

# Virtualization Components

Cloud Plus

Ch 5

# Virtualization

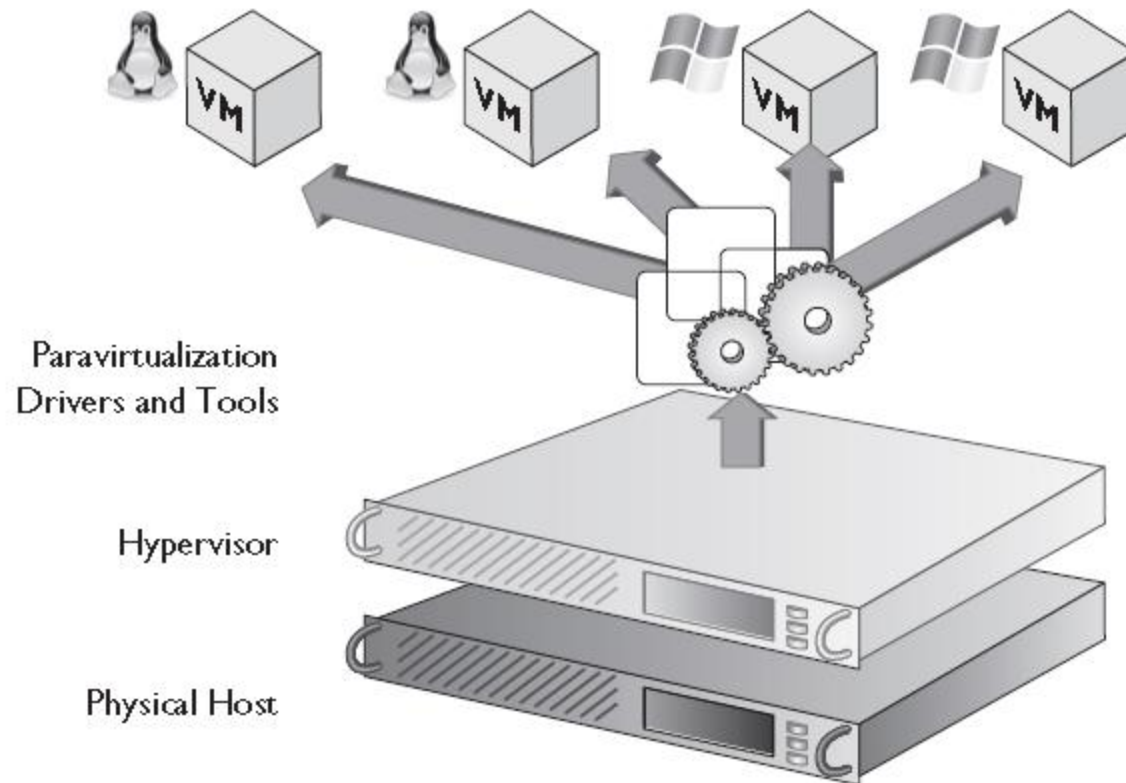
- Empowers cloud providers to deliver lower-cost hosting environments.
- Allows organizations to run multiple virtual servers on one physical server.
- Helps consolidate infrastructure and reduce total cost of ownership by cutting data center space, power consumption, and administrative overhead.
- With virtualization, an organization can:
  - Do more with less physical hardware
  - Deliver applications faster.

# Hypervisor

- Software or hardware that creates and runs virtual machines.
  - Entity that allows multiple operating systems to run on a single physical machine.
- Computer running hypervisor is defined as “host” computer.
- Virtual machines running on host are called “guest” machines.
- Hypervisor responsible for managing guest O/S resources, including:
  - Memory
  - CPU
  - Other resources...

# Type 1 and Type 2 Hypervisors

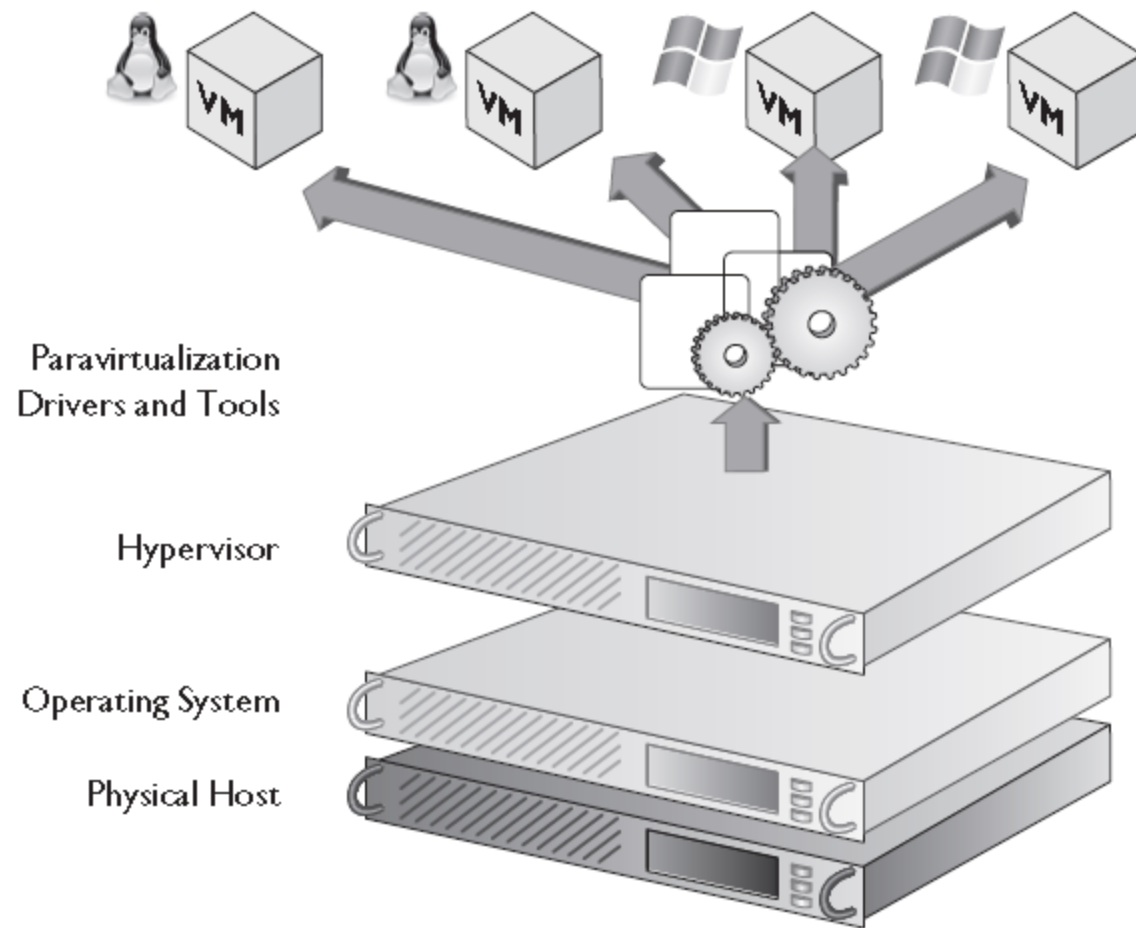
- Type 1 hypervisor created and deployed on a bare metal.
- The software communicates directly with the physical server hardware and boots before the operating system.
- Almost all major virtualization distributors, including VMware, Citrix, and Microsoft, currently use type 1 hypervisors.



- Type 1 hypervisor.

# Type 2 Hypervisor

- Loaded on top of existing operating system installation.
  - For example, a system that is running Microsoft Windows 7 might have a VMware workstation installed on top of that operating system.
- Relies heavily on the underlying operating system, if the system crashes or doesn't boot, all of the guest virtual machines are affected.



- Type 2 Hypervisor

# Type 1 vs Type 2

- Type 1 hypervisor of choice for high performance, scalability, and reliability.
- Type 2 hypervisor sits on top of operating system, makes the virtualized environment less scalable and more complex.



# Proprietary vs Open Source

- Proprietary hypervisor is one that is developed and licensed under an exclusive legal right of the copyright holder.
- Created and distributed under a license agreement to the customer. Microsoft's Hyper-V and VMware's ESX/ESXi are examples of proprietary hypervisors.

# Open Source

- An open-source hypervisor is provided at no cost and delivers the same ability as a proprietary hypervisor to run multiple guest virtual machines on a single host.
- Some examples of open-source hypervisors are Citrix XenServer and the kernel-based virtual machine (KVM).
- Choosing between proprietary and open-source hypervisors can be a difficult decision.

# Attributes

- Some of the factors that need to be considered are:
  - Security
  - Trust of the manufacturer
  - Operating systems that are supported.
- Some organizations also choose not to use an open source because their IT staff is not familiar with the interface.
- For example, an organization may choose to use Microsoft Hyper-V over Citrix XenServer because their IT staff is already familiar with the Microsoft product line and will not have as big of a learning curve as they might if they used an open- source hypervisor.

# Consumer versus Enterprise

- A lot of the new desktop operating systems come with a virtualization option already built in.
  - For example, Microsoft Windows 8 now comes with Hyper-V, allowing desktop-level hardware to run a virtual environment.
- When comparing what a consumer would use for a hypervisor to what an enterprise might use, it is important to consider the goals of the user.
- An enterprise organization is most likely looking to run multiple operating systems on a single piece of physical hardware, and those operating systems are going to support a large amount of users and a variety of software.
  - In an enterprise environment like this, a type 1 hypervisor is more suitable based on the advantages of type 1 that we have already discussed.

# Consumer

- In comparison a consumer looking to configure a virtual environment on a desktop is probably not looking to support a large number of users; more than likely they are looking to test a new operating system or application in an isolated environment that is separate from the operating system running their desktop.
  - In this case a type 2 hypervisor is more likely to fit the need.
- Type 2 would allow the desktop to continue to run the original operating system and then virtually run the new operating system or application that the user is trying to test.

# Virtualization Host

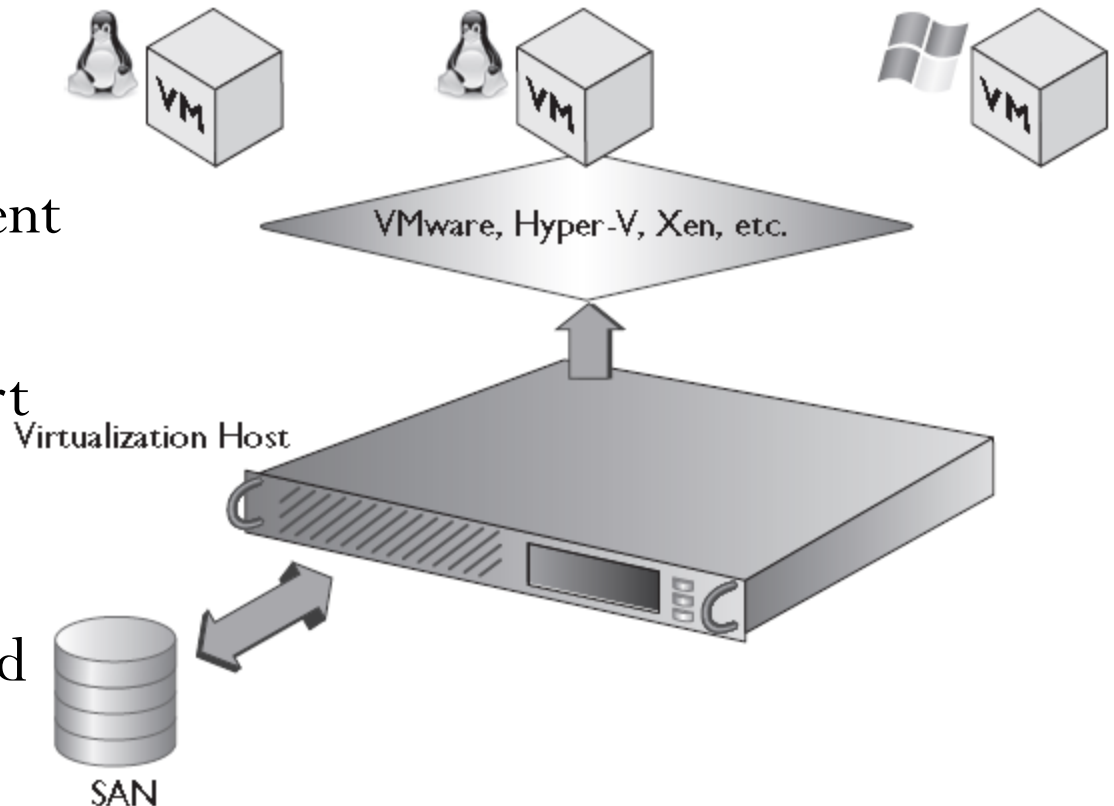
- Virtualization host is the system that is installed first and then hosts or contains the guest virtual machines.
- Host server provides all of the underlying hardware and compute resources for the guest virtual machines, including memory, CPU, hard disk, and network I/O.
- Since the host machine provides the resources for the guest, it must contain at least enough hardware resources to meet the minimum requirements for its guest virtual machines.

# Hardware Perquisites

- A host computer allows different operating systems to coexist on the same host computer.
- Before a computer system can become a virtualization host, there are a number of hardware prerequisites that a computer system must meet. Including:
  - BIOS configuration
  - Memory
  - CPU
  - NIC.

# Hardware-Assisted Virtualization

- Hardware-assisted virtualization enables efficient full virtualization.
- Both AMD and Intel support hardware-assisted virtualization.
- All processors manufactured after 2003 have hardware-assisted virtualization built in.





# Old Hardware

- If an organization has already purchased the hardware or wants to repurpose older hardware as a virtualization host, there are free software tools they can download and run that will check to see if their hardware supports hardware-assisted virtualization.
- For example, if a company is trying to use an older server as a virtualization host to run Microsoft Hyper-V, Microsoft has a free software tool that can determine if that server supports hardware-assisted virtualization and Microsoft Hyper-V.

# Basic Input/Output System (BIOS)

- The BIOS is built-in software that comes with the computer.
  - Usually stored on either a ROM chip or a flash memory chip.
- BIOS determines what features a computer supports without having to access any additional software that is loaded on the computer.
  - For example, the BIOS can contain the software that is needed to control the keyboard, the display settings, disk drives, USB settings, power options, and multiple other options.
- The BIOS allows a computer to boot itself and is available even if the hard disks in the computer fail or are corrupted.

# BIOS Attributes

- Modern operating systems rely on the BIOS to support hardware-assisted virtualization.
- With the advancement in virtualization and desktop computers, it is no longer necessary to have a host machine running a server-class hardware.
- Much of the desktop hardware now natively supports hardware-assisted virtualization.

# Firmware Configurations

- Firmware upgrades can be performed on a number of devices, including:
  - Motherboards
  - network cards
  - hard drives.
- In some cases it might be necessary to do a firmware upgrade to a computer's BIOS in order for it to support hardware-assisted virtualization.
- Generally done on older hardware.
- Motherboard manufacturers place firmware updates and the software needed to update the BIOS firmware on their websites.

# Central Processing Unit (CPU) and Cores

- Making sure that the host machine can support at least the minimum number of guest virtual machines that the organization is trying to run is a critical step in creating a successful virtualization environment.
- One of the many benefits of virtualization is the ability to provision virtual machines on the fly as the organization's demands grow, making the purchase of additional hardware unnecessary.
- If the host computer is not sized correctly, however, it is not possible to add virtual machines without adding compute resources to the host computer.

# Correct CPU Type

- Both AMD (AMD-V) and Intel (Intel VT) support virtualization, so the manufacturer is not as critical.
  - A multicore processor is a single physical CPU with two or more independent CPUs called cores.
- Generally speaking, with virtualization a company is better off spending money on more cores with more cache rather than on faster CPU speed.
  - For example, if the company has to choose between a system with a 12-core CPU running at 2.2 GHz or a system with a 6-core CPU running at 2.93 GHz, the 12-core CPU is the better choice.
- With virtualization the company can spread the virtual machine load across more CPU cores.
  - Translates into faster and more consistent virtual machine performance.

# Assigning CPU Resources

- Virtual machines use virtual CPUs (vCPUs), which can be added to a virtual machine when it is created.
- Number of vCPUs that the company should add is dependent on a number of factors, but it is possible to assign multiple vCPUs to a single virtual machine.
- Also possible for an organization to assign more vCPUs to their virtual machines than they have physical CPU cores.

# Assigning more vCPUs than CPU cores

- Most of the time it is safe to assign four to six vCPUs for every CPU core on the server.
  - Evaluating the environment and the goal of that environment is key.
  - For example, a heavily used Microsoft SQL server is going to be a very processor-intensive virtual machine.
- VMware, Hyper-V, and Citrix all have calculators available to help determine exactly how to distribute vCPUs based on best practices for that particular virtualization product.



**TABLE 5-1** Virtualization Host Maximum Resources

Component	VMware ESXi 5.1	Hyper-V 3.0	XenServer 6.1
Logical CPUs per Host	160	320	160
Virtual CPUs per Host	2048	2048	900
RAM per Host	2 TB	4 TB	1 TB
Virtual Machines per Host	512	1024	150
Network Cards per Host	32	No limits imposed by Hyper-V	16

# Memory Capacity and Configurations

- Planning the amount of memory needed on a host machine is quite different from planning the number of CPUs.
- CPU resources can be oversubscribed (i.e., you can add more vCPUs than you have physical CPUs), but with memory it is much harder to oversubscribe.
- So planning for memory is critical. The more RAM and the faster the RAM speed, the better for a virtualization host.

# Adjusting Memory

- Some virtualization platforms allow for adjusting virtual machine memory on the fly, essentially allowing one virtual machine to borrow memory from another virtual machine without shutting down the system.
- More memory on the host machine is always better.
- The job of the IT administrator is to maximize the cost savings of virtualization and the value it brings to the organization.
- Careful planning is required to provide enough memory on the host machine to dynamically provision virtual machines as the organization's needs grow and at the same time to make the most cost-efficient choices.

# Network Interface Cards (NICs)

- Correct network configuration and card are critical.
  - Network latency can diminish the speed of a virtual environment.
- Need to understand the physical aspects of the network so as not to introduce a bottleneck.
  - For example, if the organization is using a 10-gigabit NIC to connect to a 10-gigabit port on a switch, they must make sure that all the patch cables support 10-gigabit speeds and that the switch is configured to use 10 gigabits and is not hard coded to use 1-gigabit speeds.
- Network only as fast as the slowest link.
  - Having a misconfigured switch or a bad cable can cause a bottleneck and result in slower performance.

# NIC Key Features

Feature	Description
Checksum Off-Load	Off-loads the process of TCP packets to the network controller from the CPU
TCP Segmentation Off-Load (TSO)	Converts large chunks of data into smaller packets to be transmitted through the network
64-Bit Direct Memory Access (DMA) Addresses	Permits high-throughput and low-latency networking
Jumbo Frames (JF)	Extends Ethernet to 9,000 bytes, allowing for less packet overhead on the server and fewer server interrupts
Large Receive Off-Load (LRO)	Increases inbound throughput by reducing CPU overhead, aggregating multiple incoming packets from a single stream into a larger buffer

- Other key features to consider when purchasing NICs for the virtualization host computer.

# Virtual Machine

- After carefully planning and designing the virtualization host computer, it is ready to support guest virtual machines.
- With virtualization comes the ability to maximize the physical server and no longer have “unused” resources.
- While this is a huge advantage and cost savings to an organization, it also requires more planning than the one-to-one way of thinking prior to virtualization.

# Virtual Machine a File

- Before virtualization IT administrators were confined to physical resources.
- With virtualization an IT administrator now has the ability to add compute resources to a virtual machine without having to purchase additional hardware.
- Think of a virtual machine as a portable file that can be moved, copied, and reassigned to a different virtualization host with minimal administration.

# Isolation

- The guest operating system is unaware that it is running in a virtual environment.
  - It allows applications and software to be installed as if it were running on a physical server.
- The applications can be installed on separate virtual machines, which provides complete isolation from other applications running on the host computer or another virtual machine.
- Great way to test new applications without interfering with existing applications, or to create a development environment completely segmented from the production environment.



# Virtual Disks

- Just like a physical server, a virtual machine needs to have a place to install an operating system and applications and to store files and folders.
- A virtual disk is a file that represents a physical disk drive to the virtual machine.
- A virtual disk file resides on the host computer and is seen by the guest virtual machine.
- Contains the same properties and features of a physical drive, including disk partitions, a file system, and files and folders.

# Virtual Disk

- When creating a virtual disk, a few decisions need to be made, including the type of disk, the name and location of the disk, and the size of the disk.
  - Each major virtualization manufacturers have different terms when describing virtual disk configurations.
- For example, if you are using Microsoft Hyper-V, you would have the options of making a dynamically expanding virtual disk, a fixed virtual disk, or a differencing virtual disk.
- If you are creating a fixed-size disk, you would specify the size of the disk when it is created.
- If you are creating a dynamically expanding virtual disk, the disk starts as a small size and adds storage as needed.

# Think and Thin Disk

- On the other hand, if you are creating a virtual disk in VMware ESXi, you have the option of creating a thick disk or a thin disk.
- A thick disk is similar to a fixed disk in Microsoft Hyper-V in that the size is specified and allocated during the creation of the virtual disk.
- A thin disk is similar to a dynamically expanding disk in Microsoft Hyper-V in that the disk starts out small and adds space as required by the virtual machine.
- Different virtualization manufacturers use different terms to define their virtual disks, the concepts are similar.
  - Whether you are using Hyper-V, ESXi, or XenServer, you still need to decide which type of disk to use for which application.

# Thin Provisioning

- If you are concerned about disk space, then using a thin disk or dynamically expanding disk would be the best option.
  - If size is not a concern, then you could use a fixed-size or thick disk.
- When planning for virtual disks, another concept that is critical to understand is thin provisioning.
- Thin provisioning allows virtual disks to allocate and commit storage space on demand and use only the space they currently require.
- With thin provisioning, a company can create multiple virtual disks and set the limits of those virtual disks to an amount greater than the total available storage space.
- Essentially allows them to overcommit the storage capacity.

# Monitoring

- Careful monitoring must be implemented in this scenario to control the actual disk usage, but if configured correctly, thin provisioning can save an organization time and money.
- When configuring a thick-provisioned or fixed-size virtual disk, the organization allocates the storage space while the initial disk is being created.
- Means that the virtual disk is guaranteed and consumes whatever amount of disk space the company specifies during creation of that virtual disk.
- When comparing thin and thick provisioning and which one works best in the organization's environment, it is important to keep a few things in mind.

# Provisioning

- Thick provisioning provides better performance because the drive size is not being built as the application requires more drive space.
- Thin provisioning does not have the same performance level as a thick disk and needs to be monitored closely to prevent running out of available disk space since storage space is by definition overcommitted.
- The application can also help determine which type of virtual disk to choose.
  - For example, an application that writes a lot of data to the drive, like Microsoft SQL, would not perform as well on a thin-provisioned disk.
- If the application is not writing to the virtual disk that often and space is a concern, then a thin-provisioned disk would be more appropriate.

Components (per Virtual Machine)	VMware ESXi 5.1	Microsoft Hyper-V 3.0	Citrix XenServer 6.1
Memory	1 TB	1 TB	128 GB
Virtual CPUs	64	64	32
Virtual IDE Hard Disks	4	4	XenServer does not emulate SCSI or IDE and uses xvd devices with a maximum of 16
Virtual SCSI Disks	60	256	
Virtual NICs	10	12	7

- Maximum number of virtual IDE and SCSI disks that are available for various types of virtual machines.

# Virtual NICs

- Proper virtual NIC and network settings configuration is a key component to minimizing virtual environment bottlenecks.
- A virtual NIC allows an organization to change some of the properties of the NIC itself, including MAC address settings, network connections, and VLAN ID.
- This allows for greater control over the virtual NIC from within the hypervisor software. Once the settings are configured and the virtual NIC is installed on the virtual machine, it functions almost like a physical NIC installed on a physical server.
- See Table 5-3



# Virtual Network

- After attaching a virtual NIC to a virtual machine, the organization has the ability to add that virtual NIC to a virtual network.
- A virtual network is a group of network devices that are configured to access local or external network resources, and consists of virtual network links.
- In effect, a virtual network is the network where traffic between the virtual servers is routed using virtual switches and virtual routers.
- A virtual router is software-based router that allows a virtualization host to act like a hardware router over the network.

# Networking Options

- In addition to configuring a virtual switch, an administrator has the option to configure bridged networking.
  - Allows the virtual machine to communicate with the outside world using the physical NIC so it can appear as a normal host to the rest of the network.
- Some options need to be considered when configuring a virtual machine to communicate with the rest of the local area network.
  - For example, the company might not want their virtual machine to communicate with anything on the LAN, in which case they can isolate it to communicate only with other virtual machines on the same host.
  - In a different scenario they might want to bridge the connection between their virtual machine and the LAN used by the host computer so that the virtual machine can communicate with devices that are external to the host computer.

# Isolation

- Virtualization can isolate applications for testing and deployment.
- After the virtual machine's operating system recognizes and installs the virtual NIC, it can be configured just like a physical NIC.
  - It is possible to set the IP address, the DNS, the default gateway, netmask, the link speed, and so on.
- The actual network configuration of the virtual NIC is identical to that of a physical network adapter.
- So the virtual machine connects to the network in the same manner a physical machine would that has the same IP address and subnet mask configuration.

- A virtual machine can be configured to use one or more virtual Ethernet adapters, allowing each adapter to have its own MAC and IP address.
- Table 5-3 shows the maximum number of virtual NICs that are available on various types of virtual machines.

# Virtual Switches

- A virtual switch makes it possible to connect other network devices together.
- Controls how the network traffic flows between the virtual machines and the host computer as well as how network traffic flows between the virtual machine and other network devices in the organization.
- Allows the company to isolate network traffic to their virtual machines.
- Can provide some of the same security features as a physical switch.
  - Including policy enforcement, isolation, traffic shaping, and simplified troubleshooting.
- Can support VLANs and is compatible with standard VLAN implementations.
- However, a virtual switch cannot be attached to another virtual switch; instead, more ports can be added to the existing switch.

# Switches

- An organization can create different types of virtual switches.
- An external virtual switch allows the virtual machine to communicate with other virtual machines on the same host and with other network devices located outside the host computer.
- An internal virtual switch allows the virtual machines and the host to communicate with each other, but the virtual machine is unable to communicate with network devices located outside the host computer.

# Memory

- Managing memory on a virtual machine is different than managing memory on a physical server.
  - When dealing with a physical server, an organization has to decide at the time of purchase how much memory that server needs to have.
  - When building or deploying a virtual machine, the company can change the memory on the fly as needed.
- A virtual machine only consumes memory if that virtual machine is running.
- Managing virtual machine memory is easier and allows the organization to maximize their resources for that virtual machine.

# Managing Virtual Memory

- They can set the initial size of the virtual machine's memory and change that setting after the virtual machine has been created and is operational.
  - For example, they may have a virtual machine running file and print services and may be uncertain what the memory requirements ultimately will be.
  - In this instance they can configure a low amount of memory to start and then monitor the virtual machine to determine its memory utilization.
  - If it reaches 90 or 100 percent utilization, they can easily increase the amount of memory without having to purchase additional hardware.
- Keep in mind, however, that this is only possible if there is additional memory available on the virtualization host computer.



# Memory Configuration

- Host computer must also have enough physical memory available to start the virtual machine.
- In addition, the company must consider what types of applications the virtual machine will be running.
  - If a specific application requires a lot of memory on a physical server, it will need the same setup on a virtual machine.
- The organization must also take into account what other virtual machines are running on the host computer that will be competing with this virtual machine for memory resources.
- And they need to consider what other applications are going to be running on the host computer.

# Running Apps onHost

- Not a major factor on a type 1 hypervisor.
- However, if there are additional applications running on the host computer besides the hypervisor, the company should take that into consideration.
- On a type 2 hypervisor other applications would be running on the host computer and would require memory, so those applications would need to be factored in when determining memory size for the virtual machine.

# Assigning Memory to a Virtual Machine

- One option: configure a static amount of memory.
  - If an organization uses this setting for all the virtual machines on a host computer, then the host computer must have at least enough physical memory to support those virtual machines.
- A second option: use dynamic memory, which allows a company to assign a minimum and maximum amount of memory to a virtual machine..
- Dynamic memory also allows for overcommitting the host computer's physical memory so that more virtual machines can be run on that host computer.
- An organization can enable dynamic memory on a per virtual-machine basis, targeting only those virtual machines that can benefit from it..

# Storage Virtualization

- Storage virtualization groups multiple network storage devices into a single storage unit that can be managed from a central console and used by a virtual machine or host computer.
- Storage virtualization usually occurs in a storage area network (SAN) where a high-speed collection of shared storage devices can be used.
- Managing storage devices can be complex and tedious.
- Storage virtualization simplifies the administration of common storage tasks, such as archiving, recovery, backups, and the configuration of storage.

# Virtual Storage Advantages

- A virtualized storage environment has some distinct advantages over non- virtualized storage.
  - In a non-virtualized storage environment, host computers connect directly to the storage that is internal to the host or to an external array.
  - In this scenario the server takes complete ownership of the physical storage, with an entire disk tied to a single server.
- Virtualized storage enables the use of shared storage devices and solves the issue of a single server owning the storage by allowing multiple host servers and virtual machines to simultaneously access the storage.

# Shared Storage

- Shared storage can present storage to a host computer, and the host computer in turn can present the storage to the virtual machine.
- Multiple host computers can access shared storage at the same time, which allows the virtual machines to migrate between host computers.
- Virtualization software supports all the common storage interconnects for block-based storage, including Fibre Channel, iSCSI, Fibre Channel over Ethernet (FCoE), and direct attached storage.
- The virtualization software provides an interface to simplify how the virtual machine accesses the storage.
- It also presents SCSI and IDE controllers to the virtual machines so that the operating system can recognize the storage.
- The virtual machine sees only a simple physical disk attached via the IDE or SCSI controller provided by the virtualization software.

# Virtualized Storage Advantages

- Include ease of management, improved efficiency, and the ability to present storage types that the native operating system might not support.
- If an organization uses Fibre Channel to connect to shared storage, they are taking advantage of Network\_port ID virtualization (NPIV), a technology that allows multiple host computers to share a single physical Fibre Channel port identification, or N\_port.
- This allows a single host bus adapter to register multiple World Wide Names (WWNs) and N\_port identification numbers.
- By using NPIV each host server can present a different WWN to the shared storage device, which allows each host computer to see its own storage.

# Clustered Storage

- In addition to storage virtualization, an organization might look to clustered storage to provide increased performance, capacity, and reliability for the storage environment that the virtual machines access.
- Clustered storage combines multiple storage devices together to distribute the workload between storage devices and provide access to the virtual machine files, regardless of the physical location of the files.



# Guest Tools

- Guest tools are software additions that are added to a virtual machine after the operating system has been installed.
- They enhance the performance of a virtual machine and improve the interaction between the virtual machine and the host computer.
- Guest tools also make it easier to manage a virtual machine by providing enhanced features, such as faster graphics performance, time synchronization between host and guest, increased network performance, and the ability to copy files between the virtual machine and the host computer.
- The guest tools are also responsible for integrating the drivers into the guest virtual machine operating system.

# Guest Tools

- A guest virtual machine operating system can run without installing guest tools, but it loses a lot of the important functionality and ease of administration without them.
- Installing the guest tools is easy and straightforward on all major virtualization applications and is sometimes even built into the operating system.
  - For example, a Windows Server 2012 virtual machine created using Microsoft Hyper-V has the virtual machine integration services already loaded.
- Most operating systems, including Microsoft Windows, Linux, Solaris, FreeBSD, NetWare, and Mac OS X, support installation of guest tools.

# Copy and Paste Virtual to Real

- Guest tools help the virtual machine interact with the host machine. Some virtual machine features may not work without the guest tools being installed on that virtual machine.

# Questions