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Using TIA Portal in a Virtualized Infrastructure

STEP 7, WinCC and WinCC Runtime with Clients and Servers

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1 Task

1.1 Overview

Introduction

Virtualizing applications and servers is well established in information technology. The advantages of virtualization can also be used in automation technology. This application example shows the options these advantages bring.

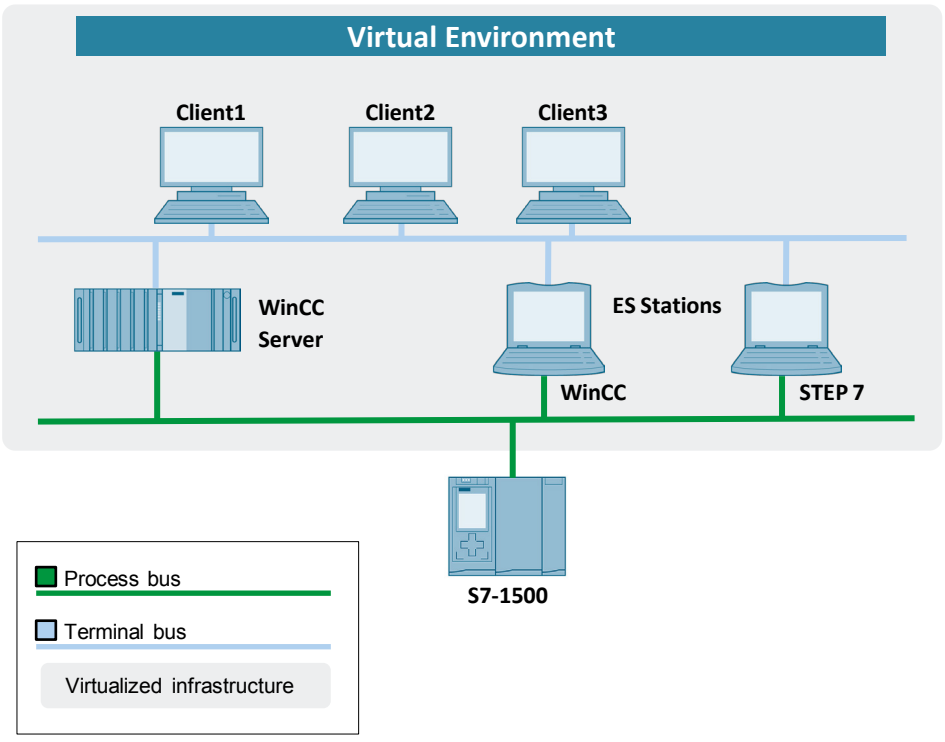
The application example does not discuss the virtualization of a single workstation. It shows the virtualization of an entire infrastructure with the following components:

- Engineering stations
  - WinCC (TIA Portal)
  - STEP 7 (TIA Portal)
- WinCC Runtimes
  - WinCC Runtime Professional Server
  - WinCC Runtime Professional Client

Overview of the automation task

The figure below provides an overview of the automation task.

Figure 1-1 TIA Portal in a virtualized infrastructure



1.2 Requirements

Additional virtualized applications

In addition to the TIA Portal other applications should be virtualized. Respectively the TIA Portal automation software should be added to an existing virtualization cluster.

Access to hardware

- A program download from the virtualized STEP 7 PC to a controller should be possible.
- The virtualized WinCC server should have read/write access to tags of a controller.

Operation of the running machine

- Operation with WinCC Runtime Professional Client.
- Engineering with STEP 7 (TIA Portal).

2 Solution

2.1 Overview

A VMware cluster based on vSphere 5.5 is used to solve this task. It consists of:

- Four ESXi hosts
- vCenter Server as the central management component
- Two storage systems

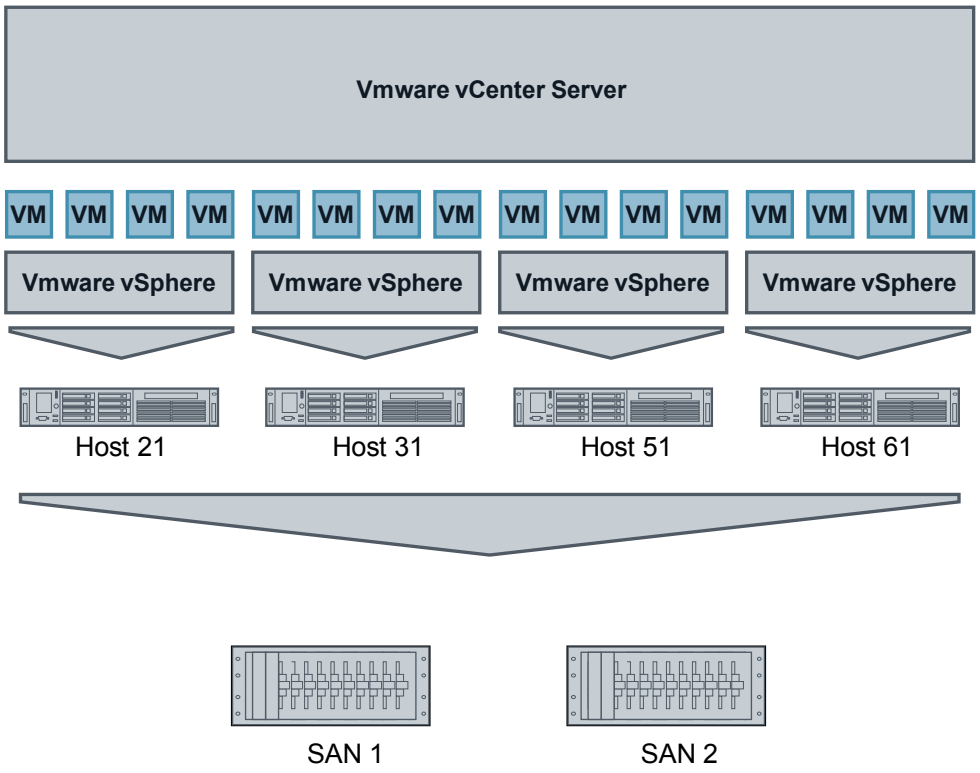
Note The task can also be solved with just a single host if this host provides enough resources.

The individual virtual machines are operated through remote access.

Diagrammatic representation

The diagrammatic representation below shows the most important components of the solution:

Figure 2-1 Architecture of the hardware used



NOTE The numbering of the hosts is an example. You are free to give your own names or numbers (like 1-4).

Advantages

The solution presented here offers the following advantages:

- Improved use of existing virtualized infrastructure systems.
- Easily expandable.
- Independent of the hardware used (hosts).

Scope

This application does not include a description of

- the basics of virtualization.
- setting up a cluster environment with VMware vSphere.
- setting up the remote connection/software for running the virtualized machines.

Required knowledge

Basic knowledge of virtualization using VMware is required. In particular, knowledge of installing and configuring ESXi hosts and, where needed, vSphere vCenter Server for using cluster functionalities.

Basic knowledge of remote connections.

2.2 Hardware and software components

2.2.1 Scope

The following example focuses on the use of VMware ESXi and vCenter Server, therefore on VMware vSphere.

Workstation or Player will not be discussed as they are not released for productive operation.

2.2.2 Validity

This document is valid for:

- STEP 7 Professional V13 SP1
- WinCC Runtime Professional V13 SP1
- VMware ESXi V5.5
- VMware vSphere V5.5

2.2.3 Components used

This application was created with the following components:

Software for the use of virtualization

Virtualization software

- VMware vSphere Client/vSphere Web Client
- VMware vSphere Server ESXi
- VMware vCenter Server

Note Depending on the VMware license used, certain VMware functionalities described below may not be available in your environment.

Recommended functions configured in this example:

- DRS (Distributed Resource Scheduler)
- SDRS (Storage DRS)
- HA (High Availability)
- vDS (vSphere Distributed Switch)
- DPM (Distributed Power Management)
- vSphere Web Client
- *vRealize Operations Manager (only to determine IOPS/load)*

Hardware components

Table 2-1

Component	No.	Article number
SIMATIC S7-1500 CPU 1516F-3PN/DP	1	6ES7 516-3FN00-0AB0

Software components

Table 2-2 Engineering station

Component	No.	Article number
SIMATIC WinCC Professional max. PowerTags V13 SP1	1	6AV2103-0XA03-0AA5
SIMATIC STEP 7 Professional V13 Floating License	1	6ES7822-1AA03-0YA5
STEP 7 Safety Advanced V13 SP1	1	6ES7833-1FA13-0YA5
Windows 7 Professional SP1 (64-bit)	1	

Table 2-3 WinCC server

Component	No.	Article number
SIMATIC WinCC Runtime Professional 153600 PowerTags V13 SP1	1	6AV2105-0RA03-0AA0
SIMATIC WinCC Logging for Runtime Professional 5000 LoggingTags	1	6AV2107-0GD00-0BB0
SIMATIC WinCC Recipes for Runtime Professional	1	6AV2107-0JB00-0BB0
SIMATIC WinCC Server for Runtime Professional	1	6AV2107-0EB00-0BB0
Microsoft Windows Server 2012 R2 Standard Edition (64-bit)	1	

Table 2-4 WinCC client

Component	No.	Article number
SIMATIC WinCC Client for Runtime Professional V13 SP1	3	6AV2107-0DB03-0AA0
Windows 7 Professional SP1 (64-bit)	3	

2.2.4 TIA Portal project

Realistic conditions

The application example is based on a sample project. It consists of a STEP 7 project and a WinCC project.

- STEP 7 project
  The control project provides process tags for WinCC.
- WinCC project
  The WinCC project generates a realistic load for the virtualized machines. This allows you to make comparisons with real applications.

Sample project

Each project implemented using WinCC is different and has different quantity frameworks.

The following quantity framework is the basis of this document. The project serves as a reference regarding the hardware used, the number of virtual machines and the configuration of the virtual machines.

WinCC quantity framework/project

Table 2-3

Component	Details
CPU used	1x S7-1516 firmware V1.8.3
Number of WinCC V13 SP1 Professional clients	3
Number of external S7 tags	103548
Trend archiving	1000 Int / second 1000 Byte / second 1000 Real / second 1000 Bool / 500 milliseconds
Alarm archiving	10 discrete alarms / second
User Archive	12 data records, each with 4 integers at a 5-second interval, writing
Screens	29 screens with: Trend view, alarm view, recipe view, screen windows, animated objects, VBS scripts

WinCC screens

To generate a certain load, the following static screen will be displayed on the WinCC Clients in this project.

The screen consists of a total of 1000 objects. The objects are divided into 500 I/O fields and 500 rectangles. All objects are connected to integer tags on the controller. Every second, they increase their value by one. To generate a graphical load, the rectangles change their color every 10 values. The design animation is used for this purpose.

Figure 2-2, Configured load screen – changes in color for different process values

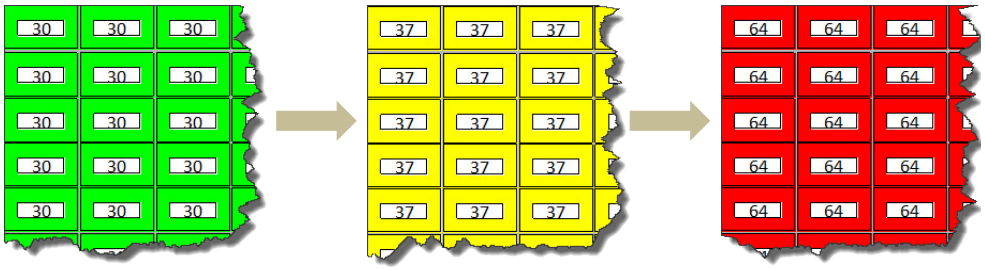
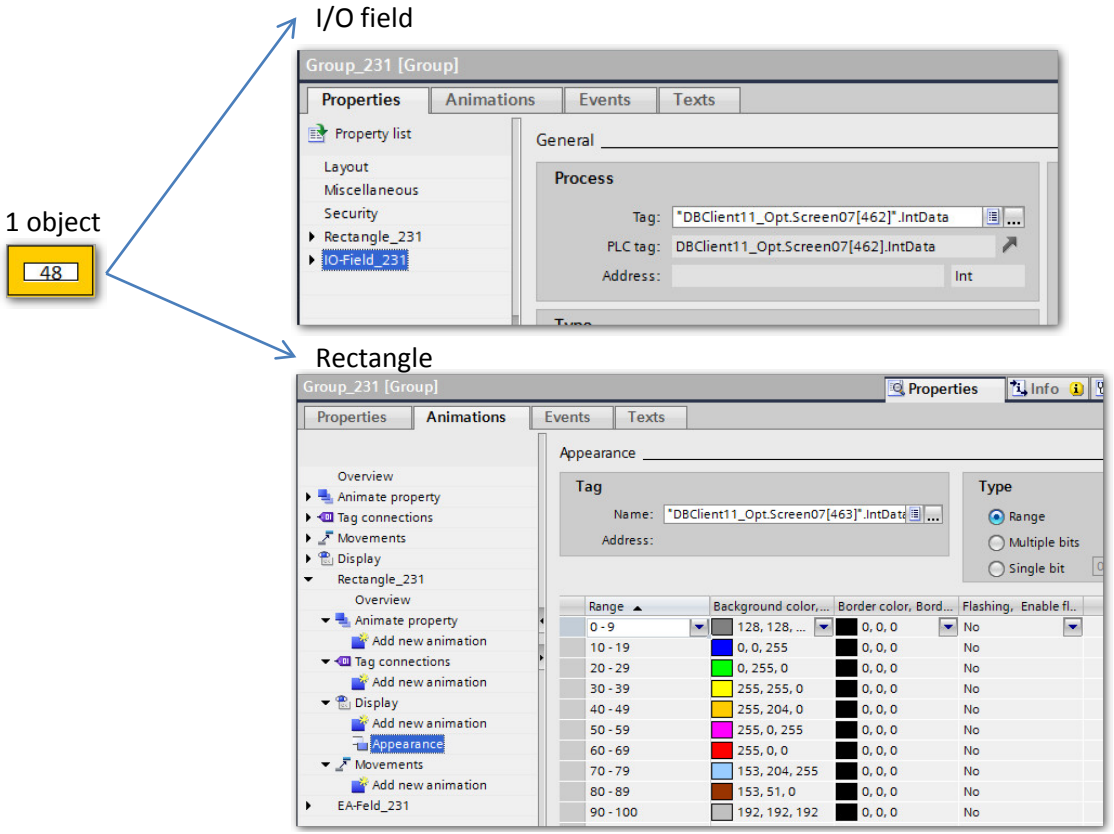


Figure 2-3, Configuration in WinCC



3 Configuration and Project Engineering

3.1 Procedure

The following steps are necessary to virtualize the project described above:

1. **Virtualization infrastructure**
   Create your virtualization infrastructure based on VMware vSphere, consisting of
   a. one or more independent ESXi hosts *or*
   b. a cluster managed by vCenter Server.

2. **Creating virtual machines for TIA Portal**
   Create the following virtual machines (VMs) for your TIA project:
   - Engineering station (ES)
   - WinCC server
   - Three WinCC clients

3. **Operating the virtual machines**
   Customize the virtual machines in order to use the respective VMware vSphere functions.

4. **Other notes, tips and tricks**
   Optimize the individual virtual machines in terms of security and performance and diagnose problems that may arise.

The following pages explain items 1 through 4.

For 1, the architecture used is briefly outlined. For detailed descriptions of setting up and running an ESXi host or vCenter, please refer to VMware.

3.2 Virtualization infrastructure

3.2.1 Selecting the suitable virtualization hardware

General hardware compatibility

Each ESXi host and its components must be listed in the VMware HCL (Hardware Compatibility List) for the respective ESXi version and license.

For more information, please use the following link:
https://www.vmware.com/resources/compatibility/search.php \3\

Computing power depends on the virtualized configuration

The required hardware regarding computing power, storage capacity, main memory, etc. depends on the TIA Portal project. This document uses a specific example to provide appropriate decision-making aids. (See chapter "2.2.4 TIA Portal project".)

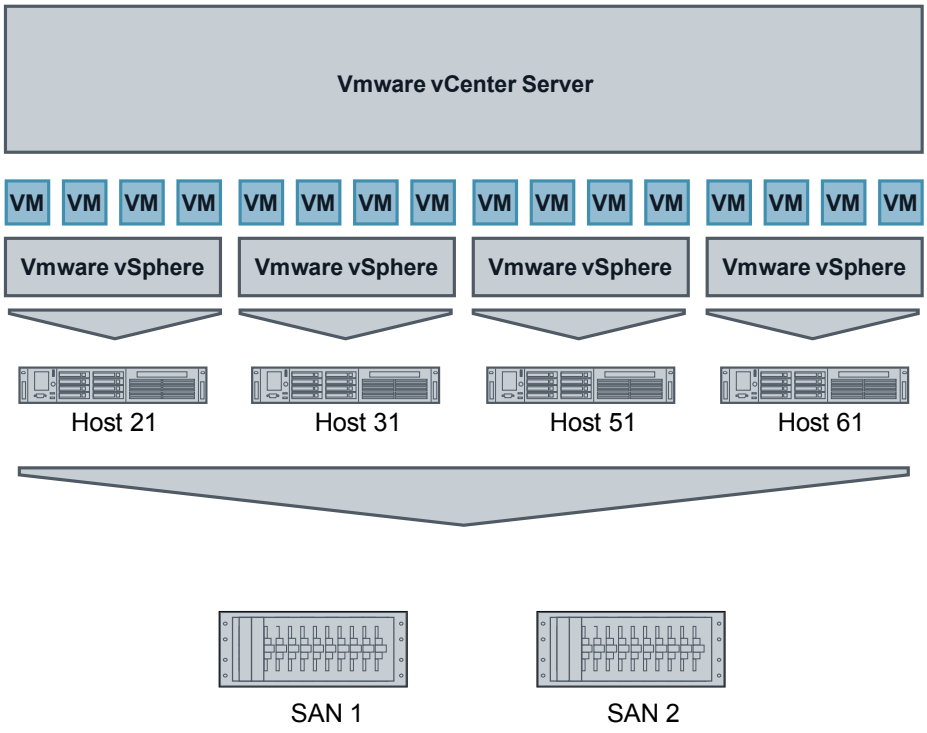
3.2.2 Architecture, installation and configuration of the virtualization hardware

This example combines four ESXi hosts to form a single cluster.

Many of the characteristics described in the following can also be used with one or more independent ESXi hosts without cluster functionality.

Architecture

Figure 3-1 Architecture of the hardware used



The following table shows the servers used and their performance features.

Table 3-1 Hosts and performance features

Host name	Processor type	CPU cores	Main memory in GB
21	Intel Xeon E5645 @ 2.4 GHz	12	96
31	Intel Xeon E5645 @ 2.4 GHz	12	96
51	Intel Xeon E5-2680 v3 @ 2.5 GHz	24	256
61	Intel Xeon E7540 @ 2.0 GHz	24	384

The application example is based on this existing infrastructure and demonstrates which steps are necessary in order to use virtual machines with TIA Portal software.

Configuration

For the configuration and installation of such a vSphere infrastructure, please refer to the appropriate VMware documents.

Note When configuring the options to be used, follow the VMware guides (e.g., “vSphere Installation and Setup Guide”).

For related information, please use the following link. (https://www.vmware.com/support/pubs/) \4\

This application example provides detailed descriptions of the most important aspects of configuring individual components and functions in interaction with TIA Portal. In particular, the following requirements must be met:

- One or more ESXi hosts have been installed and configured.
- Storage system with a suitable configuration (RAID) (hosts connected/integrated).
- Creation/configuration of a virtual switch (physical network adapters connected).
- Optional: vCenter Server with the following correctly configured functions:
  - HA (High Availability)
  - DRS (Distributed Resource Scheduler)
  - DPM (Distributed Power Management)
  - vSphere Web Client
  - vDS (vSphere Distributed Switch)

3.2.3 Operating the virtual infrastructure

After successful installation and basic configuration of an ESXi host, this host is configured using vSphere Client. If a vSphere vCenter Server has been set up, the vSphere Web Client can also be used. The Web Client provides additional functionalities that were only introduced with the latest versions of VMware vSphere. Where possible, this document always shows both client variants. Both can equally be used to implement the described reference architecture.

3.2.4 Storage system

The subordinate storage system is a core element within a virtualized infrastructure. To use functions such as HA , the virtual machines must be located on a storage system that offers the following:

- All hosts of the cluster can access it.
- The performance of the hard drives or the RAID configuration can meet all requirements of the active virtual machines. This also applies to a single ESXi host.

This specific example uses the following storage system structure:

- Two separate systems, SAN1 and SAN2.
- Connected via HBAs (host bus adapters) using optical fiber cables. The speeds are 4 GB/s or 8 GB/s.

Basically, each technology supported by VMware can be used (iSCSI, NFS or FC) as it is transparent to the virtual machines. What is decisive is the provided datastore size and, in particular, its performance.

Due to the shared use, it must be ensured that the IOPS (Input/Output Operations Per Second) requirements of each single machine can be met. If this is not possible, the requests enter a queue and the latencies increase, which manifests itself in a degraded performance within the virtual machine that finally can no longer be operated. See also chapter 4.4 Troubleshooting and performance.

The following chapter, IOPS, lists the measured values. They serve as a reference for the required performance.

Note For increased resilience against failure, redundant connection of the storage systems is recommended. Each system is connected to each host via two independent paths.

IOPS

The storage system is a key component and must be able to meet the requirements of the virtual machines accessing it.

In particular, the IOPS of the individual virtual machines need to be considered.

The following figure shows the measured values for the individual virtual machines for 14 days. They were measured using vRealize Operations Manager (a paid VMware software option):

NOTE The example project from chapter 2.2.4 was the basis for the following values. In this project a single PLC connection is used. No interaction to the WinCC Clients was done, no screens were changed and there was no reboot or maintenance during the measurement.

The measuring values are lower than expect in real.

Figure 3-2 IOPS measured over a period of 14 days

Virtual Machine Disk I/O Diagnose List

Name	Datastore I/O|Reads per second	Datastore I/O|Writes per second	Datastore I/O|Read Rate (KBps)	Datastore I/O|Write Rate (KBps)
WinCC_Server	0.13 IOPS	46.69 IOPS	2.65 KBps	2,017.36 KBps
WinCC_Client1	0.19 IOPS	7.4 IOPS	10 KBps	72.43 KBps
WinCC_Client2	0.22 IOPS	7.38 IOPS	10.58 KBps	71.4 KBps
WinCC_Client3	0.52 IOPS	7.45 IOPS	17.07 KBps	75.96 KBps
Engineering_Station	8.91 IOPS	3.08 IOPS	546.65 KBps	79.34 KBps
Highest Value	**8.91 IOPS**	**46.69 IOPS**	**546.65 KBps**	**2,017.36 KBps**

As can be seen in Figure 3-2, the WinCC server, on average, requires roughly 47 write I/Os and the engineering station requires almost 9 read I/Os. The clients require approx. 7.5 write I/Os.
For the project used, this results in the following average total requirement:

- Approx. 10 read I/Os and
- approx. 72.5 write I/Os.

Figure 3-3 Stress measured over a period of 14 days

Virtual Machine Stress

Name	CPU Cores	CPU Recommendatio	Memory Amount	Memory Recommendation	Disk I/O Read Rate Recommendation	Disk I/O Write Rate Recommendation
Engineering_Station	2 Cores	3 vCPUs	8 GB	8.75 GB	460.42 KBps	129.96 KBps
WinCC_Client3	2 Cores	2 vCPUs	4 GB	4.69 GB	49.76 KBps	93.83 KBps
WinCC_Client1	2 Cores	2 vCPUs	4 GB	4.69 GB	39.59 KBps	90.47 KBps
WinCC_Client2	2 Cores	2 vCPUs	4 GB	4.66 GB	40.61 KBps	91.92 KBps
WinCC_Server	2 Cores	2 vCPUs	8 GB	7.78 GB	32.83 KBps	1.64 MBps
Highest Value	**2 Cores**	**3 vCPUs**	**8 GB**	**8.89 GB**	**460.42 KBps**	**1.64 MBps**

Figure 3-3 shows the recommendations with the set values. Three vCPUs are recommended for the engineering station as high CPU load occurs during the compilation processes, i.e., repeated peaks occur. As these are only temporary peaks, two vCPUs are sufficient.

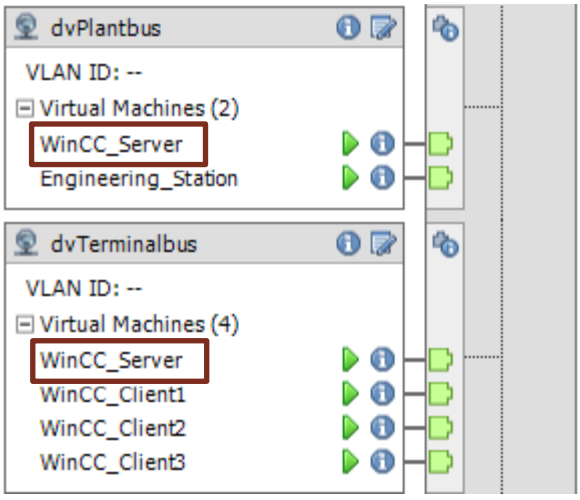
Regarding their configuration, all other machines match the recommendations.

3.2.5 Virtual network

Like physical computers, virtual machines, too, must be connected to a switch. This enables communication between the virtual machines and the automation components, i.e., the controllers.

Connect the virtual network adapters to a virtual switch or port group of a virtual switch. See Figure 3-4 Port configuration overview

Figure 3-4 Port configuration overview



Two options are available:

5. vSS (vSphere Standard Switch) and
6. vDS (vSphere Distributed Switch)

vSphere Standard Switch

vSS is available to each ESXi host, regardless of the license used. The configuration is performed for each host.

Note On each host, assign the same name to the port groups. This allows you to run the virtual machines on different hosts.

vSphere Distributed Switch

The vDS is available depending on the vSphere license used. The advantage is the centralized configuration of the switch, which is then automatically distributed to all hosts. This avoids typing errors when entering the port groups and saves time when configuring and customizing.

The vSphere Distributed Switch is described below.

Create two port groups:

- One for the plant bus and
- one for the terminal bus.

The assignment to the respective port groups is made via the settings of the individual virtual machines per network adapter. The configuration of the WinCC server assigned to one of the two port groups with one network adapter each is shown as an example.

Figure 3-5 Configuration of the WinCC server in the standard vSphere Client

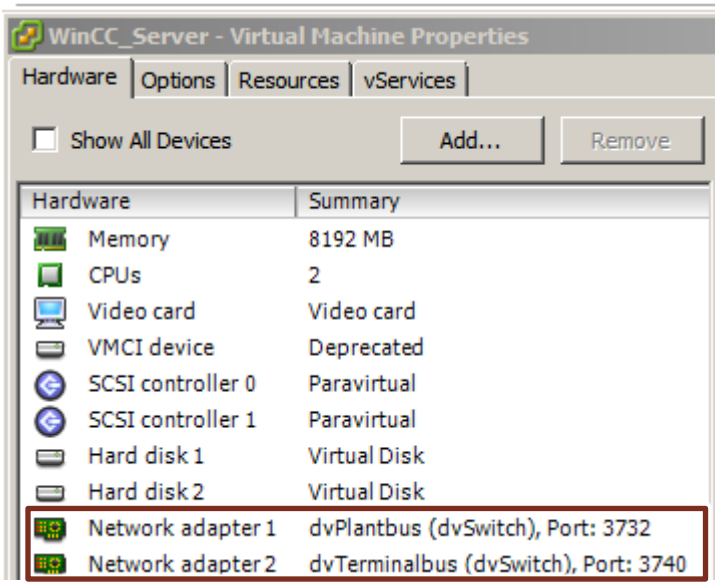
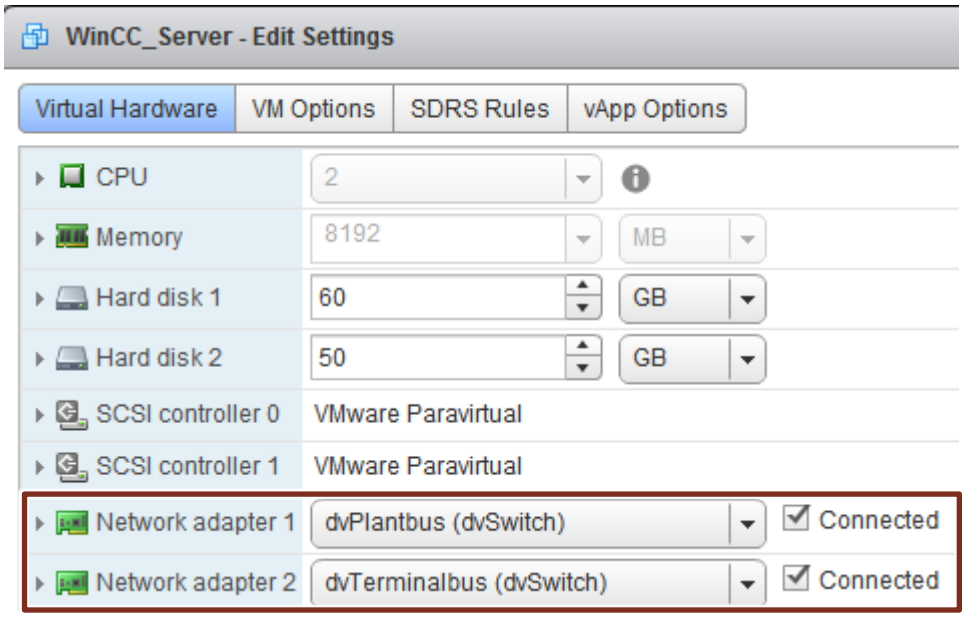


Figure 3-6 Configuration of the WinCC server in the vSphere Web Client



Note

Depending on the network structure, two Distributed Switches (vDS) may be necessary. The appropriate physical network adapters of the hosts are assigned to them. This is used for separate access to the different network segments and other switches and components.

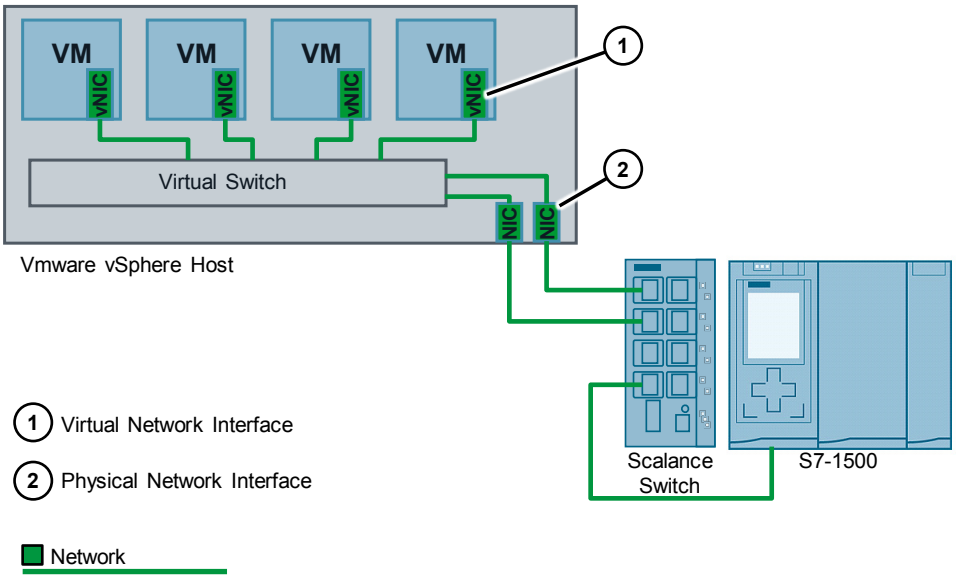
Consult a network administrator on large network or on complex configurations.

Connection and reachability of the S7 controller

If your S7 controllers are connected to the Ethernet port of “Network adapter 1”, they can be reached via the virtual machines.

This requires that the virtualized “dvPlantbus” be made available to the virtual machines.

Figure 3-7 Connection of the S7 controller



3.3 vSphere configuration example

Depending on the license used, the functions shown in the following sections are provided by VMware within a cluster. For the correct configuration, please refer to the appropriate VMware documentation.

For related information, please use the following link.
https://www.vmware.com/support/pubs/ \4\.

The individual sections below show the parameterization used for this application example.

3.3.1 Cluster Settings

HA (High Availability)

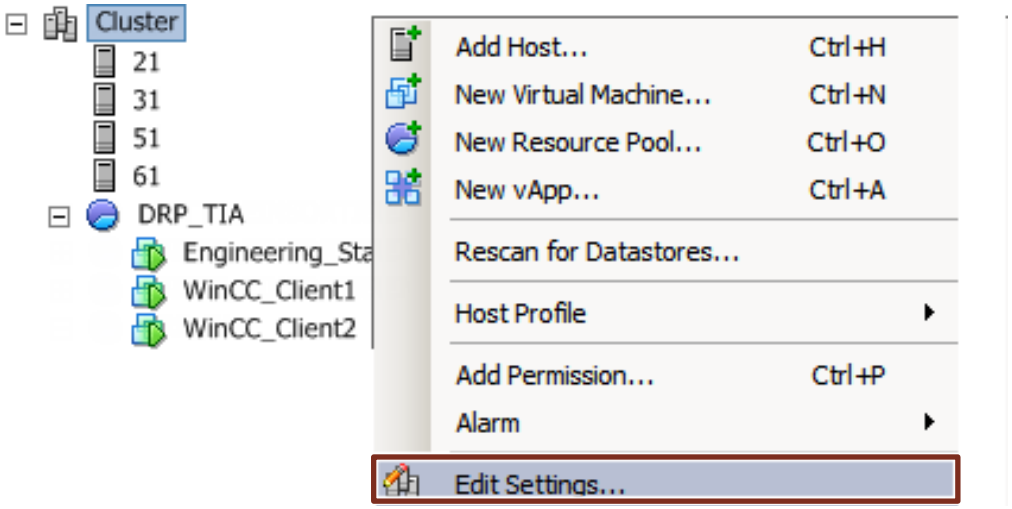
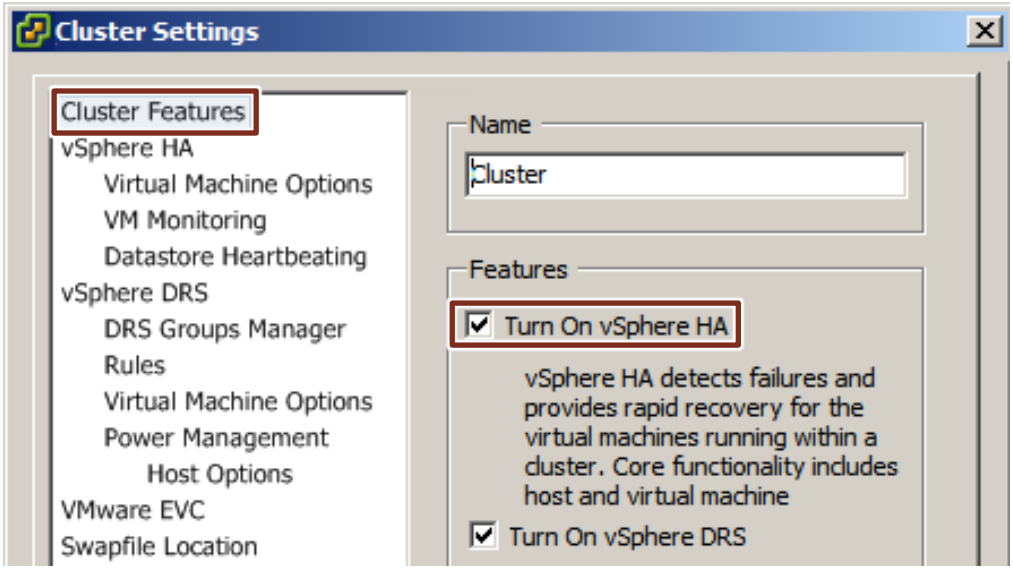
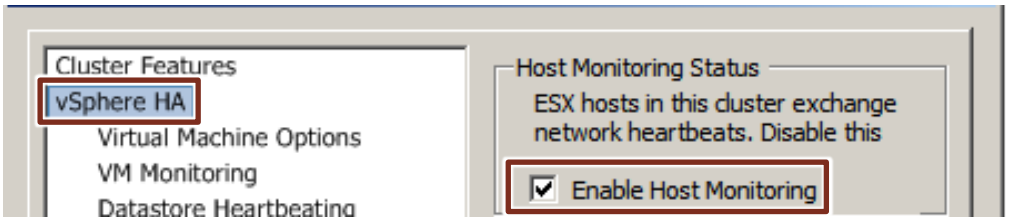
vSphere HA minimizes unplanned downtime:

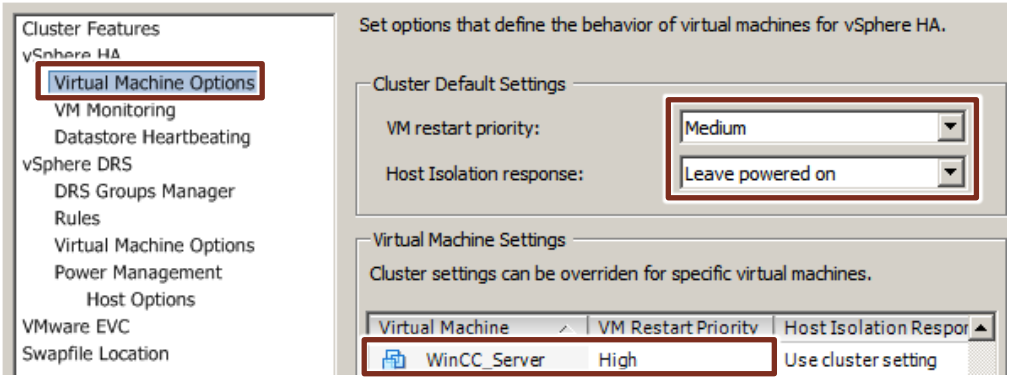
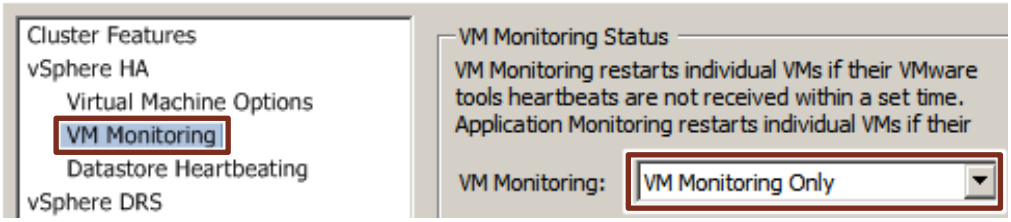
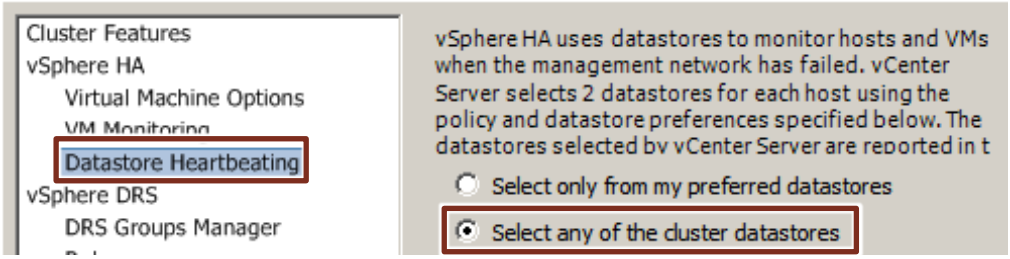
- In the event of a server failure, vSphere HA restarts virtual machines on other hosts in the cluster.
- vSphere HA continuously monitors the operating system of the virtual machine and resets the machine if an error (e.g., a blue screen) is detected.
- vSphere HA restarts virtual machines on other hosts if problems regarding access to their datastore are detected.

To use the function, vSphere HA must be enabled for the cluster and the VMware requirements must be met.

Perform the following steps in the vSphere Client:

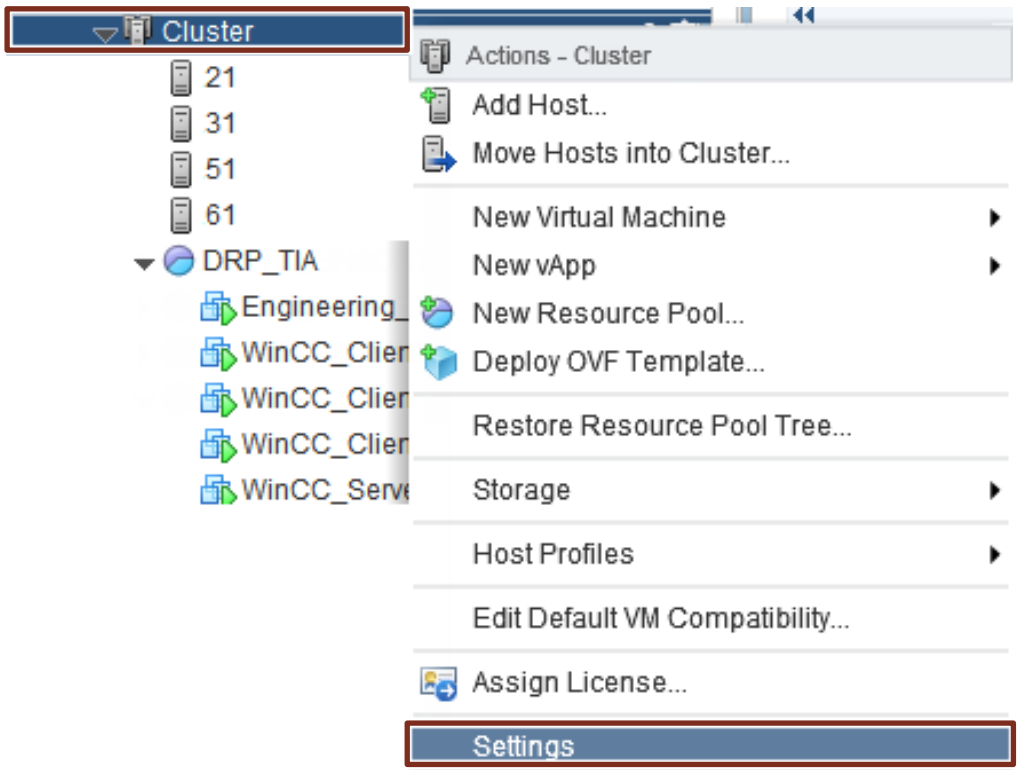
Table 3-2

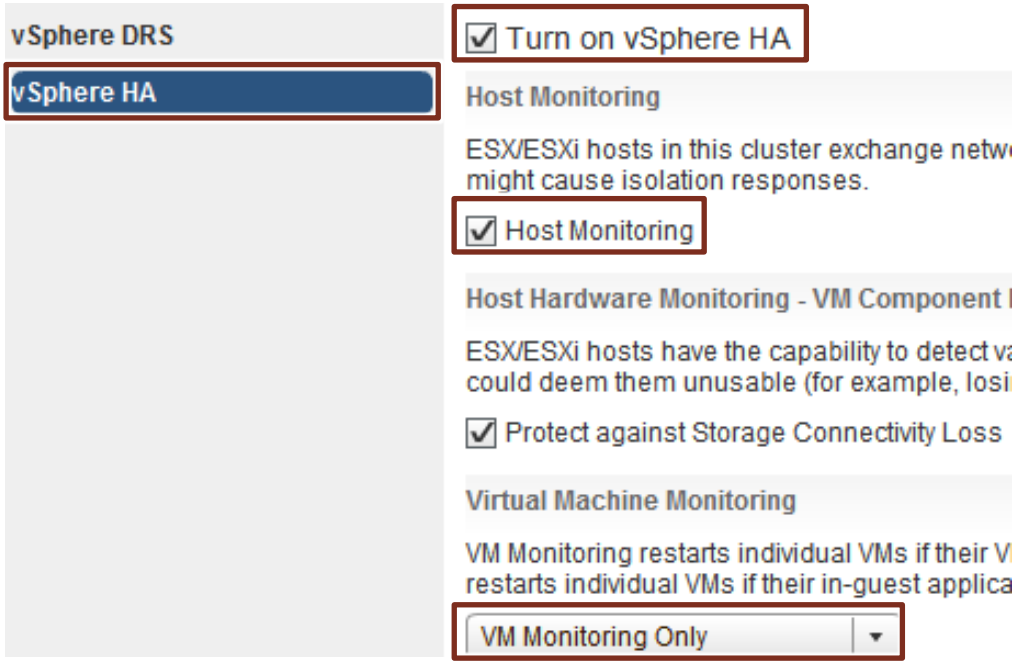
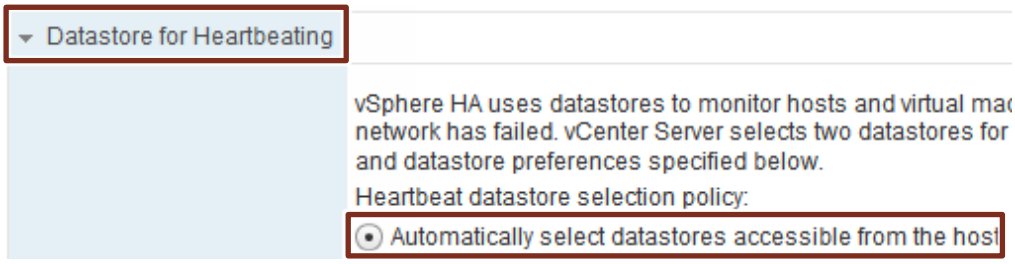
No.	Action
1.	**Open the Cluster Settings dialog box** 
2.	**In the Cluster Settings, enable HA** 
3.	**Host Monitoring** Enable host monitoring 

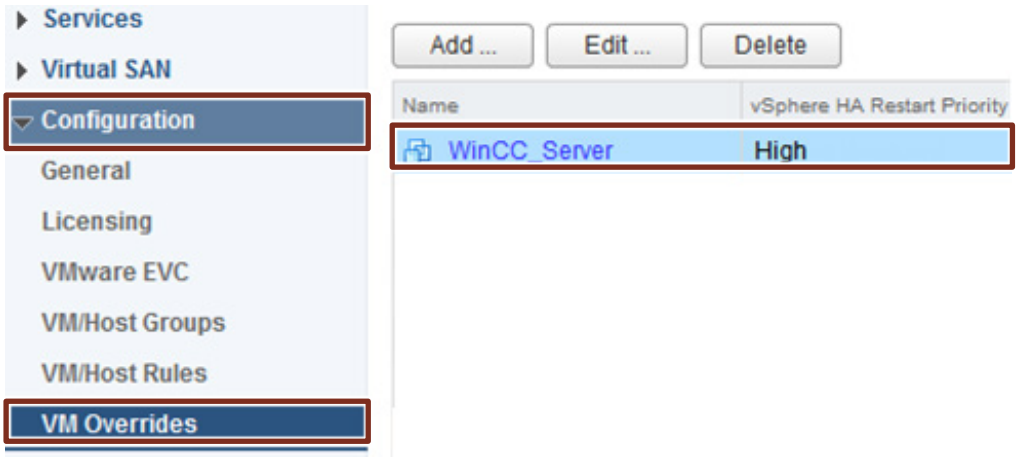
No.	Action
4.	**Virtual Machine Options** Keep the default values for “restart priority” and “host isolation response” for virtual machines. **Optional**: Change the “restart priority” for the virtual machine of the WinCC server to High. If multiple virtual machines have to be restarted, this virtual machine is assigned a higher priority. 
5.	**VM Monitoring** Set VM Monitoring to “VM Monitoring Only”. 
6.	**Datastore Heartbeating** Select the “Select any of the cluster datastores” option for datastore monitoring. 

Alternatively, you can perform these steps in the vSphere Web Client:

Table 3-3

No.	Action
1.	**Open the Cluster Settings dialog box** 

No.	Action
2.	**Configuration of vSphere HA** • In the Cluster Settings, enable HA • Enable host monitoring • Select the “VM Monitoring Only” option 
3.	**Datastore for Heartbeating** Select the “Automatically select datastores accessible from the host” option for datastore monitoring. 

No.	Action
4.	**VM Overrides** **Optional**: Change the VM restart priority for the WinCC server to High. If multiple virtual machines have to be restarted, it is assigned a higher priority. 

NOTICE	HA does not protect against loss of data, it only reduces downtime. In the event of a failure and automatic restart, data can be lost or starting the operating system can fail, for example, due to a corrupt file system. The risks caused by a failure do not differ from physical computers.

Note

To avoid loss of data, we recommend using the redundancy solution from Siemens.

Do not run the two redundant partners on the same ESXi host.
For this purpose, VM-VM anti-affinity rules can be set up. They prevent running virtual machines on the same host. For details, see anti-affinity rules.

Note

Furthermore, HA cannot be used if hardware was integrated into a virtual machine using the pass-through mechanism. When restarting the virtual machine on a different host, the hardware is no longer available.

For more information and a detailed description of how to correctly configure vSphere HA, please refer to the VMware documentation: “vSphere Availability Guide”.

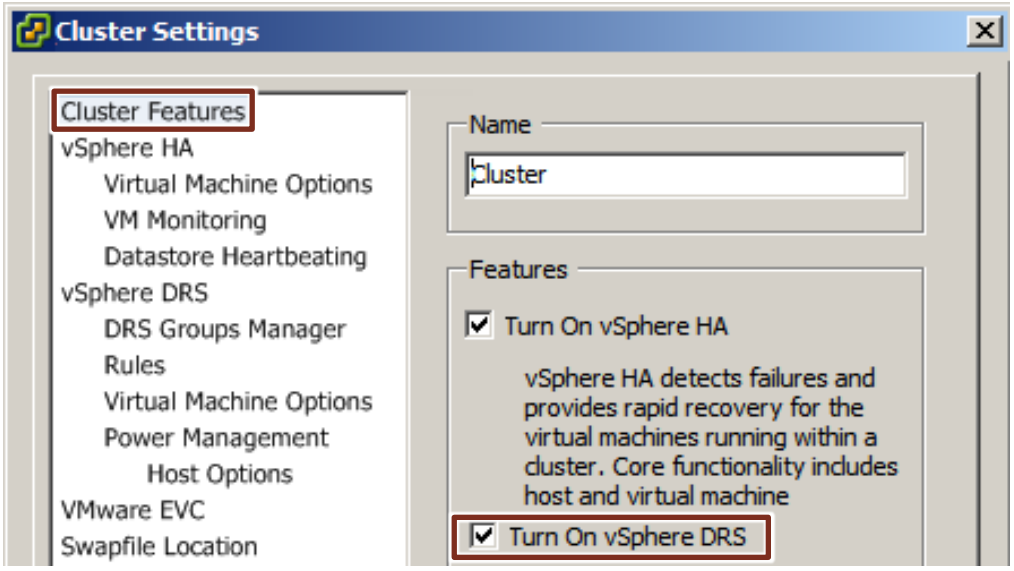
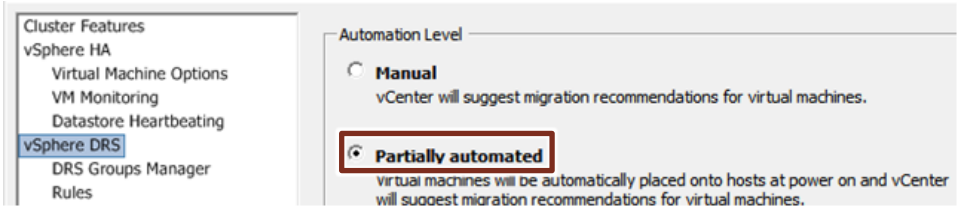
For related information, please use the following link.
https://www.vmware.com/support/pubs/ \4\

DRS (Distributed Resource Scheduler)

DRS summarizes the resources of a cluster and decides, e.g. when turning on a VM, on which host it runs.

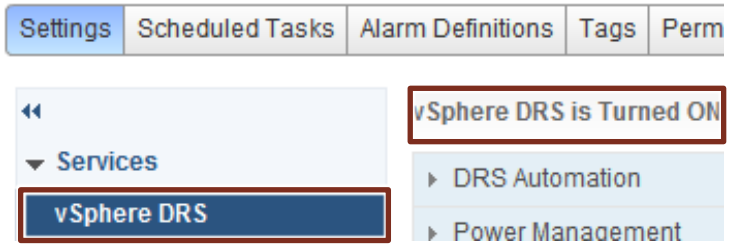
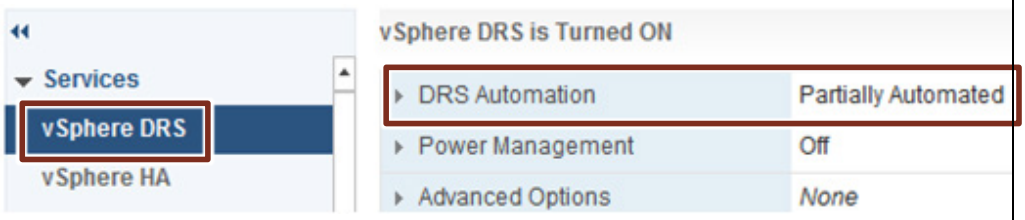
To configure DRS, perform the following steps:

Table 3-4

No.	Action
1.	**In the Cluster Settings, enable DRS** 
2.	Activate „Partially automated“  Note Your virtual machine is not moving during operation with this setting. Only at starting your virtual machine the host is selected by automatic.

No.	Action
3.	**Resource pool** • Create a resource pool • Name it, for example, DRP_TIA • You can make custom settings for each resource pool, for example reserve RAM or CPU resources. Do not change the default settings • Add your virtual machine to this resource pool. 

Alternatively, you can perform these steps in the vSphere Web Client:

No.	Action
1.	**In the Cluster Settings, enable DRS** 
2.	Activate „Partially automated“  Note Your virtual machine is not moving during operation with this setting. Only at starting your virtual machine the host is selected by automatic.

No.	Action
3.	**Resource pool** • Create a resource pool • Name it, for example, DRP_TIA • You can make custom settings for each resource pool, for example reserve RAM or CPU resources. Do not change the default settings • Add your virtual machine to this resource pool. DRP_TIA Engineering_Station WinCC_Client1 WinCC_Client2 WinCC_Client3 WinCC_Server

DPM (Distributed Power Management)

Within a cluster, DPM can be used to automatically move virtual machines between hosts and therefore turn off hosts that are not needed. This saves power.

Turn off DPM for all hosts running virtual machines with SIMATIC software.
Moving virtual machines while SIMATIC software is active is not supported.

Figure 3-8 DPM configuration in the vSphere Client

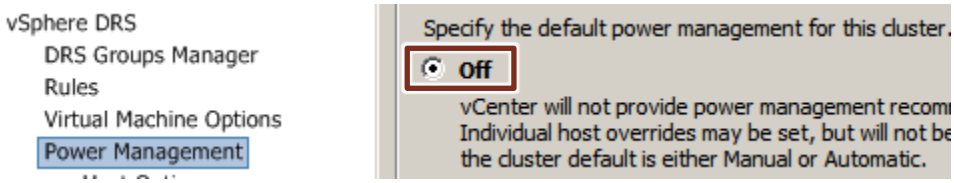
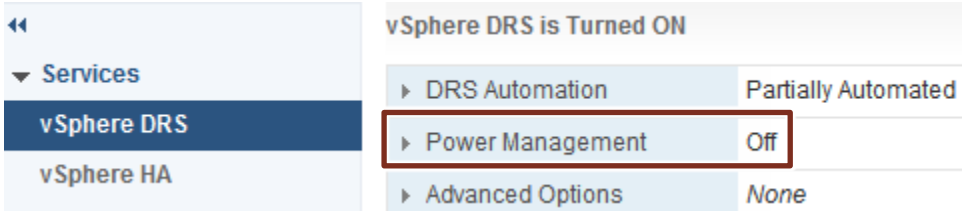


Figure 3-9 DPM configuration in the vSphere Web Client

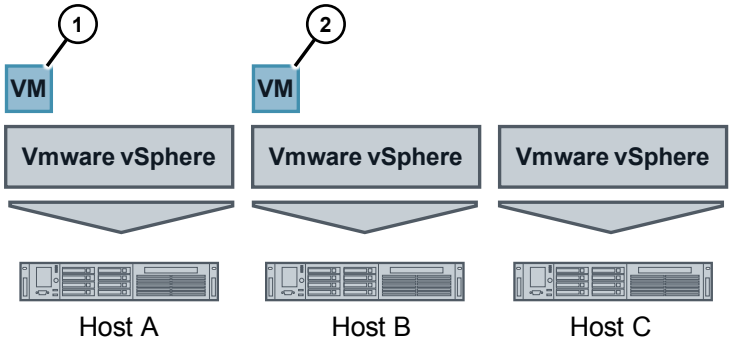


Using affinity and anti-affinity rules

Within a vSphere cluster, you can define rules to ensure that certain virtual machines always run on the same host or on different hosts.

If you are using a redundant WinCC server pair, make sure that both machines run on different hosts.

Figure 3-10, distribution of redundant WinCC Servers

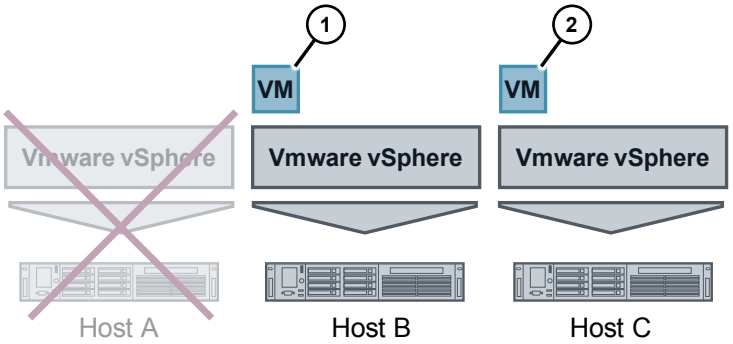


1 Redundant WinCC Server - Master

2 Redundant WinCC Server - Slave

If the host is down, the virtual machine of the redundant server will be restarted at another host.

Figure 3-11, distribution of redundant WinCC Servers



1 Redundant WinCC Server - Master

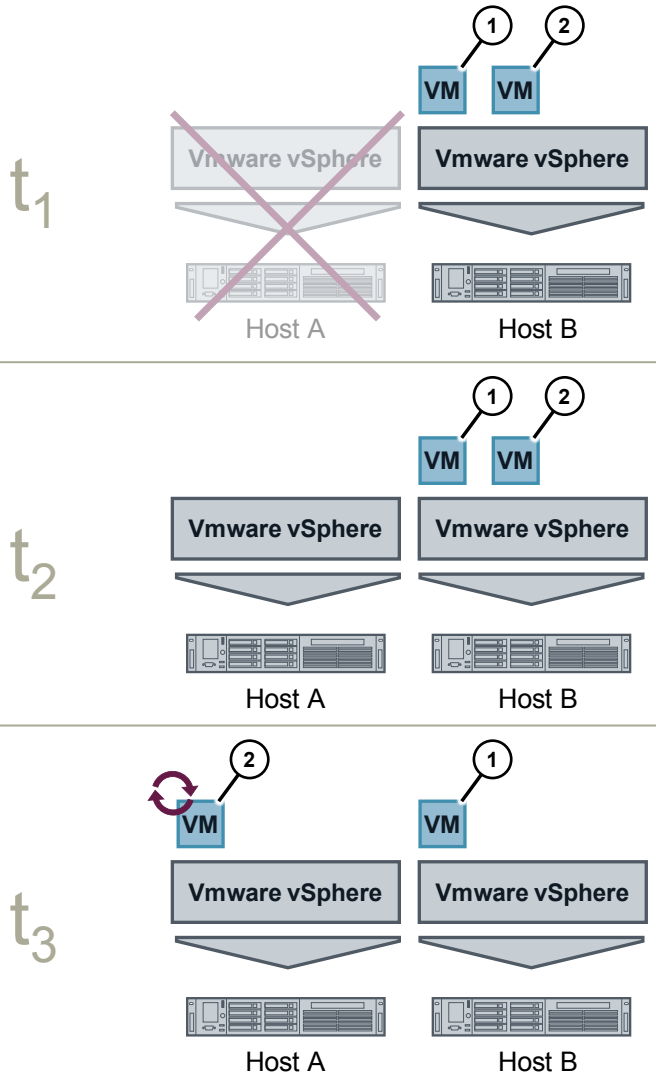
2 Redundant WinCC Server - Slave

Special case, only one Host is still running at HA Clusters

All hosts are down but one is running, the virtual machine (from the down host) is restarted at this least host. Both the Master and the Slave are running at the same host.

If the hosts came back, a redundant Server has to be restarted manually. The virtual machine will be started at the other host. Both servers are running at different host due to the affinity and anti-affinity rules.

Figure 3-12, distribution of redundant WinCC Servers

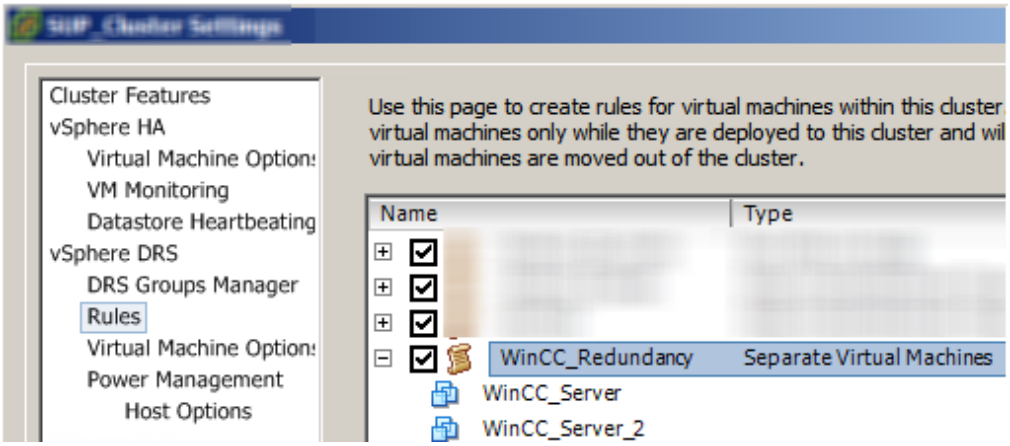


(1) Redundant WinCC Server - Master

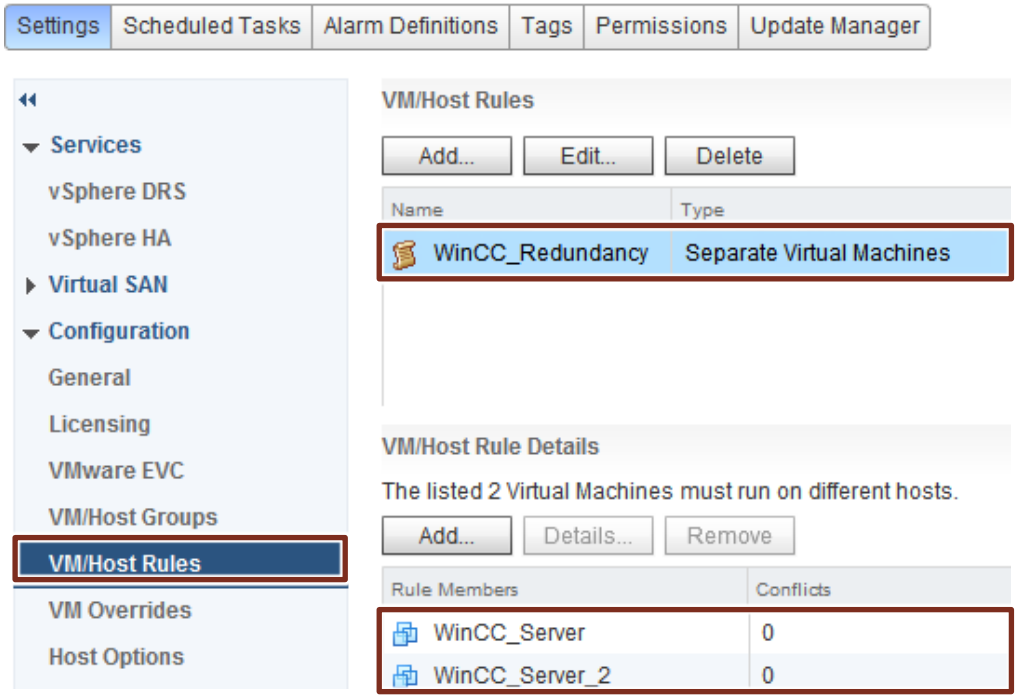
(2) Redundant WinCC Server - Slave

To do this, perform the following steps:

Table 3-5

No.	Action
1.	**Open the Cluster Settings dialog box (see HA (High Availability))**
2.	**Create a rule** • In the DRS settings, select the Rules option • Add a new rule and name it, for example, WinCC_Redundancy • Select the “Separate Virtual Machines” option and add the two WinCC servers 

Alternatively, you can perform these steps in the vSphere Web Client:

No.	Action
1.	**Open the Cluster Settings dialog box (see HA (High Availability))**
2.	**Create a rule** • Select the VM/Host Rules item • Add a new rule and name it, for example, WinCC_Redundancy • Select the “Separate Virtual Machines” option and add the two WinCC servers 

3.3.2 vMotion and Storage vMotion

vMotion and Storage vMotion are two technologies that allow the live migration of running virtual machines.

vMotion

vMotion allows the migration of the running virtual machine between the individual hosts of the cluster. The running virtual machine is relocated from one host to another.

Storage vMotion

Storage vMotion allows the migration of the hard disk files of running virtual machines between storage arrays. The vmdk files are migrated from one datastore to another.

Note Storage vMotion also allows you to change the disk format. For example, you can change a thin-provisioned hard disk file to thick-provisioned.

NOTICE **Do not use vMotion and Storage vMotion when SIMATIC software is active.**

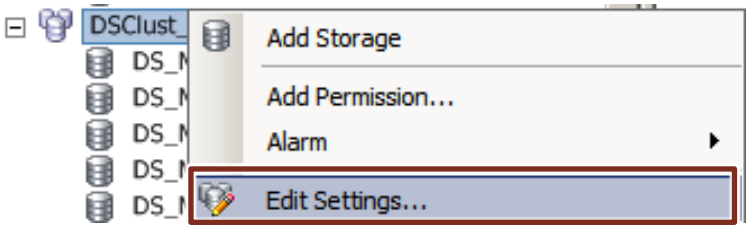
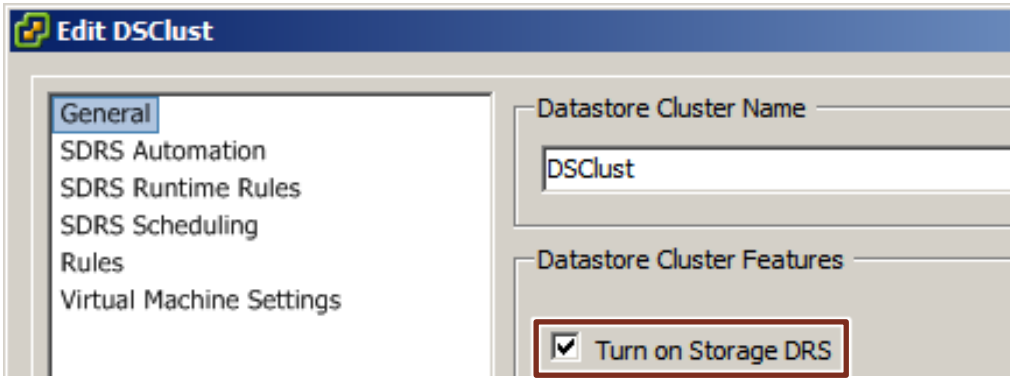
To avoid loss of data, use this option only when all SIMATIC software is inactive.

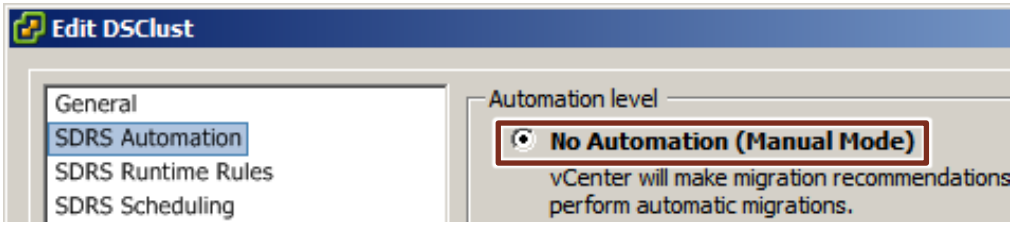
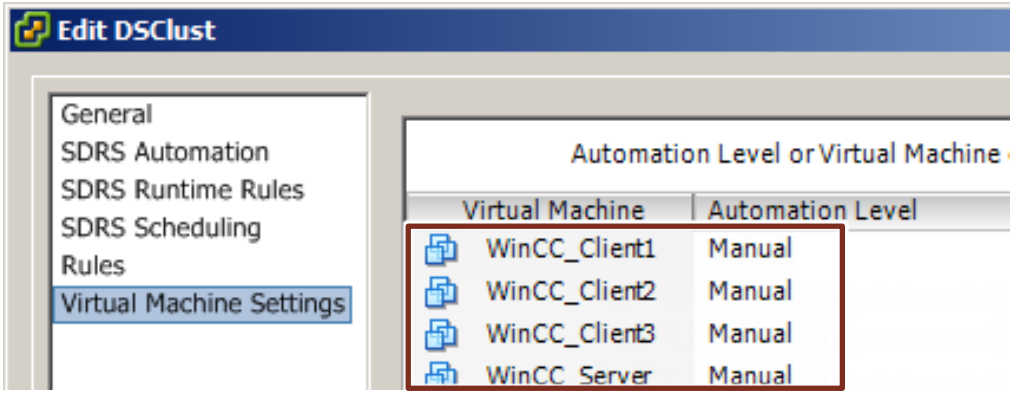
3.3.3 SDRS (Storage DRS)

Storage DRS enables moving virtual machines automatically within a datastore cluster. A datastore cluster consists of individual datastores.

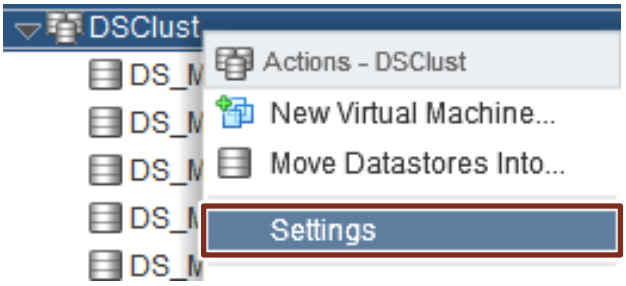
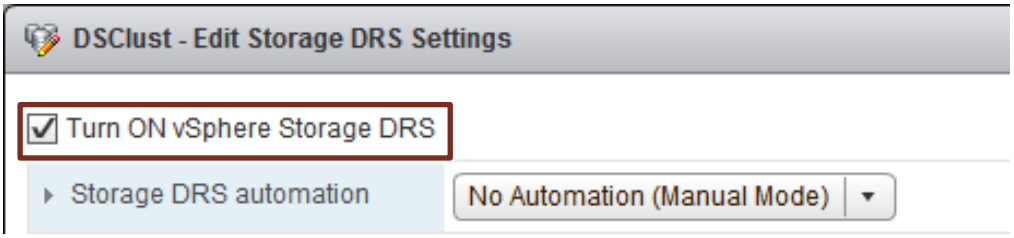
Perform the following steps in order to use datastore clusters.

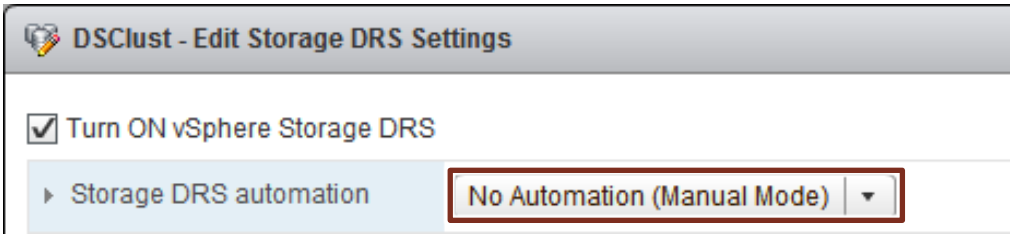
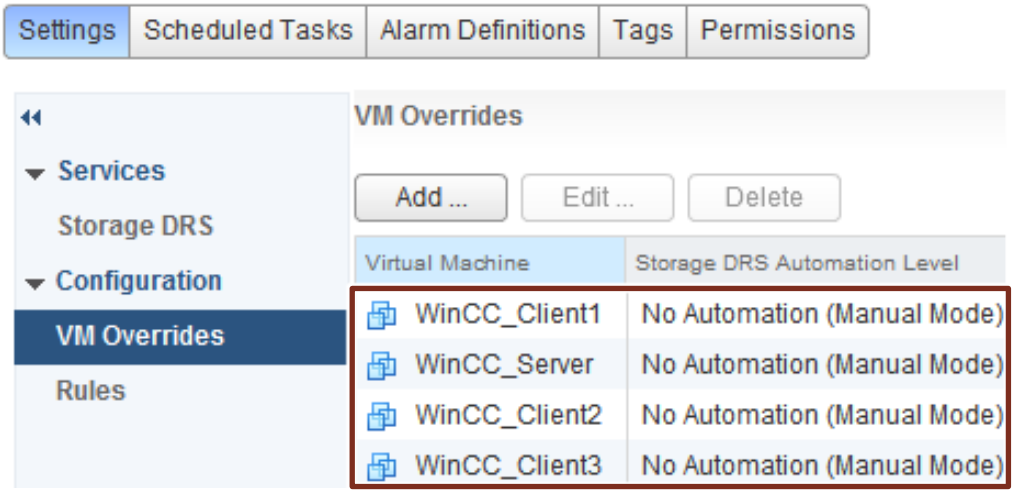
Table 3-6

No.	Action
1.	**Open the settings of the datastore cluster** 
2.	**Turn on storage DRS** 

No.	Action
3.	**Configuration** If you enable this functionality and use SDRS, assure one of the following two options for the virtual machine with SIMATIC SW: • The cluster is in manual mode. No virtual machine is migrated automatically.  • If the option "fully automated" is selected, the virtual machines with SIMATIC software have to be excluded from this automatism. 

Alternatively, you can perform these steps in the vSphere Web Client:

No.	Action
1.	**Open the settings of the datastore cluster** 
2.	**Turn on storage DRS** 

No.	Action
3.	**Configuration** If you enable this functionality and use SDRS, assure one of the following two options for the automation of virtual machines: • The cluster is in manual mode. No virtual machine is migrated automatically.  • If the option "fully automated" is selected, the virtual machines with SIMATIC software have to be excluded from this automatism. 

NOTICE	**Do not move virtual machines with active SIMATIC software.** This applies to vMotion and storage vMotion processes.

3.3.4 FT (Fault Tolerance)

Fault tolerance provides uninterrupted availability by assuring that the states of the primary and secondary virtual machine are identical for the entire time the instruction is being executed.

An FT protected virtual machine can include only one virtual CPU in the version that is used. VMware Fault Tolerance requires a dedicated network link between the two physical servers which has sufficient bandwidth to transfer the required data between the virtual machines.

For more information on vSphere FT, see the VMware documentation "vSphere Availability".

For more information, follow this link:
https://www.vmware.com/support/pubs/ \4\

FT does not provide protection in the event of a software fault. If, for instance, an error occurs during program execution on the primary PC, this error will be replicated on the second PC, too.

Note In contrast, the Siemens redundancy solution allows operating two independent servers. If one of the two machines fails, it will automatically synchronize the data once the partner is back up again. As the two machines run independently of one another, errors of the operating system or an application will not be replicated.

NOTICE	**FT was not considered further within the context of this reference architecture and will not be supported in connection with the SIMATIC software**.

3.4 Creating virtual machines for the TIA Portal

3.4.1 Introduction

As described above, the TIA project we use comprises 5 computers which are integrated into an existing vSphere environment as virtual machines.

There are various options to create a virtual machine:

- Wizard to create a new virtual machine
- VMware Converter
- VMware Workstation
- Creating a virtual machine based on a Windows template

Note

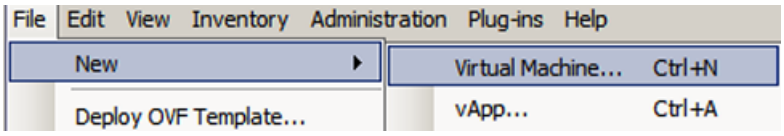
Recommendation:
Create your virtual machine in the environment in which it will be used. This avoids possible problems caused by conversion processes.

3.4.2 Wizard to create a new virtual machine

The easiest way to create a new virtual machine is to use the Create New Virtual Machine wizard.

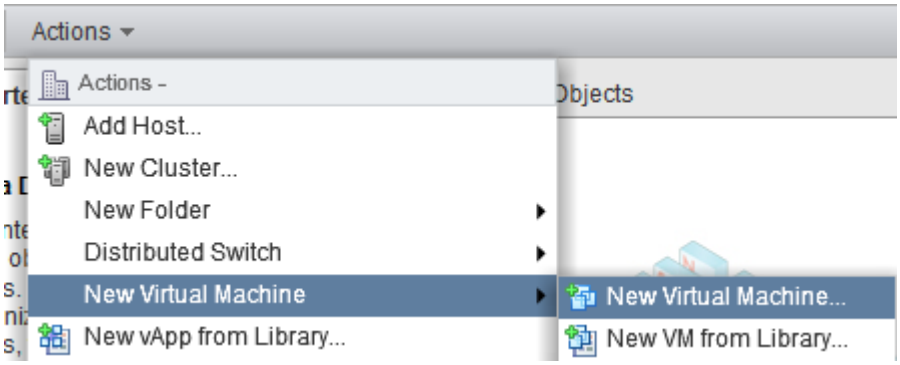
Starting the wizard in the vSphere Client

1. Click "File > New > Virtual Machine".



Starting the wizard in the vSphere Web Client

2. Click "Actions > New Virtual Machine > New Virtual Machine".



Note

For the next steps to create a virtual machine, please refer to the VMware documentation "vSphere Virtual Machine Administration", e.g. chapter 2.
For more information, follow this link:
https://www.vmware.com/support/pubs/ \4\

For more specifics on the exact virtual machine settings using TIA Portal components, see 3.4.6 Configuring the individual virtual machines.

3.4.3 VMware Converter

This free tool can be downloaded from VMware and is capable of converting an existing physical PC into a virtual machine (P2V - Physical to Virtual) or of migrating and converting an existing virtual machine between different systems (V2V - Virtual to Virtual).

P2V

NOTICE

Do **not** convert a physical server or client using the VMware Converter into a virtual machine. This can create scenarios that impair the smooth operation of the SIMATIC software.

V2V

The converter allows migrating existing virtual machines created with VMware Workstation to an ESXi host. Please note that certain functions will not be available on an ESXi server and will hence be removed accordingly during conversion. This includes:

- shared folders
- HD audio
- COM ports, etc.

Please read KB article 1004588 "Best practices for using and troubleshooting VMware Converter" by VMware.

For more information, follow this link:
https://kb.vmware.com/selfservice/microsites/microsite.do \5\

Note

Recommendation:
Create your virtual machine in the environment in which it will be used. This avoids possible problems caused by conversion processes.

3.4.4 VMware Workstation

It is also possible to create virtual machines using the workstation and subsequently migrate them to an ESXi host. This is comparable to the converter functionality. For more details, read the KB article 1012258 "Exporting virtual machines from VMware Workstation to ESX/ESXi" by VMware.

For more information, follow this link:
https://kb.vmware.com/selfservice/microsites/microsite.do \5\

Note Recommendation:
Create your virtual machine in the environment in which it will be used. This avoids possible problems caused by conversion processes.

3.4.5 Creating a virtual machine based on a Windows template

Templates for virtual machines

vSphere vCenter Server enables providing existing virtual machines as templates. These templates are the basis for new systems to be created.

Note In this context, templates refer to virtual machines that were converted to templates. In both templates, only the operating system is installed **without SIMATIC software.**

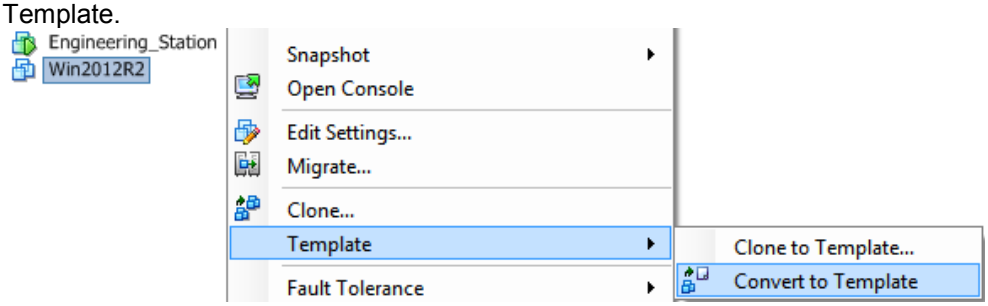
Creating templates

Templates for Windows 7x64 and Windows Server 2012 R2 form the basis of the virtual machines that are used.

To create a virtual machine from a template, proceed as follows.

Converting a virtual machine to a template in the vSphere Client

1. Right-click the virtual machine to convert to a template > Template > Convert to Template.



Converting a virtual machine to a template in the vSphere Web Client

1. Click the virtual machine you wish to convert to a template > Template > Convert to Template.

Figure 3-13

Creating a virtual machine from a template

When cloning a template, the system preparation program (Sysprep) is executed in the background. This assures that a new SID (security identifier) is generated.

Note

For more details, see the VMware KB article 1005593 "Clone a Virtual Machine in the vSphere Client".
(Search for: "Sysprep file locations and versions".)

For more information, follow this link:
https://kb.vmware.com/selfservice/microsites/microsite.do \5\

If you use this approach, make sure that:

- Each machine is properly licensed with a separate license.
- The computer name is unique.
- The IP address is unique.

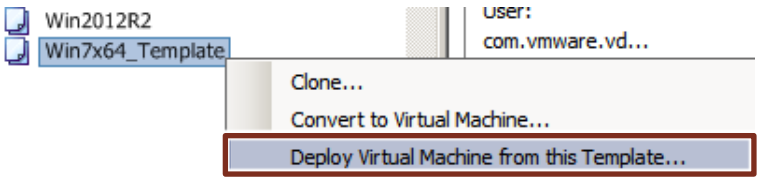
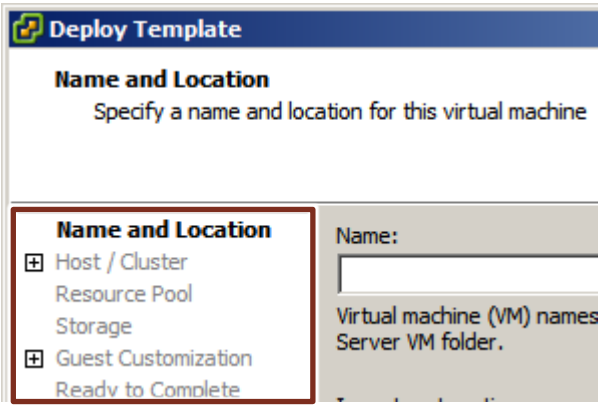
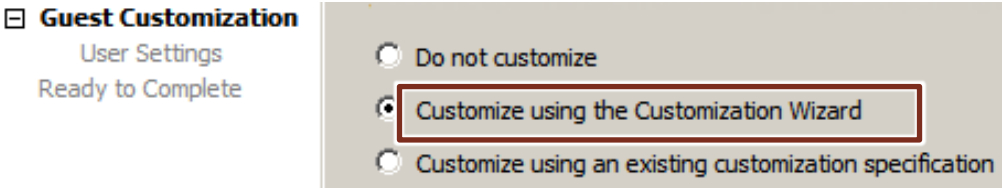
Note

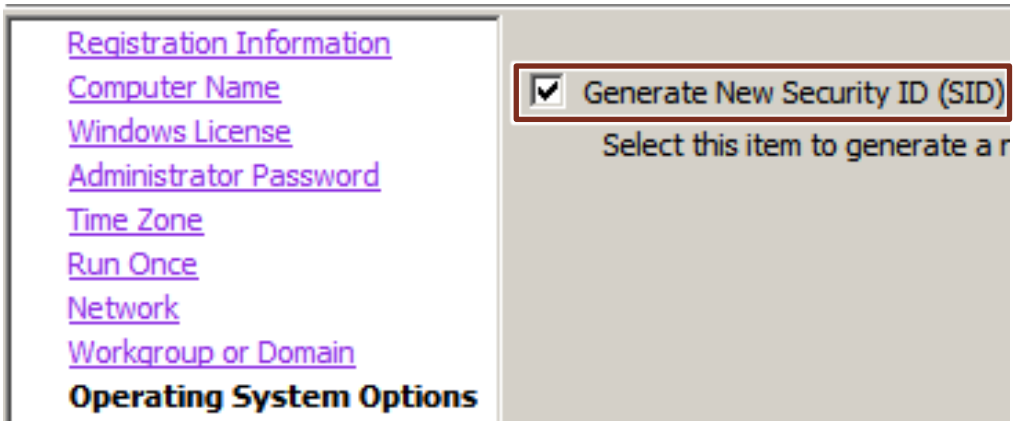
The required adjustments can be saved to a "customization specification" for reuse.

The customization specification facilitates the process of setting when creating virtual machines from a template.

Steps for creating a virtual machine from a template using vSphere Client

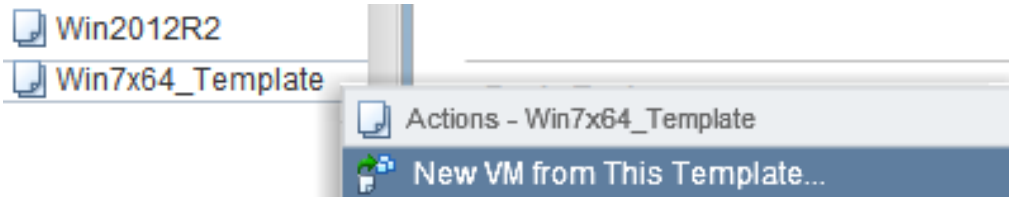
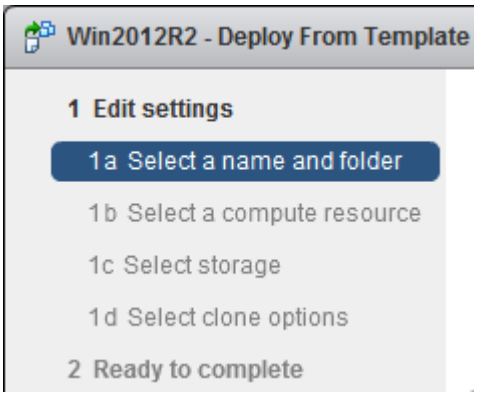
Table 3-7

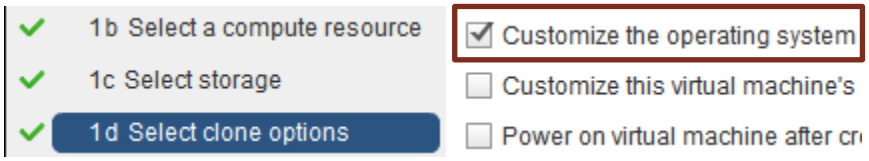
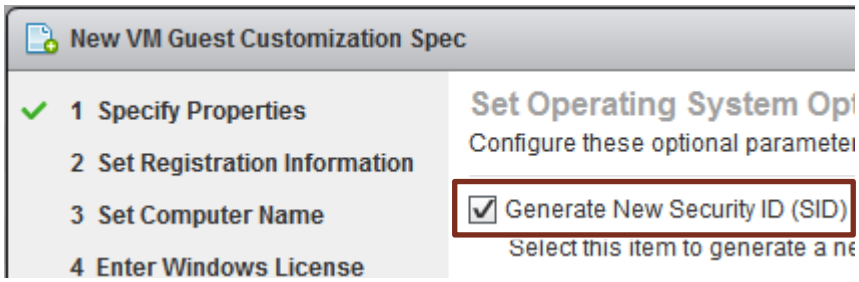
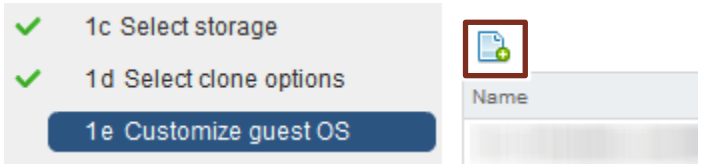
No.	Action
4.	**Select a template** The template must exist already. For details, see the VMware documentation "vSphere Virtual Machine Administration, keyword: Provide virtual machines in the vSphere Web Client". For more information, follow this link: https://www.vmware.com/support/pubs/ \4\ 
5.	**Deploy from template** Follow the instructions, assign a name and include the virtual machine in your infrastructure accordingly. 
6.	**Customization specification** Use the customization specification to adjust or assign the following settings: - new SID - IP addresses - Windows license - computer name 

No.	Action
7.	**New SID** The option to create a new SID has to be selected. 

Steps to create a virtual machine from a template using vSphere Web Client

Table 3-8

No.	Action
1.	**Select a template** 
2.	**Deploy from template** Follow the instructions, assign a name and include the virtual machine in your infrastructure accordingly. 

No.	Action
3.	**Customization specification** Use the customization specification to adjust or assign the following settings: • new SID • IP addresses • Windows license • computer name • 
4.	**Create a new SID** 
5.	**Create new specification**  If you have already created a specification, you can select and reuse it.

NOTICE	**Do not clone or copy virtual machines. Use only the described method by "creating a virtual machine from a template". This assures that addresses, names or security ID, for example, are unique and avoids conflicts.**

NOTICE	**Make sure that all software products are properly licensed when creating new virtual machines from templates.** **For example, Windows server services can be impaired by missing licenses.**

NOTE	Recommendation Due to the mentioned risks above, consult an IT administrator. Receive advice to uniqueness of your virtual machines and licensing your used software.

3.4.6 Configuring the individual virtual machines

Note Combine similar types of your virtual machines in groups. Then you can use e.g. your own Windows templates and your own configurations for the groups you have created.

In this example, virtual machines were combined in the following groups.

- WinCC servers
- WinCC clients
- engineering stations

The following components are used for the virtual machines. The three tables show the use for the individual machines:

Table 3-9 Client

Hardware component	Setting
vCPU[1]	2
RAM	4 GB
Network adapter 1	VMXNET 3[2] (terminal bus)
Hard drive 1	SCSI (0:0) 40 GB (Thick Eager)
SCSI Controller 0	LSI Logic SAS (or Paravirtual[3])

Table 3-10 Engineering Stations

Hardware component	Setting
vCPU	2
RAM	8 GB
Network adapter 1	VMXNET 3² (system bus)
Hard drive 1 for the operating system	SCSI (0:0) 80 GB (Thick Eager)
Hard drive 2 for the project	SCSI (1:0) 15 GB (Thick Eager)
SCSI Controller 0	Paravirtual
SCSI Controller 1	Paravirtual

[1] Which combination of sockets and cores is used is not significant for the performance. Only the number of vCPUs is relevant in this context. The distribution can have an impact on licensing inside your virtual maschine.

[2] For applications that exchange great volumes of data, we recommend using a VMXNET3 NIC to run them on the same host and same vSwitch, because the bandwidth is not limited by a physical network card with this method.

[3] Requires additional drivers during Windows installation.

Table 3-11 WinCC Server

Hardware component	Setting
CPU	2
RAM	8 GB
Network adapter 1	VMXNET 3² (system bus)
Network adapter 2	VMXNET 3² (terminal bus)
Hard drive 1 for BS	SCSI (0:0) 60 GB (Thick Eager)
Hard drive 2 for the project	SCSI (1:0) 50 GB (Thick Eager)
SCSI Controller 0	Paravirtual
SCSI Controller 1	Paravirtual

Recommended configuration for all types

Hardware version

- Use "hardware version 10". It is the default setting with ESXi 5.5.

Hard drives and hard drive controllers

- Create all hard drives in the format Thick Provision Eager Zeroed.
  This setting takes longer to create but it will boost performance during operation later on.
  This setting is recommended for productive facilities.

NOTE Thick Provision Eager Zeroed allocates the whole storage space and writes zeros into.
The storage space is occupied in the hosts file system.

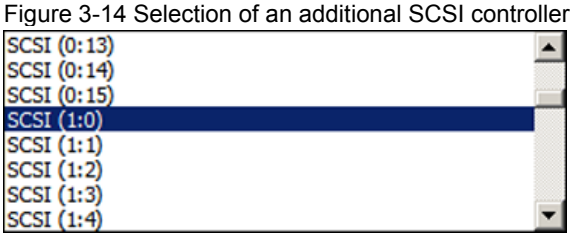
Get advice of a storage administrator on large configurations.

For more information, follow this link:
https://www.vmware.com/pdf/vcops-vapp-585-deploy-guide.pdf (p.15) \6\

- When using multiple hard drives in one virtual machine, each should be assigned its own controller. The SCSI link can be selected for each hard drive. You can create up to four SCSI controllers with 16 devices each. Distribute the hard drives evenly over the controllers.

  For more information, see the book "Virtualizing Microsoft Business Critical Applications on VMware vSphere" (p. 90). \7\

Figure 3-14 Selection of an additional SCSI controller



Example for three hard drives
Table 3-12

Hard disk	SCSI controller
Hard drive 1	SCSI (1:0)
Hard drive 2	SCSI (2:0)
Hard drive 3	SCSI (3:0)

- The paravirtual controller is suitable for read and write intensive processes. This concerns e.g. the engineering station and the WinCC server. Hard drive access is increased during compilation in the engineering station and during archiving and various database processes of the WinCC server.

  For more information, follow this link:
  https://www.vmware.com/pdf/Perf_Best_Practices_vSphere5.5.pdf (p. 50) \8\

  or search the KB article 1010398 for "Configuring disks to use VMware Paravirtual SCSI adapters".
  https://kb.vmware.com/selfservice/microsites/microsite.do \7\

CPU

Note Generally, the number of initially configured vCPUs should not be too high. Each vCPU assigned additionally will increase the administrative effort by the Hypervisor and can negatively affect the performance of the virtual machine.

NOTICE **Do not exceed more than 100% of your processing power**

This means that more RAM or CPU performance is allocated in total for all virtual machines on a physical host than is actually provided by the latter. In that case, the automation software might no longer work correctly and unexpected side effects can occur.

System critical applications, behavior during virtualizing server overloading

Increase the shares for CPU, RAM and hard drives for virtual machines that are system critical. In the event of a virtualizing server overload, the virtual machines assigned greater shares will be treated preferentially by being allocated resources more frequently.

Example of the WinCC server in the vSphere Client

Figure 3-15 CPU allocation

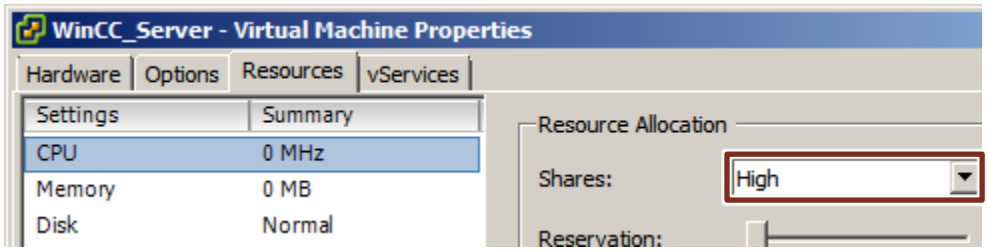


Figure 3-16 RAM allocation

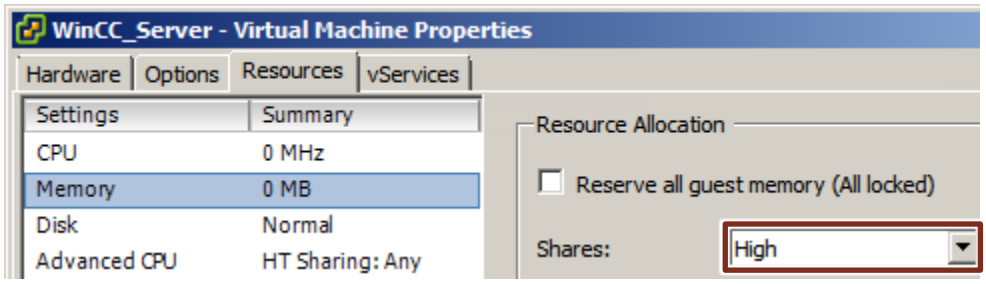
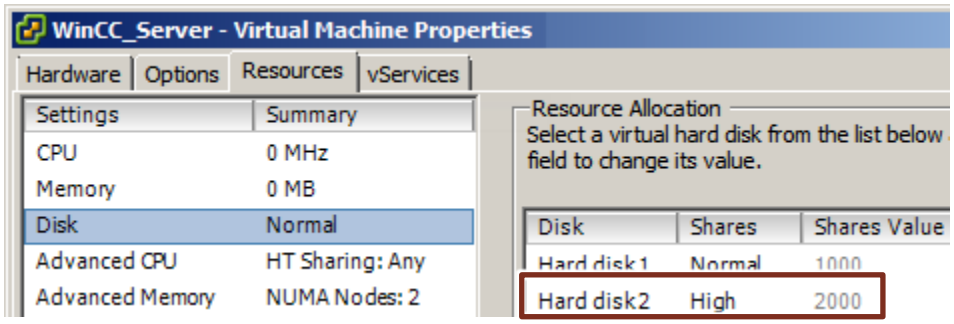


Figure 3-17 Hard drive allocation



Example of the WinCC Server in the vSphere Web Client

Figure 3-18 CPU and RAM allocation in the vSphere Web Client

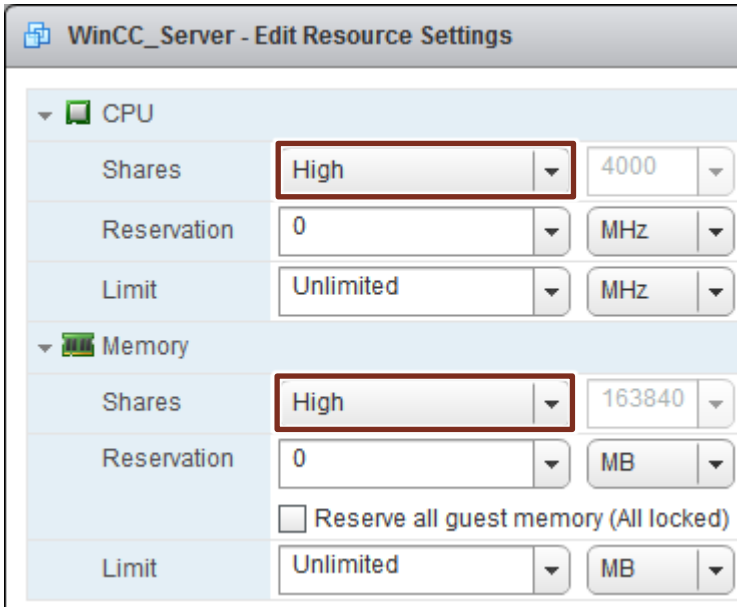
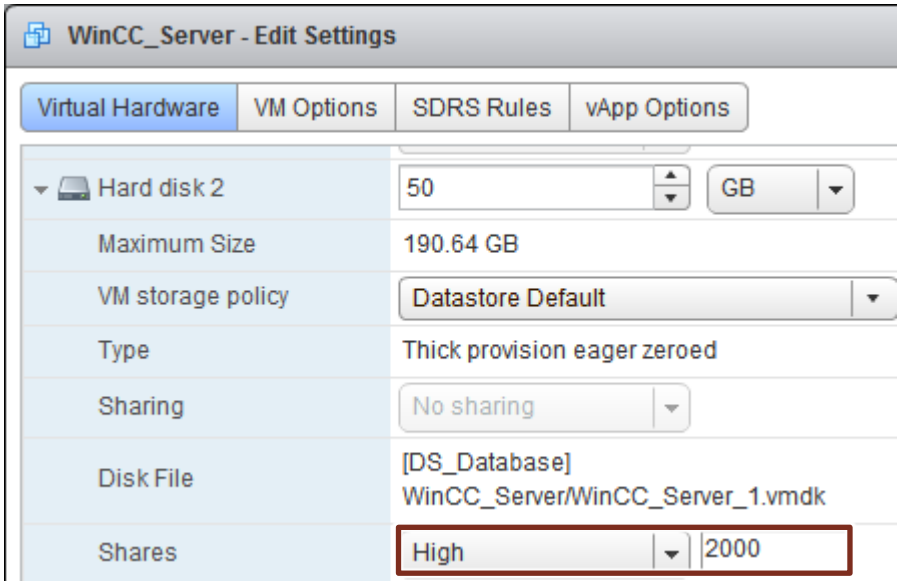


Figure 3-19 Hard drive allocation in the vSphere Web Client



Note

Increasing the shares does not boost performance but only increases the percentage of allocated resources in the event of a system overload. This event should not occur in productive facilities. This mechanism can only assure that certain virtual machines are treated preferentially in such an exceptional situation.

3.4.7 Exchanging data with a virtual machine (e.g. to install SIMATIC SW)

There are several ways to exchange data, e.g. software for the installation, with a virtual machine:

- connecting ISO file through CD drive
- mounting a shared drive, e.g. drive sharing
- file transfer using a PowerCLI script:

NOTE Using ISO files or mounting a shared drive are recommended.

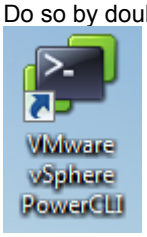
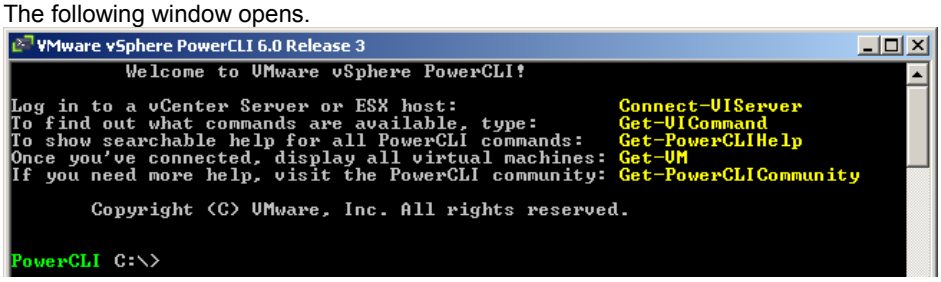
Use the “PowerCLI” in agreement with your administrator only.

Data exchange through PowerCLI script

For details on how to install vSphere PowerCLI and a full documentation, follow the link below.
https://www.vmware.com/support/developer/PowerCLI/ \9\

If vSphere PowerCLI is installed, you can use the following commands to exchange files between your computer and a virtual machine. Proceed as follows:

Table 3-13

No.	Action
1.	**Start PowerCLI** Do so by double-clicking the icon of the VMware vSphere PowerCLI  The following window opens. 
2.	**Connect to your vCenter Server / ESXi Host.** Enter the following command for this purpose: `Connect-VIServer -Server 10.23.112.235 -User admin -Password pass`
3.	**Transferring or retrieving files** Use the following command to transfer data from your PC to a virtual machine or to retrieve data.

No.	Action
	• Transferring data from your PC to the virtual machine: "GuestToLocal". • Retrieving data from the virtual machine to your PC: "LocalToGuest". `Copy-VMGuestFile -Source c:\text.txt -Destination c:\temp\ - VM NAME_OF_YOUR_VM -LocalToGuest -HostUser USER_NAME_OF_THE_ESXI_HOST - HostPassword PASWWORD_OF_THE_ESXI_HOST -GuestUser WINDOWSUSER- GuestPassword PASSWORD_FOR_WINDOWSUSER` This instruction copies the file text.txt from your computer's C partition to a virtual machine named NAME_OF_YOUR_VM to the path c:\temp.
4.	**End transfer** Use the following command to end the transfer and release the resources again. `Disconnect-VIServer 10.23.112.235`

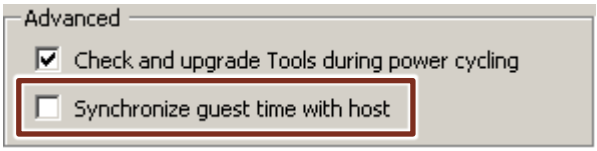
3.4.8 Time synchronization

Synchronizing the virtual machines

The host (ESXi) must use the same time source as the operating systems within the virtual machines. Before time synchronization mechanisms take effect in the virtual machine, the host's time is used when starting the virtual machine. If the two times differ, undesired behavior can occur as a result.

Use one of the two methods of time synchronization in the virtual machine:

- VMware Tools or



- another time synchronization method, e.g. WinCC mechanisms
  For more information, see the Online Support, Entry ID: "86535497".
  https://support.industry.siemens.com/cs/ww/en/view/86535497).

NOTICE	The two methods used to synchronize the virtual machine time (e.g. NTP) and VMware Tools (time synchronization with the host) must not be used at the same time.

Synchronization of the hosts

The ESXi hosts need a time source. Set this source accordingly using the vSphere Client.

Figure 3-20 NTP Server Configuration in the vSphere Client

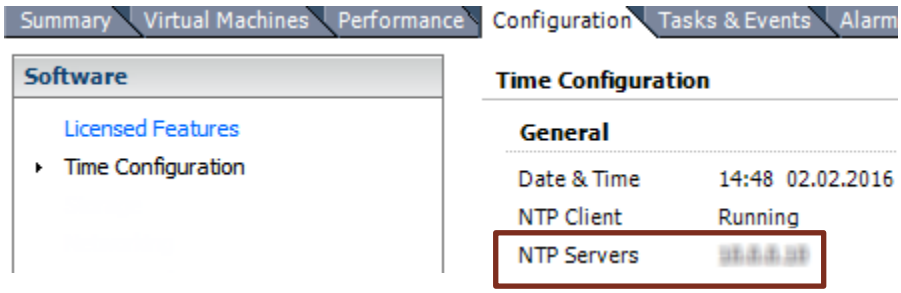
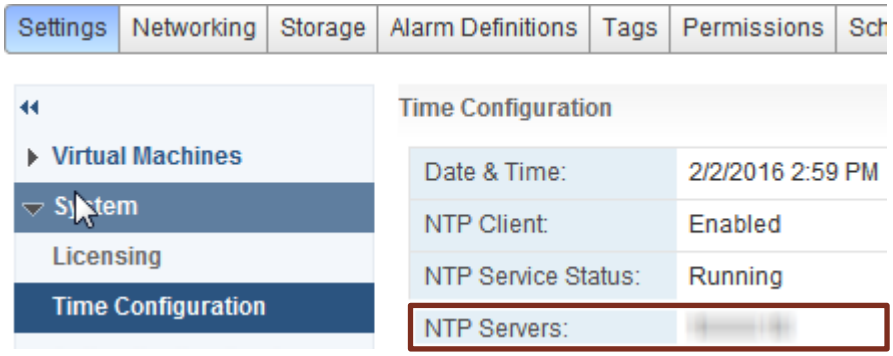


Figure 3-21 NTP server configuration in the vSphere Web Client



3.4.9 Installing SIMATIC software

If the virtual machine contains the installation sources, you can install the SIMATIC SW as usual.

For more information, refer to the system manuals.

- STEP 7 Professional V13 SP1
  https://support.industry.siemens.com/cs/de/en/view/109011420 \11\
- WinCC Professional V13 SP1
  https://support.industry.siemens.com/cs/ww/en/view/109096785 \12\

4 Further Notes, Tips and Tricks

4.1 General recommendations

Snapshots

Do not use snapshots during productive operation. This can negatively affect the virtual machine's general performance capability.

For more information, follow this link:
https://www.vmware.com/pdf/vcops-vapp-585-deploy-guide.pdf (p. 15) \6\

Search KB entry 1025279 "Snapshots are not backups" for "Best practices for virtual machine snapshots in the VMware environment".
https://kb.vmware.com/selfservice/microsites/microsite.do \5\

vMotion or vMotion Storage

Do not use vMotion or vMotion Storage for virtual machines in which SIMATIC software is active.

VMware Tools

Install the latest version of the VMware Tools.

Hard drives

Thick Provision Eager Zeroed format

Create the hard drives in the format "Thick Provision Eager Zeroed". It will provide the best performance properties.

For more information, follow this link:
https://www.vmware.com/pdf/vcops-vapp-585-deploy-guide.pdf (p. 15) \6\

Distributing multiple hard drives of a virtual machine

Distribute the hard drives evenly across the virtual SCSI adapters.

For more information, see the book "Virtualizing Microsoft Business Critical Applications on VMware vSphere" (p. 90). \7\

I/O intensive applications

Use the paravirtual storage adapter (PVSCSI) for I/O intensive applications. It reduces the CPU load and is capable of improving especially the system's overall performance. Also observe the information provided by the following links. For more information, follow this link:
https://www.vmware.com/pdf/Perf_Best_Practices_vSphere5.5.pdf (p. 50) \8\

or in the KB article 1010398. Look for "Configuring disks to use VMware Paravirtual SCSI adapters".
https://kb.vmware.com/selfservice/microsites/microsite.do \7\

Unnecessary hardware in virtual machines

Remove all unnecessary hardware from the configuration. Each unnecessary element can negatively affect the performance capability of your virtual machine.

For more information, follow this link:
https://www.vmware.com/pdf/Perf_Best_Practices_vSphere5.5.pdf (p. 19) \8\

This includes:

- floppy disk
- CD ROM
- HD audio
-

4.2 Important security settings

Based on the "Hardening Guide", make the following settings to assure that the SIMATIC products run smoothly. The guide gives a detailed description of additional measures.

For more information, follow this link:
https://www.vmware.com/security/hardening-guides \13\

Disabling automatic updating of VMware Tools

An automatic upgrade of the VMware Tools can cause the host operating system to be restarted automatically. During reboot a WinCC Server is not accessible or WinCC Client is not operable.

Disable automatic installation:

Use PowerCli as described in section 3.4.7 Exchanging data with a virtual machine.

1. Connect to your vCenter Server / ESXi Host.
2. Connect-VIServer -Server 10.23.112.235 -User admin -Password pass
3. Enter the following command:
4. VM.disable-VMtools-autoinstall= True (Get-VM| New-AdvancedSetting -Name "isolation.tools.autoInstall.disable" -value $true)
5. Log off:
6. Disconnect-VIServer 10.23.112.235
7. For other ways to make this change, see the VMware Hardening Guide.

Time synchronization through NTP

Synchronize your ESXi host with a time source. Use the same time source as for time synchronization of your operating systems within the VMs. For more details, see chapter 3.4.8.

Applying patches for ESXi

Always keep the patches of your ESXi hosts up to date. You can do so using the Update Manager for example.

NOTICE	Reboot of host required and with that rebooting virtual machines is required. For successful installation of patches a reboot is required mostly. With that virtual machines have to reboot too. WinCC Servers are not accessible or WinCC Clients are not operable during this.

For more information, follow this link:
https://www.vmware.com/support/policies/security_response \14\

4.3 Compilation times

The compilation times of the engineering station strongly depend on the CPU in use. For this project, two vCPUs were assigned to the engineering station, measuring the times for compiling on different hosts and different data stores. Table 4-1 shows these values.

Table 4-1 Compilation times

No.	Store system	Host name	Time in minutes and seconds for 4 compilations and their average
1.	DotHill (Raid 5)	61	47:40 - 41:26 - 41:42 - 40:00 ∅ 42:52
2.	Dot Hill Fast (Raid 10)	61	37:43 - 40:51 - 39:58 - 45:27 ∅ 41:00
3.	IBM Datastore (Raid 5)	61	38:59 - 40:04 - 40:42 - 40:47 ∅ 40:08
4.	DotHill (Raid 5)	51	20:20 - 20:33 - 19:47 - 20:21 ∅ 20:15
5.	Dot Hill Fast (Raid 10)	51	8:01 PM - 8:11 PM - 7:44 PM - 7:32 PM ∅ 7:52 PM
6.	IBM Datastore (Raid 5)	51	8:50 PM - 8:01 PM - 8:38 PM - 8:48 PM ∅ 8:34 PM
7.	DotHill – CPU reserv.	51	7:15 PM - 7:17 PM - 7:08 PM - 7:06 PM ∅ 7:11 PM

The table below gives an overview of the CPU types used.

Table 4-2 Hosts and performance features

Host name	Processor type	CPU cores	RAM
51	Intel Xeon E5-2680 v3 @ 2.5GHz	24 CPUs	262039.60 MB
61	Intel Xeon E7540 @ 2.0GHz	24 CPUs	393087.10 MB

The measured values show a clear dependence between the compilation time and the CPU used. The data store plays a minor role in this context. Given the shared use of CPU, RAM and data store, the values may vary as a function of the host's overall utilization and the Hypervisor's scheduling behavior.

Reserving the CPU for the engineering station slightly reduces the time. This is shown in line 7 of the Table 4-1. 4800 MHz were reserved exclusively for this virtual machine. However, the full extend is only used during compilation. For the remaining time, it is not used.

Note Reserving resources can boost the virtual machine's performance. But the reserved resources are then no longer available to other virtual machines and hence limit the number of possible virtual machines on this host. Avoid reservations.

4.4 Troubleshooting and performance

VMware provides various means to diagnose performance bottlenecks. Below, we will briefly describe use of the vSphere Client and of the "esxtop" tool.

For more information, see the manual "vSphere Monitoring and Performance". https://www.vmware.com/support/pubs/ \4\

4.4.1 Performance monitoring with vSphere Client or Web Client

The performance of each virtual machine can be monitored. Click the "Performance" tab for this purpose. It shows various views in tables or charts,

giving a quick overview of the current and past situation of your virtual machine. The diagnosis should always be made at the Hypervisor level and not in the virtual machine.

The overview includes:

- CPU
- RAM
- datastore

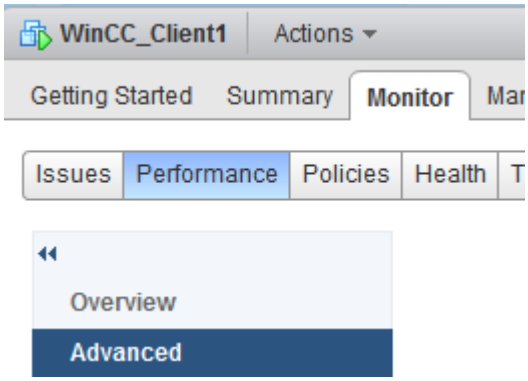
vSphere Client

Figure 4-1 vSphere Client performance monitoring

vSphere Web Client

In the Web Client this view is accessible at "Monitor" and "Performance".

Figure 4-2 vSphere Web Client performance monitoring



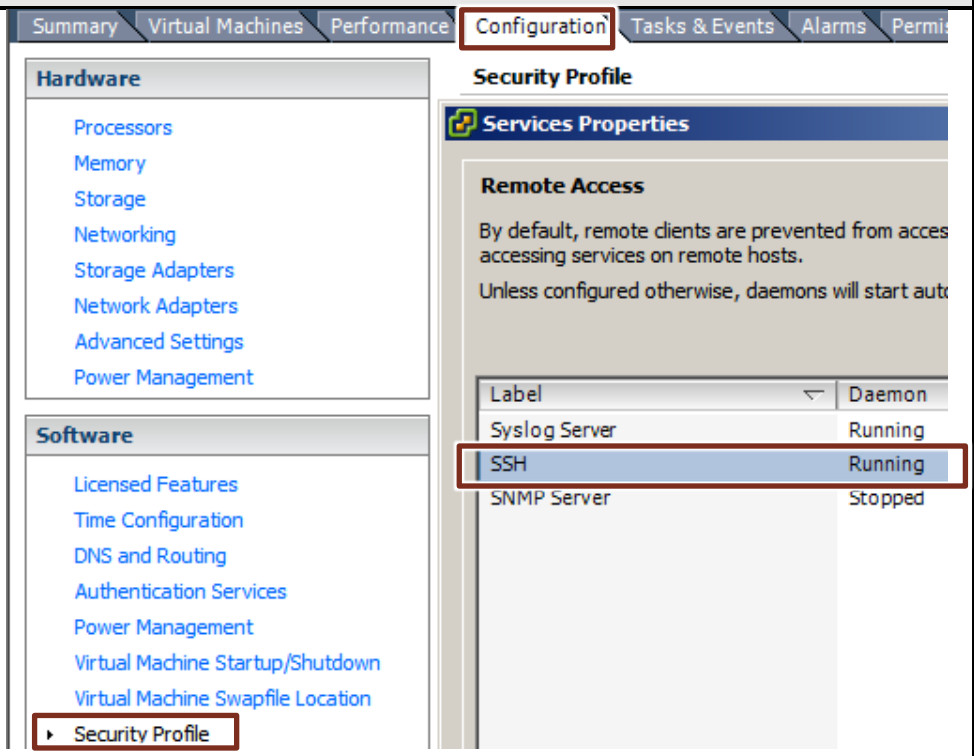
4.4.2 ESXTOP

The tool esxtop / resxtop provides detailed insight. To use esxtop, perform the following steps:

Table 4-3

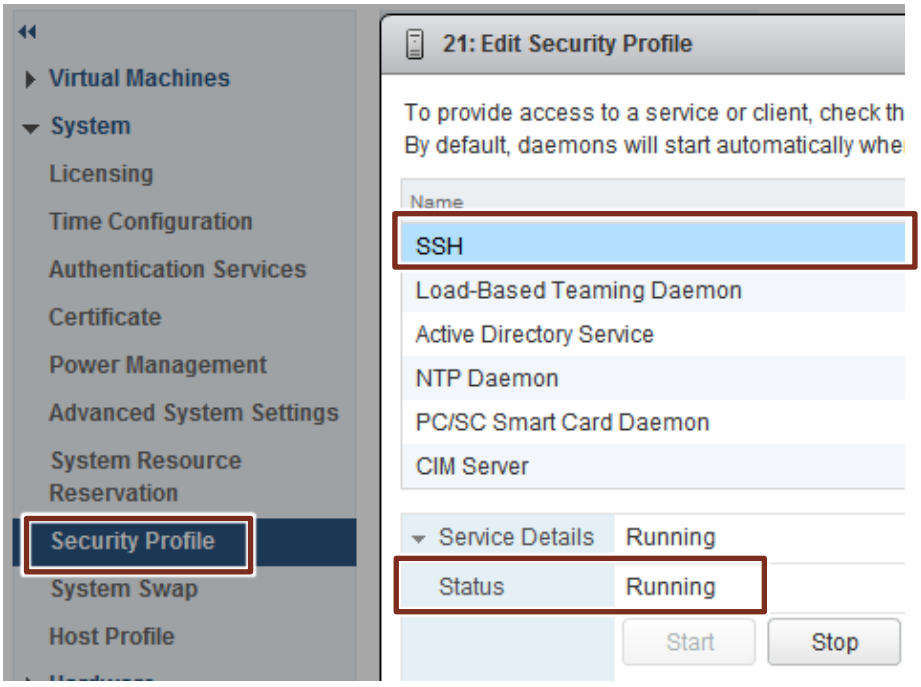
No.	Action
1.	**Activate SSH** Activate SSH on the host. You need to do this for each host where SSH is needed. Adjust the firewall rules accordingly. **In the vSphere Client:** • Select the "Configuration" tab. • Select the "Security Profile" in the "Software" section. • Select the properties under "Services" and • activate SSH.

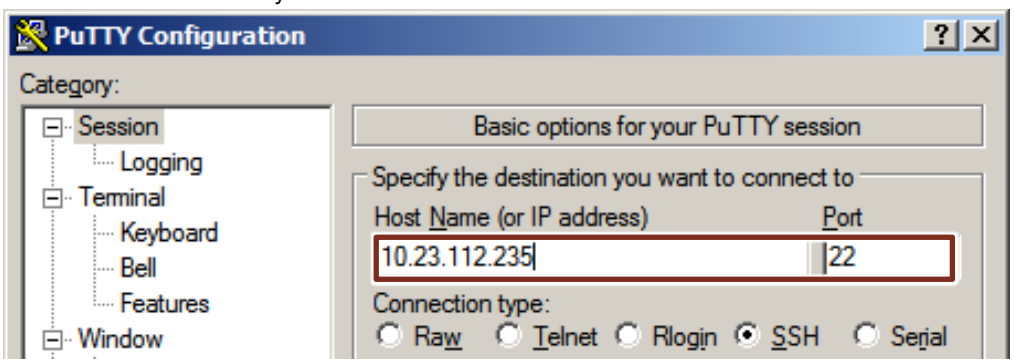
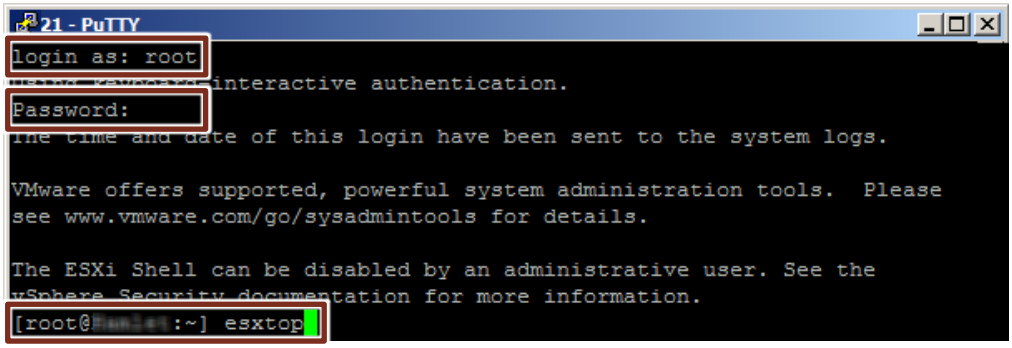
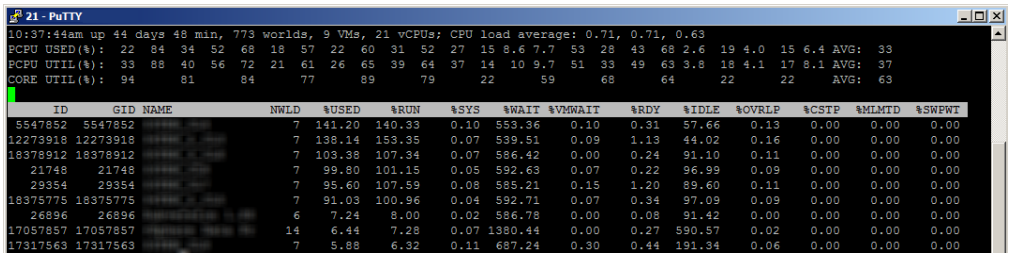
No.	Action



In the vSphere Web Client

- Expand the "System" section.
- Select "Security Profile".
- Then select "Edit Security Profile" and
- activate SSH.



No.	Action
2.	**Session login** • Log in to the console, e.g. using putty.  • Enter the address of your ESXi host. 
3.	**esxtop** Enter the login data and start esxtop. 
4.	**The following overview opens (example).** 

4.4.3 Examples

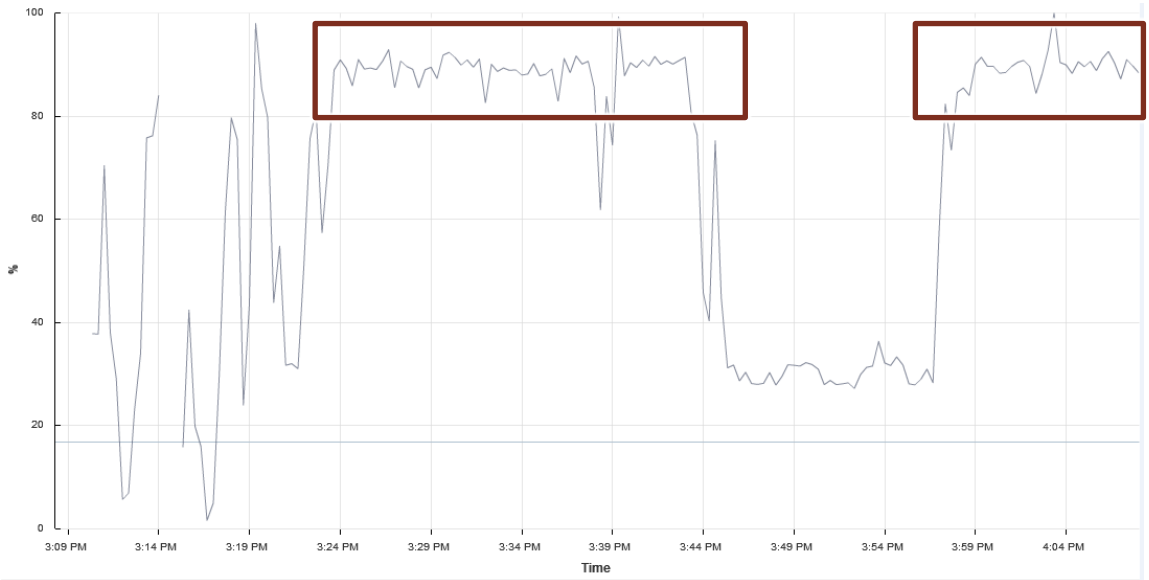
Below we will present some typical scenarios that impair the virtual machine's performance and its proper behavior. The diagnosis is demonstrated using esxtop and the two client variants.

CPU

If CPU utilization is permanently at 100% or near 100%, check the configuration of your virtual machine.

The following illustration shows the curve of an engineering station. The two highlighted areas are two compilation processes of the TIA Portal. High utilization is normal during these phases. Subsequently, the curve drops visibly.

Figure 4-3 CPU usage during compilation



Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	Engineering_Station	Usage	Average	%	88.45	100	1.57	66.452

Example of a CPU diagnosis:

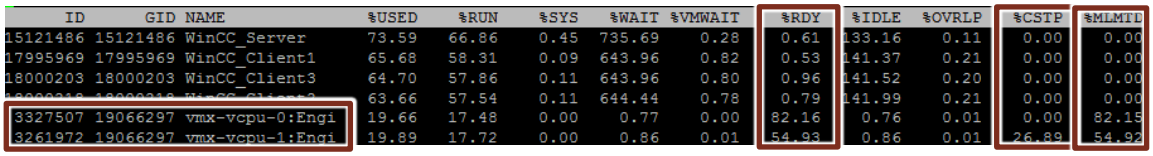
Enter the following commands in esxtop:

8. c for cpu
9. V to display VMs
10. e and the GID of the virtual machine to display the individual vCPUs

The relevant columns are %RDY, %CSTP and %MLMTD. %RDY shows the time in percent a virtual machine must wait for an allocation. The engineering station is depicted with one line per allocated CPU core in the illustration.

Values of more than 10% in the %RDY column indicate too many vCPUs of the virtual machine, or in this case, a set limit of the CPU resource. This is visible in the %MLMTD column.

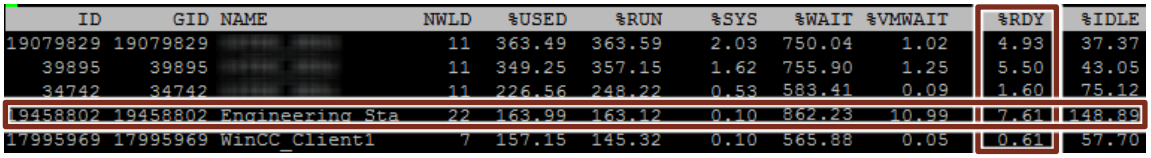
Figure 4-4 esxtop CPU limit



ID	GID	NAME	%USED	%RUN	%SYS	%WAIT	%VMWAIT	%RDY	%IDLE	%OVRLP	%CSTP	%MLMTD
15121486	15121486	WinCC_Server	73.59	66.86	0.45	735.69	0.28	0.61	133.16	0.11	0.00	0.00
17995969	17995969	WinCC_Client1	65.68	58.31	0.09	643.96	0.82	0.53	141.37	0.21	0.00	0.00
18000203	18000203	WinCC_Client3	64.70	57.86	0.11	643.96	0.80	0.96	141.52	0.20	0.00	0.00
[illegible]	[illegible]	[illegible]	63.66	57.54	0.11	644.44	0.78	0.79	141.99	0.21	0.00	0.00
3327507	19066297	vmx-vcpu-0:Engi	19.66	17.48	0.00	0.77	0.00	82.16	0.76	0.01	0.00	82.15
3261972	19066297	vmx-vcpu-1:Engi	19.89	17.72	0.00	0.86	0.01	54.93	0.86	0.01	26.89	54.92

Another example shows how the engineering station is influenced by a virtual machine on the same host. 16 vCPUs on a host with just 12 physical cores per CPU were allocated to this second virtual machine. This also impairs the engineering station's performance as is indicated by the elevated value in the %RDY column. 7.61 in the example.

Figure 4-5 esxtop CPU impact



ID	GID	NAME	NWLD	%USED	%RUN	%SYS	%WAIT	%VMWAIT	%RDY	%IDLE
19079829	19079829	[illegible]	11	363.49	363.59	2.03	750.04	1.02	4.93	37.37
39895	39895	[illegible]	11	349.25	357.15	1.62	755.90	1.25	5.50	43.05
34742	34742	[illegible]	11	226.56	248.22	0.53	583.41	0.09	1.60	75.12
19458802	19458802	Engineering Sta	22	163.99	163.12	0.10	862.23	10.99	7.61	148.89
17995969	17995969	WinCC_Client1	7	157.15	145.32	0.10	565.88	0.05	0.61	57.70

RAM

Allocate RAM appropriately. Excessive RAM per virtual machine will equally result in unnecessary administration overhead. Make sure not to overcommit RAM especially when it comes to virtual machines for SIMATIC software.

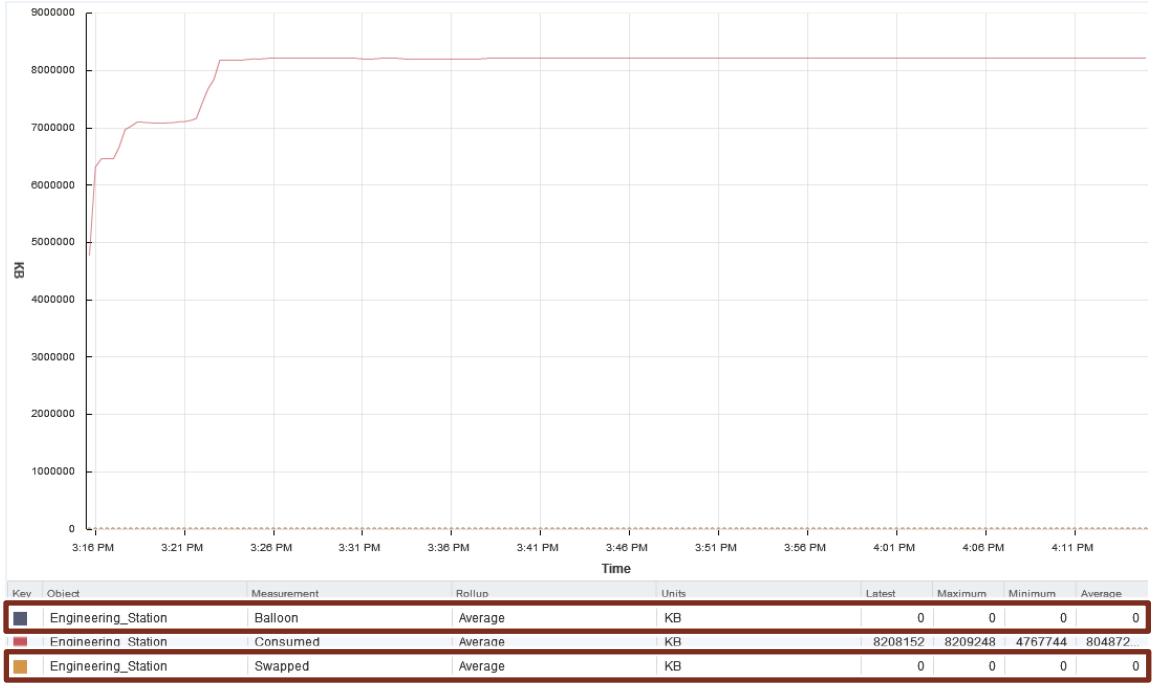
Use of the Balloon driver and swapping processes are among the first signs of trouble with RAM allocation.

Make sure that:

- Balloon is at 0 KB and
- no swapping is taking place

Figure 4-6 shows the normal behavior. If Balloon or swapping increase, this indicates problems in the form of insufficient RAM.

Figure 4-6 RAM profile – Balloon consumes 0 KB



Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	Engineering_Station	Balloon	Average	KB	0	0	0	0
	Engineering_Station	Consumed	Average	KB	8208152	8209248	4767744	804872...
	Engineering_Station	Swapped	Average	KB	0	0	0	0

Hard drives

Increased latency times of the hard drives impair the performance of the operating systems within the virtual machines and hence the running applications. If the applications respond poorly, check the latency times of the hard drives using vSphere Client or esxtop.

The following illustrations show extremely high latency times, both on average and maximum.

In this case, the store system cannot satisfy the requests of the virtual machine, making the virtual machines nearly impossible to operate.

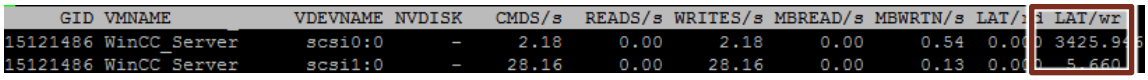
Figure 4-7 Latency times in the vSphere Client

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	scsi1:0	Write latency	Average	Millisec...	8	33	0	0,383
	scsi1:0	Read latency	Average	Millisec...	0	1	0	0,006
	scsi0:0	Read latency	Average	Millisec...	0	6	0	0,033
	scsi0:0	Write latency	Average	Millisec...	385	10554	1	195,206

Figure 4-8 Latency times in the vSphere Web Client

Key	Object	Measurement	Units	Latest	Maximum	Minimum	Average	Rollup
	scsi1:0	Read latency	ms	0	1	0	0.006	Average
	scsi0:0	Read latency	ms	0	6	0	0.033	Average
	scsi1:0	Write latency	ms	8	33	0	0.383	Average
	scsi0:0	Write latency	ms	385	10554	1	195.206	Average

Figure 4-9 Latency times with esxtop



GID	VMNAME	VDEVNAME	NVDISK	CMDS/s	READS/s	WRITES/s	MBREAD/s	MBWRTN/s	LAT/	LAT/wr
15121486	WinCC_Server	scsi0:0	-	2.18	0.00	2.18	0.00	0.54	0.00	3425.94
15121486	WinCC_Server	scsi1:0	-	28.16	0.00	28.16	0.00	0.13	0.00	5.660

The following latencies were measured over a period of 14 days for the virtualized TIA project.

Figure 4-10 Latency times of the engineering station

Performance Chart Legend

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	scsi0:0	Read latency	Average	Millisecond	0	4	0	0,136
	scsi1:0	Read latency	Average	Millisecond	0	3	0	0,019
	scsi0:0	Write latency	Average	Millisecond	0	1	0	0,006
	scsi1:0	Write latency	Average	Millisecond	0	0	0	0

Figure 4-11 Latencies of Client1

Performance Chart Legend

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	scsi0:0	Read latency	Average	Millisecond	0	0	0	0
	scsi0:0	Write latency	Average	Millisecond	0	7	0	0,062

Figure 4-12 Latencies of WinCC Server

Performance Chart Legend

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	scsi0:0	Read latency	Average	Millisecond	0	0	0	0
	scsi1:0	Read latency	Average	Millisecond	0	0	0	0
	scsi0:0	Write latency	Average	Millisecond	2	18	1	1,852
	scsi1:0	Write latency	Average	Millisecond	0	7	0	0,049

Network

A source of error may also be located in the network. If packets are discarded within the virtual network, this can be determined using network diagnostic tools.

The following figure shows the discarded receive packets after blocking of a port group.

Figure 4-13 Discarded packets in the vSphere Client

Key	Object	Measurement	Rollup	Units	Latest	Maximum	Minimum	Average
	WinCC_Server	Receive packets dropped	Summation	Number	547093	1383509	413167	900824,94
	WinCC_Server	Transmit packets dropped	Summation	Number	0	57	0	0,263

Figure 4-14 Discarded packets in the vSphere Web Client

Key	Object	Measurement	Units	Latest	Maximum	Minimum	Average
	WinCC_Server	Receive packets dropped	num	547093	1383509	413167	900824.943
	WinCC_Server	Transmit packets dropp...	num	0	57	0	0.263

In esxtop the discarded packets are shown as percentages. In this example, only the port group of the terminal bus network is affected.

Enter the following commands in esxtop:

11. n for network
12. f to add columns
13. Make sure that DRPTX/s and DRPRX/s are selected.

Figure 4-15 Discarded packets esxtop

PORT-ID	USED-BY	DNAME	TEAM-PNIC	%DRPRX	%DRPTX
33554433	Management	vSwitch0	n/a	0.00	0.00
33554434	vmnic0	vSwitch0	-	0.00	0.00
50331878	3160876:WinCC_Client	DvsPortset-0	vmnic2	63.15	0.00
50331879	3161681:WinCC_Client	DvsPortset-0	vmnic2	63.60	0.00
50331880	3161689:WinCC_Client	DvsPortset-0	vmnic3	62.79	0.00
50331857	2718764:WinCC_Server	DvsPortset-0	vmnic3	0.00	0.00
50331858	2718764:WinCC_Server	DvsPortset-0	vmnic1	66.67	0.00
50331861	2731284:Engineering_	DvsPortset-0	vmnic2	0.00	0.00

5 Related Literature

Table 5-1

	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	This entry https://support.industry.siemens.com/cs/ww/en/view/109486064
\3\	HCL – Hardware Compatibility List https://www.vmware.com/resources/compatibility/search.php
\4\	VMware Documentation https://www.vmware.com/support/pubs/
\5\	VMware Knowledge Base https://kb.vmware.com/selfservice/microsites/microsite.do
\6\	vApp Deployment and Configuration Guide https://www.vmware.com/pdf/vcops-vapp-585-deploy-guide.pdf
\7\	Virtualizing Microsoft Business Critical Applications on VMware vSphere - Matt Liebowitz, Alexander Fontana- 2013 – ISBN 0321912039
\8\	Performance Best Practices for VMware vSphere® 5.5 https://www.vmware.com/pdf/Perf_Best_Practices_vSphere5.5.pdf
\9\	Documentation PowerCLI https://www.vmware.com/support/developer/PowerCLI/
\10\	Time synchronization - Time synchronization in the automation environment https://support.industry.siemens.com/cs/tr/tr/view/86535497/en
\11\	"STEP 7 Professional V13 SP1" Manual https://support.industry.siemens.com/cs/tr/en/view/109011420
\12\	WinCC Professional V13 SP1 https://support.industry.siemens.com/cs/tr/en/view/109096785
\13\	Hardening Guide https://www.vmware.com/security/hardening-guides
\14\	Security Response Policy https://www.vmware.com/support/policies/security_response

6 List of Abbreviations

E
E/A *Eingabe/Ausgabe*
ES *Engineering Station*
ESXi *Hypervisor zur Virtualisierung*
F
FC *Fibre Channel*
FT *Fault Tolerance*
H
HBA *Host Bus Adapter*
HCL *Hardware Compatibility List*
I
IOPs *Input/Output Operations Per Second*
iSCSI *internet Small Computer System Interface*
N
NFS *Network File System*
NIC *Network Interface Card*
NTP *Network Time Protocol*
P
P2V *Physical to Virtual*
R
RAID *Redundant Array of Independent Disks*
S
SAN *Storage Area Network, Speichernetzwerk*
SAS *Serial Attached SCSI*
SCSI *Small Computer System Interface*
SID *Security Identifier*
SSH *Secure Shell*
V
V2V *Virtual to Virtual*
VM *virtuelle Maschine*
vmdk *Virtual Machine Disk, Dateityp/-endung*
VMXNET *virtual network adapter*
vSS *vSphere Standard Switch*

7 History

Table 7-1

Version	Date	Modifications
V1.0	03/2016	First version