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All memory linked clone Virtual Desktop Infrastructure as a flexible, high performance, durable and hardware efficient temporary learning environment

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Abstract — **The purpose of this article is to give an overview of advanced Virtual Desktop Infrastructure (VDI) virtualization system for building flexible, durable and hardware efficient platform for student laboratory learning. Building a temporary learning environment deployed on demand, and destroyed when not in use. Linking technologies like VDI, golden/master image, linked clone, memory drive and NFS into a flexible learning desktop environment.**

Key Words – Virtual Desktop Infrastructure, VDI, Linked Clone, Golden Image, Memory Linked Clone, Learning Environment, Education, Virtualization, Desktop On Demand, Network Virtualization, Desktop Virtualization, NFS, Memory Datastore, Security, Education Flexibility

I. INTRODUCTION

Virtualization is playing an important part in almost all information technology infrastructure and therefore has an impact in today's learning environments. It is important that students in early stages of higher education, if not sooner, have one on one experience in benefits and practical user cases in that field. In a classroom environment, the transition time between users is short as it is the case between class sessions. Often, the solution is to lock the computer down so that students are unable to make permanent changes to settings, or the computer rolls back to a stable state after a reboot [1]. To overcome these problems, VDI technologies give the flexibility to provide students controllable environments needed for successful completion of class requirements, as well as flexibility to control many of the system settings that would otherwise be unavailable in traditional computer laboratories.

II. VIRTUALIZATION

Virtualization represents a technique which use a virtual machine monitor or a host called "hypervisor" to enable multiple operating system instances to run on a single physical server [2].

A hypervisor is a function which abstracts operating systems and applications from the underlying computer hardware. This abstraction allows the underlying host machine hardware to independently operate one or more virtual machines as guests, allowing multiple guest VM's to effectively share the system's physical compute resources, such as processor cycles, memory space, network bandwidth, etc.

Benefits of virtualization:

- Run old applications
- Access and browse virus-infected data on isolated system in complete safety
- Test software, upgrades, or new configurations
- Run one OS on top of another
- Back up an entire operating system
- Create a personal cloud computer
- Make fast backup of your server
- Reuse old hardware

A. *Server Virtualization*

Most servers operate at less than 15 percent of capacity [3], leading to server sprawl and complexity. Server virtualization addresses these inefficiencies by allowing multiple operating systems to run on a single physical server as virtual machines.

By aggregating server cluster into a single consolidated resource - which improves overall efficiency and reduces cost. Server virtualization also enables faster workload deployment, increased application performance, and higher availability.

B. *Network Virtualization*

Network virtualization is the complete reproduction of a physical network in a software environment. Virtual machines or applications run on virtual network exactly the same as if on a physical network. Network virtualization presents logical networking devices and services - logical ports, switches, routers, firewalls, load balancers, VPNs, etc. Virtual networks offer the same features and guarantees of a physical network with the operational benefits and hardware independence of virtualization.

C. *Desktop Virtualization*

Deploying desktops as a managed service gives the opportunity to respond quicker in the dynamic environment. Spinning virtual machines operating systems and giving connections to their desktops. It can reduce costs and increase service by quickly and easily delivering virtualized desktops and applications on demand.

III. VIRTUAL DESKTOP INFRASTRUCTURE (VDI)

Virtual desktop infrastructure (VDI) is virtualization technology that hosts a desktop operating system on a centralized server in a data center (Figure 1.). VDI is a variation on client-server computing model, sometimes referred to as server-based computing.

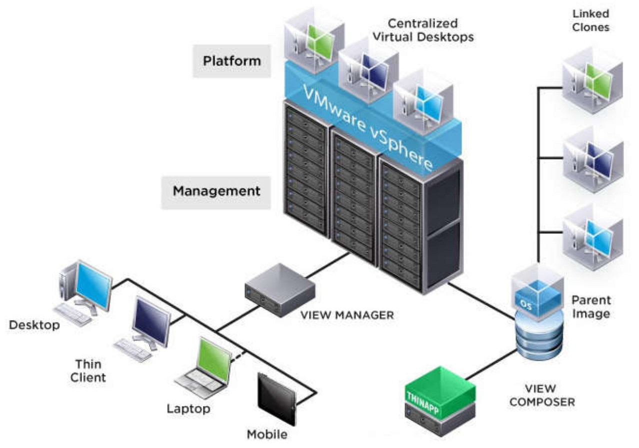

Figure 1. Virtual desktop infrastructure schema

A. *Benefits of VDI*

1) Virtual machine live migration

Live migration refers to the process of moving a running virtual machine or application between different physical machines without disconnecting the client or application. Memory, storage, and network connectivity of the virtual machine are transferred from the original guest machine to the destination.

With the introduction of long-distance migration technologies, running virtual machine can be moved between data centers that are separated by latent connections.

2) VDI Redundancy

Virtualization platform has the possibility to be configured in a redundant mode, to prevent data loss in case of host failure (Figure 2.). The redundancy is possible in a single data center, as well as over the Internet.

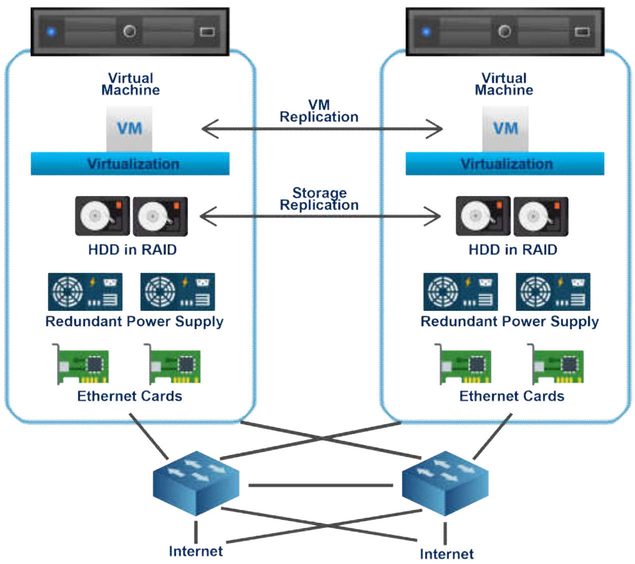

Figure 2. Virtualization redundancy scheme

The term redundancy is often misinterpreted with availability. While these two are related, they are not the same. In virtualization and VDI technologies, redundancy refers to the use of multiple servers (hosts), network paths or RAID protected datastores configured to duplicate critical components of a system with the intention of increasing reliability of the system. If one host fails, the synchronized clone of virtual machine instance is automatically available and it fails over without the client ever notices the failover process (Figure 3.). No data is lost, and the performance is not significantly diminished.

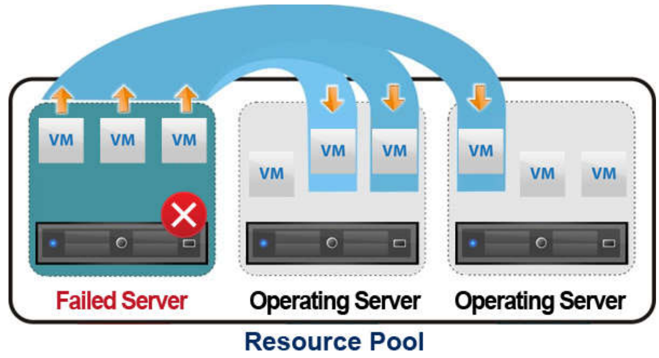

Figure 3. Failover process in virtual environment schema

3) Infrastructure management

With virtualized servers, data centers are decoupled from hardware that can fail and take a server offline. Hosts can fail, but server virtualization provides a native architecture as well as a rich offering of management tools to keep workloads available. This abstraction can be made to break down barriers once associated with specific server brands, allowing administrators to focus on infrastructure management.

Abstraction also extends to storage environments. Migrating to new disk systems in a SAN environment is generally easy with virtualized technologies [4]. Often, it can be done with zero downtime to the virtual machine.

4) Security

Separating development from production workloads, allocating isolated resources for update testing and, in the case of desktop virtualization, the ability to ensure that data does not leave the data center.

5) Flexible networking

Virtual networking makes possible to have multiple networks on the same physical machine, which can be used for isolating virtual machines, as well as deploying private networks for a group of virtual machines.

6) Instant capacity

Virtualization enables elastic capacity to provide systems at a moment's notice. In the physical server world, it could take weeks to take a server from "PO to ping." Deployment issues involving cabling, shipping, purchase orders, lab build time and other operational processes, in comparison to the deployment of a virtualized data center.

7) Virtualization cost benefits

Data centers can consolidate server requirements to fewer, more powerful systems that use resources more effectively [5]. This extends to space, power, port and cabling savings. These supporting elements of infrastructure can be very expensive, especially with respect to network and storage ports.

8) Isolating applications

With virtualization, it is possible to put applications on dedicated operating systems on a virtual server so that there are no local compatibilities issues. This also allows correct provisioning of a virtual machine for the precise amount of memory and disk access, which are two primary resource areas in virtualization.

9) Implementation of VDI to save power

By measuring the electricity usage for fully power desktop and VDI thin terminal, researchers found that VDI enables its users to save about 30-80% of electricity usage [6].

10) Reduction in e-Waste

Thin client or Virtual Desktop devices have very little electronics parts and circuits compared to a desktop. The life of terminal thin clients is usually projected to be at least 10 years. Hence it can be used for a much longer period of time. No moving parts, help to use the device for a longer period of time without any maintenance or up gradation and hence reduce the landfill and save the environment in turn [7].

11) Software licensing

Client desktops only need software licenses for the peak instantaneous usage of any given product. Just as virtual servers maximize utilization of physical server resources, VDI clients maximize utilization of software licenses.

12) Remote Infrastructure

The client can connect to the VDI network using personal smart hardware without compromising the security of the network. Communication is encrypted and resources can be shared between personal and VDI environments. This type of remote access can be used to replicate the exact conditions and/or exercises needed in modern educational purposes as an e-Learning platform.

B. Drawbacks of VDI

1) Costs

Storage can make VDI cost prohibitive. When a desktop runs locally, the operating system, applications, data, and settings are all stored on the endpoint. There is no extra storage cost; it's included in the price of the PC. However, with persistent VDI, the OS, applications, data and settings for every single user must be stored in the data center. Capacity needs, and the cost required to meet them.

Converged infrastructure and hyper-converged infrastructure products, which bundle storage, servers, networking, and virtualization software have emerged to help address the scalability and cost challenges associated with virtual desktop infrastructure.

2) HDD Bottleneck

VDI technology usually uses SAN or NAS devices to store virtual machine files needed for normal operations. When it comes to scalability, this poses a big problem in terms of IOPS storage devices has to provide. Bigger and faster RAID arrays have to be implemented, adding the costs and complexity [4].

3) Network reliance

VDI's reliance on network connectivity presents a challenge. Clients can not access their virtual desktops without a network connection, and weak connectivity can hinder desktop performance. This problem is especially common with graphics-intensive applications and other software with high processing demands.

4) Software licensing

VDI can complicate software licensing and support. Nonpersistent VDI especially causes issues, because some licensing and support agreements do not allow for software to be shared among multiple devices and/or users.

IV. VDI IMAGE TYPES

A virtual disk image is the image of a virtual hard disk or the logical disk associated with a virtual machine. It is used in virtualization environments to create a replica of the disk space/drive assigned to one or more virtual machines.

A. Full Clone imaging technology

A full clone is an independent copy of a virtual machine that shares nothing with the parent virtual machine after the cloning operation. Ongoing operation of a full clone is entirely separate from the parent virtual machine (Figure 4, Figure 6 left).

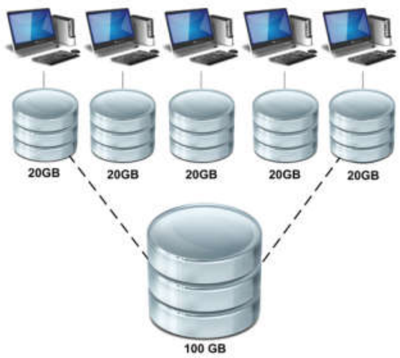

Figure 4. Full clone storage schema

B. Linked Clone imaging technology

A linked clone is a copy of a virtual machine that shares virtual disks with the parent virtual machine in an ongoing manner. This conserves disk space and allows multiple virtual machines to use the same software installation (Figure 5, Figure 6 center).

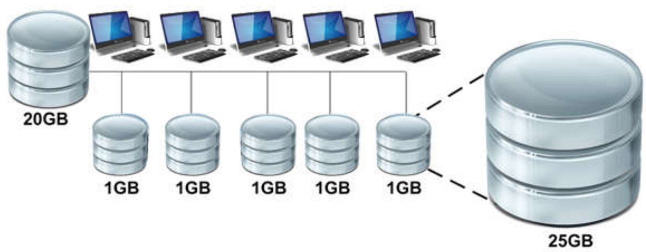

Figure 5. Linked clone storage schema

V. DIFFERENCE BETWEEN FULL CLONE AND LINKED CLONE

A full clone is an independent virtual machine, with no need to access the parent storage. A linked clone must have continued access to the parent (gold/master image) [5]. Without access to the parent, a linked clone is disabled.

A linked clone is made from a snapshot of the parent and is stored in the delta files on preconfigured datastore. All files available on the parent at the moment of the snapshot continue to remain available to the linked clone. Ongoing changes to the virtual disk of the parent do not affect the linked clone, and changes to the disk of the linked clone do not affect the parent.

A. *Benefits of Full Clones*

Full clones do not require an ongoing connection to the parent virtual machine. The overall performance of a full clone is the same as a never-cloned virtual machine, while a linked clone trades potential performance degradation for a guaranteed conservation of disk space. If the focused is performance, one should prefer a full clone.

B. *Benefits of Linked Clones*

A full clone can take several minutes if the files involved are large. A linked clone lowers the barriers to creating new virtual machines, so one can swiftly and easily create a unique virtual machine for each task you have.

Another benefit of linked clones is that they are easier to share. If a group of clients needs to access the same virtual disks, then the clients can easily pass around clones with references to those virtual disks. For example, the support team can reproduce a bug in a linked clone and then email that linked clone to development. This is feasible only when a virtual machine is not gigabytes in size.

VI. ALL MEMORY LINKED CLONES

The temporary VDI environment that is needed for students learning exercises, as well as numerous other scenarios, provide the flexibility system administrators can exploit, and move linked clones delta files from hard disks to RAM memory (Figure 6 right).

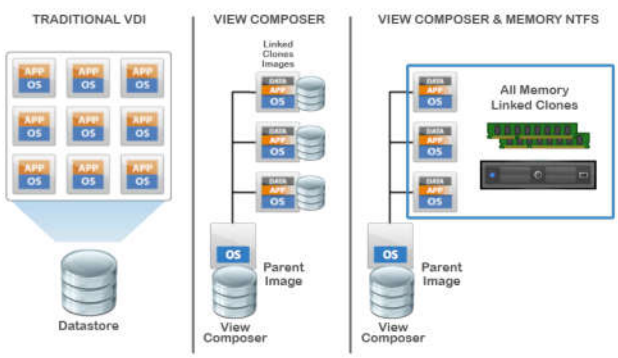

Figure 6. Traditional VDI datastore shema (left);
Linked clone VDI datastore shema (center);
Linked clone VDI with all memory datastore schema (right)

During research, Linux NFS and Ram disk libraries were used to make a network accessible NFS RAM disk that was connected to VMware Horizon VDI linked clone software and the proposed architecture performed as expected.

A. *Benefits*

1) *Durability*

IDE, SATA, SCSI and SAS hard drives that are used in storage devices that support SAN and NAS devices has the limitation in terms of the number read/writes tasks that can be performed before their blocks become corrupt. RAM memory is more durable and it is expected to bring longevity to the VDI system.

2) *Performance*

Hard disks are slower than RAM memory in terms of access speeds and thruput (Figure 7.)[8]. The creation of virtual machine linked clone instances is therefore faster.

Disk Type	Values/sec
Random, disk	316
Sequential, disk	53.2M
Random, SSD	1924
Sequential, SSD	42.2M
Random, memory	36.7M
Sequential, memory	358.2M
Note: Disk tests were carried out on a freshly booted machine to eliminate the effect of operating-system disk caching, SSD test used a latest-generation Intel high-performance SATA SSD	

Figure 7. Comparing random and sequential access in disk and memory [8]

It should be noted that All Memory datastores accessed over a TCP connection are not recommended for best performance, as the TCP technology has its own limitations in terms of access speeds. All Memory datastores should reside on the same physical host for best performance.

3) *Smaller number of HDD's*

The number of HDD storage space required is minimal, as it only has to hold the parent (master/gold) image and perform read operations that can also be stored in memory.

B. *Drawbacks*

1) *Need for more RAM memory*

The capacity of RAM memory has to be bigger that in the case of a conventional linked clone technology, as it uses RAM to store delta files.

2) *Temporary storage*

The delta files are stored in nonpersistent RAM memory and are not suitable for long-term data storing.

VII. CONCLUSION

Virtualization is playing an important part in almost all information technology infrastructure machinery. As VDI technologies tend to be a part of every client-based virtualization environment, we expect to see more of its user cases in learning [9].

For the purposes of building a cost effective, durable, flexible, hardware efficient, deployed/destroyed on demand, short-lived VDI platform for student laboratory learning, researchers suggest migrating linked clone delta files from persistent storage devices to faster and durable RAM memory.

Experiment was performed as a practical proof of concept that this infrastructure can be made with widely spread VDI commercial technology, confirmed the theoretical model, and further researches should be performed to measure the exact benefits and correlation of RAM memory specifications and overall system performance, like VDI instance build/destroy time, connection speeds, and use of hardware resources.

Operational system and application flexibility, IT maintenance, installations, provisioning, testing, smart use of licenses, persistent client experience, enhanced security, connectivity over the Internet, resource sharing, optimal desktop solutions, reduction in power consumption as well as a reduction in waste generated are all linked in a single solution.

Using a highly available infrastructure for the VDI hosts can add redundancy to the system and can potentially withstand most of the malfunctions that occur in the data centers.

The biggest drawdown of VDI is client-server network connectivity, as VDI technology relies on it for normal operation.

The future researchers should be focused on experimental performance measurements, as well as developing a dump memory procedure for long-term delta file storage.

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