Virtualization

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Characteristics of Virtualized Environments

- Virtualization technology is one of the fundamental components of cloud computing, especially in regard to infrastructure-based services
- Virtualization allows the creation of a secure, customizable, and isolated execution environment for running applications, even if they are untrusted, without affecting other users' applications
- For example, we can run Windows OS on top of a virtual machine, which itself is running on Linux OS
- Virtualization provides a great opportunity to build elastically scalable systems that can provision additional capability with minimum costs
- Therefore, virtualization is widely used to deliver customizable computing environments on demand

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- Virtualization is a large umbrella of technologies and concepts that are meant to provide an abstract environment—whether virtual hardware or an operating system—to run applications
- virtualization is often synonymous with hardware virtualization, which plays a fundamental role in efficiently delivering Infrastructure-as-a-Service (IaaS) solutions for cloud computing
- Moreover, virtualization technologies provide a virtual environment for not only executing applications but also for storage, memory, and networking
- Virtualization technologies have gained renewed interested recently due to the confluence of several phenomena:
    - Increased performance and computing capacity
    - Underutilized hardware and software resources
    - Lack of space
    - Rise of administrative costs

Contd.

- Virtualization is a broad concept that refers to the creation of a virtual version of something, whether hardware, a software environment, storage, or a network
- In a virtualized environment there are three major components: guest, host, and virtualization layer

The Virtualization Reference Mode

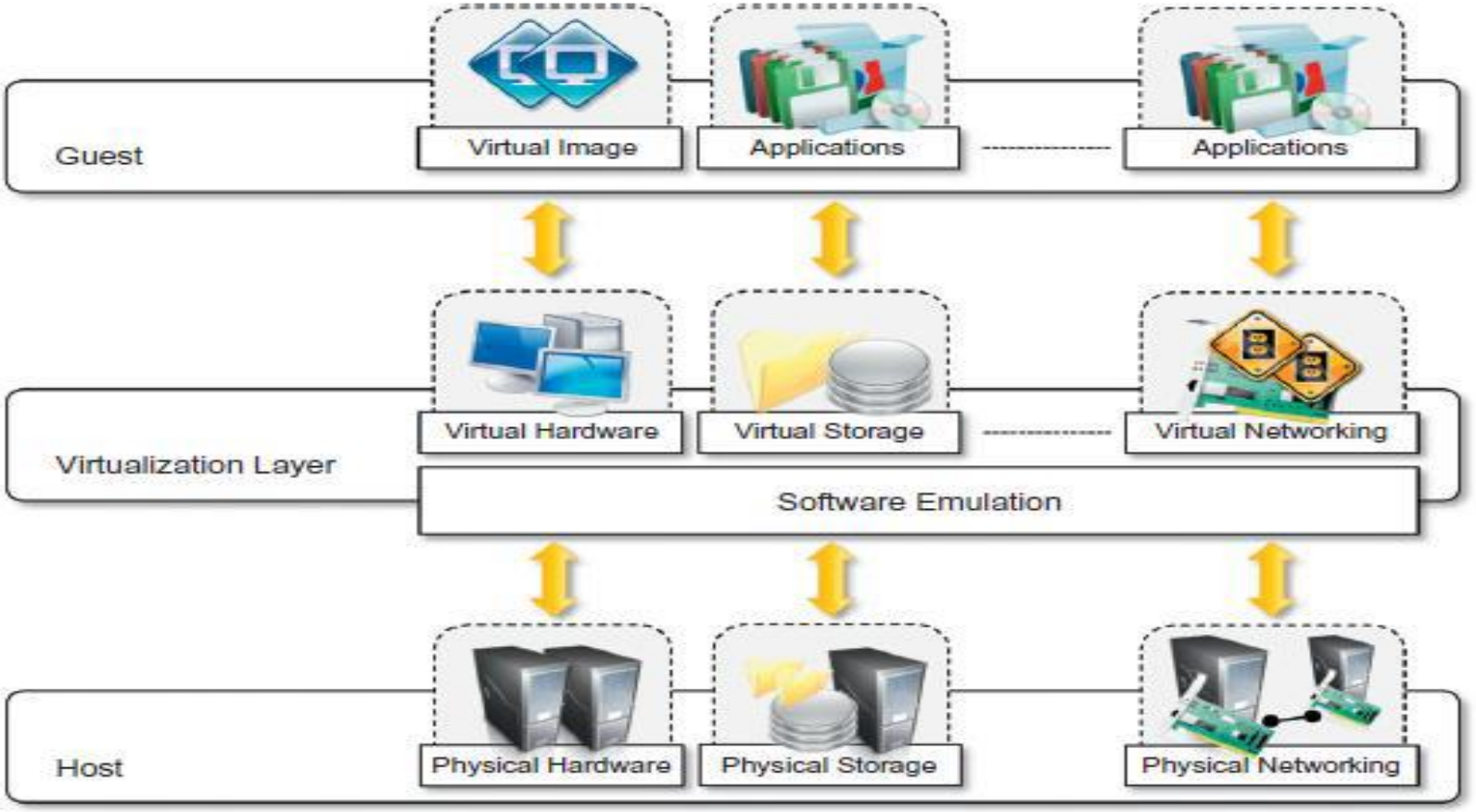

FIGURE 3.1

The virtualization reference model.

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- The guest represents the system component that interacts with the virtualization layer rather than with the host, as would normally happen
- The host represents the original environment where the guest is supposed to be managed
- The virtualization layer is responsible for recreating the same or a different environment where the guest will operate
- Such a general abstraction finds different applications and then implementations of the virtualization technology
- The most intuitive and popular is represented by hardware virtualization, which also constitutes the original realization of the virtualization concept
- In the case of hardware virtualization, the guest is represented by a system image comprising an operating system and installed applications

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- These are installed on top of virtual hardware that is controlled and managed by the virtualization layer, also called the virtual machine manager
- The host is instead represented by the physical hardware, and in some cases the operating system, that defines the environment where the virtual machine manager is running
- The guest applications and users interacts with a virtual network, such as a virtual private network(VPN)
- The technologies of today allow profitable use of virtualization and make it possible to fully exploit the advantages that come with it
- Such advantages have always been characteristics of virtualized solutions
    - Increased security
    - Managed execution
    - Portability

Increased security

- The ability to control the execution of a guest in a completely transparent manner opens new possibilities for delivering a secure, controlled execution environment
- The virtual machine represents an emulated environment in which the guest is executed
- All the operations of the guest are generally performed against the virtual machine, which then translates and applies them to the host
- This level of indirection allows the virtual machine manager to control and filter the activity of the guest, thus preventing some harmful operations from being performed

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- Resources exposed by the host can then be hidden or simply protected from the guest
- Increased security is a requirement when dealing with untrusted code
- For example, applets downloaded from the Internet run in a sand boxed 3 version of the Java Virtual Machine(JVM), which provides them with limited access to the hosting operating system resources
- Both the JVM and the .NET runtime provide extensive security policies for customizing the execution environment of applications

Managed Execution

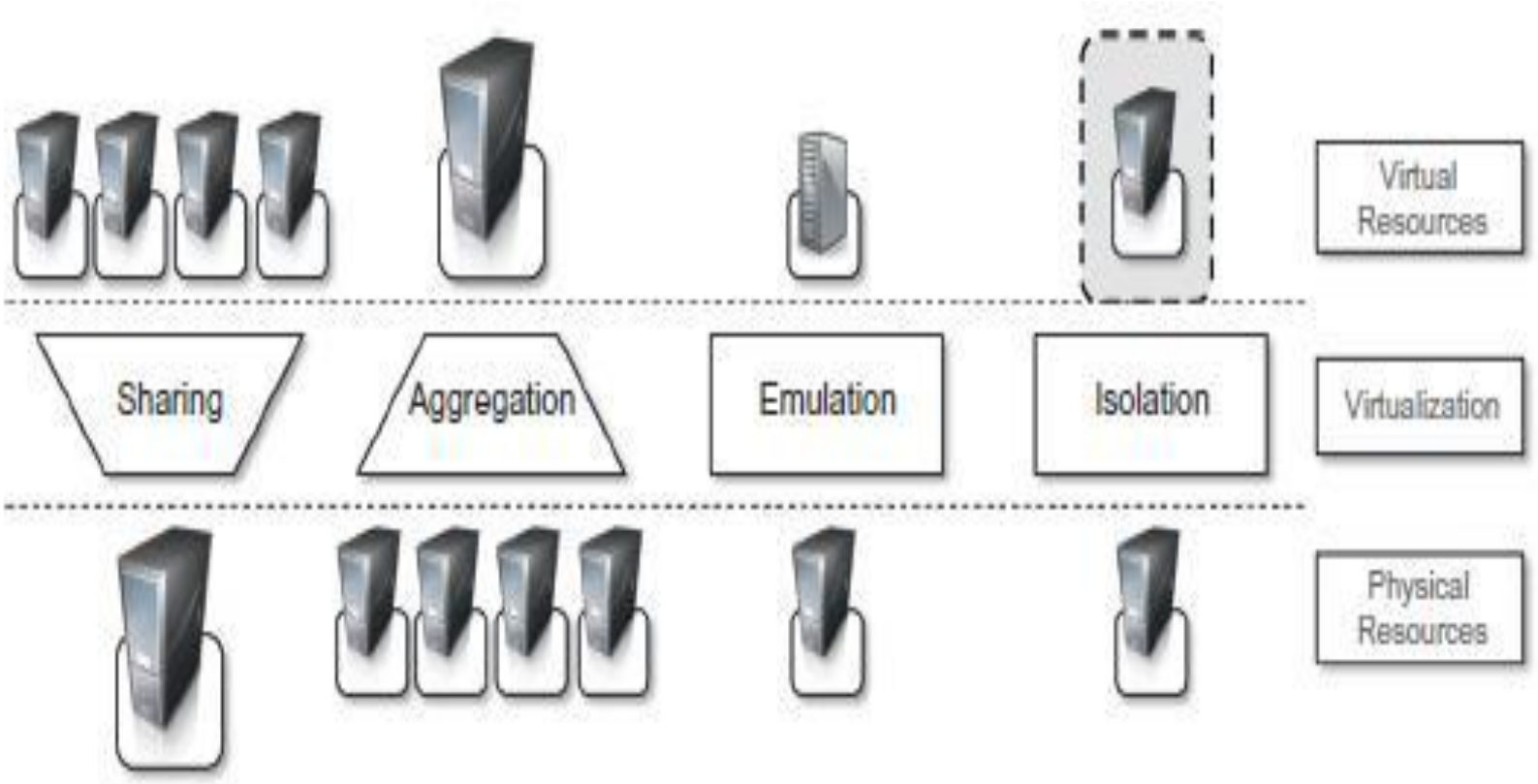

FIGURE 3.2

Functions enabled by managed execution.

Sharing

- Virtualization of the execution environment not only allows increased security, but a wider range of features also can be implemented
- In particular, sharing, aggregation, emulation, and isolation are the most relevant features
- Sharing:
  - Virtualization allows the creation of a separate computing environments within the same host
  - In this way it is possible to fully exploit the capabilities of a powerful guest, which would otherwise be underutilized
  - Sharing is a particularly important feature in virtualized data centers, where this basic feature is used to reduce the number of active servers and limit power consumption

Aggregation

- Not only is it possible to share physical resource among several guests, but virtualization also allows aggregation, which is the opposite process
- A group of separate hosts can be tied together and represented to guests as a single virtual host
- This function is naturally implemented in middleware for distributed computing, with a classical example represented by cluster management software

Emulation

- Guest programs are executed within an environment that is controlled by the virtualization layer, which ultimately is a program
- Allowing the execution of guest programs requiring specific characteristics that are not present in the physical host
- This feature becomes very useful for testing purposes
- Hardware virtualization solutions are able to provide virtual hardware and emulate a particular kind of device such as Small Computer System Interface (SCSI) devices for file I/O, without the hosting machine having such hardware installed

Isolation

- Virtualization allows providing guests whether they are operating systems, applications, or other entities with a completely separate environment, in which they are executed
- Isolation brings several benefits; for example, it allows multiple guests to run on the same host without interfering with each other

Portability

- The concept of portability applies in different ways according to the specific type of virtualization considered
- In the case of a hardware virtualization solution, the guest is packaged into a virtual image that, in most cases, can be safely moved and executed on top of different virtual machines
- Virtual images are generally proprietary formats that require a specific virtual machine manager to be executed
- In the case of programming-level virtualization, as implemented by the JVM or the .NET runtime, the binary code representing application components (jars or assemblies) can be run without any recompilation on any implementation of the corresponding virtual machine