

# **Cloud Computing**

## **(16BT61201)**

**Dr.Sasikumar Gurumoorthy**

**Professor  
CSSE,SVEC  
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**Instructor:**

**Dr.G. Sasikumar** , [sasichief@gmail.com](mailto:sasichief@gmail.com)

**Textbook**

1. Thomas Erl and Ricardo Puttini "Cloud Computing- Concepts, Technology and Architecture," Pearson, 2013.
2. Ivanka Menken and Gerard Blokdijk "Cloud Computing Virtualization Specialist Complete Certification Kit - Study Guide Book," Lightning Source, 2009.

**Requirements**

Homework x2 20% (do not copy)

Test 15%

Quiz & Oral presentation 15%

Final exam 50%

**Provisional web page:** [Cloud Computing-SVEC@GSK](#)

**Web:** <https://www.facebook.com/groups/cloudcomputingskg/>–

**Lecture slides (PDF), assignments, other information**

**E-mail : cloudcomputingskg@groups.facebook.com**

# People

- **Faculty - CC**
  - **Dr. Sasikumar Gurumoorthy**  
**Office:SMV-614 (CSSE-HOD Office)**  
**E-mail: sasichief@gmail.com**

## REFERENCE BOOKS

1. Barrie Sosinsky, "Cloud Computing Bible," Wiley India Pvt Ltd, 2011.
2. Rajkumar Buyya, James Broberg and Andrzej Goscinski, "Cloud Computing Principles and Paradigms," John Wiley and Sons, 2011.
3. John W. Rittinghouse and James F. Ransome, "Cloud Computing Implementation, Management and Security," CRC Press, Taylor & Francis Group, 2010.

# Cloud Computing (16BT61201)

## Unit I: Introduction to Virtualization

**NOTICE:** Slides are extracted from “*Cloud Computing Virtualization Specialist Complete Certification Kit: Study Guide Book*” & Other *Internet* resources.

# Discussion Contents

## ❖ Introduction to Virtualization:

- Definition
- Objectives
- Characteristics
- Benefits of virtualization
- Taxonomy of virtualization technologies
- Pros and cons of virtualization.

## ❖ Virtualization Technologies:

- VMware
- Hyper-V
- Zen and virtual iron.

# Part – I

## ❖ Introduction to Virtualization:

- Definition
- Objectives
- Characteristics
- Benefits of virtualization
- Taxonomy of virtualization technologies
- Pros and cons of virtualization.

# Objectives of Virtualization

## Definition & Introduction:

**Virtualization** defined as the emulation of one or more workstations /servers within a single physical computer. In other words, Virtualization is the emulation of hardware within a software platform.

**Virtualization** allows the simulation of hardware via software. To make this possible, some type of virtualization software is required on a physical machine. Examples: Vmware, Virtual Box, Hypervisor, etc.

**Full Virtualization** is, allowing one physical computer to share its resources across a multitude of environments. This means that a single computer can essentially take the role of multiple computers.

Also, Virtualization is not limited to the simulation of entire machines. There are **many**

**different types of virtualization, each for varying purposes** like Virtual Memory Simulation, Storage Memory Simulation, OS Simulation, Application Simulation, Network Simulation, etc.



# Objectives of Virtualization

There are four main objectives to virtualization, demonstrating the value offered to organizations:

1. Increased use of hardware resources;
2. Reduced management and resource costs;
3. Improved business flexibility; and
4. Improved security and reduced downtime.

## **1. Increased use of Hardware resources:**

With improvements in technology, typical server hardware resources are not being used to their full capacity. On average, only 5-15% of hardware resources are being utilized. One of the goals of virtualization is to resolve this problem. By allowing a physical server to run virtualization software, a server's resources are used much more efficiently. This can greatly reduce both management and operating costs.

*For example, if an organization used 5 different servers for 5 different services, instead of having 5 physical servers, these servers could be run on a single physical server operating as virtual servers.*

# Objectives of Virtualization

## **2. Reduced Management and Resource Costs :**

Due to the sheer number of physical servers/workstations in use today, most organizations have to deal with issues such as space, power and cooling. Not only is this bad for the environment but, due to the increase in power demands, the construction of more buildings etc is also very costly for businesses.

Using a virtualized infrastructure, businesses can save large amounts of money because they require far fewer physical machines.

## **3. Improved Business Flexibility:**

Whenever a business needs to expand its number of workstations or servers, it is often a lengthy and costly process. An organization first has to make room for the physical location of the machines. The new machines then have to be ordered in, setup, etc. This is a time consuming process and wastes a business's resources both directly and indirectly.

Virtual machines can be easily setup. There are no additional hardware costs, no need for extra physical space and no need to wait around. Virtual machine management software also makes it easier for administrators to setup virtual machines and control access to particular resources, etc.

# Objectives of Virtualization

## **4. Improved Security and Reduced Downtime:**

When a physical machine fails, usually all of its software content becomes inaccessible. All the content of that machine becomes unavailable and there is often some downtime to go along with this, until the problem is fixed. Virtual machines are separate entities from one another. Therefore if one of them fails or has a virus, they are completely isolated from all the other software on that physical machine, including other virtual machines. This greatly increases security, because problems can be contained.

Another great advantage of virtual machines is that they are not hardware dependent. What this means is that if a server fails due to a hardware fault, the virtual machines stored on that particular server can be migrated to another server. Functionality can then resume as though nothing has happened, even though the original server may no longer be working.

# Objectives of Virtualization

Precisely, cost involved in the utilization of hardware resources **before** and **after** virtualization is as below:

Before virtualization:

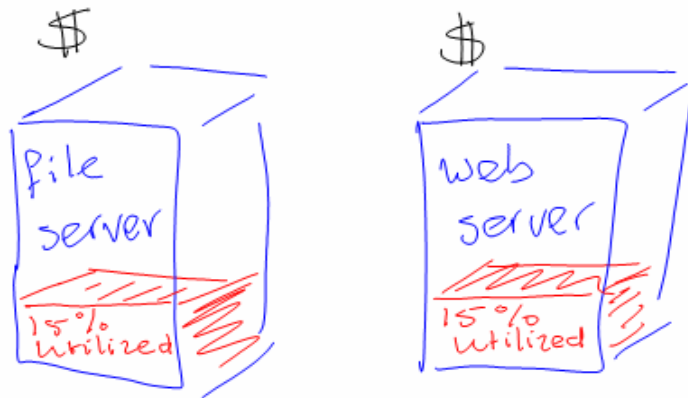


2x purchase  
2x maintenance  
2x depreciation  
2x floor space  
2x energy usage

# Objectives of Virtualization

Precisely, cost involved in the utilization of hardware resources **before** and **after** virtualization is as below:

Before virtualization:



2x purchase  
2x maintenance  
2x depreciation  
2x floor space  
2x energy usage

after virtualization:



1 x purchase  
1 x maintenance  
1 x depreciation  
1 x floor space  
1 x energy usage  
⇒ better utilization

✓

# Characteristics of Virtualization

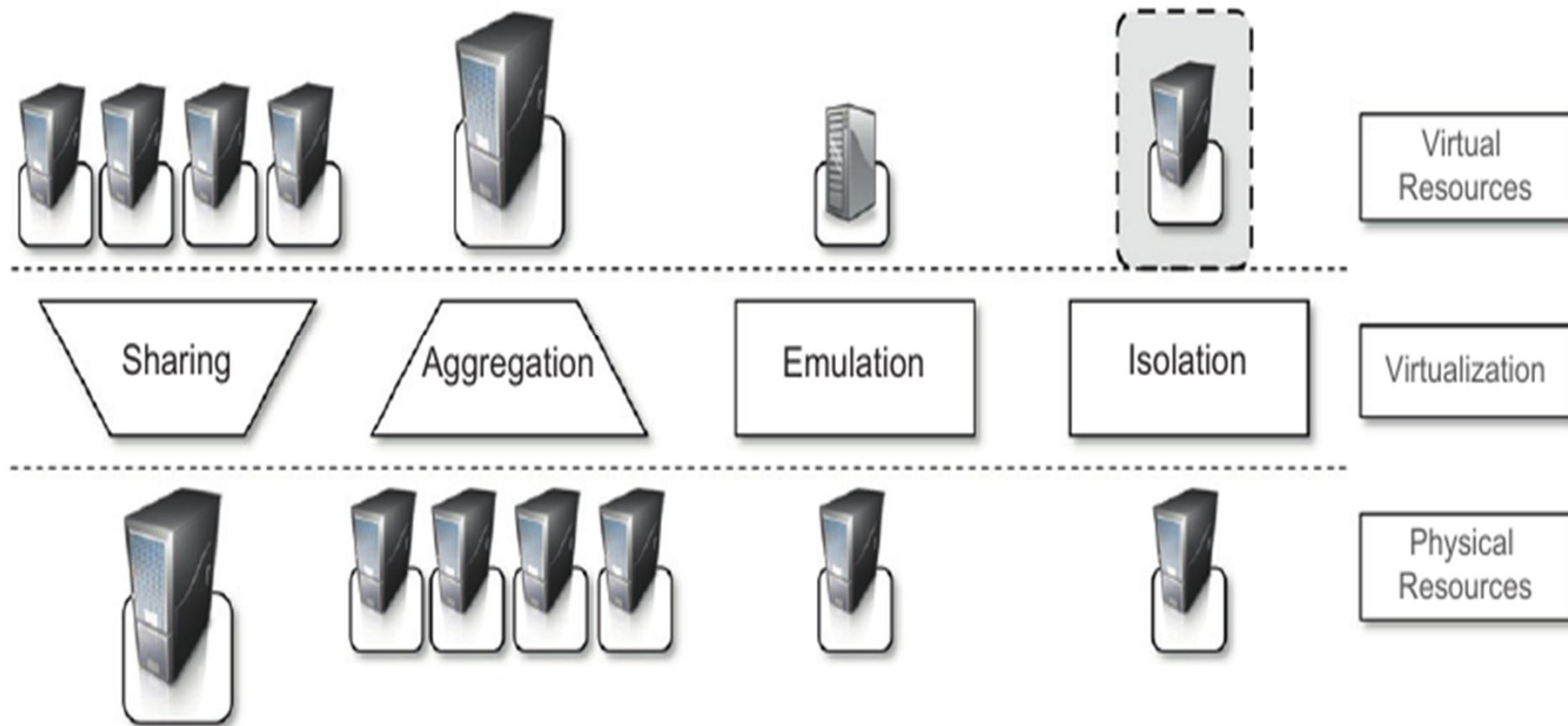
- **Increased Security**
  - Ability to control the execution of a guest
  - Guest is executed in emulated environment.
  - Virtual Machine Manager control and filter the activity of the guest.
  - Hiding of resources.
  - Having no effect on other users/guest environment.

# Characteristics of Virtualization

- **Managed Execution types :-**
  - **Sharing**
    - Creating separate computing environment within the same host.
    - Underline host is fully utilized.
  - **Aggregation**
    - A group of separate hosts can be tied together and represented as single virtual host.
  - **Emulation**
    - Controlling & Tuning the environment exposed to guest.
  - **Isolation**
    - Complete separate environment for guests.

# Characteristics of Virtualization

## Managed Execution





## **Characteristics of Virtualization** [Cont.]

- **Performance Tuning** –
  - control the performance of guest.
- **Virtual Machine Migration** –
  - move virtual image into another machine.
- **Portability** –
  - safely moved and executed on top of different virtual machine.
  - Availability of system is with you.

# History of Virtualization

The concept of virtualization was first devised in the **1960s by IBM** to help split large mainframe machines into separate ‘virtual machines’.

Before virtualization was introduced, a mainframe could only work on one process at a time, becoming a waste of resources. Virtualization was introduced to solve this problem. It worked by splitting up a mainframe machine’s hardware resources into separate entities. Due to this fact, a single physical mainframe machine could now run multiple applications and processes at the same time.

This was done to maximize their available mainframe computers efficiency.

During the **1980s**, x86 became the dominant instruction set architecture in computer technology, and the client-server model was established to allow for distributed computing. The client-server model allowed administrators to connect together with many low cost workstations. Resources could then be distributed among these workstations using a few powerful servers. **This reduced the need for virtualization!!**

The massive use of Windows and Linux based operating systems during the 1990s further solidified the x86 architecture and client-server model.

# History of Virtualization

The massive growth in the use of computer technology created new IT infrastructure demands as well as problems.

Some of these problems included:

- Low hardware infrastructure utilization;
- Rising physical infrastructure costs;
- Rising IT management costs;
- Insufficient disaster protection; and
- High maintenance and costly end-user desktops.

The promising solution to resolve the above-mentioned issues was hardware virtualization and thus, **in 1999**, VMware introduced their first virtualization application for x86 based systems. Modern day machines can now have their powerful hardware resources split up, just like mainframe machines did during the 1960s

# Benefits of Virtualization

Virtualized technology offers many benefits to organizations looking to migrate from a physical environment to a virtual setting. Some of the specific benefits to businesses are described below:

1. **Easier Manageability:** Through virtualization, administrators can monitor and manage entire groups of servers/workstations from a single physical machine.
2. **Elimination of Compatibility Issues:** In the past, running MAC OS, Linux or Windows on the same machine created many compatibility issues. These days, using virtual machines, many different operating systems and applications can run on a single physical machine, without affecting one another.
3. **Fault Isolation:** Any kind of error within a virtual machine will not affect any other virtual machine. Problems are automatically isolated, which can then be fixed or looked into by an administrator, while all other systems and services continue normal operation.
4. **Portability:** Virtual machine data is stored in files on a physical machine. This means that virtual machines can be transferred effortlessly from one physical machine to another, without any changes to functionality.

# Benefits of Virtualization

- 5. Increased Security:** Administrators can separate information and applications on a single physical machine into different virtual machines. This prevents users from being able to access or view what they should not be able to. Also, if a virus gets on to a physical machine, it will usually affect the entire machine. Virtual machines are separate entities, therefore any viruses or problems will be isolated within that virtual machine. The physical machine and all other virtual machines will not be affected. Virtualization also makes it easier to revert back to a previous state. For example an entire virtual machine could be backed up manually at regular intervals or using the virtual machines built in checkpoint feature, it could be reverted to a previous fully working state.
- 6. Efficient use of Resources:** Many virtual machines can run on a single physical machine, utilizing that physical machine's resources much more efficiently than if it was just running a single service or application. If a business previously used five physical servers, to provide five different services, they would now only require a single physical server. This one server would be much more efficiently used and its resources would not be wasted.

# Benefits of Virtualization

- 7. Problem-Free Testing:** One or more virtual machines can be set up as test machines. These can then be used to test the stability of certain applications or programs, without affecting the functionality of day to day business operations.
- 8. Rapid Deployment:** The Hard Drive of a virtual machine is often represented as a single file on a physical machine. This means that this Hard Drive can easily be duplicated or transferred to other physical machines. By using one virtual machine as a 'template' machine, its virtual Hard Drive file can be used to rapidly create new virtual machine clones. The advantage of this is that an administrator would only have to carry out an OS installation once.
- 9. Reduced Costs:** Costs are reduced in the form of less physical hardware, less power and cooling requirements, less physical space and less staffing requirements. Once a business has moved to virtualized environment, they begin to reap the many rewards that this kind of solution provides. Less physical machines, means less physical space is required, therefore a business office and building costs are greatly reduced. Both heat and power outputs are also significantly reduced and again this helps to reduce the running costs for a business. Networking costs are also reduced because fewer switches, hubs and wiring closets are required. As you can see, one of the greatest reasons why a business would want to adopt virtualization is simply because of the large amounts of money that they could saved, both in the long- and short-term.

# Benefits of Virtualization

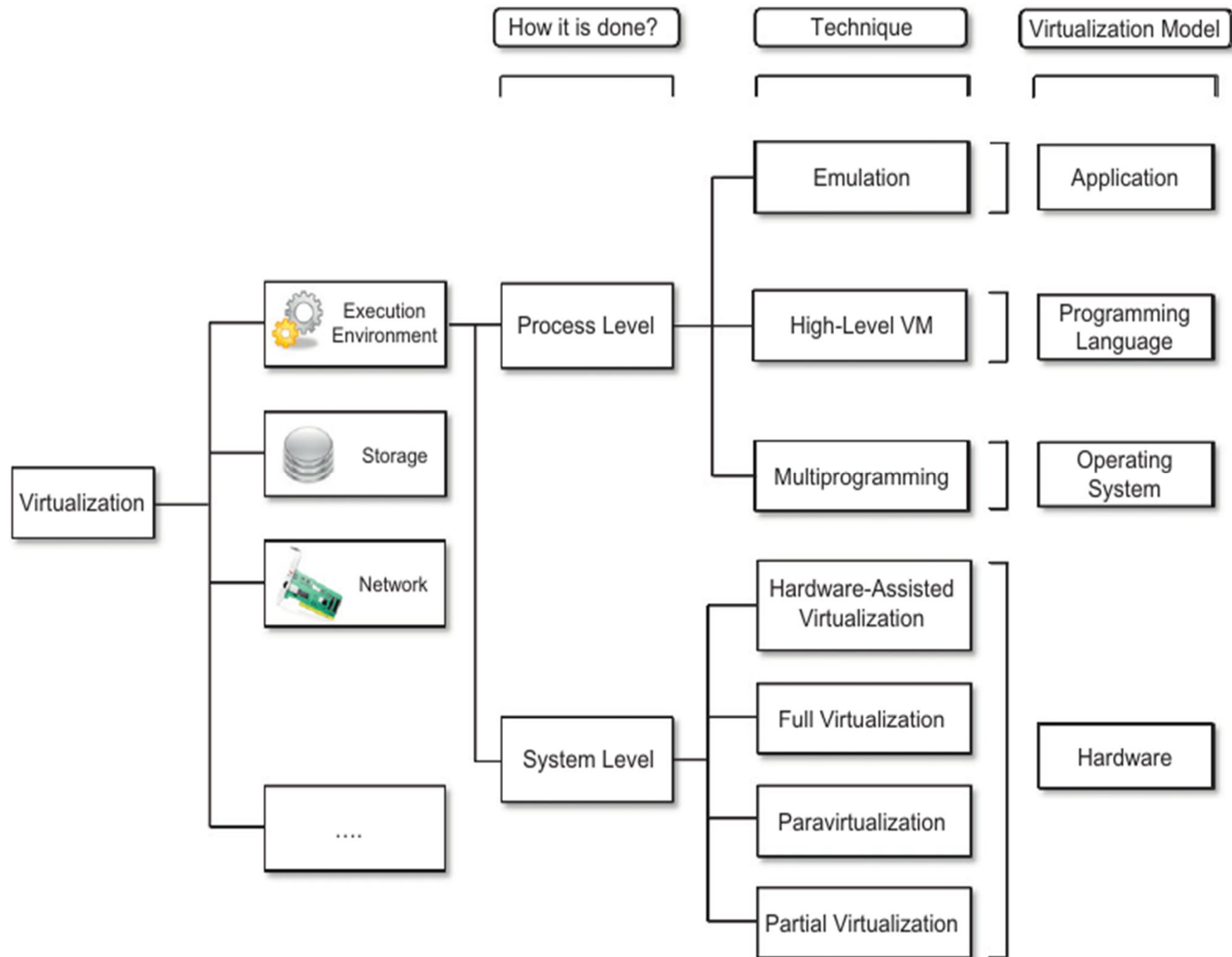
- 10. The Ability to Separate Applications:** Services and applications that may conflict with one another can be installed and run on separate virtual machines. Because these services and applications are still running on the same physical machine, resources and processing power are not wasted.
- 11. Easier Manageability and Improved Uptime:** Virtualization makes administering and managing an IT environment much easier. Less physical machines mean that administrators have less hardware faults or issues to deal with. This means that they can use their time on much more productive and beneficial tasks. Multiple virtual machines can also be configured and monitored from a single location. Again this makes things much easier for administrators, as they do not have to go from physical machine to machine when configuring updates or making changes.
- 12. Easy Maintenance:** Backing up and restoring a virtualized environment is also much easier than a physical one. If there are problems on one physical machine, an administrator can easily copy over entire virtual machines to another physical machine. A business can then continue operating with a minimum of downtime.

# Taxonomy of Virtualization Technologies

- Virtualization is mainly used to emulate **execution environment**, **storage** and **networks**.
- Execution Environment classified into two :-
  - **Process-level** – implemented on top of an existing operating system.
  - **System-level** – implemented directly on hardware and do not or minimum requirement of existing operating system



# Taxonomy of virtualization



# Pros & Cons of Virtualization

- Disadvantages

- **Performance degradation** -

- As it interposes and abstraction layer between guest & host.

- **Inefficiency and degraded user experience** -

- Some of specific features of the host is unexposed.

- **Security holes and new threats**

- Case 1 – emulating a host in a completely transparent manner.
    - Case 2 - H/w virtualization , malicious programs can preload themselves before the OS and act as a thin VMM.

# Pros & Cons of Virtualization

- Plays an important role in cloud computing.
- Primarily used to offer configurable computing environments and storage.
- H/w virtualization enabling solution in IaaS
- Programming language virtualization in PaaS.
- Virtualization provides :-
  - Consolidating
  - Isolation
  - Controlled environments

## Part – II

### ❖ Virtualization Technologies:

- VMware
- Ubuntu (Server Edition)
- Microsoft Hyper-V

# Virtualization Technologies: VMware

VMware is one of the most widely known virtualization companies. VMware offer a number of different virtualization applications. Each one has its own advantages and disadvantages, depending on the scenarios they are used in.

**VMware Workstation** would be best utilized in an environment which contains multiple enduser desktops. These desktops could be virtualized into a few physical machines.

**VMware ESX Server** would be best used to create high performance virtual servers which provide important services.

**VMware Server** is offered for free, however it is not as efficient as VMware ESX Server. However it would still be great to use for the virtualization of less mission-critical servers.

**Which virtualization solution a business should go for really depends upon their Client's Working Scenario, driven by Business Requirements.**

**For example** how large they are, whether their servers are resource-intensive and what their future prospects are. Once a business determines these things they can go about choosing a suitable virtualization solution.

# Virtualization Technologies: VMware

VMware offers a number of virtualization programs.

Their most popular virtualization applications are briefly detailed below.

## 1. Desktop Editions

- a) **VMware Workstation:** Initially launched in 1999, VMware workstation is one of the longest running modern day virtualization applications. It allows users to create multiple x86-based virtual machines on a single physical machine. A wide number of guest operating systems such as Windows, Linux and MAC OS X can then be installed on to these virtual machines.
- b) **VMware Fusion:** This is similar to VMware Workstation, the only difference is that VMware Fusion was designed for users of the MacIntel hardware platform. It is fully compatible with all virtual machines created by other VMware applications.
- c) **VMware Player:** This application is a freeware application and is offered to users who do not have a license to run VMware Workstation or VMware Fusion. Unlike the other two applications, VMware Player cannot create virtual machines, however it can run them.

# Virtualization Technologies: VMware

## 2. Server Editions

- a) **VMware ESX Server:** This is an enterprise level virtualization product that is offered by VMware. It does not require a host OS to be installed as it is installed directly onto a server's hardware (i.e. is a bare metal virtualization solution). This is unlike the desktop editions which are installed as applications from within their host OS. VMware ESX Server is much more efficient than other virtualization technologies because it has lower system overheads and interacts with its hardware directly.
- b) **VMware ESXi:** This application is similar to the VMware ESX Server application. The only difference is that it takes up less memory, because its Service Console is replaced with a simpler interface. From July 2008, VMware ESXi is available to download for free.
- c) **VMware Server:** This is VMware's free server virtualization application. It is an application which needs to be installed onto a host OS that is either Window or Linux based. Due to this fact it is not as efficient as the other VMware server editions, which are installed directly on their hardware. However VMware Server does allow you to create multiple virtual machines which can have a number of different guest operating systems installed.

# Virtualization Technologies: VMware

Microsoft has released their Hyper-V software, which is a direct competitor to VMware's own ESX Server edition. At the moment, tests show that performance wise, ESX Server Edition currently leads the way.

Although VMware is the dominant brand in virtualization, other companies are now starting to catch up and, now even download powerful open source virtualization technologies for free.



# Virtualization Technologies: MS Hyper-V

Windows Server is Microsoft's premier server OS. Its latest version, Windows Server 2008 is Windows first OS that is integrated with full virtualization. This feature is known as WSV (Windows Server Virtualization).

Along with its previous server roles, Windows Server 2008 has a new Hyper-V role. Selecting this role allows you to create a virtualized server environment. Within this environment you can then create multiple virtual servers.

Hyper-V is much more efficient than stand alone virtual server applications because it is actually integrated into the Windows Server 2008 operating system.

WSV offers many of the benefits that you would expect to receive from virtualization technology, such as rapid server deployment and the ability to take snapshots for backup purposes, etc. However it also offers a few extra features.

For example it can offer up to 32 GB of RAM and up to 4 processors per guest OS. It also provides support for virtual LANs and can run both 32bit and 64bit virtual machines. WSV has plenty of resources and can be flexibly administered by IT professionals.

# Virtualization Technologies: MS Hyper-V

WSVs main competitor is VMware ESX edition. They are both very strong virtualization technologies and both companies have a solid footing in the virtualization market area.

WSVs main advantage is that it supports more hardware than VMware ESX currently does. As long as you can install Windows Server 2008 on a machine, you should be able to run WSV.

VMware however, has a much larger feature set than WSV and it is a tried and tested virtualization solution.

# Virtualization Technologies: Ubuntu (Server)

Ubuntu is a popular community-developed, Linux-based operating system. There are various editions of Ubuntu, such as Desktop Edition, Server Edition, etc.

The great thing about Ubuntu is that it is open source and completely free. It comes with a number of preinstalled applications and a GUI (Graphical User Interface), which is one of the many reasons why it is so popular.

Ubuntu (Server Edition) also offers Kernel-based virtual machine (KVM). KVM is basically Linux's own full virtualization solution (for example Microsoft Virtual PC is Microsoft's virtualization solution).

Due to the open source nature of Linux, many developers have optimized and continuously updated Linux's KVM technology. KVM can work with both Intel's (Intel VT) and AMD's (AMD-V) hardware virtualization technologies.

Hardware virtualization is simply a virtualized software environment, which has received some help in virtualization, from hardware (usually the processor). This makes the virtualization process much more efficient. Most modern x86 processors for both Intel and AMD will have virtualization technology built-in.

# Virtualization Technologies: Ubuntu (Server)

KVM is a more than capable virtualization technology and can run multiple virtual machines with a wide range of guest operating systems installed. Also because KVM is implemented within the operating systems kernel, it is much more efficient and requires fewer resources than an application-based virtualization solution would.

The kernel is a vital part of an operating system, which provides communication between the hardware and software components of a machine. KVM requires far fewer overheads than other application-level virtualization technologies, because it is a part of its operating systems kernel and can communicate directly with the hardware that it is running on.

KVM also uses a common interface known as VirtIO, for the transfer of data between virtualization technologies and its physical disk or network. This means that far less emulation needs to take place, for simulated hardware. *For example*, traditionally a virtual NIC (Network Interface Card), along with its operating system's entire kernel would have to be simulated, so that it could transfer data between itself and its physical NIC.

However using VirtIO, an entire virtual kernel does not have to be simulated, because VirtIO provides a common interface for the transfer of data between many different operating systems.

# Thank You

*Text Book to be followed:*

*“Cloud Computing Virtualization Specialist Complete Certification Kit: Study Guide Book”.*