Comparison of OS Level and Hypervisor Server Virtualization

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Abstract: - As business needs rapidly grow, more dynamic organizations are required to react sooner and better than competitors. Although the infrastructure is important for all events, but the presented service for custumers is more significant. Nowadays datacenter’s flexibility seems to be more critical than ever. The business is more complex to manage and maintain these infrastructures to adapt customer’s demands. The virtual architecture would be the best tool to respond the current situation. Server virtualization is a vital layer of virtualization’s architecture. In this paper different architectures of server virtualization are compared. The functional and nonfunctional parameters will be discussed in three different types of architecture, without any virtualization, OS level and hypervisor. Fault manageability, scalability and more reliable server farm will be achieved by the virtualization deployment.

Key-Words: - Server Virtualization – OS level – Hypervisor

1 Introduction

As Information Technology (IT) and business professionals face more devices, services, changes and demands in the business, the challenges are to manage this complexity to achieve agility while keeping costs under control. The changing needs of the customer should be met by business to thrive. Also they must be well-matched to overcome the challenges, delivering the right solutions at the right time, offering some attractive thing to the customer. One word can describe the nature of this kind of business environment: dynamic situation [1].

Furthermore the need of these dynamic environments we have some problems such as disaster recovery, complexity, difficult management and branch office environments will be considered. Virtualization strategy could be offered to present the best solution. It’s goal is to present resources to the systems that would be employed as logical pools, assigned and reassigned as business situation changes [1].

Effective sharing and utilizing of machine resources have been an active research area since the early days of computing. Virtualization technology was a popular way toward effective resource sharing some for decades ago. It was later replaced by time-sharing systems which incur lower computing overhead. Recent advances in computing platform performance brought virtualization technology back to the main stage. Furthermore, innovations in architecture support for virtualization made many exciting usage models possible [2].

IT systems have become rapidly larger and more complex, and also more difficult to build an optimal infrastructure in today's dynamic changing situation. Server virtualization as very important layer of virtualization architecture represents a base technology for addressing this problem. It enables the flexible construction of virtual machines (VMs) with almost no hardware limitations, and consequently reduces the total cost of ownership (TCO) and makes it easier to use them in the changing business environment [3].

Virtual servers are easy to create -anyone is able to do it-, manage and maintain. Also VMs could cause lose of tracking and more complexity than you need [4]. So virtualization management must be carefully considered. In other word virtualization deployment without right management will be worse than the absent of the technology at all.

However server virtualization benefits and importance is presented in Fig.1. It will save cost by increasing resource utilization, efficiency and staff time.
The rest of this paper is organized as following:

In section 2 architecture of virtualization and the process layer of the architecture (server virtualization) will be discussed. OS level and hypervisor server virtualization will be explained in section 3. In section 4 the server functional and nonfunctional requirements will be discussed and compared. At last the paper will be concluded in section 5.

2 Virtualization

Virtualization is not only a technology but a concept derived from SOA but defined in datacenter environment. This means every layer of our environment is a service provider for another layer and the layers are going to be independent from one another. In another word Virtualization is a way to abstract applications and their underlying components from the hardware supporting them and present a logical view of these resources.

As it can be seen in Fig.2 our environment is divided into 6 different layers:

Access layer: A service is provided that any device can access applications (services) without compatibility testing or anything else.

Application layer: The applications will use different operating systems services without concerning about their hardware platform or OS compatibilities.

Processing layer: This layer is hardware or software technology that provides physical hardware configurations as services for operating systems and applications. In another word this layer provides physical hardware resources for its upper layers.

Storage layer: This layer provides storage services to other layers and operating systems and gives a logical view of our storage resources.

Network layer: This layer presents a logical view of our organization network that might differ from our physical view.

Management and security layer: This layer will provide security and management services for the virtual environments. This service is usually presented by additional software tools that the vendors provide. The security could be considered in an independent layer from management issues. In this case the overall layers will be increased to 7. The scope of virtualization’s influence in our environments will be in the following domains:

People: Although different skills and more expert staff are needed but the main influence is the virtual teams. From now on datacenter’s management team will be a virtual team and maybe in miles of distance from each other.

Process: Configuration managements and business processes are going to be different. We might have virtual processes or our processes will be processed with different resources.

Technology: The main difference in this domain will be less compatibility tastings [1].

Fig.2: Virtualization architecture [6]

2.1 Server Virtualization

Server virtualization plays a very important role in the processing layer of our virtualization architecture. As it can be seen in Fig.3 server virtualization layer (Named Virtualization in the Fig.3) is a layer that separates OS and its higher layer applications from the underlying hardware resources and gives a different view of hardware resources. The idea is to combine different hardware resources and utilize the use of these resources. A hardware pool is considered with all the resources and different virtual machines and servers can be defined to give services by using these resources.

In this infrastructure virtual machines and servers are created easily. The only thing that matters is the burden on resources that should be considered by the user. VMs are configured and setup exactly as physical machines.

Fig.3: Server virtualization concept

Today CPU vendors provide support for process virtualization, enabling simplifications of virtual machine monitor software (VMM). The VMMs can support a wider range of legacy and future operating systems while maintaining high performance [7].

3 Theoretical

There are two different architectures for implementing the virtual technology. The first is OS level architecture and the second is hypervisor architecture. We are going to discuss these two architectures in the next subsections of this document.
3.1 OS Level Server Virtualization

In this section one of the common architectures of server virtualization is discussed. As it can be seen in Fig.4 there is a Resource pool (usually consists of CPUs, RAMs, Storages, network Interfaces) which is called hardware layer and above that is the host operating system (windows server 2003, 2008, Linux and so on).

As some recent researchers have discussed [8, 9,11] in this architecture some applications could be run directly on the host OS and others virtually at the same time. The one’s running virtually communicate with the virtual layer which is installed on the host OS and run their instructions through that virtual layer.

Every VM has an operating system which is called guest operating system (it can be windows XP, windows server 2003 or 2008, Linux …) and applications needed run on these machines (considering the load on our resources) [10].

As some recent researches have discussed [6, 10] in this architecture, it’s really the OS sharing. This means hardware resources truly belong to the host operating system and it is only our host operating system that can manage these resources. Now with this comment what virtualization does is it makes the guest operating systems think that they have the resources and most of the instructions run directly from the guest operating system (if the CPU supports virtualization).

In some cases the instructions can’t run on the guest and the operating system gives its demands to its underlying layer which is the virtualization layer and our virtual layer passes the demand to the operating system and the host operating system depending on its resource allocations responds to the demands. This is why we say that in this architecture we are truly sharing our host operating systems. This architecture is also called software VM [12].

As it can be seen an important matter here is the host operating system and the virtualization layers overhead on our operating system. Let me explain this with an example:

It is useful to know that one the most important vendors of this architecture is Microsoft and the first solution of this technology that Microsoft presented was Microsoft virtual server 2005. Until now the host operating system for this solution was windows server 2003 but today we have the 2008 version as well. As our experiences show the performance of the Microsoft virtual server 2005 on windows server 2008 has been better than the 2003 server version.

There is a kind of OS level architecture that the host operating system is shared between application containers, but each application sees its own virtual OS. All VMs must run on the same host OS. This architecture is called Virtual OS or operating system partitioning. Some vendors are Solaris Containers, SWSoft Virtuozzo [12].

Some other important vendors of this architecture are VMware GSX, UML and Vserver. A significant limitation of Vserver is that it cannot run kernels for guest virtual machines different to the hosting one but it provides a very good performance and low overhead [13].

3.2 Hypervisor Server Virtualization

Hypervisor server virtualization is another common architecture presented these days for server virtualization. As some recent researches have discussed [10, 11, 12, 14] in this architecture the virtualization layer is right next to the hardware layer and it acts like an operating system. The virtualization layer has all the resources and when resources are allocated to VMs it is done virtually. This means the virtual layer shares the resources between the virtual machines and the machines think that they have the resources (Fig.5).

In this architecture the overhead is on the virtual layer and it handles everything. Above the virtual layer are our virtual machines and a service control and its application to control servers and allocate resources to virtual machines. Making too many virtual machines will increase the virtual layers overhead and descend the performance thus resources will be waste.
vendor is Microsoft which has implemented this architecture in Windows Server 2008 and it’s available to all the users of this windows but this product is in its early days and needs time to catch up with VMware. Xen source provides open source Linux based software for this purpose.

4 Comparison of Virtual Server Architectures

In this section different architectures of server virtualization and datacenters without virtualization will be compared. Datacenters requirement are divided into functional and nonfunctional. In the next section functional requirements are going to be discussed. Later in section 4.2 nonfunctional requirements will be issued.

4.1 Functional Parameters

In this part datacenters functional Parameters will be discussed. Resource management, machine migration, Backup and load balancing will be discussed specifically. At the end of the section in Table 1 all the functional requirements discussed in this paper are presented.

Roll back is when a problem occurs in the machine and the system can roll back into a pervious state without reaching backup files.

Virtual manageability is when accessing and managing a system through a wan connection.

Clustering service is when a machine is down and it is needed to shift its application to another machine.

Access to the virtual layer is the security layer that controls user’s access to VMM.

4.1.1 Resource Management

Before virtualization servers had to be stopped and resources were added physically. After that the servers were run again. In the OS level architecture servers were paused and resources were added to the hardware pool and servers were reconfigured. After that servers could run. Now about the hypervisor architecture resources are added to the hardware pool without pausing virtual machines and again without pausing the VM resources are assigned to the VMs.

4.1.2 Migrate a Machine

Before virtualization the system was shut down and physically moved to the new location, turned on and its network configurations must have been reconfigured. In the OS level the VM is paused and its files are copied to the new location and virtual layer must be reconfigured to run the new VM. The hypervisor level operation is just like the OS level except that in this architecture there is no need to pause the machine.

4.1.3 Make Backup from Your Data

Before virtualization any software with the ability to do so can be used and images must be made. In the OS level architecture any software with the ability can do with pausing the system and special ones can do it without any system pause. In this architecture backup is also available with copying VM files without using any additional software and there is no need to store images of the system but the VMs must be paused.

Now about the hypervisor architecture, Software adapted with the vendor’s specifications can do it without any machine pause. In this architecture it is available to do it with copying VM files and there is no need to store images of your system no need to pause your virtual machines either.

4.1.4 Load Balancing

Before virtualization for a running application with additional software load balancing could be done between different machines. This load balancing would be done for special resources (mostly CPUs) but with this technology no special software is required. When more than one resource is allocated to a VM load balancing between those resources are done automatically.

With this technology when desired resource allocation can be changed in seconds and load balancing between VMs is done manually (in the Os level with a pause in the system and in the hypervisor is done without down time).

The technique discussed in the first paragraph of this section is also available with VMs. With the same software the load of an application can be balance between virtual machines the same as it was between physical machines.

4.2 Nonfunctional Parameters

In this part datacenters nonfunctional parameters will be discussed. Security, utilization, availability, manageability and performance will be discussed specifically. At the end of the section in Table 2 all the nonfunctional requirements discussed in this paper are presented.

Reliability is how much the system is dependable. The system must response and its response must be valid. Scalability is the ability to extend systems real fast and with the lowest effort and cost available.

4.2.1 Security

Every consideration for a specific machine must be concerned. If a machines security is breached hours are needed to reload and reconfigure the system.
In the OS level architecture every virtual machine has its own consideration and the host system does nothing to protect them. About the virtual layer, if the host operating system security is breached it means the intruder has access to all virtual machines. So a strong security for the host operating system is suggested. Connecting the host OS to a WAN connection is not suggested. In LAN connection need special care for the system is required. If a virtual machine security is breeched it can easily be reloaded and the intruder can never access the virtual layer through a virtual machine.

About the hypervisor architecture every virtual machine has its own consideration and the virtual layer does nothing to protect them. This is a part that the vendors must consider more deeply in future [15]. At the moment the connection must be through virtual machines and the virtual layer must be beyond intruder’s hands. If a VM’s security is breeched it can be easily reloaded and the intruder can never access the virtual layer through a virtual machine.

### 4.2.4 Manageability

Before virtualization each machine was managed separately and special software was needed to monitor every machine. Hours were spent to get reports out from datacenters but in the virtualized environment you manage each VM separately but reports from the datacenter and each VM are generated in seconds with the appropriate tool. Because of resource integration all the machines are monitored automatically by the virtual layer and the appropriate tool can generate all the reports needed.

### 4.2.5 Performance

Before virtualization there was some ways to increase performance of a single system. If hardware is considered its performance has decreased because of the virtual layers overhead [15].

In the virtual environments because of resource utilization the performance of the whole datacenter increases. Because of resource a complete view of the datacenter is available and resource assignment is done more efficiently.

In the OS level architecture the virtual layer is thin and the overhead is not much but the host operating system is very important and it can be a bottle neck. In the hypervisor architecture the virtual layer is bigger and has more overhead.

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Table 1: Server virtualization architectures functional parameters comparison

<table>
<thead>
<tr>
<th>Add/Remove or Assign Resource</th>
<th>Server Migration</th>
<th>Backup</th>
<th>Load Balancing</th>
<th>Roll Back</th>
<th>Virtual Manageability</th>
<th>Clustering Service</th>
<th>Access to the Virtual Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before virtualization</td>
<td>With Shut down</td>
<td>Without down time</td>
<td>software requirement</td>
<td>Not available</td>
<td>VPN and administration website</td>
<td>Special configuration</td>
<td>OS level authentication and admin per VM</td>
</tr>
<tr>
<td>OS level</td>
<td>With Pause</td>
<td>Without down time</td>
<td>Manually for RAM and CPU</td>
<td>Not available</td>
<td>VPN and administration website</td>
<td>Special configuration</td>
<td>OS level authentication and admin per VM</td>
</tr>
<tr>
<td>hypervisor</td>
<td>Without down time</td>
<td>Just move it without down time</td>
<td>Automatically for all resources</td>
<td>Available</td>
<td>VPN and administration website</td>
<td>Easy configuration</td>
<td>Role base authentication</td>
</tr>
</tbody>
</table>

In the hypervisor architecture every virtualization will be utilized because of integration and dynamic resource allocation the resources use will be utilized in the whole environment. By utilizing resources money and energy (cooling, power …) is saved so efficiency is going to increase.
5 Conclusion

Although virtualization history goes back to 1960, but the tools that are provided these days for server virtualization are really a revolution in datacenters. The possibility to assign and reassign resources in datacenters (all kind of resources) is new. The size of server farm is not an issue any more. The question today is which architecture, topology and tools is the best.

In this paper functional and nonfunctional indicators for servers were discussed. Although virtualization has some overhead and will decrease performance, but all we gain from that (manageability, maintainability and scalability) will rationalize all disadvantages.

Although there are lots of benefits in server virtualization, but the right technology will not be the same with different situation. The most manageability and dynamic resource allocation would be seen well in hypervisor than OS level technology. Also the simplest recovery and installation could be seen in OS level architecture.

References:

Table 2: Server virtualization architectures nonfunctional parameters comparison

<table>
<thead>
<tr>
<th>Before Virtualization</th>
<th>OS level Virtualization</th>
<th>Hypervisor Virtualization</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS security</td>
<td>Depend on Hosts security</td>
<td>Except virtual layer</td>
</tr>
<tr>
<td>Per server</td>
<td>Whole datacenter</td>
<td>Whole datacenter</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Complex with long time</td>
<td>Simple with no time</td>
<td>Simple with no time</td>
</tr>
<tr>
<td>Low</td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td>Depends on hardware resources</td>
<td>Depends a lot on the host OS</td>
<td>Completely reliable</td>
</tr>
<tr>
<td>Not scalable</td>
<td>VMs: yes Hardware: No</td>
<td>Completely scalable</td>
</tr>
</tbody>
</table>

Security Utilization Availability Manageability Environmental Performance Reliability Scalability

Before Virtualization

OS level Virtualization

Hypervisor Virtualization

Table 2: Server virtualization architectures nonfunctional parameters comparison