Windchill® 9.1 Performance on VMware vSphere 4.0

Enterprise Deployment Resource

Windchill 9.1

Windchill PDMLink®
Windchill ProjectLink™
Pro/INTRALINK® 9.1
Pro/ENGINEER® Wildfire® 4.0

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Contents

About This Document

This document discusses the investigation that was performed in the PTC Enterprise Deployment Center to validate the performance of Windchill-based servers operating within a VMware virtualized environment.

The document provides details on the configuration used for the investigation, results from the tests, and best practices to consider when deploying Windchill server-based products within a VMware virtualized environment. The best practices can be used to improve Windchill server performance.

Audience

This document is intended for IT administrators, architects, system administrators, and business administrators. It assumes that the reader has the following knowledge and skills:

- Managing VMware ESX 4.0 operations, such as virtual switch management, connections to external storage, virtual machine creation and management, and so on.
- Installation and configuration of a database server.
- Installation and configuration of Windchill PDMLink 9.1.

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Change Record

The following table identifies notable changes that have been made to the document:

Date	Description of Change
22 March 2010	Initial publication.
24 March 2010	Updated chapter 2 to clarify processor allocation to both the physical and virtual systems.

1

Overview

This chapter provides an overview of the virtualization-based investigation that was performed by the PTC Enterprise Deployment Center. It identifies the goals of the investigation, describes how tests were performed, and presents the conclusions drawn from the investigation.

Goal

The main goal of the VMware investigation is to quantify and compare the performance of the 9.1 Windchill PDMLink solution operating on a VMware-virtualized platform versus operating directly on a physical platform.

Specific objectives include:

- Reporting performance results using Windchill 9.1 solutions on VMware virtualized platform.
- Comparing performance results obtained from the virtualized platform to performance results of a physical platform using the same hardware.
- Comparing virtual and physical platform behavior under various system load conditions.
- Documenting best practice considerations to deploy Windchill 9.1 in a VMware virtualized environment.

Investigation

Matching hardware was used in the virtual and physical environments to run the database and Windchill servers. Both environments shared client and storage resources within the PTC Enterprise Deployment Center lab.

Each system had two Windows 2003 servers: one for the database server and one for the Windchill server. The Windchill Configuration Assistant was run on each system as a means of validating that each environment had the same available resources and that the Windchill configuration was the same for each system.

Note: The Windchill Configuration Assistant (WCA) is not currently available for direct download by PTC customers. To obtain the assistant, contact PTC Global Services or a PTC partner.

Two test sets were executed:

- The first set of tests focused on single-user performance. The Windchill Pro/ENGINEER Data Management Performance Benchmark was run against each system, and the results from these tests were compared.
- The second set of tests focused on multi-user load simulation. Load simulations used by PTC product development were applied to both systems, and the results from these tests were compared.

Conclusions

The results of this performance investigation indicate that the virtualized systems can perform as well as physical systems.

For the single-user experience, there was no discernable difference between Windchill operating on a virtual system and Windchill operating on a physical system.

The single-user tests concentrated on CAD data management transactions. These types of transactions are typically considered to be the most resource intensive on a Windchill system. The data from the investigation indicates these Windchill transactions will perform equally well on either system.

From the multi-user load investigation, the results show that the virtual system performed as well as a physical system. The data indicated that that there actually was a slight overall improvement in performance on the virtual system.

The multi-user tests also concentrated on users that perform CAD data management transactions. Given that these types of users can stress a Windchill system more than other Windchill users, PTC expects that other user loads applied to a virtual system will perform as well as they would if they were applied to a physical system.

The investigation also highlighted the importance of using VMware resource allocation configurations, such as using Memory Reservation, to ensure Windchill performance. Over-allocation of the VMware ESX host was not part of the investigation since all virtual machines operated within the limits of the physical hardware. However, this is not the case in a typical VMware production deployment. In typical deployments, many virtual machines are running simultaneously and over-allocation is a common practice. In production environments, the use of Memory Reservation is strongly advised.

2

Investigation Test Plan

This investigation test plan was developed to compare the performance of a Windchill 9.1 system running on a VMware virtual environment to the same system running on a physical environment.

This test plan covers three main components:

- Equipment Used
- Windchill Configuration
- Tests Performed

Equipment Used

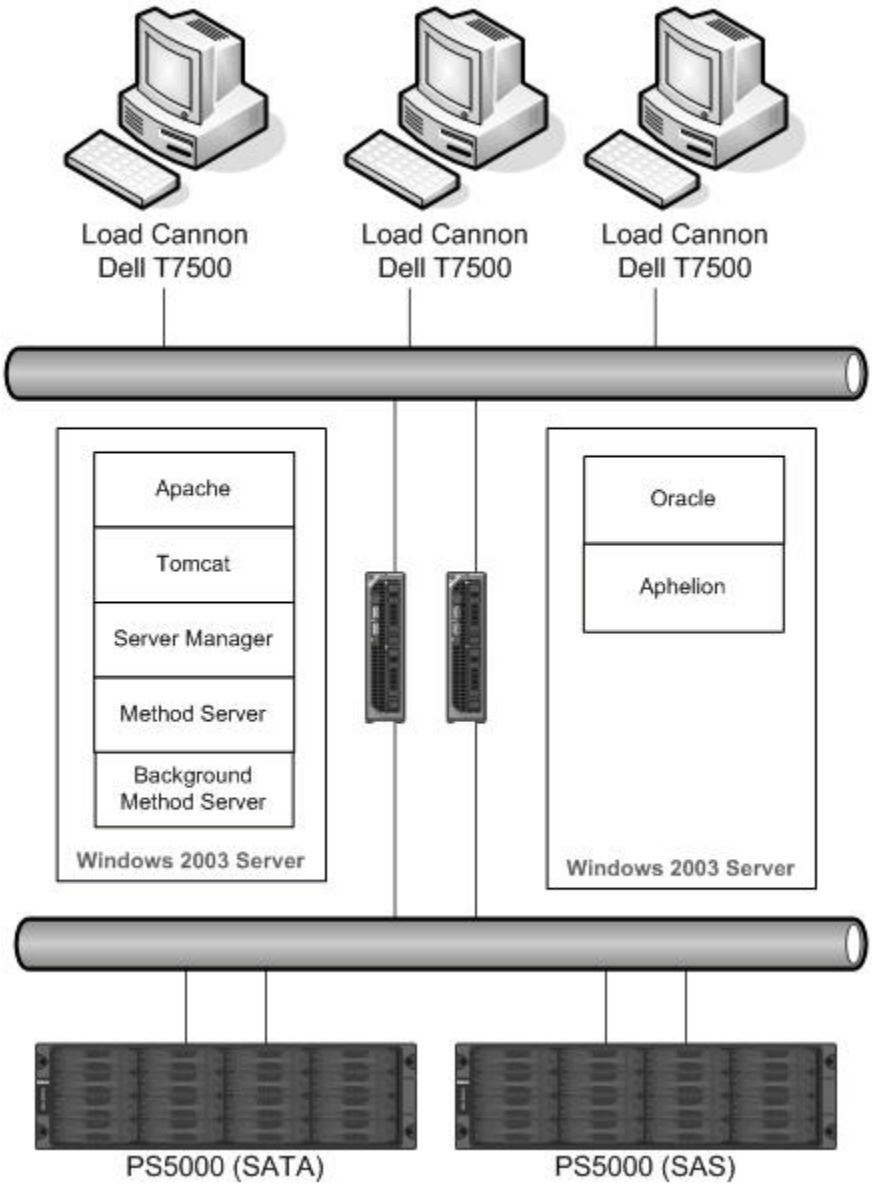
The following equipment was used in the investigation.

Equipment	Quantity	Purpose
Dell M610 blade servers	4	Same servers used in the comparison:. • Physical Oracle server • Physical Windchill server • Virtual Oracle server • Virtual Windchill server
Dell EqualLogic PS5000	2	Provide iSCSI based storage to the blade servers. • RAID 50 space on SATA drives • RAID 10 space on SAS drives.
Dell T7500	3	Load cannons and client machines used with above systems.

Windchill Configuration

The following diagram describes the physical system configuration used in the investigation.

Physical Architecture used in Performance Study



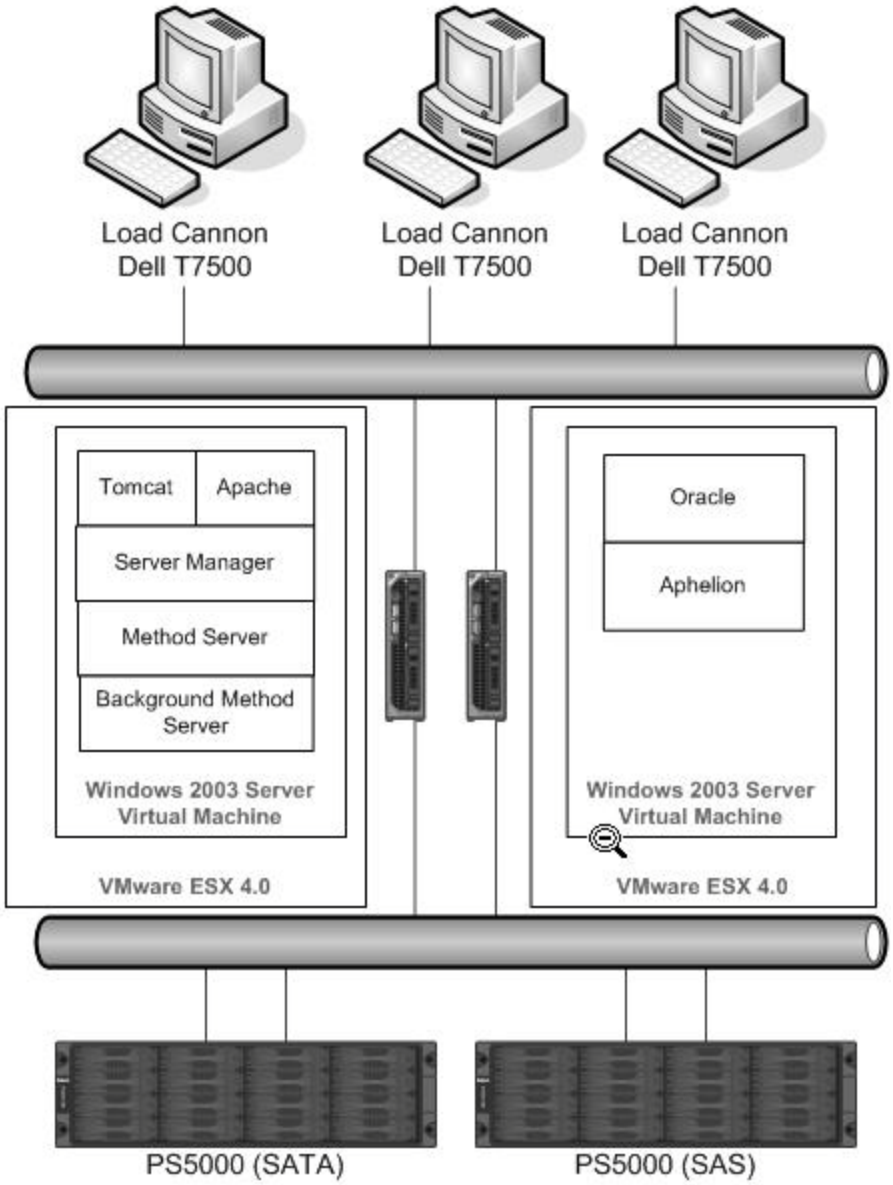
In the middle of the diagram are two 4-core Windows 2003 servers: one running Apache, Tomcat, and Windchill; the other running Oracle and Aphelion.

The Windows 2003 server boot disk is on the local hard drive, but all other disk space is provided by PS5000 storage appliances. Ethernet traffic between servers and storage appliances is managed through a network dedicated to storage-based content.

The client machines represent the multi-user load cannons used in the tests, but were also used to run single-user tests.

This next diagram describes the virtual system configuration used in the investigation.

Virtual Architecture used in Performance Study



In the middle of the diagram are two 8 core servers, each server is running VMware ESX 4.0. Each ESX host has one 4 vCPU virtual machine running Windows 2003 Server. One virtual machine runs Apache, Tomcat, and Windchill; the other runs Oracle and Aphelion.

Note: To develop a direct comparison between physical and virtual systems, the processors available to all Windchill and database servers were limited to 4 cores. For the physical system, the BIOS was manipulated so that only a total of 4 cores was available. For the virtual system, the virtual machines were designated in the ESX host to have only 4 cores available.

All virtual machine disk space is provided by the PS5000 storage appliances. Ethernet traffic between servers and storage appliances is managed through a network dedicated to storage-based content.

The client machines represent the multi-user load cannons used in the tests, but were also used to run single-user tests.

For both systems, the Windchill Configuration Assistant (WCA) was consistently used to tune them. The interactive mode of the WCA was used to ensure that both systems had the exact same tuning parameters applied. As a result, each of these systems had:

- One method server with 4 GB of heap.
- One background method server with 4 GB of heap.
- One server manager with 1 GB heap.
- A servlet engine with 4 GB of heap.
- Each JVM had the same Java options applied.
- All cache properties set in wt.properties were the same.

Tests Performed

The following single-user and multi-user tests were performed.

Single User Performance Test

The PTC World Car Performance Benchmark Test was run against a VMware virtualized Windchill system and a physical system using the same hardware specifications. The same client machine was used in each test.

Multi-User Load Test

Simulated multi-user load tests consisting of a variety of commonly used CAD user operations were run against a VMware virtualized Windchill system and a physical system using the same hardware specifications.

Note: The capability of VMware vSphere to over allocate hardware resources was not tested here. All virtual machines operated within the limits of the hardware resources.

3

Single-User Performance Test

This chapter outlines the details of the single-user performance test that was performed, and discusses the results and conclusions drawn from the tests.

Performance Benchmark

The Windchill Pro/ENGINEER Data Management Performance Benchmark Test enables customers, as well as PTC personnel, to measure and assess single-user performance for a particular implementation of Windchill. In executing the tests, a customer can determine with reasonable accuracy whether their system is performing within expected limits. For details on the tests in benchmark, see Windchill Pro/ENGINEER Data Management Performance Benchmark Test – Instructions which can be accessed using the following link:

http://www.ptc.com/view?im_dbkey=83520

This benchmark has a good test plan for comparing the single-user performance on a virtual system to performance on a physical system.

Test Description

Each system was configured to run this benchmark. The same client machine running Pro/ENGINEER Wildfire 4.0 M130 was used for investigating the virtual system and the physical system.

Note: There is one notable deviation from the full Windchill Pro/ENGINEER Data Management Benchmark. The World Car assembly supplied with the benchmark was not used. Instead, a slightly different version of the World Car assembly already existed in the database for the multi-user load investigation; therefore, this assembly was used in its place. The same assembly was used with both the physical and virtual systems; therefore, this comparison of results should be fair and appropriate. However, the results from this single-user investigation should not be compared to the standard values found in the benchmark documentation.

Each transaction listed in the benchmark was manually performed three times on each system. The average times from these transactions was collected and then used to compare the performance on the virtual system to the performance on the physical system.

The single-user test focused on Pro/ENGINEER centric actions as these are recognized as using the most resources in Windchill server processing. Based on these results, PTC also makes conclusions on the performance of non-Pro/ENGINEER processes on a virtual system.

Results

The following table contains the averaged results of the single-user performance tests discussed in this document. The physical system's results are used as the baseline in the values presented in the **Performance Difference (%)** column. A positive % value in the column means that the virtual system was that much slower than the physical system. Likewise, a negative value means that the virtual system performed faster than the physical system. A value of 0% indicates no difference between the two systems.

Action	Transaction	Physical Time (sec)	Virtual Time (sec)	Performance Difference (%)
Add to WS [as Link]	Launch Pro/ENGINEER	6	6	0
	Add to WS Search	2	2	0
	Display Add to WS page	2	2	0
	Go to Advanced tab	2	2	0
	Collect Required Dependents	10	10	0
	Collect All Dependents	10	9	-7
	Collect related family table objects	62	47	-24
	Finish Add to WS process	244	254	4
Refresh	Workspace refresh	5	5	0
Rename	Launch second session	15	15	0
	Search	47	52	11
	Display Rename page	11	11	0

Action	Transaction	Physical Time (sec)	Virtual Time (sec)	Performance Difference (%)
	Refresh rename page	2	2	0
	Finish rename process.	26	28	8
Set Compare Status View	Complete toggle table display	10	12	20
	Complete toggle to default table display	5	5	0
WS Sync	Synchronize workspace	201	213	6
Checkout	Checkout and display workspace page	28	25	-9
Edit Attributes	Display Edit Attributes page	17	15	-9
	Display required dependents	6	5	-17
	Sort by status type	3	3	0
	List modifiable attribute items	3	3	0
	Complete Edit Attributes action	12	12	0
Check in	Display check in page	7	7	0
	Complete check in	56	62	11
Undo Checkout	Checkout and display workspace page	26	24	-4
	Display undo checkout page	4	4	0
	Complete undo checkout action.	25	27	8

To summarize the performance of the 28 transactions:

- 15 transactions performed equally.
- 23 transactions performed within a two second difference.

Notable differences:

- **Add to workspace** > **Collect related family table objects transaction** - the virtual system was 15 seconds faster than the physical system.
- **Rename** > **search transaction** – the virtual system was 5 seconds slower than the physical system.
- **Synchronize workspace** – the virtual system was 12 seconds slower than the physical system.
- **Complete check in** – the virtual system was 6 seconds slower than the physical system.

Conclusions

Overall, there is no appreciable difference in overall performance of the Windchill system when it was operating in a virtual environment as compared to operating in a physical environment.

Recognizing that CAD data management transactions are the most resource intensive on the Windchill system, PTC concludes that other Windchill transactions will perform equally well on either system when the resources used on the systems are equivalent.

4

Multi-User Load Test

This chapter outlines the details of the multi-user load test that was performed, and discusses the results and conclusions drawn from the tests.

CAD-based Multi-User Load Test

For this test, a multi-user load simulator based on Silk Performer was used to apply Pro/ENGINEER centric loads to the virtual and physical systems. This is the same load engine used by PTC for performance investigations and server hardware sizing.

The users from this load engine simulate Pro/ENGINEER load on the server. These users create, add to workspace and delete workspace using SOAP calls. These users also simulate Pro/ENGINEER-related operations using both RMI and SOAP calls. The operations are:

- Create new workspace
- Download assembly
- Checkout assembly
- Check in assembly
- Undo Checkout
- Copy As and Rename assembly

Test Description

Three test loads were applied to each system. The loads have weighted active user equivalents of 100, 200, and 300 CAD users. Each test was run three times, for a total of nine load tests per system.

The primary information collected during the investigation was the overall average response time experienced by the Silk load cannons, and the CPU utilization on the Windchill and database servers.

The three runs at each load level were averaged, and this average value from each system was used for the comparison.

Note: This was not a stress test of the ESX host. The memory and processors on the host were not over allocated.

Results

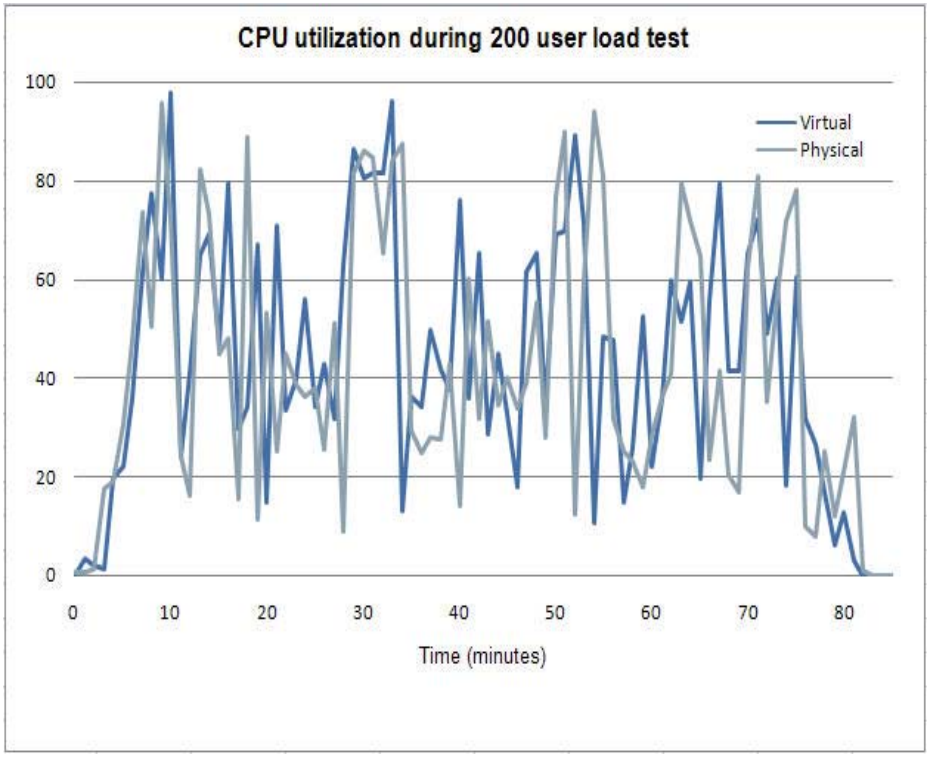
The following table provides the results from the multi-user load investigation.

Load	System	Average Response Time (sec)	CPU Utilization Windchill % (Avg / Max)	CPU Utilization Database % (Avg / Max)
100	Virtual	114	20 / 84	11 / 36
	Physical	120	18 / 72	12 / 32
200	Virtual	126	30 / 100	17 / 36
	Physical	133	26 / 99	16 / 36
300	Virtual	154	32 / 100	22 / 46
	Physical	176	27 / 100	20 / 40

The results indicate that the virtual system had response times approximately 5% better than the physical system.

On both the Windchill machines and the database machines, the CPU utilization was fairly close.

From each system, the CPU utilization results were plotted using one of the 200 weighted active user load runs. The following diagram shows how closely the CPU utilizations of each system compare.



The diagram shows the same general trends of processing are experienced on each system. The larger peaks tend to match closely in timing and processor utilization.

Conclusions

Overall, the results show that the virtual system performs as well as a physical system, and even shows slightly improved performance.

Recognizing that the CAD user-based load investigation provides a heavier stress level on a Windchill system than other Windchill users, PTC concludes that any user load applied to a virtual system will perform as well as if that user load were on a physical system.

5

Global WAN Performance

Considerations

The performance of Windchill from a global perspective is most reliant on the network characteristics between the Windchill server and the end users. The better the network characteristics (such as low latency, high bandwidth, and lower congestion), the better the WAN end-user performance experience will be.

For an in-depth discussion on global performance, see the WAN Accelerators and Windchill Performance technical brief which can be accessed using the following link:

http://www.ptc.com/view?im_dbkey=92390

Two factors to consider for these tests and their influence on global performance are:

- This investigation focused on the server side of the Windchill architecture. The network characteristics between the client load cannons and both virtual and physical systems were the same. For differences in end user network characteristics resulting from geographical distance from the Windchill server, the performance experience should be the same whether using a virtual or physical system to run Windchill.
- This investigation only involved VMware's ESX products, using them in a datacenter centric capacity. Other VMware products, such as View Manager (which can be impacted by network characteristics), were not used.

Conclusions

Based on the above considerations, WAN performance testing was not necessary for this investigation. Global performance will be the same, whether the Windchill system is virtualized or not.

A

Deployment Considerations

This appendix provides considerations and recommendations for preparing the vSphere 4.0 ESX server for hosting a Windchill 9.1 system.

The VMware ESX server is the base for providing an enterprise level virtualization solution. ESX is the platform that is installed onto a machine and manages virtual machine operation on the machine.

The following sections contain information on the ESX server installation, network configuration, and storage options that are specific to the actions performed when deploying an ESX server in the Enterprise Deployment Center Lab. This information and other relevant information can be found in the VMware document named **PERFORMANCE BEST PRACTICES FOR VMWARE VSPHERE 4.0**. You can access the document using the following link:

http://www.vmware.com/pdf/Perf_Best_Practices_vSphere4.0.pdf

ESX Server Configuration

The following considerations were made when installing ESX servers for the investigation described in this document.

BIOS Settings

There are BIOS settings for enhancing virtualization performance. It is worthwhile to review the BIOS options of a server and adjust the virtualization capabilities.

For example, reviewing the BIOS settings on a Dell blade server, there is a **Virtualization Technology** variable under **Processor Settings**. The value for the Virtualization Technology variable should be **enabled**.

Time Keeping

For the most accurate timekeeping, consider using an external timekeeping utility for the ESX server. An external timekeeping source (typically provided by on the same server as the company DNS) can be more accurate compared to the timekeeping option found in VMware tools.

Network Configuration

Network access for Windchill and Oracle should be provided through a virtual switch that is meant only to handle virtual machine Ethernet traffic. Other networking tasks performed by the ESX server, namely ESX service console and VMkernel traffic, should be managed through other virtual switches.

Management Network

An ESX server should have a virtual switch connecting only to a network intended only for administrative and server management traffic. The ESX Service Console would reside on this virtual switch. Among other tasks, the ESX Service Console is the interface between the ESX server and vSphere Client connections, through which the majority of administrative actions occur.

Virtual Machine Network

An ESX server should have one or more virtual switches intended to manage virtual machine ethernet traffic. One or more physical NICs would be associated to this virtual switch, carrying the traffic to intended internet/intranet sources.

Storage and Other Networks

When using ethernet-based backend storage, best performance is obtained when this storage traffic is carried on a private network separated from virtual machine traffic. An ESX server should have a virtual switch connecting only to the private storage network. VMKernels for the ESX server are then linked to this virtual switch to manage the connection to the storage sources.

Other VMware solutions, such as VMotion, should also use a different virtual switch, to keep that traffic away from the virtual machine network.

External Storage Configuration

External storage (also known as backend storage) is an important component in the performance of virtual machines. Storage protocols used and the number of datastores available to the ESX host and virtual machines can influence performance.

VMware recommendations

For production level environments, VMware recommends using external (or backend) storage configurations.

Use external storage to maintain virtual machine content. Needed IOPs speed is dependent on hard drive space provided from a shelf of hard drives operating as one on capable storage platforms.

Storage Protocols

Fiber channel, iSCSI, and NFS protocols for connecting the ESX server to backend storage are all acceptable for Windchill operation. The protocol choices are usually made by the system administrators planning the VMware deployment.

For example, the VMware performance investigation performed at PTC used iSCSI protocol to connect the ESX server with Dell EqualLogic as the backend storage.

VMware Datastores

A VMware datastore is a segment of storage recognized by the ESX host. This storage can be a LUN provided by iSCSI or fiber channeled storage, a volume provided by an NFS mount, or local disk storage. The virtual machine hard drives are stored within these datastores.

Better performance can be achieved when an ESX host has access to many datastores, and a virtual machine's hard drives are assigned to different datastores.

Virtual Machine Configuration

The following are some guidelines to consider when working with a virtual machine. They discuss use of VMware tools, virtual hardware, and using virtual hard drives.

VMware Tools

VMware Tools is a package of drivers and utilities provided on the ESX host that improves the performance of the virtual machine and enables more integration between the virtual machine and the ESX host.

The latest version of VMware Tools should be installed into the virtual machine. If the virtual machine existed on an earlier version of ESX server or was Workstation virtual machine migrated to an ESX server, then the VMware Tools can be out of date.

Virtual Hardware

Ensure that the virtual hardware within the virtual machine is up to date. There are many reasons why the virtual hardware could be out of date: the ESX server was upgraded, the virtual machine is migrated from another ESX server, or the virtual machine is a clone from an out of date template.

Virtual Network Adapter

VMware recommends using the latest ethernet adapter within the virtual machine. The latest adapter is **VMXNET 3**. Ensure that this is the chosen adapter when creating the virtual machine.

If the virtual machine already exists, then ensure that this ethernet adapter is used.

Note: For existing virtual machines, the VMware Tools and virtual hardware need to be upgraded so that the VMXNET3 adapter is available.

Virtual Hard Drives

When a virtual machine has multiple hard drives, better performance can be achieved when each hard drive is assigned to a different datastore.

Partition Alignment of Hard Drives

VMware recommends using partitions that align to 64KB track boundaries. Such alignment prevents performance I/O degradation due to unaligned tracks. For detailed discussions, refer to **RECOMMENDATIONS FOR ALIGNING VMFS PARTITIONS** that can be accessed from the following link:

http://www.vmware.com/pdf/esx3_partition_align.pdf

The first consideration of partition alignment is when a datastore is connected to the ESX host. The best practice is to use the vSphere client to establish this connection, as it automatically aligns the partitions when the LUN is formatted with VMFS (Virtual Machine File System).

Note: VMFS formatting is not available to datastores provided through NFS mounts to the ESX host.

The second consideration of partition alignment is when the virtual drive for a virtual machine is allocated. The virtual drive partition should also be aligned to 64KB track boundaries.

The virtual drive partitioning is only recommended for data disks. It is not required or recommended for boot disks.

Virtual Hard Drive Modes

When adding the virtual hard drives to the virtual machine, better performance is achieved when the drives are marked as independent and persistent.

Time Keeping

For the most accurate timekeeping, consider using an external timekeeping utility for the virtual machine. An external timekeeping source (typically provided by on the same server as a company's DNS) can be more accurate compared to the timekeeping option found in VMware tools.

Virtualization of Windchill

There are several configuration options to consider for improving performance of Windchill running in a virtual machine, such as reserving memory for the Windchill virtual machine and the use of virtual hard drives.

Java Performance Recommendations

VMware provides guidelines for running Java-based applications in **JAVA IN VIRTUAL MACHINES ON VMWARE ESX: BEST PRACTICES** document that can be accessed from the following link:

http://www.vmware.com/files/pdf/Java_in_Virtual_Machines_on_ESX-FINAL-Jan-15-2009.pdf

Based on VMware recommendations and customer input, PTC recommends the use of Memory Reservation for a virtual machine on the ESX host.

Also follow the other recommendations that the Windchill Configuration Assistant makes to tune the Windchill system.

Memory Reservation

For Java-based applications, VMware recommends using the memory reservation function on the ESX host to ensure that the Windchill virtual machine has enough memory and does not have to rely on swapping memory.

Adjust the Reservation value to reserve enough memory for normal operations on this virtual machine. For example, on a monolithic Windchill server, reserve enough memory to cover the operating system, the web server, the servlet engine, Windchill server manager, background method server, and method servers. (This example assumes that the LDAP and database are on a separate installation.)

Typical Windchill architectures may have assigned additional memory to the virtual machine to handle memory fluctuations such as occurrences of orphaned method servers. This additional memory does not need to be included in the Reservation.

LUN Recommendations

Similar to recommendations for Oracle, performance can be improved when Windchill applications are installed on their own virtual hard drive. The Windchill virtual hard drive should reside on a datastore that is separate from the operating system drive.

This also applies to the Windchill vault. Performance can be improved when the vault drive resides on a datastore that is separate from other drives connected to the virtual machine.

Virtualization of Database Server

The following sections list many useful reference documents that describe virtualizing Oracle and SQL Server databases.

References for Deploying Oracle in a Virtual Environment

Oracle Database Scalability in VMware ESX
http://www.vmware.com/pdf/Oracle_Scaling_in_ESX_Server.pdf

Virtualizing Performance-Critical Database Applications in VMware vSphere
http://www.vmware.com/pdf/Perf_ESX40_Oracle-eval.pdf

Virtualizing Oracle 10g/11g on VMware Infrastructure
http://www.vmware.com/files/pdf/partners/oracle/vmw-oracle-virtualizing-oracle-db10g11g-vmware-on-infrastructure.pdf

References for Deploying SQL Server in a Virtual Environment

Performance and Scalability of Microsoft SQL Server on VMware vSphere 4
http://www.vmware.com/files/pdf/perf_vsphere_sql_scalability.pdf

SQL Server Performance in a VMware Infrastructure 3 Environment
http://www.vmware.com/files/pdf/SQLServerWorkloads.pdf

Microsoft SQL Server and VMware Virtual Infrastructure
http://www.vmware.com/files/pdf/solutions/sql_server_virtual_bp.pdf

B

References

The following sections provide the list of reference documents used throughout the installation and configuration of both the virtual and physical systems, or used when conducting the tests performed on them.

VMware Installation and Configuration

Performance Best Practices for VMware vSphere 4.0
http://www.vmware.com/pdf/Perf_Best_Practices_vSphere4.0.pdf

Networking Best Practices for VMware vSphere 4 on Dell PowerEdge Blade Servers
http://i.dell.com/sites/content/business/solutions/engineering-docs/en/Documents/NetworkingGuide_vSphere4_Blades.pdf

iSCSI SAN Configuration Guide, ESX 4.0
http://www.vmware.com/pdf/vsphere4/r40/vsp_40_iscsi_san_cfg.pdf

Configuring VMware vSphere Software iSCSI with Dell EqualLogic PS Series Storage
http://www.equallogic.com/resourcecenter/assetview.aspx?id=8453

Recommendations for Aligning VMFS Partitions
http://www.vmware.com/pdf/esx3_partition_align.pdf

Java Performance on VMware

Java in Virtual Machines on VMware ESX: Best Practices
http://www.vmware.com/files/pdf/Java_in_Virtual_Machines_on_ESX-FINAL-Jan-15-2009.pdf

Oracle on VMware Solutions

Oracle Database Scalability in VMware ESX
http://www.vmware.com/pdf/Oracle_Scaling_in_ESX_Server.pdf

Virtualizing Performance-Critical Database Applications in VMware vSphere
http://www.vmware.com/pdf/Perf_ESX40_Oracle-eval.pdf

Virtualizing Oracle 10g/11g on VMware Infrastructure
http://www.vmware.com/files/pdf/partners/oracle/vmw-oracle-virtualizing-oracle-db10g11g-vmware-on-infrastructure.pdf

SQL Server on VMware Solutions

Performance and Scalability of Microsoft SQL Server on VMware vSphere 4
http://www.vmware.com/files/pdf/perf_vsphere_sql_scalability.pdf

SQL Server Performance in a VMware Infrastructure 3 Environment
http://www.vmware.com/files/pdf/SQLServerWorkloads.pdf

Microsoft SQL Server and VMware Virtual Infrastructure
http://www.vmware.com/files/pdf/solutions/sql_server_virtual_bp.pdf

Physical Installation and Configuration

Dell Reference Configuration, Deploying Oracle Database on Dell EqualLogic PS5000XV iSCSI Storage
http://www.equallogic.com/resourcecenter/assetview.aspx?id=5115

Windchill Tools

Windchill Configuration Assistant Resource Page
http://internal.ptc.com/appserver/wcms/standards/textoimgfilelink.jsp?&im_dbkey=101328&icg_dbkey=891

Windchill Pro/ENGINEER Data Management Performance Benchmark Test
http://www.ptc.com/view?im_dbkey=83520