What is virtualization?

Virtualization is a process that allows for more efficient use of physical computer hardware and is the foundation of cloud computing.

Virtualization uses software to create an abstraction layer over computer hardware, enabling the division of a single computer's hardware components—such as processors, memory and storage—into multiple virtual machines (VMs). Each VM runs its own operating system (OS) and behaves like an independent computer, even though it is running on just a portion of the actual underlying computer hardware.

It follows that virtualization enables more efficient use of physical computer hardware and allows a greater return on an organization's hardware investment.

Today, virtualization is a standard practice in enterprise IT architecture. It is also the technology that drives cloud computing economics. Virtualization enables cloud providers to serve users with their existing physical computer hardware. It enables cloud users to purchase only the computing resources they need when they need it, and to scale those resources cost-effectively as their workloads grow.

Benefits of virtualization

Virtualization brings several benefits to data center operators and service providers:

Resource efficiency

Before virtualization, IT staff would allocate a dedicated physical CPU to each application server, buying and setting up a separate server for every application. This approach, favoring one application and one operating system per computer, was adopted for its reliability. Invariably, each physical server would be underused. In contrast, server virtualization enables you to run several applications—each on its own VM with its own OS—on a single physical computer (typically an x86 server) without sacrificing reliability. This enables maximum use of the physical hardware's computing capacity.

Easier management

Replacing physical computers with software-defined VMs makes it easier to use and manage policies written in software. This allows you to create automated IT service management workflows. For example, automated deployment and configuration tools enable administrators to define collections of virtual machines and applications as services, in software templates. This means that they can install those services repeatedly and consistently without cumbersome, time-consuming and error-prone manual setup. Admins can use virtualization security policies to mandate certain security configurations based on the role of the virtual machine. Policies can even increase resource efficiency by retiring unused virtual machines to save on space and computing power.

Minimal downtime

OS and application crashes can cause downtime and disrupt user productivity. Admins can run multiple redundant virtual machines alongside each other and failover between them when problems arise. Running multiple redundant physical servers is more expensive.

Faster provisioning

Buying, installing and configuring hardware for each application is time-consuming. If the hardware is already in place, provisioning virtual machines to run all your applications is significantly faster. You can even automate it using management software and build it into existing workflows.

Virtual machines

Virtual machines are virtual environments that simulate a physical computer in software form. They normally comprise several files containing the VM's configuration, the storage for the virtual hard drive, and some snapshots of the VM that preserve its state at a particular point in time.

Hypervisors

A hypervisor is the software layer that coordinates VMs. It serves as an interface between the VM and the underlying physical hardware, ensuring that each has access to the physical resources it needs to execute. It also ensures that the VMs don't interfere with each other by impinging on each other's memory space or compute cycles.

There are two types of hypervisors:

Type 1 hypervisors

Type 1 or "bare-metal" hypervisors interact with the underlying physical resources, replacing the traditional operating system altogether. They most commonly appear in virtual server scenarios.

Type 2 hypervisors

Type 2 hypervisors run as an application on an existing OS. Most commonly used on endpoint devices to run alternative operating systems, they carry a performance overhead because they must use the host OS to access and coordinate the underlying hardware resources.

Types of virtualization

To this point we've discussed server virtualization, but many other IT infrastructure elements can be virtualized to deliver significant advantages to IT managers in particular and the enterprise as a whole. In this section, we cover the following types of virtualization:

- Desktop virtualization
- Network virtualization
- Storage virtualization
- Data virtualization
- Application virtualization
- Data center virtualization
- CPU virtualization
- GPU virtualization
- Linux virtualization
- Cloud virtualization

Desktop virtualization

Desktop virtualization lets you run multiple desktop operating systems, each in its own VM on the same computer.

There are two types of desktop virtualization:

Virtual desktop infrastructure

Virtual desktop infrastructure (VDI) runs multiple desktops in VMs on a central server and streams them to users who log in on thin client devices. In this way, VDI lets an organization provide its users access to a variety of OSs from any device, without installing them on any device.

Local desktop virtualization

Local desktop virtualization runs a hypervisor on a local computer, enabling the user to run one or more additional OSs on that computer and switch from one OS to another as needed without changing anything about the primary OS.

For more information on virtual desktops, see "Desktop-as-a-Service (DaaS)."

Network virtualization

Network virtualization uses software to create a "view" of the network that an administrator can use to manage the network from a single console. It abstracts hardware elements and functions (for example connections, switches and routers) and abstracts them into software running on a hypervisor. The network administrator can modify and control these elements without touching the underlying physical components, which dramatically simplifies network management.

Types of network virtualization include software-defined networking, which virtualizes hardware that controls network traffic routing, called the control plane. Another type is network function virtualization, which virtualizes one or more hardware appliances that provide a specific network function (for example a firewall, load balancer or traffic analyzer), making those appliances easier to configure, provision and manage.

Storage virtualization

Storage virtualization enables all the storage devices on the network—whether they're installed on individual servers or stand-alone storage units—to be accessed and managed as a single storage device. Specifically, storage virtualization masses all blocks of storage into a single shared pool from which they can be assigned to any VM on the network as needed. Storage virtualization makes it easier to provision storage for VMs and makes maximum use of all available storage on the network.

For a closer look at storage virtualization, check out "What is Cloud Storage?"

Data virtualization

Modern enterprises store data from multiple applications, by using multiple file formats, in multiple locations, ranging from the cloud to on-premise hardware and software systems. Data virtualization lets any application access all of that data—irrespective of source, format or location.

Data virtualization tools create a software layer between the applications accessing the data and the systems storing it. The layer translates an application's data request or query as needed and returns results that can span multiple systems. Data virtualization can help break down data silos when other types of integration aren't feasible, desirable or affordable.

Application virtualization

Application virtualization runs application software without installing it directly on the user's OS. This differs from complete desktop virtualization because only the application runs in a virtual environment—the OS on the end user's device runs as usual. There are three types of application virtualization:

- **Local application virtualization:** The entire application runs on the endpoint device but runs in a runtime environment instead of on the native hardware.
- **Application streaming:** The application lives on a server which sends small components of the software to run on the end user's device when needed.
- **Server-based application virtualization** The application runs entirely on a server that sends only its user interface to the client device.

Data center virtualization

Data center virtualization abstracts most of a data center's hardware into software, effectively enabling an administrator to divide a single physical data center into multiple virtual data centers for different clients.

Each client can access its own infrastructure as a service (IaaS), which would run on the same underlying physical hardware. Virtual data centers offer an easy on-ramp into cloud-based computing, letting a company quickly set up a complete data center environment without purchasing infrastructure hardware.

CPU virtualization

Central processing unit (CPU) virtualization is the fundamental technology that makes hypervisors, virtual machines, and operating systems possible. It allows a single CPU to be divided into multiple virtual CPUs for use by multiple VMs.

At first, CPU virtualization was entirely software-defined, but many of today's processors include extended instruction sets that support CPU virtualization, which improves VM performance.

GPU virtualization

A graphical processing unit (GPU) is a special multi-core processor that improves overall computing performance by taking over heavy-duty graphic or mathematical processing. GPU virtualization lets multiple VMs use all or some of a single GPU's processing power for faster video, AI and other graphic- or math-intensive applications.