



Oracle RAC Virtualization

Final Report

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1 Introduction

The report presents an overview of the virtualization technologies used by Oracle, as part of the Openlab Summer Student Programme 2008. The main subject of the project was Database Virtualization using Oracle VM and Oracle Enterprise Linux.

The report begins with an introduction of virtualization technologies focusing on the solution used by Oracle (which integrates Xen virtualization). You will find an explanation of current importance of virtualization together with a short description of the main virtualization methods.

The second chapter describes the infrastructure created (using virtual machines) for the tests, followed by the third chapter that contains general information about the software tested.

The fourth chapter talks briefly about the installation of Oracle VM and Xen, followed by the testing methods presented in the fifth chapter.

The last three chapters show the obtained results, analyze the Live Migration and present the project's results.



1.1 Project Description

The main aim of this project was to test the performance of Oracle virtualization solution (Oracle VM) applied to Oracle Real Application Clusters. A review of the updates in the area of virtualization as of summer 2008 was done. The advantages and drawbacks of the current virtualization methods and setup were identified. The results obtained can be compared with last year's results, but there are differences that should be taken into account when doing a comparison: different guest OS and technique.

1.2 Why virtualization?

Virtualization is one of the hottest topics in information technology today. The increasing speed and capabilities of today's x86 processors have made virtualization possible on commodity hardware thus providing an attractive way of making the most of that hardware.

As new hardware becomes more powerful, the problem of its underutilization is placed in the daily agenda of the majority of IT departments. In addition, the increasing power consumption and the need for more cooling entities make the overall picture more complex.

Virtualization is the key technology for solving these problems. It establishes an abstraction layer which separates the operating system and the user applications from the underlying hardware. This allows running several virtual machines on the same hardware which leads to a better utilisation of the hardware, better isolation of the user applications from each other; less power consumption and easier cooling facilities for the computer centers.

1.3 Virtualization types

There are multiple types of virtualization¹: Guest OS, Parallel Virtual Machine, Hypervisor-based (Paravirtualization), Full Virtualization, Kernel-level virtualization and Hardware Virtualization. In our project, we are most interested in these two types:

Hypervisor - based: A small virtual machine monitor (known as a hypervisor) runs on top of your machine's hardware and provides two basic functions. First, it identifies, traps, and responds to protected or privileged CPU operations made by each virtual machine. Second, it handles queuing, dispatching, and returning the results of hardware requests from your virtual machines. An administrative operating system then runs on top of the hypervisor, as do the virtual machines themselves. This administrative operating system can communicate with the hypervisor and is used to manage the virtual machine instances.

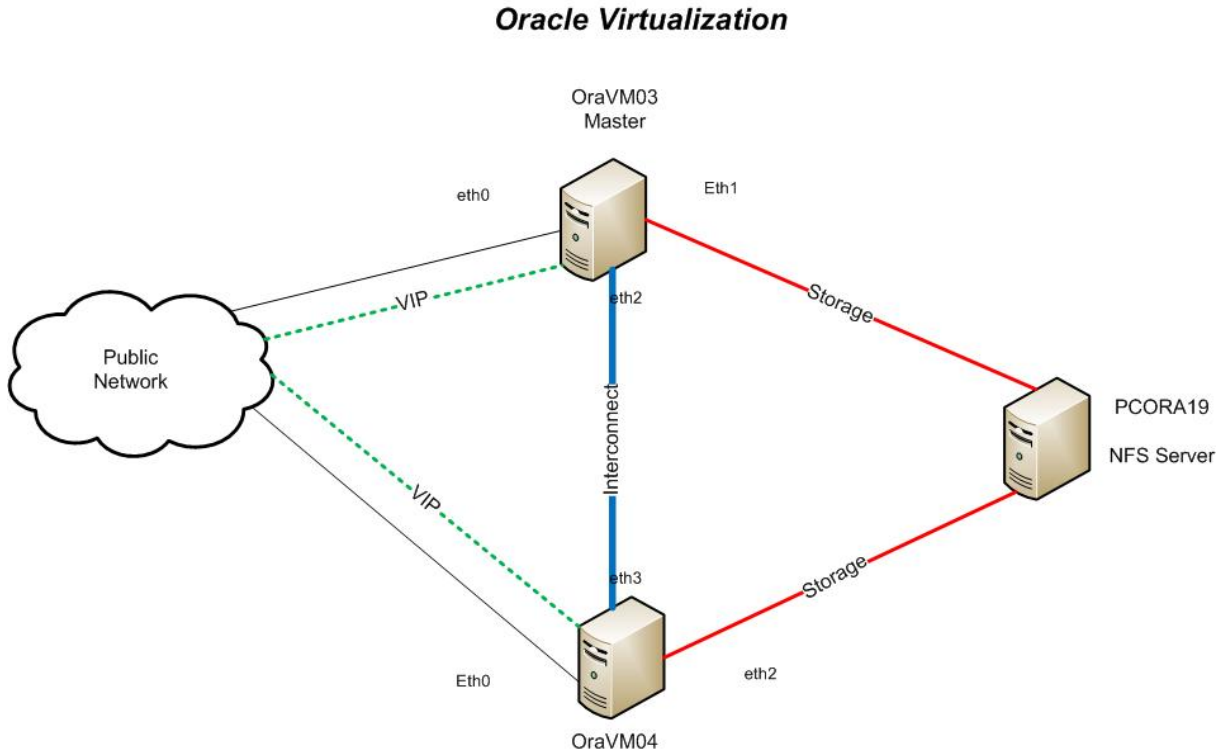
Hardware virtualization: Very similar to both paravirtualization and full virtualization, hardware virtualization uses a hypervisor, but it is only available on systems that provide hardware support for virtualization. Hypervisor - based systems such as Xen and VMWare ESX Server, and kernel - level virtualization technologies such as KVM, can take advantage of the hardware support for virtualization that is provided on the latest generation of Intel (Intel VT, aka Vanderpool) and AMD (AMD - V, aka Pacifica) processors. Virtual machines in a hardware virtualization environment can run unmodified operating systems because the hypervisor can use the hardware's support for virtualization to handle privileged and protected operations and hardware access requests, and to communicate with and manage the virtual machines.

¹ William Von Hagen, Professional Xen Virtualization, Wrox, Wiley Publishing, Inc., 2008



2 Infrastructure

Two identical computers were used for testing the virtualisation solutions. Another computer was setup to provide the storage used by the database files trough NFS.



Example: Computer setup and roles for OracleVM
Figure 1

For each virtualisation solution 2 virtual machines with the same characteristics were created. The main virtualization solution was Oracle VM with Oracle Enterprise Linux (OEL). OEL was born from Red Hat Enterprise Linux 5 and comes already patched with Xen.

For the first setup we have used Oracle solution, creating hardware virtualized machines, thus taking advantage of the virtualization aware CPUs (AMD-V in our case, on AMD Athlon(tm) 64 X2 Dual Core Processor 4600+).

Second setup was made using only Oracle Enterprise Linux. By exploiting the fact that OEL is patched with Xen it was possible to create the virtual machines using Xen and Red Hat tools installed by default (virt-manager & virt-viewer).

Third and fourth scenarios used paravirtualized identical machines created with Oracle VM and Xen.



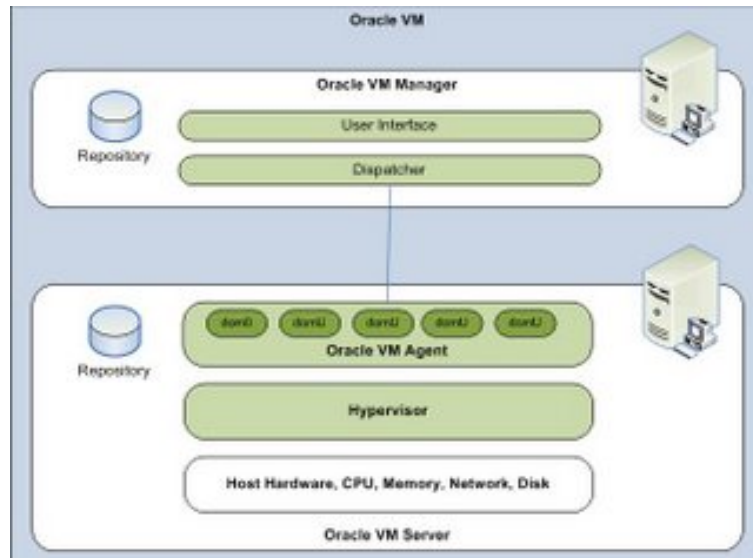
3 Virtualization solutions and not only

This is a short presentation of the virtualization solutions used and the products that implement them. Also some words on the other stuff used in this project.

3.1 Oracle VM

Oracle VM is a server virtualization software which fully supports both Oracle and non-Oracle applications. Oracle VM offers scalable, low-cost server virtualization that is up to three times more efficient than existing server virtualization products from other vendors².

Consisting of open source server software and an integrated Web-based management console, Oracle VM provides an easy-to-use graphical interface for creating and managing virtual server pools, running on x86 and x86-64-based systems, across an enterprise.



Oracle VM Architecture

Figure 2

Users can create and manage Virtual Machines (VMs) that exist on the same physical server but behave like independent physical servers. Each virtual machine created with Oracle VM has its own virtual CPUs, network interfaces, storage and operating system. With Oracle VM, users have an *easy-to-use browser-based tool* for creating, cloning, sharing, configuring, booting and migrating VMs.

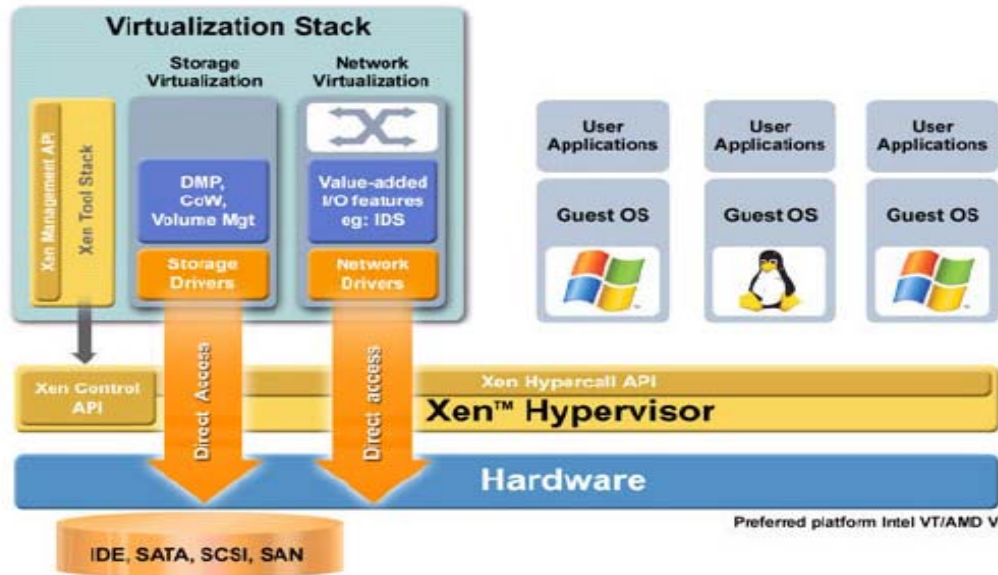
² www.oracle.com



3.2 Xen

Xen is an open-source virtual machine monitor (known also as hypervisor), that uses paravirtualization as a virtualization technique. Paravirtualization requires modifications in the guest operating system before they can run as virtual machines. Xen is widely known as one of the fastest and most secured software tools for virtualization. It supports the hardware virtualization functions provided by Intel and AMD cpus(Intel VT and AMD-V)

The Xen hypervisor is the abstraction layer mentioned above. Its installation will create a Xen-ready kernel and the virtualization stack. On boot, Xen starts first a domain called “Domain0” (“dom0”) which has the ultimate control over all the hardware on the system. It monitors and manages all other unprivileged domains (“domU”) and their hardware accesses. The domUs contain the guest operating system and have no privileged access to the hardware. User applications are running on top of domUs OS



Xen Architecture
Figure 3

3.3 RAC – Oracle Real Application Clusters

Oracle is widely known for its stable and reliable RDBMS products. Oracle Real Application Clusters (RAC) is new feature available since version 9.1 which provides with a means to scale up database systems more easily and cost effectively. It employs several nodes to act as a single database server. This feature is transparent to user applications, which can run unchanged on the database cluster.

This setup offers higher availability due to the lack of a single point of failure. If one of the nodes in the cluster fails, applications will continue running, using the remaining healthy nodes. Flexibility and scalability are other key advantages of RAC - the cluster can be extended or scaled down by adding or removing the nodes from the cluster.

Real Application Clusters is a software that enables you to use clustered hardware by running multiple instances against the same database. The database files are stored on disks that are either physically or logically connected to each node, so that every active instance can read from or write to them.

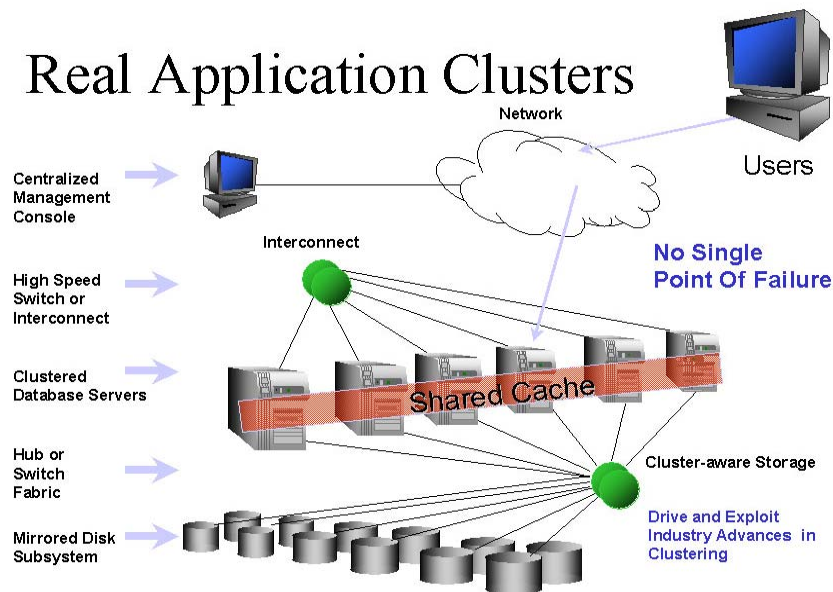


The Real Application Clusters software manages data access, so that changes are coordinated between the instances and each instance sees a consistent image of the database. The cluster interconnect enables instances to pass coordination information and data images between each other.

This architecture enables users and applications to benefit from the processing power of multiple machines. RAC architecture also achieves redundancy in the case of, for example, a system crashing or becoming unavailable; the application can still access the database on any surviving instances.

3.3.1 Architecture³

The Oracle RAC architecture consists of: several clustered servers, the public network between the users and the cluster, fast interconnect between the cluster nodes, cluster-aware storage and the mirrored disk subsystem. The database data are stored on the cluster-aware storage, and are accessible by all the servers in the cluster. The clustered servers share the global cache, managed by “cache fusion” functionality.



Oracle RAC Architecture
Figure 4

³ Oracle: Oracle Real Application Clusters 11g, Author: Barb Lundhild, April 2007 (25/08/2007)



4 Installation

The aim of the project was to research the performance of Oracle RAC and Oracle RDBMS running on Oracle virtualization solution – Oracle VM. The base distribution used for all installations (hosts and guests) was Oracle Enterprise Linux Release 5 Update 2, 64 bit version.

Four machines in total were used for the tests. First, Oracle VM Sever - which is a standalone OS – was installed on node1. Oracle Enterprise Linux (OEL) and Oracle VM Manager were installed on node2. During the project, Oracle VM Manager installation was moved to node3, since node2 was intended to accommodate the Xen virtualization solution, used later for performance comparison.

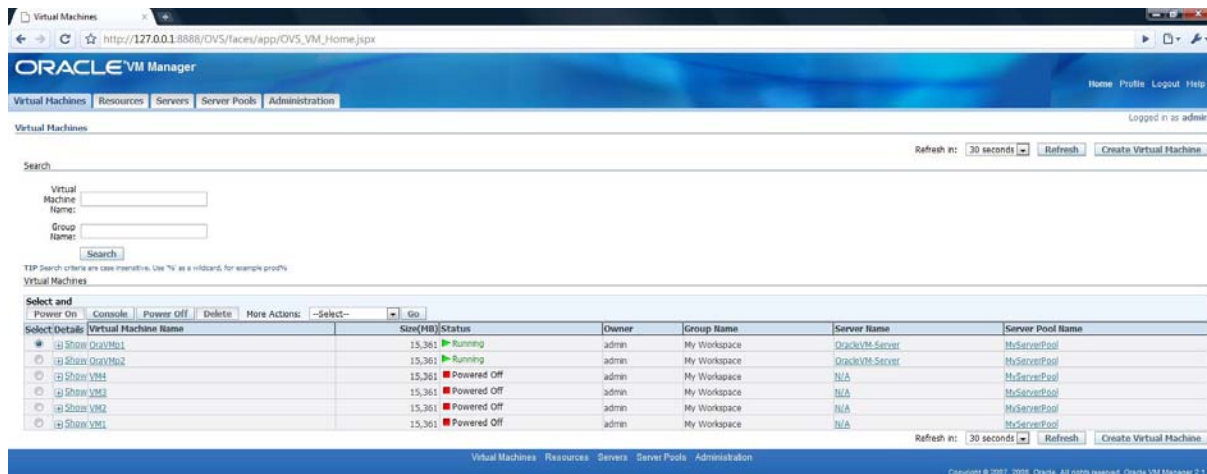
We have started with creating RAC on hardware virtualized VMs using Oracle VM and later with pure Xen. The Xen setup was created with the help of OEL - which is already patched with Xen. Both configurations was tested and benchmarked. Next, 2 the same technologies were used to create a paravirtualized RACs. In all cases, the necessary storage was located on a node4(Kubuntu 8.04 as OS), mounted on the database nodes through NFS. More details about the installations can be found in the installation guide provided as a separate document.

4.1 Oracle VM

Oracle VM is made of Oracle VM Sever and Oracle VM Manager.

Oracle VM Sever is installed on a dedicated machine (node1 in our project) and that is where all the created virtual machines run. The server installation is like a normal Oracle Enterprise Linux installation.

Oracle VM Manager can be installed on any machine (node3). Oracle VM Manager controls the Oracle VM Sever(s) through a web interface.



Oracle VM Manager web interface

Figure 5

Using Oracle VM the following virtual machines were created:

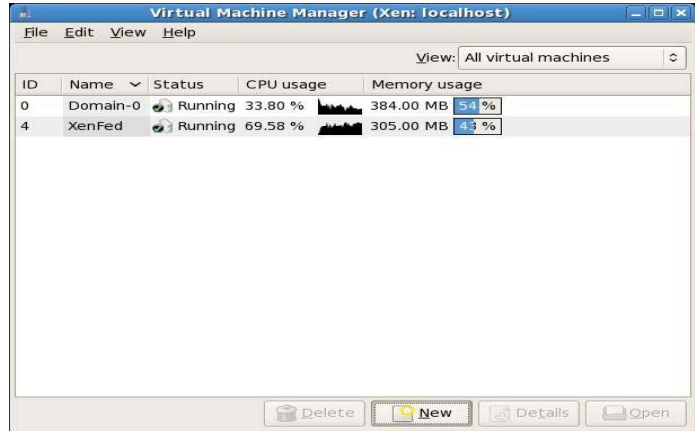
- 2 virtual machines using hardware virtualization
- 2 virtual machines using paravirtualization



4.2 Xen

Xen is already included in Oracle Enterprise Linux Release 5 Update 2, and no specific installation is needed.

Virtual Machine Manager - that is shipped with OEL distribution (*virt-manager*) – was used to create the virtual machines. After the creation of a virtual machine (using hardware virtualization) the virt-manager was not able to modify the machine configuration or even view it's properties. The logs show “*KeyError*”.(More details about this in the installation report).However, it allowed me to clone the machine, thus creating the second one identical to the first.



Virtual Machine Manager (virt-manager)
Figure 6

Since the console view of the virtual machines using virt-manager was not available, *virt-viewer* - a minimal tool for displaying the graphical console of a virtual machine – was used to control the machine. When creating paravirtualized machines, there was no problem with the *virt-manager* tool.

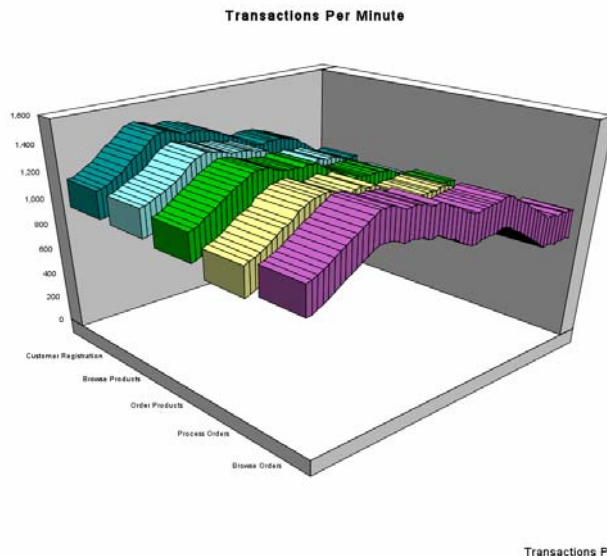
Using OEL (that comes patched with Xen) the following virtual machines were created:

- 2 virtual machines using hardware virtualization
- 2 virtual machines using paravirtualization

5 Testing

Swingbench was used to test the performance of the database in virtualized environment. It is a free load generator (and benchmark) designed to stress test an Oracle database.

Swingbench has many predefined tests available, from which we have chosen the Stress Test (ST) and Order Entry (OE) to measure the database performance. Two variations of the tests were done: with and without load-balancing between the RAC instances.



Swingbench graph - testing a RAC database running on virtual machines
Figure 7



6 Results

This aim of the project was to test the Oracle virtualization technology and comparing it to its parent – pure Xen. The table bellow shows the obtained results during the tests.

		OraVM		XenVM		OraVMp		XenVMp	
		TPS	TPM	TPS	TPM	TPS	TPM	TPS	TPM
OE-LB		22.26	1335.6	18.67	1118.4	73.91	4434.6	55	3233
OE-NLB ¹	1st instance	10.05	603	8.7	522.6	100.31	6018.6		
	2nd instance	11.66	699.6	9.55	573	7.45	447		
ST-LB		145.59	8735.4	120.74	7244.4	510.75	30645	478	28169
ST-NLB ²		137.45	8247	126.3	7578	469.68	28180		

OE = Order Entry

ST -Stress Test

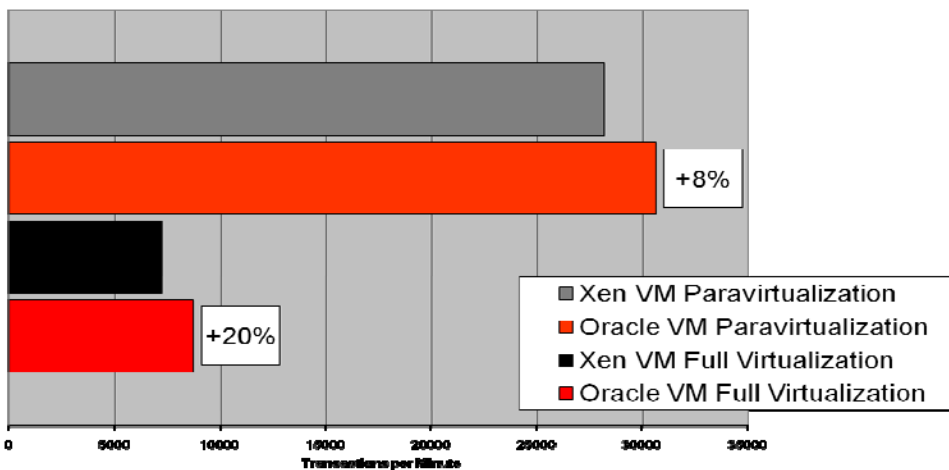
LB = Load Blancing

NLB = No Load

Balancing

¹the test was done using 2 Swingbench instances running in the same time and on a different SID with 15 users each instance

²the test was done using the LOAD BALANCE = NO option in tnsnames.ora



Oracle VM performance comparison

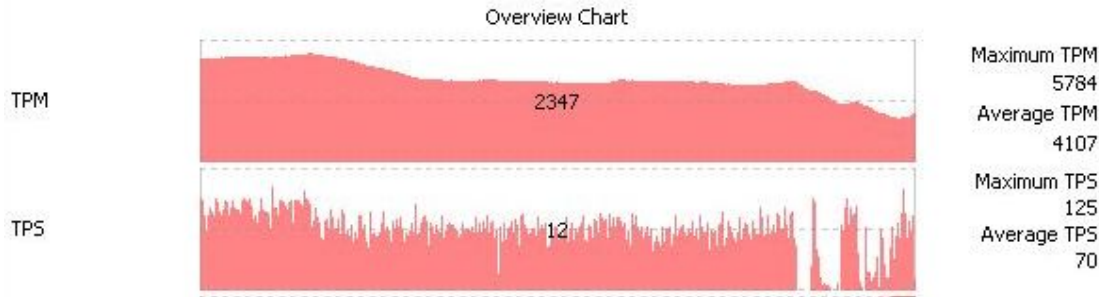
Figure 8



Live Migration and High Availability

Live migration is the movement of a virtual machine from one physical host to another with minimal down-time. This process takes place without any noticeable effect from the point of view of the end user. Live migration allows an administrator to take a physical machine offline for maintenance or upgrading without subjecting the system's users to downtime.

One of the most significant advantages of live migration is the fact that it facilitates proactive maintenance. If an imminent failure is suspected, the potential problem can be resolved before disruption of service occurs. Live migration can also be used for load balancing, in which work is shared among computers in order to optimize the utilization of available CPU resources.



Swingbench graphics during virtual machine live migration(single instance database)
Figure 7

Oracle virtualization technology enables High Availability through live migration. If the physical server running multiple virtual machines shuts down (power outage, reset, regular maintenance), the running virtual machines are automatically migrated to another server. Oracle VM has the servers organized in HA “pools”, with all the servers in the pool must have access to the same shared storage. Live migration is only possible between two servers of the same HA pool. Our tests showed that migration of virtual machines is almost unnoticeable to the user, with nearly no downtime and network connectivity disruptions.

8 Conclusions

Oracle virtualization technology offers extra advantages in comparison with other virtualization solutions. Some of its features are inherited from Xen, but others are original and make Oracle stand out in the virtualization market.

Oracle provides an easy way to manage the virtual machines using the Oracle VM Manager, a web based application that interacts with the virtual machines and controls everything related to them. Another great feature of Oracle VM is the usage of templates. A template is just like a “mould” of an existing virtual machine. Template can be made out of an existing virtual machine, and later to be used for creation of similar virtual machines, if needed. Oracle VM manager also gives the possibility of saving installation images (CDs/DVDs) on the available storage so the installation kits are available all the time.

During the performance comparisons, we have found that the databases, using Oracle VM for their virtual machines gained between 10% and 20% of performance in comparison to the ones using virtual machines on top of pure Xen, which shows that Oracle had done a good job tuning its solution for database use.

Live Migration tests showed almost no downtime during the process, which makes us positive on its future usage in our setups.

Recently, Oracle has announced its official support for RAC databases, although with a lot of limitations.



We believe these limitations will be dropped with time, and some of our non-critical production RAC databases could be moved into virtualized environment.