Guide to Operating Systems, 6th Edition

Module 8: Virtualization and Cloud Computing Fundamentals

Learning Objectives

By the end of this module, you should be able to:

- Describe the components of virtualization

- Use and describe hosted virtualization

- Use and describe bare-metal virtualization

- Describe application virtualization

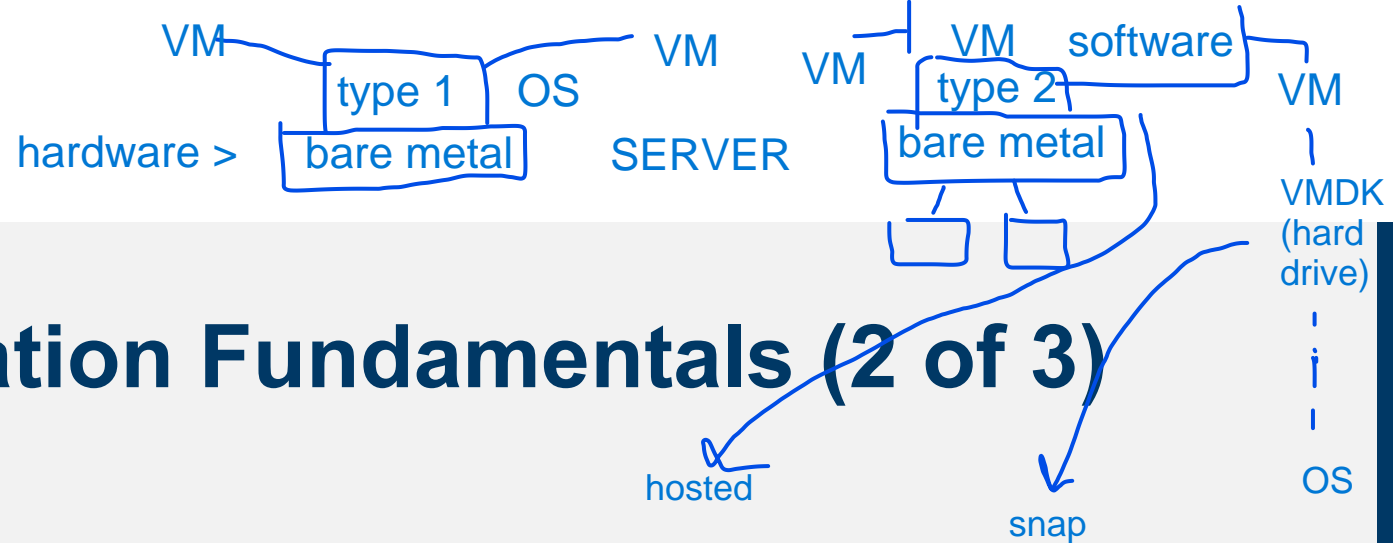- Describe cloud computing

Benefits of Virtualization

1. testing + isolation/security
2. cost (don't have to buy more hardware)
3. agility (how quickly to spin stuff up)
4. availability (maintenance, HA = high availability = some sort of fault tolerance)

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AWS VM = another name is EC2 (elastic cloud computing)

Virtualization Fundamentals (1 of 3)

- **Virtualization** is a process that creates a software environment to emulate a computer's hardware and BIOS

  − Allows multiple OSs to run on the same physical computer at the same time

- Virtualization terms:

  − A **virtual machine (VM)** is the virtual environment that emulates a physical computer's hardware and BIOS

  i.e. on this computer, Linux

  − A **guest OS** is the operating system installed on a VM

  − A **host computer** is the physical computer on which the VM software is installed

VM · type 1 · OS · VM · VM · VM · software · VM

hardware > · bare metal · SERVER · type 2 · bare metal · VMDK (hard drive)

hosted · snap · OS

Virtualization Fundamentals (2 of 3)

- Virtualization terms (continued):

  - **Virtualization software** creates and manages VMs and creates the virtual environment in which a guest OS is installed

  - The **hypervisor** creates and monitors the virtual hardware environment, which allows multiple VMs to share physical hardware resources

    - A **type 1 hypervisor** runs directly on the host computer's hardware and controls and monitors guest OSs (also called **bare-metal virtualization**)

    - A **type 2 hypervisor** is installed in a general-purpose host OS, and the host OS accesses host hardware on behalf of the guest OS (also called **hosted virtualization**)

Virtualization Fundamentals (3 of 3)

- Virtualization terms (continued):

  - A **virtual disk** consists of files residing on the host computer that represent a virtual machine's hard drive

  - A **virtual network** is a network configuration created by virtualization

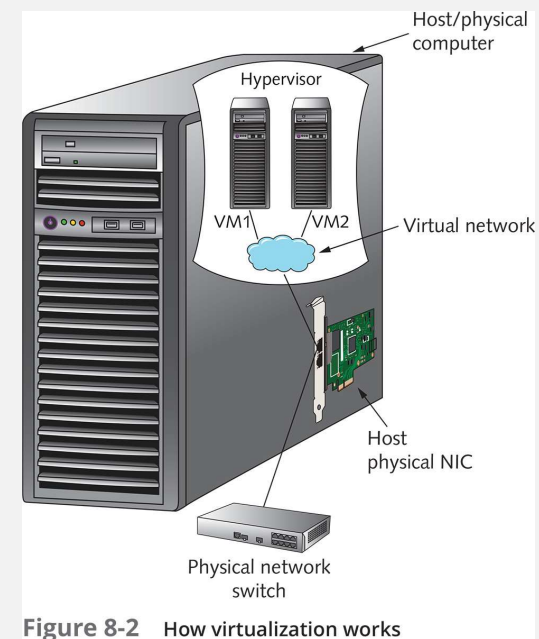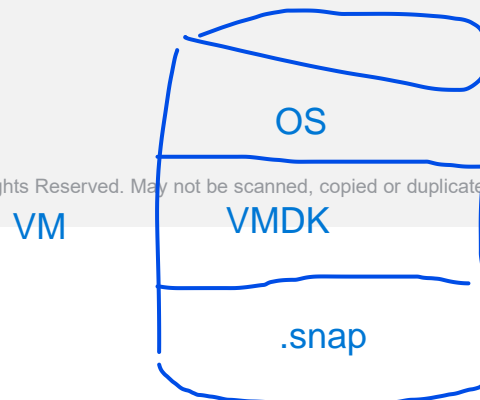 - A **snapshot** is a partial copy of a VM made at a particular moment

Figure 8-2   How virtualization works

[handwritten annotations:]

VM

OS

VMDK   < fixed 8:20

.snap

recommit back into vmdk

to track how the vmdk changes?
problem: fills until it runs out of space
also performance issues

Hosted Virtualization

- Hosted virtualization uses a type 2 hypervisor

- It has an advantage of supporting a wider variety of guest OSs because there are few incompatibility problems between the guest OS and hardware

- It is easy and straightforward to use   more flexible
    - You install the virtualization software on your computer and begin creating virtual machines

- Hardware requirements include enough memory to support the host and guest OSs, adequate CPU power, and enough space to store the virtual disk

Hosted Virtualization Applications

- OS training

- Software training

- Application isolation

- Network isolation

- Software development   test across multiple things

- What-if scenarios

- Use of legacy applications   some applications written only for legacy stuff

- Physical-to-virtual conversion   antiquated physical machine

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Hosted Virtualization Products

- Well-known hosted virtualization products:
  - VMware Workstation Pro   creation
  - VMware Workstation Player   running VMs
  - VMware Fusion   virtual desktop
  - Parallels Desktop for Mac
  - VirtualBox

Using VMware Workstation Pro (1 of 3)

- You can download a free trial version and try it for 30 days

    - After installation, a wizard takes you through the steps of creating a virtual machine

- Offers flexible networking options

    - Allows you to configure the NIC on your VM to use one of the five virtual network options or create your own custom virtual network

- Five preconfigured options:

    - Bridged, NAT, host-only, custom, LAN segment

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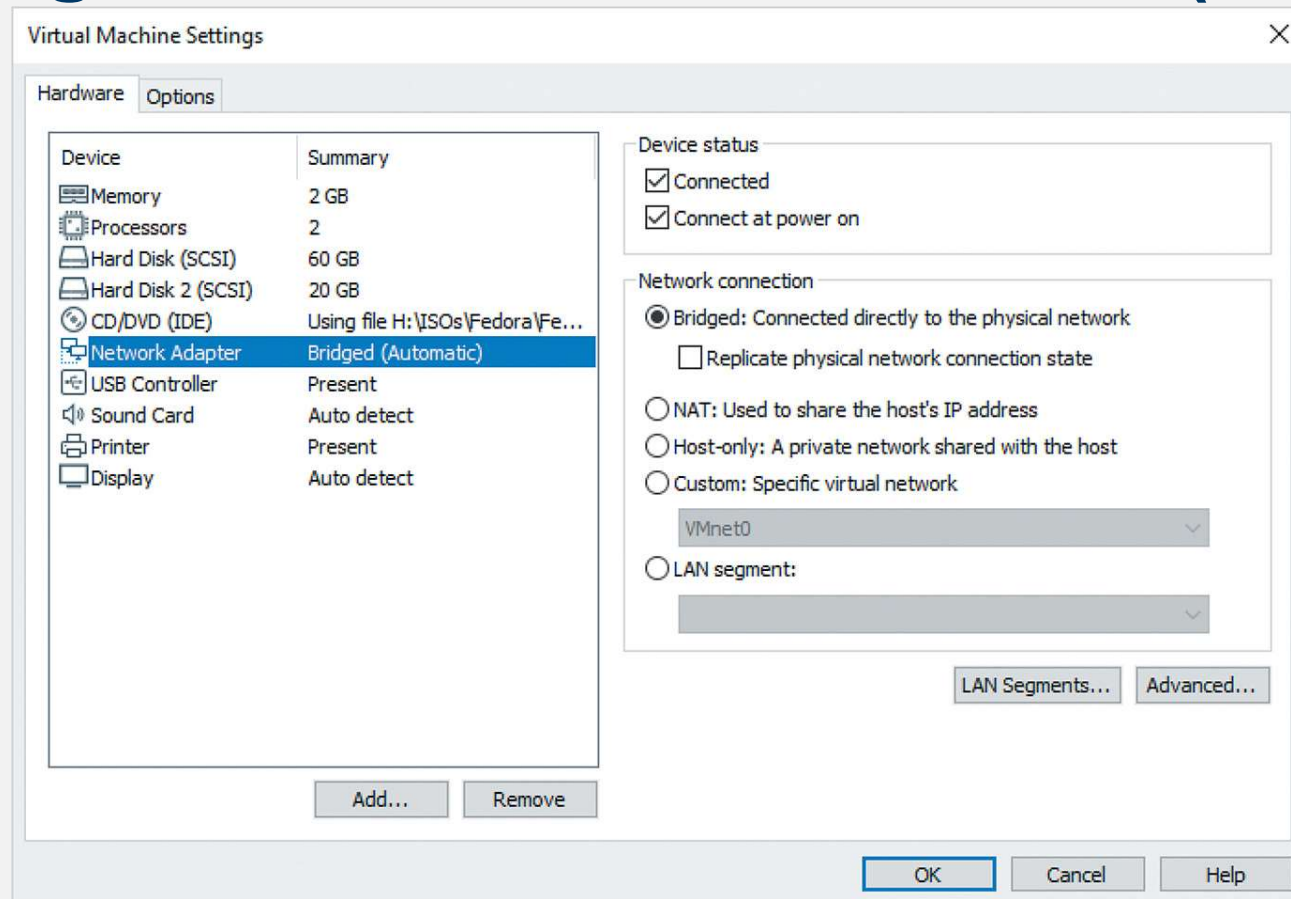# Using VMware Workstation Pro (2 of 3)

Figure 8-3 VMware virtual network options

Using VMware Workstation Pro (3 of 3)

- VMware Tools should be installed in the guest OS to ensure the best performance and ease of use

    - VMware Tools is a collection of tools and drivers, which adds optimized network, video, and disk drivers and guest-host integration tools

- Other advanced features are available for developers

    - Which is why VMware Workstation is considered the flagship hosted virtualization product

Using VMware Workstation Player (1 of 2)

- VMware Workstation Player is a stripped-down version of VMware Workstation Pro that offers the basics of desktop virtualization

- To create a VM in VMware Workstation Player, you use a wizard that is nearly identical to the one in VMware Workstation Pro

    − It includes an option to download a virtual appliance, which is a ready-to-use VM that contains a guest OS with preconfigured applications or network services

    − A good option for new virtualization users and for classroom and training centers

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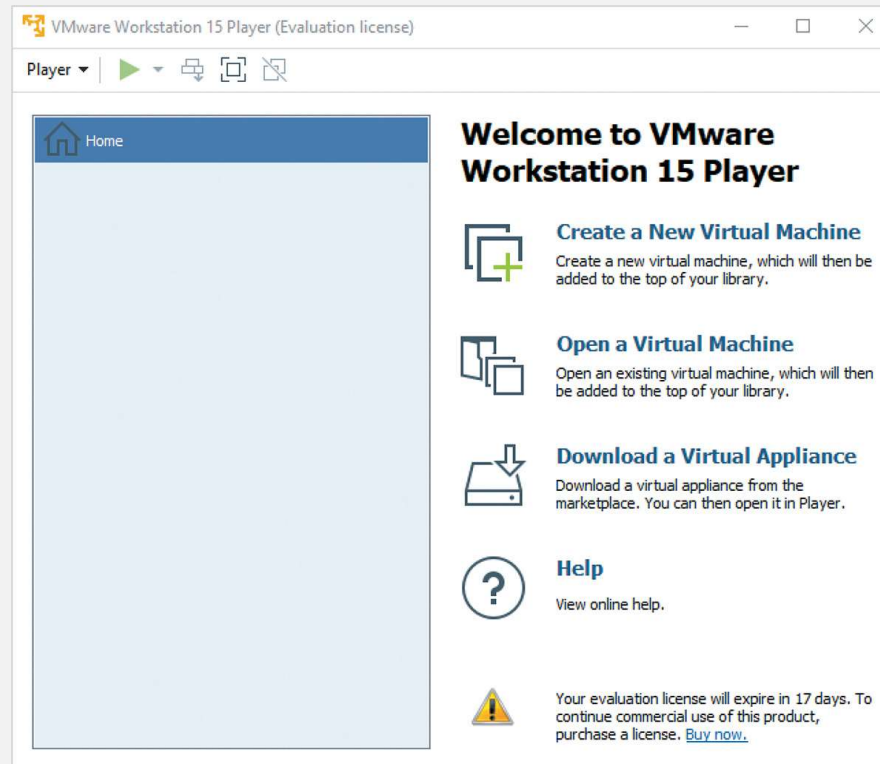
Using VMware Workstation Player (2 of 2)

Figure 8-4   The VMware Workstation Player Welcome window

Source: VMware, Inc.

Using VirtualBox (1 of 2)

- VirtualBox can be installed on Windows, macOS, Linux, and Solaris hosts and supports a wide range of Windows, Linux, and other guest OSs

- VMs are created using a wizard that walks you through the process of selecting the guest OS and the VM's hard disk and RAM configuration

  − The VirtualBox user interface consists of a console where you can create VMs and view the status of all VMs

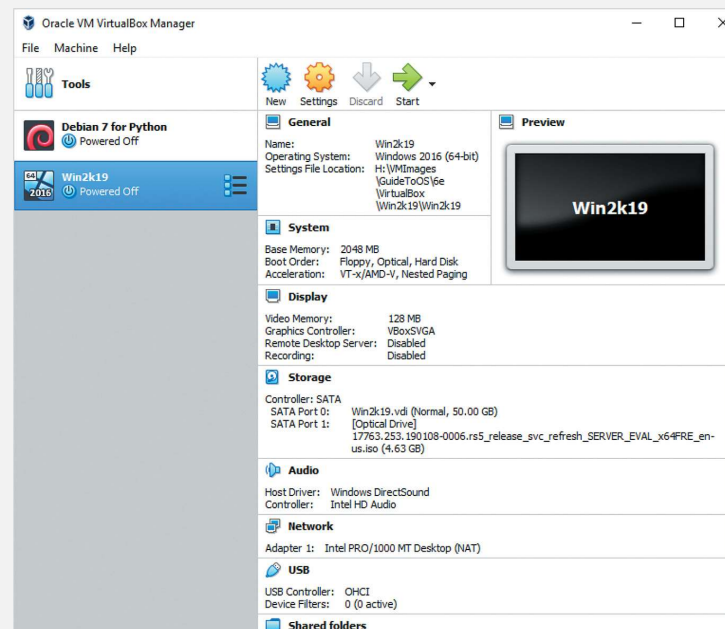CENGAGE

Using VirtualBox (2 of 2)

Figure 8-5 Oracle VM VirtualBox Manager

Source: Oracle Corporation

Knowledge Check 1

- Which of the following implements OS virtualization by being installed in a general-purpose host OS and the host OS accesses host hardware on behalf of the guest OS?

  - A) hosted virtualization

  - B) virtual disk

  - C) type 1 hypervisor

  - D) bare-metal hypervisor

QUESTION

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Knowledge Check 1: Answer

- Which of the following implements OS virtualization by being installed in a general-purpose host OS and the host OS accesses host hardware on behalf of the guest OS?

- A) hosted virtualization

ANSWER

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Bare-Metal Virtualization

more efficient because not dealing with underlying OS that does other things (hypervisor only does virtualization)

- Bare-metal virtualization products use a type 1 hypervisor and are targeted mainly for production virtualization in datacenters

- They are installed directly on hardware and have more stringent host machine requirements   only installed on certain pieces of hardware

- They offer more features for managing VMs than hosted virtualization

  − These products are a little more complicated to install and use as well

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Bare-Metal Virtualization Applications (1 of 2)

- *Consolidate servers*

  - Retire old or unreliable hardware

  - Make optimal use of multicore, high-performance servers

  - Maintain application separation

  - Reclaim rack or floor space

  - Reduce cooling and power requirements

- *Test installations and upgrades*

- *Test a preconfigured application*

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Bare-Metal Virtualization Applications (2 of 2)

- *Test what-if scenarios*

- *Live migration*
  - − VMs can be migrated to new hardware while they're running for performance and reliability improvements with practically no downtime

- *Dynamic provisioning*

  you can add things to it
  - − Advanced VM management systems can deploy VMs and storage dynamically to meet application requirements

Bare-Metal Virtualization Products (1 of 2)

- *Microsoft Hyper-V* was introduced with Windows Server 2008 and can be installed as a server role

  not as costly

  − Acts as a management OS for VMs installed with Hyper-V

  − Supports advanced features, such as host server <mark>clustering</mark> and live migration

  − Requires a 64-bit CPU with virtualization extensions enabled on the host system

  − Microsoft provides virtual instances of the OS with no additional licensing fees

  more compatible than esx

  − Hyper-V can be enabled in Windows 8 and later versions

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Bare-Metal Virtualization Products (2 of 2)

based on redhat + KBM also (Linux based)

- *Citrix XenServer* uses Linux as a management OS on the host

  - A XenServer host computer requires a 64-bit CPU with virtualization extensions to run Windows guest OSs

- *VMware vSphere* – includes VMware ESX Server, which is installed directly on the physical server without a management OS

  - Most configuration tasks are performed from a remote client OS using vSphere Client

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Using Hyper-V (1 of 6)

- Hyper-V is Microsoft's type 1 hypervisor that runs on both Windows Server and Windows 10

- On Windows Server, you install Hyper-V from Server Manager using the "Turn Windows features on or off" tool

- If you use Hyper-V Server, you must install the Hyper-V Manager console on another computer to create and manage VMs on the server

- You need to create one or more virtual switches to begin creating and managing VMs

Using Hyper-V (2 of 6)

- A Hyper-V virtual switch can be one of three types:

  - External

  - Internal

  - Private

- VMs that provide a service to users on the physical network are typically configured to use an external virtual switch
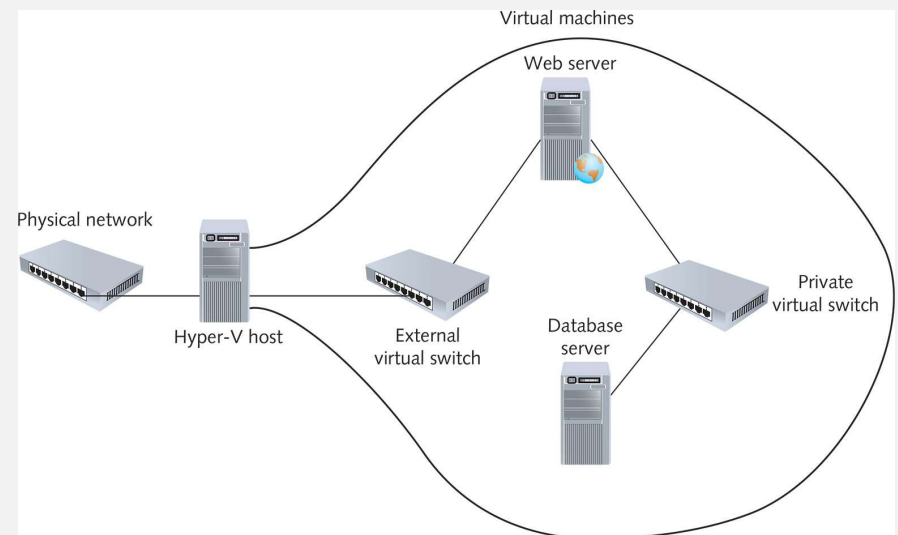

Figure 8-7 An example virtual machine scenario using an external and private network

Using Hyper-V (3 of 6)

- Creating Virtual Switches in Hyper-V

    - In Hyper-V Manager, you create a virtual switch by clicking Virtual Switch Manager, selecting the type of switch you want to create, and clicking Create Virtual Switch

    - After a virtual switch is created, you can connect new and existing VMs to it
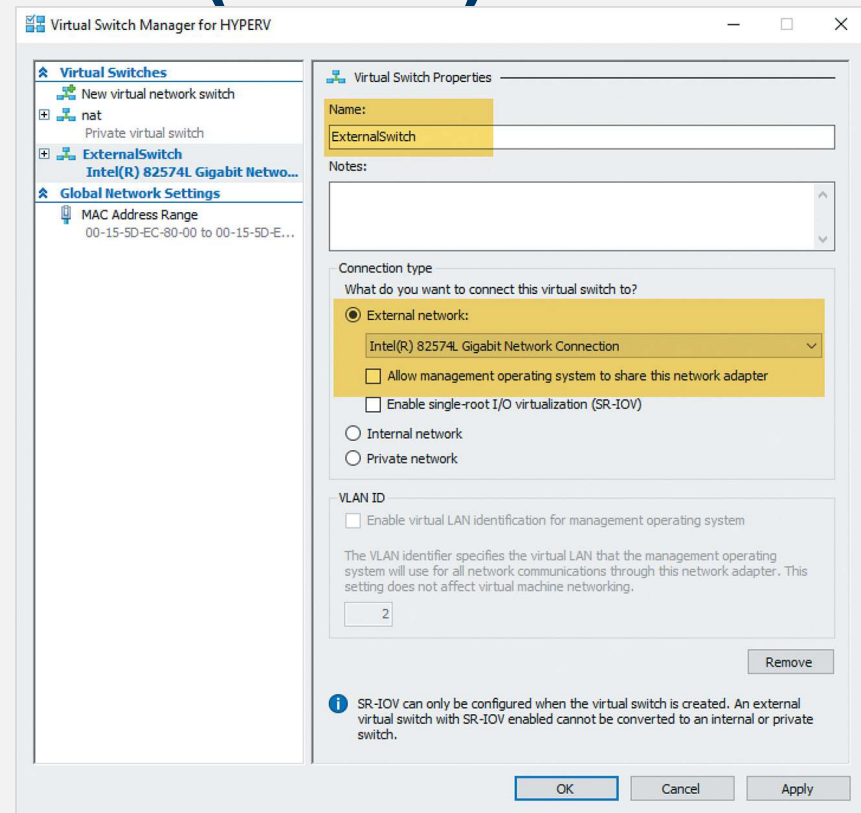
Figure 8-8   Creating a virtual switch in Hyper-V

Using Hyper-V (4 of 6)

similar to virtualbox

- The process of creating a VM:

  - 1. Start the New Virtual Machine Wizard in Hyper-V Manager

  - 2. Give the new VM a descriptive name

  - 3. Choose a location for the VM

  - 4. Choose a generation 1 or generation 2 VM

  - 5. Assign the amount of memory the VM requires

  - 6. Configure networking

  - 7. Create a virtual hard disk

  - 8. Install an OS

- You can perform the following management actions:

  - Connect

  - Settings

  - Start

  - Checkpoint

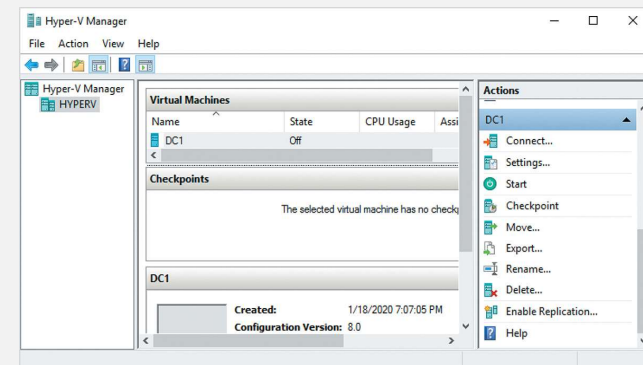 - Move

  - Export

Figure 8-9   VM management tasks in Hyper-V Manager

Using Hyper-V (6 of 6)

- You can perform the following management actions (continued):

  – Rename

  – Delete

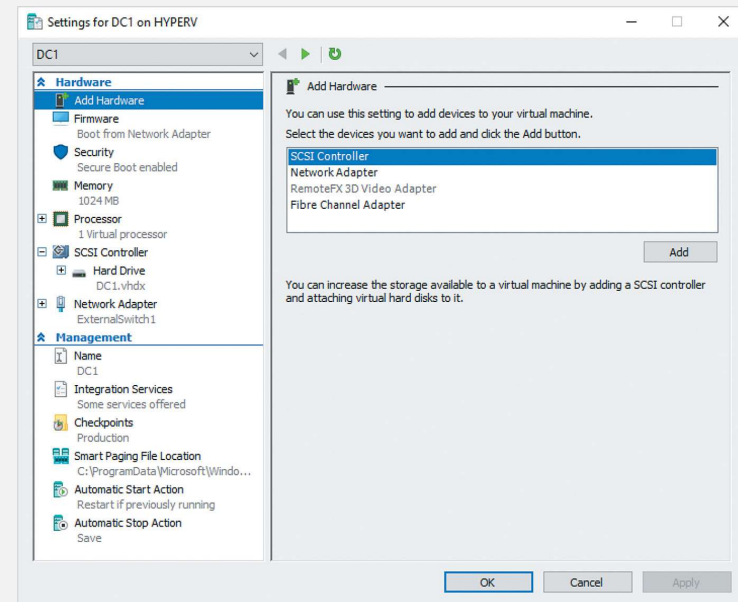 – Enable Replication

Figure 8-10   VM settings in Hyper-V Manager

Using VMware vSphere (1 of 5)

- VMware vSphere is a type 1 hypervisor that is similar to Hyper-V

    - It is based on the VMware ESXi hypervisor

- ESXi has a simple text-based menu interface that you use to configure basic settings such as IP address and host name

Figure 8-11   The VMware ESXi hypervisor console
Source: VMware, Inc.

Using VMware vSphere (2 of 5)

- You can access the management interface from a Web browser on another computer

  - VMware calls this interface the vSphere Web Client

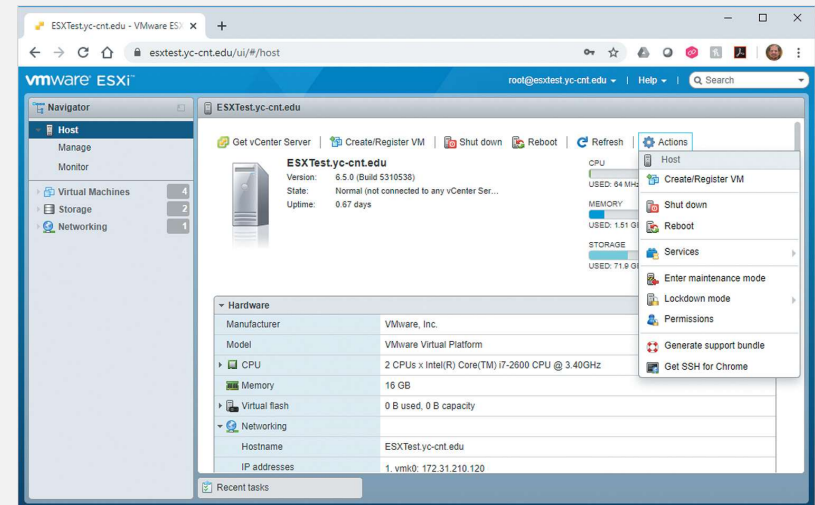 - Lets you manage aspects of the physical computer

Figure 8-12 The vSphere Web Client
Source: VMware, Inc.

Using VMware vSphere (3 of 5)

- Networking with vSphere

    when a server is created

    - By default, a virtual switch called vSwitch0 is created upon initial installation of ESXi and associated with a physical NIC

    - You need a minimum of two port groups: one for the management network and one for the VM traffic   sending traffic thru

    - The ESXi installation process creates two default port groups named Management Network and VM Network

        communicating

select a creation type, select a name and folder, select a computer resource, select storage, compatibility, guest OS, customize hardware, ready

- Creating VMs in vSphere

  - From the vSphere Web Client, click Create/Register VM and use the wizard to guide you through the steps

    - 1. Assign a name and choose the guest OS

    - 2. Choose the datastore to store the VM configuration and virtual disks

    - 3. Choose hardware options

  - Once the VM is created, you can select it in the vSphere Web Client and power it on
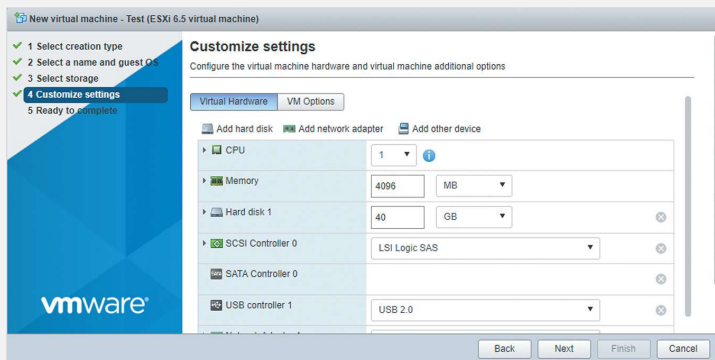
Using VMware vSphere (5 of 5)

Figure 8-14   Configuring hardware options for a new vSphere VM
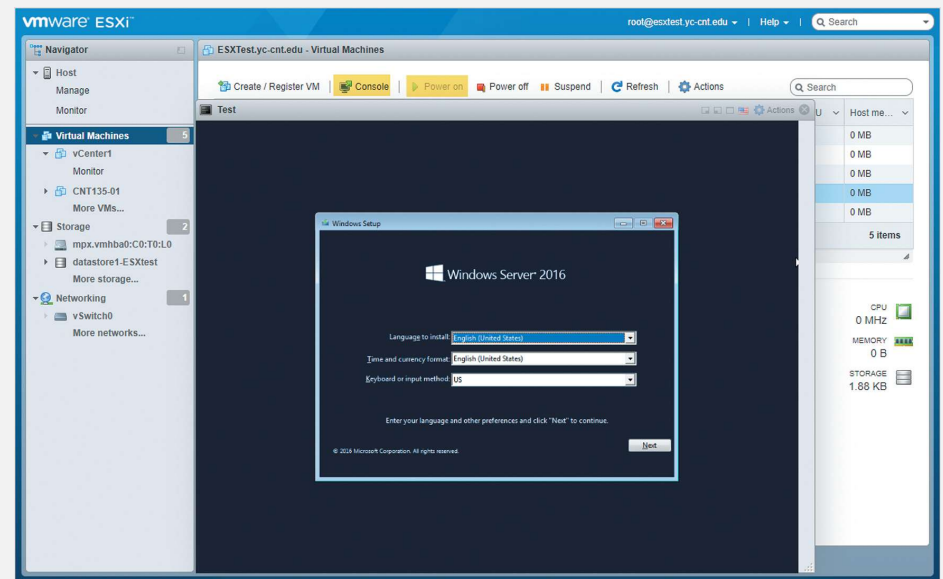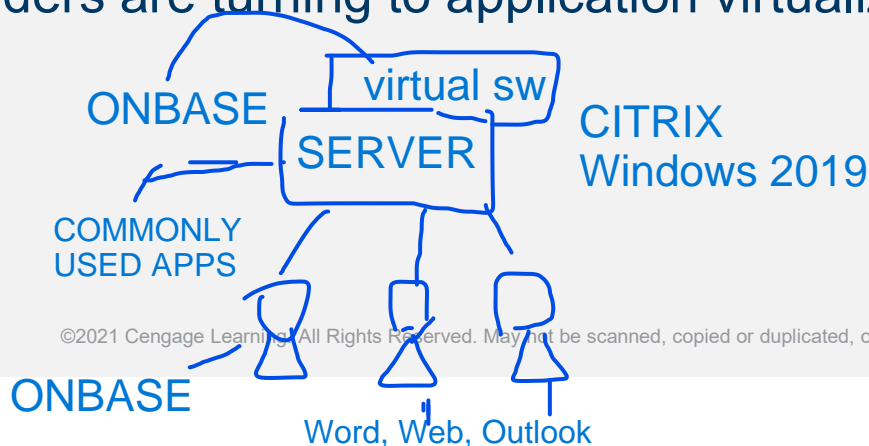Source: VMware, Inc.

Figure 8-15   Installing a guest OS in a vSphere VM
Source: VMware, Inc.

Application Virtualization

- Whole-system virtualization allows you to run an OS in a VM that is totally different from the OS running on the host

  - This type of virtualization is often used to isolate a single application from the host for testing purposes or when <mark>multiple instances of the same application must run on one host</mark> academic virtual desktop

- To mitigate resource overhead required for whole-system virtualization, many cloud providers are turning to application virtualization in the form of containers

ONBASE

virtual sw

SERVER

CITRIX
Windows 2019

COMMONLY
USED APPS

ONBASE

Word, Web, Outlook

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resource allocation is expensive

virtualization has a hypervisor (what's going to understand how to read that file, common = vm-ware, virtual box), and on top of that is the guest OS (has their own kernel, expensive resource allocation), then has bin/lib + app on top

both have infrastructure and OS

type 1: hypervisor built with OS, type 2: built on top of OS

Containers

has docker daemon, the bin/lib/app stuff on top, each container has one process (our application) = using name spaces to say segments of the system (how much RAM, network bandwidth you can have) = on same host, tightly couple self to resources, a lot faster + portable, works on an image?

- A **container** is a virtualized software environment in which an application can run but is isolated from the rest of the OS and other applications

- "Containerized" applications have their own copy of critical OS structures like the registry, file system, and network configuration

- Container virtualization is available in most Linux distributions and starting with Windows Server 2016

  - Both use a container management platform called **Docker**

    lightweight, portable, fast, no hypervisor (not a separate kernel, same resources as host OS), better dependency management, no "it works on my computer but not theirs" (package stuff together)

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this layer isn't impactful, what's great as a dev is you create all the modules, space, etc. (isolated), so reproduceable

code
iis, ie, apk
windows
server

code
docker
windows
server

virtual

Windows Sandbox (1 of 2)

as soon as it exits?, it reboots everything because data doesn't persist here, so good for testing if reboot is not required

- Windows Sandbox is a feature available with Windows Pro and Enterprise that provides a temporary isolated environment in which to run an application

    − It is built on containers technology

    − It is a desktop OS feature primarily designed to allow you to test an application to make sure it will not interfere with any existing applications

- Sandbox can be installed on a physical machine or a VM

- You install it from the Windows Features control panel applet   ez

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Windows Sandbox (2 of 2)

- Sandbox is essentially a lightweight VM based on the Windows 10 OS it is running on

- It looks like a full VM, but it is actually sharing much of the host OS that is loaded into RAM

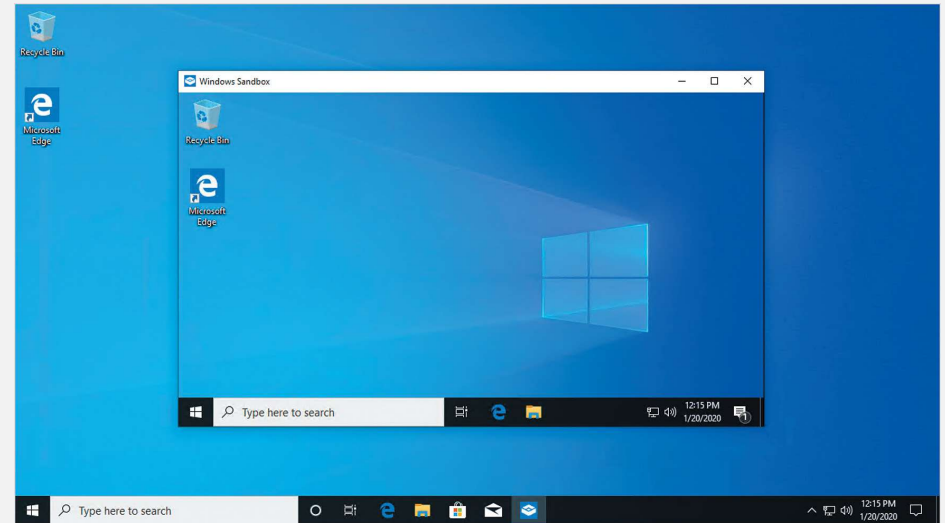- Once running, you can copy and paste an application into the Sandbox window and install it

Figure 8-17 A running Windows Sandbox

can't come out of the sandbox (complicates things)

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Cloud Computing (1 of 2)

- **Cloud computing** is a networking model in which data, applications, and processing power are managed by servers on the Internet

  - Users of resources pay for what they use rather than for the equipment and software needed to provide the resources

- Benefits:

  - Reduced physical plant costs

  - Reduced upfront costs

  - Reduced personnel costs

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Cloud Computing (2 of 2)

- There are three main categories of cloud computing:

  - Software as a service

  - Platform as a service

  - Infrastructure as a service

- The phrase *as a service* means the resource resides on another server or network from the one using the resource

  outside of what you're doing

highest level

Software as a Service

Canvas is also an example

abbreviated whether it's infrastructure

- **SaaS** is also called *hosted applications* or *on-demand applications*

  − The best-known examples are Google Apps and Microsoft Office 365

- It is usually offered as a subscription based on the number of users

don't have to rely on IT staff to make changes

- Customers can take advantage of new software editions much faster

- SaaS is available anywhere the customer has a connection to the Internet

what are they?
what do they do?
what are their advantages/disadvantages?

advantage: you don't have to maintain
disadvantage: fixing it is out of your control, and there's a cost balance (ex. photoshop is a paid subscription)

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docker/virtualization level
Platform as a Service

infrastructure is in place for you (docker instance can now push your code up to it, everything's provided up to code push)

- **PaaS** is also called *hosted platform* and is similar to SaaS, but the customer develops applications with the service provider's tools and infrastructure

  - The customer develops and owns the application and then delivers it to a third party

- The most common PaaS products are:
  don't have to remember this example

  - Salesforce.com's Apex, Azure for Windows, Google's AppEngine for Python and Java, WaveMaker for Ajax, and Engine Yard for Ruby on Rails

similar advantages/disadvantages

velocity is quicker, can code push, maintenance
downside: not on your site (mercy of the third party if they're having problems)

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Infrastructure as a Service

lower level (wanna be able to manage everything above infrastructure)

don't wanna maintain things but want other things to host

- **IaaS** is also called *hosted infrastructure*; it allows a company to use storage or entire virtual servers

pay for what you use, but bad if you don't manage your costs and stuff (only use what you need ig, can ramp up fast)

- If a customer needs another 100 GB of storage space, they can pay for the space without worrying about how that space is actually provided

- If a customer needs another server, they pay for the amount of processing and storage the additional server actually requires

  − Customers rent the resources they are using but are responsible for application installations and upgrades

challenge: working/testing on something can be costly too and things might not even work

Private Cloud versus Public Cloud

- **Public cloud services**

  - Cloud services are delivered by a third-party provider

- **Private cloud services**

  - When a company delivers cloud services to its own employees through the use of virtualization technologies

  - Deployed from the company's own datacenter

  - Examples of virtualization technologies:

    - VMware and Microsoft Hyper-V

Knowledge Check 2

- Which of the following is a virtualized software environment in which an application can run but is isolated from the rest of the OS and other applications?

    - A) software as a service (SaaS)

    - B) cloud computing

    - C) container

    - D) Hyper-V

QUESTION

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Knowledge Check 2: Answer

- Which of the following is a virtualized software environment in which an application can run but is isolated from the rest of the OS and other applications?

- C) container

ANSWER

Summary (1 of 2)

type 1 is high level stuff

- Virtualization is a process that creates a software environment to emulate a computer's hardware and BIOS, allowing multiple OSs to run on the same physical computer at the same time

- Virtualization can be divided into two categories: hosted and bare-metal virtualization

- Hosted virtualization products are installed on a desktop OS and include VMware Workstation and VirtualBox

- Bare-metal virtualization products are targeted mainly for production virtualization in datacenters

Summary (2 of 2)

- To mitigate the resource overhead required for whole-system virtualization, many cloud providers and datacenters are turning to application virtualization in the form of containers

- Windows Sandbox is a feature available with Windows 10 Pro and Enterprise that is built on containers technology

- Cloud computing is a networking model in which data, applications, and processing power are managed by servers on the Internet

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