

## 2.2 Virtualization Types:

### 1. Hardware-level virtualization:

- Hardware-level virtualization is a virtualization technique that provides an abstract execution environment in terms of computer hardware on top of which a guest operating system can be run.
- In this model, the guest is represented by the operating system, the host by the physical computer hardware, the virtual machine by its emulation, and the virtual machine manager by the hypervisor.
- Hardware-level virtualization is also called system virtualization, since it provides ISA to virtual machines, which is the representation of the hardware interface of a system. This is to differentiate it from process virtual machines, which expose ABI to virtual machines.

### 2. Programming language-level virtualization:

- Programming language-level virtualization is mostly used to achieve ease of deployment of applications, managed execution, and portability across different platforms and operating systems.
- It consists of a virtual machine executing the byte code of a program, which is the result of the compilation process.
- Compilers implemented and used this technology to produce a binary format representing the machine code for an abstract architecture.
- The characteristics of this architecture vary from implementation to implementation. Generally these virtual machines constitute a simplification of the underlying hardware instruction set and provide some high-level instructions that map some of the features of the languages compiled for them. At runtime, the byte code can be either interpreted or compiled on the fly—or jitted<sup>5</sup>—against the underlying hardware instruction set.

### 3. Application-level virtualization:

- Application-level virtualization is a technique allowing applications to be run in runtime environments that do not natively support all the features required by such applications.
- In this scenario, applications are not installed in the expected runtime environment but are run as though they were.
- In general, these techniques are mostly concerned with partial file systems, libraries, and operating system component emulation. Such emulation is performed by a thin layer—a program or an operating system component—that is in charge of executing the application.
- This Virtualization can also be used to execute program binaries compiled for different hardware architectures.

### 4. Storage virtualization:

- Storage virtualization is a system administration practice that allows decoupling the physical organization of the hardware from its logical representation.
- Using this technique, users do not have to be worried about the specific location of their data, which can be identified using a logical path.
- Storage virtualization allows us to harness a wide range of storage facilities and represent them under a single logical file system.
- There are different techniques for storage virtualization, one of the most popular being network-based virtualization by means of storage area networks (SANs). SANs use a network accessible device through a large bandwidth connection to provide storage facilities.

## 5. Network virtualization:

- Network virtualization combines hardware appliances and specific software for the creation and management of a virtual network.
- Network virtualization can aggregate different physical networks into a single logical network (external network virtualization) or provide network-like functionality to an operating system partition (internal network virtualization).
- The result of external network virtualization is generally a virtual LAN (VLAN). A VLAN is an aggregation of hosts that communicate with each other as though they were located under the same broadcasting domain.
- Internal network virtualization is generally applied together with hardware and operating system-level virtualization, in which the guests obtain a virtual network interface to communicate with.
- There are several options for implementing internal network virtualization: The guest can share the same network interface of the host and use Network Address Translation (NAT) to access the network; the virtual machine manager can emulate, and install on the host, an additional network device, together with the driver; or the guest can have a private network only with the guest.

## 6. Desktop virtualization:

- Desktop virtualization abstracts the desktop environment available on a personal computer in order to provide access to it using a client/server approach. Desktop virtualization provides the same outcome of hardware virtualization but serves a different purpose.
- Similarly to hardware virtualization, desktop virtualization makes accessible a different system as though it were natively installed on the host, but this system is remotely stored on a different host and accessed through a network connection.
- Moreover, desktop virtualization addresses the problem of making the same desktop environment accessible from everywhere. Although the term desktop virtualization strictly refers to the ability to remotely access a desktop environment, generally the desktop environment is stored in a remote server or a data center.
- The basic services for remotely accessing a desktop environment are implemented in software components such as Windows Remote Services, VNC, and X Server. Infrastructures for desktop virtualization based on cloud computing solutions include Sun Virtual Desktop Infrastructure (VDI), Parallels Virtual Desktop Infrastructure (VDI), Citrix XenDesktop, and others.

## 7. Application server virtualization:

- Application server virtualization abstracts a collection of application servers that provide the same services as a single virtual application server by using load-balancing strategies and providing a high-availability infrastructure for the services hosted in the application server.
- This is a particular form of virtualization and serves the same purpose of storage virtualization: providing a better quality of service rather than emulating a different environment.