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Open Source Virtual Machines on Xen: Creation, Implementaion and Analysis.

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Abstract

With the rapid emergence of Cloud Computing, lots of organizations, communities, groups and individuals are rushing towards Cloud services. The cloud services have the inherent benefits like minimum running and executing cost, hassle free service accessibility, on demand availability of services, viz. computing services, storage services and even using the platforms and applications directly on pay as per use basis. The backbone of Cloud is Virtualization Technology, which is re-invented to use the underlying physical resources like CPU usage, storage devices, network devices and I/O devices in an efficient and optimum way. Virtual Machine Monitors (VMMs) facilitates this by running multiple instances of Virtual Machines (VMs) that are configurable, updatable, reusable and manageable. To achieve this, open source VMM namely Xen is chosen, which is highly used in most of the Clouds used for commercial and academic purposes. A wide and detailed study of Xen VM creation, implementation, suggestions and critical analysis of the same is presented here, which may help understand the Xen usage in a better way and about the intricacies and challenges of adopting Xen for developing and running applications on it.

Keywords Virtual Machine Monitor; Virtual Machines; Virtualization; Xen; Cloud computing; CPU utilization; resource usage.

1. Introduction and motivation

The reasons for the advances in cloud computing is mainly because of the recent advances in Internet backbone, high performance, and scalable infrastructures in the web and data centers. A major advantage of cloud computing adoption is utilization of services without owning and managing the computing resources. The working definition of cloud computing which is given on the basis of services provided and technologies involved in cloud computing. Cloud computing is compared with other previous synonymous existing services and underlying technologies viz. utility computing, services provided via the internet using the web browsers, Saas (Software-as-a-service), Grid Computing, and data centers etc. The Cloud Computing, in which the computing and data moves to portable PCs and the data centers. Most of the applications will be delivered as a service over the Internet on to the cloud infrastructures, viz. the computing hardware, systems software and other applications software, which are the services provided by the cloud computing model. The backbone of cloud computing infrastructure and services are because of advances in virtualization technologies, development of service oriented softwares, advancements in grid technologies. It is stated that underlying services were already in use namely managed services, SaaS(Software as a Service), Web Services, utility computing. PaaS(Platform as a Service) etc., services. Google Application Engine, Amazon's Web Services, Zoho, Microsoft's Azure, which offer services like IaaS (Infrastructure as a Service), PaaS(Platform as a Service), SaaS etc. in different ways. These services are provided on demand, in a dynamic way using the instances for variable computing power. Scalable data and intensive computing resources are also leveraged on demand by pay-per-use model to the clusters of loosely coupled compatible processors.

Virtualization is the major technology being used to provision the resources viz, software virtualization, hardware virtualization, and network virtualization. These virtualization strategies are implemented at hardware levels, Operating system levels and at application levels. Full virtualization, Para- Virtualization, System

virtualization and Application virtualization techniques are being used depending upon the application requirements. These advances in virtualization technologies have given birth to exponential growth of commercial infrastructure for cloud computing.

Some of the major advantages of virtualization are improvement in resource utilization, better maintainability, good management, and enhancement in reliability of the computer systems. A large number of users with heterogeneous Operating Systems requirements can share the virtualized server in an easy and convenient way. Operating Systems can also be upgraded and staged to the Virtual Machines. Consequently the downtime and the failures in the guest softwares can be minimized and isolated, and are restricted to the individual Virtual Machines in which they occur. These benefits of virtualizations are considered to be highly valuable in high-end server systems. In the academic and research groups too, the newly developed and emerged Virtual Machine Monitor based products are highly appreciated and admired by the cloud users as they have a broader range of applications in both the client and server based systems. The key challenges for developing applications lies in handling the heterogeneity in terms of tasks, resources, applications and infrastructures which inherently belong to grid and cloud resources. Virtual machines are created on top of the physical infrastructure in a customized way which is the basis of Cloud computing model. These are facilitated by the Virtual Machine Monitors (VMMs). Various commercial and open source VMMs are available and a lot more are still getting evolved everyday by various organizations.

2. Some contemporary challenging R & D problems in the Distributed and Cloud computing

The availability and robustness of the distributed and cloud services and applications need to be designed into the software architecture with the assumption that they almost not existing. Also the underlying hardware are prone to failure at any moment of time, which may further make the services unreliable and may get broken or become unavailable at any moment of time. Since there may be a large number of unpredictable demands to access the cloud services, especially the public cloud services, hence the probability of congestion and random accessibility shall be addressed with great care and caution. In reality these problems were always there at scale, even with the most reliable hardware, so cloud ready architecture is about taking the patterns that are required to be used at large scale. At the same time using them at a smaller scale too must leverage the lowest cost infrastructure.

Some of the major research challenges in distributed and cloud computing area and related issues are:

- Workload Isolation, Workload Consolidation, Workload Migration.
- Sharing of resources between cloud service providers
- Algorithms for high availability, performance, proximity, legal domains, price, or energy efficiency
- Networking in the deployment of services across multiple cloud providers
- Additional privacy, security and trust management layers atop providers
- Automatic management of service elasticity integrating and managing applications in a multi-tenant, elastic and scalable environment
- Contribution towards Green IT with the design and innovation of low power consumption techniques.

3. Brief summary of literature reviewed and the conclusion drawn regarding research problems

The key sources of literature reviewed in the chosen area includes International Conference papers, referred International journals, proceedings related to cloud technologies, some selected books and other online materials.

Most of the existing research work related to resource allocation and virtualization can be described as attempts to fix existing distributed problems, rather than a conscious and focused approach towards a cloud computing environment where the resources are mainly virtualized to cater the user demands. As a result, several aspects of resource allocation strategies and virtualization issues remain unexplored and unmatched. Hence many modifications and improvements are required. Efficient allocation and scheduling of physical resources among multiple host Operating Systems are need to be catered. Here the work has been restricted only to LINUX/UNIX based platform for guest and host OSes. In addition, multiple open source VMMs were required to be installed. Open source platforms and VMMs have been chosen so that additions/modifications can be implemented and tested.

To provision the resources, virtualization can be done at different levels namely, hardware virtualization, software virtualization, and network virtualization. These virtualization strategies can be implemented at hardware levels,

operating system levels and at network levels. Full virtualization, Para-virtualization, System virtualization and Application virtualization techniques can be used depending upon the application requirements.

Hypervisors are implemented and installed at the beginning at different levels. If the system is in running state, the same cannot be installed, it requires a reboot.

4. Proposed objective and Motivation of work

Despite the promise of new and existing virtualization usages, many challenges stand in the way of achieving efficient virtualization of today's IA-based systems. Creative software techniques as Binary translation and Para-virtualization have addressed some of these problems. Inherently, lot of expectations are there from Virtualization viz., the applications shall run on any available machine depending on the choice and inclination of the operator and user based on the availability of resources and their priorities. Behavioural, content control, encryption, coding.

The focus of the problem is logically interpreted from that since virtualization enables easier and faster application migration as well as secure resource allocation to applications. Higher degrees of server consolidation are likely to result in such virtualization-based hosting platforms (VHPs). The objective is to use the kernel and process virtualization to allocate the resources. But virtualization solutions incur performance overhead, hence a thin layer in the open source VMM is proposed, which closely behaves like a device driver, i.e., it becomes active as and when resources are required to be allocated. Once the resources are allocated to guest OS applications, this thin hypervisor may go to sleep mode. Consequently the resources held and utilized by it are discharged for further use by other processes.

5. Proposed /used research method with risks associated with this method

The proposed research method is to Install and use Linux as Host OS along with Linux supported open-source virtualization software tool, i.e. Xen. On top of that the Guest OS shall be installed. This Guest OS too will be open source i.e, Linux or Red Hat supporting versions. Further modifications can be done in the Kernel of these guest OSes to observe the behavioural changes. To achieve this, the system calls of Linux are used to access and modify the traditional and in built resource allocation strategies on the VT_x and VT_i processors. The newly created portable thin VMM can be deployed to the existing open source host OS which can be activated and deactivated on the run. This thin VMM may allocate the resources in a secured way and decide which software is to be run at which level along with priority scheduling i.e. allocates the resources in root and non-root operation modes. Once the scheduling and resource provisioning is done, it will go in sleep mode, which will reduce the overhead of continuously running along with the normal applications. This thin VMM will be instantiated by the request process from the guest OS. The performance evaluation in terms of time, CPU cycles, memory utilization etc. may now be observed and published.

The proposed design approach for the hypervisor is layered, as a result the control will be separated for all hardware devices using data memory mapping. This can be achieved by modifying the device drivers to take the control via the hypervisor. Further para-virtualization and hardware-based virtualization systems can be used, which depend on a privileged abstraction layer which acts as a mediator between the individually instantiated kernels and hardware devices. This thin layer shall create a separation between the hardware resources and un-trusted kernels, which are de- privileged using ring aliasing.

Some significant risks associated with this approach:

- Solutions are highly complex and incomplete to run the modified guest operating systems, as only a limited number of challenges are addressed, whereas many more need to be addressed depending upon the application requirements.
- Will not work on all platforms: as guest and host OSes are chosen as Open Source, Not all OSes are open source, and hence these can't be applied to such Operating Systems, consequently putting a limiting factor.
- Implementations and testing are done over open source VMM, hence the same can't be tested on commercial VMMs like VMWare, VirtualBox versions etc.
- Testing with with VT_x and VT_i processors a complex issue.
- The virtualization software must support different guest operating systems (Windows, Linux, UNIX etc.) to make it possible to create a virtual lab with diversified platforms, which is not possible in our approach.

6. Proposed approach with risk analysis

In this approach the term virtualization is used to denote the virtualization at the system abstraction layer. This is achieved by developing a thin software layer that runs directly on top of the host operating system. This VMM virtualizes the resources of a physical machine by supporting the execution of this VM. This VM is made to run separate guest operating systems above it and the VMM provides safety and isolation to the overlying operating systems.

Significant risks associated with the implementation of RA algorithms in Virtualized environment

- Privilege-based protection may prevent the unprivileged system calls to access some of the states of the CPU, especially the states that require direct access to the underlying hardware resources, resulting in faults and consequently the guest software running may understand that it is running in de-privileged state.
- Interrupt virtualization not fully possible.
- Access to hidden states not represented in software-accessible register. Hence difficulty to represent such issues.

The executable codes, if run in the pages that are non-executable, generate exceptions for the page-fault which indicates that there is violation of the permission.

7. Experiment/Simulation details and results:

- Testing and execution of existing Linux kernel architecture for further addition and modification of system calls used for handling different resources.
- Running and understanding of Virtualization softwares, OpenNebula, Xen, VirtualBox, to understand the working and functional execution of codes.
- Customizing operating systems for its VMs. Viz. Linux 2.6, Redhat 9+, Ubuntu.
- Changing the static priorities of conventional processes
- Setting and manipulating the real time priorities of the processes
- Getting the timing details of scheduling policies

8. Limitations

- All mat Guest and host OSes are chosen as Open Source, Not all OSes are open source, and hence these can't be applied to such Operating Systems, consequently putting a limiting factor.
- Cannot be fully complete in their ability to run modified operating systems.
- Testing for large number of heterogeneous guest OSes, which are not having open source codes, is not possible.

9. Conclusion and future work

- Further continuing the current testing with refinement and focus to run the VMs (Virtual Machines) and migrate them to other physical hardware on the fly for balancing the load and better system resource utilization.
- Testing and modifications of device drivers of guest Operating Systems can be mapped to the currently chosen Virtual Machine.
- The scheduling policies can be made to run with the real-time priority policies of the processes. Further many real-time scheduling policies can be combined to get better performance in terms of CPU usage, switching between different VMs etc.
- Testing can further be extended onto VT_x and VT_i processors that support Virtualization Technology for IA-32 and ITANIUM architectures respectively.

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