		39,775	0
Consolidated Database Server Software						
ACME OS V2.4	SW65-389	2	500	1	500	
ACME OS TPC Performance Package	SW11-001	2	10	1	10	
ACME RDBMS V5.5	SW47-237	2	1,000	1	1,000	
ACME 3 Year Software Maintenance	SW99-192	2	450	1		450
			Sub Total		1,510	450
Infrastructure						
SomeCheap 24-Port Switch	T5730-029	3	75	1	75	
SomeCheap Ethernet Cable Package	C4780-893	3	15	2	30	
SomeCheap 3-Year Hardware Coverage	W384-223	3	25	1		25
			Sub Total		105	25
		Total Extended Price			$97,040	$1,475
Super Widget 2% Discount		**Total Discounts**			$1,941	$0
		Grand Total			$95,099	$1,475

Pricing: 1=Super Direct, 2 = ACME, 3=SomeCheap
Network Components

Three-year Cost of Ownership: USD	**$96,574**
VMSQphH @ 100GB	**2,434.2**
$ USD/VMSQphH @ 100GB	**$39.67**

Benchmark results and test methodology audited by [Auditor Names and Companies]

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed components. For complete details, see the pricing 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.

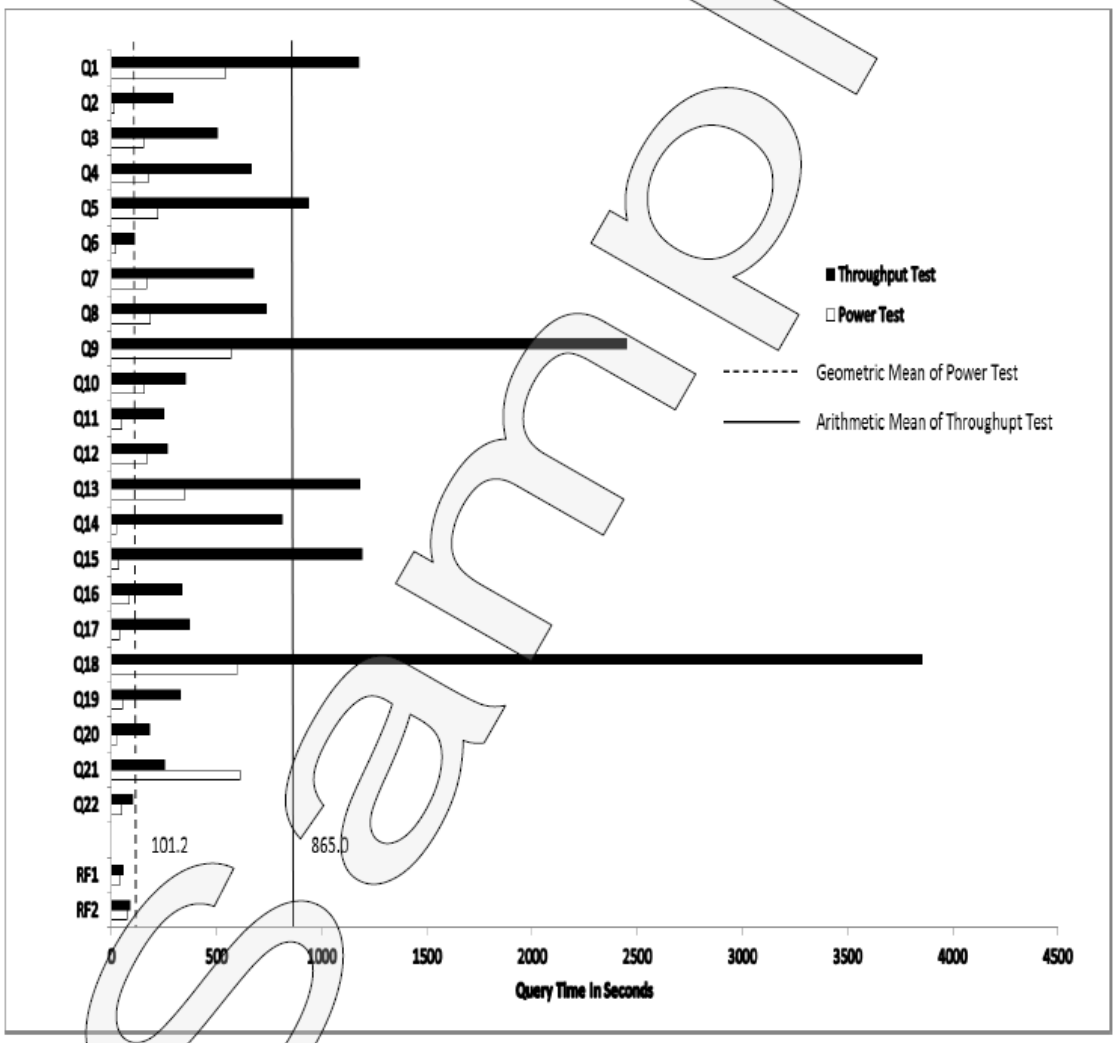
Sample

Super Widget Model RY01234

TPC-VMS:	1.0.0
TPC-H:	2.14.3
TPC-Pricing:	1.7.0
TPC-Energy:	1.5.0
Report Date:	April 1, 2012

Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date
$96,574.00	2,434.2 VMSQphH @ 100GB	$ 39.67 USD/VMSQphh @ 100GB	April 1, 2012

VM 1 Implementation Overview



Database Load Time = 3:35:22	Storage Redundancy Levels			
Load Included Backup: Y	Base Tables	0	DBMS Temporary Tables	0
Total Storage / Database Size = 17.0	Auxiliary Data Structures	1	OS and DBMS Software	1
Memory / Database Size = 16%				

Note: Database Size includes on raw data (e.g. no temp DB, indexes, or redundant space)

Sample

	Super Widget Model RY01234		TPC-VMS: 1.0.0 TPC-H: 2.14.3 TPC-Pricing: 1.7.0 TPC-Energy: 1.5.0 Report Date: April 1, 2012
Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date
$96,574.00	2,434.2 VMSQphh@100GB	$ 39.67 USD/VMQphH@100GB	April 1, 2012

VM 1 Numerical Quantities

Measurement Results:

Database Scale Factor	= 100GB
Total Data Storage / Database Size	= 17.0
Start of Database Load	= 2012-01-01 21:05:35
End of Database Load	= 2012-01-01 23:59:58
Database Load Time	= 2:54:23
Query Streams for Throughput Test	= 5
VMS TPC-H Power	= 3322.7
VMS TPC-H Throughput	= 1781.8
VMS TPC-H Composite Query-per-Hour Metric (QphH@100GB)	= 2,434.2
Total System Price Over 3 Years	= $96,574
VMS TPC-H Price/Performance Metric ($/QphH@100GB)	= $39.67

Measurement Intervals:

Measurement Intervals in Throughput Test (Ts)	= 20,757.4 seconds

Duration of Stream Execution:

Stream ID	Seed	Start Date	Start Time	Stop Date	Stop Time	Duration
Stream00	703235958	1/1/2012	7:46:46	1/1/2012	9:00:06	1:13:20
Stream01	703235959	1/1/2012	9:00:06	1/1/2012	14:13:21	5:13:15
Stream02	703235960	1/1/2012	9:00:06	1/1/2012	14:26:53	5:26:47
Stream03	703235961	1/1/2012	9:00:06	1/1/2012	14:34:09	5:34:03
Stream04	703235962	1/1/2012	9:00:06	1/1/2012	14:30:19	5:30:13
Stream05	703235963	1/1/2012	9:00:06	1/1/2012	13:41:42	4:41:36
Refresh00		1/1/2012	7:46:46	1/1/2012	9:00:06	1:13:20
Refresh01		1/1/2012	14:34:09	1/1/2012	14:36:21	0:02:12
Refresh02		1/1/2012	14:36:21	1/1/2012	14:38:46	0:02:25
Refresh03		1/1/2012	14:38:46	1/1/2012	14:41:12	0:02:26
Refresh04		1/1/2012	14:41:12	1/1/2012	14:43:39	0:02:27
Refresh05		1/1/2012	14:43:39	1/1/2012	14:46:04	0:02:25

Sample

Super Widget Model RY01234

TPC-VMS:	1.0.0
TPC-H:	2.14.3
TPC-Pricing:	1.7.0
TPC-Energy:	1.5.0
Report Date:	April 1, 2012

Total System Cost	TPC-VMS Throughput	Price/Performance	Availability Date
$96,574.00	2,434.2 VMSQphh@100GB	$ 39.67 USD/VMQphH@100GB	April 1, 2012

VM 1 TPC-H Timing Interval (in seconds)

Query	Q01	Q02	Q03	Q04	Q05	Q06	Q07	Q08
Stream00	542.0	13.1	153.0	172.3	218.8	19.9	167.5	185.4
Stream01	1,069.7	87.9	644.8	509.7	1,113.6	171.0	763.3	744.0
Stream02	1,231.9	148.0	781.9	783.7	1,000.4	39.4	638.6	732.8
Stream03	1,103.3	395.2	152.1	648.1	972.9	102.6	750.1	1,511.5
Stream04	1,172.3	424.3	409.7	709.2	836.7	93.6	591.4	423.2
Stream05	1,297.2	401.2	529.4	672.6	762.7	145.1	625.8	277.6
Min Qi	1,069.7	87.9	152.1	509.7	762.7	39.4	591.4	277.6
Max Qi	1,297.2	424.3	781.9	783.7	1,113.6	171.0	763.3	1,511.5
Avg Qi	1,174.9	291.3	503.6	664.7	937.3	110.3	673.8	737.8
Query	**Q09**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**
Stream00	570.6	156.5	47.3	166.5	349.4	23.8	34.9	86.5
Stream01	2,917.5	277.0	264.3	335.2	1,170.6	587.4	1,155.2	284.5
Stream02	1,626.3	376.0	324.5	294.8	1,144.3	1,738.1	1,216.5	399.6
Stream03	2,453.8	423.8	331.6	176.2	1,049.6	642.3	1,428.4	239.5
Stream04	2,976.6	335.0	205.3	271.3	1,394.9	635.0	1,434.0	425.5
Stream05	2,284.4	352.0	129.9	248.2	1,154.2	471.2	734.5	325.1
Min Qi	1,626.3	277.0	129.9	176.2	1,049.6	471.2	734.5	239.5
Max Qi	2,976.6	423.8	331.6	335.2	1,394.9	1,738.1	1,434.0	425.5
Avg Qi	2,451.7	352.8	251.1	265.1	1,182.7	814.8	1,193.7	334.8
Query	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**	**RF1**	**RF2**
Stream00	37.8	596.9	52.4	26.9	613.5	47.4	42.9	74.5
Stream01	368.7	3,481.2	164.3	87.3	2,482.3	116.2	42.5	89.2
Stream02	594.3	4,307.8	384.8	98.0	1,625.5	119.5	57.8	87.5
Stream03	474.5	4,052.7	397.0	437.0	2,195.5	104.7	57.8	88.1
Stream04	255.5	3,954.8	540.2	146.0	2,482.9	95.3	57.8	89.1
Stream05	158.1	3,490.9	153.2	131.7	2,473.5	77.1	56.5	88.4
Min Qi	158.1	3,481.2	153.2	87.3	1,625.5	77.1	42.5	87.5
Max Qi	594.3	4,307.8	540.2	437.0	2,482.9	119.5	57.8	89.2
Avg Qi	370.2	3,857.5	327.9	180.0	2,251.9	102.6	54.5	88.5

Draft