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Creating a Hyper-V 2016 Virtualization Lab Environment

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Abstract		
<p>The purpose of this thesis was to create a virtual lab environment for introducing Windows server 2016 Hyper-V server role and its new features to the South-Eastern Finland University of Applied Sciences (Xamk) students. The practical part was completed by using the VMware workstation player. Created lab tasks for educating students are based on material found on official Microsofts information sources.</p>		
<p>The lab environment is hosted on one of Xamk university computers. Using VMware workstation player virtual machine with Windows server 2016 was created. For domain services, an already existing virtual machine with Windows server 2012 was utilized. To test more advanced virtualization techniques an extra nested virtualization host virtual machine was deployed.</p>		
<p>The end result of this thesis work was a functional and tested lab environment introducing students new important virtualization features such as nested virtualization, virtual machines groups and collections, Windows PowerShell direct and live migration without failover clustering. In addition to the virtual lab environment, an educational document was created, it contains tasks and instructions that help to gain valuable experience with Windows server 2016 and new Hyper-V virtualization functions. Lab tasks encourage students to use Windows PowerShell framework that is essential for successful computer network administrator.</p>		
Keywords		
Windows server 2016, Hyper-V, Virtual lab environment		

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Appendix 1. Hyper-V 2016 Lab 1. Introduction to new Hyper-V features

1 INTRODUCTION

In our modern times of technology, virtualization is a very commonly used tool that allows saving money and utilizing computer hardware much better. It is believed that the concept of virtualization started developing between 1960 and 1970 when IBM made a huge investment in the development of robust time-sharing solutions. The time-sharing concept allows a large group of users to use the same pooled computing resources to optimize the efficiency of computer hardware. The newfound virtualization model caused a positive effect in computer technology: it considerably dropped costs of computing resources and made it possible for companies or individuals to use a computer without purchasing it. Even today virtualization is still developed because quite often servers are too powerful to utilize all available resources efficiently.

Windows Server 2016 is currently the newest version of server operating system released by Microsoft. However, South-Eastern Finland University of Applied Sciences (Xamk) is still using Windows Server 2012 virtual machines. Because of that students can't experiment and gain experience with new technology. The main goal of this thesis is to develop a virtual lab environment that will help to introduce Xamk students to Windows server 2016 and the new virtualization features it brings. By following the instructions students will get experience on new Hyper-V virtualization topics: nested virtualization, virtual machines groups and machines, Windows PowerShell Direct and live migration without failover cluster.

2 VIRTUALIZATION

This chapter will cover theoretical part of virtualization technology. Virtualization process will be explained in detail in order to understand why many big companies implement virtualization into their IT infrastructure. Also, this chapter will cover many virtualization types and explain their individual characteristics. Since the virtualization is a complex and flexible technology it can be used on many different platforms utilizing different tools. Virtualization tools and requirements will also be discussed.

2.1 What is virtualization ?

Virtualization means creating something virtual instead of real, such as OS, a storage device or network entities, hardware. Virtualization is very popular with companies who have big IT infrastructures, because it enables running desktop computers, servers or storage devices in a virtualized environment with almost identical functionality as real physical devices. Another beneficial feature that virtualization technology brings is that it enables running multiple virtual machines on the same physical host optimizing computing resources. Operating systems inside virtual machines interact with the software emulations of real hardware. Because of that guest operating systems have no information that it uses virtualized hardware. Performance of operating systems running on virtual machines instead of true hardware have been always worse, but it is considered a small drawback, because most operating systems and applications don't require full utilization hardware. This creates greater flexibility, isolation and control by removing the dependency on the hardware platform. (Margaret 2016.)

2.2 Virtualization types

Currently, there are six areas where virtualization is optimized and commonly used today:

1. Network virtualization

Network virtualization is a virtualization function that combines available network resources by separating available bandwidth into channels. Each channel is independent of the others and can be applied or reapplied to a particular device. The concept of virtualizing networks hides the true complexity of the network by splitting it into smaller, manageable segments making it a lot more flexible and easier to manage. (Margaret 2016.)

2. Storage virtualization

According to Margaret (2016), storage virtualization is a virtualization method that gathers all of the available physical storage from multiple network storage devices into a singular virtual storage device that can be managed by a central console.

3. Server virtualization

Server virtualization camouflages server resources like quantity and details of singular physical servers, operating systems, and processors from the virtual server. The idea is to make it easier for every user to manage his server by hiding complicated details of server resources while making resource sharing and utilization much easier. (Margaret 2016.)

The software layer that permits this utility is known as a hypervisor. Type 1 hypervisor usually sits directly on bare metal, enabling hardware virtualization for virtual machines. KVM is a Linux kernel based hypervisor that has Type 1 virtualization benefits. Type 2 hypervisors require a hosted operating system, they are often used for testing or lab environments. (Margaret 2016.)

4. Data virtualization

According to Margaret (2016), data virtualization is utilizing data management systems to allow programs to get and manipulate data without the requirement for technical details.

5. Desktop virtualization

Desktop virtualization is a type of virtualization that tends to virtualize workstation load instead of the server. This grants the user access to the desktop remotely, often using a thin client. Because the workstation is fundamentally running in a data center server, a connection to it can be more secure and portable. Using this type of virtualization requires attention to operating system licenses. (Margaret 2016.)

6. Application virtualization

Application virtualization means isolating the application layer from the OS. By using this method the application can work in an encapsulated mode without dependency on the operating system beneath. This allows running Linux applications on Windows operating system and vice versa, also adding an extra layer of isolation. (Margaret 2016.)

2.3 Hypervisors

The hypervisor is the resource allocation system that interfaces the virtual machines to the hardware. Hypervisors also act as a key management system for virtual machine control. Currently, there are two types of hypervisor: Bare metal and hosted. (Tony 2014.)

The bare metal hypervisor is also known as Type 1 or native hypervisor. It doesn't require any operating system to be preinstalled, because, it is OS, just in very stripped, basic form. If host devices purpose is virtualization alone, this is the most efficient type of hypervisor, because it allows accessing hardware through the hypervisor. Hosted virtualization is known as type 2 or management layer approach. Quite often for this approach users use their own hardware and operating system to host and run virtualization software like hyper-v or Vmware. Therefore, as figure 1 shows fundamentally, Type 1 and Type 2 hypervisors use a different approaches for virtualization. (Jones 2009.)

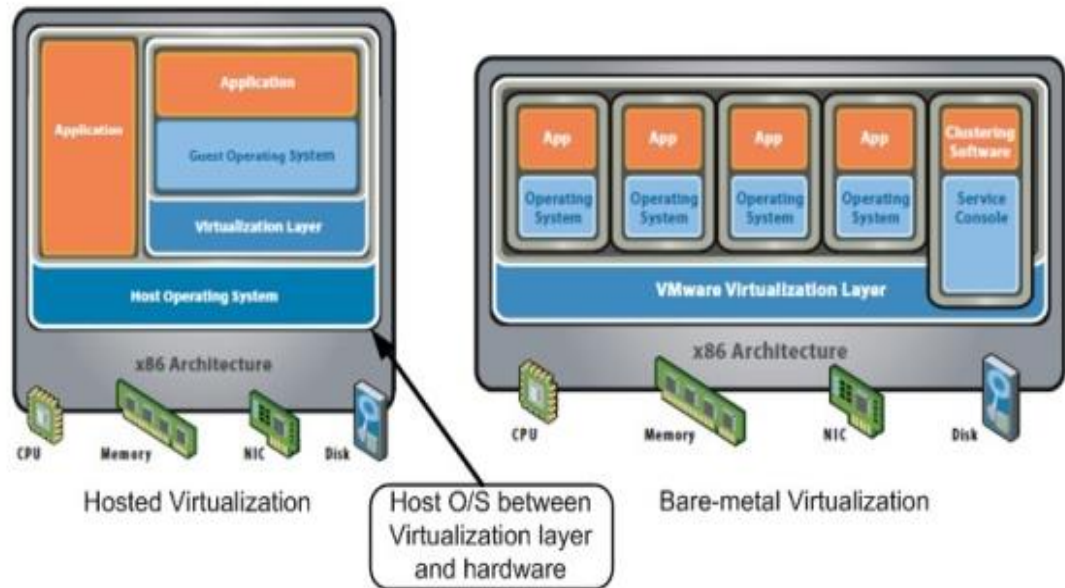


Figure 1. Hosted and baremetal hypervisors (Siebert 2009.)

2.4 Containers

Containers share a lot of similarities with virtual machines. However, instead of virtualizing hardware they create virtual machines on OS level. Containers were developed to create a flexible isolated environment for running applications, as introduced in figure 2. Containers may look like virtual machines, but their structure is very different. Containers have their own space to process computing operations, an ability to execute commands as an administrator, their networking entities are all private and custom. In Linux, containers have a functionality to share the hosts kernel between other containers. (Kasireddy 2016.)

2.5 Cloud computing

Cloud computing is a technology that allows providing computing services using the internet. Most common services that are provided with cloud computing are: renting virtual machines for server hosting, renting virtual storage or application platforms. Cloud computing is very popular because it is a very attractive solution for both business owners and end users. End users can easily gain almost any amount of computing resources without the need to worry about provisioning and management of those resources. Also, since every service is accessed through

internet end users don't need to worry about network and hardware security as much. There are three types of clouds: Public, private, hybrid. Public cloud is open to everyone, usually used for email or application testing. Private cloud is hiding behind firewall and hosts all computing resources internally, it is usually used for securing important data. Hybrid cloud is made of public and private clouds to protect some areas better than other ones. To sum up, cloud computing is a cost-effective service that offers flexible, cost-effective solutions over the internet. (Margaret 2017.)

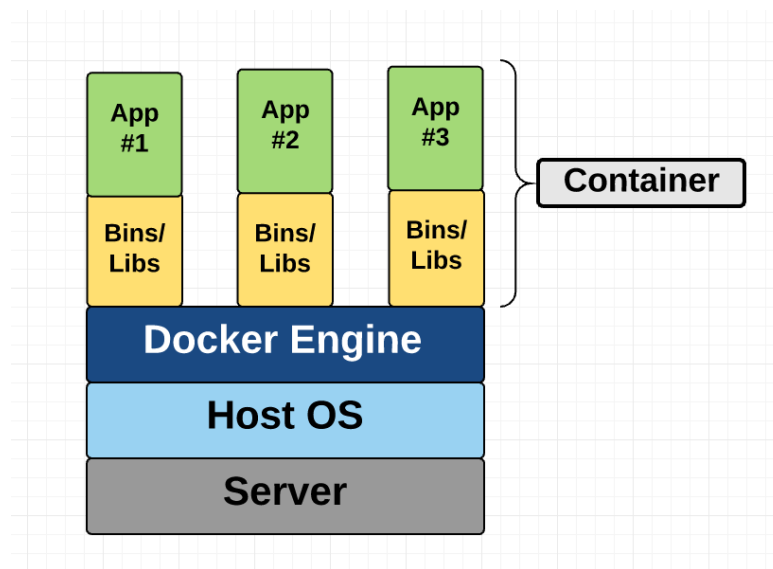


Figure 2. Container structure (Kasireddy 2016.)

2.6 VMware

VMware inc. was created on February 10, 1998, and it is an information technology company. The main focus of the company is the development and application of virtualization technologies with x86 server-based computing and separating application software from hardware. The source of company income comes from selling various products that enhance IT resources management across private clouds. (Reuters 2018.)

The VMware workstation is a hosted hypervisor that is capable of running on x64 and x86 Windows and Linux operating systems. It enables users to host virtual machines on a single physical machine, and use both virtual machines and host

computer simultaneously. Each virtual machine hosted with VMware software can execute various operating systems like Windows, Linux, MS-Dos, and BSD. Virtual machines on VMware platform can be easily customized. Users have tools to create virtual networks that are usually used for communication between VMs. Also, users can modify various hardware parameters like the processor, RAM memory, storage and other physical devices. Overall, VMware has many great features that provide flexibility when managing virtual machines: snapshots, guest isolation, shared folders and a lot more. (Margaret 2017.)

2.7 Hyper-V

Hyper-V was developed by Microsoft as a virtualization tool that completes virtualization tasks through a hypervisor-based emulations. Hyper-V is a server hypervisor that allows hosting multiple virtual servers or desktops on a single physical host. (Siron 2013.)

The Hyper-V requirement is that the processor must support hardware virtualization and data execution prevention. It is desired that the computer processor supports second-level address translation because that helps with memory-intensive workloads. Older hyper-v servers can be running with 512 MB of RAM. However, for virtualization servers, at least 4 GB of RAM is a necessity. Non-Windows processes like backup software running on host server will require an even bigger pool of memory for optimal work. (Siron 2013.)

2.8 KVM

The kernel-based virtual machine also known as KVM is a software that allows transforming physical host running the Linux operating system into the hypervisor. This type of virtualization requires the physical host to support either AMD-V or Intel VT technologies. According to Redhat (2018), to run KVM Linux can't be older than 2007 version and it is necessary to install it on the x86 platform. Because KVM is basically running on Linux operating system it uses SELinux and sVirt to strengthen VM security and isolation. Since Linux is one of most flexible OS, this enables KVM to use NAS and multipath I/O to improve storage flexibility and

redundancy. Many companies save money by using KVM since it is open source and has major qualities required for optimized and flexible virtualization: Live migration, lower latency, scheduling and resource control... However, managing KVM requires deep knowledge about Linux OS and practical skills with the command line, so to learn how to use it efficiently may take some time. (Von Hagen 2014.)

2.9 Migration

Virtual machine migration is an action of transferring virtual machine from one virtualization host to another. It is one of the most important virtualization features that helps hyper-v to manage more complex virtualization environments. During the process of migration all virtual machine components like virtual storage, network adapters move to another host. Usually, virtual machine migration required that virtual machine has to be offline. This kind of requirement made migration much more complicated since servers hosted on virtual machines had to be turned off. Usually, servers that are hosting important services can't afford downtime. To tackle this problem feature called live-migration was introduced, live migration has the ability to move virtual machines while they are running. There are even more migration types with unique characteristics: storage live migration, shared-nothing live migration, quick migration. (Roussey 2017.)

One of the less used migration types is shared nothing live migration. This type of migration shares one important similarity with live migration: No need to power off virtual machines to proceed with the migration. The main goal of shared-nothing live migration is to transfer virtual machines between virtualization hosts. In most common scenarios shared-nothing live migration is executed hand in hand with Storage live migration. (Roussey 2017.)

2.10 Intel-VT

Intel VT is a feature of Intel processors that allows creating virtual machines or environments with help of software that is running on an operating system. Intel virtualization technology enables users to use the full power of their processor, by

splitting processing power into smaller logical processors that will be used by multiple virtual machines or OS's creating flexibility to create advanced virtual environments. (Technopedia 2018.)

2.11 Virtual memory

Virtual memory is very often used in virtualization environments, its purpose is to support physical memory. It allows utilizing computer hardware in combination with software to compensate for physical memory shortages by temporarily sending data from main memory to disk storage, look at figure 3. Random-access memory is not infinite in computers because it requires physical space for hardware. Because servers tend to run multiple services it is very easy to reach RAM shortage. A server that utilizes virtual memory can load much more resources heavy applications. Another benefit of virtual memory is its ability to handle the double amount of addresses compared to main memory. Applications are using virtual addresses for data and commands storage, when the application is executed, the process of converting virtual addresses into actual memory addresses begins. However, virtual memory has one huge disadvantage, the computer using virtual memory slows down because it requires extra computing power for address translations. (Margaret 2017.)

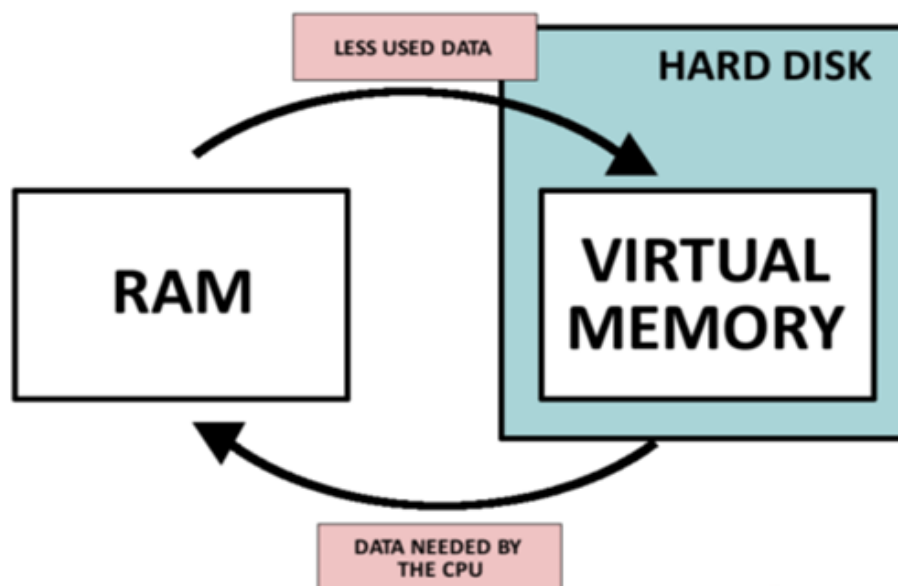


Figure 3. Virtual memory process (Teach-ict.)

3 WINDOWS SERVER 2016 VIRTUALIZATION ENVIRONMENT

Hyper-V provides tools to host multiple virtual machines on a single host. Administrator by using a Hyper-V manager or Windows PowerShell has all tools to create, manage virtual machines. Hyper-V also has capabilities to create a virtual network and virtual storage pools, because of that it is possible to create complex virtual environments. Windows Server 2016 introduced a lot of new hyper-v features, that further enhance virtualization capabilities. (Microsoft 2016.)

3.1 Windows Server 2016

The operating system is a type of software that is designed to communicate with physical hardware, by doing that it enables applications to use computer resources. Today, every smartphone, laptop, desktop computer has an operating system, because without it devices lose a lot of functionality. Current operating system leaders are Linux and Windows. Both Linux and Windows operating systems provide a file management system and graphical interface, however, it can be disabled. One of the most important reasons why the operating system is necessary for a computer is that it provides a platform and graphical interface for computer programs, look at figure 4. (Techterms 2016.)

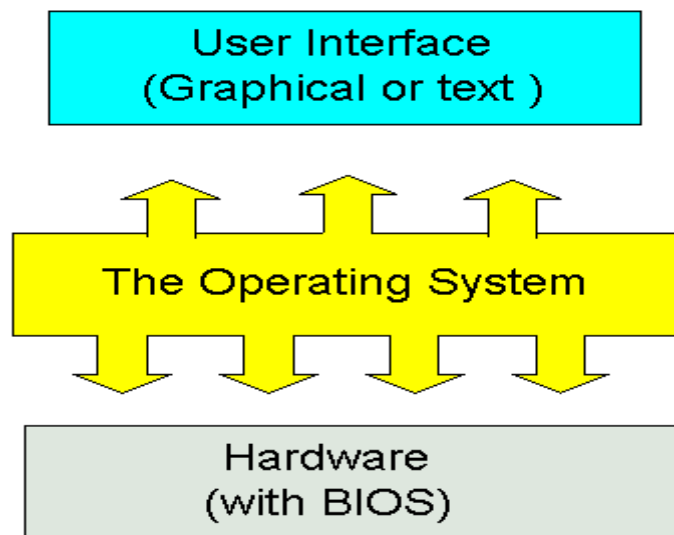


Figure 4. Operating system scheme (Karbosguide.)

Windows Server 2016 is a Microsoft's operating system that is specifically developed for servers. Windows Server 2016 was simultaneously developed with Windows 10, because of that they have a lot of interface similarities. This operating system is very different operating systems that are used for desktops because it supports unlimited user connections, optimized to use huge amounts of memory and storage, can be the host for the domain. Furthermore, Microsofts server operating systems are very expensive, because they require licenses based on processors core numbers. Windows Server 2016 introduces a lot of new features: Nano server, containers, Linux secure boot, ReFS, storage space direct, nested virtualization and many more. (Vigo 2017.)

3.2 Hyper-V 2016 requirements

Not every computer and operating system can run Hyper-V. To fully utilize hyper-v capabilities, the host needs to meet certain prerequisites first. According to Microsoft, Hyper-V requires: VM monitor extensions, 4 GB of RAM, Intel-VT_x or other virtualization technology (look at figure 5) enabled in BIOS and a 64-bit processor that contains SLAT technology. Usually, hyper-v could only be installed only on server operating systems, but windows 10 can also be hyper-v virtualization host. (Microsoft 2016.)

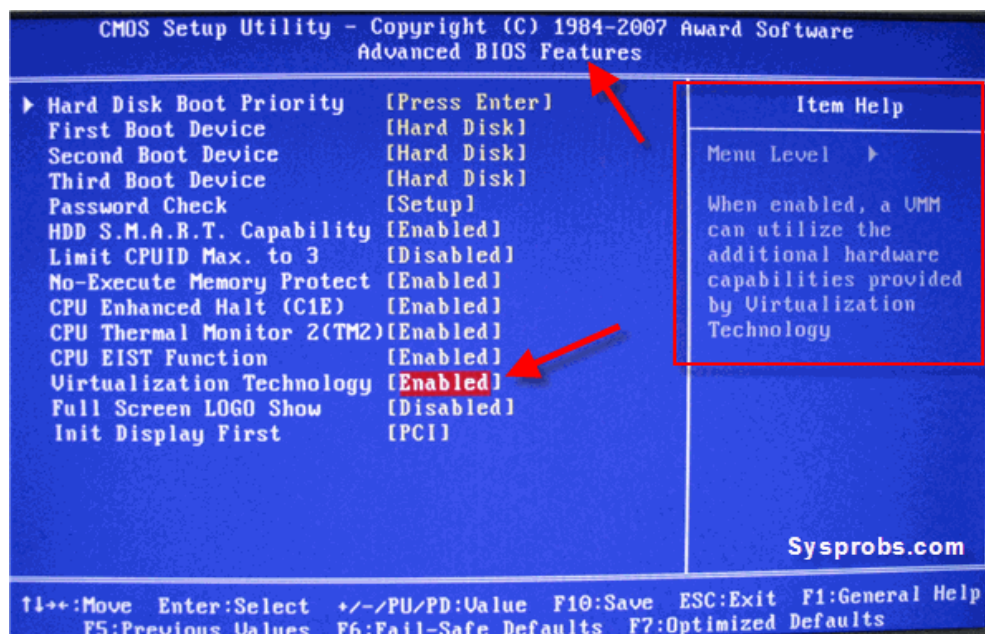


Figure 5. BIOS processor settings (Tareen 2018.)

3.3 Hyper-V virtual networks

Virtual networks are very useful, they help to establish the connection between virtual machine and host. Since virtual machines have no access to actual hardware, Hyper-V capabilities allow to create and configure various virtual networks that function as they would be real. Hyper-V has virtual network management software that is used for creation and management of virtual network adapters. Hyper-V has no limit on how many virtual switches it can create because there are no physical hardware limitations. Currently, there are three types of virtual networks available on Hyper-V: External, internal and private. (Shinder 2010.)

Virtual private networks are not very popular, because they have a very specific use. Virtual private networks are used for communication between guest operating systems on the virtualization host. While virtual private networks are great for connecting between virtual machines, they don't allow the host to communicate with virtual machines. This type of virtual network is perfect if certain virtual machines require complete isolation from other virtual networks. One big disadvantage that this networking method has is that it makes really difficult to receive files from virtualization host. (Shinder 2010.)

The internal virtual network is isolated like virtual private network, however, it provides connectivity between virtual machines and virtualization host. This type of virtual network has no DHCP functionality, so it makes managing virtual networking a bit more complicated since IP addresses have to be assigned manually. (Shinder 2010.)

The external virtual network is unique because it associates with physical network adapters. This type of virtual network grants virtual machines accesses to a physical network which is used by the virtualization host. Because virtual machines can see and communicate with the virtualization host where is possible to share management traffic that is going through the external virtual adapter. (Shinder 2010.)

3.4 Hyper-V nested virtualization

Windows Server-2016 introduced a new major virtualization feature that is called nested virtualization. Nested virtualization allows to better utilize computer processor by allowing hyper-v virtual machine to host another hyper-v hypervisor. This type of virtualization was introduced because it allows to use server resources more efficiently and create more complex virtualization environments. Virtualization requires processor extensions to host and run virtual machines. When hyper-v has executed it blocks all other software that is trying to use those processor extensions look at figure 6. That was the reason why hyper-v was unable to host another hyper-v inside a virtual machine, but this problem is solved in Windows Server 2016 Hyper-V, look at figure 7 (Microsoft 2016.)

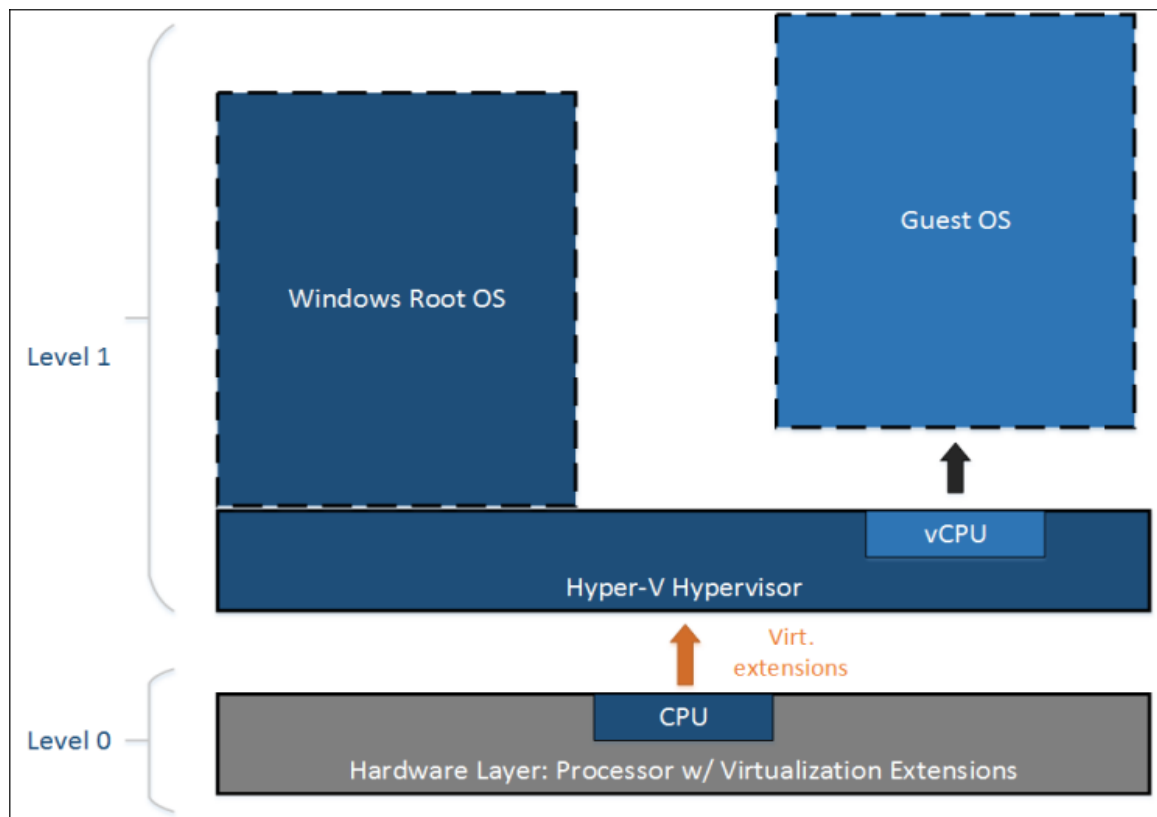


Figure 6. Hyper-V without nesting (Microsoft 2016.)

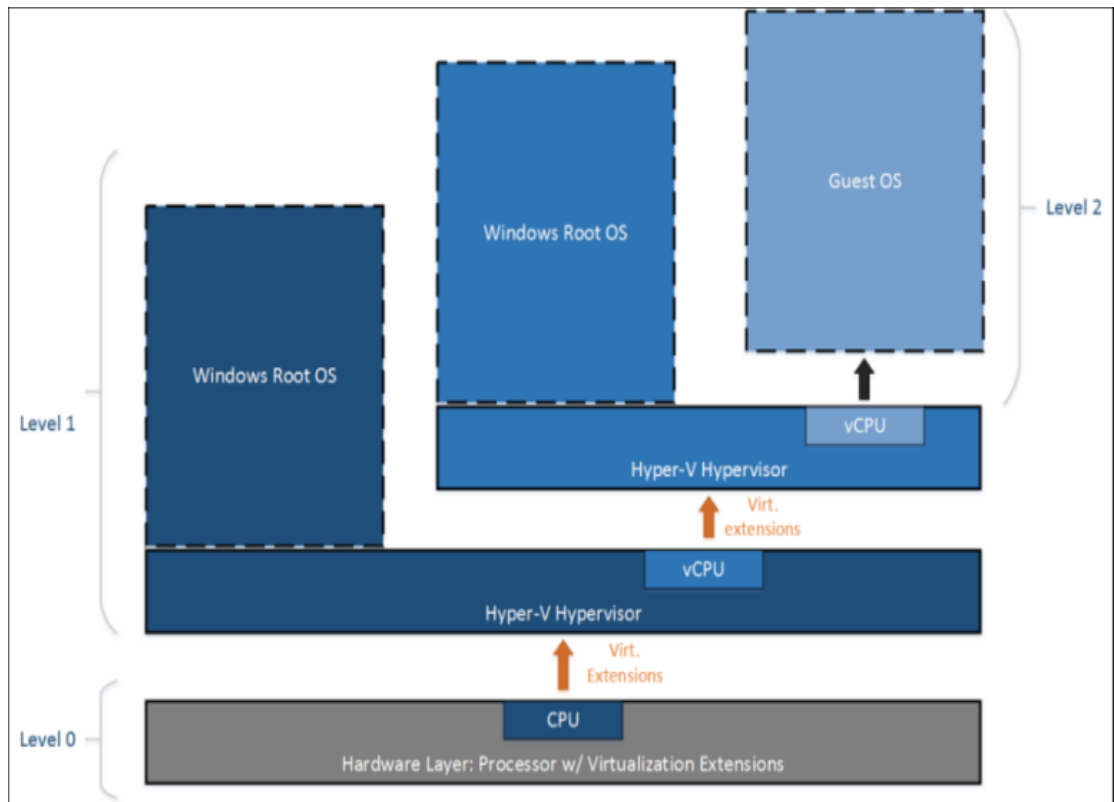


Figure 7. Hyper-V with nesting (Microsoft 2016.)

3.5 New Hyper-V functions in Windows server 2016

Windows Server 2016 is the new addition to server operating systems from Microsoft. According to Microsoft (2016), this version of the operating system introduced a lot of new virtualization features that help to improve and optimize work with virtual environments, as shown in table 1.

Table 1. Windows 2016 new virtualization features (Microsoft 2017.)

Containers	Containers allow running isolated platforms, that are mainly used for safe application testing.
Nano server	The Nano server is a lightweight windows server operating system, that has only minimal functionality. Purpose of nano server is to run cloud applications and containers.

Storage replica	Windows server 2016 introduces asynchronous replication of virtual hard disks. Replication can now be executed at block levels.
Nested virtualization	Now Hyper-V can be hosted inside another Hyper-V virtual machine.
Hyper-V hot add NICs and memory	Adding or removing network adapters on running virtual machine is now possible. Also, running virtual machines with fixed memory now can have memory added with no downtime
Shielded virtual machines	Protection for any generation two virtual machine against the compromised fabric.

3.6 Windows nano server

Nano server is one of the most important features introduced with Windows server 2016. The purpose of Windows nano server is to reduce needless computer resources usage by eliminating user interface and other not necessary applications and processes. The installation of this operating system is headless. A cloud environment is becoming much more successful and popular these days. That is the main purpose why Windows nano server was developed. Regular windows servers are not perfect for running huge amounts of virtual machines, because they have bigger requirements for virtual machines. Nano server doesn't have a lot of needless functions for virtualization, so it gained efficiency. When it comes to virtualization nano server has the ability to deploy multiple virtual machines and application containers in a couple minutes. Also, compared to the regular Windows server it needs approximately 80% fewer reboots. Because Windows nano server has lighter system architecture, security is also improved. Since nano server is dedicated more to cloud environments, a lot of management tools are still available: MMC snap-ins, Windows PowerShell, server manager, MS system center and Desired state configuration. (Ferrill 2015.)

4 PRACTICAL PART

This part of the thesis demonstrates how using knowledge of the theoretical part virtual environment for virtual labs was developed. I will demonstrate how to create and configure virtual machines in VMware workstation player, also I demonstrate the installation process of Windows server 2016. In addition, I will test all tasks of the virtual lab I prepared for students.

4.1 Host computer system information

Using virtualization to create and run virtual machines with server operating systems require powerful hardware with processor virtualization extensions. Used class computer met all necessary hardware requirements, as shown in table 2

Table 2. Host computer specifications

OS Name	Microsoft Windows 10 Educational
System Type	X64-based PC
Processor	Intel(R) Core(TM) i5-6500 CPU @ 3.20GHz, 4 Cores
Installed physical memory (RAM)	16 GB
Hyper-V - VM Monitor Mode Extensions	Yes
Hyper-V - Second Level Address Translation Extensions	Yes
Hyper-V - Virtualization Enabled in Firmware	Yes
Hyper-V – Data Execution Protection	Yes

4.2 Creating Windows server 2016 virtual machine in VMware

To test new virtualization functions of Windows server 2016 I created a virtual machine in the VMware player. I used the VMware new virtual machine wizard. In the wizard, I selected to create a custom virtual machine to make more advanced configurations as shown in figure 8.



Figure 8. New virtual machine wizard

Next, I selected hardware compatibility to be Workstation14 this essentially increases compatibility range of hardware. For installation, I used an ISO image with the Windows server 2016 evaluation version, this is demonstrated in figure 9.

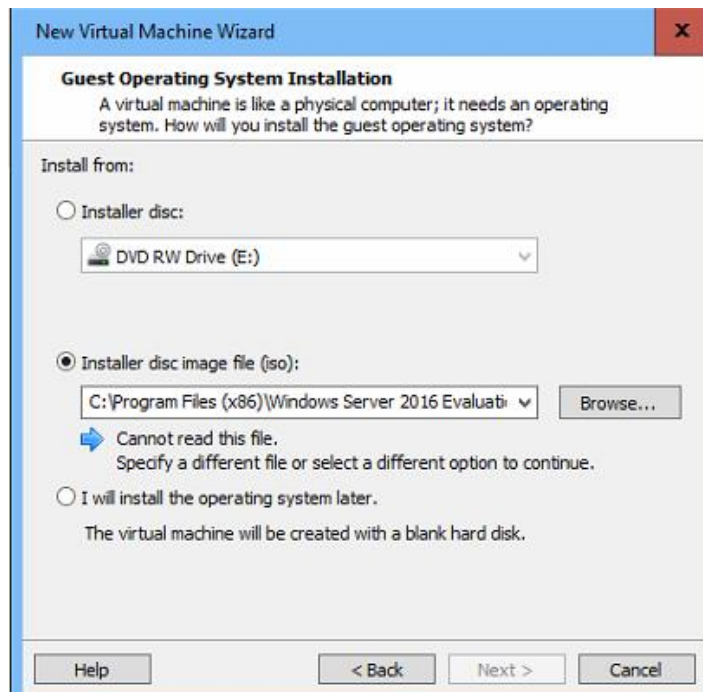


Figure 9. Installation media

I completed the rest of the wizard steps by choosing default options and created “WinSrv2016” virtual machine. In the virtual machine setting, I changed the maximum memory usage to 7.5 GB since I will need a lot of virtual memory to host multiple virtual machines on Hyper-V. Processor cores were set to 4 because running multiple virtual machines on a single virtual host can require a lot of processing power. Also, I disconnected the floppy device to avoid installation errors it usually produces during initiation of the installation wizard, this is demonstrated in figure 10. The Intel VT-x virtualization extensions were also enabled since without them processor cant execute virtualization.

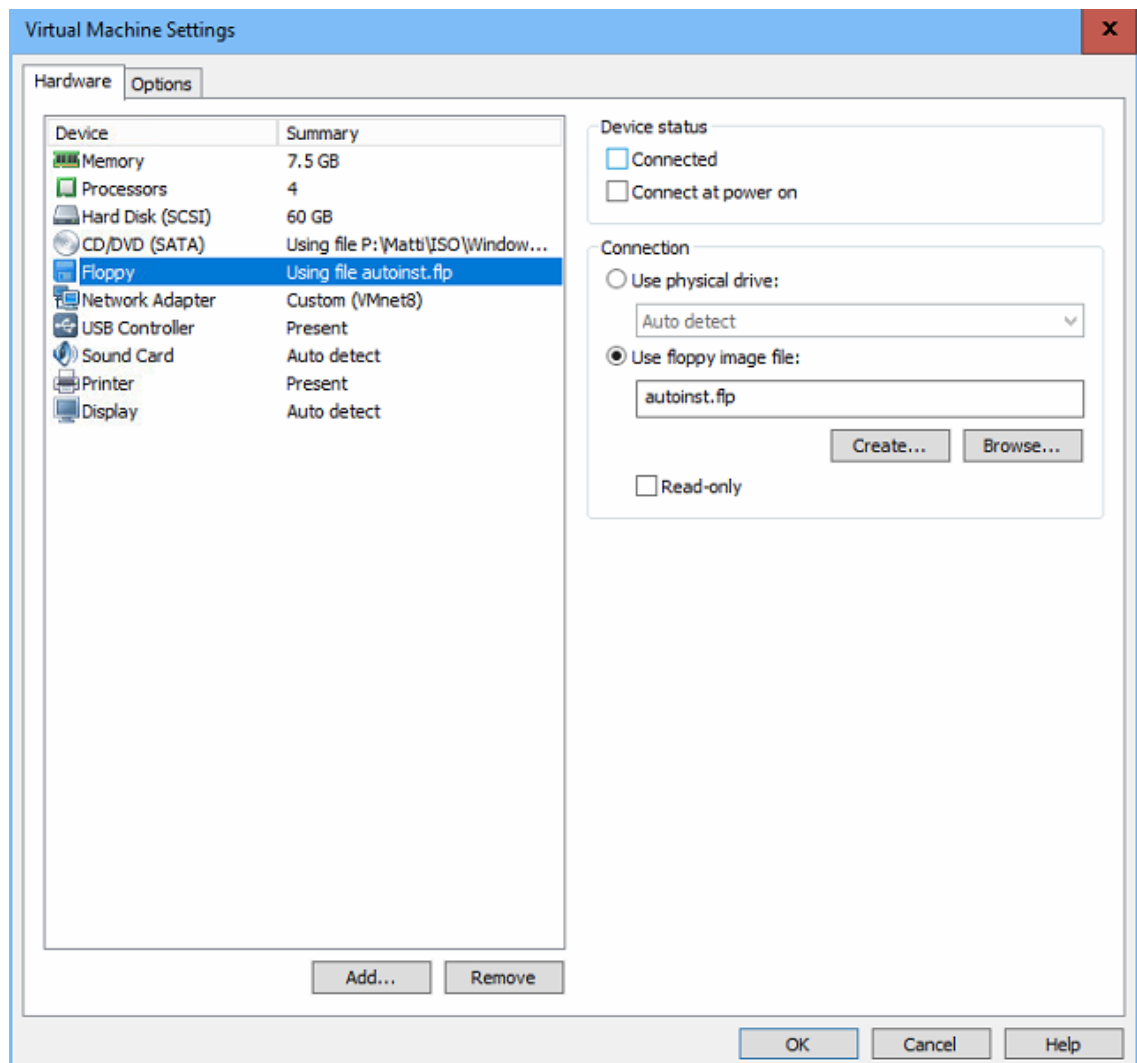


Figure 10. WinSrv2016 virtual machine settings

To ensure connectivity between virtual machines I created a custom NAT network that will be used to establish the connection with the domain controller virtual machine, as shown in figure 11.

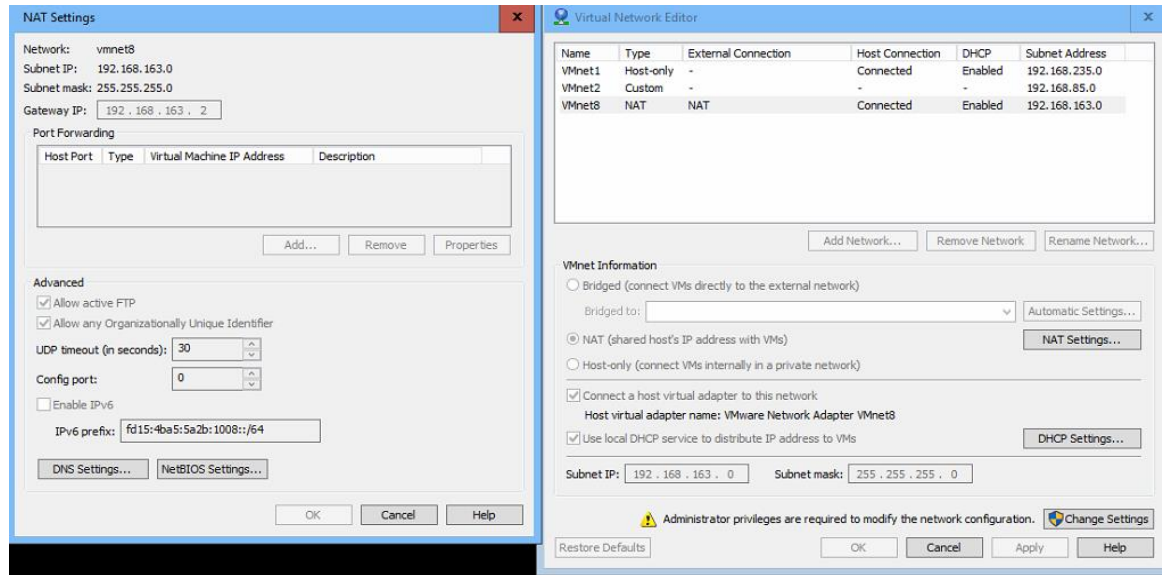


Figure 11. Virtual network editor

Next, I powered on the 'WinSrv2016' virtual machine and began the installation of Windows server 2016. In the installation wizard I selected English language and keyboard layout. In the following step of the installation, I created four hard drive partitions: system, recovery, MSR and primary. These steps are demonstrated in figure 12.

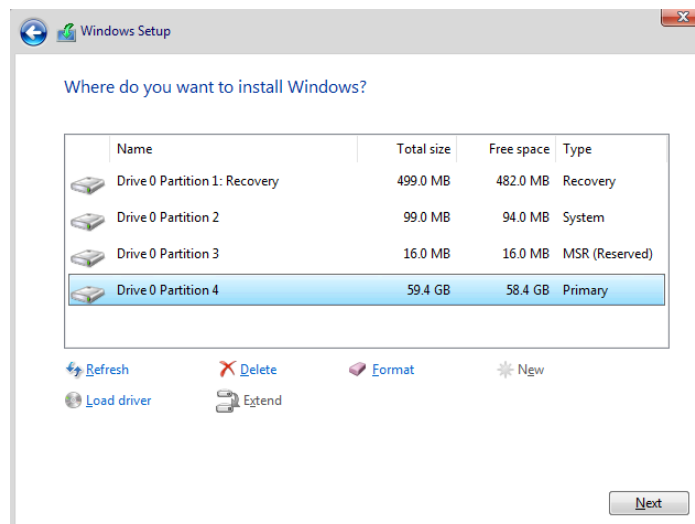


Figure 12. Windows server 2016 installation wizard

4.3 Setting up Windows Server 2016 virtualization environment

Once the installation of Windows was finished, I changed the IP settings of network adapters, so it is using virtual NAT network I created in the previous step and has the ability to contact domain server that is in another virtual machine with address 192.168.163.10. The Internet is reached using gateway address 192.168.163.2, as shown in figure 13.

```
Windows IP Configuration

Ethernet adapter vEthernet (Internal):

    Connection-specific DNS Suffix  . : 
    Link-local IPv6 Address . . . . . : fe80::80b4:35df:4c42:2ec%6
    IPv4 Address. . . . . : 192.168.163.6
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.163.2

Ethernet adapter Ethernet0:

    Connection-specific DNS Suffix  . : localdomain
    IPv4 Address. . . . . : 192.168.163.187
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.163.2

Ethernet adapter vEthernet (External):

    Connection-specific DNS Suffix  . : localdomain
    Link-local IPv6 Address . . . . . : fe80::3cee:d4b3:be8c:7716%8
    IPv4 Address. . . . . : 192.168.163.151
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.163.2

Tunnel adapter isatap.localdomain:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix  . : localdomain

Tunnel adapter isatap.{42F2984A-94B5-4D75-9031-8BB2D883E893}:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix  . :
```

Figure 13. Network configuration of WinSrV2016

Next, I joined “WinSrv2016” to the MAMKLAB.FI domain that is hosted on the “WinServer-DC” virtual machine, as demonstrated on figure 14. Domain services will be required later for virtual machines migration and domain delegation services.

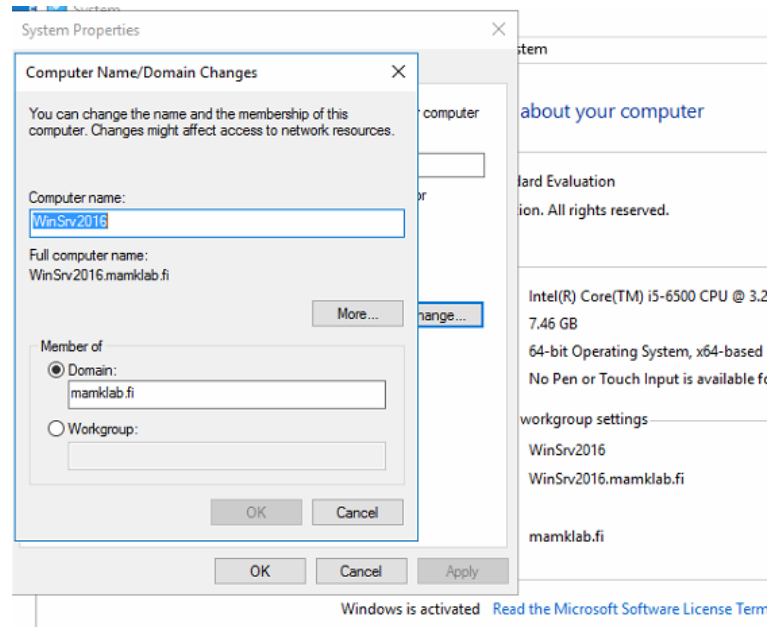


Figure 14. Domain connection

Moving on, I installed Hyper-V server role to enable virtualization on WinSrv2016. By using the Hyper-V manager I created three empty virtual machines PC1, PC2 and PC3. Empty virtual machines will be used in virtual labs for WM groups and collections feature testing. To test the nested virtualization, I created an additional WinServer2016 virtual machine, this is demonstrated on figure 15.

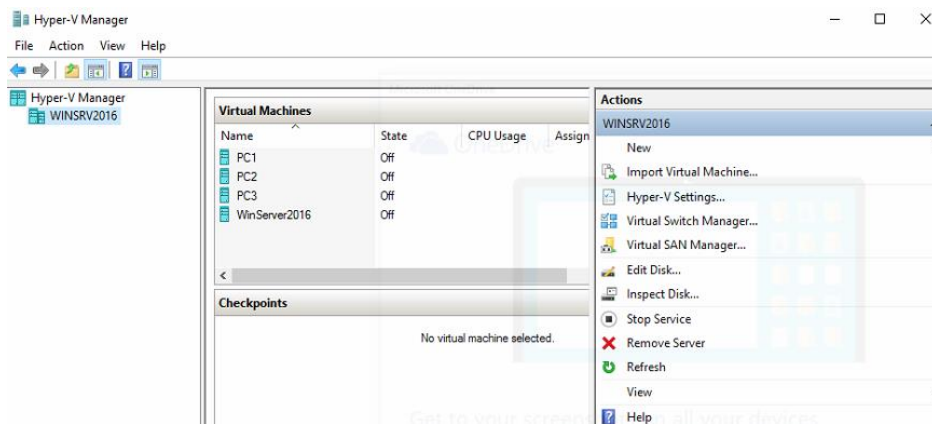


Figure 15. WinSrv2016 Hyper-V manager

By using virtual the switch manager I created two virtual switches: Internal and External. These two switches will allow virtual machines to communicate with the virtualization host and other virtual machines hosted on VMware virtualization player. The external switch is connected to the host network adapter, as shown in figure 16.

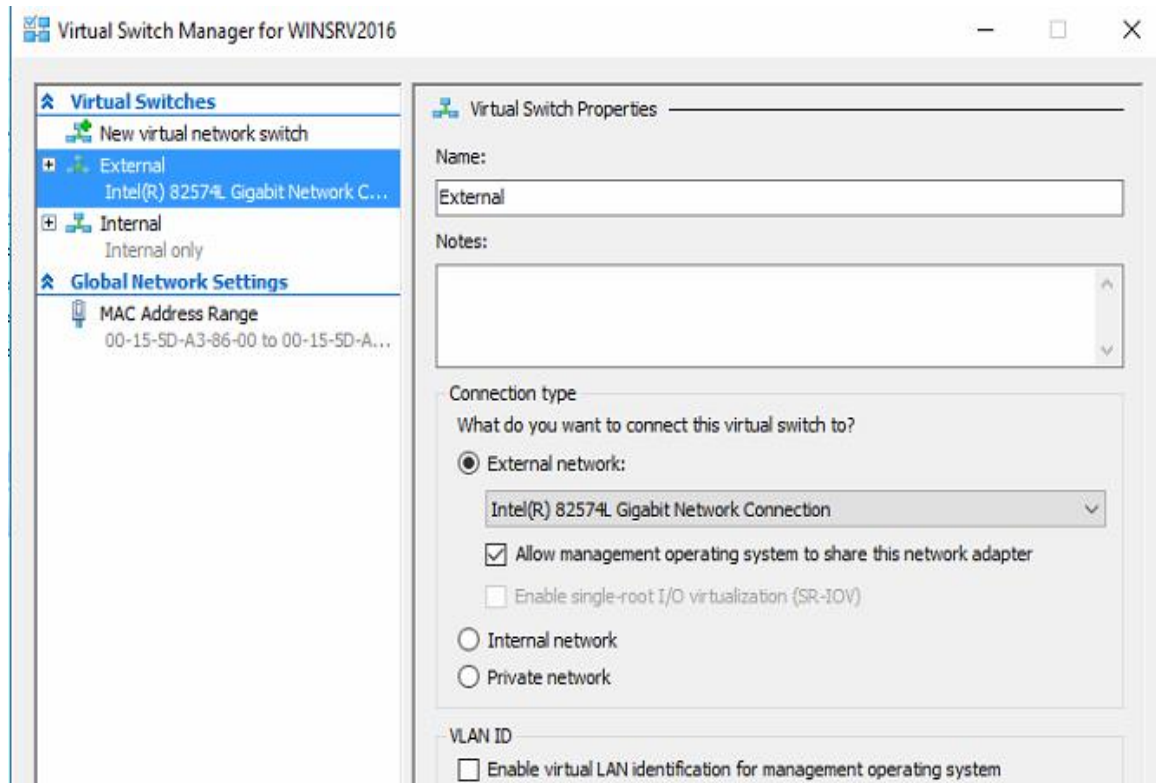


Figure 16. Virtual switch manager.

Since for virtual machines hosting I had limited resources, for WinServer2016 I granted 3 GB of ram and two virtual processing cores, as shown in figure 17. I also added an External and Internal network adapter to establish connectivity between the virtualization host and the domain controller. For installation media, I used same ISO file with Windows Server 2016 Evaluation image. I also granted only 32 GB of storage space which is minimum for this operating system.

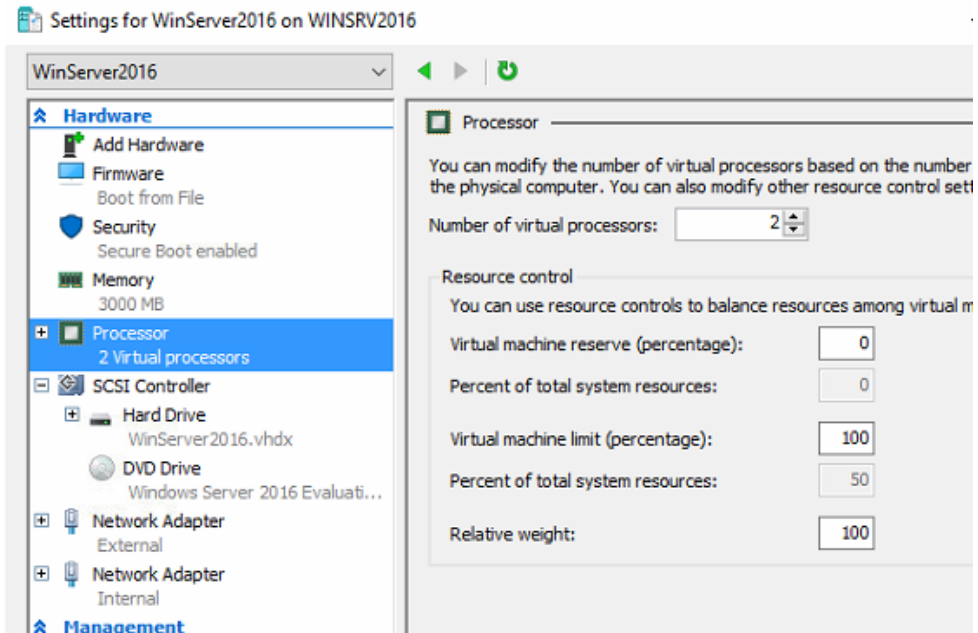


Figure 17. WinServer2016 virtual machine settings

Next, I powered on the WinServer2016 virtual machine and installed Windows server 2016. This virtual machine will require domain services for testing virtualization features, so I needed to join it to the MAMKLAB.FI domain. To achieve that I changed network configuration appropriately so it could contact WinServer-DC, as shown in figure 18.

```
C:\Users\administrator.MAMKLAB>ipconfig

Windows IP Configuration

Ethernet adapter Ethernet 3:

    Connection-specific DNS Suffix  . : 
    Link-local IPv6 Address . . . . . : fe80::3549:c3d3:36a6:66f0%3
    IPv4 Address. . . . . : 192.168.163.7
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.163.2

Ethernet adapter Ethernet 2:

    Connection-specific DNS Suffix  . : localdomain
    Link-local IPv6 Address . . . . . : fe80::6dd2:99ce:2556:11ca%4
    IPv4 Address. . . . . : 192.168.163.137
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 192.168.163.2

Tunnel adapter isatap.localdomain:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix  . : localdomain

Tunnel adapter isatap.{442000AE-CBE5-4AD4-8FAD-36A563F6EE81}:
```

Figure 18. WinServer2016 network configuration

4.4 Testing the new Windows Server 2016 virtualization features

To ensure that my virtual lab environment is working properly I tested all the prepared tasks and virtual environment configurations. Based on discovered errors, corrections there made to ensure the final product is without any major flaws.

4.4.1 Enabling nested virtualization and connectivity for guest VMs.

The first task is to enable the nested virtualization for the nested Hyper-V host virtual machine by using Windows PowerShell command, as shown in figure 19. Without completing this step, installation of the Hyper-V server role on the WinServer2016 is impossible since nested Hyper-V by default doesn't have access to processors virtualization extensions.

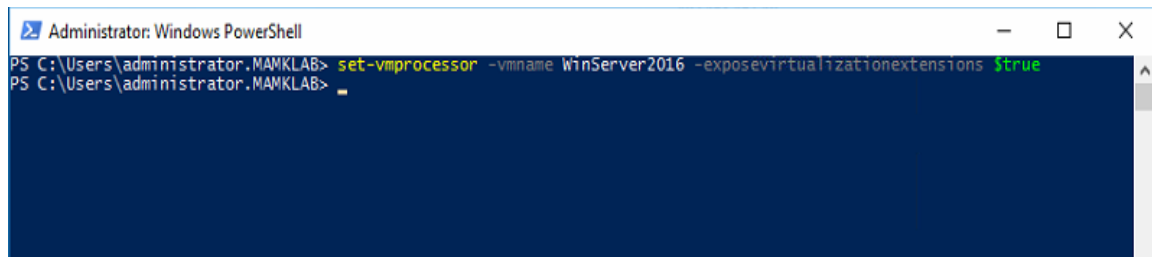
A screenshot of a Windows PowerShell window titled "Administrator: Windows PowerShell". The window has a dark blue background. The command prompt shows the following text: "PS C:\Users\administrator.MAMKLAB> set-vmprocessor -vmname WinServer2016 -exposevirtualizationextensions \$true". The command is highlighted in green. Below the command, there is a small white cursor. The window also shows standard Windows window controls (minimize, maximize, close) in the top right corner.

Figure 19. Enabling virtualization extensions

Next step is to connect to the WinServer2016 virtual machine and install Hyper-V server role using the server manager. For that purpose, I used the add roles and features wizard. In the wizard, I choose Role-based or feature-based installation, selected Hyper-V role. On migration tab I also enabled live migrations then I followed default options and finished the installation, this is shown in figure 20.

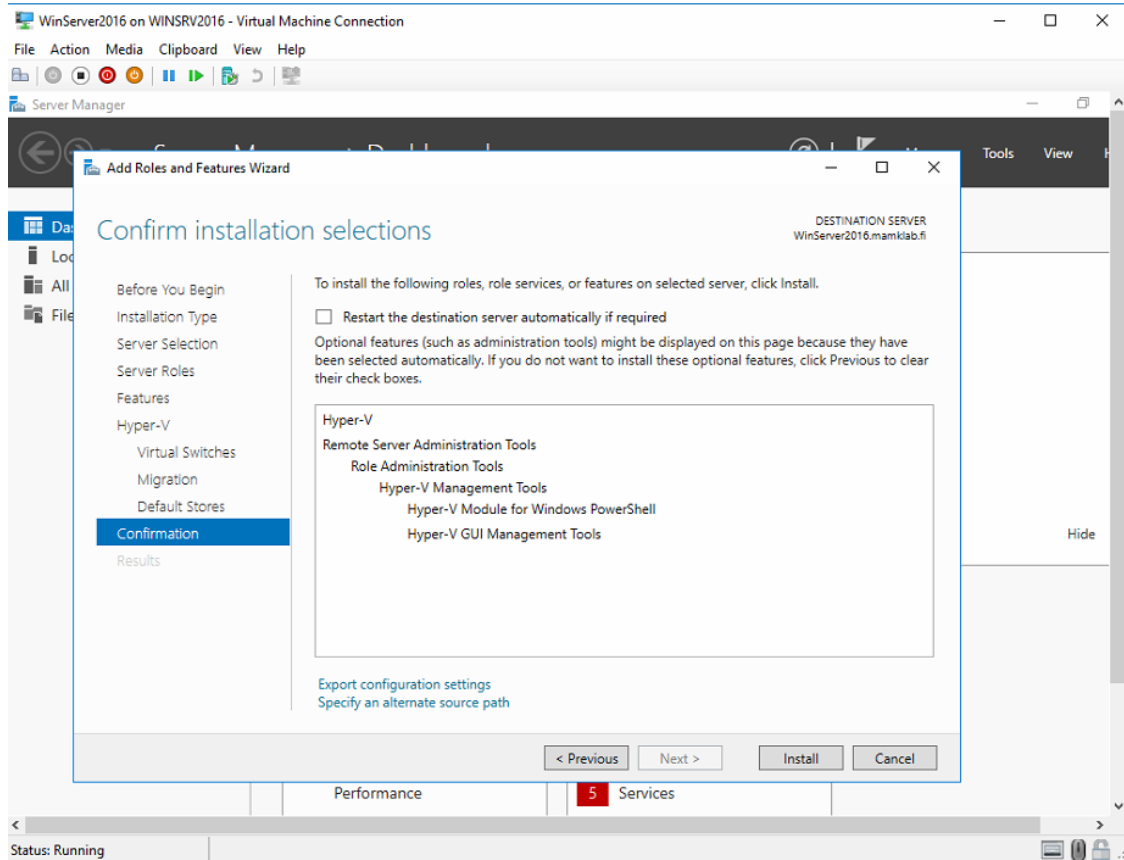


Figure 20. Installing Hyper-V role

The next step is to create a virtual NAT network by using Windows PowerShell commands, as demonstrated in figure 21. To turn on NAT I used the following commands:

New-VMSwitch -Name VmNAT -SwitchType Internal

New-NetNat -Name LocalNAT -InternalIPInterfaceAddressPrefix "192.168.100.0/24"

```

Administrator: Windows PowerShell
PS C:\Users\administrator.MAMKLAB> New-VMSwitch -name VmNAT -switchType Internal
Name SwitchType NetAdapterInterfaceDescription
-----
VmNAT Internal

PS C:\Users\administrator.MAMKLAB> New-NetNat -Name LocalNAT -InternalIPInterfaceAddressPrefix '192.168.163.0/24'
Name
ExternalIPInterfaceAddressPrefix :
InternalIPInterfaceAddressPrefix : 192.168.163.0/24
IcmpQueryTimeout                 : 30
TcpEstablishedConnectionTimeout : 1800
TcpTransientConnectionTimeout   : 120
TcpFilteringBehavior             : AddressDependentFiltering
UdpFilteringBehavior             : AddressDependentFiltering
UdpIdleSessionTimeout           : 120
UdpInboundRefresh               : False
Store                           : Local
Active                           : True

PS C:\Users\administrator.MAMKLAB>

```

Figure 21. Creating new virtual NAT

Then I assigned an IP address to the new internal network adapter that will be used as a gateway for virtual machines that will reside on the nested virtualization host. To do that I used the following command:

```
Get-netadapter "vEthernet (VmNAT)" | New-NetIPAddress -IPAddress 192.168.100.80 -AddressFamily IPv4 -PrefixLength 24
```

4.4.2 Testing VM groups and collections feature

To test this feature I used Windows Powershell commands. First, I tested creating virtual machine groups by using the following command:

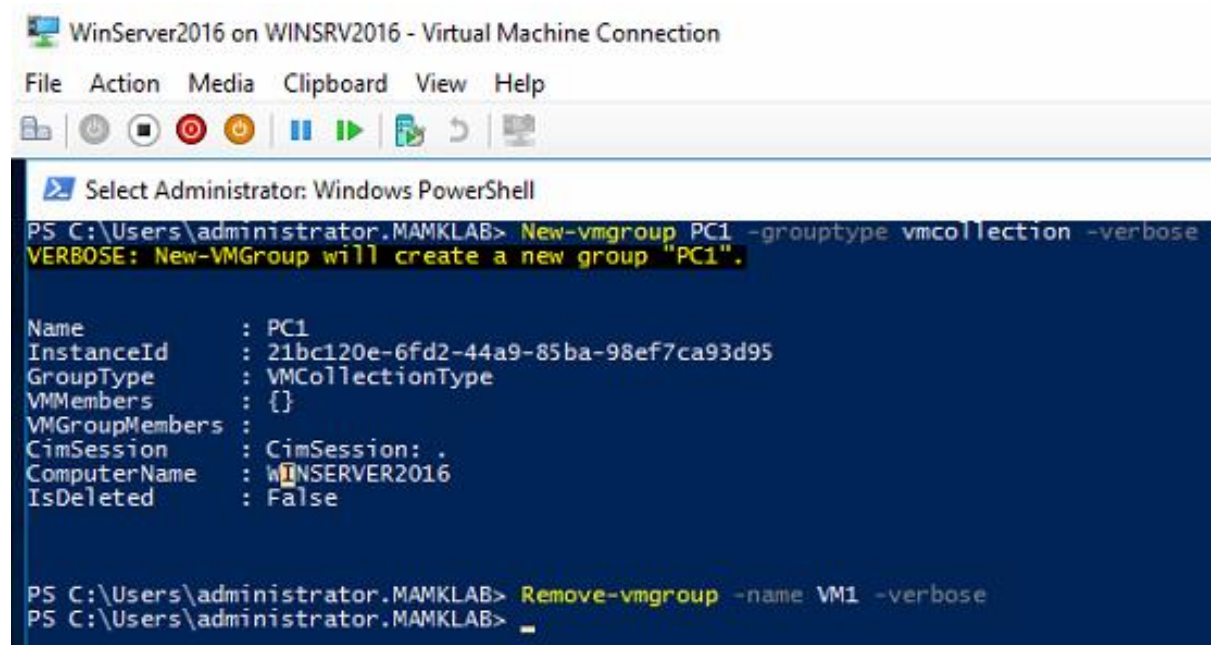
```
New-VMGroup -Name VM1 -GroupType VMCollection -Verbose
```

To test adding a virtual machine to the virtual machine group I tried the following command: **Add-VMGroupMember -VMGroup (Get-VMGroup VM1) -VM (Get-VM PC1) -Verbose**

I also tested deleting VM group by using the following command:

```
Remove-VMgroup -Name VM1 -Verbose
```

The tests were successful, commands worked as intended, as figure 22 shows.



The screenshot shows a Windows PowerShell terminal window titled "WinServer2016 on WINSRV2016 - Virtual Machine Connection". The terminal displays the following commands and their output:

```
PS C:\Users\administrator.MAMKLAB> New-vmgroup PC1 -groupType vmcollection -verbose
VERBOSE: New-VMGroup will create a new group "PC1".

Name           : PC1
InstanceId      : 21bc120e-6fd2-44a9-85ba-98ef7ca93d95
GroupType       : VMCollectionType
VMMembers       : {}
VMGroupMembers :
CimSession      : CimSession: .
ComputerName    : WINSERVER2016
IsDeleted       : False

PS C:\Users\administrator.MAMKLAB> Remove-vmgroup -name VM1 -verbose
PS C:\Users\administrator.MAMKLAB>
```

Figure 22. Testing VM groups commands

4.4.3 Testing Windows PowerShell Direct

To test Windows PowerShell Direct first, I connected to WinServer2016 using Windows PowerShell command:

Enter-PSSession -VMName WinServer2016

When asked for credentials, I used the domain administrator account, this is shown in figure 23.

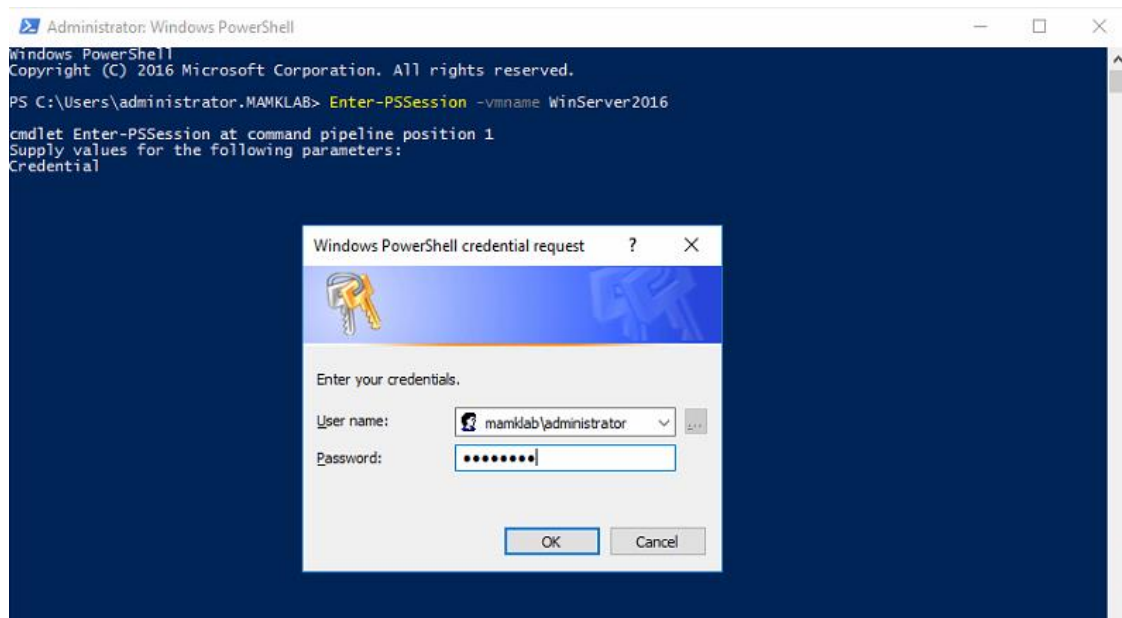


Figure 23. Windows Powershell direct connection

To further test the functionality of PowerShell Direct I created new virtual machine on the nested virtualization host WinServer2016 using the PowerShell of WinSrv2016, as demonstrated on figure 24.

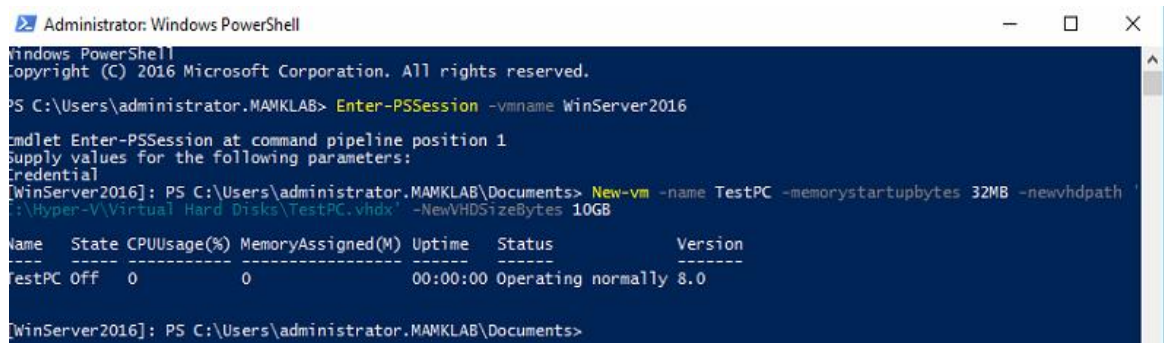


Figure 24. Creating VM through PowerShell Direct

4.4.4 Testing live migration without Failover Clustering

To test live migration without Failover Clustering on Windows server 2016 first I needed to configure constrained delegation in the domain controller server WinServer-DC. Before that, I registered that WinServer2016 virtual machine has virtual migration service by using following Windows Powershell command:

Setspn -S 'Microsoft Virtual System Migration Service/WinServer2016' WinServer2016

When through Active Directory Users and Computers I accessed the settings of WinSrv2016. On the delegation tab I configured to trust this computer for delegation to specified services only. Instead of using only Kerberos protocol I allowed to use any authentication protocol, as shown in figure 25.

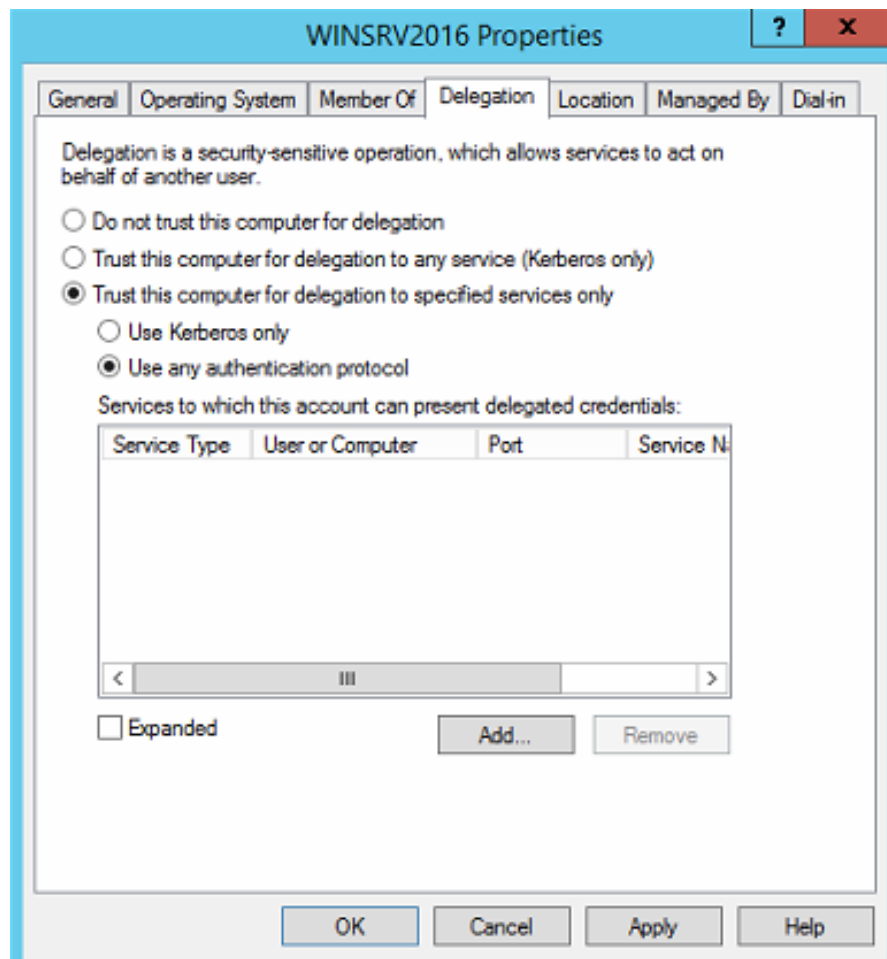


Figure 25. Configuring delegation for WinSrv2016

When I pressed Add and selected WinServer2016 as a target computer. I selected cifs and Microsoft virtual migration services since without them the migration between virtualization host and the nested hyper-v wouldn't work, as shown in figure 25.

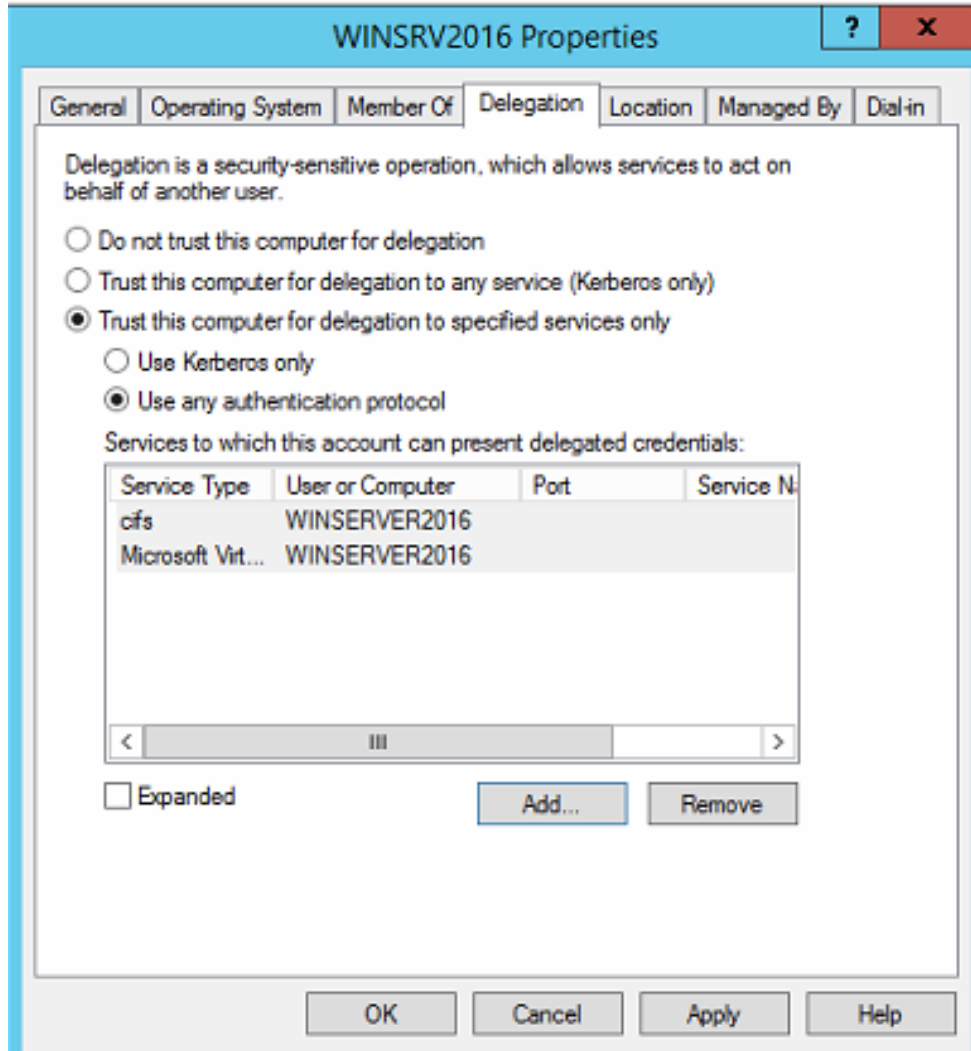


Figure 25. Configuring delegation for WinSrv2016

I repeated the same steps with WinServer2016 but for services target chose WinSrv2016 virtual machine. Before testing live migration between the virtualization host and the nested hyper-v virtual machine I went to hyper-v manager on WinServer2016. To make live migration possible in Hyper-V settings of both WinSrv2016 and WinServer2016, on a live migration tab I checked the enable incoming and outgoing migrations. For incoming live migrations, I chose to use any available network, this is demonstrated in figure 26.

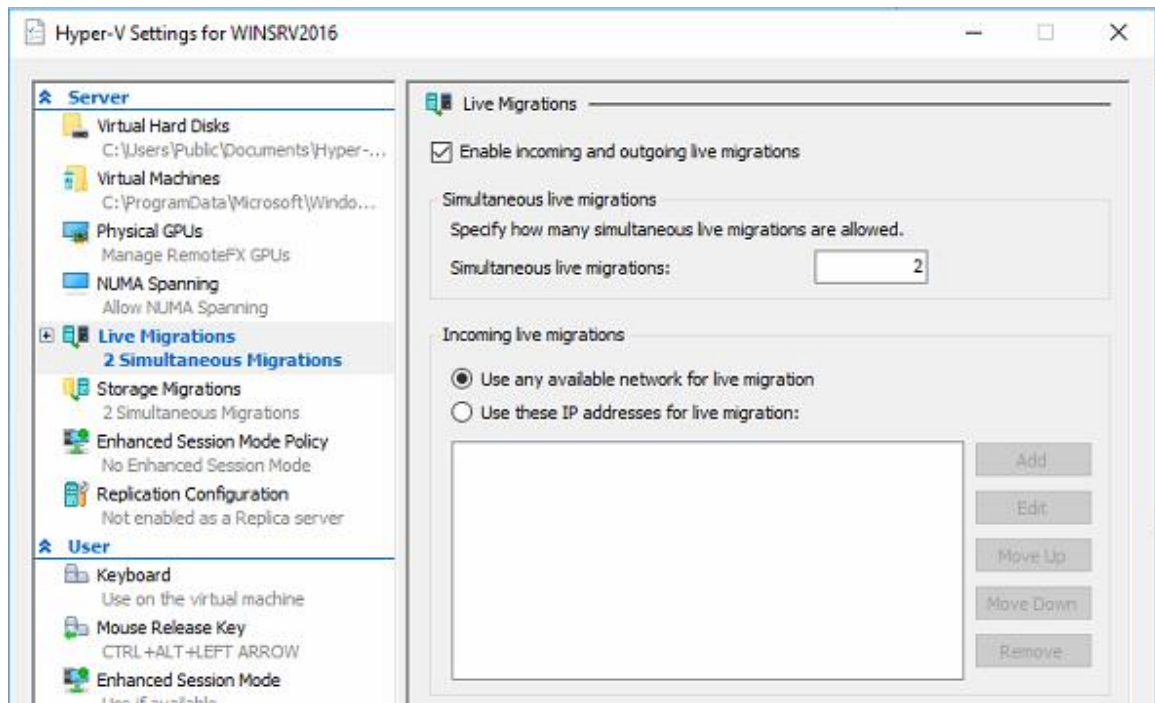


Figure 26. Live migration settings

On the advanced tab of live migrations, I selected to use the Kerberos authentication protocol, as demonstrated in figure 27. This will allow to securely authenticate that domain administrator account is being used to initiate migration.

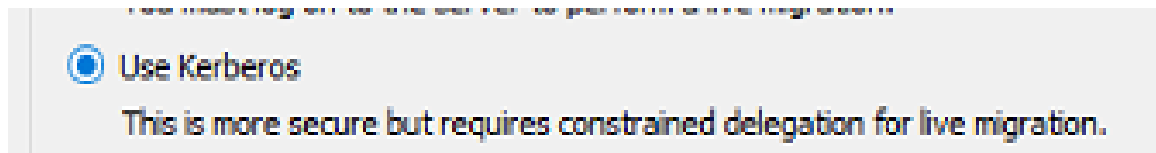


Figure 27. Kerberos

To initiate the migration of PC1 to WinServer2016 I powered on “PC1” and started the migration wizard. In the wizard I chose to move a virtual machine. This option will move both the virtual machine and its storage, as figure 28 shows.

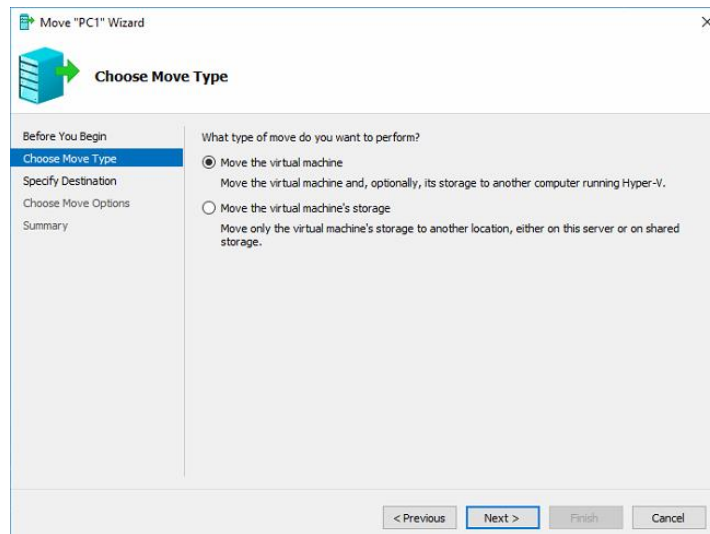


Figure 28. Choosing migration move type

In the next step, I needed to choose the migration destination computer. Using the search engine I chose the nested virtualization host WinServer2016, as shown in figure 29.

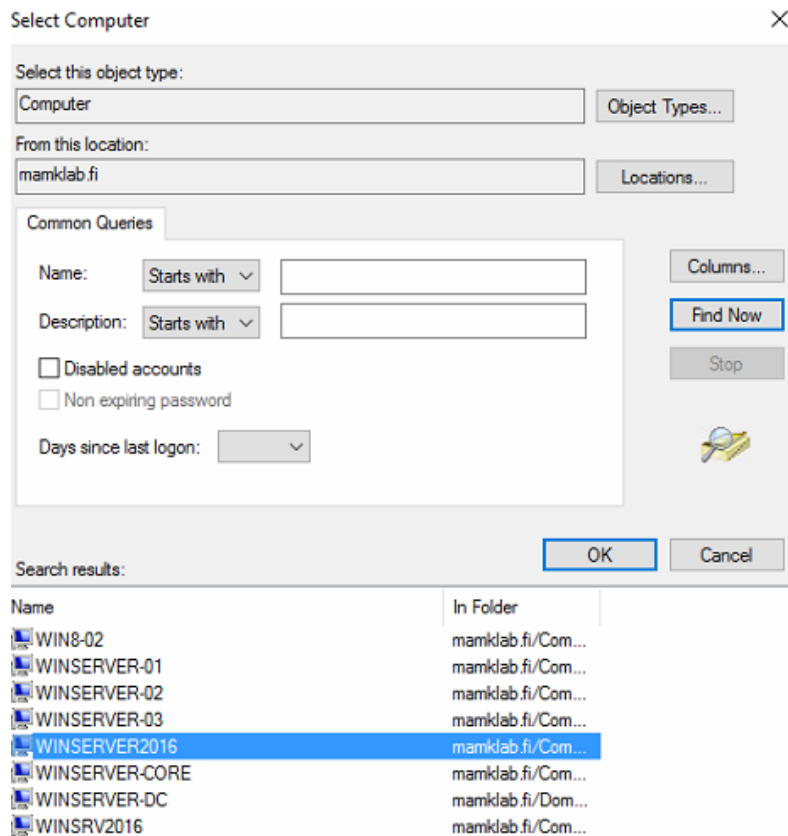


Figure 29. Migration destination

On the next step of the wizard, I selected to move virtual machine data to a single location on the destination hosts storage, as shown in figure 30.

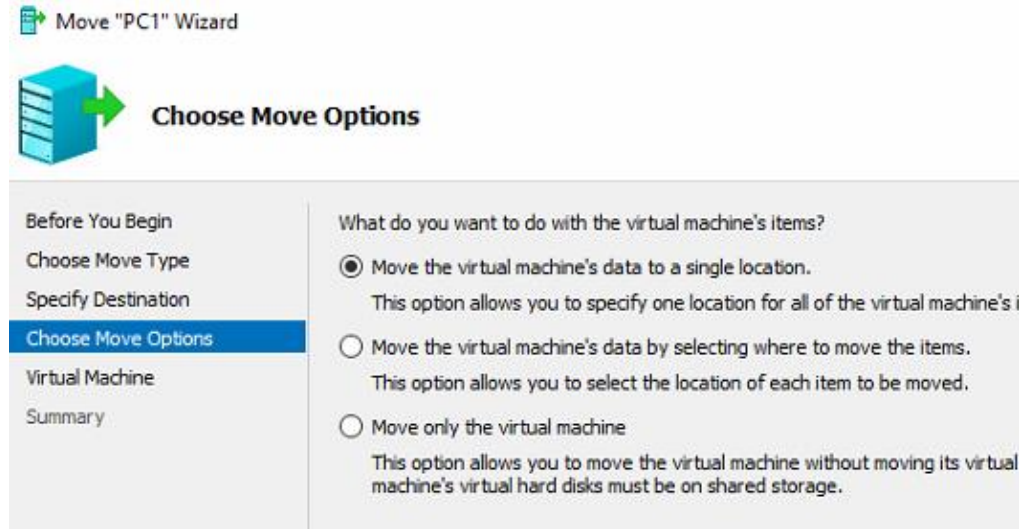


Figure 30. Choosing move options

After finishing the migration wizard it took about two minutes to move the PC1 virtual machine from the virtualization host to the nested-virtualization machine WinServer2016. Live migration was successful, PC" was still running, as demonstrated in figure 31.

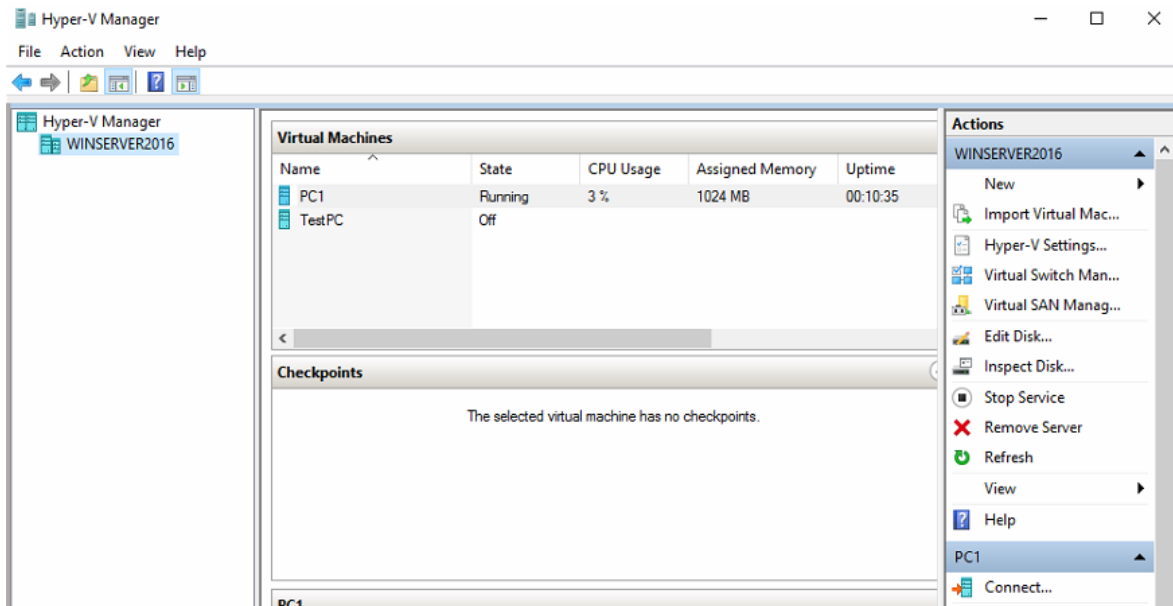


Figure 31. Live migration result

4.4.5 Testing Windows Powershell commands

Next, I tested Windows Powershell commands to configure various virtual processor parameters. I used PC2 virtual machine as the testing target. The first PowerShell command is used to set processor cores to one, processing power reserve to 20%, processing power to 80%, and a relative weight of 180.

Set-VMProcessor PC2 -Count 2 -Reserve 10 -maximum 80 -Relativeweight 180

I also tested a command that enables the specific virtual machine to use live migration:

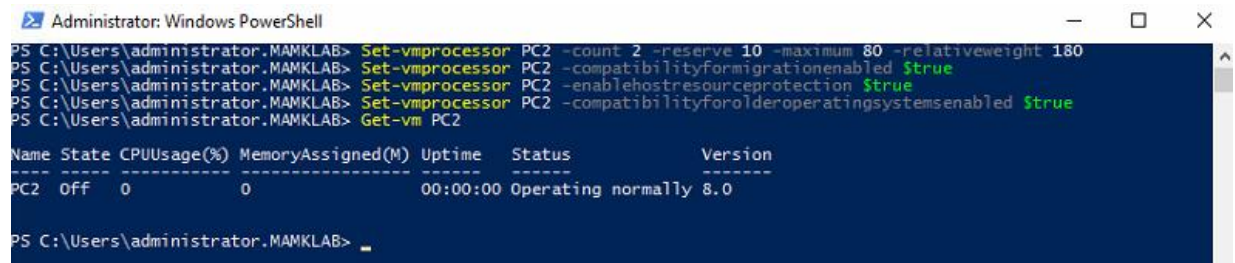
Set-VMProcessor PC2 -CompatibilityForMigrationEnabled \$true

Next, I enabled resource host protection and support for older generation operating systems in the following way:

Set-VMProcessor PC2 -EnableHostresourceprotection \$true

Set-VMProcessor PC2 -CompatibilityForOlderOperatingSystemsEnabled \$true

All the commands worked as intended without any errors, as shown in figure 32.



```

Administrator: Windows PowerShell
PS C:\Users\administrator.MAMKLAB> Set-vmprocessor PC2 -count 2 -reserve 10 -maximum 80 -relativeweight 180
PS C:\Users\administrator.MAMKLAB> Set-vmprocessor PC2 -compatibilityformigrationenabled $true
PS C:\Users\administrator.MAMKLAB> Set-vmprocessor PC2 -enablehostresourceprotection $true
PS C:\Users\administrator.MAMKLAB> Set-vmprocessor PC2 -compatibilityforolderoperatingsystemsenabled $true
PS C:\Users\administrator.MAMKLAB> Get-vm PC2

Name State CPUUsage(%) MemoryAssigned(M) Uptime Status Version
-----
PC2 Off 0 0 00:00:00 Operating normally 8.0
  
```

Figure 32. PowerShell commands result

4.5 Conclusion

Testing of the educational virtual environment was successful. Virtual machines work as intended. Lab tasks were tested multiple types to ensure that they work well with the created virtual environment. During the testing I discovered couple major errors that stop the process of completing lab tasks, however, they were solved with couple minor adjustments and Windows PowerShell commands.

5 CONCLUSIONS

Virtualization is a constantly improving technology that allows users to run multiple virtual machines on a single physical host. Many big companies try to integrate virtualization into their IT infrastructure to save money. Because technology is constantly advancing, servers became too powerful to utilize their full potential. Virtualization allows to splitting server resources and use them more cost-efficiently while greatly reducing the space needed for the physical hardware. Since virtualization is a very popular topic many big companies try to compete with each other by constantly improving their products virtualization efficiency. For example, with the release of Windows Server 2016, Microsoft introduced a lot of new virtualization features: Nested virtualization, Nano server and Containers. Nested virtualization is a new technology that will play a big role in the future because it allows creating more complex virtualization environments that will be used to further divide computing resources to achieve greater efficiency. Since cloud technology goes hand in hand with virtualization nano servers and containers are essential for cloud infrastructure. Virtualization is a really complex and flexible technology that won't stop growing anytime soon.

The goal of my thesis project was to research the new virtualization features Windows server 2016 has and based on them develop a virtual lab environment with lab sheets for South-Eastern Finland University of Applied Sciences. For the physical host, I used one of the computers at the university. The computer had a powerful processor and a lot of random-access memory so I was able to run multiple virtual machines at the same time without any computer resource shortages. To create and host a Windows Server 2016 virtual machine I used VMware Workstation. The VMware workstation is one of the most popular virtualization tools that allow to fully customize virtual machines. For testing some features, I had to use extra existing virtual machine to have a domain controller. For the communication between the virtual machines, I created custom a NAT network using virtual network editor. After installation of Windows server 2016, I installed and configured Hyper-V service role, made additional network configurations so virtual machines that are hosted on Hyper-V could communicate with the other VMware workstation virtual machines.

To create virtual lab tasks I used Microsofts book Introducing Windows Server 2016 by John McCabe. I created five tasks for the virtual lab that teach: nested virtualization basics, VM groups, and collections, Windows Powershell direct, live migration without failover cluster and WindowsPowershell commands. I tested every lab step to make sure that there are no errors for the students.

To sum up, this project was challenging and educational. I prepared and tested virtual lab environment designed for Xamk university students while gaining a lot of new knowledge about virtualization technology. In addition to the virtual lab environment, document with lab tasks were prepared. Thesis project was completed successfully. For further development, more labs could be created that focus on other new features of Windows server 2016.

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Advanced Enterprise Server Environment

Hyper-V 2016 Lab 1. Introduction to new

Hyper-V features

Lukas Jonikas

Before starting the lab, check the notes from Moodle.

For this lab, you will need the following Lab VMs: **WinSrv2016, WinServer-DC**

Step 1. Enable nested virtualization and connectivity for guest VMs

- Start **WinSrv2016** and log in as **Mamklab\Administrator / P@ssw0rd**
- Start **WinServer-DC**
- To turn on nested virtualization, first, on the host, you must run the following Windows PowerShell command as administrator against a VM that is turned off.
 - o **Set-VMProcessor -VMName WinServer2016 -ExposeVirtualizationExtensions \$true**
- Now go to Hyper-V manager and turn on **WinServer2016**. Log in as **Administrator/P@ssw0rd**
- Install Hyper-V role by pressing add roles and features on server manager.
 - o On server roles select Hyper-V
 - o Press Allow this server to send and receive live migrations of virtual machines
 - o Select Restart the destination server automatically if required
 - o Let server to restart
- Next turn on NAT on the nested Hyper-V VM(**WinServer2016**) by using following the commands:
 - o **New-VMSwitch -Name VmNAT -SwitchType Internal**
 - o **New-NetNat -Name LocalNAT -InternalIPInterfaceAddressPrefix "192.168.100.0/24"**
- When this is done, you need to assign an IP address to the new internal adapter. This essentially will be the gateway address for the VMs running under the nested Hyper-V. Here's the Windows PowerShell command to do this:
 - o **Get-netadapter "vEthernet (VmNAT)" | New-NetIPAddress -IPAddress 192.168.100.80 -AddressFamily IPv4 -PrefixLength 24**
- To check if a new NAT adapter is created use:
 - o **Netsh interface ipv4 show interfaces**

Step 2. VM groups and collections

- Go back to **WinSrv2016**
- To make the management of multiple VMs easier, Windows Server 2016 has added support for groupings of VMs. VM groups are exactly what the name implies: logical groupings of VMs. Let's practice creating VM groups on Windows power Shell.
 - o Try creating three VM groups: VM1, VM2, VM3.
 - **New-VMGroup -Name GroupName -GroupType VMCollection -Verbose**
 - o Add PC1 to VM1 group and PC3 to group VM3

- **Add-VMGroupMember –VMGroup (Get-VMGroup VM1) –VM (Get-VM PC1) -Verbose**
 - Verify that PC1 is added to VM1 Group:
 - **Get-VM | ft Name, State, Groups -AutoSize**
 - Delete group VM2 and verify that it is deleted:
 - **Remove-VMgroup –Name VM2 –Verbose**
 - **Get-VMgroup * | ft Name, vmmembers –Autosize**

Step 3. Test Windows PowerShell Direct

- *Windows PowerShell Direct grants you a way to run Windows PowerShell commands in a VM from the Host computer. Windows PowerShell Direct functions between the host and the VM. This means it doesn't require networking or firewall requirements, and it works regardless of your remote management configuration.*
- Try using Windows Power Shell direct to ping WinSrv2016 from WinServer2016 Vm.
 - Open Windows Power Shell on **WinSrv2016**
 - To connect to the virtual machine from a host, use: **Enter-PSSession -VMName <VMName>**
 - Use mamklab\Administrator/P@ssw0rd to authenticate
 - Test PowerShell Direct by creating virtual machine in WinServer2016.
 - **New-VM -Name 'TestPC' -MemoryStartupBytes 32MB -NewVHDPATH "C:\Hyper-V\Virtual Hard Disks\TestPC.vhdx" -NewVHDSIZEBytes 10GB**

Step 4. Preparing hosts for live migration without Failover Clustering

- Configure constrained delegation. For kerberos to be used for authentication of live migration traffic, configure constrained delegation using an account that is a member of the Domain Administrators group.
- Go to WinServer-DC and login as **mamklab\Administrator/P@ssw0rd**
 - Register that WinServer2016 has Microsoft Virtual System Migration service. In Windows PowerShell on WinServer-DC type:
 - **Setspn –S 'Microsoft Virtual System Migration Service/WinServer2016' WinServer2016**
- Configure constrained delegation in order to use Kerberos for authentication of live migration traffic.
 - Open Active Directory Users and Computers
 - On left navigation windows go to mamklab.fi >> Computers
 - Go to properties of WinSrv2016. On delegation tab select
 - **Trust this computer for delegation to specified services only**
 - **Use any authentication protocol**
 - Press add and select WinServer2016 computer. Add **cifs** and **Microsoft Virtual System Migration** services
 - Now go to properties of WinServer2016. On delegation tab select
 - **Trust this computer for delegation to specified services only**
 - **Use any authentication protocol**
 - Press add and select WinSrv2016 computer. Add **cifs** and **Microsoft Virtual System Migration** services
- Prepare the source and destination servers for live migration.
 - Now go to WinSrv2016
 - Open Hyper-V manager and press connect to server. Connect to WinServer2016.
 - On Hyper-V manager apply these steps to both WinServer2016 and WinSrv2016:
 - **Go to Hyper-V settings >> Live migrations**
 - **Click Enable incoming and outgoing live migrations**

- **Use any available network for live migration**
 - **Go to advanced settings of live migrations and select Use Kerberos**
- *Note: You can also prepare the source and destination servers for live migration using Windows PowerShell:*
 - **Enable-VMMigration**
 - **Set-VMMigrationNetwork IP**
 - **Set-VMHost -VirtualMachineMigrationAuthenticationType Kerberos**
- Test live migration without failover cluster from Hyper-V host to nested Hyper-V. First, you need to remove PC1 from VM1 group since that group doesn't exist in WinServer2016.
 - In Hyper-V manager select PC1 and power in on, then press move. Select:
 - **Move the virtual machine**
 - **Destination computer: WinServer2016**
 - **Move the virtual machine's data to single location**
 - **Destination location: Select C hard disk**
- Check if migration was successful to WinServer2016 with PowerShell direct
 - **Enter-PSSession -VMName <VMName>**
 - **Get-VM**

Step 5. Configuring VM processor settings using Windows Powershell

- Managing VM processor usage is very important in order to optimize virtual machines infrastructure. Test useful Windows PowerShell commands that allows to configure important processor parameters.
 - Set PC2 virtual machine to have one processor, processing power reserve 20%, a limit of 80%, and a relative weight of 180.
 - **Set-VMProcessor PC2 –Count 2 –Reserve 10 –maximum 80 –Relativewight 180**
 - Enable PC2 processor compatibility for live migration.
 - **Set-VMProcessor PC2 -CompatibilityForMigrationEnabled \$true**
 - Enable compatibility for running older operating systems.
 - **Set-VMProcessor PC2 – CompatibilityForOlderOperatingSystemsEnabled \$true**
 - Enable host resource protection for PC2.
 - **Set-VMProcessor PC2 –EnableHostresourceprotection \$true**
 - To check if commands worked use:
 - **Get-Vm PC2**

That's it! When you have finished doing the lab, **show the results to the teacher before shutting down the VMs!**

Also **remember to do the Quiz in Moodle!**