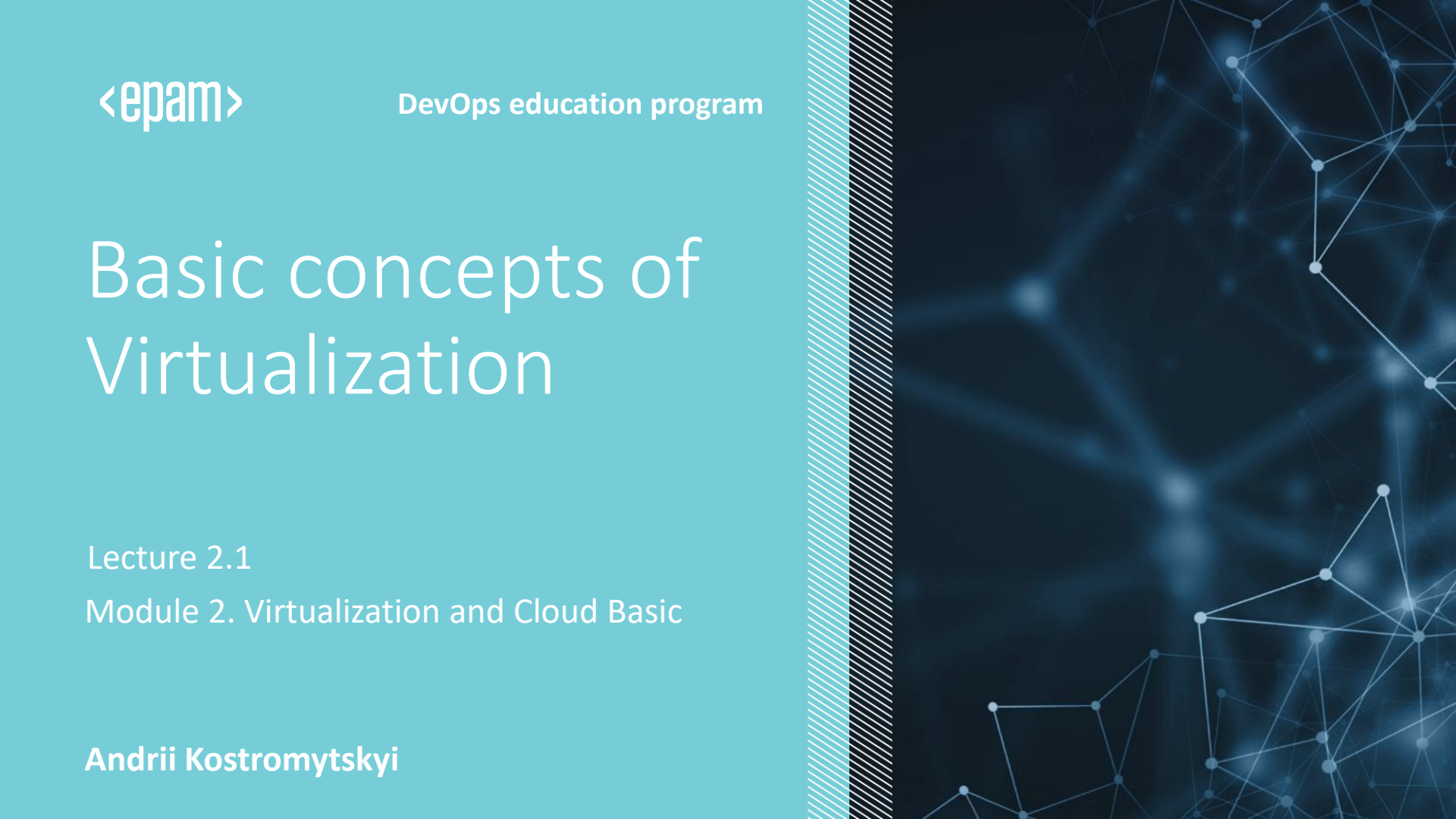

epam
DevOps education program
Basic concepts of Virtualization
Lecture 2.1
Module 2. Virtualization and Cloud Basic
Andrii Kostromytskyi

Agenda

- What is Virtualization?
- Virtualization types
- Hypervisors types
- Q&A.

WHAT IS VIRTUALIZATION?

Application Delivery

Many software products and solutions for delivering applications to the end user can be divided, depending on the approach to the solution, into:

- Terminal Access Based Solutions.
- Web solutions.
- Virtualization solutions.

Terminal access

Before computers became personal, the architecture of any application required a **mainframe** (high-performance computer) and the devices it controlled — terminals.

All computational tasks are performed on a powerful remote computer, while the user interacts with the server through the terminal (remote console).

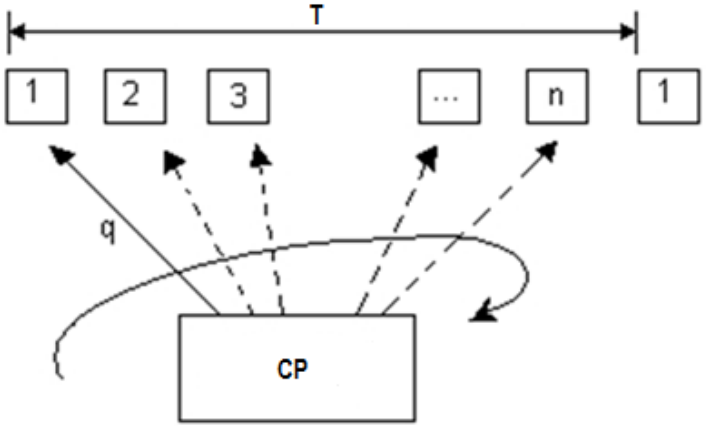
Advantages of terminal access:

- Reducing the cost of maintaining workstations in the network, servers, software
- Higher security
- Ease of scaling information solutions

Disadvantages of terminal access solutions:

- It is necessary to ensure uninterrupted operation of the terminal server
- High server hardware requirements
- Peak server loads will slow down all terminals without exception

Terminal access



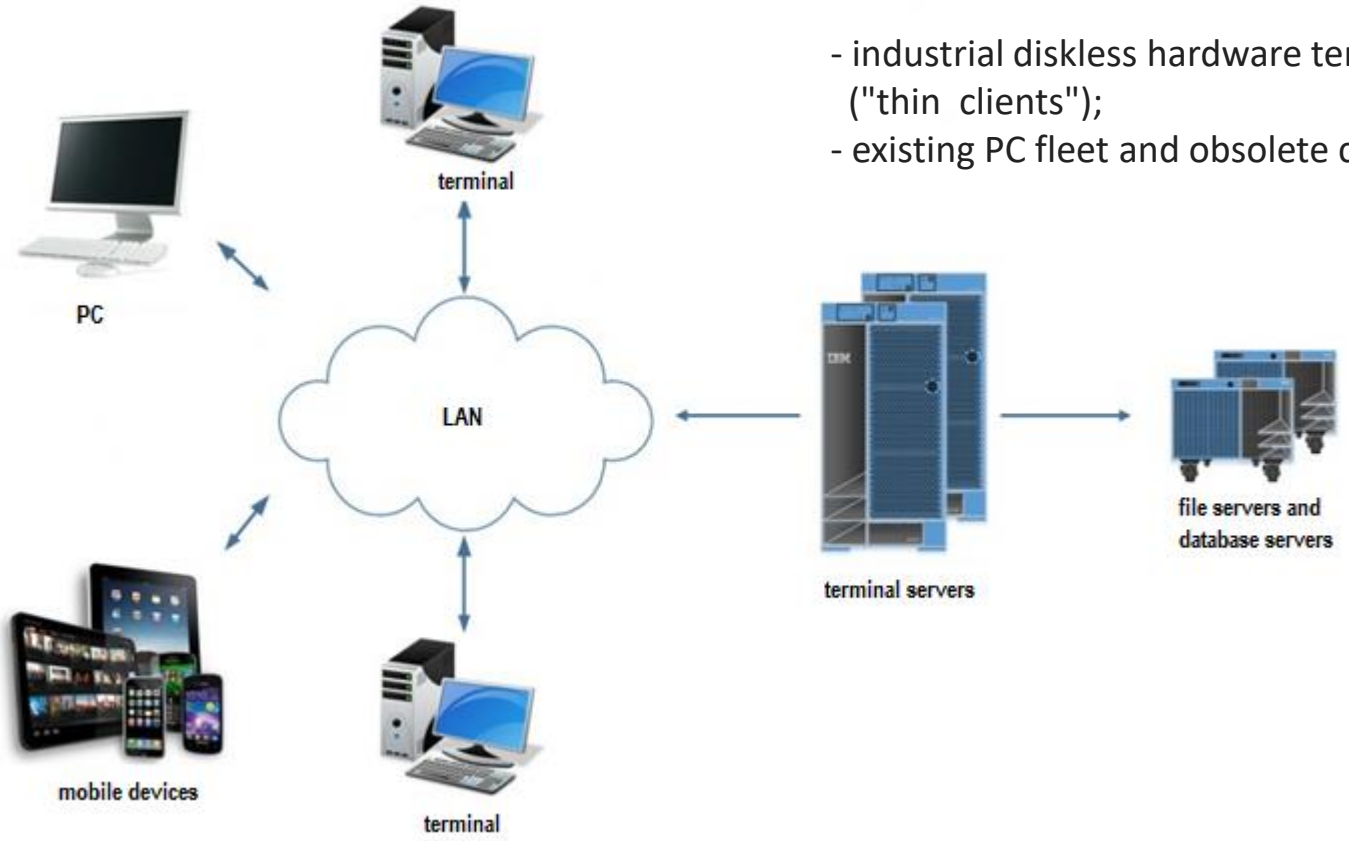
processor thread queue

WAX 11/780

PDP 11/34

CM 1420

Modern terminal access



- industrial diskless hardware terminals ("thin clients");
- existing PC fleet and obsolete computers

Web applications

There is a *client* and *server*. In this case, the application server is obviously a remote web server, and the client is a browser. The web application consists of client and server parts.

Web Application Benefits:

- The application does not depend on the client OS and its software.
- Mobility.
- Minimum requirements for customer resources.
- The hardware architecture of the application (sometimes the logic) is hidden from the user.

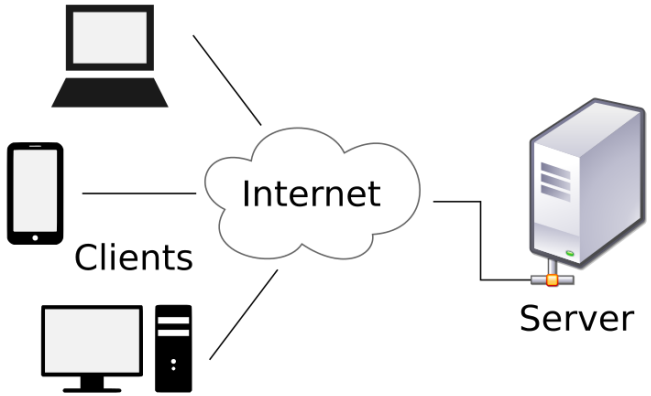
Disadvantages of web applications:

- Cost, availability and quality of communication.
- Limited features of some browsers.
- Safety.

Client-server-model

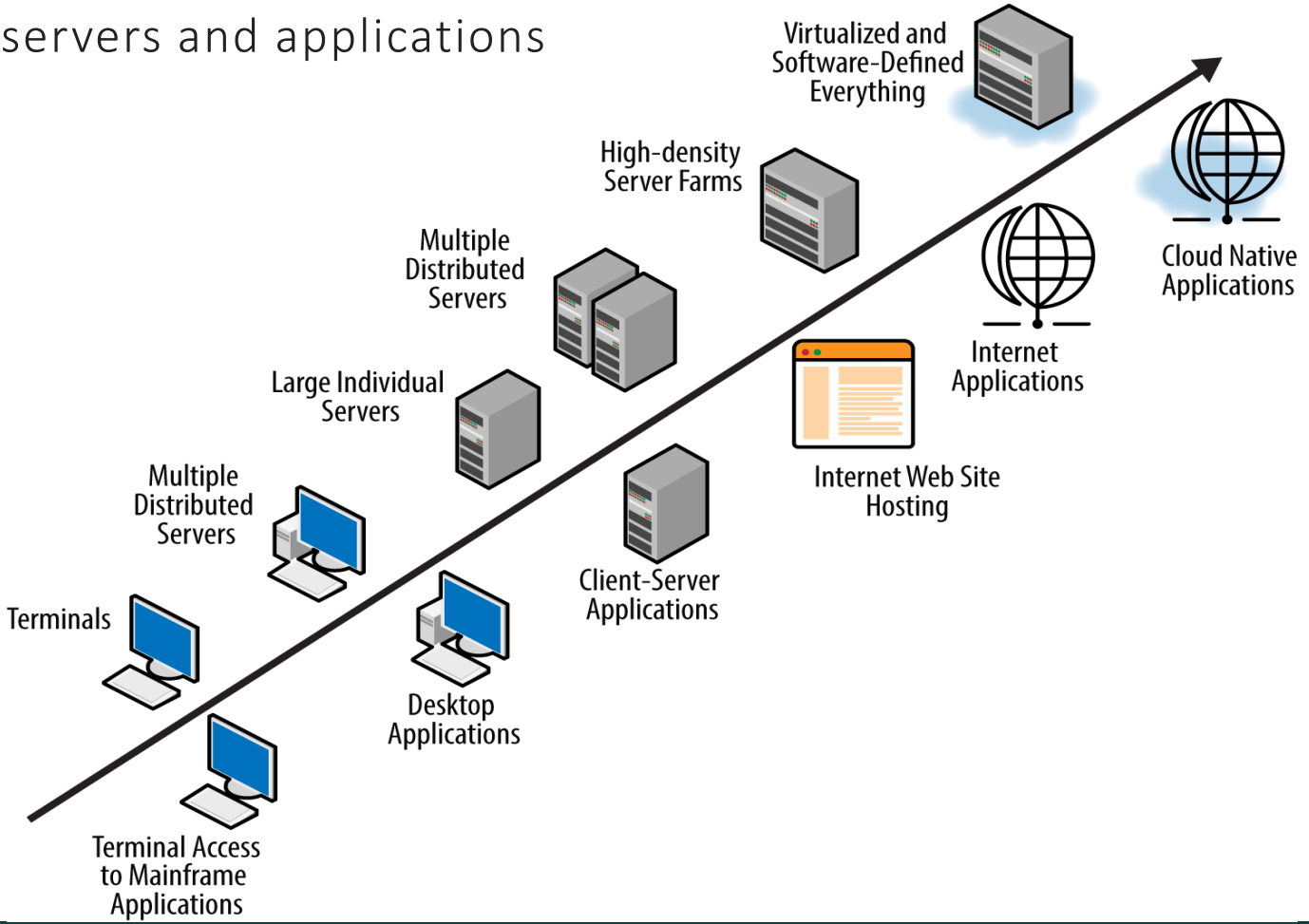
Main components:

- a set of servers that provide information or other services to programs that access them;
- a set of clients who use the services provided by servers;
- a network that provides interaction between clients and servers.

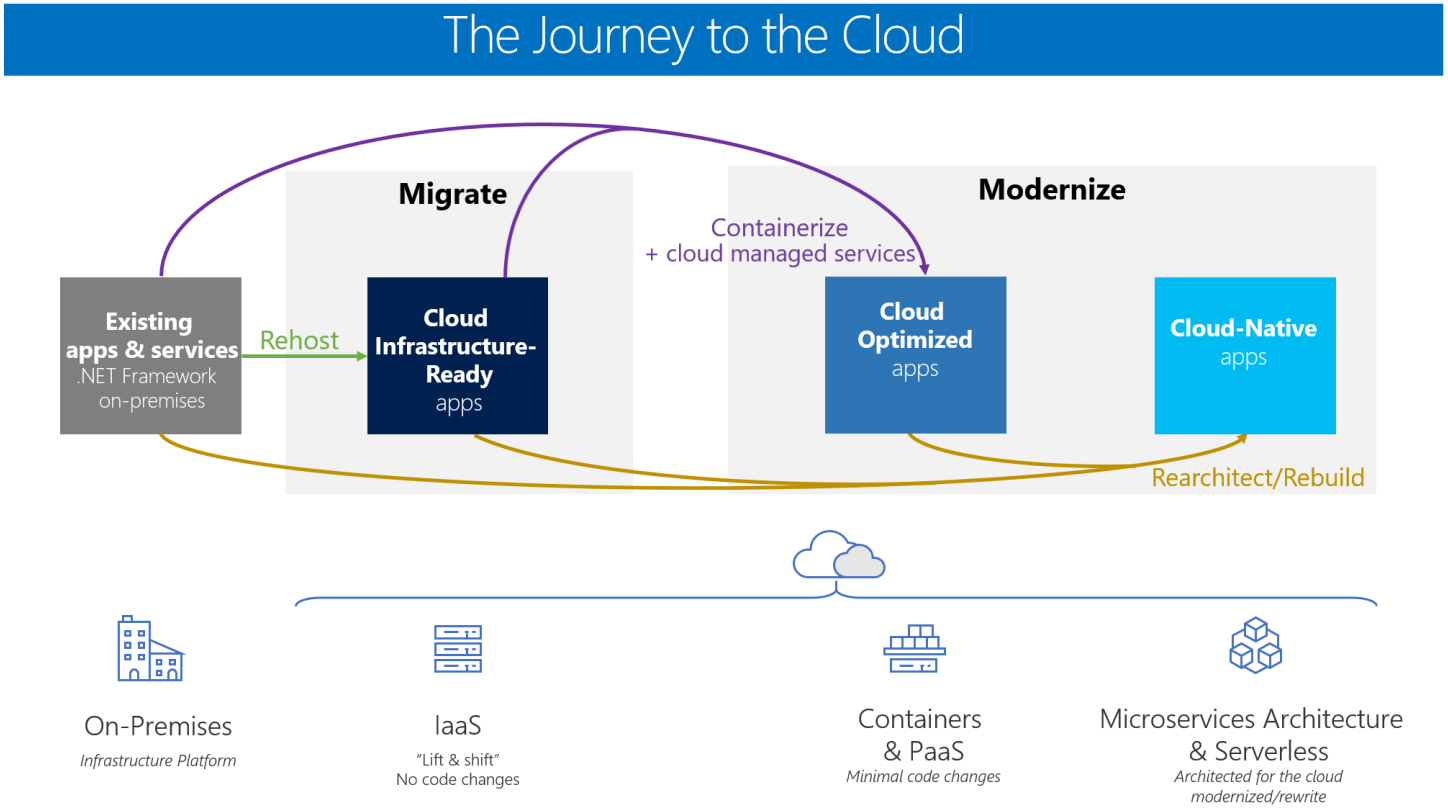


The servers are independent of each other. Customers also operate in parallel and independently of each other. There is no rigid binding of clients to servers. More than typical is the situation when one server processes requests from different clients at the same time; on the other hand, the client can access one server or another. Clients need to know about available servers, but may have no idea about the existence of other clients.

The evolution of servers and applications



Options for upgrading existing applications and services (.NET example)



Virtualization

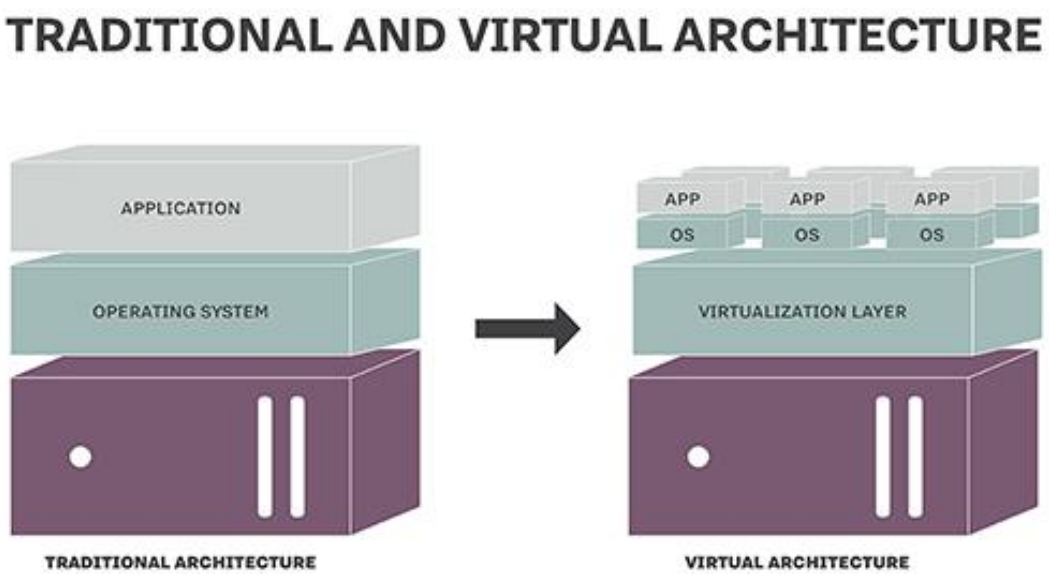
Virtualization technology is based on the separation of performance from implementation. In other words, the user is dealing with the presentation of the solution, while the real architecture is:

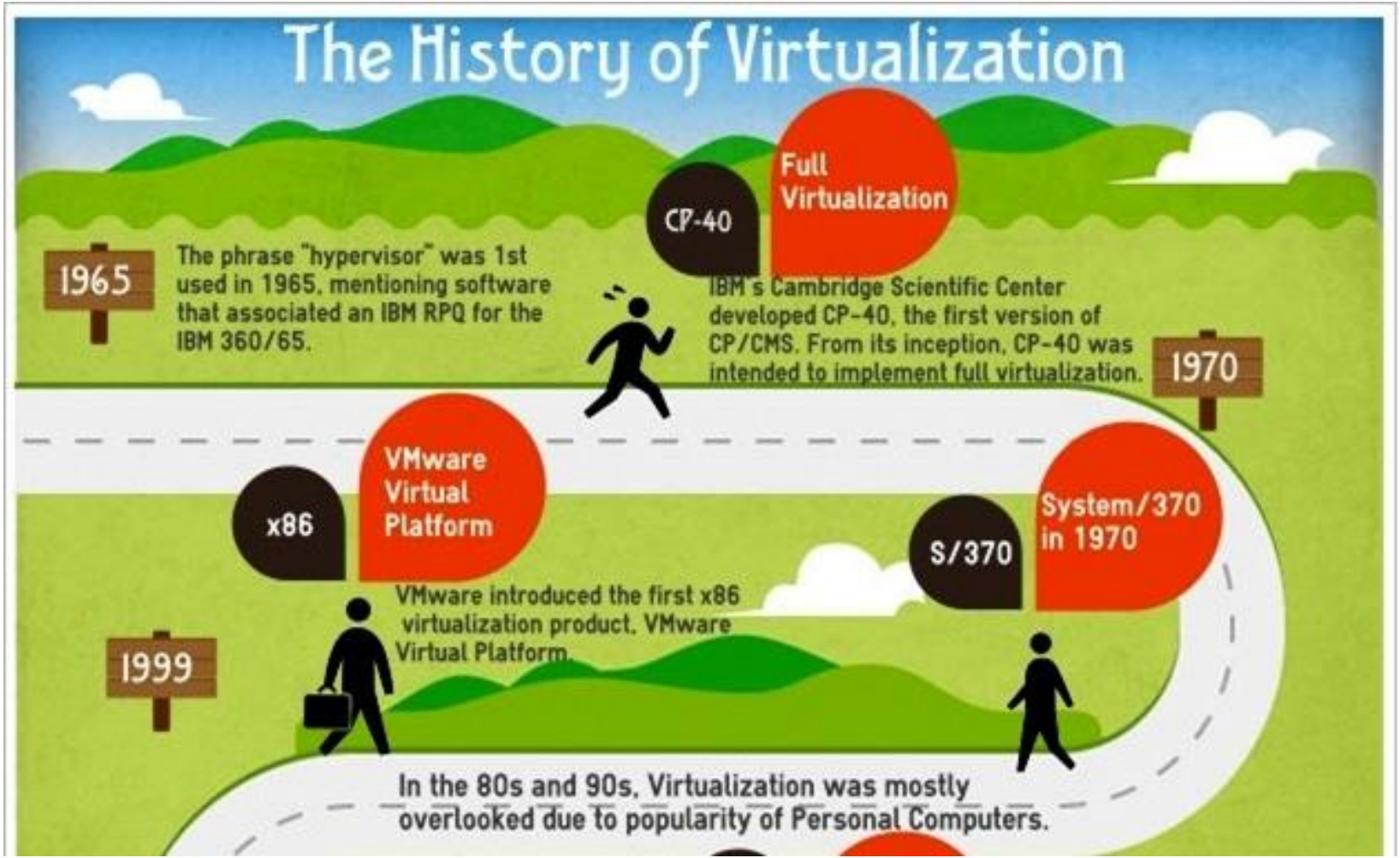
- hidden from him
- may have a completely different structure

Virtualization - isolation of computing processes and resources from each other.

Virtualization Benefits

- The most flexible use of computing power for heterogeneous platforms
- Solving the problem of downtime and inefficient use of equipment
- Ability to create isolated servers on the same physical equipment
- Deployment and Migration Speed
- Simplify Administration




The History of Virtualization
1965
The phrase "hypervisor" was 1st used in 1965, mentioning software that associated an IBM RPQ for the IBM 360/65.
CP-40
Full Virtualization
IBM's Cambridge Scientific Center developed CP-40, the first version of CP/CMS. From its inception, CP-40 was intended to implement full virtualization.
1970
x86
VMware Virtual Platform
VMware introduced the first x86 virtualization product, VMware Virtual Platform.
1999
S/370
System/370 in 1970
In the 80s and 90s, Virtualization was mostly overlooked due to popularity of Personal Computers.


2005
Free
Free desktop virtualization
Corporate play to encourage consumer applications of virtualization by VMware.
VMware releases VMware Player, a free player for virtual machines
LivePC
VMware Server
New level of playing field in Application Virtualization and Application Streaming.
2006
What is Virtualization?
Private Cloud
Cloud Computing
VMware, Microsoft, Citrix, Red Hat
2012
Types of Virtualization: Hardware (Full, Partial, Para), Desktop, Software (OS, Application, Service), Memory, Storage, Data, Network
Source-Timeline of Virtualization development (Wikipedia)

VIRTUALIZATION TYPES

Emulation and virtualization

In the nineties of the twentieth century, there was a rapid development of technology, while not only virtualization tools were created, but also a variety of emulators (DOSEMU, Wine and Bochs). With their help, users were able to reproduce the work of software designed for a specific OS on another (for example, run software for Windows on a Mac or Windows itself inside a Mac).

At the same time, using virtualization, you can “split” one system into two (or more) virtual servers, with their own software and hardware - each of them will function as a real machine, which is a more productive option.

Types of virtualization (in-place in the IT infrastructure) 1

- **Virtualization of the operating system.** It is the most common form of virtualization at the moment. A virtual operating system (virtual machine) is, as a rule, a combination of several operating systems that operate on the same hardware basis. Each of the virtual machines is managed separately using VMM (Virtual Machine Manager). The leaders in the supply of solutions for virtualization of information systems are **VMware, Microsoft, Oracle.**
- **Virtualization of application servers.** This virtualization process is understood as the process of intelligent load balancing. The load balancer manages several web servers and applications as a single system, while the user "sees" only one server, which, in fact, provides the functionality of several servers.

Types of virtualization (in-place in the IT infrastructure) 2

- **Application Virtualization.** This is the use of software solutions in an isolated virtual environment
- **Network virtualization.** It is a combination of hardware and software resources in a single virtual network. Allocate internal network virtualization - creating a virtual network between the virtual machines of the same system, and external - combining several networks into one virtual.
- **Hardware virtualization**. In this case, virtualization consists in breaking down the hardware components into segments that are managed separately from each other. In some cases, OS virtualization is not possible without hardware virtualization.
- **Storage virtualization.** In turn, it is divided into two types: block virtualization and file virtualization.

- File virtualization, as a rule, is used in storage systems, while keeping records of which files and directories are
located on certain media.

- Block virtualization. Used in distributed storage networks.

Types of Virtualization

Other types of virtualization:

- server (KVM, Xen, ESXi),
- desktop virtualization
- memory virtualization.
- software virtualization
- dynamic translation
- paravirtualization
- integrated virtualization
- hardware virtualization

The server market in 2014 exceeded the physical server market.

Server manufacturers revenue (Gartner)

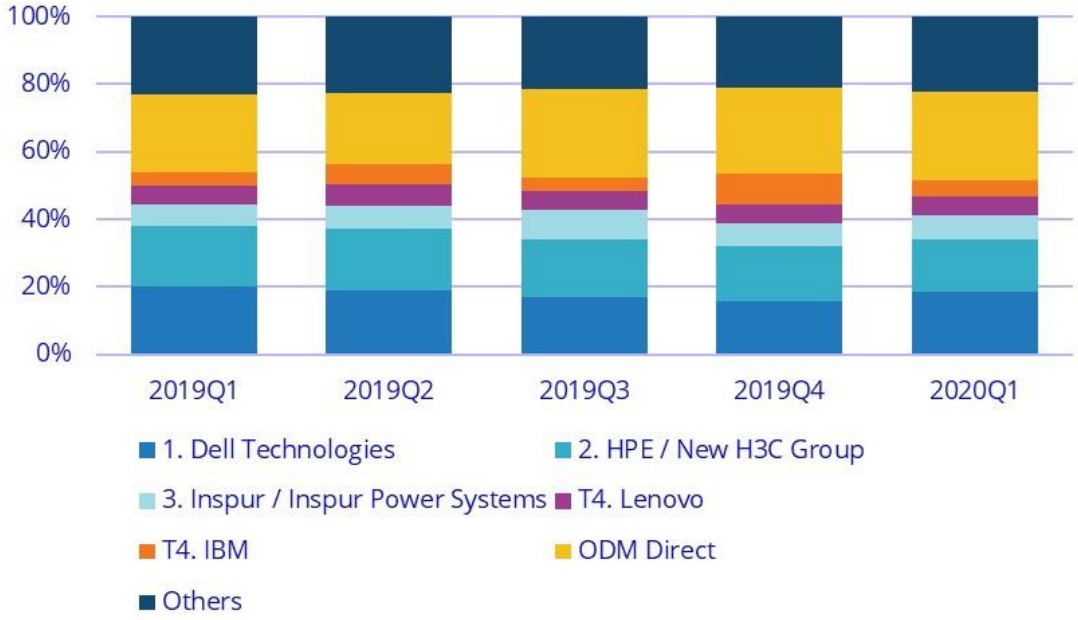
Worldwide: Server Vendor Revenue Estimates, 4Q19 (U.S. Dollars)

Company	4Q19 Revenue	4Q19 Market Share (%)	4Q18 Revenue	4Q18 Market Share (%)	4Q19-4Q18 Growth (%)
Dell EMC	3,986,574,446	17.3	4,426,376,226	20.2	-9.9
HPE	3,551,891,310	15.4	3,887,881,501	17.8	-8.6
IBM	2,294,258,503	10.0	1,783,691,221	8.1	28.6
Inspur Electronics	1,831,676,801	8.0	1,801,622,141	8.2	1.7
Huawei	1,488,740,004	6.5	1,815,071,726	8.3	-18.0
Others	9,860,302,857	42.8	8,186,405,788	37.4	20.4
Total	**23,013,443,922**	**100.0**	**21,901,048,604**	**100.0**	**5.1**

http://tadviser.com/index.php/Article:Servers_(world_market)

IDC
ANALYZE THE FUTURE

Worldwide Top 5 Server Companies, 2020Q1
Vendor Revenue Market Share



Source: IDC 2020

link

Operating system virtualization

Software virtualization

- Dynamic translation

- Paravirtualization

- Built-in virtualization

Hardware virtualization

OS-level virtualization

Hardware virtualization

This is virtualization with support for a special processor architecture (Intel VT, AMD-V)

Benefits:

- Simplify the development of virtualization software platforms by providing hardware management interfaces and support for virtual guest systems. This reduces the complexity and time required to develop virtualization systems.
- The ability to increase the performance of virtualization platforms. Virtual guest systems are managed directly by a small intermediate layer of software, a hypervisor, which gives increased performance.
- The security is improved, it becomes possible to switch between several running independent virtualization platforms at the hardware level. Each of the virtual machines can work independently, in its space of hardware resources, completely isolated from each other. This eliminates the loss of performance to maintain the host platform and increase security.
- The guest system is no longer tied to the architecture of the host platform and to the implementation of the virtualization platform. Hardware virtualization technology makes it possible to run 64-bit guest systems on 32-bit host systems (with 32-bit host virtualization environments).

OS level virtualization

The physical server is virtualized at the OS level, allowing you to run isolated and secure virtual servers on the same physical server. This technology does not allow running OSs with kernels other than the kernel type of the underlying OS. With virtualization at the operating system level, there is no separate hypervisor layer. The host operating system is responsible for sharing hardware resources between multiple virtual servers and maintaining their independence from each other.

- Solaris Containers / Zones
- FreeBSD Jail
- Linux-VServer
- LXC (Linux Containers)
- FreeVPS
- OpenVZ
- Virtuozzo iCore Virtual Accounts

Virtualization Applications

- **Virtual machines**

- This is an environment that is presented to the "guest" operating system as hardware. However, this is actually a software environment that is emulated by the host system software. This emulation must be reliable enough so that the guest drivers can work stably. When using paravirtualization, the virtual machine does not emulate hardware, but instead suggests using a special API.

- **Resource virtualization**

dividing one physical node into several parts, each of which is visible to the owner as a separate server. Not a virtual machine technology, implemented at the kernel level of the operating system

- **Application Virtualization**

the process of using an application that is converted from requiring installation to an operating system into one that does not require (you only need to start it)

Application Virtualization

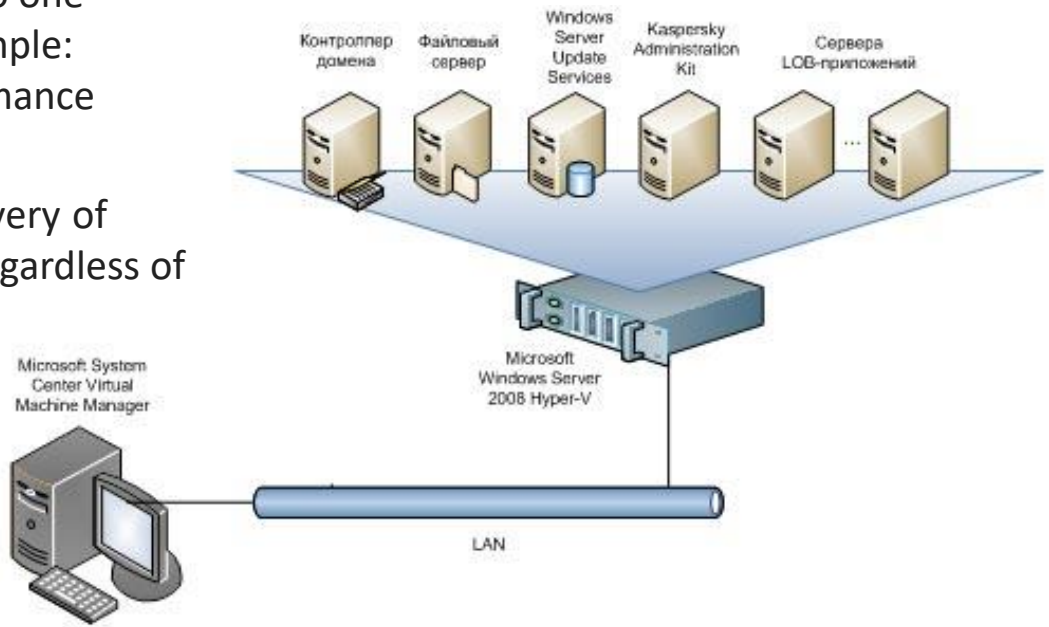
The process of using an application that is converted from requiring installation in the OS to not requiring. For application virtualization, the virtualizer software determines during installation of the virtualized application which OS components are required and emulates them, thus creating the necessary specialized environment for this particular virtualized application and thereby ensuring the isolation of this application. To create a virtual application, the virtualized is placed in a container, usually designed as a folder.

Benefits:

- isolation of application execution: lack of incompatibilities and conflicts;
- each time in its original form: the registry is not cluttered, there are no configuration files - it is necessary for the server;
- lower resource costs compared to emulating the entire OS.

Server Virtualization

- placement of several logical servers within one physical (consolidation)
- combining several physical servers into one logical one to solve a specific problem. Example: Oracle Real Application Cluster, high performance clusters.
- server virtualization simplifies the recovery of failed systems on any available computer, regardless of its specific configuration



Server Virtualization Requirements

- The presence of a management interface.
- Memory management.
- Availability of resource planner.
- Monitoring the status of a virtual machine.
- Storage and network access systems.
- Virtual devices.
- Virtual device drivers.

Trends to Watch

- Hyper-Converged Infrastructure (HCI)
- Software-defined
- AI/ML
- Cloud-Native Applications (+DevOps)
- Internet of Things (IoT)
- Serverless
- NoSQL
- Object storage
- Multi-cloud

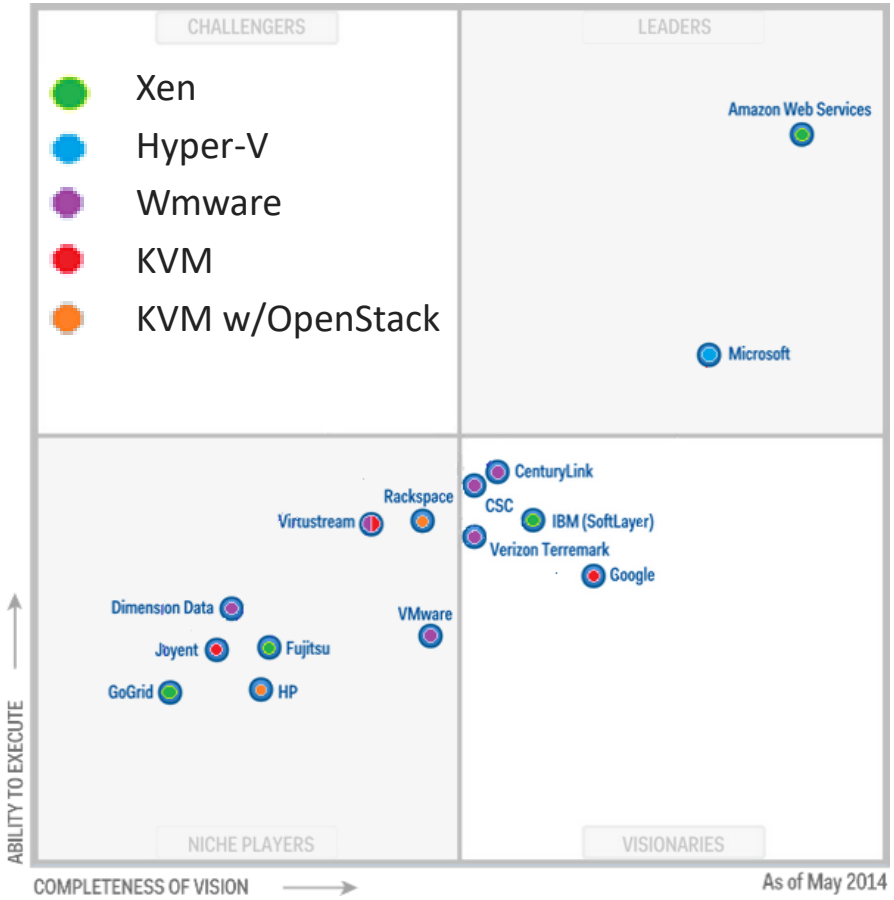
HYPERVISORS TYPES

Hypervisors

Hypervisor - **software** or hardware scheme that provides simultaneous parallel operation of several operating systems on one computer.

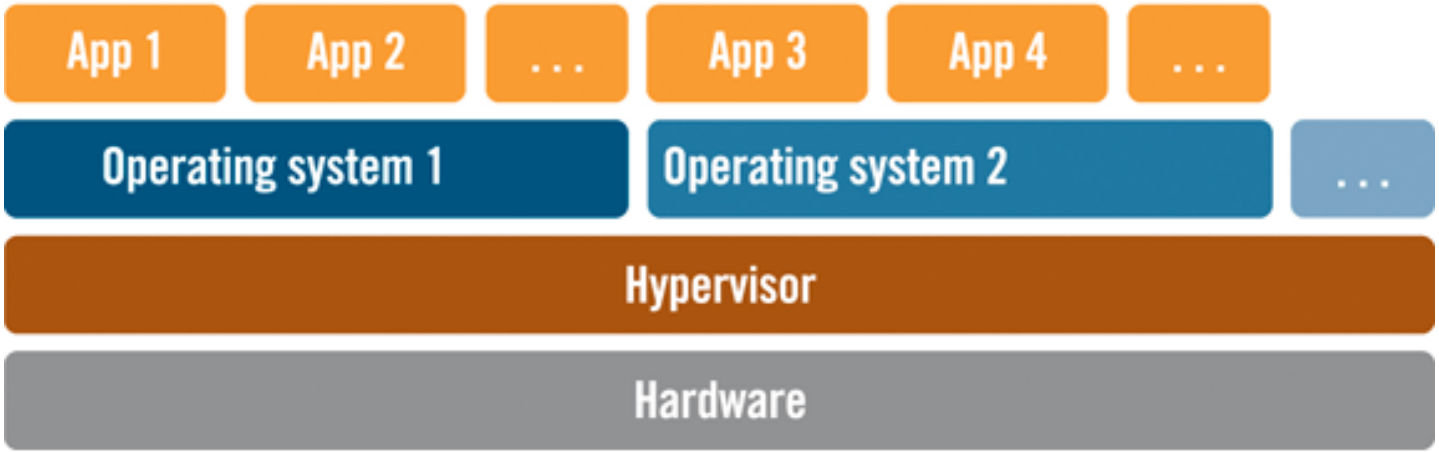
The main purpose of the hypervisor is to provide isolated runtimes for each virtual machine and to control the access of the virtual machine and guest operating system to the physical hardware resources of the computer.

- VMware vSphere Hypervisor
- Microsoft Hyper-V
- Citrix XenServer
- Oracle VirtualBox
- Red Hat Enterprise Virtualization Hypervisor (REVH)
- KVM
- Parallels
- Qemu



Hypervisor, type 1

it runs as a control program directly on the hardware side of the computer. Virtual machine operating systems run higher



Microsoft Hyper-V. VMware ESX Server. Citrix XenServer.

Hypervisor, type 1

Guest OS believe that they are working directly on the **hardware platform**, do not see the hypervisor

- OS not changed
- better performance

Choice for data centers

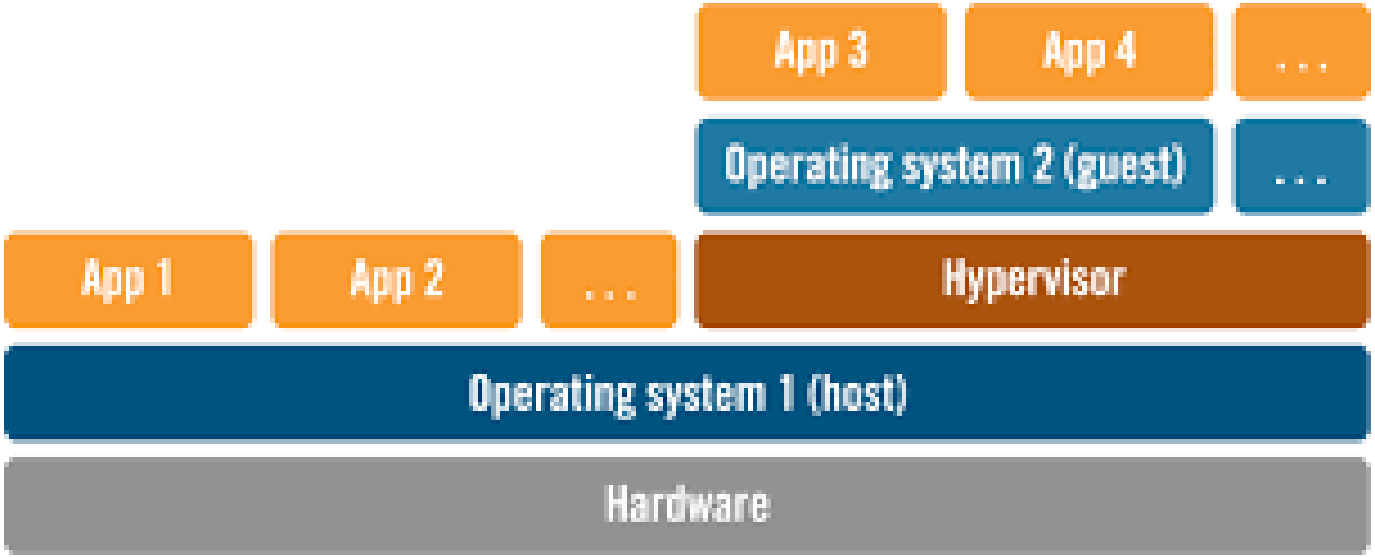
- consolidation of several operating systems and programs for a smaller number of HW
- Move guests between systems to balance performance
- snapshots and cloning

Creating and managing guest operating systems

- can be run in kernel mode
- You can implement device drivers
- Other traditional OS resources (such as services) such as CPU and memory management are also provided

Hypervisor, type 2

it runs on the host operating system. Guest virtual machine operating systems are at a higher level



VMware Workstation, Oracle VM VirtualBox, Microsoft Virtual PC, Parallels Desktop

Hypervisor, type 3, 4

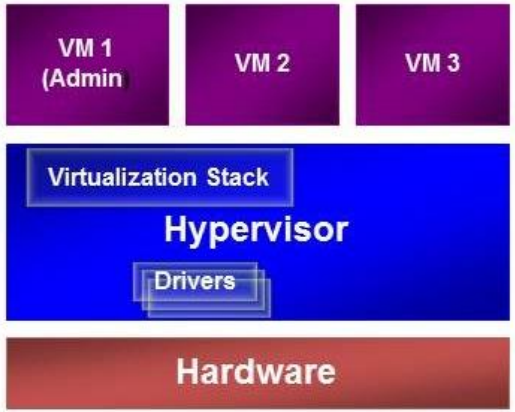
The **monolithic** hypervisor includes hardware device drivers (hardware virtualization).

Microkernel. In this case, device drivers are located inside the host operating system. In this case, the host operating system, like guest, runs in a virtual environment and is called the "parent". Only the parent operating system has access to the hardware, the daughter ones, in turn, can interact with the hardware only through the "parent"

Hypervisor. Monolithic vs. Microkernel

VMware ESX

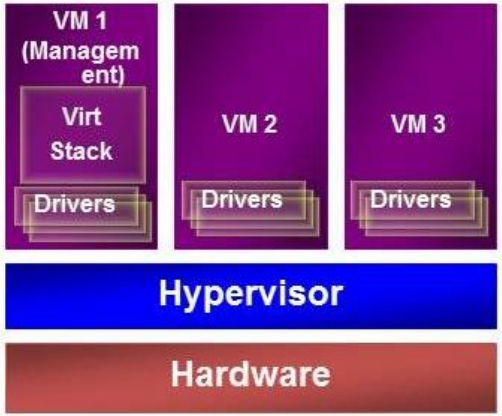
- Monolithic Hypervisor



- Implements a proprietary driver model within the hypervisor
- More simple than a modern kernel, but still complex

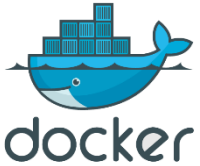
Microsoft Hyper - V.

- Microkernel Hypervisor



- Simple partitioning functionality
- Increases reliability and minimizes attack surface
- No third-party code (drivers run within VMs)

Containerization



Key Features:

- Containers look like a regular Linux system. They include regular startup scripts. Third-party applications can run in containers without the need for modification.
- The user can change any configuration files and install any additional software in containers.
- Containers are completely isolated from each other (file system, processes, sysctl variables) and virtual machines.
- Containers share dynamic libraries, which greatly saves memory.
- Processes in containers are planned for execution on all available CPUs. Containers are not limited to one CPU and can use all the power of the host CPU.

Benefits of Container Virtualization

- Containers run at the same level as physical servers. The lack of virtualized hardware and the use of real hardware and drivers provide unrivaled performance.
- Each container can scale to the resources of an entire physical server.
- Virtualization technology at the OS level allows you to achieve the highest density among the available virtualization solutions. It is possible to create and run hundreds of containers on one ordinary physical server.
- Containers use a single OS, which makes their support and updating very simple. Applications can also be deployed in separate environments.

Containerization vs Virtualization

- Containers: maximum applications on a minimum number of servers. But you need to take extra care of security.
- Virtual machines: run many applications and / or support different operating systems. And if the security issue for the organization comes first, it’s also better to stay with VM.
- It is necessary to use containers together with virtual machines both in the clouds and in your own data centers, depending on the tasks.

Magic quadrant Gartner

for x86 server virtualization infrastructure

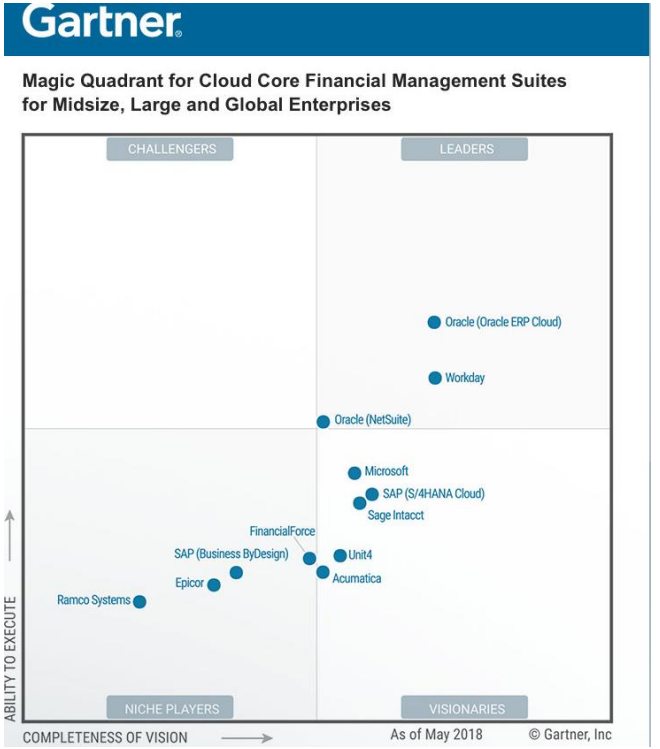
Source: Gartner (August 2016)

One of the largest developers of software solutions in the field of virtualization is the American company VMware. The company was established in 1998.
The main product lines of the company:
VMware Cloud Foundation single data center software platform
vSphere server virtualization platform and the ideal foundation for creating a cloud environment
ЦОД NSX network virtualization platform for software data center.
vSAN dramatically simplified enterprise-grade shared storage for hyper-converged infrastructure
vSAN ReadyNode hyper converged hardware solutions partners
vCloud Suite multi-vendor hybrid cloud management platform
Workspace ONE Providing and administering any application on any device
Horizon 7 single platform for provisioning, protection and administration of virtual computers (VDI) and applications
App Volumes set of integrated solutions for managing applications and users for virtual environments
Workstation Player running multiple operating systems as virtual machines on one computer
Pivotal App Suite The Pivotal middleware platform that development and operations teams use to create and run specialized cloud applications
vCloud NFV Network Services Virtualization Platform for Telecommunications Providers
vSphere Hypervisor free hardware hypervisor, which is used for server virtualization and application consolidation on less hardware

Oracle, a US-based server hardware corporation, is the second-largest software provider (after Microsoft).
The most famous product of the company is Oracle Database
In 2010, Oracle acquired Sun Microsystems, one of the most popular virtualization software vendors. In view of this, there is continuity in many Oracle virtualization products.

Oracle Virtualization Product Line:
Oracle VM - server virtualization software. Use Xen hypervisor.
Oracle VM Server for SPARC - allows you to run up to 128 VMs on servers running SPARC T-series processors
xVM (Sun xVM hypervisor and Sun xVM Server) - virtualization product based on Xen hypervisor code for OpenSolaris

Oracle VM VirtualBox - it is obvious from the name of the software product that its main purpose is to provide virtualization of workstations.



Server Virtualization Solution (Hyper - V)

Hyper -V is a hypervisor-based server virtualization solution for x64 systems. It supports various operating systems, network load balancing, microkernel architecture, hardware virtualization, and equipment sharing. In addition, functions for creating snapshots of virtual machines and quick migration are available.

The capabilities of Microsoft Hyper-V are greatly enhanced with the help of Microsoft System Center components. Virtual machine manager Allows you to centrally manage many Hyper-V servers across the enterprise, manage virtual machine templates, monitor the status of virtual machines, and convert physical servers to virtual machines.

Desktop Virtualization

- Microsoft Virtual PC - a component of the Windows 7 operating system that allows users to run multiple operating systems on one computer. Includes Windows XP mode, which is an already configured virtual machine with the operating system Windows XP + SP3.
- Microsoft Enterprise Desktop Virtualization - a solution for corporate virtualization of workstations, allows administrators to create and manage corporate images of virtual machines on all workstations running Windows.
- Microsoft Application Virtualization - a solution for converting applications into centrally managed virtual services.

Remote Desktop Virtualization

A feature of remote desktop virtualization is that the virtual environment itself runs on the server. Microsoft solutions in this area:

- Remote Desktop Service - is a former terminal service. Includes the ability to provide users with virtual machines via RDP (Remote Desktop Protocol).
- Microsoft Application Virtualization for Remote Desktop Services - a solution that allows you to transform applications into centrally managed virtual services and provide them to users using the RDP protocol.
- Remote Desktop Infrastructure - an architectural model that includes Hyper - V, Microsoft Desktop - Optimization Pack, and Microsoft System Center. Users are given access to a personal virtual remote table using the RDP protocol.

Q & A

Thank you!