The Emergence of Virtualization

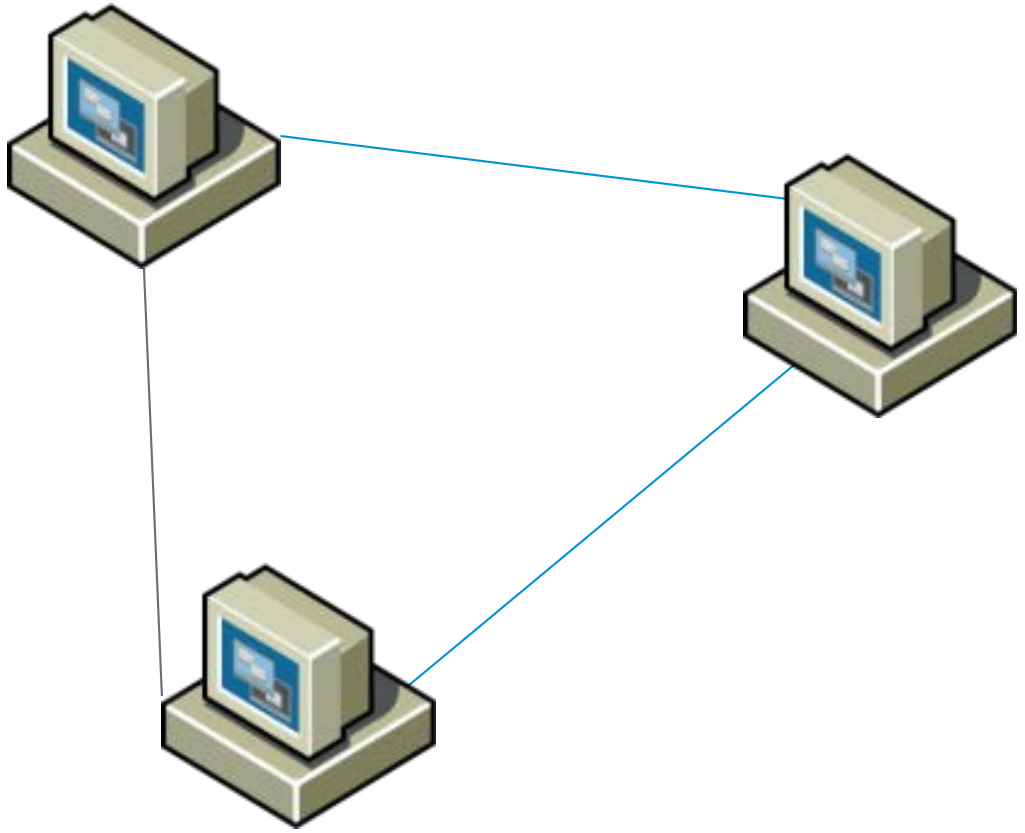
The Basics of Client-Server Computing

The move from mainframe to Personal Computer (PC) computing started in the 1980s.

IBM PC architecture was released in 1981.

Local Area Networks enabled cost effective computing for smaller business.

Client-Server computing, based on IBM PC systems running Intel x86 architecture, transformed business computing by the late 1980s.



Running Applications

Applications and operating systems are the software that runs on client and server systems.

Software is stored on non-volatile storage such as hard drives or SSDs.

To run software, it must be loaded from storage into memory, or RAM.

Processors (CPUs) appear to run many things at once by switching rapidly between tasks.

Server Computing

Server computers provide centralized services.

Clients connect via networks.

Servers tend to be expensive, powerful systems.

Servers are usually deployed in server rooms or data centers.

Servers tended to be dedicated to a single application or service.

Virtualization, Emulation and Remote Access

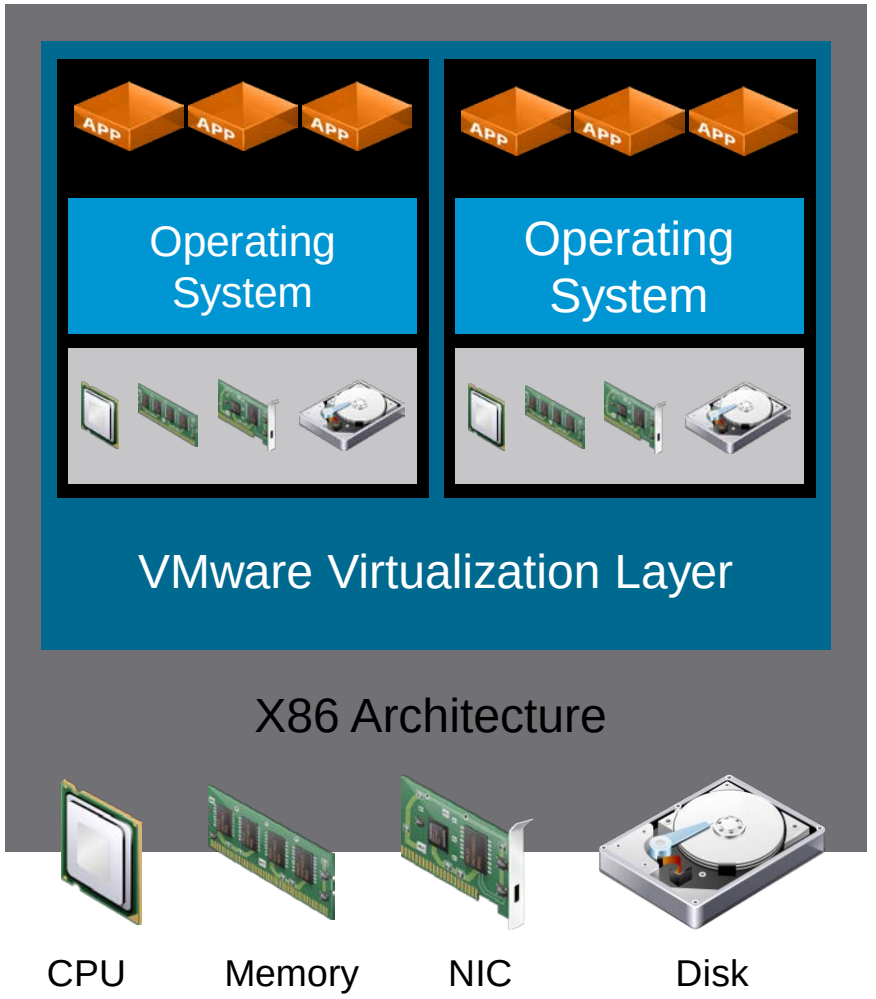
Computers boot into one operating system.

Switching between operating systems or instances usually requires a separate machine.

There are two software solutions that allow multiple operating systems to run concurrently on a single physical machine:

- Virtualizations: run at native speeds
- Emulation: more flexible but much slower

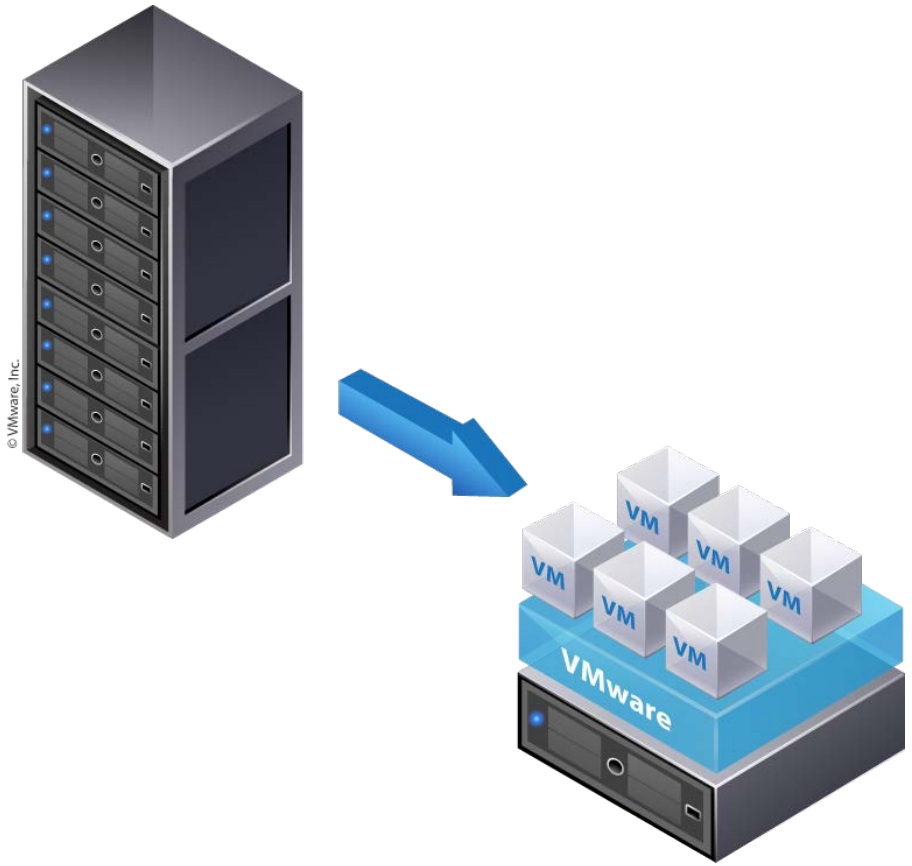
Remote access provides a user interface remotely over a network.



Benefits of Virtualization

Virtualization provides a powerful tool to help systems designers and administrators optimize their environments:

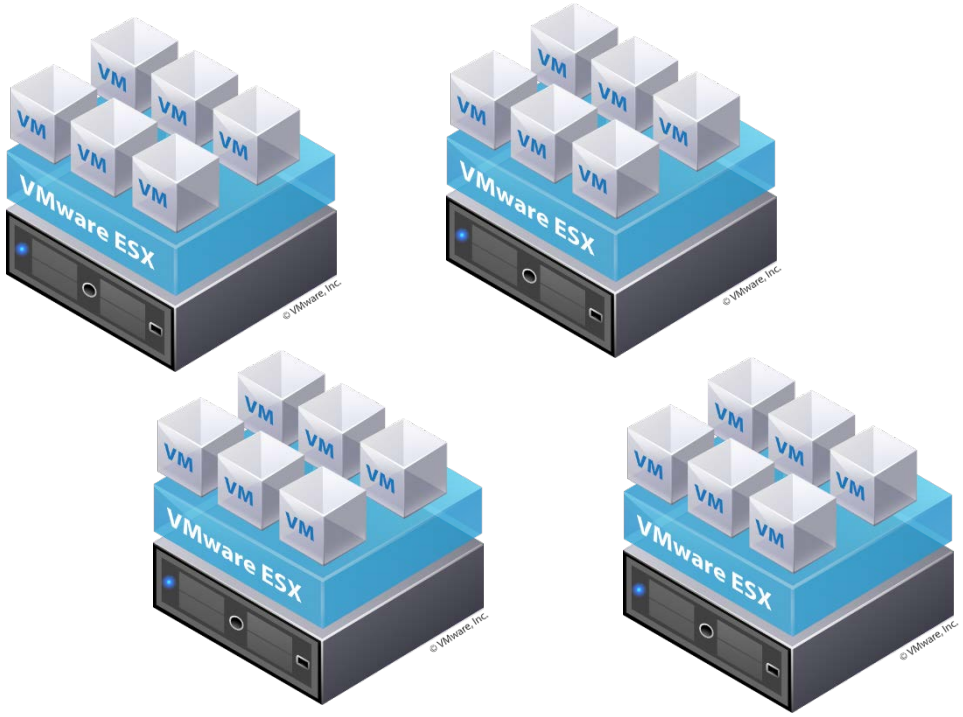
- Multiple separate servers can be consolidated as virtual machines on a single physical computer.
- Converts hardware to software.
- It is very simple to modify a virtual machine configuration.
- Moving virtual machines between physical systems is quick and easy.



Challenges of Virtualization

There are a number of challenges and downsides to virtualization:

- Initial lack of software vendors support.
- Physical failures can affect multiple virtual machines.
- High consolidation ratios can result in more complex physical servers.
- Performance management becomes critical as virtual machine performance issues can affect other virtual machines.
- Storage management can be challenging.



Types of Hypervisors

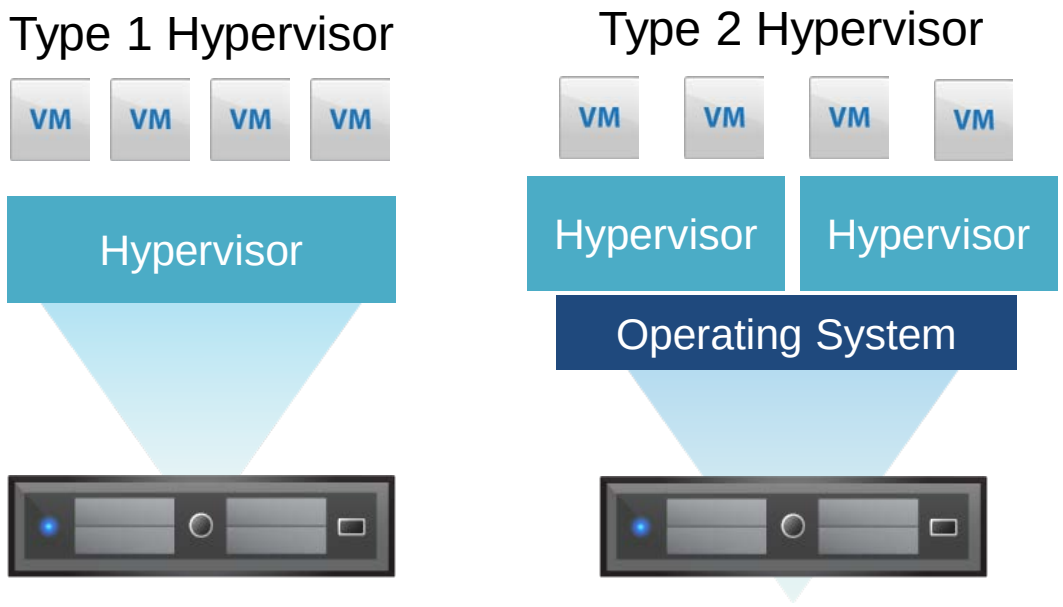
The software that implements and manages virtualization is called a hypervisor.

VMware Workstation and VMware Server run inside another operating system and are Type 2 hypervisors.

Type 2 hypervisors are not ideal for server solutions.

The alternative is a Type 1 hypervisor that completely replaces the operating system on the physical machine.

VMware ESX® , VMware ESXi™, and now VMware vSphere® are VMware's Type 1 hypervisors.

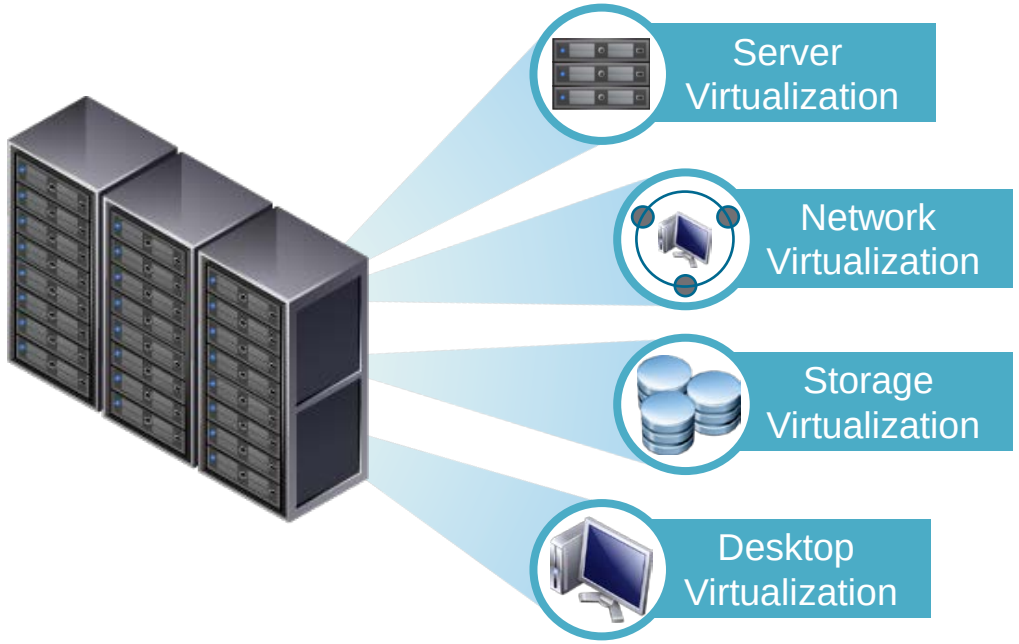


Core Virtualization Technologies

Effective virtualization requires the effective ability to manage compute, storage and network resources.

Consolidation encouraged system designers to move away from separate solutions to a more effective shared infrastructure approach.

Advanced virtualization features enabled IT administrators provide resilience at the virtual level. This allowed them to implement simpler application solutions without sacrificing performance or reliability.

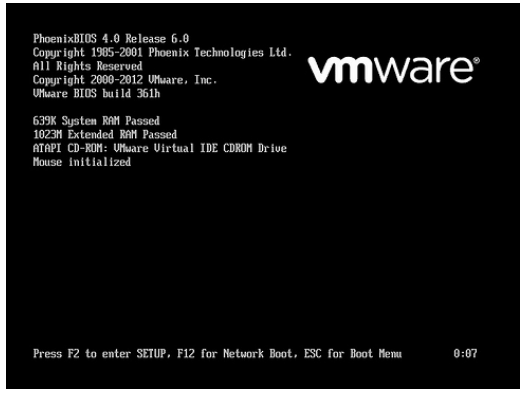


Lesson 2: Server Virtualization

Booting a Computer and Running Software

When a computer is powered on, the following steps allow the system to start up and run software:

1. A number of tests (POST) are carried out.
2. If the POST passes, the system proceeds to a boot phase.
3. The computer reads data from the start of the first disk in the system.
4. The user can log in to the system and run applications.



Running Multiple Virtual Machines at Once

The start up process is different when a machine boots into a hypervisor.

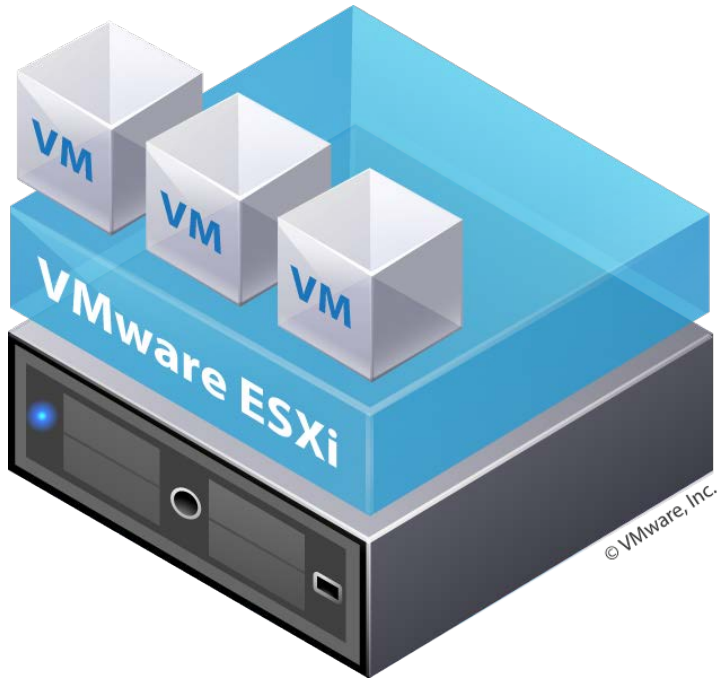
It is not intended for Type 1 hypervisors to be used from the console. Some functionality may allow an administrator to perform basic tasks.

A management interface is used to configure or start many virtual machines.

Virtual machines follow their own boot process.

The hypervisor manages the BIOS and virtual hardware presented to each virtual machine.

The hypervisor schedules CPU time for each virtual machine.



Computer Memory and Virtualization

Computer memory, or RAM, is required to run applications.

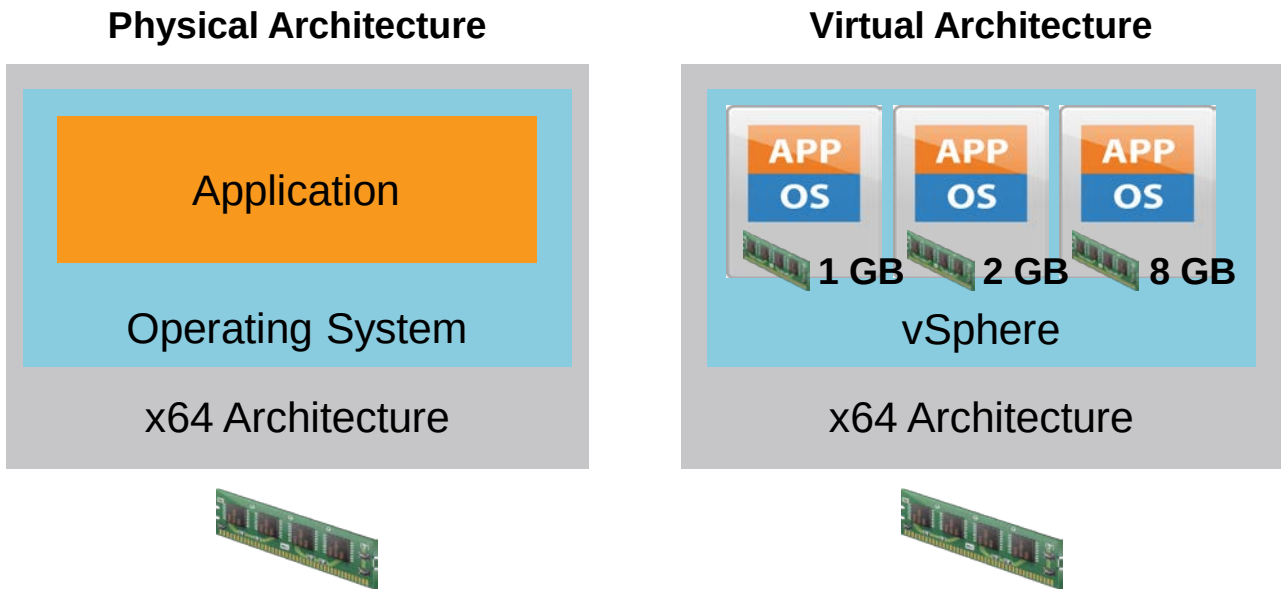
RAM is volatile, so contents are lost when power is lost.

RAM provides the working memory for the CPU.

Persistent, non-volatile storage is different and refers to hard drives, SSDs etc.

The virtual machine configuration defines how much memory the virtual machine requires.

The hypervisor can allocate physical memory as and when required.



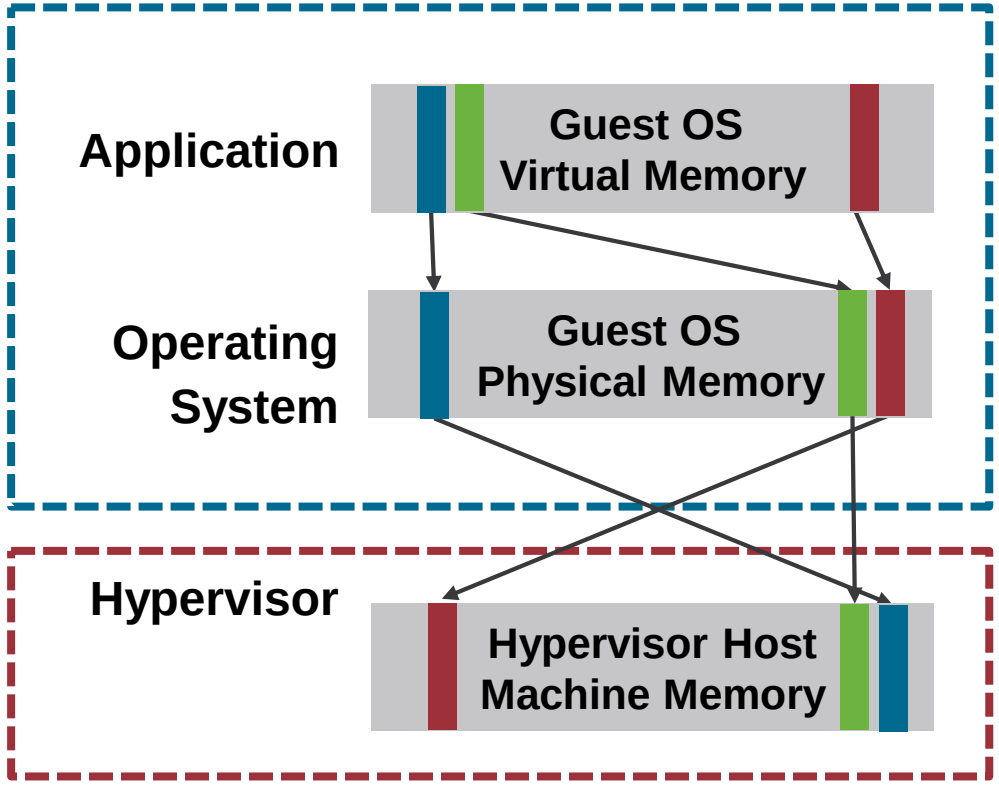
Reading and Writing Memory

RAM is designed for read and write.

In practice, a lot of RAM allocated to machines is empty.

The hypervisor can intelligently allocate physical RAM as needed to optimize use.

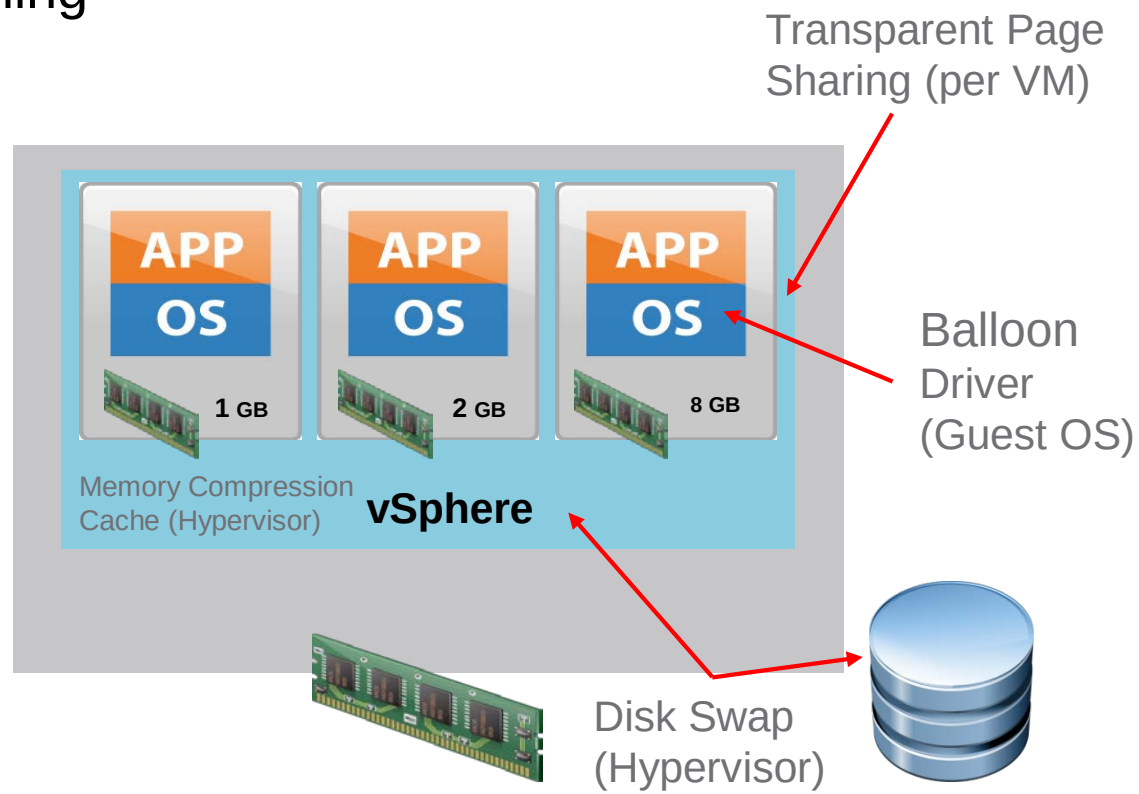
Optimization enables multiple virtual machines to run on physical hardware with less physical memory than appears to be configured for the virtual machines.



VMware Memory Virtualization Technologies

The vSphere Hypervisor dynamically allocates memory and provides the following memory virtualization techniques:

- Transparent Page Sharing
- Memory reclamation using Guest Ballooning
- Memory compression
- Virtual Memory swapping



Basic Networking concepts – Switching and Routing

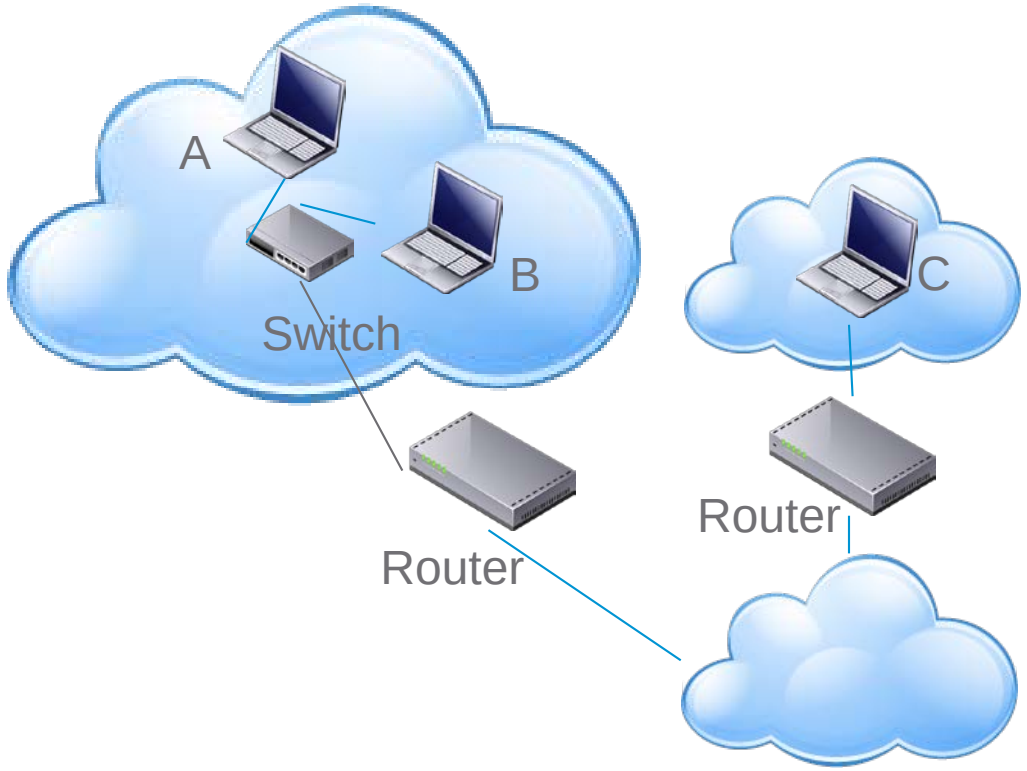
Networking concepts are critical to virtual machines.

Switches directly connect machines over short range, local networks.

Ethernet is the dominant local networking technology today.

IP addressing and routers allow local switched networks to be connected.

IP based networks can be as large as necessary, up to the global level of the internet.



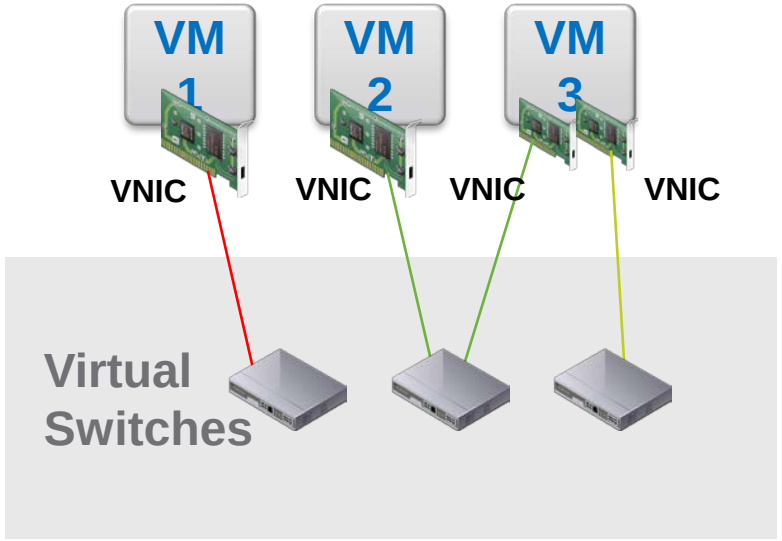
Virtualized Networks inside a Hypervisor

A hypervisor simulates switching internally to connect virtual machines to each other.

Multiple virtual switches can be configured to control which virtual machines can connect to each other.

Within a single hypervisor, the speed of network connections between virtual machines is controlled by the hypervisor.

Routing can happen, but would be implemented using software running inside virtual machines.



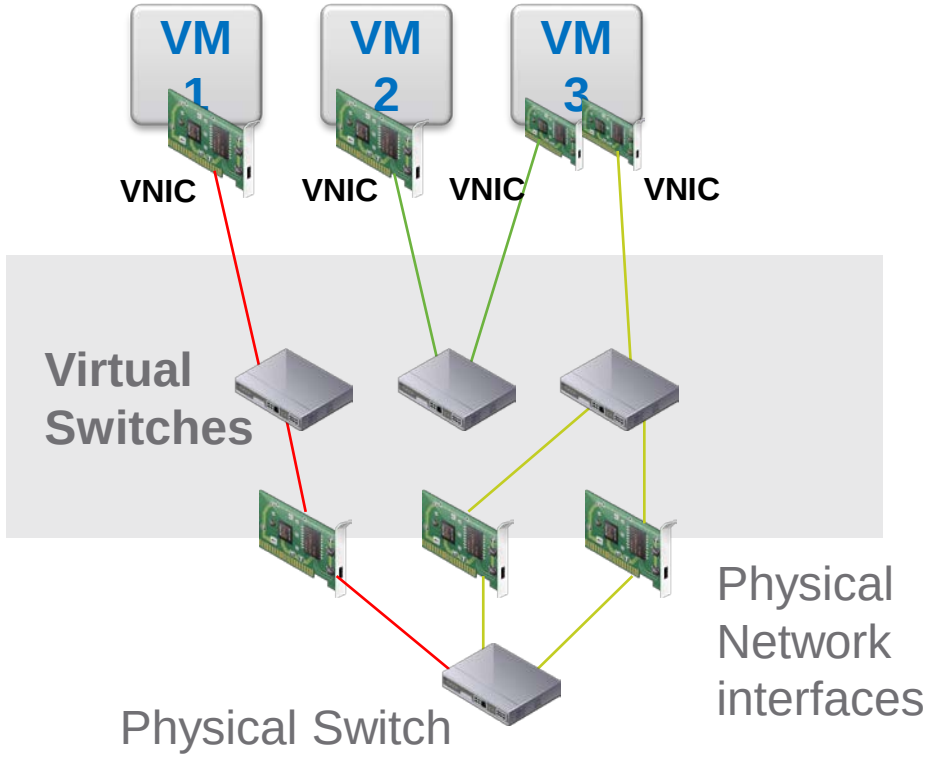
Connecting Virtual Networks to Physical Networks

Virtual switches can be connected to physical networks.

Uplinks to physical switches are configured using physical network adapters in the hypervisor.

This allows virtual machines to connect to real world switched and routed networks.

Multiple network uplinks can be used to provide resiliency and improved performance.



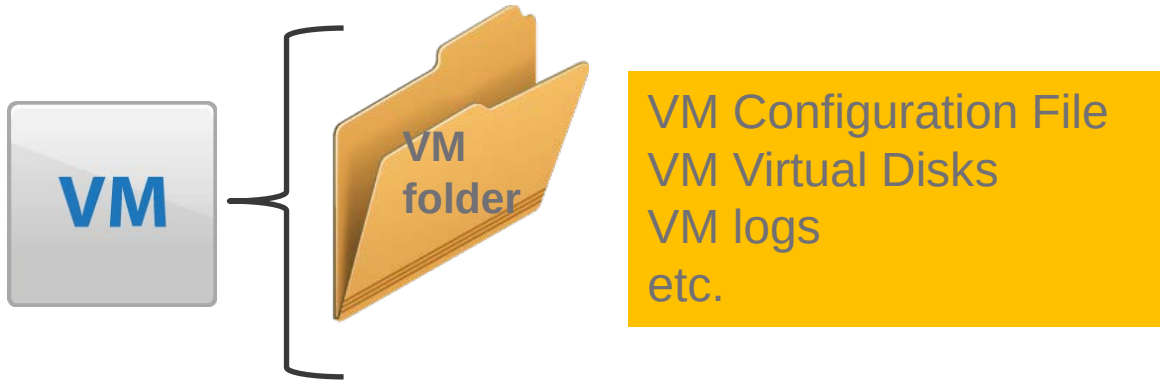
Saving a Virtual Machine Configuration

Virtual machines are defined in software.

A virtual machine consists of a set of files.

The files are easy to copy, move or back up, even though certain files may be large.

Copying files is much simpler than replicating, moving or backing up a complete physical machine.



Lesson 3: Storage Virtualization

The Role of Storage in Virtualization

Non-volatile storage is critical to virtual machines.

Storage plays a critical role in delivering the benefits of virtualization.

Performance and reliability are critical for systems that store virtual machines.

A single hypervisor may be connected to hundreds of terabytes of storage.

Virtual Machine Files

Virtual machines are stored as a collection of files.

The configuration file may be just a few kilobytes. Other support files, such as log files, may be a few megabytes. Virtual hard disk files will be many gigabytes, or even terabytes, in size.

The following files apply to VMware virtual machines managed by a vSphere Hypervisor:

Configuration file	*VM_name*.vmx
Swap files	*VM_name*.vswp
	vmx-*VM_name*.vswp
BIOS file	*VM_name*.nvram
Log files	vmware.log
Template file	*VM_name*.vmtx
Raw device map file	*VM_name*-rdm.vmd*k*
Disk descriptor file	*VM_name*.vmdk
Disk data file	*VM_name*-flat.vmdk
Suspend state file	*VM_name*.vmss
Snapshot data file	*VM_name*.vmsd
Snapshot state file	*VM_name*.vmsn
Snapshot disk file	*VM_name*-delta.vmdk

Working With Virtual Machines as Files

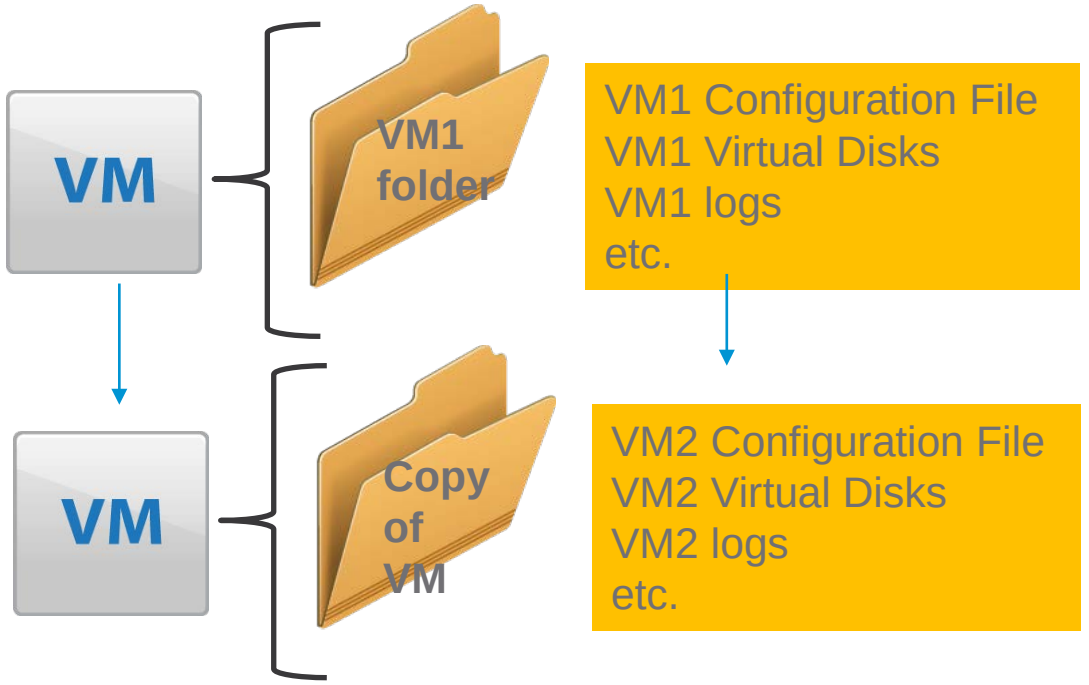
Virtual machines can be managed in the same way that files are managed. This is a lot easier compared to doing the same with physical systems.

Replicas can be made by copying.

Templates can be made to control copying.

Customization can be used to ensure the copies are configured correctly.

Backing up virtual machines is simplified.



Storage hardware: Drives, Disks, and Devices

The basics of storage technologies, and how they work, needs to be understood to fully appreciate the importance of storage in virtualized infrastructure.

- Hard disks
  - Electromechanical drives
  - High capacity
  - Relatively slow
  - Cost effective
- Solid-State-Devices (SSDs)
  - 0% electronics
  - Lower capacity
  - Ultra high-performance
  - Relatively expensive

SAS is the dominant interface type for servers as it provides more storage management features and allows more devices to be connected at higher speeds.

Storage hardware: RAID, Storage Arrays, and Storage Networks.

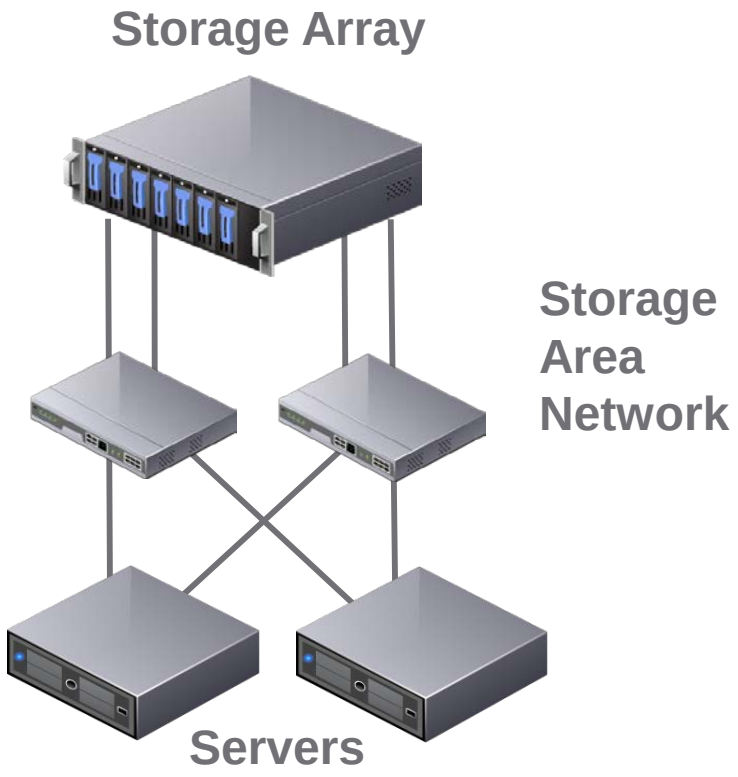
Configuring very large amounts of storage to a server is complex.

A large number of drives may be required.

Having many drives leads to an increased risk of drive failures.

RAID provides a way to aggregate and manage multiple drives.

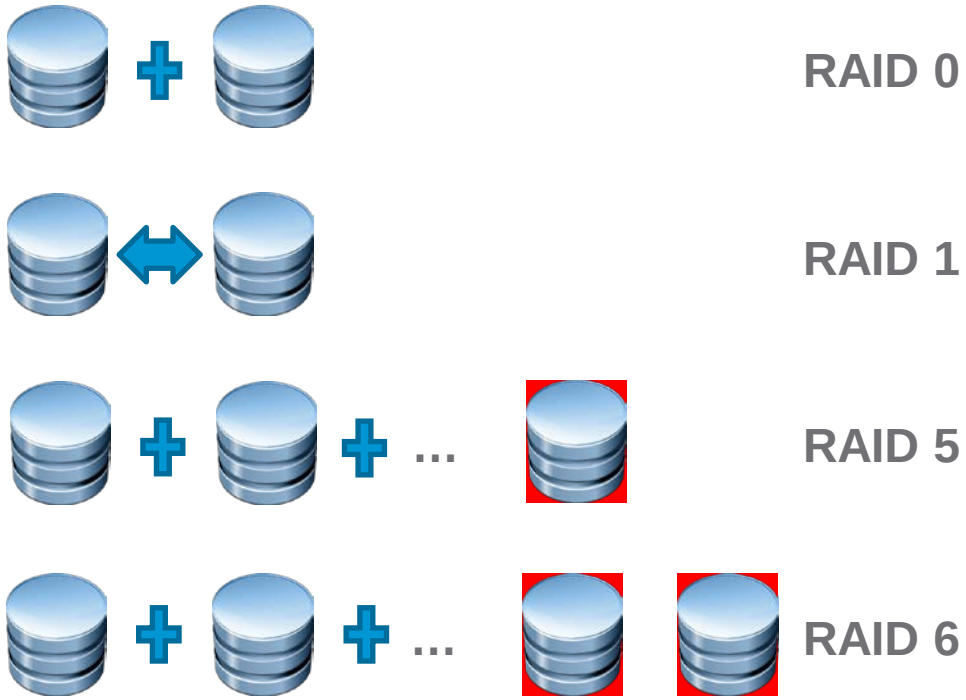
SAN and NAS arrays provide network based, high capacity storage solutions and deliver incredibly high performance.



RAID Types

RAID uses mirroring and error-correction to protect against drive failure:

- RAID 0: Fast but no protection.
- RAID 1: Fast but not efficient.
- RAID 5: Relatively slow but good protection and efficient.
- RAID 6: Slowest but best protection, and efficient.



File Systems

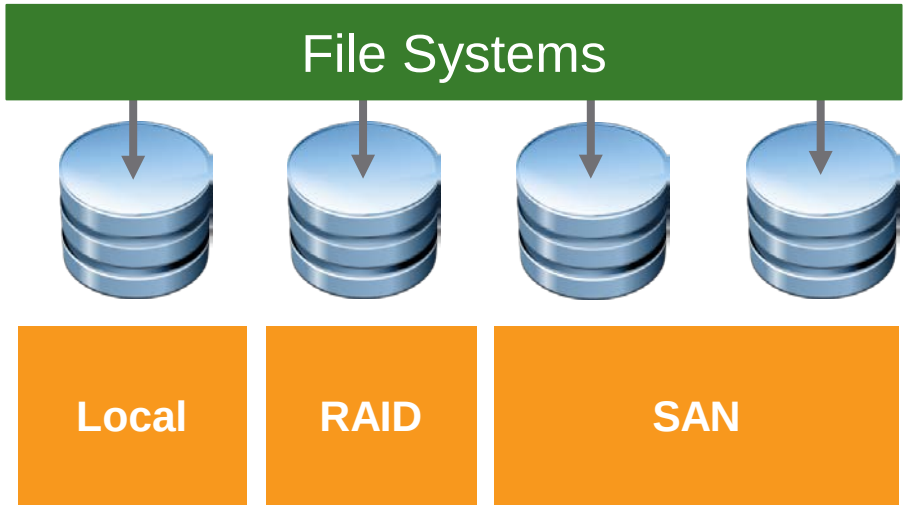
Raw storage from disks, RAID or SAN arrays must be formatted.

File systems provide folder structures and other features to allow files to be written and read.

File systems are responsible for managing and securing the files and the data in them.

Common file systems are FAT, NTFS and Ext.

VMware developed their VMFS file system specifically to support virtual machines and the clustering of its hypervisors.



Storage Technologies

File System Structures and Contents

File systems are organised using folders or directories.

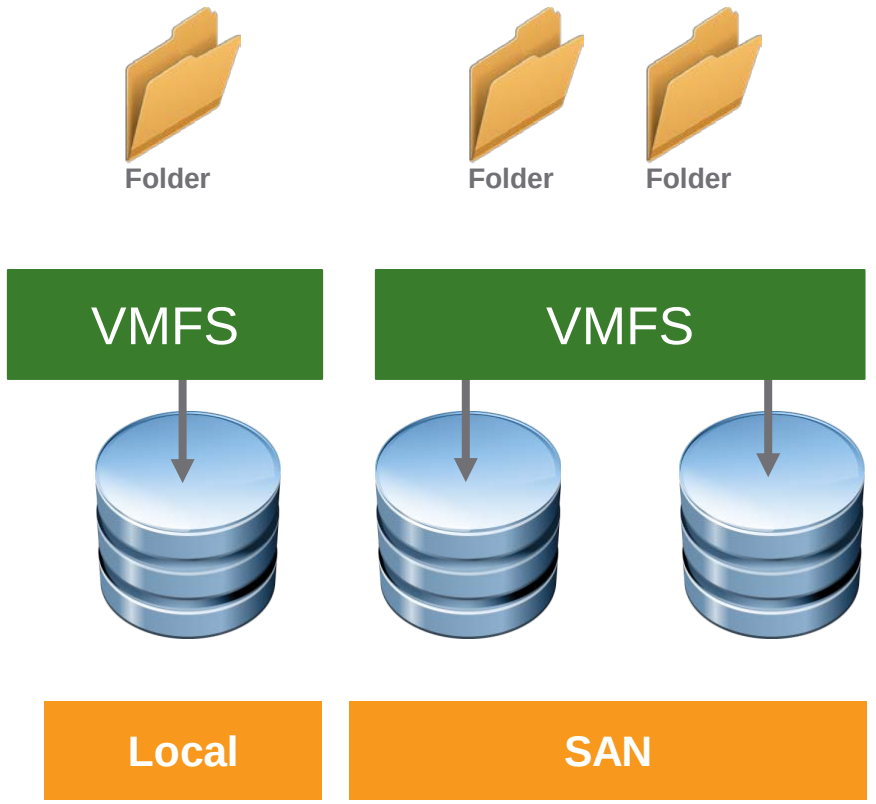
Files are saved in those folders.

A file system typically maps to a single physical disk or block of storage from an array or SAN.

File systems can span multiple disks using mount points or extents.

Each file system will have limits on file sizes, maximum capacity, etc.

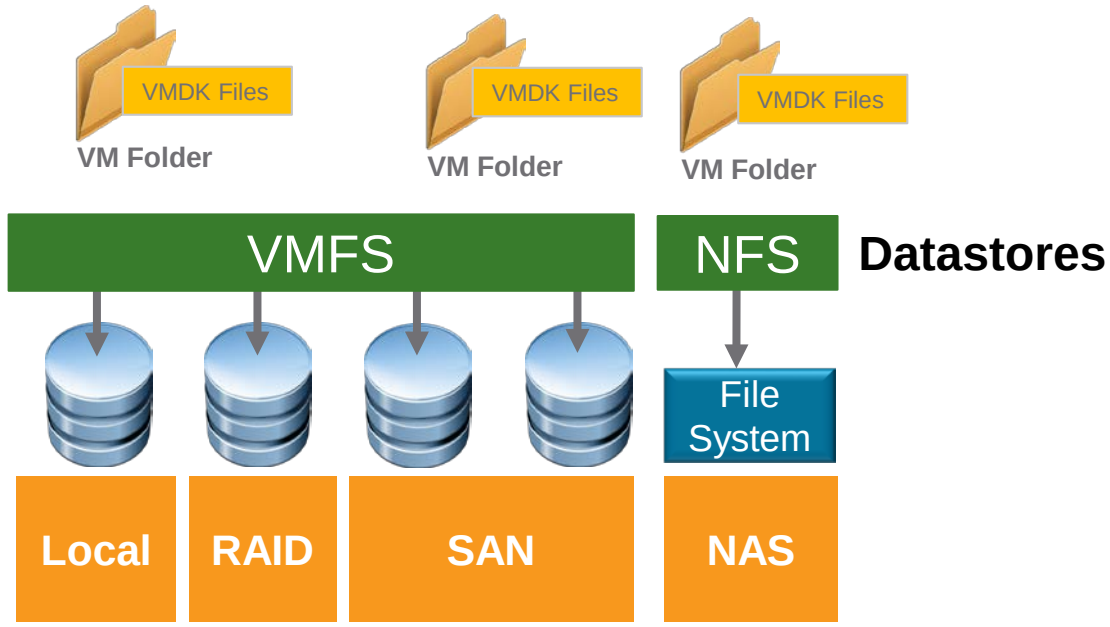
Files may contain other files or even disk images.



VMware Storage Virtualization

VMware vSphere support a wide range of storage technologies:

- VMware VMFS for local or SAN storage.
- NAS storage must be NFS3 or NFS4.
- vSphere datastores are either VMFS volumes or NFS shares.
- Virtual machine disks are stored in VMDK format.
- VMDKs can be either thick or thin provisioned.



Storage Technologies

Virtual Disks

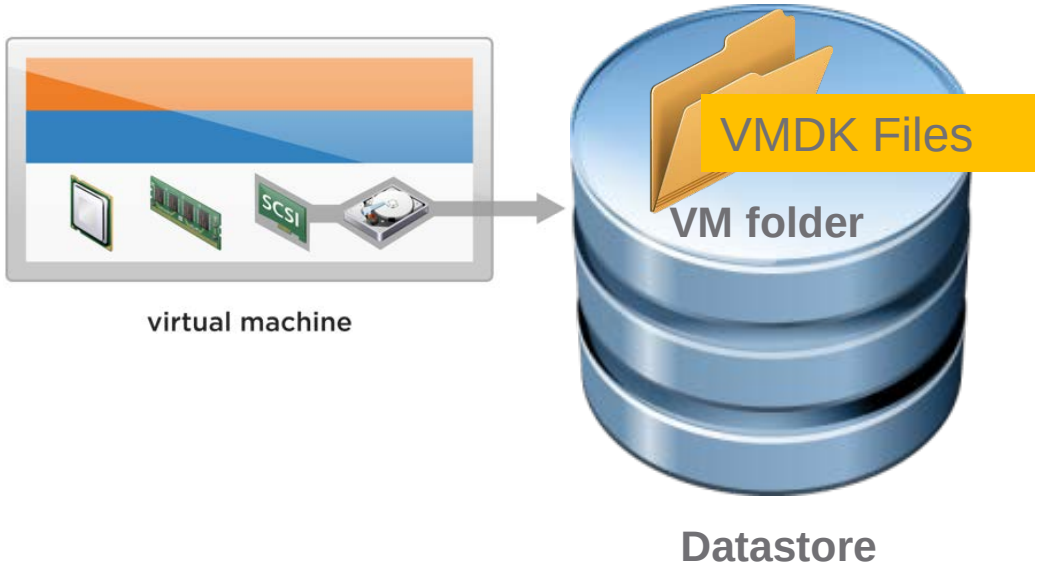
Virtual machines must have virtual disks configured for them.

Virtual disks appear to the virtual machine in the same way physical disks appear to a physical machine.

Virtual disk files contain the raw data for those disks.

Virtual disk formats include Microsoft VHD and VMware VMDK.

Some other formats may be used for CD/DVD-ROM (ISO) and floppy disks (IMG).



Lesson 4: Desktop Virtualization

Terminal Servers and Remote Access

Terminal services provide remote user sessions and applications.

A good solution for users who may not have a dedicated computer.

Very useful for scenarios where tight security around data or applications is important.

Sessions can be accessed using low cost terminals and remote display protocols.

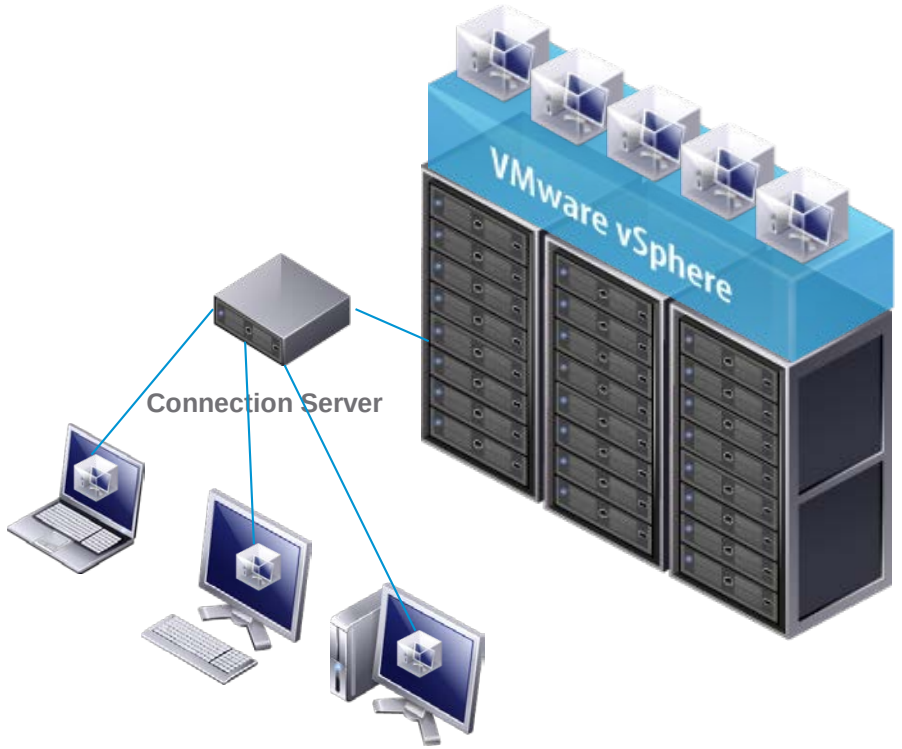
Delivering Virtual Desktops from Servers

Virtual desktops use server based hypervisors to run virtual machines with desktop operating systems for end users.

Suited to users who need more access to the complete operating system.

Suited to users who need to run a specific operating system, not the OS of the server.

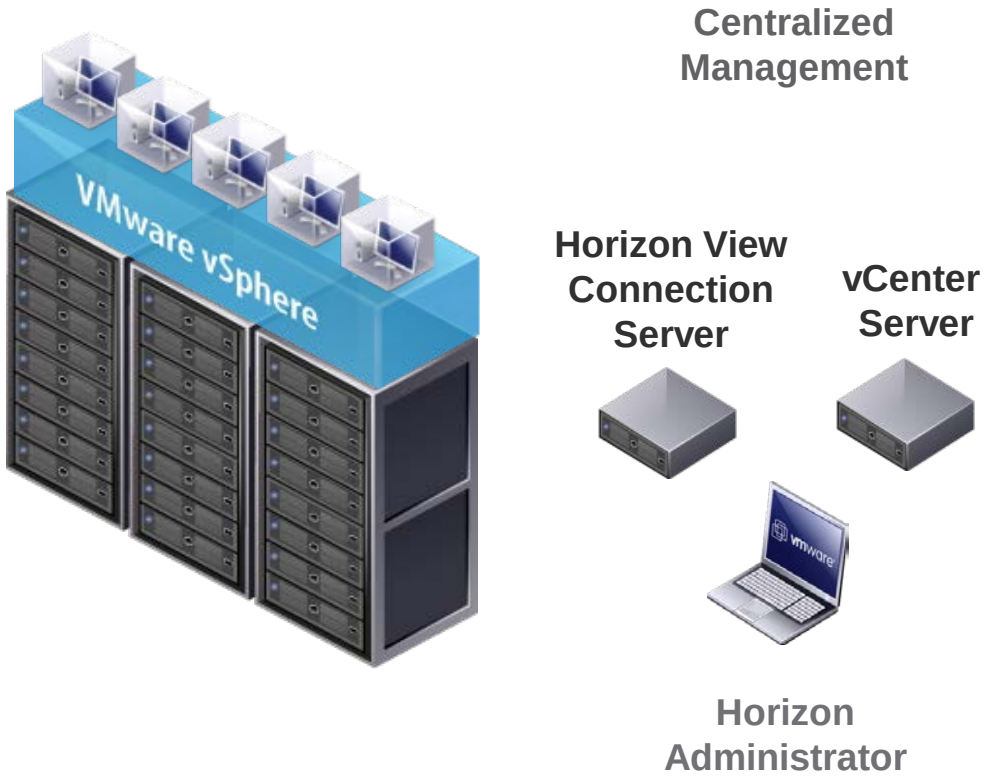
Sessions can be accessed using low cost terminals and remote display protocols.



Administration Benefits of Virtual Desktops

The following benefits apply to virtual desktops:

- Centrally managed and controlled.
- No physical systems spread throughout an office or campus.
- Patching / upgrading can be better managed.
- Out of hours maintenance is simplified.
- Slipstream processes allow updates to be pre-prepared, and quickly implemented when users log out.
- Rolling back in case of issues is simpler.
- Users can easily be given access to multiple systems with minimal admin overhead.



Low-Cost Terminals and Deployment

Traditional PCs require a lot of expensive desk-side support.

With thin or zero clients, the need for desk-side technical support is substantially reduced.

Limited configuration steps for thin/zero clients can be implemented in advance by some vendors, further eliminating on-site support overhead.

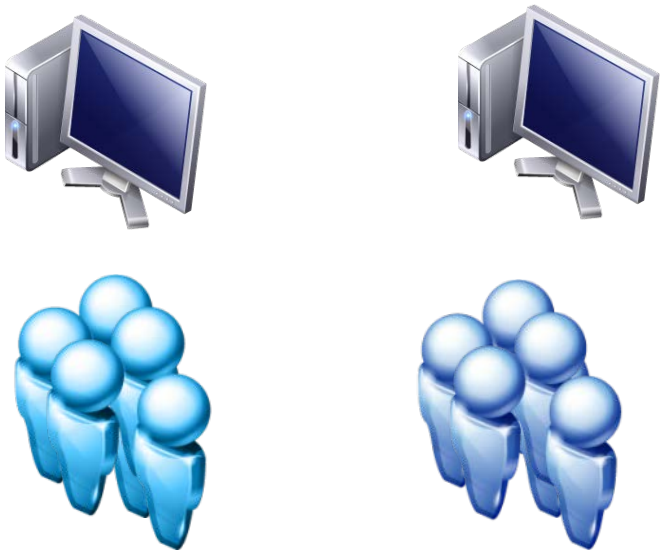
Shared Desktops

Not all users have a dedicated computer.

Shared desktop environments are often harsh, and the machines are heavily used.

Shared desktops present a risk to user data if it is stored locally.

Terminal server or virtual desktop solutions are ideal in this case as the user data and environment is protected even if a shared desktop fails.



True Remote / Roaming Solutions

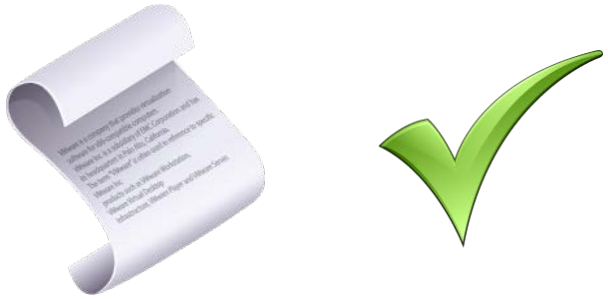
Highly mobile users may also benefit from using a virtual desktop solution:

- IT support / help may be hard to access.
- Opting for a remote desktop minimises the dependency on the user's mobile computer.
- Replacing a lost, stolen or broken machine does not require extensive restoration of apps and data.
- Improved security exists in cases of loss or theft.

Management Benefits

Virtual desktop environments provide a centrally managed solution with the following benefits:

- Simplified rollout of security patches and applications.
- Operating system migrations options provide for improved user options and reliability.
- Legal compliance auditing and enforcement is much simpler.
- Data loss risks can be reduced or even eliminated for security conscious organizations.



Security Benefits

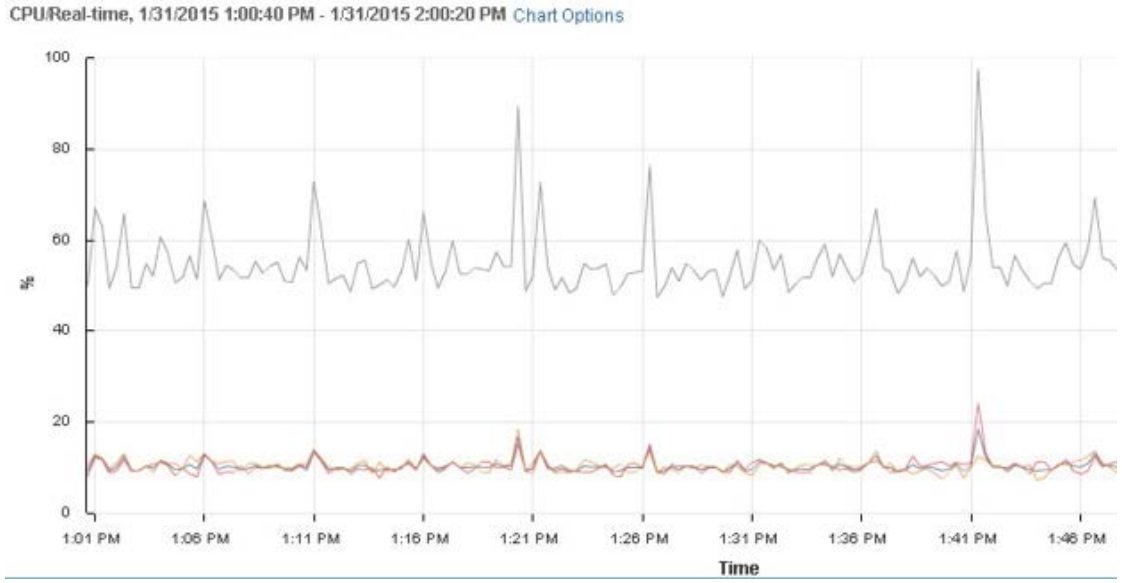
Virtual desktops can be configured to neutralize many threats that potentially impact end user computers:

- Improved security resulting from running deep inside the enterprise network.
- Eliminate the threat from rogue devices connecting to edge/office networks.
- Tight control of network traffic to and from virtual desktops can be more easily implemented, including monitoring.
- It’s possible to eliminate the threats from connecting unauthorised peripherals, or copying data unsafely.

Virtual Desktop Challenges

Virtual desktops present their own challenges:

- Network connectivity is critical.
- Load patterns follow regular user behaviours and can cause performance demand spikes.
- Scheduled IT activities that are not carefully planned, like an urgent security patch, might cause a rapid spike in performance demand.
- Storage design for large virtual desktop deployments can be difficult and expensive.



VMware Desktop Virtualization

VMware provide a management solution for virtual desktops called VMware Horizon®, formerly known as VMware View®.

VMware Horizon works in conjunction with vSphere Hypervisor and Microsoft Remote Desktop Services Hosts.

Supporting technologies used by VMware Horizon include:

- User Environment Manager
- App Volumes
- Linked Clones
- Instant Clones