

## Levels of Virtualizations Implementations

Virtualization is the capability to run multiple instances of computer systems on the same hardware. The way hardware is being used can vary based on the configuration of the virtual machine.

The best example of this is your own desktop PC or laptop. You might be running Windows on your system, but with virtualization, now you can also run Macintosh or Linux Ubuntu on it.

### The Five Levels of Implementing Virtualization

1. Instruction Set Architecture Level (ISA)
2. Hardware Abstraction Level (HAL)
3. Operating System Level
4. Library Level
5. Application Level

#### 1. Instruction Set Architecture Level (ISA)

- In ISA, virtualization works through an ISA emulation.
- This is helpful to run loads of inherited code which was originally written for different hardware configurations.
- These codes can be run on the virtual machine through an ISA.
- The basic emulation, through, requires an interpreter. This interpreter interprets the source code and converts it to a hardware readable format for processing.

#### 2. Hardware Abstraction Level (HAL)

- As the name suggests, this level helps perform virtualization at the hardware level. It uses a bare hypervisor for its functioning.
- This level helps form the virtual machine and manages the hardware through virtualization.

- It enables virtualization of each hardware component such as I/O devices, processors, memory, etc.
- This way multiple users can use the same hardware with numerous instances of virtualization at the same time.

### 3. Operating System Level

- At the operating system level, the virtualization model creates an abstract layer between the applications and the OS.
- It is like an isolated container on the physical server and operating system that utilizes hardware and software. Each of these containers' functions like servers.
- When the number of users is high, and no one is willing to share hardware, this level of virtualization comes in handy.

### 4. Library Level

- OS system calls are lengthy and bulky. Which is why applications opt for APIs from user-level libraries.
- Library interfacing virtualization is made possible by API hooks. These API hooks control the communication link from the system to the applications.

### 5. Application Level

- Application-level virtualization comes handy when you wish to virtualize only an application. It does not virtualize an entire platform or environment.
- On an operating system, applications work as one process. Hence it is also known as process-level virtualization. (Wizard)
- It is generally useful when running virtual machines with high-level languages. Here, the application sits on top of the virtualization layer, which is above the application program.

## Five Levels of Virtualization

### Application Level

JVM / .NET CLR

### Library Level

WINE / vCUDA

### Operating System Level

Virtual Environment / FVM

### Hardware Abstraction Level

VMWare / Virtual PC

### Instruction Set Architecture Level

BIRD / Dynamo