RCEE & RHEd2010
Kuching,Sarawak
7 – 9 June 2010

Flexible and Dynamic Learning with Virtual Machine

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Abstract

Teaching and learning Computer Science curriculums involved many hands-on activities that required students to directly interact with a computer system's components and applications especially in Computer Architecture and Operating System subjects. Currently, to understand components of computer and operating system like Linux and Windows will require two labs with two different operating systems installed on each machine. Virtualization is a technology that promotes creating a virtual machine in any environment regardless of Linux or Windows. Students can have one or more virtual machines with different operating systems run simultaneously on a single machine [4]. This virtual machine has its own virtual components which are almost similar as in the physical machine. As the virtual machine runs on an isolated environment these components can be investigated and modified freely without affecting the physical machine that hosts it[2][8]. This technology will provide a very flexible and dynamic platform for student to hands-on [9]. This paper will share some capabilities of virtual machines and propose the usage in teaching and learning Computer Science curriculum especially in Computer Architecture and Operating System.

Keywords: Virtual machine, virtualization, full virtualization, paravirtualization

1. Introduction

Computer technology has evolved from the biggest as mainframe in size until the smallest as Iphone gadget in size. As the technology has grown fast, it witnesses the changes in our teaching and learning paradigm [11][12]. Almost all Computer Science curriculums involved teaching and learning activities in a computer laboratory [3][5][6][10]. This is to provide an extensive hands-on learning for student to understand the physical components that built it and important applications that support it [6] [11].

Usually, a first year Computer Science students learn a basic architecture of a computer system to make them familiar with the machine [5][6]. They also learn an Operating System to understand the main interaction between the operating system with the physical components that build up the machine [3][6]. Once they have familiar with the computer architecture and the main system, then they will go for higher curriculum which need them to develop, to secure and to investigate defect on an application [5] [10].

In current approach, computer school or faculty always have two different labs for machine with Linux and Windows operating systems. Any subject that required Linux will use Linux Lab and vice versa. This requirement will increase the cost and maintenance time for university to set up a computer laboratory [4][7]. This problem can be solved using virtualization technology which provides an isolated and secure virtual machine for students to interact with [7][10]. This technology can create one or many machines with different type of operating system that run simultaneously on a single machine [2].

Detail architecture of virtual machine will be explained later in section 3.The other benefit of virtual machine will be address in section 4 and solution for implementation will be discussed in section 5.

2. Limitation in Current Practice

Currently, teaching Computer Architecture need a student to interact with one physical machine [10] [11]. The limitation of using one machine as a tool in teaching Computer Architecture subject can be describe as in Figure 1.The figure [2] shows an architecture of x86 machine with one single operating system image installed on it. It has several hardware and software components that is tightly couple to one and other which is not feasible to play around with every single component and the configuration on the machine [9]. Students need a clear guide and instruction to modify the component as it will affect the whole system performance [11]. It also shares the same underlying resources which installation of many applications on top of it can conflict each other. This will make the learning

process not flexible and more maintenance work to do which will increase the cost [4][7].

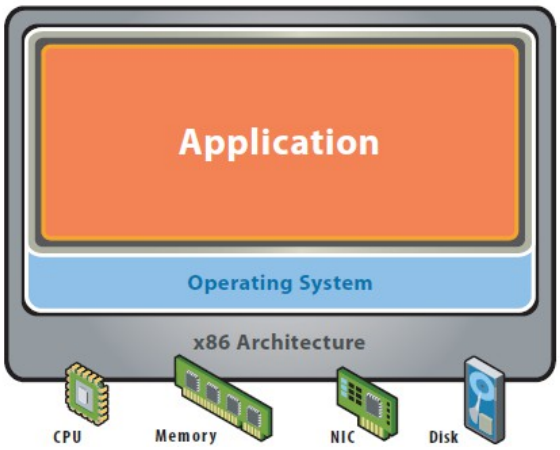

Fig.1. x86 Architecture before Virtualization [2]

3. Virtualization

Virtualization can be describes as a separation of a resource or request for a service from the underlying physical that provide the service [2]. Virtualizing a system or component such as a processor, memory, or an I/O device at a given abstraction level maps its interface and visible resources onto the interface. Consequently, the real system appears as a different virtual system or even as multiple virtual systems [8].

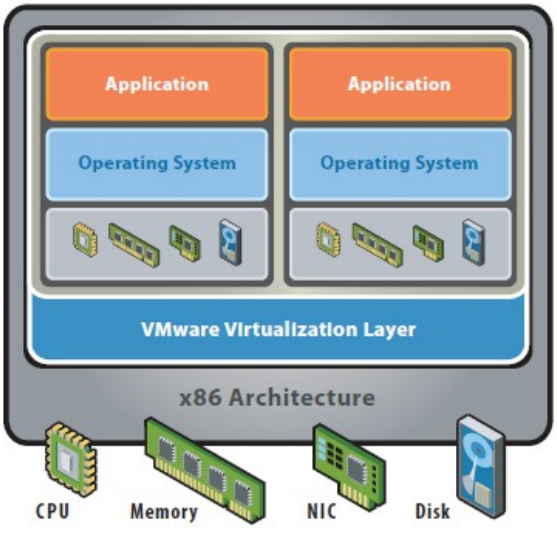

Fig.2. x86 Architecture after Virtualization [2]

Virtualization can be applied at any range of system layers including hardware virtualization, processor virtualization, instruction set virtualization and operating system level virtualization [13]. At hardware level virtualization, two types of virtualization can be applied are full virtualization and paravirtualization.

In full virtualization, it uses Virtual Machine Monitor (VMM) or hypervisor as a separation layer between virtual machine operating systems and the bare hardware [13]. As shown in Figure 2[2], virtualization provides an abstraction layer between computing, storage and networking hardware, and the applications running on it. The abstraction layer was representing by VMWare Virtualization layer. A VMM component can run directly on real hardware. It could create multiple virtual machines which each instance run its own operating system.

Paravirtualization is another method that uses hypervisor. It requires modifications to the operating system that run in a virtual machine. This will make the operating system aware the differences between the real and virtual environment.Table 1 shows, sample of full virtualization and paravirtualization applications.

Virtualization Type	Software Available
Full virtualization	IBM VM/370,VMware ESX, Microsoft Virtual PC,z/VM
Paravirtualization	Xen,UML

Table 1. List of Virtualization Applications

4. Benefit of Virtual Machine

As mentioned in [11], it is important to provide students with an efficient, rigorous and engaging learning environment with necessary tool to become proficient in Computer Architecture subject.

Implementing virtual machine in current teaching will provide flexible and dynamic learning activities because [2][9]:

1. It supports multiple operating system environments operating on the same physical computer. These multiple operating system runs in an isolation and secure environment that separate each other. Student can see and differentiate behavior of different operating systems.

2. It can also provide an illusion of hardware or hardware configuration through an instruction set architecture (ISA) which is different from the real machine. Student will feel confident to play around with the system's components.

3. Modifying a virtual machine has similar benefits as modifying a real machine. The modified process or service can run separately from all processes in the real machine. This make modification and investigation activities much easier and will not affect the real system performance.

4. Easier to manipulate the state of a virtual machine than the state of a physical machine. The state of the virtual machine can be saved, cloned, encrypted, moved, or restored. Student can save their virtual machine state in their laptop, can open it at anytime and anywhere when needed.

5. Proposed Teaching and Learning with Server Virtualization

Virtual machine capabilities as mentioned earlier provide more flexible and dynamic way of learning which will increase students' interest and make them enjoy the learning activities in the lab or anywhere as long as they can get access to their virtual machine.

Figure 3 shows the proposed infrastructure for managing students' access to virtual machines on centralized virtual server. Every virtual machine installed with different operating system image. The virtual machine contained an image of a machine that belongs to a student which can be access directly from computer lab, home or anywhere as long as they can access the server.

The proposed infrastructure is not mean for dynamic and learning only but it also propose a new way of managing resources by lab administrator which will minimize their burden of maintaining the single system on a single machine in every lab. They can easily create and delete any virtual machine anytime only on single server. This will save much cost of having many physical servers and maintenance cost for the university. For server centralization, several vendors that offer server virtualization service are Citrix, IBM, HP and etc[4] [7].

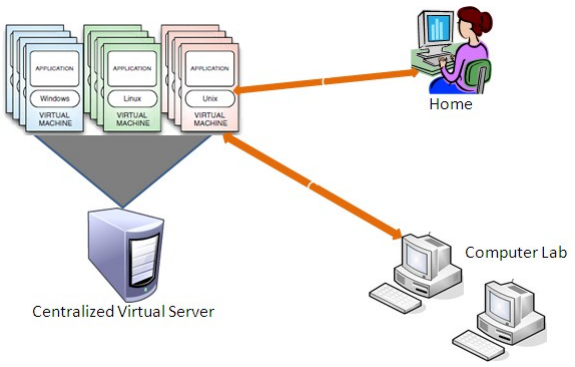

Fig.3: Proposed Infrastructure for Centralized Virtual Server

6. Conclusion

Teaching and learning Computer Architecture and Operating System subjects are more challenging nowadays with more new invention of computing technologies. Students need more flexible and dynamic learning tools that help them investigate computer system, components and architecture in a safe manner. Virtualization technology has been seen as new solution for this problem. Virtual machine is a way of virtualizing computer's components, resources and operating system that provide the flexibility and dynamic environment for learning and teaching. This virtualized platform can be create, save and delete at anytime. Students can access their virtual machine anytime and anywhere when needed. It can also be used to replace a traditional way of managing lab resources which is through server virtualization. This can save much on the resource maintenance works and cost as well.

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