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# Virtualization benefits in High Performance Computing Applications

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**Abstract**

Virtualization is not a new computer technology in this age. It was developed by IBM in 1960's. Virtualization was used to access the pricey resources of mainframe computers. Furthermore it conceals the computer resources from the operating system. Since computer resources are growing day by day, there is an emergent need to utilize them efficiently and effectively. It proffers a lot of benefits to different applications including High Performing Computing (HPC) applications. We have highlighted a review of some benefits aided by This paper provides a review of some benefits that are aided by employing virtualization in HPC environments and analysis of some of the technologies that are designed to support virtualization.

**Keywords**: virtualization, HPC, hypervisor

## Introduction

Virtualization is a method to divide computing resources logically. Virtualized resources can be computer hardware, computer software, storage, memory, data, operating system, and network resources. Virtualization technology is one of the technologies in computer science field which is not a new technology [1].

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Virtualization is an implementation that hides the computer hardware and software resources from the operating system [2]. Virtualization is as old as the 1960, at that time, virtualization was recommended by the IBM [3]. In old days, virtualization was a way to access the costly resources of mainframe computers. Now, computing system resources are growing day by day at a very large scale. It is required that these resources should be used efficiently over and above cost incurred using these resources should be negligible. Virtualization is only the way to achieve these objectives. Virtualization started supporting different applications' requirement demand; some of them are server consolidation, application performance isolation, dynamic migration of workloads, and research on security areas [3] .

Special virtualization techniques are available to fulfill these demands. "Xen" is a technique of virtualization that meets the demand of performance isolation with the help of high performance Virtual Machine Monitor (VMM) [4]. Other virtualization technologies are VMWare ESX, Oracle VirtualBox and Kernalbased Virtual Machine (KVM) are more common[3], [4]. Virtualization technologies provide number of benefits i-e simplified management, security, lowest performance cost and shifting the virtual machine from one place to another without disconnecting the application [5] . Virtualization is a source of easy division of computer hardware and software resources while maintaining the security and quality of service provided to the customer, so interest is increasing in designing the microprocessors that fits the virtualization support [6]. Virtualization is increasing rapidly in research communities and IT industry [5], [7] .

In virtualization resources are multiplexed by a supervisor which is now called hypervisor or virtual machine monitor [8]. Hypervisor is software that performs large number of tasks that are considered to be performed by the operating system. Hypervisor can be embedded in the operating system, to gain the efficient virtualized environment [6]. Hypervisor resides in between the hardware and operating system, allows different virtualized operating systems to start at the same time [2].

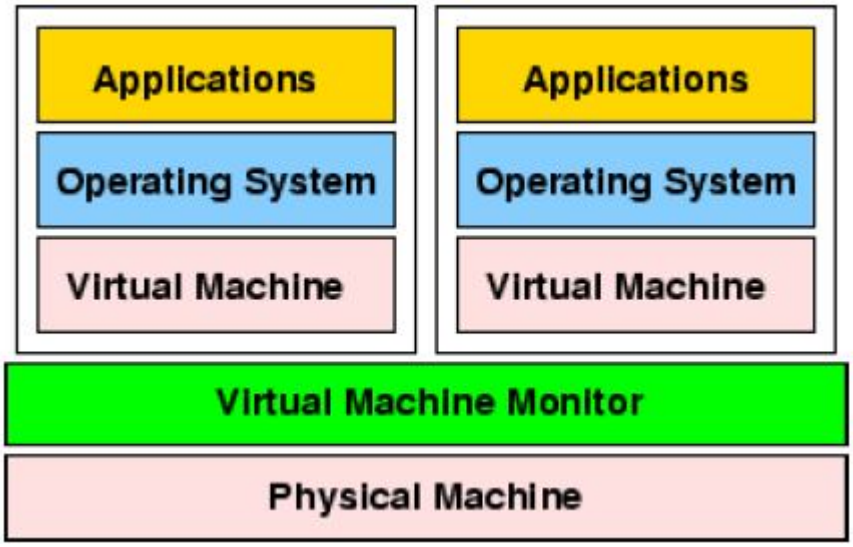


**Fig 1: A virtual machine monitor provides a virtual machine abstraction in which standard operating systems and applications may run. Each virtual machine is fully isolated from the rest of the virtual machines**

HPC applications need to be accelerated. They are used in data mining, medical industry, financial trading, data ware housing, to bioscience, data security and many more. In IT industry acceleration in data processing increasing extensively and industry started to develop and deploy HPC applications every day.

It is perceived that the virtualization ruin the performance of HPC applications as well as there is a shortage of information about the benefits that the virtualization might bring, so virtualization can be reviewed because of its performance cost rather the benefits which it implies to the HPC applications environment [7]. Virtualization can increase the flexibility and usability of application to the vast number of end users while maximizing the reliability and performance of HPC applications, so these are the incentives to use the virtualization in HPC environment [9]. Significant difference lies in the performance of HPC applications on operating system and typical server and work station[8]. Virtualization in HPC environment can only occur if it has little impact of performance on the application [9]. HPC applications can take advantages provided by the virtualization [5]. Multiplexing HPC applications with the minimal performance issue is an advantage to the HPC environment. Virtualization of HPC applications allow them to use the services of operating system that only mean to them [8].

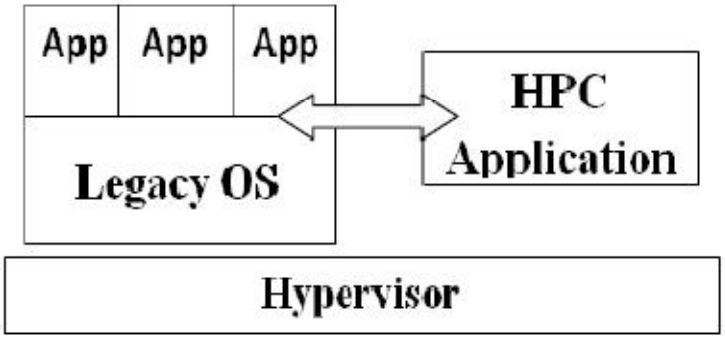


**Fig 2: Architectural overview of coexisting HPC application with the legacy OS [8]**

Although virtualization provide a wide range of benefits but it has not been extensively accepted to the HPC environment because of some disputes; virtualization overhear: in HPC application efficient communication is critical, but in virtualizing systems hypervisor takes some tasks from the virtual machines to perform. This is not suitable in HPC environment. Ease of management: virtualization in HPC environment need a framework to provide the management ease for the virtual machines. HPC applications cannot have benefit from the virtualization until the management framework is applied [5].

In spite of these challenges, virtualization can provide extensive benefits to the HPC applications. In this paper we will review some potential benefits that the virtualization can bring to the HPC environment when HPC applications are multiplexed.

**Related Work**

There are several uses of virtualization in HPC environment [7]. As well as virtualization offers many benefits to the HPC applications, although the use of virtualized HPC applications is lagging but it is becoming the thrust of enterprise industry. Virtualization provides many benefits to the HPC applications in terms of performance, scalability, availability, and security.

Along with the several benefits productivity is one of the potential benefits that the virtualization offers to the HPC applications and systems.

It can provide HPC applications and systems with increased development and testing. As virtualization offers a bunch of virtual machines and each of them can be configured for specific task. With the use of virtualization testing and development can be performed on the same machine. Another aspect of productivity of the HPC applications with the use of virtualization is that the productivity can be increased by running various copies of OS and applications on the same machine [8].

Regarding virtualization, performance is the major question to answer as the performance of virtualized HPC applications is as good as they are in physical machines [10]. Performance isolation is one of the issues of virtualization that is being given great importance while designing the virtualization technologies like xen and IBM Hypervisor. HPC applications can benefit from virtualized environment in terms of performance in many ways. In virtualization optimized operating systems are used for HPC applications. It is the responsibility of hypervisor to allocate resources to different applications in HPC environment so the performance of different HPC applications is isolated and they can perform their tasks as efficiently as they were in physical machines[8].

As discussed above that the virtualization multiplexes the resources of a single machine to be used as multiple machines. These multiple machines are virtual faces of different machines. In HPC environment several applications run on these VM's. Along with the performance and productivity, availability can also be discussed as the advantage of virtualization in HPC environment. Availability can be defined in terms of isolation. As applications in virtualized HPC environment run on different virtual machines and the hypervisor is responsible for the allocation of resources [10] so availability is not an issue. If one VM is busy in development than another VM is always available to perform testing or other tasks, it is intended to serve [8].

Security is one of the features provided by the virtualization and HPC applications can take advantage from this aspect of virtualization. Applications are running on their own virtual machines providing a security barricade to secure the information of one job with the other running on the same virtual machine which is virtually divided [7]. As well as virtualization provides information security because VMs can be designed to prevent from attacks of unauthorized persons because it makes applications more complicated to attack [11].

Virtualization also offers other resource related benefits in terms of resource management, fault tolerance and other functionality. In virtualization HPC applications are greatly dependent on the availability of the resources and related to the breakdown of the virtualized resources [12]. Two methods are used to avoid such problems a) fault tolerance migration and b) fault tolerance monitoring. In HPC environment application break down and restart is an important issue [10]. Fault tolerance migration is also called reactive approach and it is valuable way to restart HPC application after a breakdown [12]. This approach has the aptitude to save the current state of the application and again start the application from this point [7]. Fault tolerance monitoring is the proactive approach it includes continues monitoring of the HPC applications environment [10]. It monitors whether any interruption to the system occurs [12]. Virtualization provides the solutions for these two types of tolerances without having separate hardware and software manageability[10].

Now we are going to execute the analysis of some special techniques which are used in Virtualization for high performance computing (HPC) that are Palacios VMM, KVM, VirtalBox, Xen, VMWare, Kitten and highlighting some of the parameters presented in the table below.

Various Virtualization technologies used in HPC environment:

| | Palacios VMM | KVM | VirtualBox | Xen | VMWare | Kitten |
|---|---|---|---|---|---|---|
| **Para virtualization** | No | No | No | Yes | No | No |
| **Full virtualization** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Host CPU** | x86 & x86_64 | X86, x86_64,IA64,PPC | x86 & x86_64 | X86, x86_64,IA64 | x86 & x86_64 | x86 & x86_64 |
| **Guest CPU** | x86 & x86_64 | X86, x86_64,IA64,PPC | x86 & x86_64 | X86, x86_64,IA64 | x86 & x86_64 | x86 & x86_64 |
| **Host OS** | Linux | Linux | Linux, Windows, Unix | Linux, Unix | Proprietary Unix | Linux |
| **Guest OS** | Linux, Windows, Unix | Linux, Windows, Unix | Linux, Windows, Unix | Linux, Windows, Unix | Linux, Windows, Unix | Linux, Windows, Unix |
| **VT-X/AMD-V** | optional | required | optional | Optional | optional | optional |
| **Live Migration** | Yes | Yes | Yes | Yes | Yes | Yes |
| **Licence** | BSD | GPL | GPL/Proprietary | GPL | Proprietary | GPL |

**Table 1: Analysis of Various Virtualization Technologies Used in HPC Environment**

Virtualization is preferred cost saving plan in software industry. HPC applications can also get benefit from the other virtualization benefits such as saving costs used in purchase of several servers, scalability, load balancing, lower power consumption and efficiency etc [11].

## Performance Evaluation

Table 1 shows the analysis of various virtualization technologies that can be used for HPC environments. Among them Palacios and kitten are specially designed for HPC applications to gain high productivity, scalability and improved performance of HPC applications. Both are embedded to achieve scalability and improved performance, kitten is a light weight OS in which Palacios is embedded as a kernel code [9].

## Conclusion

Virtualization is a way to logically divide the computer resources so that they can be utilized proficiently. Virtualization started fulfilling the demands of different applications such as server consolidation, application performance isolation, dynamic migration of workloads and application security. HPC applications are those which require to be accelerated. Virtualization can also assist the HPC environments regarding reliability, security, performance isolation, fault tolerance and availability. Different virtualization technologies are available and some are specially designed to aid HPC environments. In Future, we will discuss the simulation behaviors of the virtualization technologies used in HPC applications.

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