Virtual Machine Migration with an Open Source Hypervisor

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Abstract

The Virtualization technology [VT] plays vital role in efficient utilization of computer resources in any organization and is the basic concept used in cloud computing. Main advantage of using VT is that we need less Information technology [IT] infrastructure resources. We prove here that live migration feature provided by XEN hypervisor is quiet useful. It increases availability of application and is transparency to user. We executes live migrate command of XEN, the VM runs on source host till all memory pages are transferred to destination host (pre-copy). We can also observe that during and after migration VM preserves its IP address. The main use of virtualization technology is server consolidation i.e. to run multiple server operating systems (VMs) on single physical hardware. By running multiple VMs on single physical machine we can reduce expenditure on IT hardware.

Keywords: Virtualization, XEN, Hypervisor, VMM, live migration.

I. INTRODUCTION

Virtualization is used to "slice" a single physical host into one or more virtual machines (VMs) that share its resources [7]. It is a technique to divide computer resources into multiple execution environments by making use of concepts like hardware/software partitioning, time-sharing, simulation, emulation etc. Virtualization can be applied to almost any and all parts of IT infrastructure. The main benefit or goal of virtualization is to maximize utilization of IT resources. To manage efficient resource utilization on an abstraction layer is used which is called VMM (Virtual Machine Monitor) or Hypervisor. There are number of Hypervisors available in market like XEN, KVM, VM ware etc. Among all XEN is widely adopted and an open source VMM. Fig 1 shows simple virtualization example [1].

This paper is organized as follows: Section 2 discusses basic approaches to virtualization. Section 3 gives details about advantages and issues of VT. Section 4 gives introduction to XEN hypervisor. Section 5 discusses about simple experiment with XEN and section 6 concludes the paper.

Fig. 1 General virtualization concept

II. Methodology

Virtualization Approaches:

There are various ways to implement virtualization. Following are some of the approaches by which we can implement virtualization in our environment [3].

2.1 Guest OS Virtualization

In this method all virtual machines (VM) run within an application installed in host OS. This application handles access to the hardware resources on physical host system. Microsoft's Virtual PC is this kind of virtualization product.

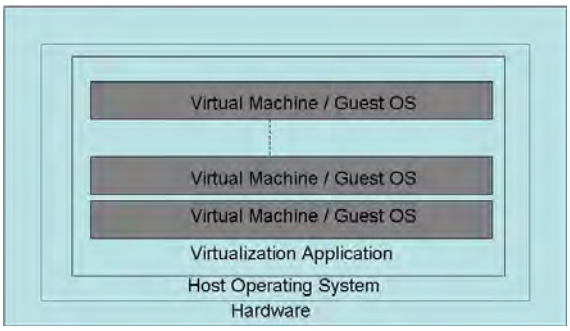

Fig. 2 Guest OS virtualization

2.2 Shared kernel virtualization

In this case one OS kernel supports multiple VMs. Each VM has own root file system.

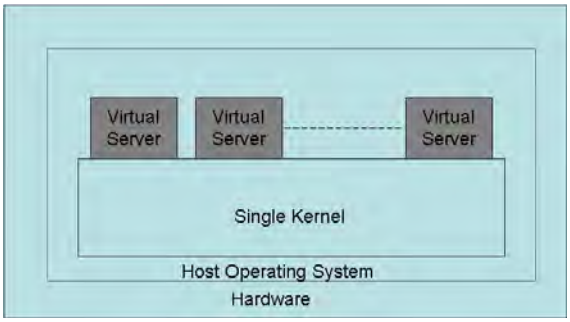

Fig. 3 Shared kernel Virtualization

2.3 Hypervisor Based Virtualization

Hypervisor is a low level VMM. It runs directly on hardware and manages access to various hardware resources made by guest domains. Hypervisor supports VMs in "Para virtualization", "Full virtualization" and "Hardware assisted virtualization" environments. XEN is widely used and open source hypervisor [12].

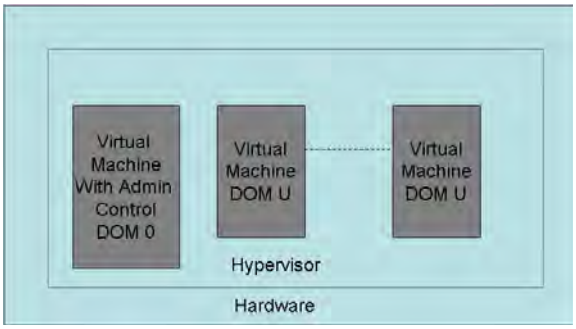

Fig. 4 Hypervisor based virtualization

2.4 Emulator Based Virtualization

Here in this approach emulator runs virtual machines by simulating a specific type of processor along with its instruction se t and in this emulated environment VMs are executed.

2.5 Kernel Based Virtualization

In this approach Linux kernel itself runs multiple VMs as user processes. Linux with KVM is this kind of technique.

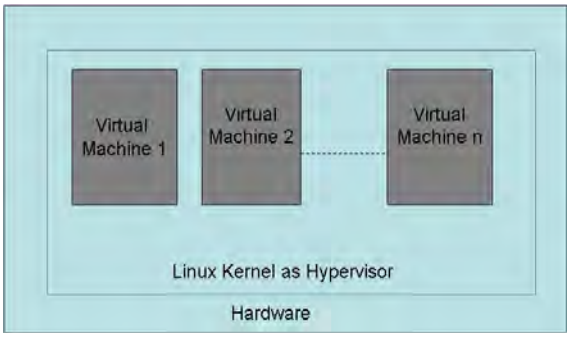

Fig 5 Kernel based virtual machine

VT advantages and issues

VT provides many advantages and following are the major advantages of it [7].

3.1 VT Advantages

A. Efficient use of existing hardware

Generally we use physical hardware to run a server operating system but in this case hardware resource utilization is very less [1]. Using VT multiple server operating systems are consolidated to run on single physical hardware so it maximizes resource utilization.

B. Reduction in cost of hardware

As multiple server operating systems are consolidated to run on single hardware we need less physical IT infrastructure to run servers. So indirectly it reduces cost of hardware.

C. Simple administration

With virtualization multiple servers can run on single physical hardware so administration of servers can be done at single place and it is simple [2].

D. Less power consumption

To run each physical server we need power supply. Power is also needed to cool down physical resources. But with Virtualization we need less physical hardware so less amount of power is consumed.

E. Increased availability

Virtualization provides facilities like live migration of virtual machines from one physical sever to other. In this migration down time is zero or very low which cannot be noticed by users [3]. So because of maintenance or any other failure in one server, VM can be migrated to other server and this in turn increases availability of services.

F. Increased security

Virtual machines running on shared resource are isolated from each other so it increases security. E.g. In embedded systems we need some real time operations along with some extra features. So we can use virtualization concept to run two operating systems simultaneously on hardware. One of which is RTOS (Real time OS) [4] and other is GPOS. (General purpose OS)

G. Easy system and application testing

In application development life cycle testing is critical step. Application must be tested on various platforms. With virtualization we can install multiple OS on single hardware and testing process is easy otherwise we need to have different machines for different platform.

H. Useful in system level development

In system level development like diver development we need to reboot kernel frequently because it must be tested with different kernels. Booting physical machine each time is time consuming process. If virtualization is used we need not reboot whole machine but just one VM. So development and testing can be done in parallel.

3.2 Virtualization Issues

Virtualization has number of advantages as discussed above but while adopting virtualization one must consider issues related to virtualized environment. Following are some of the common issues to be considered before adopting it [13].

A. Single point of failure

We have discussed number of approaches to virtualization in section 2. The main problem with virtualization is single point of failure because if there is any problem in hypervisor or hardware all VMs will stop working and all services will be stopped.

B. Performance issues

As physical resources are shared among various VMs there is some effect on performance of VM. Proper planning of load on each VM must be done before moving it from physical environment to virtualized environment.

XEN Introduction

XEN is an open source hypervisor.[9] The XEN hypervisor is a layer of software running directly on computer hardware replacing the operating system thereby allowing the computer hardware to run multiple guest operating systems concurrently (fig 6).

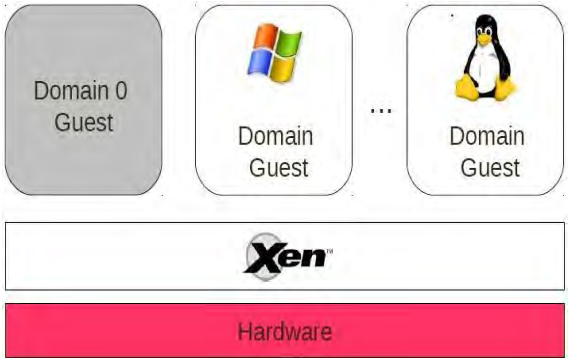

Fig. 6 XEN architecture

A computer running the XEN hypervisor contains three main components.

- XEN Hypervisor
- Domain 0 Privileged Domain (Dom0) – Privileged guest running on the hypervisor with direct hardware access and guest management responsibilities.
- Multiple Domain U, Unprivileged Domain Guests (Dom U) – Unprivileged guests running on the hypervisor; they have no direct access to hardware (e.g. memory, disk, etc.).

The Domain 0 Guest referred to as Dom0 is launched by the XEN hypervisor during initial system start-up and can run any operating system except Windows. The Dom0 has unique privileges to access the XEN hypervisor that is not allocated to any other Domain Guests. These privileges allow it to manage all aspects of Domain Guests such as starting, stopping, I/O requests, etc. A system administrator can log into Dom0 and manage the entire computer system. The Domain Guests referred to as DomUs or unprivileged domains are launched. XEN supports two types of virtualization modes [17].

4.1 Para Virtualization (PV)

Under para virtualization the kernel of the guest operating system is modified specifically to run on the hypervisor. This typically involves replacing any privileged operations that will only run in ring 0 of the CPU with calls to the hypervisor (known as *hyper calls*). The hypervisor in turn performs the task on behalf of the guest kernel [14].

4.2 Hardware-Assisted Full Virtualization (HVM)

Full virtualization provides support for unmodified guest operating systems. The term *unmodified* refers to operating system kernels which have not been altered to run on a hypervisor and therefore still execute privileged operations as though running in ring 0 of the CPU. In this scenario, the hypervisor provides CPU emulation to handle and modify privileged and protected CPU operations made by unmodified guest operating system kernels [2][18].

III. Implementation of XEN

5.1 Experiment Goal

The experiment is done to check performance of IIS web server in virtualized environment. Generally benchmark tools are used to check performance of machine [12]. In my experiment I tried to measure performance of IIS under XEN by sending 1000 requests to IIS and by checking delay in ms. I have used ab Tool for making benchmark test of IIS which comes as a package in Cent OS [10].

5.2 Experimental Setup

For experiment used hardware and software details are as below.

Hardware

- 2 Lenovo computers with core 2 duo processor
- 2GM RAM in each machine
- 100Mbps network
- Both machines have Intel VT support

Software

- Cent OS 5 is used in both machines as host OS with XEN support
- One machine is configured to serve as NFS server where VM image is saved.
- Windows XP sp2 with IIS is configured to work as guest OS (VM) - ab tool is used to measure performance

5.3 Experiment Method

Generally virtual machine images are stored centrally in devices like SAN (Storage area network). But SAN is costly and was n ot available with me for experiment purpose so I used NFS server. Other options to SAN are iscsi protocol, NFS and aoe protocol. In this experiment NFS server is used to save image of virtual machine. One machine creates WinXP (IIS) VM using XEN and via other machine benchmark test is made. *gnuplot* is used to draw graph of trace obtained from ab benchmarking tool. As explained above the test was carried out and following are the figures showing screen shots of experiment [16].

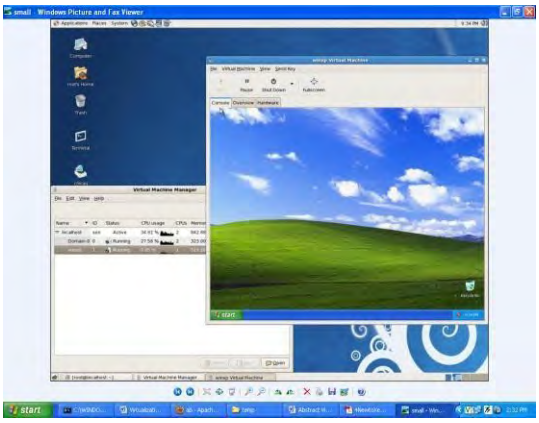

Fig. 7 Win XP as virtualized host in Cent OS

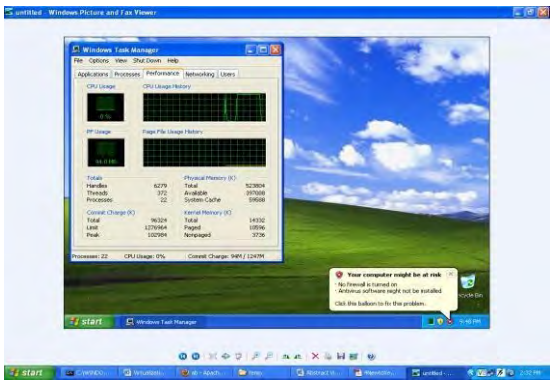

Fig. 8 CPU load when 1000 requests made to IIS in VM

IV. RESULTS AND ANALYSIS

Following graph in fig 9 shows number of request and latency in response (ms) for Server X in terms of remote test normally all the requests are being served in 300ms which is nearly equal to benchmark

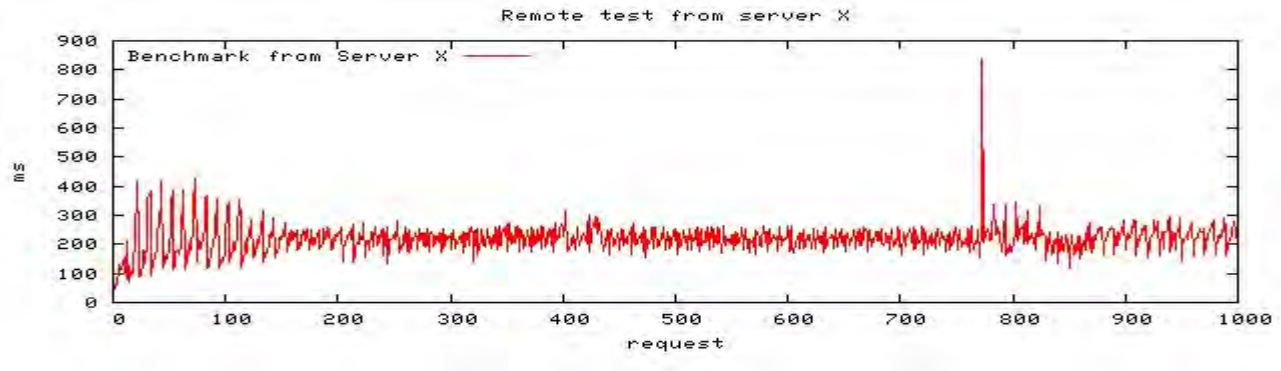

Fig. 9 Remote Test Graph plotted via gnuplot for Server X

Benchmark condition graph shown in below fig 10 shows that remote test for server X variation is likely to match above one.

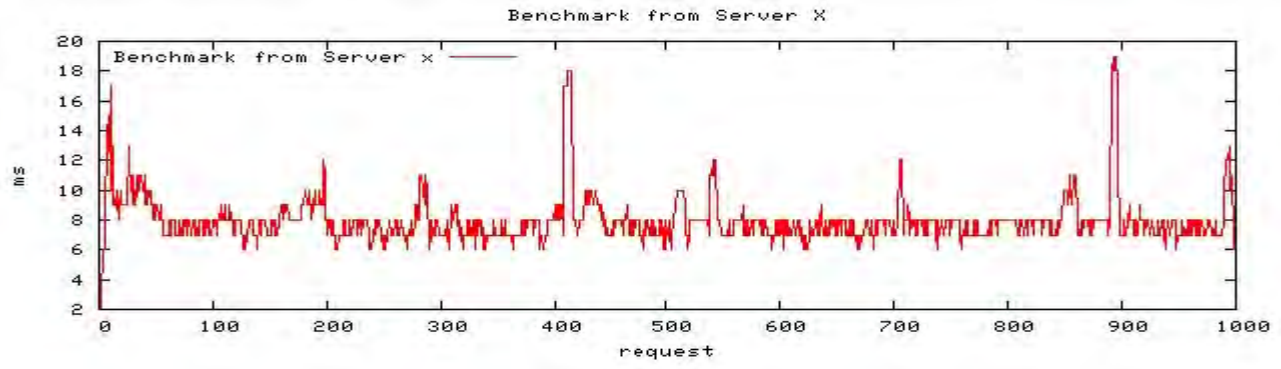

Fig. 10 Benchmark condition for Server X graph plotted via gnuplot

Graph in figure 10 shows that during normal VM execution (case 1) time required to serve each request is between 0-25 ms.

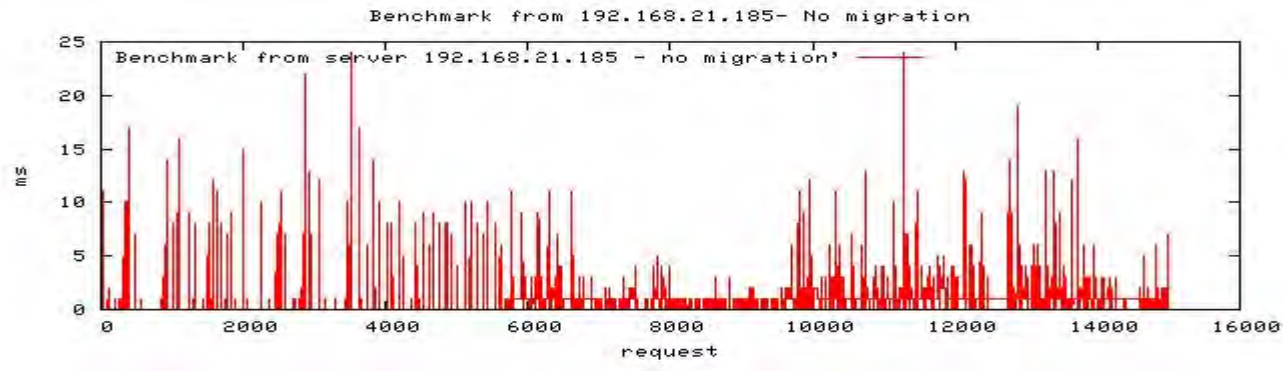

Fig. 10 Apache performance in normal condition

Graph in figure 7 shows three phases (case 2) i.e. Performance of apache web server before migration, during migration and after migration. We can notice that before and after migration performance is same case 1 but during migration we can notice more delay in serving request (upto 250 ms per request). Here one important thing to be noticed is that live migration causes little more delay in response but it is transparent to user and application.

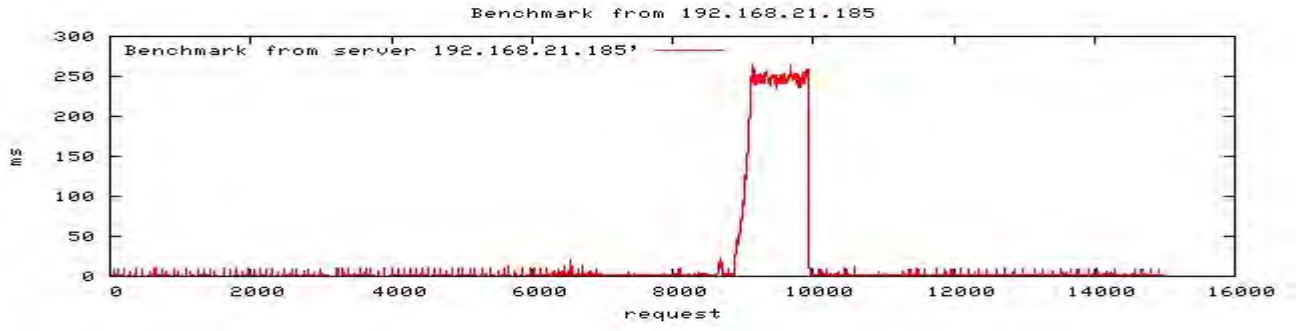

Fig. 11 Apache performance before, during and after live migration

V. CONCLUSION

With this experiment we can conclude that live migration feature provided by XEN hypervisor is quiet useful. It increases availability by 2.5 times of application and is transparent to user. When we executes live migrate command of XEN, the VM runs on source host till all memory pages are transferred to destination host (pre-copy). We can also observe that during and after migration VM preserves its IP address.

Windows XP form VM image is faster than booting it on physical host. It's overall increase is around 34% then earlier And form the delay versus request graph it is found that the performance of IIS in virtualized environment is also good.

VI. Future Work

The future work is to develop efficient memory management scheme among virtual machines running on same physical hardware. Virtual machine's live migration from one physical machine to other physical machine can also be done.

One can make further improvements to XEN's pre-copy live migration algorithm to minimize network traffic and downtime by adjusting page copy iterations between source and destination. A new migration mechanism based on post-copy or hybrid approach can also be developed.

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