Virtualization in practice

Jiří Holeček

Annotation

The educational material provides the reader with a basic overview of virtualization in various industries with an emphasis on IT, including practical examples.

Objectives

The purpose of the educational material is to provide the reader with a basic overview of virtualization in various industries with an emphasis on IT. The reader will get a practical introduction to setting up a virtual machine, installing an operating system and configuring it in a virtual environment. In addition, the reader can experience virtual reality in practice with the help of the demonstrations provided.

Keywords

virtualization; VR; virtual reality; virtual desktop; virtual computer; virtual network; VLAN; SDN; virtual operator

Date of Creation

15. 12. 2021

Duration

40 hours

Language

English

License

ISBN

Literature

[1] Virtualizace v Linuxu. Wikiknihy: Myslete svobodně. Učte se svobodně [online]. San Francisco (CA): Wikimedia Foundation, 2013-, 2017 [cit. 2021-12-15]. Available from: https://cs.wikibooks.org/wiki/Virtualizace_v_Linuxu

[2] Virtuální svět. Wikipedia: the free encyclopedia [online]. San Francisco (CA): Wikimedia Foundation, 2001- , 2021 [cit. 2021-12-15]. Available from: https://cs.wikipedia.org/wiki/Virtuální_svět

[3] Virtuální realita. *Wikipedia: the free encyclopedia* [online]. San Francisco (CA): Wikimedia Foundation, 2001-, 2022 [cit. 2021-12-15]. Available from: https://cs.wikipedia.org/wiki/Virtuální_realita

[4] Virtuální ekonomika. *Wikipedia: the free encyclopedia* [online]. San Francisco (CA): Wikimedia Foundation, 2001-, 2021 [cit. 2021-12-15]. Available from: https://cs.wikipedia.org/wiki/Virtuální_ekonomika

[5] Free Images: nature, advertising, live, street sign, yellow, signage, note, road sign, present, brand, font, dream, text, shield, fantasy, bill, anniversary, be, reality, existence, virtual, thing, traffic sign, town sign, place name sign, presence, virtualization 4961x3508 - - 905837 - Free stock photos - PxHere. Free Images & Free stock photos - PxHere [online]. Hangzhou: Long Zhou, 2017 [cit. 2021-12-15]. Available from: https://pxhere.com/en/photo/905837

[6] What is virtualization architecture? - Definition from WhatIs.com. Computer Glossary, Computer Terms - Technology Definitions and Cheat Sheets from WhatIs.com - The Tech Dictionary and IT Encyclopedia [online]. Newton, MA: TechTarget, 2022 [cit. 2021-12-15]. Available from: https://whatis.techtarget.com/definition/virtualization-architecture

[7] *Oracle VM VirtualBox* [online]. Austin, Texas: Oracle [cit. 2021-12-15]. Available from: https://www.virtualbox.org/

[8] CÁNEPA, Gabriel. 10 Top Most Popular Linux Distributions of 2021. *Tecmint: Linux Howtos, Tutorials & Guides* [online]. May 31, 2021 [cit. 2021-12-15]. Available from: https://www.tecmint.com/top-most-popular-linux-distributions/

[9] Co je virtualizace?. *Cloudové výpočetní služby | Microsoft Azure* [online]. Redmond, Washington, USA: Microsoft, 2022 [cit. 2021-12-15]. Available from: https://azure.microsoft.com/cs-cz/overview/what-is-virtualization/

[10] GOZANI, Mora. Network Virtualization for Dummies: VMware Special Edition [online]. Hoboken, NJ: John Wiley, 2016 [cit. 2021-11-18]. ISBN 978-1-119-12583-9. Available from: https://microage.com/wp-content/uploads/2016/12/Network-Virtualization-For-Dummies.pdf

[11] Cloud Computing Network Internet - Free image on Pixabay. *2.5 million+ Stunning Free Images to Use Anywhere [online]. Berlin: Pixabay, Jan. 22, 2017 [cit. 2021-12-15]. Available from: https://pixabay.com/illustrations/cloud-computing-network-internet-2001090//*

[12] DENWID. Software Defined Networking System Overview. *Wikipedia: the free encyclopedia [online]. San Francisco (CA): Wikimedia Foundation, 2001-, 2013-08-08 [cit. 2021-12-15]. Available from: https://en.wikipedia.org/wiki/File:Software_Defined_Networking_System_Overview.svg*

[13] Ghost Hologram Light - Free photo on Pixabay. *2.5 million+ Stunning Free Images to Use Anywhere* [online]. Berlin: Pixabay, Sept. 29, 2018 [cit. 2021-12-15]. Available from: https://pixabay.com/photos/ghost-hologram-light-illuminated-3710687//

[14] HOORENBEEK, Froukje. User generated content in the virtual world Second Life. *Wikipedia Commons* [online]. San Francisco (CA): Wikimedia Foundation, 2001-, 11 March 2015 [cit. 2021-12-15]. Available from: https://commons.wikimedia.org/wiki/File:User_generated_content_in_the_virtual_world_Second_Life.png

[15] Questionmark, 3d, font, theme, symbol, question, puzzles, problem. *Piqsels - Millions of stunning royalty free photos* [online]. [cit. 2021-12-15]. Available from: https://www.piqsels.com/en/public-domain-photo-zwtoj

[16] ZAWINSKI, Jamie. The.Matrix.glmatrix.2. *Wikipedia Commons* [online]. San Francisco (CA): Wikimedia Foundation, 2001-, 3/27/2008 [cit. 2021-12-15]. Available from: https://commons.wikimedia.org/wiki/File:The.Matrix.glmatrix.2.png

CHAPTER 1

What is virtualization and why use it?

The educational material Virtualization in Practice provides the reader with an overview of virtualization with a focus on information technology and electronics. In these sectors, the reader may encounter virtualization on a regular basis, either intentionally or may use the services of virtualized systems without being familiar with it.

Interaktivní prvek

Virtualization is basically an "illusion" where multiple copies of a resource are created (e.g. in IT, memory, processor, hard drive, in the virtual reality of a real object, etc.) and each user has access to one or more of these copies. Since copies are created only as virtual images, we speak of so-called virtual objects - we have virtual memory as an image of physical memory, virtual disk as an image of a physical disk, virtual processor as an image of a physical processor. From these virtual components we are able to build a whole virtual machine for the user. The user may have complete control over the entire virtual machine, but in fact shares specific physical resources with other users.

Fig. 1. The end of reality? [6]

Virtualization is used for many different purposes, e.g.:

Interaktivní prvek

In the domain of informatics, virtualization is a term for procedures, techniques, and resources that allow a computer to access available resources in a way that is different from how they physically exist, how they are linked together, etc. A virtualized environment can be more flexibly adapted to the needs of the user who will use it. It is possible to virtualize at various levels, from the software environment (virtualization of a desktop application or the entire operating system), see Chapter 3, through virtualization of individual hardware components (virtual processors, virtual drives, virtual memories), to virtualization of entire computers - the so-called virtual machine, see Chapter 2, or virtualization of entire networks, see Chapter 4. Other virtualization options beyond computing are discussed in Chapter 5.

CHAPTER 2

PC Hardware virtualization

Hardware virtualization is most often based on the hypervisor as a virtualization layer.

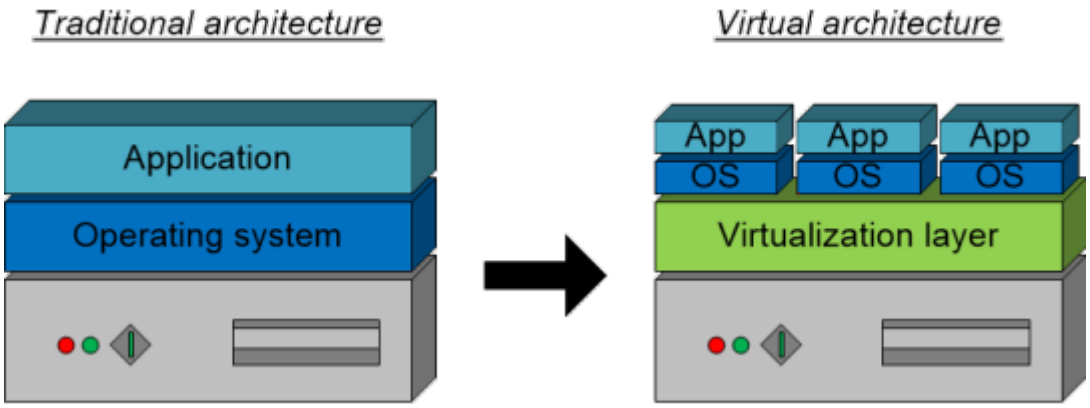

Fig. 2. Comparison of traditional and virtual architecture

2.1 Levels of virtualization

In informatics, there are several levels of virtualization:

DEFINITION

1. **Container virtualization** is virtualization at the operating system level, where separate environments, called containers, are created within a single operating system.

ADVANTAGE

Lower technical complexity.

Lower requirements for system resources.

DISADVANTAGE

This is not virtualization in the pure sense of the word, as all separate environments use the same operating system kernel.

This virtualization is discussed in more detail in Chapter 3.

EXAMPLE

Docker

DEFINITION

2. **Emulation** is virtualization based on the interpretation of machine code from one specific platform to another (different/incompatible) platform. As such, it is the only virtualization technique that allows applications/programs from a non-compatible platform to run on a guest system, such as running Android applications using ARM architecture on a Windows machine using x86/x64 architecture.

ADVANTAGE

It enables the running on of systems/applications originating from a platform that uses a different architecture.

DISADVANTAGE

The machine code interpretation of an emulated system is demanding on system resources, so the emulated system usually has reduced performance compared to the native environment.

EXAMPLE

QEMU

DEFINITION

3. **Paravirtualization** performs only a partial abstraction at the virtual machine level and provides a virtual environment similar to the physical environment on which the virtual machine runs. The hosted system knows that it is running in a virtual environment and communicates with the hypervisor (hardware access requests are translated into hypervisor calls).

ADVANTAGE

High performance is achieved because most instructions are executed by the real processor.

DISADVANTAGE

Requires installation of drivers on both host and guest operating system.

EXAMPLE

Oracle VirtualBox

Microsoft Virtual PC

VMware Workstation

NOTE

Paravirtualization is one way to implement a type 2 hypervisor.

DEFINITION

4. **Full virtualization** is achieved when all components of the computer are virtualized. Therefore, it requires the same architecture of the guest and hosted system. The guest - virtualized - system cannot recognize that it is running in a virtual environment (unlike paravirtualization), the virtual hardware corresponds to the physical hardware.

ADVANTAGE

Full separation of hosted virtual machines.

No special drivers or operating system modifications are required.

DISADVANTAGE

Emulating of the complete hardware (even without machine code reinterpretation) reduces performance in comparison to paravirtualization.

EXAMPLE

Microsoft Hyper-V

VMware ESXi

KVM

Interaktivní prvek

Interaktivní prvek

Interaktivní prvek

2.2 Hypervisor types

DEFINITION

The hypervisor isolates operating systems and applications from the physical computer's hardware and allows the host machine to run multiple virtual machines (VMs) as guests who share the physical computing resources of the system, such as processors, memory space, network bandwidth, and so on.

Interaktivní prvek

2.2.1 Hypervisor type 1

Type 1 hypervisors, sometimes called **native hypervisors**, that run directly on the host system hardware. They offer high availability and better resource management compared to other technologies. Their direct access to the system hardware enables better performance, scalability and stability.

NOTE

Examples of type 1 hypervisors: Microsoft Hyper-V, Citrix XenServer a VMware ESXi.

2.2.2 Hypervisor type 2

Type 2 hypervisors, also called **host hypervisors**, are installed on the host operating system, not directly on the hardware as a Type 1 hypervisor. Each guest OS or VM runs on top of the hypervisor. Adding a guest OS layer can potentially limit performance.

NOTE

Examples of type 2 hypervisors: VMware Workstation, Microsoft Virtual PC and Oracle VirtualBox.

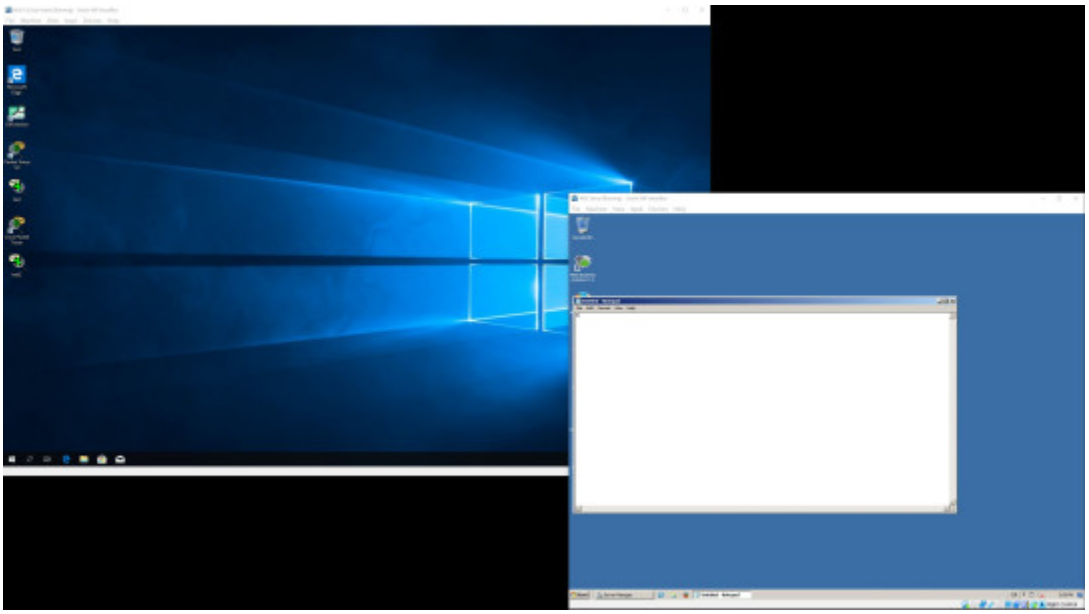

Fig. 3. Two virtual machines in VirtualBox

Interaktivní prvek

2.3 Virtual machine setup and installation demonstration

Oracle VirtualBox was chosen as the most accessible and most commonly used type 2 hypervisor for the ***virtual machine*** (**VM**) setup demonstration. VirtualBox is available for free for most platforms - Windows, OS X, Linux.

In the demonstration, we will install the Linux distribution Linux Mint (as a guest system) on Windows 10 operating system. This scenario shows a possible first experience of a Windows user with a Linux-based system, where the user has the opportunity to try out the new system without compromising his/her existing operating system.

The VirtualBox application can be downloaded from the project's official website https://www.virtualbox.org/wiki/Downloads, and an image of the Mint Linux distribution installation DVD can be downloaded from https://linuxmint.com/download.php. Most Linux distributions, MX Linux, Manjaro, Ubuntu, Debian, CentOS and others can be installed in a similar way as in this demonstration [8].

After running VirtualBox, a window similar to the one in the following figure will appear. In this window, click on New/New and a window with the basic information about the virtual machine to be created will appear, where we enter the name, the location of the virtual machine files, the type of guest operating system (in this case Linux) and its version/distribution.

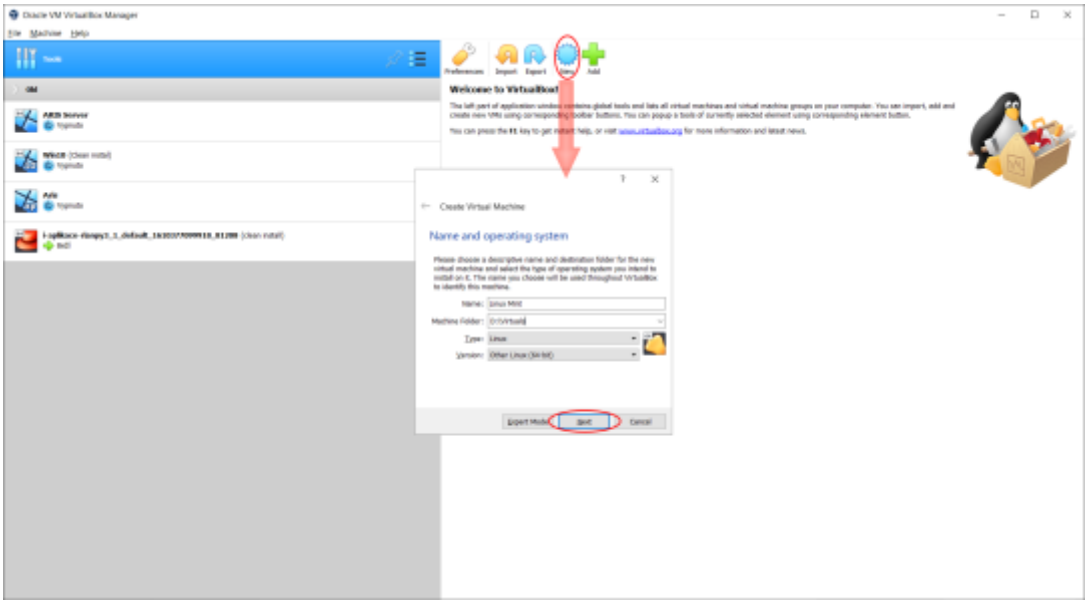

Fig. 4. The VirtualBox home screen with basic configuration of the virtual machine.

In the next dialog box, we set the size of RAM that will be available to the guest operating system. When determining the appropriate size, it is necessary to know the memory requirements of both the guest and host operating system to ensure that we do not set the guest operating system memory size too low and to ensure that after allocating memory for the guest operating system, there is enough memory left for the host system. Linux Mint memory requirements are 1 GB of RAM as a minimum, and at least 2 GB of

RAM is recommended. If the physical operating memory size is sufficient, we can set more, but we should never get into the pink-red area of the scroll bar to leave enough memory for the host operating system to operate.

Interaktivní prvek

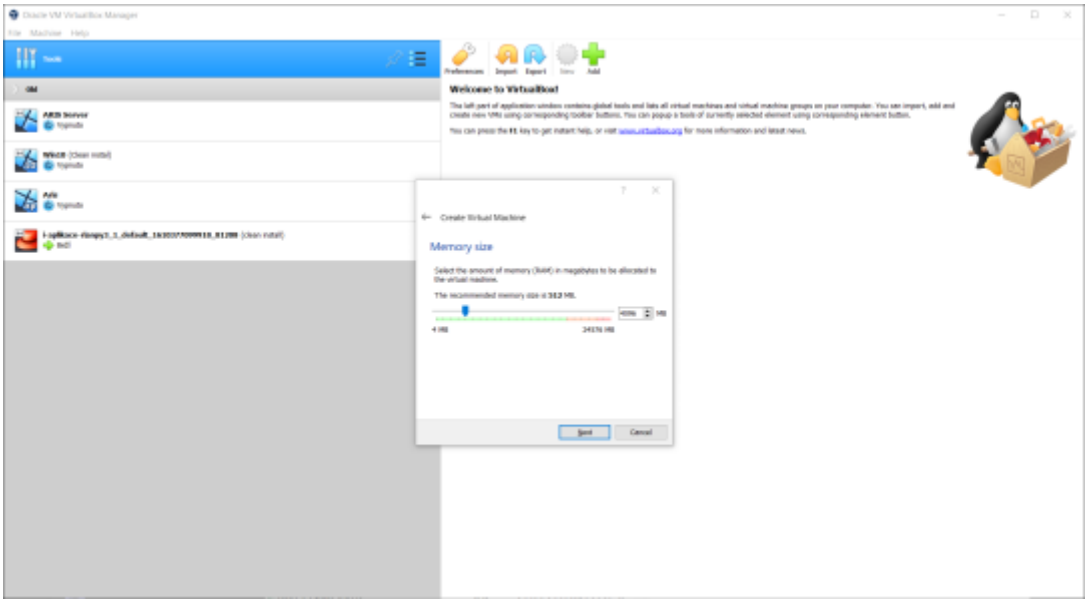

Fig. 5. Setting up virtual RAM.

The next step is to create a virtual disk. In the first dialog we will keep the item *Create a virtual hard disk now* selected and after clicking the *Create* button we will get the option to select the format in which the virtual disk will be stored:

Interaktivní prvek

In our sample case, we will again leave the pre-selected item checked, which is the *VDI* format.

In the next dialog you can choose whether the created virtual disk will be allocated dynamically, which means that it will initially take up a small amount of space on the physical storage and if more space is needed, the space will be dynamically " allocated " - to the maximum size specified in the next step, or whether the virtual disk file will be a fixed size, which means that the space corresponding to the specified maximum size will be allocated immediately upon creation. For the demonstration, we will again keep the pre-selected option (*Dynamically allocated*) checked.

In the last step of creating the virtual disk, we set the maximum disk size, also considering the requirements of the hosted system, which is 15 GB in the minimum variant and 20 GB in the recommended variant.

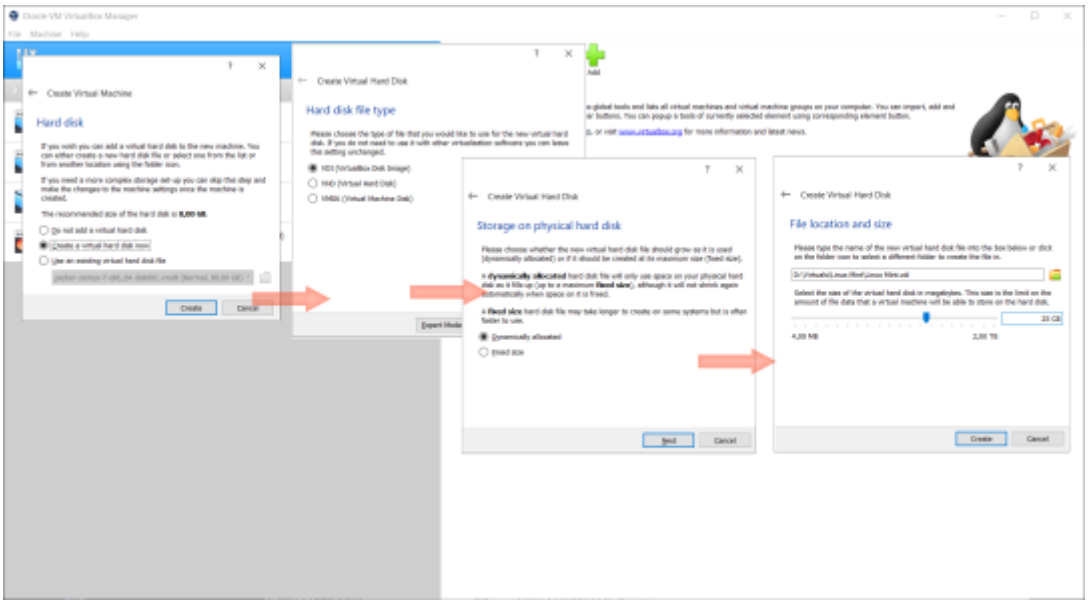

Fig. 6. Setting up a virtual disk.

At this point, we have a virtual machine ready to begin the installation of the operating system. Before we "insert" the virtual installation DVD into the virtual drive, we can adjust some parameters that can improve the performance of the virtual machine, such as the number of CPU cores used, the size of the graphics memory, etc. We set these parameters in the *Settings* dialog. In the left column, select the *System* option and in the *Processor* tab, where we set the number of processor cores. Generally, we do not allocate all processor cores to the virtual machine; we will select this option only if only the virtual machine is running on the guest computer and the host system is not used in any other way.

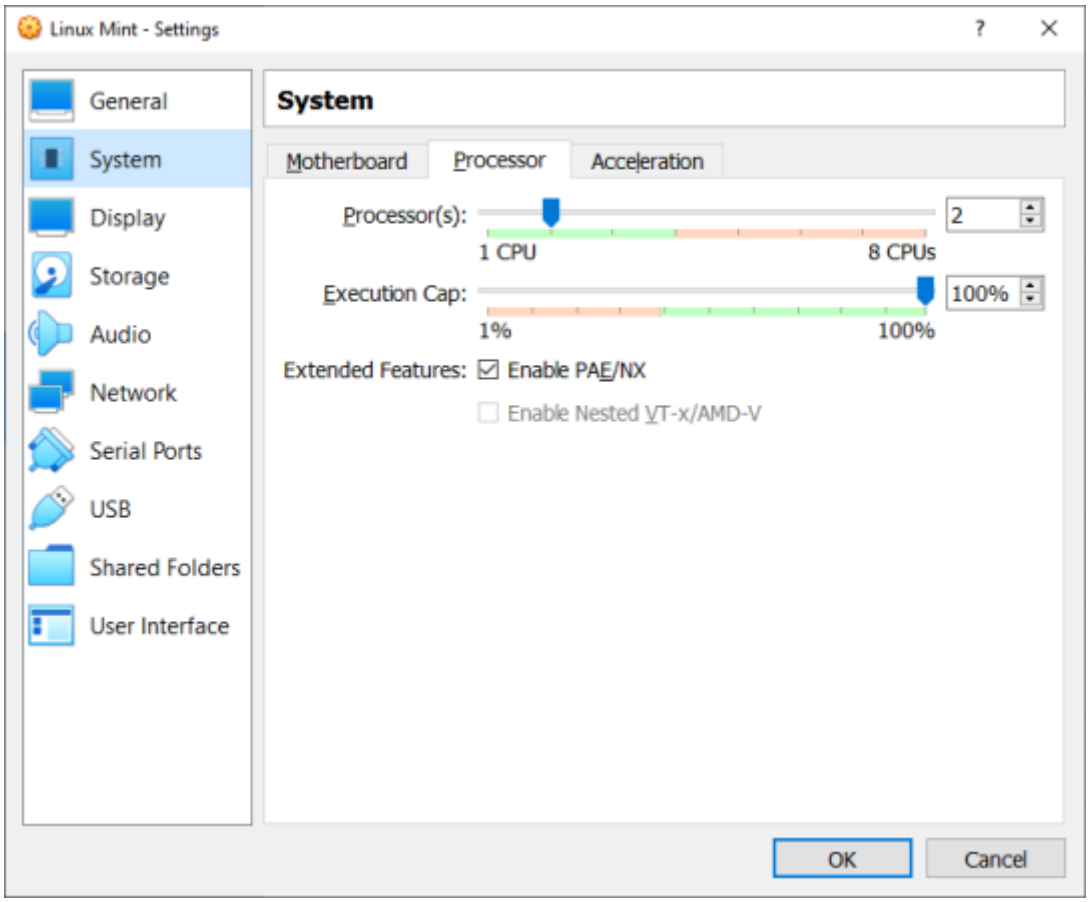

Fig. 7. Selecting the number of processors.

The size of the video memory is set in the *Display* option, on the *Screen* tab. The size of the video memory is selected according to the expected usage of the virtual machine. If we use the operating system only for terminal mode, it will be sufficient to keep the size to the recommended minimum, if we also use the desktop interface, it will be advisable to increase the size of the video memory.

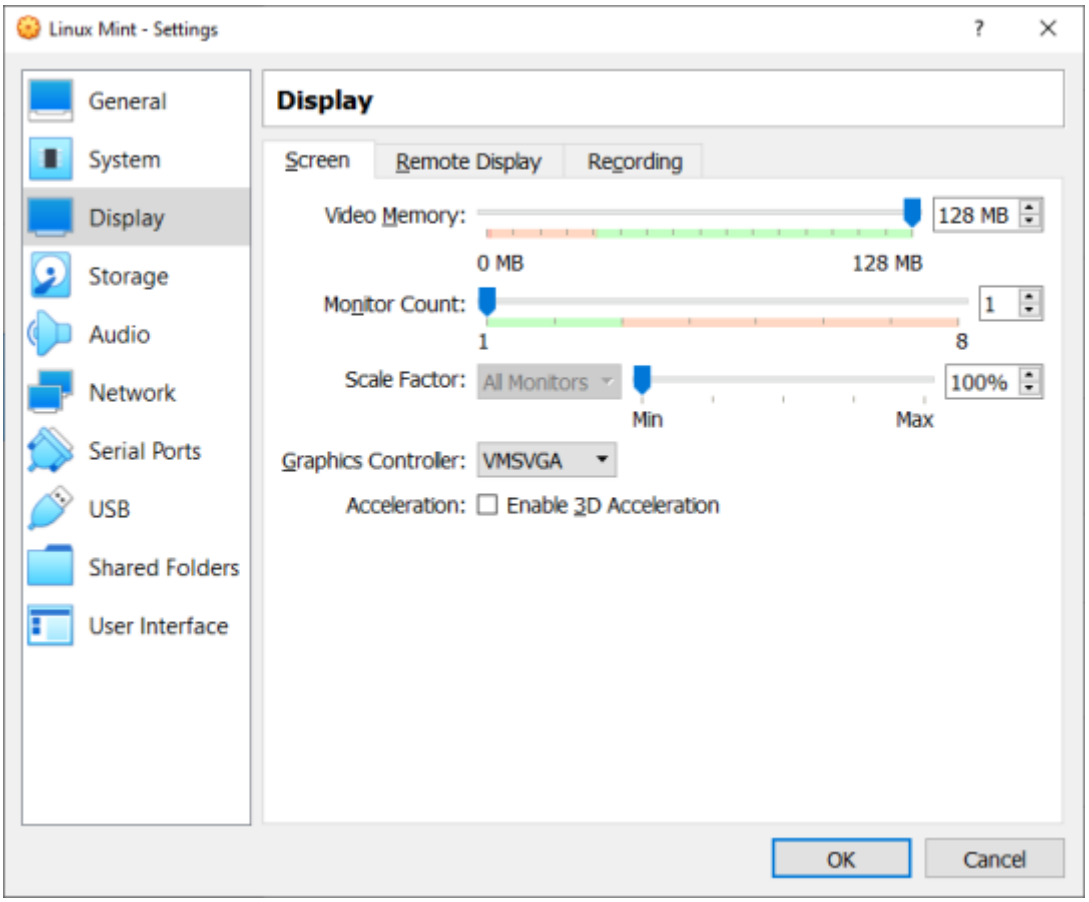

Fig. 8. Video memory settings.

The last step before installing the operating system is to select the system CD/DVD image, which is done in *Storage* section.

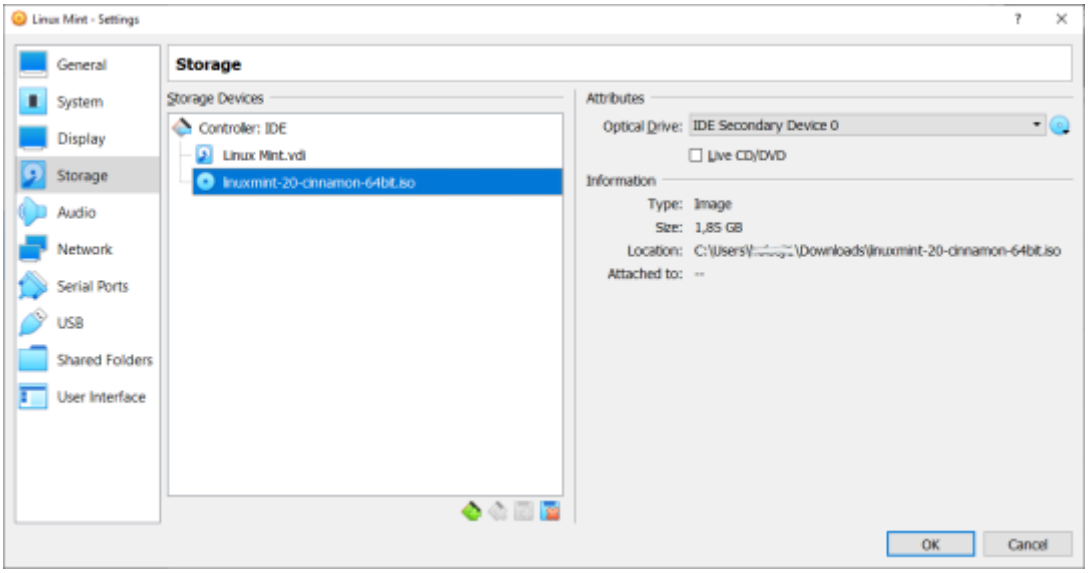

Fig. 9. Selecting the installation media image.

Now using the Start button, we launch the created virtual machine and install the operating system.

The installation procedure is shown in the video below.

Video 1. Installing Linux Mint OS in VirtualBox.

After installation of the guest operating system in a virtual environment, it is necessary to install virtual hardware drivers to take full advantage of the capabilities of the virtualized computer. If the guest system is Windows, simply select *Insert Guest Additions CD Image...* from the *Devices* menu and follow the on-screen instructions. For Linux-based operating systems, the procedure is a bit more complicated.

1. First, you need to update the operating system packages with the commands:

```
sudo apt update
sudo apt upgrade
```

Video 2. Linux Mint OS update in VirtualBox.

2. Next, you need to download and install the packages that will allow you to build the kernel modules:

```
sudo apt install build-essential module-assistant
sudo m-a prepare
```

Interaktivní prvek

Video 3. Download and install packages for building kernel modules.

3. The next procedure is similar to Windows, in the *Devices* menu select *Insert Additions CD Image...* After inserting the CD, a dialog will appear asking if we want to start the installation, which we confirm.

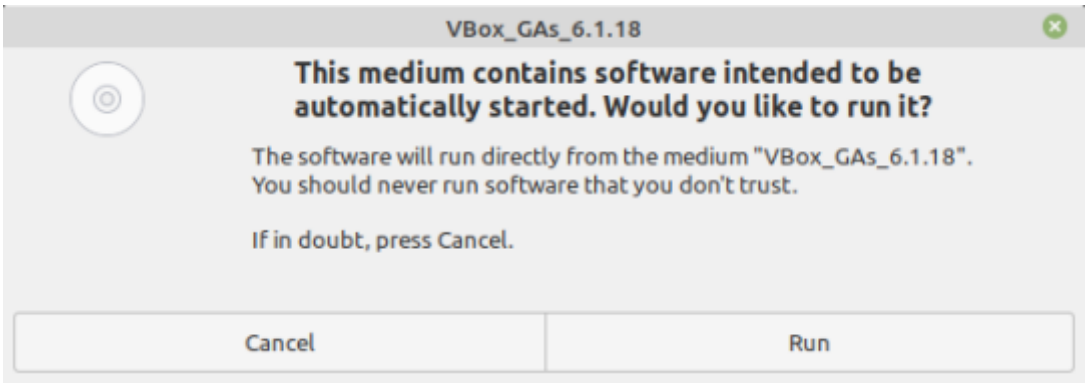

Fig. 10. Running the auto-installation of the Additions CD

4. Enter the password to elevate privileges to superuser.

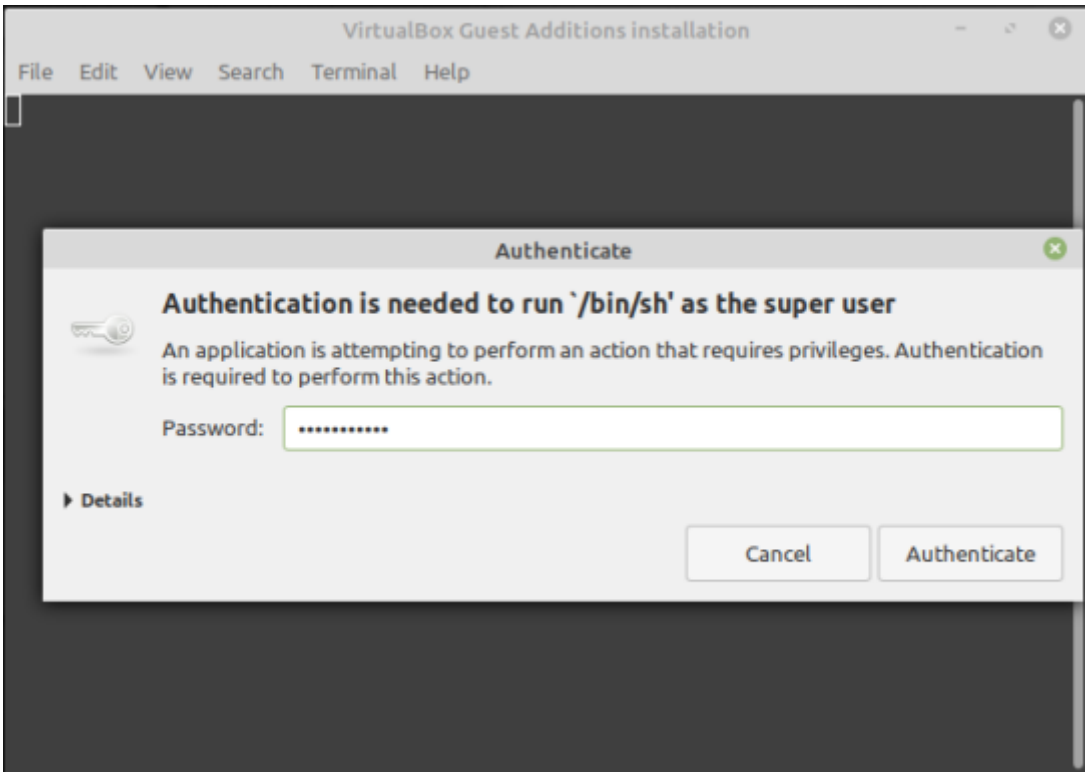

Fig. 11. Entering the password

5. After successful installation, the terminal window will print an output similar to the following, which you can close by pressing Enter and then reboot the virtual machine.

```
Verifying archive integrity... All good.
Uncompressing VirtualBox 6.1.18 Guest Additions for Linux........
VirtualBox Guest Additions installer
Copying additional installer modules ...
Installing additional modules ...
VirtualBox Guest Additions: Starting.
VirtualBox Guest Additions: Building the VirtualBox Guest Additions kernel
modules. This may take a while.
VirtualBox Guest Additions: To build modules for other installed kernels, run
VirtualBox Guest Additions:  /sbin/rcvboxadd quicksetup <version>
VirtualBox Guest Additions: or
VirtualBox Guest Additions:  /sbin/rcvboxadd quicksetup all
VirtualBox Guest Additions: Building the modules for kernel 5.4.0-91-
generic. update-initramfs: Generating /boot/initrd.img-5.4.0-91-generic
VirtualBox Guest Additions: Running kernel modules will not be replaced until
the system is restarted
Press Return to close this window...
```

Video 4. Installation of guest additions.

We now have an operating system installed in a virtual environment ready to work or to explore its features.

Video 5. Testing higher resolution settings and browser test

Similarly, you can create a virtual machine in most virtualization environments and then install a virtualized operating system.

Interaktivní prvek

2.4 Check test

Native hypervisors (type 1 hypervisors) include:

- ☐ Citrix XenServer
- ☐ Microsoft Hyper-V
- ☐ Microsoft Virtual PC
- ☐ Vmware ESXi
- ☐ Vmware Workstation
- ☐ Oracle VirtualBox

Hosted hypervisors (type 2 hypervisors) include:

- ☐ Citrix XenServer
- ☐ Microsoft Hyper-V
- ☐ Microsoft Virtual PC
- ☐ Vmware ESXi
- ☐ Vmware Workstation
- ☐ Oracle VirtualBox

Which of the following parameters is not set when creating a virtual machine?

- ☐ virtual disk size
- ☐ number of CPU cores assigned
- ☐ CPU memory cache size
- ☐ virtual memory size
- ☐ power supply fan speed

The format for storing a virtual disk is not

- ◯ VDI
- ◯ VHD
- ◯ VHS
- ◯ VMDK

Emulation is synonymous with virtualization

- ◯ Yes
- ◯ No

Select a type of virtualization that allows you to run applications with a different architecture than the guest system

- ◯ Container virtualization
- ◯ Emulation
- ◯ Paravirtualization
- ◯ Full virtualization

The statement "This is not virtualization in the true sense of the word, all separate environments use the same operating system kernel." applies to

- ◯ Container virtualization
- ◯ Emulation
- ◯ Paravirtualization
- ◯ Full virtualization

The claim "Complete separation of hosted VMs. Requires no special drivers or operating system modifications." applies to

- ◯ Container virtualization
- ◯ Emulation

- ◯ Paravirtualization
- ◯ Full virtualization

The native hypervisor is used in

- ◯ Container virtualization
- ◯ Emulation
- ◯ Paravirtualization
- ◯ Full virtualization

Select a type of virtualization that performs only partial abstraction at the virtual machine level and provides a virtual environment similar to the physical environment on which the virtual machine is running. The hosted system knows it is running in a virtual environment and communicates with the hypervisor (hardware access requests are translated into hypervisor calls)

- ◯ Container virtualization
- ◯ Emulation
- ◯ Paravirtualization
- ◯ Full virtualization

CHAPTER 3

Desktop and application virtualization

The main alternative to hypervisor-based virtualization is containerization. It uses the kernel of the operating system to run. It allows multiple virtual machines to run in isolation and independently of each other. Virtual machines are referred to as containers or ***virtual environments*** (**VE**s). In this architecture, the operating system is adapted to run as multiple stand-alone systems, allowing distributed applications to be deployed and executed without having to launch a virtual machine separately for each one. Instead, there are several isolated systems, called containers, running on a single management host, all accessing a single operating system kernel.

Interaktivní prvek

3.1 System architectures

Desktop virtualization implementations are classified according to whether the virtual desktop runs remotely or locally, whether or not a persistent connection to the providing server is required, and whether the virtual desktop is persistent between sessions. Software products that provide desktop virtualization solutions can typically combine local and remote implementations into a single product to provide the most appropriate requirements-specific support, such as Network virtualization.

3.1.1 Remote desktop virtualization

Remote desktop virtualization implementations operate in client/server mode. Applications run on the server operating system that communicates with the local client device over the network using a remote display protocol through which the user interacts with the applications. All used applications and data remain on the remote system that receives only information regarding the display, keyboard and keystrokes, movements and mouse clicks on the local client device, which can be a regular computer/laptop, a so-called thin client, a tablet or even a smartphone.

Interaktivní prvek

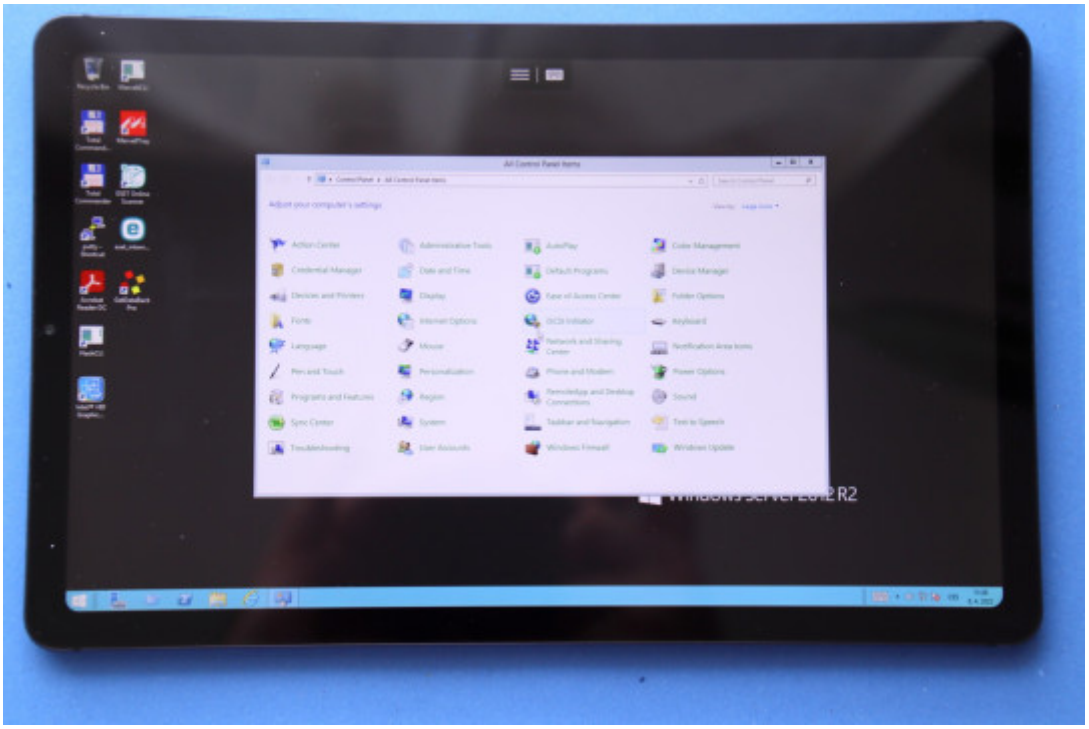

Fig. 12. Windows Server Virtualized Remote Desktop on a tablet

3.1.2 Application Virtualization

Application virtualization improves application security and compatibility by encapsulating them and isolating them from the underlying operating system on which they run. A fully virtualized application is not installed on hardware in the traditional sense. Instead, the hypervisor layer intercepts the running application which behaves as if it were connected to the original operating system and all the resources it manages, when in fact it is not.

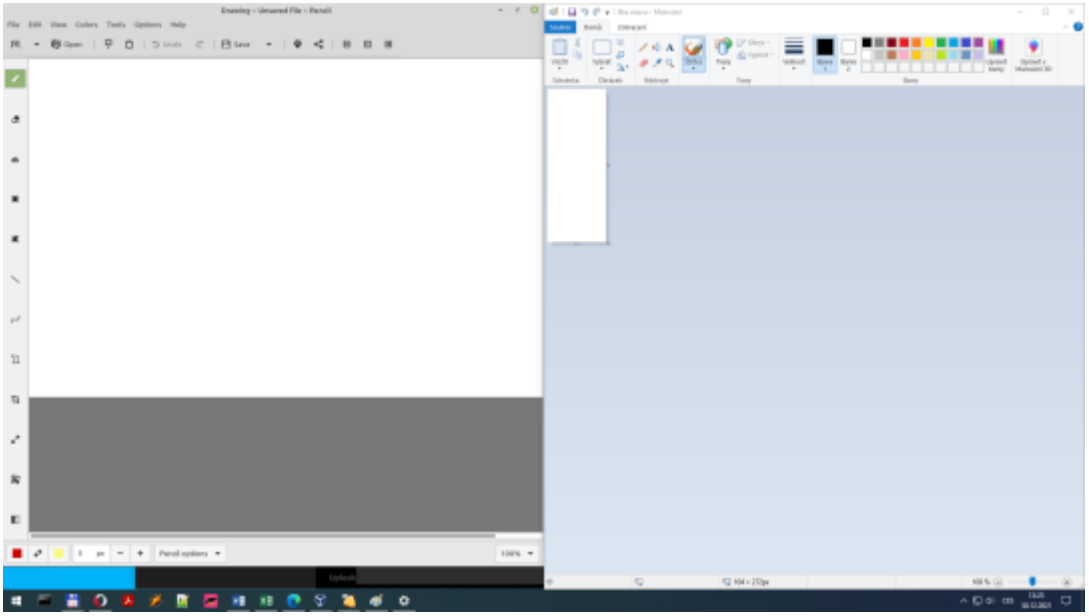

Fig. 13. Virtualized Linux Drawing and Windows Painting running together on Windows

3.1.3 User virtualization

User virtualization separates all the software aspects that define a user's personalization on the device from the operating system and applications to be managed independently and applied to the desktop as needed without the requirement for scripting, group policies, or the use of travel profiles. User virtualization can be used regardless of platform - physical, virtual, cloud, etc. The major desktop virtualization platform vendors, Citrix, Microsoft and VMware, offer some form of basic user virtualization in their platforms.

3.1.4 Local desktop virtualization

Local desktop virtualization implementations run the desktop operating system environment on the client device using hardware virtualization or emulation. Both type 1 and type 2 hypervisors can be used for hardware virtualization, depending on the implementation.

Local desktop virtualization is suitable for environments where continuous network connectivity cannot be guaranteed and where application resource requirements can be better met by local system resources. However, local desktop virtualization implementations do not always allow applications developed for one system architecture to run on another (incompatible) one. For example, it's possible to use local desktop virtualization to run Windows family systems on OS X on an Intel-based Apple Mac using

a hypervisor such as VirtualBox, Thincast Workstation, Parallels Desktop for Mac, or VMware Fusion because they both use the same x86 architecture.

3.2 Check test

The software encapsulation of an application that allows it to be isolated from other processes running on the Linux operating system is called:

- ◯ hypervisor
- ◯ supervisor
- ◯ container
- ◯ bin

When virtualizing a remote desktop, must the server and client have the same processor architecture?

- ◯ Yes
- ◯ No

CHAPTER 4

Network virtualization

Network virtualization allows you to programmatically create, operate and manage communication networks using software tools that utilize the physical infrastructure. Network and security services in the software are distributed to hypervisors and "attached" to individual virtual machines (**VM**s) in accordance with the network and security policies defined for each attached application. When a **VM** moves to another host, its network and security services move with it. If new **VM**s are created for the purpose of scaling applications, the necessary policies are then dynamically applied to these **VM**s as well.

Just as a virtual machine is a software container that provides logical computing services to an application, a virtual network is a software container that presents logical network services - logical switching, logical routing, logical firewall, logical load balancing, logical VPN, and others for data traffic. These network and security services are software-mediated and only require the IP packet forwarding from the underlying physical network. The logical network elements themselves are connected via a software representation of the physical network " wire". This therefore allows the entire network to be software-based as well.

Network virtualization orchestrates the virtual switches in server hypervisors and the network services that are delivered through them to the attached virtual machines to effectively provide a platform - or the "network hypervisor" - for virtual networking.

One way how to virtual networks can be set up is by using a ***Cloud Management Platform*** (**CMP**) to request virtual network and security services for the corresponding tasks. The controller then distributes the necessary services to the appropriate virtual switches and logically connects them to the appropriate requests.

Fig. 14. Virtual network [11]

4.1 Network virtualization and technologies that could be interchanged with each other

4.1.1 Network virtualization vs. software-defined networks

Network virtualization may evoke ***software-defined networking*** (**SDN**), but in reality they are very different concepts.

A software-defined network allows software management of switches and routers, so it does not virtualize all network components and functions.

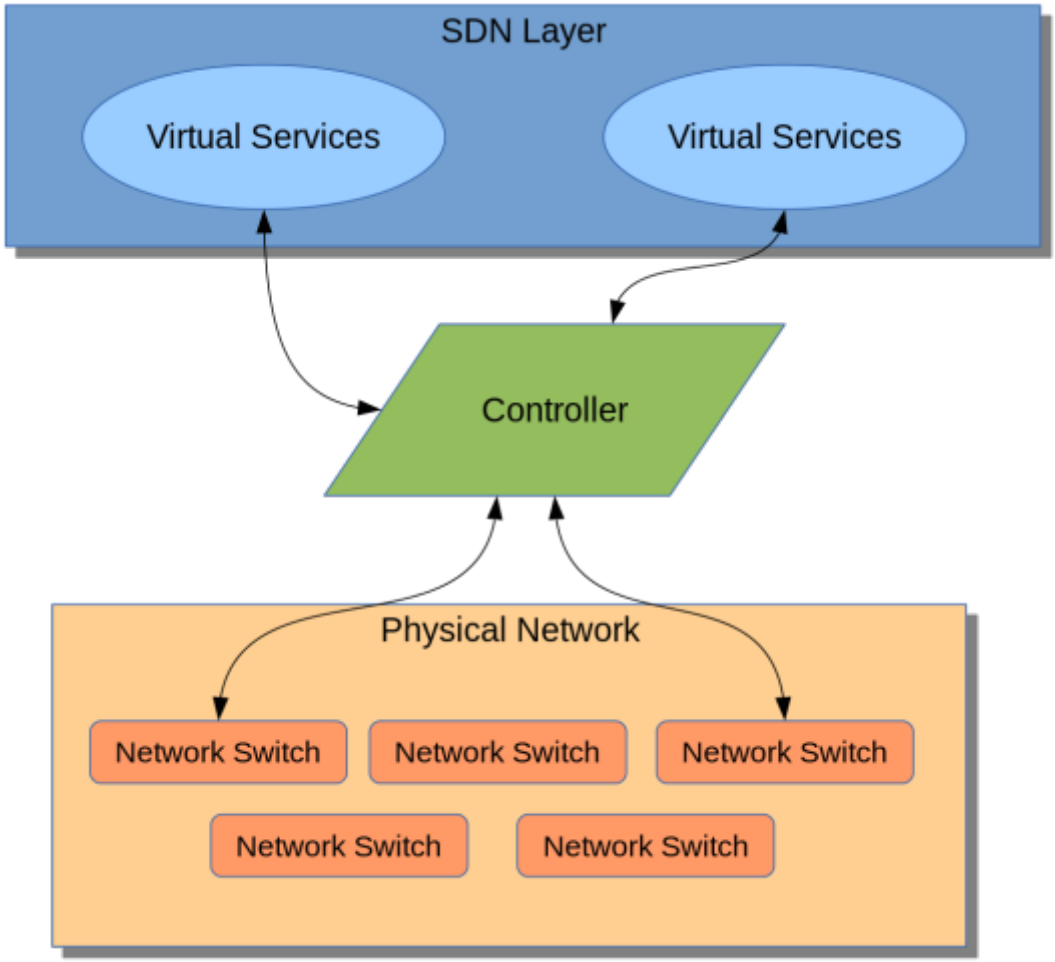

Fig. 15. Diagram of a software-defined network [11]

In contrast, network virtualization replicates all network components and functions in the software. It allows you to run the entire network in software.

Interaktivní prvek

4.1.2 Network virtualization vs. VLAN

A **VLAN** (***Virtual Local Area Network***) divides a physical ***local area network*** (**LAN**) into multiple virtual networks. Groups of ports are isolated from each other as if they were on physically different networks. The **VLAN** access is like slicing a large network pie into many small networks. Looking forward as the network grows, the limitation to 4096 **VLAN**s in a single **LAN** may be a limitation.

Network virtualization is much more than just **VLAN**s and allows you to create entire networks in software - including switching, routing, firewalling and load balancing. This provides much more flexibility than has been possible in the past. With all networking and security services handled in software and connected to **VM**s, management- and configuration-intensive processes can be simplified and automated, with networks being created automatically to meet the requirements.

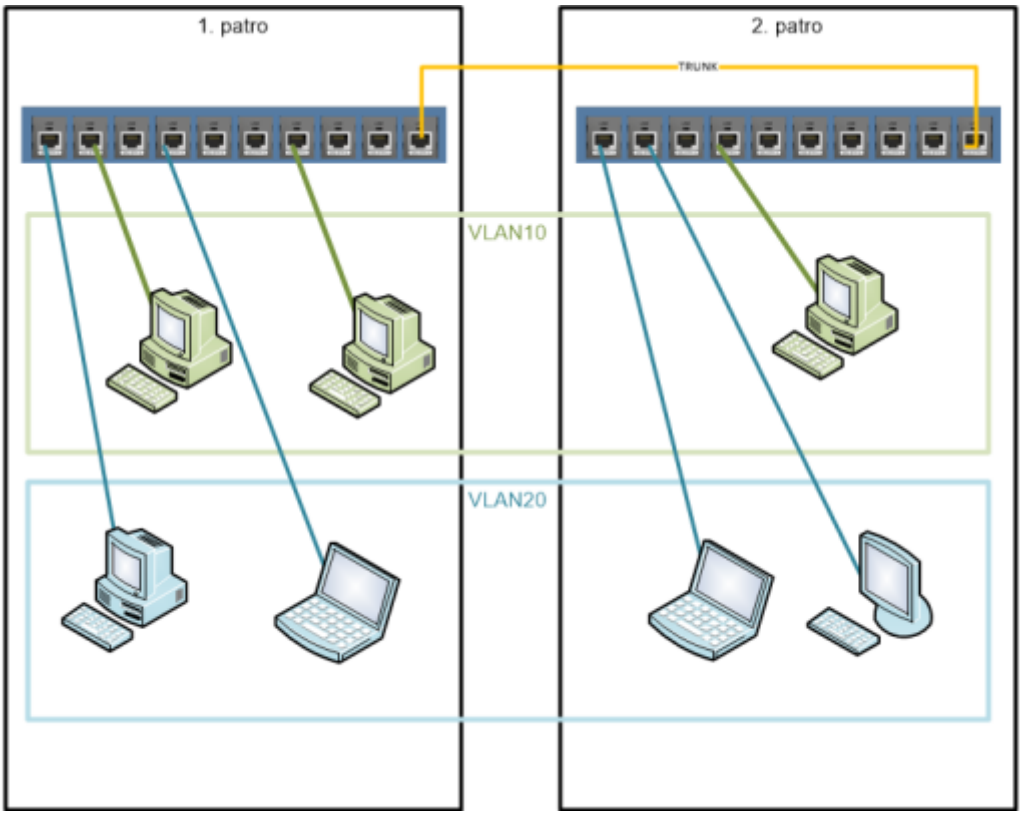

Fig. 16. Example VLAN

According to the IEEE 802.1Q recommendation, the virtual network identifier field (**VLAN** TAG) is inserted into the Ethernet frame . However, this extends the Ethernet frame by 4 bytes, which could indicate incompatibility with devices that do not support **VLAN** TAG. From a technical point of view, therefore, the switch must distinguish between two types of interfaces - access and trunk.

Interaktivní prvek

4.2 Summary of IT virtualization

Interaktivní prvek

4.3 Check test

In one LAN, there can be maximum of:

- ◯ infinite VLANs
- ◯ 256 VLANs
- ◯ 4096 VLANs
- ◯ 4294967296 VLANs

The terms network virtualization and software-defined networking are identical:

- ◯ Yes
- ◯ No
- ◯ Only when using Cisco equipment

CHAPTER 5

Other types of virtualization

The previous three chapters dealt mainly with virtualization in the IT environment, whether it was virtualization of hardware, operating systems, individual applications, or virtualization of network elements or entire communication networks. But almost anything that has any real basis can be virtualized. We can talk about virtual operators in the telecommunications market, in the energy commodities market, in the services market in general; we can also talk about virtual worlds, virtual economies and, last but not least, virtual reality.

Fig. 17. Hologram [9]

5.1 Virtual operators in telecommunications

A ***Mobile Virtual Network Operator*** (**MVNO**) is a service provider that has a network access contract with a licensed ***Mobile Network Operator*** (**MNO**). A Mobile Virtual Network Operator does not usually own any network infrastructure or mobile network license. Therefore, network access must be provided by the mobile network service provider.

Regarding the degree of dependence of the virtual operator on the services of the network operator, virtual operators can be divided into the following categories:

Interaktivní prvek

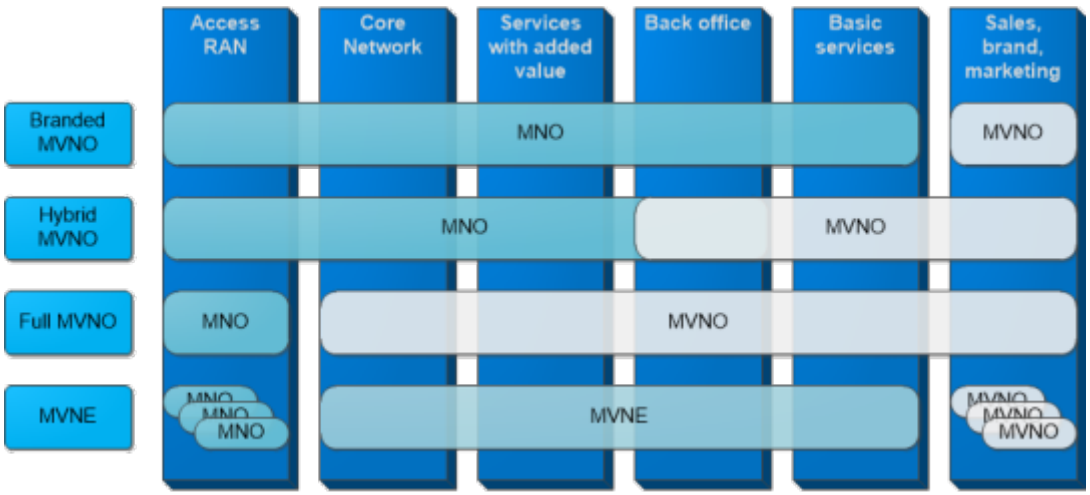

Fig. 18. Categorization of virtual mobile operators by services provided

Interaktivní prvek

5.2 Virtual world

A virtual world is a form of online community that usually takes place in a computer-simulated environment through which users can interact, create and use objects. The term virtual world becomes synonymous with interactive 3D virtual environments where users take the form of avatars visible to other users.

The computer simulation of the world offers a stimulus for users to manipulate elements of the modelled world. Such simulated worlds can resemble the real world or, conversely, represent fantasy worlds. The modelled world can simulate real-world rules such as gravity, topography, locomotion, real-time actions and communication. Communication between users can take the form of text, graphical symbols, virtual gestures, or sounds.

Massively multiplayer online (**MMO**) games generally depict a world very similar to the real world with real action and communication. Players have the ability to move between buildings, cities, and even worlds to trade or just pass the time.

Virtual worlds are not limited to games, but can also provide computer conferencing or text chat depending on their immediacy.

Fig. 19. Virtual world [10]

5.3 Virtual economy

A virtual economy (or sometimes synthetic economy) is an emerging economy that exists in the virtual world that usually exchanges virtual goods in the context of a online play, especially in massively multiplayer online (**MMO**) games. People enter these virtual economies for recreation and entertainment rather than out of necessity, meaning that virtual economies lack aspects of the real economy that are not considered "fun" (for example, avatars in virtual economies often have no biological urges at all). However, some people interact with virtual economies for "real" economic benefit.

5.4 Virtual reality

Virtual reality (**VR**) is about creating a visual, auditory, tactile or other impression of reality, usually requiring special goggles, a helmet or at least a smartphone in a special display device to generate realistic perceptions.

The basis of virtual reality is commonly a stereoscopic displaying device in the form of a headset, optionally with one or more peripherals, which are mainly used to interact with the virtual environment (controllers) or to estimate and visualize the user's position and attitude (motion sensors).

Stereoscopic imaging can be achieved in several main ways:

Interaktivní prvek

The simplest kit for getting to know the possibilities of VR is the Google Cardboard, whose model in 3D or for display in virtual reality is shown below.

Interaktivní prvek

Interactive object 1. Google Cardboard 3D + VR model

5.4.1 Practical application

Virtual reality can be used in many fields, for example:

Interaktivní prvek

Interaktivní prvek

Interactive object 2. Demonstration of a 3D model with the option to view in VR

5.5 Check test

Stereoscopic imaging in virtual reality cannot be achieved using

- ☐ color filtering
- ☐ with a quick blink of the eyes
- ☐ by displaying different views on two displays
- ☐ using rear projection

Mobile Virtual Network Operator (MVNO)

- ◯ never owns any network infrastructure
- ◯ usually does not own any network infrastructure
- ◯ always own network infrastructure

CHAPTER 6

Conclusion and final test

The Virtualization in Practice educational material took the reader through the areas of virtualization, especially in the area of information technology and electronics, which he may commonly encounter, either on purpose or using the services of virtualized systems without being aware of it.

We have described the virtualization of both software and hardware computing, introduced the different types and levels of virtualization, and illustrated in a detailed example the process of enabling a (para)virtual machine in a home environment.

Then we briefly introduced virtualization technologies in the area of computer networking, and discussed what is and what is not hidden under the term network virtualization.

In the last chapter, we then looked at virtual issues closer to the majority population, whether it is providers of virtual telecommunications services, , virtual worlds and the emerging trend of virtual reality, where we also showed virtual reality works in 3D.

However, virtualization is not limited to these areas, with the available power of current computing technology and the further expected increase in its power and specialization in virtualization, it can be expected that in the future our daily lives will increasingly take place in virtual worlds and it is up to the judgement of each user to decide what they consider to be the right balance between reality and virtuality.

Fig. 20. Matrix [17]

6.1 Final test

Fig. 21. Final test [15]

Native hypervisors (type 1 hypervisors) include:

- ☐ Citrix XenServer
- ☐ Microsoft Hyper-V
- ☐ Microsoft Virtual PC
- ☐ Vmware ESXi
- ☐ Vmware Workstation
- ☐ Oracle VirtualBox

The statement "This is not virtualization in the true sense of the word; all separate environments use the same operating system kernel." applies to

- ☐ Container virtualization
- ☐ Emulation
- ☐ Paravirtualization

☐ Full virtualization

In one LAN, there can be maximum of:

◯ 16 VLANs

◯ 256 VLANs

◯ 4096 VLANs

◯ 4294967296 VLANs

The terms network virtualization and software-defined networking are identical:

◯ Yes

◯ No

◯ Only when using Cisco equipment

Mobile Virtual Network Operator (MVNO)

◯ never owns any network infrastructure

◯ usually does not own any network infrastructure

◯ always own network infrastructure

Stereoscopic imaging in virtual reality cannot be achieved using

☐ color filtering

☐ with a quick blink of the eyes

☐ by displaying different views on two displays

☐ using rear projection

Software encapsulation of an application that allows it to be isolated from other processes running on the Linux operating system is called

- ◯ hypervisor
- ◯ supervisor
- ◯ container
- ◯ bin

Which of the following is not set when creating a virtual machine?

- ☐ virtual disk size
- ☐ number of assigned CPU cores
- ☐ CPU memory cache size
- ☐ virtual operating memory size
- ☐ power supply fan speed

The format for storing a virtual disk is not

- ◯ VDI
- ◯ VHD
- ◯ VHS
- ◯ VMDK

When virtualizing a remote desktop, must the server and client have the same processor architecture?

- ◯ Yes
- ◯ No