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Desktop Virtualization Solutions-A Comprehensive Survey

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Abstract

Virtualization has become apparent in the 1960s as a practice to enhance the use of expensive computing hardware. Virtualization targets to reduce the complexity associated with deployment and maintenance of client devices, which eventually helps IT Companies to reduce system management costs. In this paper, we propose the virtualization concept expanding into many aspects of IT world. There are various virtualization technologies which include storage, desktop virtual platforms, server consolidation, virtual desktop infrastructure and application virtualization. This is the basic prerequisite for cloud computing and its applications. This paper highlights the benefits of virtualization and provides a comparative study on the various products that have been derived from it. This paper also describes how to create a virtualization strategy introducing comprehensive desktop-virtualization solutions, thereby providing a high-level guidance to help develop a desktop-virtualization strategy.

Keywords

Virtualization, desktop virtualization, virtual desktop infrastructure, Cloud computing, Hypervisor

1. Introduction

In the last decade, the advancement in VLSI technology, increased usage of online services over the internet and the evolution and adaptation of service oriented architecture (SOA) model has been the major driving force in the growth of IT. To support this, major investments were made by industry in creating huge IT infrastructure like grid computing, net computing, server based computing, desktop computing, ubiquitous computing, social computing etc. which has not been optimized from the point view of utilization all the resources.

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One of the major challenges faced today by all business entities is to bringing down the operational and maintenance cost of the IT infrastructure and utilize all the existing available resources like compute, storage, network in addition to legacy systems.

The virtualization technology provides the road map for efficient usage of all the resources in addition to cutting down the cost through on-demand provisioning. Virtualization is a prerequisite for setting up a cloud computing infrastructure which is the buzz word of tomorrow.

2. Literature Review

Virtual machine concept was in existence since 1960s when it was developed by IBM to provide concurrent, interactive access to a mainframe computer**.**

In 2011,Li Yan [6] proposed that virtualization has a lot of advantages such as mobile computing, security, easier management and cost reduction, to greatly influence people's lives by describing the system structure of desktop virtualization technology in detail giving an overview of its advantages and disadvantages, and its applications.

In 2010, Guangda Lai, Hua Song; Xiaola Lin [5] proposed that application streaming technology is used to break the bottleneck between clients and computing resources. At the server side, virtualization technology is utilized to help achieve better physical resource management, as well as the high performance virtualized storage system. Thereby stating how efficiently the virtualization concept can be incorporated in real time systems.

In 2006, Joshua S. White also described in (Survey of Virtualization Technologies with Performance Testing) the various performances issues encountered with regard to virtual machines thus creating awareness but did not highlight end users on to how to fix it.

Peggy (2007) made the connection between virtualization and cost savings as follows: "There are three key areas of potential benefits: space, time and money. If companies can put 10 applications on 10 machines onto one or two machines, not only is that less money spent on computers, but the amount of

money spent on electricity to power and cool these boxes goes down, freeing up precious data center space as well."

Literature from other sources was also included, such as datasheets from virtualization product vendors such as VMware**.** It consists mainly of distinct security claims, arguing how a feature affects security in a certain context.

3. What is Virtualization?

Virtualization is the act of decoupling one computing resource from others without impacting the usability across these resources. Rather than connecting the various layers together the operating system (OS) to the hardware, the application to the OS, and the user interface and data to the host machine, virtualization technologies loosen the direct reliance these parts have on each other.

One of the biggest advantages of using a virtualized environment is that it's cost effective. Instead of acquiring and maintaining several physical servers to perform the actions of file, database and web servers, for instance all of these can be put on single physical computer [9].

The term "desktop virtualization" has been used to describe many approaches to delivering desktops, including single remote desktops; shared desktops, which enable many users to share a common PC desktop environment on a centralized server [1].

This paper seeks to explain the basic architecture of a desktop virtualization solution, introduce some of the providers of desktop virtualization components, discuss some of the design options which include another promising technology popularly known as NComputing, and explore the circumstances that best lend themselves to this desktop delivery alternative.

4. What is Desktop Virtualisation?

In the desktop virtualization model, a hardware virtualization layer is added to the centralized data centre server (or servers). This virtualization layer hosts numerous virtual machines (VMs), each with an operating system, applications, device configurations, and a unique desktop environment (or GUI). [2].The desktop for a given VM can include customizations, such as wallpapers and screen savers of the Windows platform, for each user. The overall structure of a desktop virtualization solution is shown in Fig. 1. Because each virtual machine is an instance of a PC, the user session functions just as a locally run version of the operating system would thereby getting dedicated operating system sessions on the shared central server.[3]

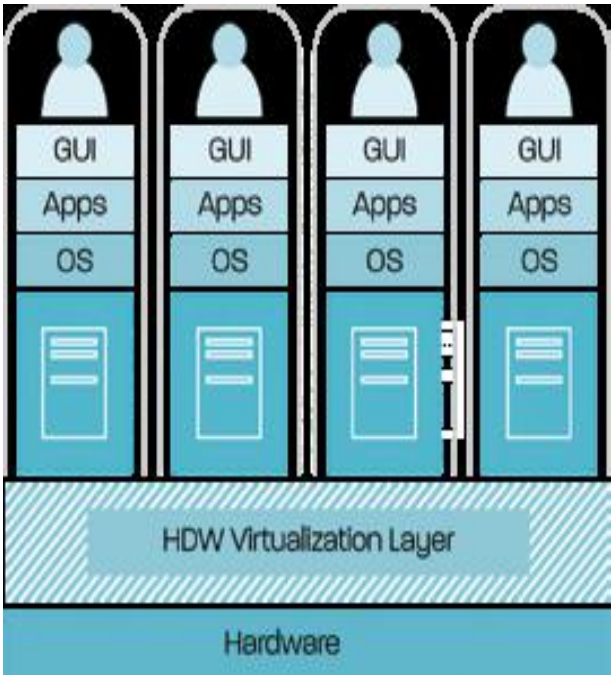

Fig. 1 Structure of Desktop Virtualization

5. Why Desktop Virtualisation?

- Isolated environments in which malicious software such as Trojans, viruses, and worms can be studied in isolation.
- R&D environments in which you need to evaluate how software applications perform
- In a variety of conditions.
- Training environments in which trainees can acquire skills using real-life software without consequences to the actual environment.
- Providing support for legacy resources that are being phased out or that are not compatible with the host OS or its applications any longer[4]

Desktops are managed centrally in the virtualized desktop model, simplifying software installations, backups, and maintenance, as well as reducing technical support and administration. The IT department can more easily manage large numbers of enterprise clients from the data centre, rather than from

each individual user's desk, hence making data more secure.

6. Components of Desktop Virtualization

A general representation of the architecture of a desktop virtualization solution is shown in Fig. 2.

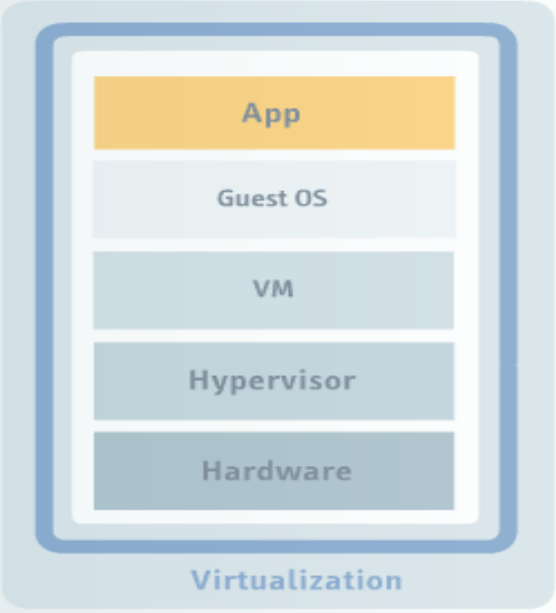

Fig. 2 Components of Desktop Virtualization

The physical machine is the computer that acts as a host for the virtualized environment. In larger corporate environments, multiple physical machines can be networked to form a virtual network.

The guest OS is also known as the virtual machine, or VM, because a VM cannot exist without a guest OS to facilitate its functioning. A single virtual environment can consist of more than one guest OS, if the physical machine has the hardware capacity and memory to host multiple VMs.

The hypervisor is the link between the physical host machine and the virtualized environment. It enables and manages the communication between the host computer and the virtual environment and vice-versa. The hypervisor is sometimes referred to as the Virtual machine monitor (VMM).

One of the main functions of a hypervisor is to ensure a VM is secure. Hypervisors limits a VM so it can only interact with resources for which it has authorization. This helps protect the integrity of data, because each VM can only send or receive data from other authorized VMs.

There are two types of hypervisor namely

(A) ***Hosted Hypervisor*****:** A hosted hypervisor needs to be compatible with the host OS on which it's installed. The host OS then acts as a go-between for the hypervisor to communicate with the host computer's physical hardware as shown in Fig. 3.

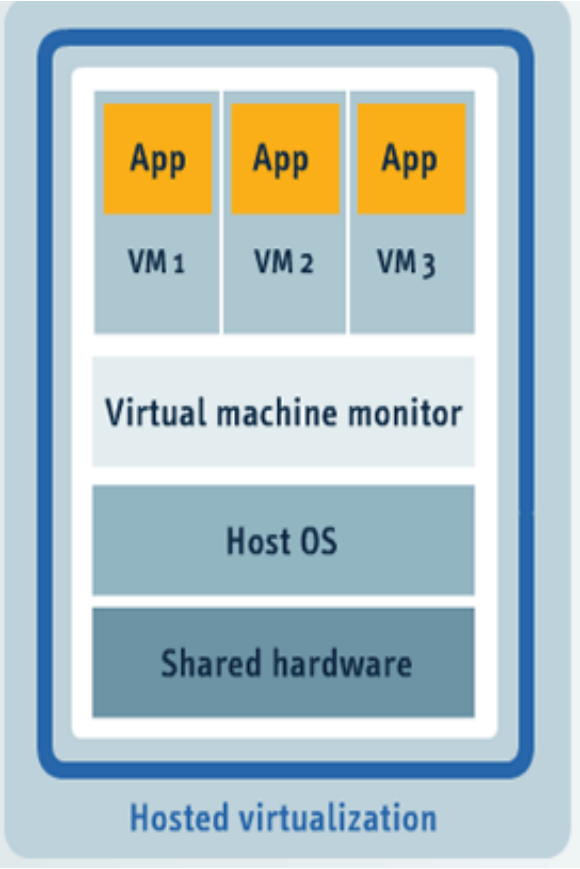

Fig. 3 Hosted Virtualization Model

Examples for host-based hypervisors include VMware Workstation, which can be installed in Windows or Linux, and Microsoft Virtual PC (Virtual Box) which is only supported in Windows, BHyVe supported on Legacy-Free hypervisor developed by FreeBSD.

(B) ***Bare Metal Hypervisor:*** When using a bare metal hypervisor model as shown in Fig. 4, the hypervisor does not require a compatible host OS and only has to meet the host system's hardware requirements. This is because a bare metal hypervisors is installed in a way that enables it to communicate with the host computer's physical hardware directly, without requiring a host OS as a go-between [6].

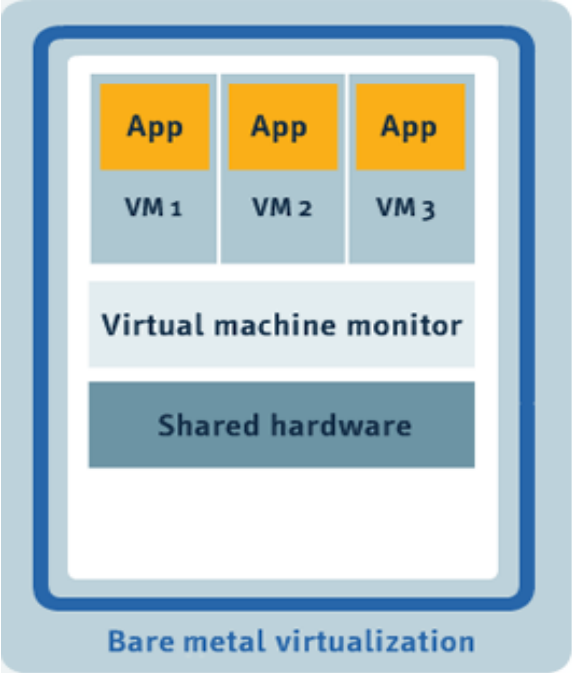

Fig. 4 Bare metal Virtualization Model

Examples for bare metal hypervisors include Citrix's XEN Server, VMware ESX Server; Kernel based virtual machine (KVM) for Linux, Oracle VM server for SPARC, Oracle VM server for x86 and Hyper-V in Microsoft's Server 2008 environments.

Two of the most commonly used processor vendors, Intel and AMD, provide hardware support specifically for virtualization. AMD's central processing unit, or CPU, has added support for virtualization, and is called AMD-V. Intel's equivalent CPU solution is known as Intel Virtualization Technology (VT).

When implementing virtualization, you should check your CPU and hardware specifications to establish whether it supports Intel VT or AMD-V. This is important, because some virtualization application software only runs on a system that has AMD-V or Intel VT support. Occasionally, may have to enable virtualization support for a chipset in the basic input output system (BIOS).

7. Desktop Virtualization Techniques

There are two techniques that enable the concept of desktop virtualization and they are as follows:
(A)Remote Desktop Services (RDS)
(B)Virtual Desktop Infrastructure (VDI)

These techniques provide the ability to centrally Host and manage desktop environments, delivering services remotely to the user's endpoint devices.

(A) Remote Desktop Services (RDS): RDS is traditionally known as terminal services. A terminal service runs on top of a Windows installation. It provides individual session to client systems. Clients receive visuals of the desktop, and resource consumption takes place on the server itself.[5]
The benefits of Remote Desktop Services are:

i. Applications are installed on the server and delivered rapidly.
ii. Applications and data are stored in the server and hence data redundancy is reduced thereby enhancing the security.
iii. Centralized management
iv. Low cost technology when compared to VDI.

With Remote Desktop Services (RDS) and Hyper-V in Windows Server 2012, organizations get the following benefits [7]:

Platform: A single platform is sufficient enough to deploy any hosted desktop making it easily manageable.

Experience: RemoteFX provides a seam-less experience for the users irrespective of their location of access to the virtual environment.

Deployment choices: RDS can host either Session based desktops, pooled VMs or personal VMs. So the customers have the flexibility to deploy the right type of VDI desktop for their users. [5]

(B) Virtual Desktop Infrastructure:

Virtual desktop infrastructure (VDI) can be used in any network environment in order to run desktop PC's using virtualization. When using VDI, desktop vms run from a central server. At start up, the end user device contacts a VDI server and the end user is presented with a VM running in the data centre [19] as shown in Fig. 5.

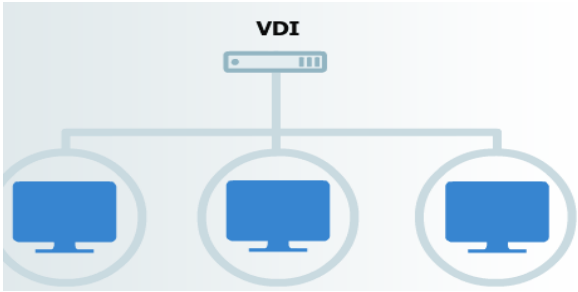

Fig. 5 Virtual Desktop Infrastructure

Virtual Desktop Infrastructure or VDI is ideal for corporate environments where data integrity or confidentiality is crucial, because the potential for data

loss is minimized by the fact that the desktop VMs don't have sufficient processing power or capacity to store data. In a typical VDI environment, desktop VMs are known as thin clients, because these clients are stripped down, so all actual data processing and storage occurs on the server. The VDI components include End point devices, VM hosting/execution Server and Connecting Broker (It is responsible for establishing and managing the connection between the endpoint device and the desktop VM).
***VDI Benefits*:** Centralized deployment and management, improved security and improved Business Continuity and Disaster recovery.

VDI Considerations: Reliance on network connection, unsuitable for high-end graphic applications and requires additional infrastructure.

However the main disadvantage of this type of setup is that in the event of network or power failure, the thin client computers would not be able to perform any work functions, which will cause potentially costly downtime [19].

8. Desktop Virtualization Solutions

There are two competing requirements: the needs of users to access their desktop with responsive performance and flexibility, and needs to protect mission-critical data while avoiding the loss of customer and employee personal information. For this purpose, various solutions have been discovered to service these requirements. The solutions are as follows:

(A) VMWARE Solutions
VMware is popularly known for its high ranking in the server virtualization market especially for its commercial product, Sphere however VMware also dominates the desktop-level virtualization market with its varied products such as:
Desktop software
VMware Workstation: enables multiple instances of x86 or x86-64 -compatible operating systems on a single physical PC.
VMware Fusion provides the same for an Intel Mac platform, along with full compatibility with other VMware products.
VMware Player: a freeware product for personal use to allow the usage of VMware workstation and Fusion without a license.
VMware ESX: an enterprise-level product that can deliver greater performance than the freeware VMware Server, due to lower system overhead. It runs directly on the server hardware, allowing the virtual servers also to access the hardware. In addition, VMware ESX integrates into VMware vCenter, which provides a highly reliable and easily manageable server deployment, such as [12]

VMotion: enables live migration of VMSs from one host to another.
Storage VMotion*:* migration of VMs from one storage device to another.
***Distributed Resource Scheduler*:** Automatic load balancing of an ESX cluster using VMotion.
HA (High Availability): In case of hardware failure in a cluster, the virtual servers will switch and restart on another host in the same cluster.
VMware Server (GSX Server) was also provided as freeware for non-commercial use which can be used to create new virtual machines. It runs on a host compatible within an existing Linux or Windows operating.
VMware has a range of file systems that it supports such as:config files(.vmx), swap files(.vswp),bios files(.nvram),snapshot data file(.vmsd),template file(.vmtx),disk descriptor(.vmdk) and many others.

(B) CISCO VXI Solutions
The need to regain control over data and to rein in the ever-increasing cost of maintaining a personal computer for each employee has made desktop virtualization a top priority in many companies. Cisco Desktop Virtualization Solution with VMware View(delivered as part of Cisco's Virtual Experience Infrastructure (VXI))centralizes the components of the desktop in the data centre to enable exceptional control of applications and data while improving IT's capability to manage and deliver desktops. This solution helps reduce IT costs and enables flexible access and an improved experience for end-users. It provides the following features:

Takes Control of Desktop and Data Security: Centralized virtual desktop solution that gives companies superior control over security, infrastructure, migration, and total cost of ownership while maintaining an outstanding user experience that comply with business, industry and government regulations.
It provides greater control over desktop and laptop environments while adding an exceptional level of security to the end-to-end infrastructure [11].
Collaboration of Cisco UCS Manager and VMware View provides consistent security policies for virtual desktops, regardless of the location.

In addition, also provides exceptional backup and recovery capabilities through centralized data repositories and a high-speed 10-Gbps unified fabric [10].

(C) RED HAT-RHEV 3.1

Red Hat Enterprise Virtualization is Red Hats' server and desktop virtualization platform provides a fully open-source virtualization platform. It consists of the management product RHEV-M (manager) and RHEV-H – (bare metal hypervisor) based on KVM (Kernel Virtual Machine) - also referred to as 'Red Hat Enterprise Virtualization Hypervisor [15].

The key benefits of this solution are:

Improved data security: RHEV for Desktops helps organizations safeguard their data by moving desktop environments into the secure datacenter behind corporate firewalls, helping to reduce the risk of theft and meet strict government regulations and data privacy laws.

Lower infrastructure costs: By centralizing desktop environments into the datacenter, provisioning new desktop environments, maintaining existing systems, and monitoring desktop activity all become very simple

Increase manageability: Desktop environments are centralized and hence reduce or even eliminate the need for on-site support. [14]

Create business continuity and data agility: By eliminating the dependencies between the operating system and the hardware, thus allows migration. Desktops are present in backup plans, ensuring a greater level of continuity.

Improve application and client flexibility: Users can access multiple types of operating environments from various types of client devices.Providingapplication flexibility regardless of what client they run.

(D) CITRIX Solutions:

Citrix was not very popular before, but now it owns the world's most-used cloud vendor software: Xen (the basis for its commercial XenServer). Citrix market-leading desktop virtualization solutions enable businesses to transform Windows desktops, apps and data into a cloud-like service accessible on any device [13]. Its features include:

- Delivers every type of virtual desktop from simple and standardized, to high-performance and personalized having the ability to meet the performance, security and flexibility requirements of each user.
- Provides individual Windows, web and SaaS applications: full virtual desktops, with a high-definition user experience [13].
- Accelerates application migration and simplifies application management for new operating systems, including Windows 7 while maintaining complete security.
- Requires limited servers and cables for desktop operations.
- Scalable, predictable performance with uncompromised user experience.

Citrix supports ICA (Independent computing Architecture) file format which configures information transfer between client and server.

(E) MICROSOFT HYPER-V

This solution helps users access virtually any application and Windows environment anywhere, while keeping their personalized experience even when they change their devices.

It enables organizations to give employees the flexibility to work everywhere, as it is through a centralized & unified infrastructure on a more comprehensive platform. It offers within its full spectrum the following features:

Efficient Management: Quick Deploy helps customers get started with VDI fairly easily, customers can set up a basic VM or session based VDI; thereby reducing the complexity associated with setting up such an environment. Intelligent patching and scanning through task randomization makes sure no single server gets inundated at the same [16].

Best value for Virtual Desktops: ensures that no single VM or session hogs all the machine resources thereby providing high system performance. Hyper-V provides a hypervisor platform that has been designed to host large VDI deployments. And RDS has made storing of VMs cheaper .

Rich Experience Everywhere: RemoteFX now supports software GPU which is readily encodes and decodes graphics and multimedia which provides the exact experience as that of a physical GPU. RemoteFX provides high end user experience with support for LAN and WAN networks, USB redirection and multi-touch-Remoting[18].

(F) NCOMPUTING

NComputing is a desktop virtualization solution shown in Fig. 6 allows organizations to share the power of a single PC with multiple users, where each user gets his individual session. It eliminates the need of full-fledged PCs, thereby cutting down on cost of hardware,space, power consumption and maintenance.

It is a desktop virtualization company that manufactures hardware and software to create virtual desktops (sometimes called zero clients or thin clients)

which enable multiple users to simultaneously share a single operating system instance. Features of this solution are as follows:

Affordable: Saves up to 70% on Hardware, maintenance.And90% on Electricity.

Easy to set up: Manages fewer systems

Efficient: Cuts Electricity cost by up to 90%

Saves on UPS Cost: Reduces-power wastage by 98%.

Compatible: Uses standard PCs, softwares, and peripherals and is deployable on Windows or Linux or Citrix environment.

Provides a Familiar environment (no special training needed).

Here are few versions provided by this company namely: vSpace Client, N-series N400 and N500,X-series - Direct Connect, L-series - Ethernet connect, U-series - USB connections, M-series - Multiple seats, vSpace Server software[17].

However there are a few limitations that cannot be neglected such as

- The maximum distance between the PC and terminal ranges only between 5 to 10 meters.
- Average video resolution.
- Unsuitable for demanding or high end applications.
- Its performance directly depends on the power of the host PC and deteriorates when the number of terminals increases.

The NComputing solution takes advantage of the fact that today's PCs are so powerful that majority of users only need a small fraction of the computing capacity, thus tapping into unused capacity so that it can be simultaneously shared by many users. Each user's hardware components such as monitor, keyboard and mouse are connected to the NComputing thin-client device, which is then connected to the shared PC thereby minimizing E-waste.

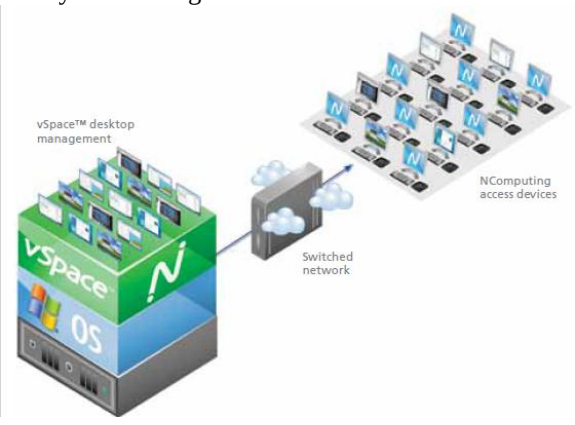

Fig. 6 NComputing Deployment Architecture [18]

Some other solutions for desktop virtualization include:

(G) SYMANTEC solutions

(H) DELL DVS: A collaboration of the citrix solution and Vmware solution is the DELL DVS. On the server end it incorporates Vmware and on the desktop end it incorporates the beneficial of the citrix solution.

9. Comparative Study

Among the parameters listed in the table I, one must consider some important parameters mandatorily for the implementation of an desktop virtualization solution, namely, number of users, CPU hosts, primary(RAM) and secondary memory(disk space) capacity, network interface cards, OS supports, security management, migration and of virtual machines and upgrading. Larger the number of users and CPU hosts supported, stronger and more cost effective is the solution which make it more prominent than its counterparts. Greater the RAM space, faster is the loading of data and response time resulting in less memory swapping and page faults. Secondary storage enables a dynamic provisioning of disk space thus providing a seam-less user experience. The network interface cards allow the efficient usage of the available network resources and increased network security collectively known as NIC teaming and zoning. Compatibility with many operating systems provides users flexibility in choosing their suited platform and also allows them to switch between platforms if required. Live migration of VM's is a process where resources are transferred from a host machine to its clients, support for this technique is key for an desktop virtualization solution and sets it apart from conventional computing. The ability of this solution is to facilitate automatic upgrading and patching giving end users an added advantage of acquiring the latest features and their advantages.

10. Conclusion

The research discussed in this paper makes it clear that desktop virtualization is now at the heart of the modern information security strategy. Desktop virtualization enables organizations to transform their approach to information security and compliance. By centralizing data, applications and access control, desktop virtualization delivers an unprecedented level of information security management, even across the complex IT environments typical of large organizations. From the above comparative study, it is difficult to conclude on a specific vendor as the current scenario of the IT industry is ever-changing and the

end user requirements keep varying. Thus the survey conducted indicating that vendor preference is dependent on the specific features needed by the company, the reputation of the vendor and the price. For organizations considering hosted desktops, client virtualization, or a combination of the two, it's necessary to first understand desktop virtualization's limitations. The virtual environment is highly network-dependent, hence it is necessary to ensure that the network can support the heavy graphics that today's desktops demand or else the end-user experience will be spoilt. The right balance of protocols, bandwidth usage and third-party tools must be found so as to facilitate an efficient virtual desktop deployment. End-users sometimes experience degraded performance when running applications not native to their client device's base operating system. While considering storage facilities at the server side, security issues will arise regarding the redundancy of the information shared in the client-server network. These must be taken into consideration. Most vendors of desktop virtualization also provide technologies for application virtualization. However, there are no integrated solutions currently available in which any aspect of virtualization can be managed from the single interface and it is expected to be implemented in the near future.

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Table 1: Comparison between Various Desktop Virtualization Solutions

Specifications	**VMware**	**Citrix-XEN**	**HYPER-V**	**Red Hat**	**NComputing**
NIC	3	1-16	Supports NIC teaming	Nic teaming	1
Boot from USB	Yes	No	Yes	No	-
No of users	64	150	50	100	4-30
Max CPU hosts (logical)	160	160	320	160	-
Max memory-host	2TB	1TB	Max 4 TB	2TB	2 GB
RAM/vm	1TB	128GB	1TB	2TB	-
Read cache	Host cache/CBRC	Intellicache(with XEN server)	CSV cache	No	-
Monitor	Multiple	Multiple	Multiple		2
Cluster size	32 hosts/4000 VMs	16 hosts/resource pool	64 hosts/8000 VMs	200 hosts/cluster	-
Memory page sharing	Yes(transparent)	No support	No support	Yes(KSM)	-
Linked images	only in VMware View and vCloud Director	Yes(clone,PVS,MCS)	Yes(differencing disk)	yes	-
OS supports	Microsoft windows family,linux family, Novell NetWare, FreeBSD, Solaris	Microsoft windows (64bit&32bit)and Linux(64&32 bit)	Windows server 2008(64 bit)	iOS, Android, Windows, Windows Mobile, Blackberry, Windows 8 (beta)	Windows and Linux
Hypervisor upgrades	yes	limited	limited	yes	-
VM patching	limited	No	yes	yes	-
Backup integration API	Yes(vstorage API data protection)	limited	Yes(VSS API)	limited	-
security	Yes (ESXi Firewall, vShield Zones and vShield Endpoint	yes	Windows Security, Hyper-V Extensible Switch (DNSSEC, PVLANs, port ACLs, BitLocker etc.)	SELinux, iptables, VLANs, Port Mirroring	-
Live migration of VMs	Yes vMotion, Metro vMotion and 'shared nothing' vMotion (4-8 concurrent)	Yes Xenmotion	Yes (Unlimited Concurrent Live, outside clusters and 'Shared Nothing')	Yes (Live Migration 1/CPU core up to 5 max)	-
Published desktops/Apps	No	XEN app	Yes(RDS Remote App and Desktop Sessions)	No	-
Graphics capability	Physical GPU (virtualized)	HDX (OpenGL,DirectX integrated with fee-based products	RemoteFX (WAN, Adaptive Graphics, USB Redirection,Media Remoting, vGPU)	SPICE(2D)	-
USB controller	1	1	No support	-	1
Floppy controller	2	1	-	-	-
Keyboard	1	1	-	-	4
mouse	1	1	-	-	5