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Processing collected data with a virtual computer

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Thesis abstract

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Supervisor: Juha Yli-Hemminki

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The goal of the thesis was to create a functional virtual environment for recovering historical data and alarms collected from a power plant or ship for more detailed analysis. In addition, the goal was to make the virtual environment as similar as possible to a power plant or a ship. The intention was also to develop guidelines for problem situations related to the settings of the virtual environment so that the restored applications would run smoothly. Tools for collecting data from the installation were also examined. VMware Workstation Pro was used as the virtual program.

As the result of the thesis there was a fully functional virtual environment that can view historical data, including trends and alarms from the power plant or ship, and run Wärtsilä Operating Interface System (WOIS). The virtual environment used in ships or power plants was also made very realistic. The domain controllers used at the site could be downloaded to their virtual machine and it was possible to investigate historical data through the virtual machine. Before starting the virtual machine, it was necessary to make a few changes to its basic settings: the RAM memory had to be increased to 8Gb, and at least two processors from one's computer were taken in use also. This way, the virtual machine was not too slow and worked smoothly. Four different applications for data collection were found, and Veeam proved to be the most suitable one for collecting the data. Veeam is an excellent application for restoring and taking backups, and it works perfectly with VMware Workstation Pro. It is easy to restore Veeam backup to an ESXi server. After restoring, connections via the virtual machines in a server can be handled remotely via FortiClient VPN or locally with an ethernet cable and the examination of sWOIS computers can be started.

[1] Keywords: virtual environment, applications, backup, servers

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Opinnäytetyön tiivistelmä

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Tämän opinnäytetyön tavoitteena oli saada tehtyä virtuaaliympäristö, jolla saadaan palautettua voimalaitoksesta tai laivasta kerätty historiadata ja hälytykset tarkempaa analysointia varten. Lisäksi tavoitteena oli saada virtuaaliympäristö mahdollisimman samankaltaiseksi kuin voimalaitoksessa tai laivassa käytetty alkuperäinen sovellusympäristö. Tarkoituksena oli myös laatia ongelmatilanteiden ohjeistus liittyen virtuaaliympäristön asetuksiin niin, että palautetut sovellukset toimivat jouhevasti. Myös työkaluja datan keräämiseen voimalaitoksesta tutkittiin. Virtuaaliohjelmana käytettiin VMware Workstation Pro -ohjelmaa.

Työn tuloksena onnistuttiin muodostamaan toimiva virtuaaliympäristö, jolla saatiin tarkasteluun voimalaitoksesta tai laivasta saatu historiadata. Laivoissa ja voimalaitoksissa käytettävä virtuaaliympäristö saatiin toimimaan. Luodut käyttäjäprofiilit oli mahdollista ladata käyttäjän omalle virtuaalikoneelle, näin historiadatan tarkastelu onnistui tätä kautta. Ennen virtuaalikoneen käynnistämistä oli syytä tehdä muutama muutos sen perusasetuksille, RAM-muisti kannatti nostaa kahdeksaan Gigabittiin ja ottaa myös omalta käyttäjän tietokoneelta vähintään kaksi prosessoria käyttöön. Näin virtuaalikone ei ollut hidas ja toimi jouhevasti. Työkaluiksi datan keräämiseen löydettiin neljä erilaista sovellusta, joista sopivammaksi osoittautui Veeam. Veeam on erinomainen ohjelma varmuuskopioiden ottamiseen ja palauttamiseen ja se toimii Vmware workstation Pro -ohjelman kanssa. Veeam-varmuuskopio on helppo palauttaa ESXi-pohjaiselle palvelimelle ja sen jälkeen voidaan ottaa yhteys palvelimeen joko etänä FortiClientin kautta tai paikallisesti Ethernet-kaapelilla ja aloittaa sWOIS-koneen tarkastelu.

[2] Asiasanat: virtuaaliympäristö, sovellusohjelmat, varmuuskopiointi, palvelimet

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Terms and Abbreviations

Virtual environment	Networked application that allows a user to interact both with the computing environment and the work of other users.
CP-40	First virtual machine developed by IBM's Cambridge Scientific Center. CP-40 ran on a unique, specially modified IBM System/360 Model 40.
CP-67	Second virtual machine developed by IBM's Cambridge Scientific Center. The operating system developed for the IBM System/360-67
Virtual machine	Software-implemented computer that can run programs like a real computer using virtualization technology.
VMware Workstation	VMware desktop virtualization application.
WOIS	Wärtsilä Operation Interface System (PC based).
WDCU	Wärtsilä Data Collection Unit.
ALARMDB	SQL Alarm Database.
Histlog	Trend data storage file.
UNIC	Wärtsilä UNIfied Controls.
SG	Spark plug ignited gas engine.
DF	Dual fuel engine, uses diesel and gas. No spark plugs, uses diesel fuel as pilot to ignite gas fuel. The backup fuel is diesel.
TRI -Fuel	Engine which can use diesel, heavy fuel or gas as a power source. No spark plugs, use diesel fuel as pilot to ignite gas fuel. As backup fuel there is diesel or heavy fuel.
sWOIS	server Wärtsilä Operation Interface System (server based).

HMI	Human machine interface.
GPS	Global positioning system.
NTP	Network time protocol.
Hyper-V	Microsoft level 1 hypervisor meaning it runs on a host machine and takes control of the host hardware.
KVM	Full virtualization solution for Linux on x86 hardware containing virtualization extensions.
ESXi	Computer software, firmware, or hardware that creates and runs virtual machines.
Plantnet	Remote connection via VPN to WOIS system at the site (same views as operator for process displays but not to do any kind of control actions).
IED	Intelligent electronic devices.
FC	Frequency converter, used to control the speed of a 3-phase electrical motor.
PLC	Programmable logic controller.
IO	Input output connections, An input module detects the status of input signals such as push-buttons, switches, temperature sensors, etc. An output module controls devices such as relays, motor starters, lights, etc.
CFA901	Common control panel
CFA902	Fuel treatment (project specific)
CFE0x1	Genset local control panel in an engine room
CFC0x1	Genset control panel in a control room

BJA0x1	Genset auxiliary control panel in an engine room
GNU	Open-source operating system like Linux
ELWIS	Electrical wisdom, knowledge center for all Energy Business, Electrical & Automation engineers in Wärtsilä (Website).

1 INTRODUCTION

Wärtsilä is a global leader in smart technologies and complete lifecycle solutions for marine and energy markets (Wärtsilä, 2021). By emphasizing sustainable innovation, total efficiency, and data analytics, Wärtsilä maximizes the environmental and economic performance of the vessels and power plants of its customers. The company has operations in over 200 locations in more than 80 countries around the world.

1.1 Background

There is an increased need to analyse engine parameters and alarms more specifically and over a long period of time for potential failure cases. Wärtsilä is supporting power plant and ship customers whose automation layout still includes Windows 7 operating systems that have not been updated. Those installations which data collection have been processed in the older Windows 7 operating system from power plants or ships can no longer be seen as a reliable system as it may fail. The failure can be caused by a damaged hard drive or a motherboard itself. The hard drive is interchangeable, but the motherboard is very hard to find since Windows 7 hardware is no longer supported. There may also be problems when trying to recover the recorded data because it may be challenging to find similar hardware as used in the installations.

Virtualization has been considered as an option to solve this problem. More specifically this means a Windows 10 computer running VMware which is running Windows 7. Windows 7 can recover WOIS files. Wärtsilä Operator Interface System is an application that allows Wärtsilä to view, for example, the operational parameters of the engines of a power plant.

1.2 Goal

The goal of this thesis is to get a well-working virtual environment for retrieving historical data and alarms collected from a power plant or a ship for more detailed analysis. In addition, the goal is to make the virtual environment as similar as possible to the real environment of a power plant or a ship. It is also intended to provide guidance for problem situations relating to virtual environment settings, so that restored applications run smoothly. Moreover, all

instructions and notes for application installations, functional tests, and building up server environments needed to be done. Because all applications will get updates at some point and they may not work or communicate with other applications anymore.

1.3 Structure

The work goes through the history and current state of a virtual environment and also the benefits and disadvantages of virtualization. The focus of this work is on the VMware Workstation Pro -virtual machine. After that, the thesis handles the user interfaces and pieces of software which are used at Wärtsilä nowadays. In the middle of the thesis it is described how Wärtsilä is currently collecting, transferring and restoring backups. After that some pieces of software are tested. Veeam is in closer observation because it is used more and more in Wärtsilä, and also in tests, Veeam appeared to be the most suitable option for collecting and restoring backups. At the end of thesis, there are presented both the positive and negative findings concerning virtual machines and the tested software.

2 VIRTUAL ENVIRONMENT

In Wärtsilä, the sWOIS system is server-based (WOIS) and it is running in a virtualized environment on server hardware (Blomqvist, n.d.). Operator stations provides the operator interface for sWOIS which includes thin client hardware that connects to the sWOIS server(s) and reporting and archiving server via the plant network. In below there is an example of sWOIS servers and operation stations (2pc), archiving and reporting server and HMI (Figure 1).

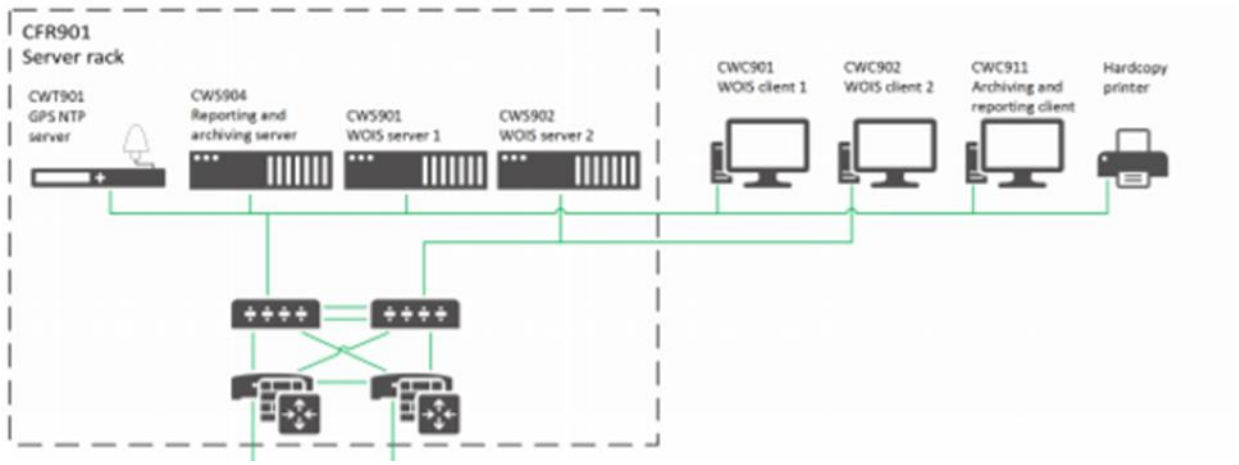


Figure 1. sWOIS layout

The single sWOIS server is a single server hardware-based system (Blomqvist, n.d.). The single sWOIS server is suitable for Wärtsilä power plants with fewer generating sets (1-3 gensets) where redundancy on the plant HMI level is not required.

The redundant sWOIS server is a redundant server hardware-based system (Blomqvist, n.d.). Redundant server is used as a backup server, if main server is freezing or failing then redundant server takes over the control. Redundancy is on the HMI application and hardware level, by having individual sWOIS servers that operate individually from each other. Redundancy for HMI application means if main HMI application is freezing or failing, redundant HMI application takes over the control. The redundant sWOIS server is suitable for Wärtsilä power plants with multiple gensets, 4-24 gensets.

In figure 2 there is an example of virtualization with Windows or Linux installed as the first host operating system on hardware. A virtual environment can be installed on top of it which can be Linux or Windows based operating system, so using the mixture of operating systems is allowed. In figure 3 there is an example of the principle of virtualization without a separate host operating system. VMware ESXi replaces base operating system Linux or Windows.

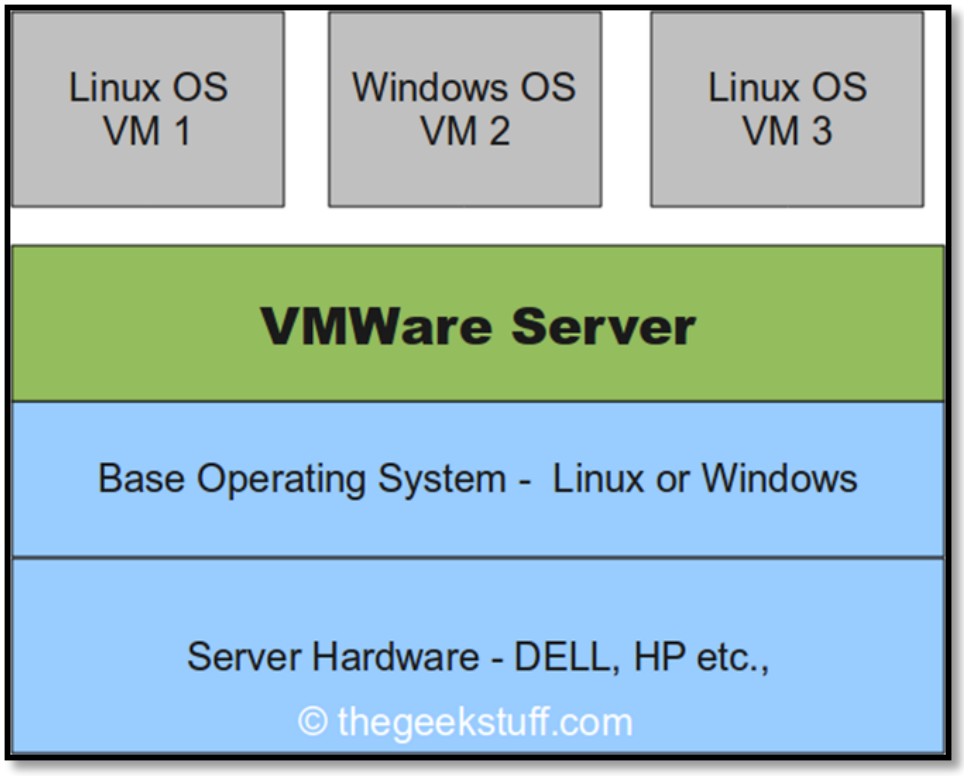


Figure 2. Example of virtualization by using VMware server.

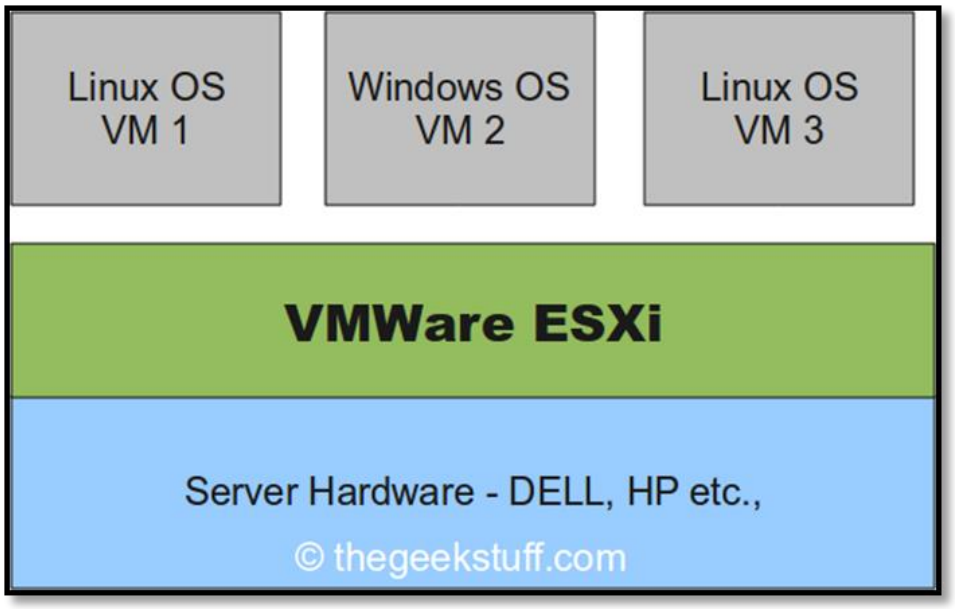


Figure 3.The principle of virtualization by using VMware ESXi.

2.1 History of virtualization

Virtualization began in the 1960s with IBM. The first model was CP-40, an operating system for the System/360 mainframe that IBM's Robert Creasy and Les Comeau started developing in 1964 to create VMs within the mainframe (Brodkin, 2009). It was quickly replaced by CP-67, the second version of IBM's hypervisor, which Rymarczyk began using upon joining IBM's Cambridge operations in 1968.

In the 1980s, several new companies were joined into the development of virtualization technology, including AT&T, Microsoft, and Locus Computing Company (Anttonen, 2021, p. 3-5). Anttonen also writes about new things during that time around virtual technologies for example application virtualization and virtual networks.

One of the most significant virtualization releases of the 1990s was the Connectix Virtual PC, which could run Microsoft's Windows operating system on Apple Macintosh computers and it was later acquired by Microsoft in 2003 (Anttonen 2021, p. 3-5). In 1998, the virtualization market gained a new entrant, a company called VMware, which quickly

became one of the pioneers of virtualization technology. VMware released its first product, VMware Workstation, in 1999, and became the world's first fully virtualized x86-based virtualization application.

2.2 Virtualization

In information technology, virtualization means a way to create a virtual version of a device as well as other resources (Anttonen 2021, p. 3-5). Anttonen mentions, these can be for example a server, storage device, network environment, or even an operating system that allows the resources to be further distributed to one or more execution environments. Even hard disk partitioning can be counted as virtualization because one hard disk is divided into two separate storage devices. Devices, programs, and users are able to execute virtual resources as if they were genuine fixed devices.

2.3 Benefits of virtualization

A virtual machine can be used to create many operating environments on a single computer with different programs or even an entire operating system (Vähimaa, 2018). Vähimaa remind that it has several useful uses: it makes it easy to test applications without cluttering the operating system or utilizing multiple operating systems on the same machine. Especially for Mac and Linux users, the possibility to keep a virtual Windows machine in reserve is valuable. For example, if you come across a need for an application that only works in the Microsoft Windows 7, it is easy to wake up a dormant Windows machine when needed. After finishing your work, you can save its status to your hard drive and continue from the same status where it was left.

2.4 Disadvantages of virtualization

Even if the host device contains powerful hardware, the virtual computer can be working slower than the host device (Roomi, 2021). Virtualization is both good and bad for security. Roomi inform that a virtual computer can be used for testing different viruses for their actions and so develop better ways to protect a virtual computer. However, virtual environments are vulnerable like all other environments. In addition, virtualization also puts pressure on

improving security because when a host computer falls victim to a hack all virtual machines are open to the attacker. Roomi warns that to improve the usability of other resources, such as host disks or parts of them, may have been opened up to virtual machines, a malicious program can also take advantage of that feature to transfer data from one machine to another.

3 VMWARE

Today, VMware is still one of the most notable names in the world when there is talk of virtualization. The range of virtualization applications they offer is very wide. The best-known products of VMware include VMware Server, VMware Workstation, VMware Player, and VMware vSphere.

3.1 VMware Workstation Pro

As a product, VMware Workstation is a well-known workstation virtualization application (vmware, 2021). VMware informs that in recognition of its 20 years long history, it has been updated almost as there is now version 16 in use. This could be considered as extensive operating system support, offering comprehensive features, and good performance. In practice, Workstation is a software product that allows the installation of various operating systems as virtual machines for testing and production use. VMware informs that the software provides a closed environment where fully independent clones and restore points can be taken from virtual machines, that feature called a snapshot. These features provide quick recovery for production machines and an easy way to test new software revisions before moving to production. The software also enables the utilization of old computer components as a platform for multiple virtual machines to provide services for the needs of the environment. The software also provides moderately extensive virtual networking capabilities for interconnecting virtual machines within the Workstation and connecting them to the outside world via a physical network card of a computer. The management and operation of virtualized machines are made possible either through the program itself or by remote access.

4 TYPICAL AUTOMATION AND CONTROL LAYOUT AT WÄRTSILÄ

Tuomio (n.d.). writes that, a power plant nowadays cannot operate without reliable communication between the devices it contains, such as protection relays, PLCs, remote IOs, HMIs, FCs, and all other IEDs (Intelligent electronic devices) which are scattered all around the plant to verify smooth operation (figure 4). The increasing intelligence and programmability of IEDs also increases the amount of information they are sharing and need to be aware of. Today configuring of devices is done via a network, production and process data is collected via a network, software patching is distributed via a network, online monitoring and controlling of devices is done via a network, and in the future there will be involved more and more devices with different communication requirements. Tuomio highlights that, the communication network is a very important part of a powerplant.

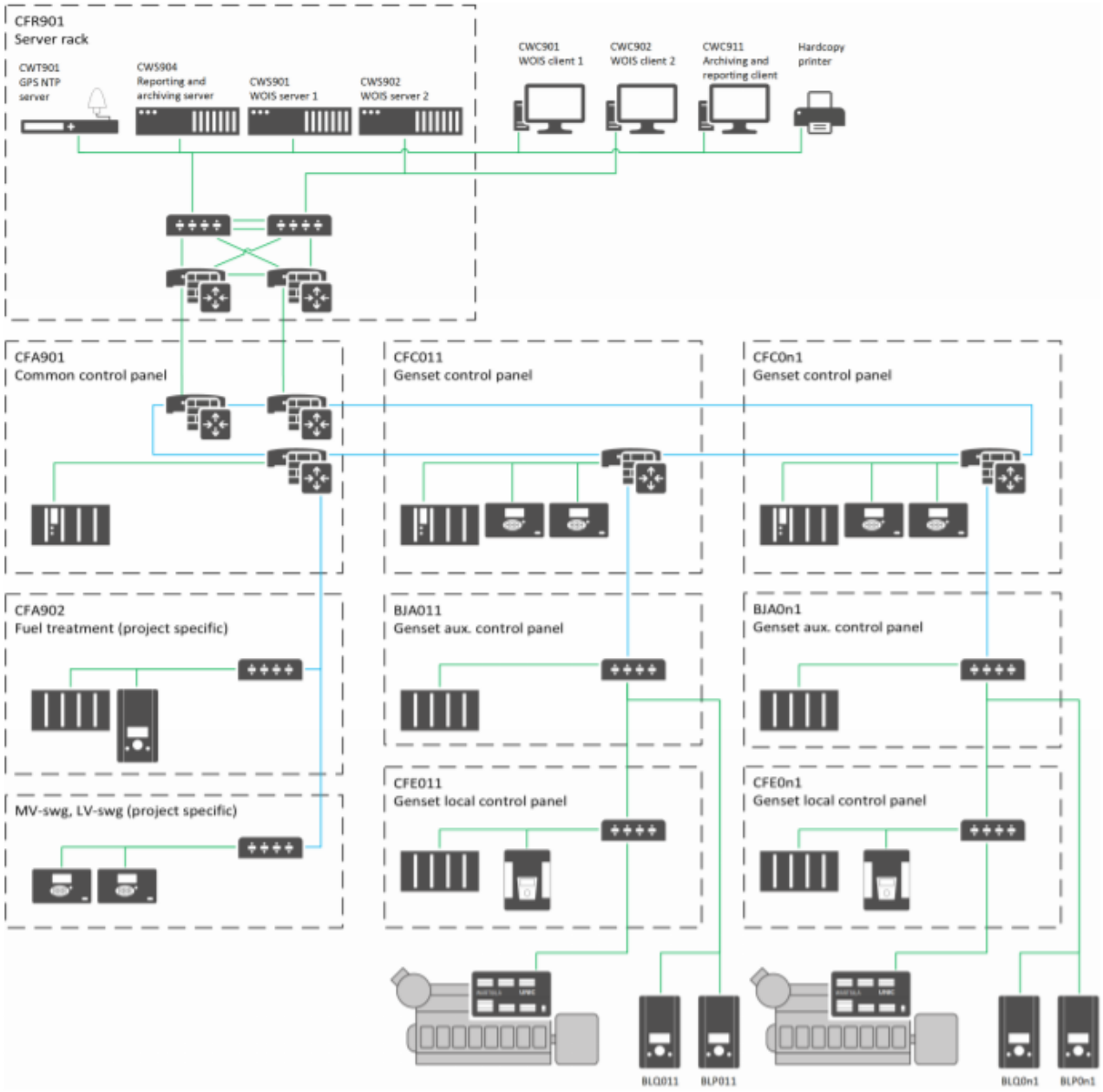


Figure 4. Typical automation system

4.1 Engine automation system, UNIC

The engine Control Unit is UNIC. Depending on the fuel used in the engine the UNIC version can be from C1 to C3. The UNIC versions vary according to the automation level and fuel type used. C1 includes speed and load controllers and basic instrumentation. It can only be used for engines running with diesel fuel. In UNIC C2 all engine related measurements and controls are taken care of an automation system, and it is used for controlling ordinary diesel

fuel engines. In UNIC C3 all engine related measurements and controls are taken care of an automation system (figure 5). It is used for controlling gas (SG), Dual Fuel (DF) or TRI-Fuel engines.

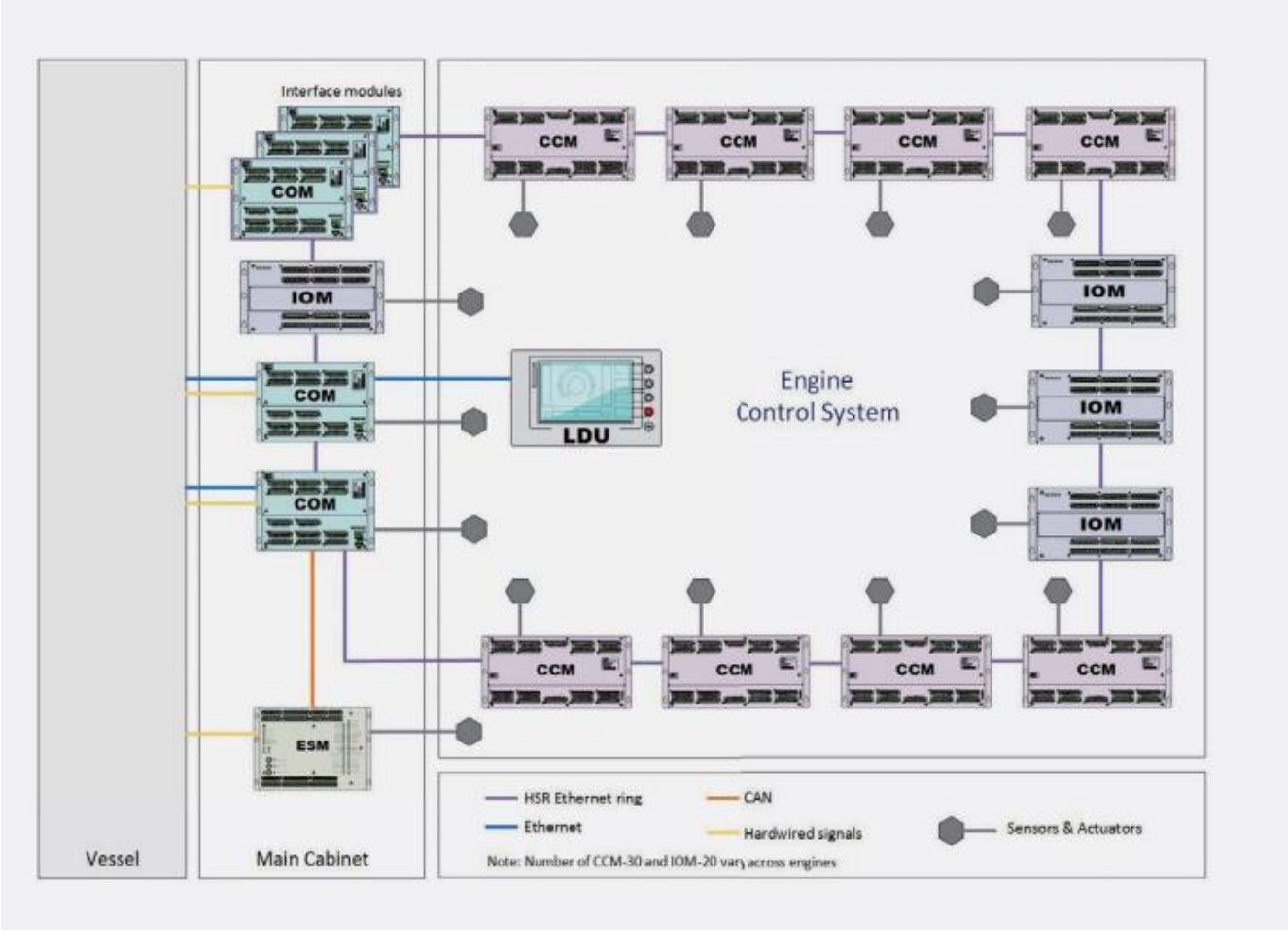


Figure 5. UNIC automation system with related components

4.2 Distributed PLC

PLC is divided into common PLC section (figure 6) and an engine PLC section (figure 7). The common PLC takes care of all automation systems at the power plant which are common to all engines (for example CFA901, CFA902). The engine PLC takes care of individual engine control. In addition, individual engine PLC is divided into two parts at the engine room: local control panel (CFE0x1), genset auxiliary control panel (BJA0x1) (figure 7 and 8) and one part at control room: genset control panel (CFC0x1).

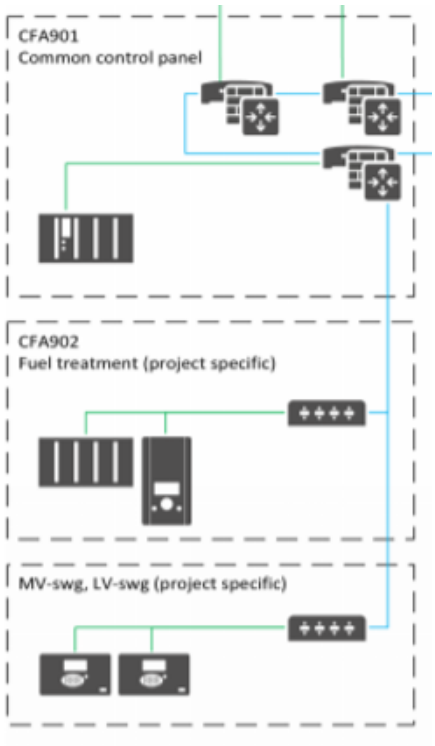


Figure 6. Common PLC system, distributed (CFA901 and CFA902).

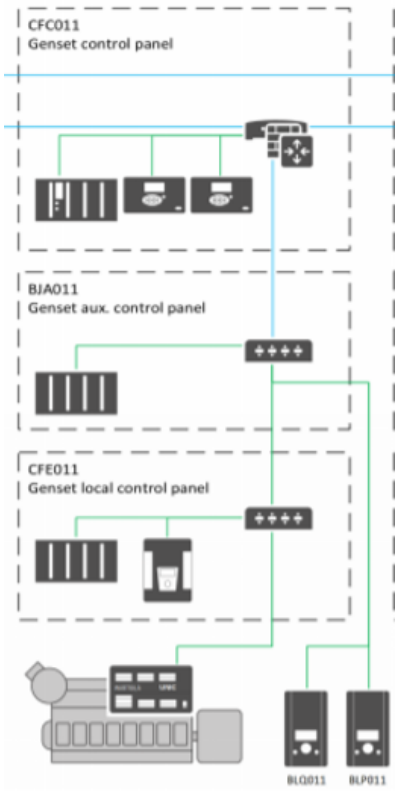


Figure 7. Engine wise PLC system, distributed (CFC0x1, BJA0x1 and CFE0x1)

Figure 8. Control for auxiliary system, pumps and cooling fans (BJA0X1)

5 WOIS AND sWOIS

WOIS is a graphical user interface, and it is an abbreviation for Wärtsilä Operator’s Interface System (figure 10). Older WOIS application is running inside earlier Windows platform systems and as hardware there is typically a personal computer (PC). The sWOIS is a server based WOIS system. The server includes several virtual machines which are linked together creating a wider monitoring environment. WOIS is used for monitoring the status and the essential data of a power plant (Wärtsilä Auxiliary System O&MM, 2019). It gives a possibility to visualize the information, which simplifies the operator's work. WOIS is used for monitoring the engine and the auxiliary systems, while the operations are mainly performed at the control panels and related controllers.

WOIS includes several displays for the supervision of the plant (figure 9). Process displays are graphical pictures with the measuring values and status information of the systems in the power plant (Wärtsilä Auxiliary System O&MM, 2019). The process displays include a plant view, common views, as well as individual genset related views. A trend display is available for each analogue value. Alarms occurring in the power plant are displayed in the alarm list.

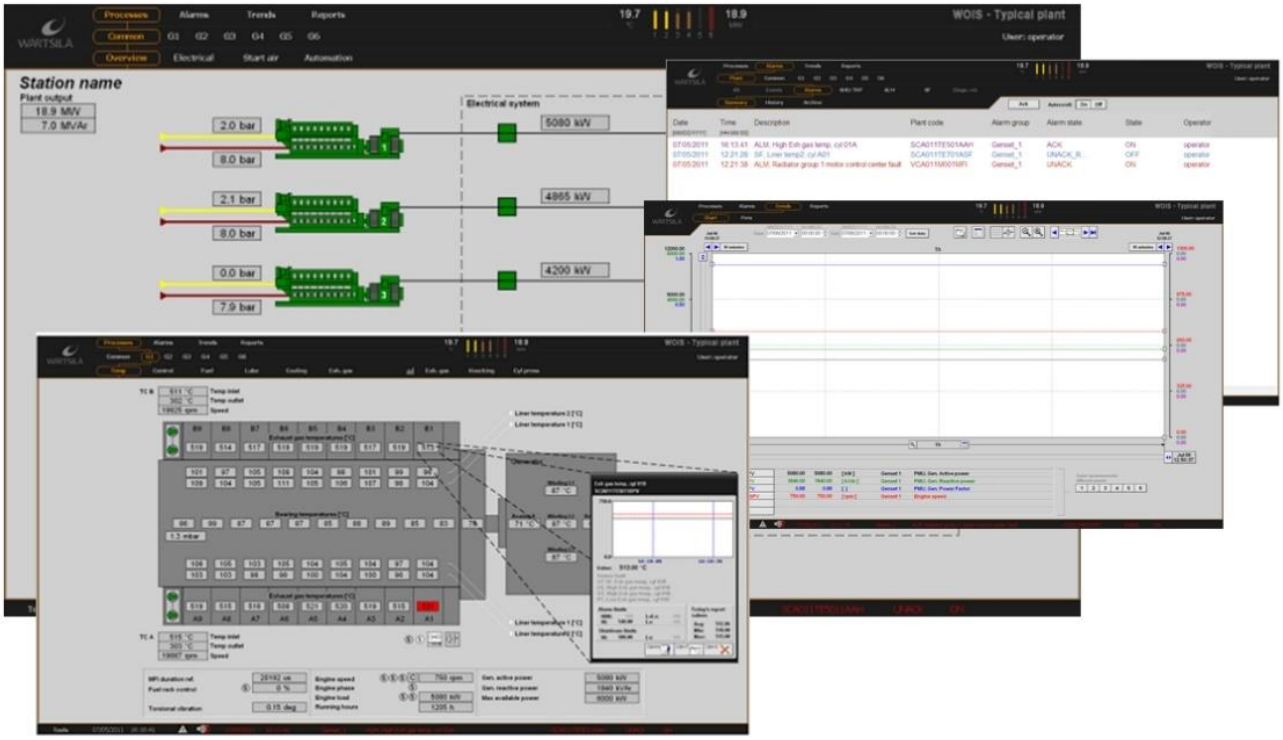


Figure 9. Plant Overview display, a process display, a sensor trend display, an historical trend display and the alarm event display.

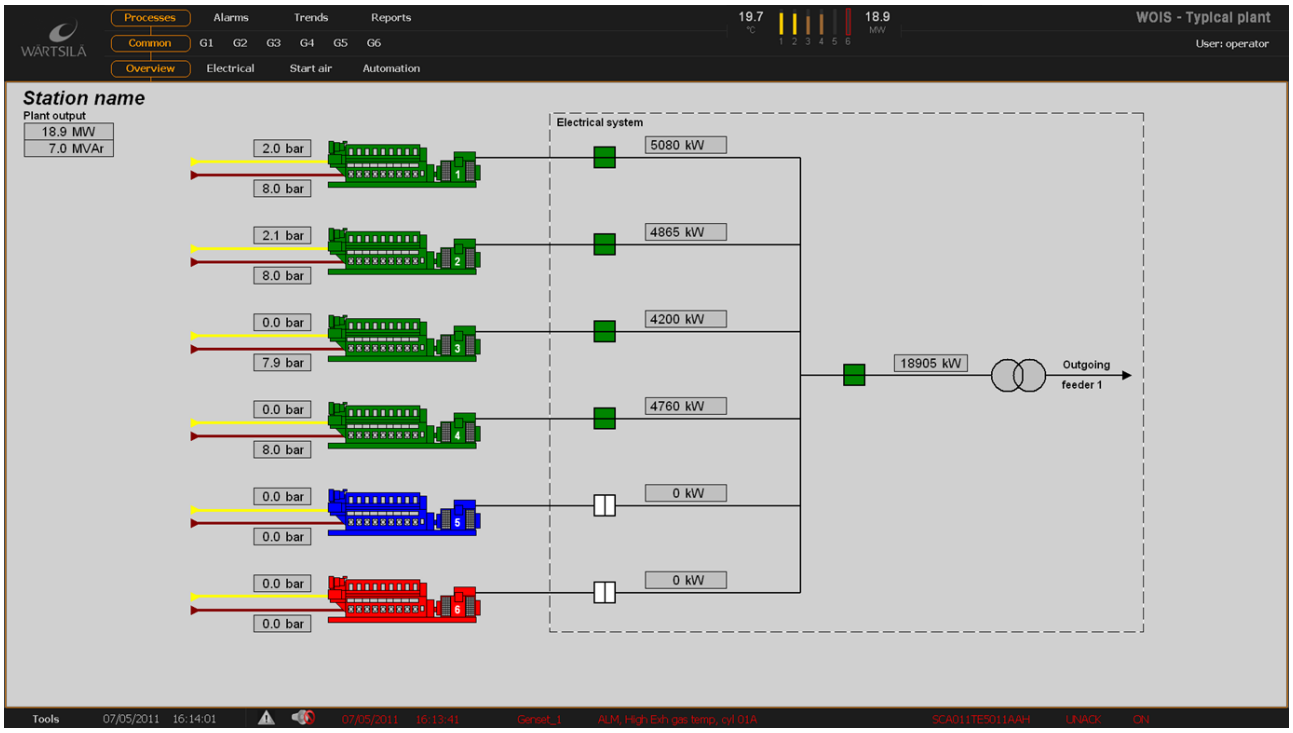


Figure 10. Common overview from WOIS

All actions necessary for normal operation, such as the start and stop of the generating sets, load increase, and load reduction are activated and supervised via WOIS, using a mouse, keyboard, and display. The operator can also observe key data from the plant such as various temperatures and pressures as well as the measurements of electrical variables such as generator power, voltage, and frequency (figure 11). The user interface is accessed from the operator station for the WOIS server. WOIS graphical user interface is specifically customized for Wärtsilä power plant solutions to provide an efficient and reliable operator interface to the Wärtsilä power plant.

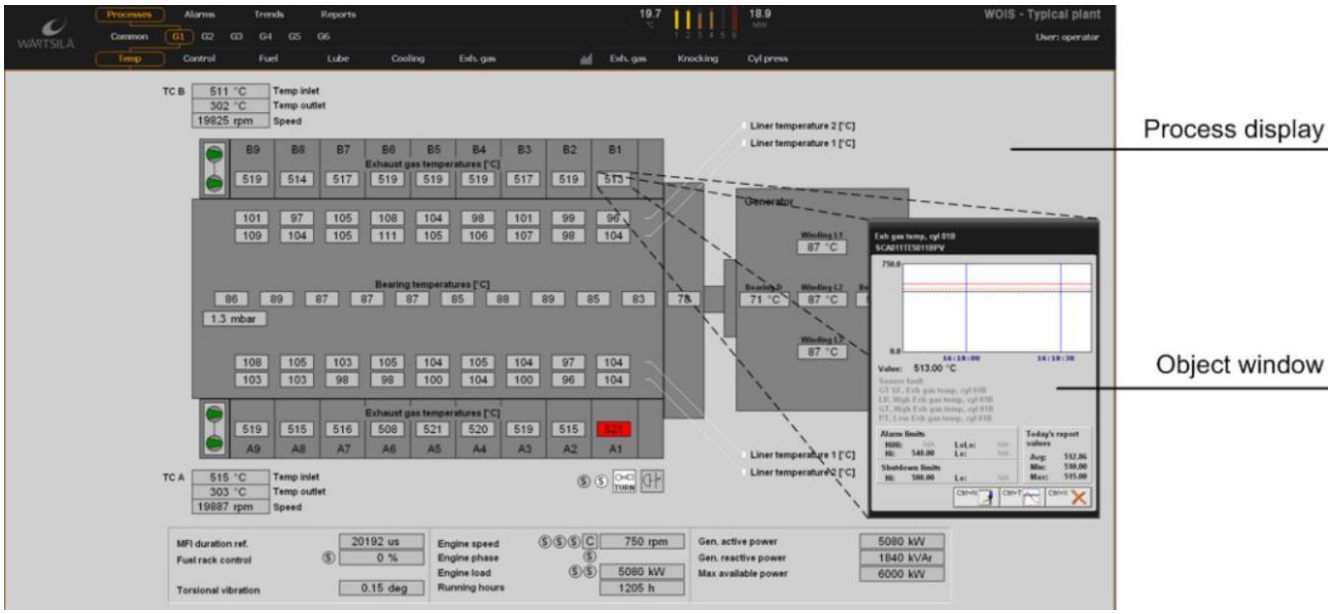


Figure 11. WOIS process display with object example

sWOIS includes different types of server computers (figure 12): WOIS server 1 (CWS901), WOIS server 2 (CWS902), Reporting and archiving server (CWS904), GPS NTP time server (CWT901).

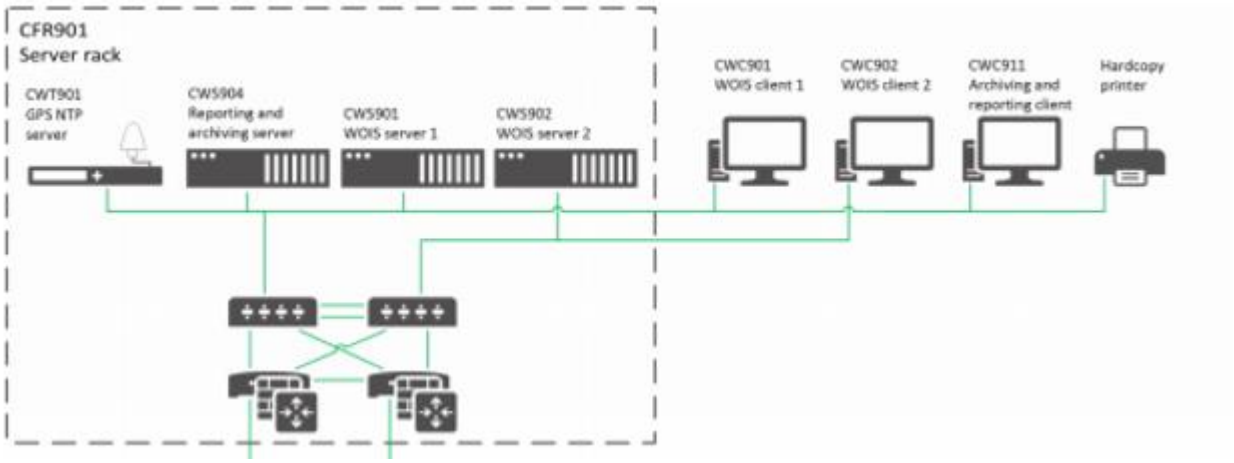


Figure 12. Server WOIS setup

6 WDCU

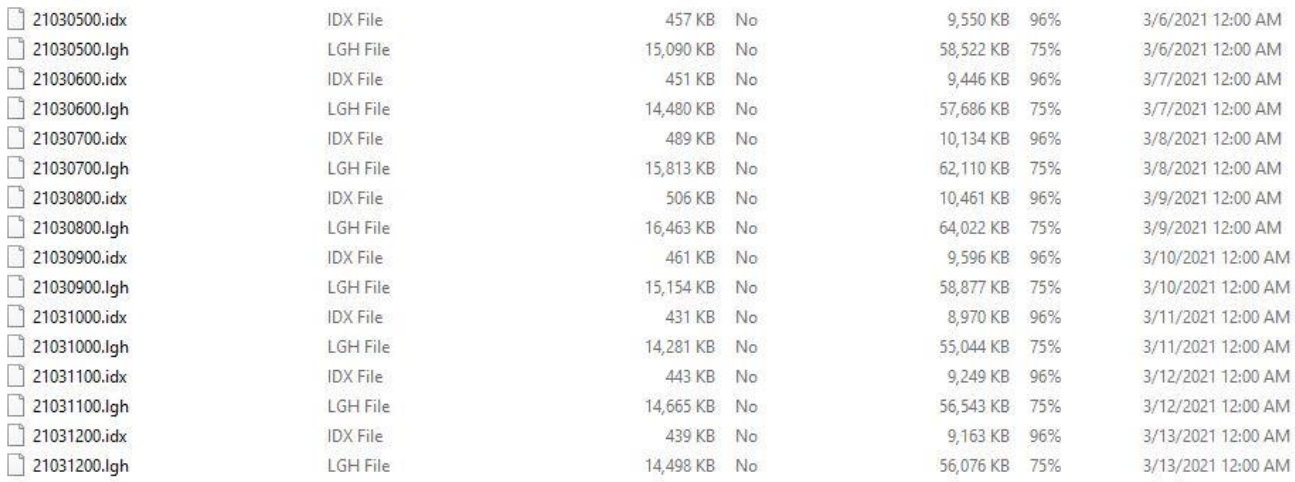
The Wärtsilä Data Collection Unit (WDCU) is designed to collect a broad variety of local data (Wärtsilä Marine Solutions, n.d.). Wärtsilä Marine Solutions tells that it makes the collected data available on the Wärtsilä Data Bridge, where it is analysed and utilized to bring operational insights to the customers. The WDCU is developed to be cyber secure by design and it is highly adaptable to specific use cases.

WDCU is a data collection unit for WOIS. It includes a trend system but a minimum amount of graphic representation and it is usually used with remote connection application (Plantnet). During this thesis, WDCU was not studied closer because it does not have anything to do with virtual machines directly, since it is used for collecting data from site to expert insight application.

7 CURRENT DATA COLLECTION SITUATION

7.1 Histlog

AVEVA InTouch HMI collects two different histlog file formats for D:\Histlog\ - folder: *.lgh and *idx every day. These are used for saving historical data for WOIS trending. It is a standard Wärtsilä way to collect *idx and *lgh historical files at midnight. That is because engine starts, or shutdowns are rare at midnight and all devices use less bandwidth from the communication network. In figure 13 there is an example of historical log files which are collected daily. The backup procedure is easy and fast to do. One just needs to copy the whole Histlog file, which includes the trend data.



21030500.idx	IDX File	457 KB	No	9,550 KB	96%	3/6/2021 12:00 AM
21030500.lgh	LGH File	15,090 KB	No	58,522 KB	75%	3/6/2021 12:00 AM
21030600.idx	IDX File	451 KB	No	9,446 KB	96%	3/7/2021 12:00 AM
21030600.lgh	LGH File	14,480 KB	No	57,686 KB	75%	3/7/2021 12:00 AM
21030700.idx	IDX File	489 KB	No	10,134 KB	96%	3/8/2021 12:00 AM
21030700.lgh	LGH File	15,813 KB	No	62,110 KB	75%	3/8/2021 12:00 AM
21030800.idx	IDX File	506 KB	No	10,461 KB	96%	3/9/2021 12:00 AM
21030800.lgh	LGH File	16,463 KB	No	64,022 KB	75%	3/9/2021 12:00 AM
21030900.idx	IDX File	461 KB	No	9,596 KB	96%	3/10/2021 12:00 AM
21030900.lgh	LGH File	15,154 KB	No	58,877 KB	75%	3/10/2021 12:00 AM
21031000.idx	IDX File	431 KB	No	8,970 KB	96%	3/11/2021 12:00 AM
21031000.lgh	LGH File	14,281 KB	No	55,044 KB	75%	3/11/2021 12:00 AM
21031100.idx	IDX File	443 KB	No	9,249 KB	96%	3/12/2021 12:00 AM
21031100.lgh	LGH File	14,665 KB	No	56,543 KB	75%	3/12/2021 12:00 AM
21031200.idx	IDX File	439 KB	No	9,163 KB	96%	3/13/2021 12:00 AM
21031200.lgh	LGH File	14,498 KB	No	56,076 KB	75%	3/13/2021 12:00 AM

Figure 13. Histlog Files

WOIS Historical Trend screen is for reviewing what has happened in different situations (figure 14). It is possible to choose what kind of a trend one wants to see. Time period setting is a good tool to use for a specific inspection at a certain time. With the cursor it is possible to zoom in for a specific moment for closer inspection.

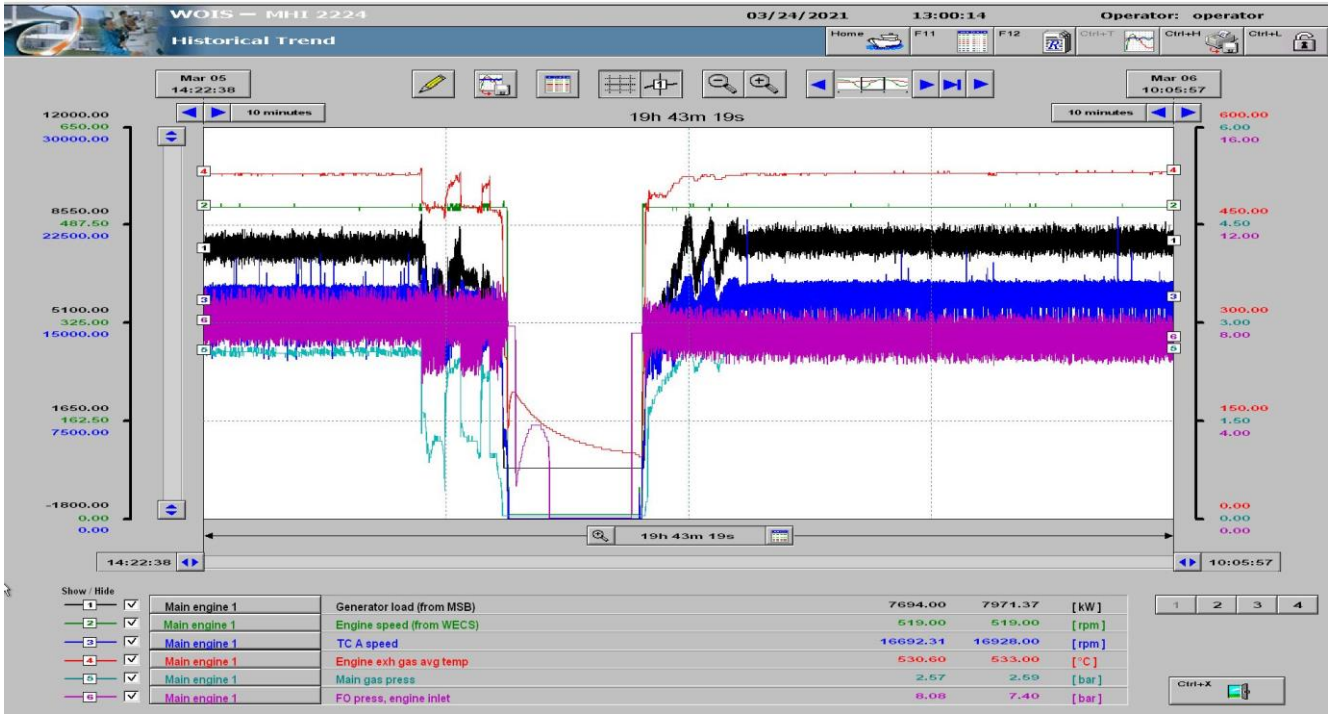


Figure 14. WOIS Historical trend

7.2 AlarmDB

AVEVA InTouch collects alarms for the D:\Alarmdb\MSSQL\Data\ -folder, *.mdf and *.ldf (figure 15). It is important to remember to copy the alarm files from the D:\Alarmdb\MSSQL\Data\ -folder, and to notice that the SQL server needs to be stopped. Otherwise, the backup procedure happens in the same way as with Histlog files, just copying the whole folder. It is also necessary to note that because the size of the backup file can exceed 10 Gb one has to use a portable storage device for the backup, such as a USB flash drive or an external hard drive (Wärtsilä 4-stroke Technical Services, 2015).

If a Wärtsilä employee does not know which SQL database version is used at some old WOIS computer, it can be figured out by a PowerShell application (figure 16). The PowerShell application tells after a couple of command lines which SQL version is used at the site. From *.mdf files one can calculate the internal data base version and that refers to the used SQL version.

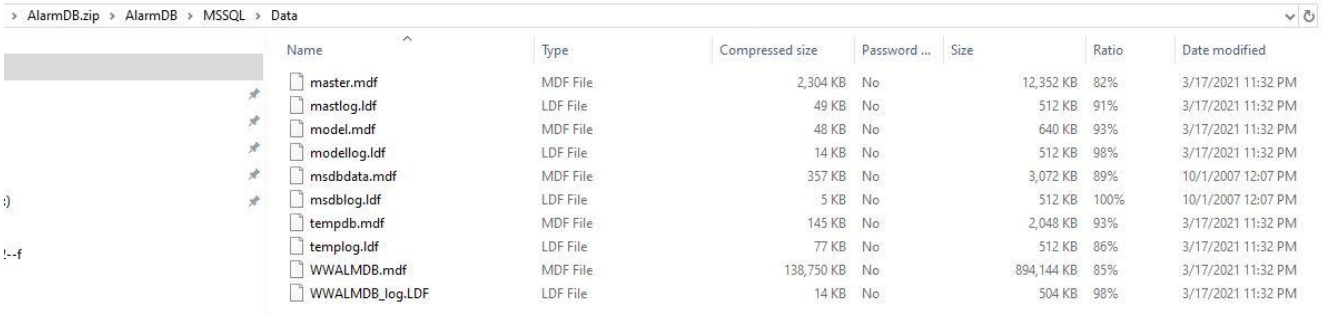


Figure 15. AlarmDB Files

```
PS C:\Users\MAK014> get-content -Encoding Byte "D:\Lobonchora_madhumati backup\WWALMDB.mdf" | select-object -skip 0x1206
4 -first 2
194
2
PS C:\Users\MAK014> 2*256+194
706
```

Figure 16. PowerShell command line

When internal database version is calculated, it is good to check table of SQL server version from internet, where all versions are listed including internal database (table 1). At the test calculation result is 706, so used SQL server version is SQL server 2012. Result is highlighted with yellow colour in the table. If one's attempt to attach a database to an earlier version, SQL server will give error 948. That is why it is always good to check which SQL database version is in use, specially with old WOIS computer.

Table 1 SQL server versions (sqlServerBuilds, 2019).

SQL Server Version	Internal Database Version	Database Compatibility Level	Supported Database Compatibility Levels
SQL Server 2019 CTP 3.2	904	150	150,140,130,120,110,100
SQL Server 2019 CTP 3.0/3.1	902	150	150,140,130,120,110,100
SQL Server 2019 CTP 2.3/2.4/2.5	897	150	150,140,130,120,110,100
SQL Server 2019 CTP 2.1/2.2	896	150	150,140,130,120,110,100
SQL Server 2019 CTP 2.0	895	150	150,140,130,120,110,100
SQL Server 2017	868/869	140	140,130,120,110,100
SQL Server 2016	852	130	130,120,110,100
SQL Server 2014	782	120	120,110,100
SQL Server 2012	706	110	110,100,90
SQL Server 2012 CTP1	684	110	110,90,80
SQL Server 2008 R2	660/661	100	100,90,80
SQL Server 2008	655	100	100,90,80
SQL Server 2005 SP2+	612	90	90,80,70
SQL Server 2005	611	90	90,80,70
SQL Server 2000	539	80	80,70
SQL Server 7.0	515	70	70
SQL Server 6.5	408	65	65
SQL Server 6.0	406	60	60

7.3 Clonezilla

Clonezilla is software which can be downloaded from the internet for free. Clonezilla is a partition and disk imaging/cloning program (Clonezilla, n.d.). There are three different types

of Clonezilla available: Clonezilla live (figure 17), Clonezilla lite server, and Clonezilla SE (server edition). Clonezilla Live is a small bootable GNU/Linux distribution for X86/amd64-based computers. Clonezilla lite server can be used to deploy an image to many computers. Clonezilla says that Clonezilla SE is a free open-source disk cloning application. Like other disk cloning applications, Clonezilla copies the contents of a hard drive for a transfer to another storage location, such as the hard drive of another computer or a removable media, like a DVD or USB drive. A similar program is Norton Ghost which supports both a full system backup and the backup of individual files or folders.

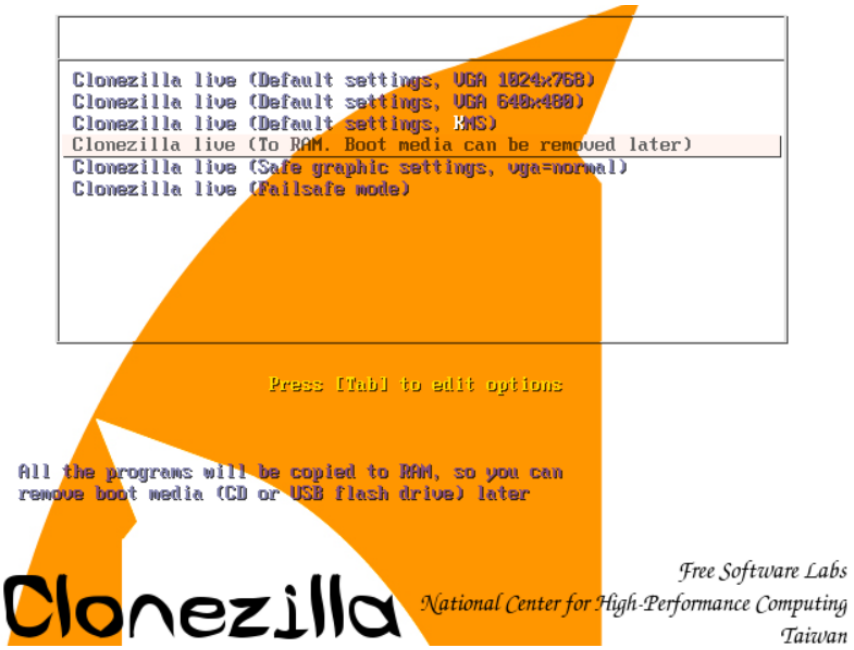


Figure 17. Clonezilla live the main screen

7.4 LGH File Inspector for Wonderware InTouch

LGH File Inspector is an application for reading historical log files from InTouch (Software toolbox, n.d.). Log files can be exported to Microsoft excel for better analysing. In LGH File Inspector you can modify e.g., delimited files, fast load files, automatic tag discovery and querying of data. The LGH File Inspector does not need Histdata or Wonderware InTouch software to run the program as it reads the *.lgh files directly from the folder.

In tests, LGH File Inspector is suitable inspector application choice for historical log files. During tests, there was only a demo version in use which can convert LGH files only 24 times, and then access to the demo version ends. The full version of the application costs 1,164.15 US$ including one year of support and maintenance.

7.5 Current data transfer

When a Wärtsilä employee is at the site and the commissioning has been finished, the employee must take a backup of all programmable types of devices, including the configurable devices of an employee's extended hard drive or the hard drive of one's own laptop.

After taking backups, the employee has three different options to send backups to the technical service, plant automation team. The employee can send backups to cloud servers via ethernet or via Wärtsilä web FTP file transfer which needs access to use. Only a Wärtsilä employee can send files to another Wärtsilä employee. Web FTP file has recommended file size which is 4Gb for each file transfer.

The third option can be used when the employee returns to Finland after finishing commissioning at the site abroad. And brings along an external hard drive where all backups are to a member of the technical service plant automation team and that person transfers the backups to Wärtsilä servers.

7.6 Current data recovery

Old WOIS backups can be recovered by the Acronis backup application. Remember that if the site using old windows XP or windows 7, the same operating system is needed from the recovery computer. When Wärtsilä employee come back to Finland and want to restore the backup to Wärtsilä Finland computer, an employee needs an Acronis application, an external hard drive where the backup from site is, and bootable Acronis USB stick. First employee put a bootable USB stick to a USB port and then starts the computer, after that

Acronis Bootable Agent starts. When Acronis is running, employees can put an external hard drive to the USB port and start backup recovery for computer. After backup recovery service person can investigate backup via Wärtsilä operating interface system (WOIS).

Newer sWOIS backups can be recovered by the VEEAM backup application which is already in common use at Wärtsilä. Restoring is the same process as old WOIS but nowadays Wärtsilä uses cloud servers (Microsoft OneDrive) so it is easy to transfer backup files to the cloud server and someone in plant automation team transfer file to Wärtsilä server. Some employees are still using old way to take backup at the site and when employee come back to Finland, he gives an external hard drive to plant automation team member and transfer backup to Wärtsilä server.

8 Virtualized WOIS solutions

8.1 Acronis Cyber Backup 12.5 Standard

Acronis Cyber Backup protects all business-critical systems physical, virtual, and cloud with a single powerful backup solution managed from a single easy-to-use console (Ohjelmistot.com, n.d.). Ohjelmistot.com tells that Acronis cyber backup is designed specifically for large enterprise environments and it provides very effective protection. It also provides fast and flexible recovery for all systems in a wide environment regardless of their complexity.

After the tests, there were noticed two issues. The first one was time related: One needs to take time to rescue or recover data and it may take 2 - 5 hours depending on the size of the backup. The second issue was reliability related. When trying to recover data again for the same computer with the same settings it failed, so it could be seen that Acronis is not very reliable (figure 18).

As the test operating system there was Windows XP (figure18). And because of Wärtsilä regulations, IP addresses have been covered in all the pictures below.

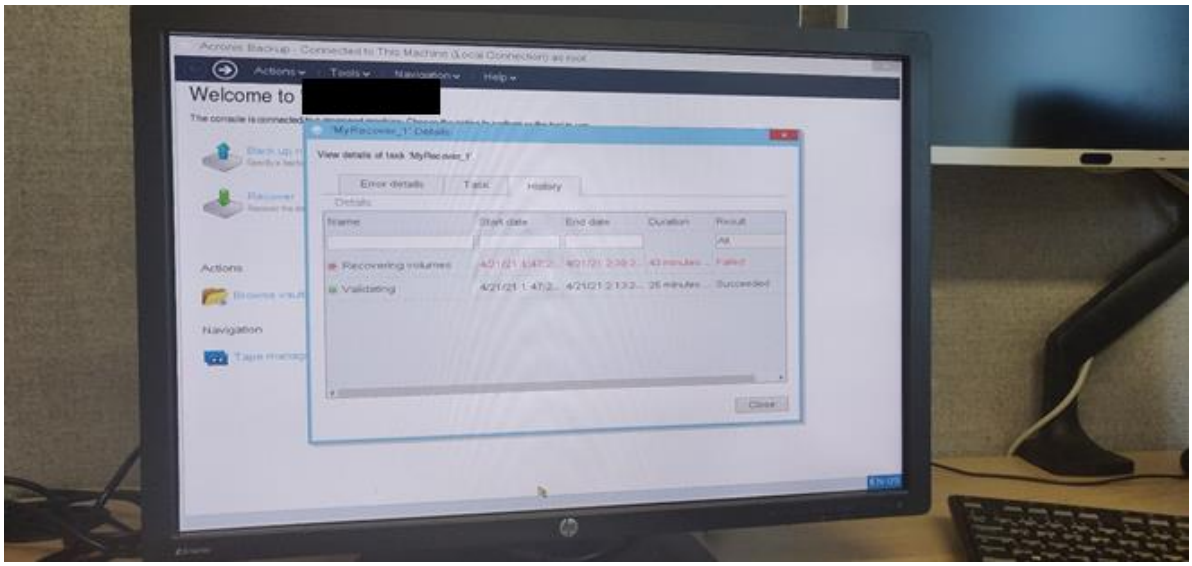


Figure 18. Acronis Cyber Backup test.

8.2 Veeam

With Veeam Backup & Replication it is possible to modernize data protection and eliminate downtime (Veeam, 2021). It is the foundation of the Veeam Platform, providing backup, recovery, and replication for critical workloads including VMware, AWS, Microsoft Azure, Windows, Linux, NAS, and enterprise apps (figure 19).

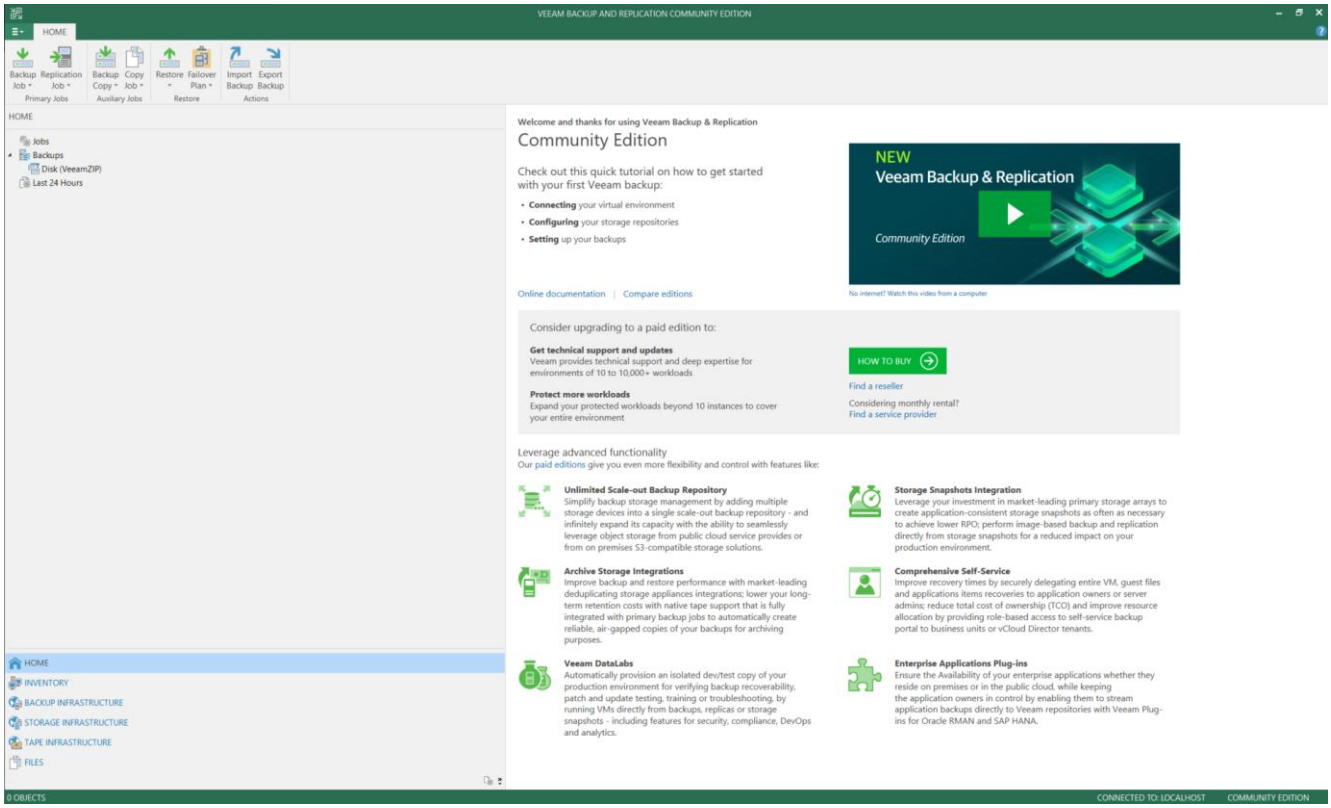


Figure 19. VEEAM backup and replication home screen

8.2.1 Extract Utility Veeam Backup

Extract Utility Veeam Backup & Replication with an extract utility can be used to restore virtual machines from Veeam backup files (Veeam, 2021). The Veeam Extract utility does not need any communication with Veeam. It can be used as an independent tool on Linux & Microsoft Windows virtual machines.

Veeam Extract Utility can be used by two interfaces, a graphic user interface or command line. In our test we used the graphic user interface (GUI). The Veeam extract utility is located in the installation folder of Veeam, as default: C:\Program Files\Veeam\Backup and Replication\Backup -folder. The folder includes three files for the extract utility: Veeam.Backup.Extractor.exe working as GUI, which can be used on Microsoft Windows machines only. Veeam Extract Utility version for Microsoft Windows is extract.exe which is using normal graphical application windows. Veeam Extract Utility version for Linux is working as the command prompt interface.

While testing the Veeam Extract Utility application it proved not to be a reliable software. Many times, when trying to restore Veeam backup to a virtual machine it gave a pop-up window “unexpected error” and nothing else, no reason for that or anything else. This problem was investigated by searching for solutions through Google and some forums adviced to check the Veeam backup version and extract utility software version, but both pieces of software we had should be fine and they were both the latest versions available. Some other forums said that if the backup has been taken from some older or newer version, it may be that Extract utility just cannot handle exactly that version. Extract Utility application was not under deeper investigation because of all the errors found and it would have taken too much time to find solutions to them. When testing the same software with another laptop there was a difference in performance and extracting worked fine without any errors. Some hardware settings of the laptop seemed to affect the extracting result.

8.2.2 Veeam backup & replication community edition

Veeam backup and replication is free backup software to protect cloud, virtual, physical or applications data (Veeam backup & protection 2021). Veeam backup & replication is very reliable and easy to use. Veeam reduces operational overhead with flexibility that fits business and market-leading reliability. Veeam Backup & Replication delivers reliable availability across all cloud, virtual and physical workloads with a simple, flexible, and reliable solution (figure 20). Veeam (2021) advertising itself for good choice to Protect data regardless of the location or workload type with powerful backup and instant recovery options (figure 21).

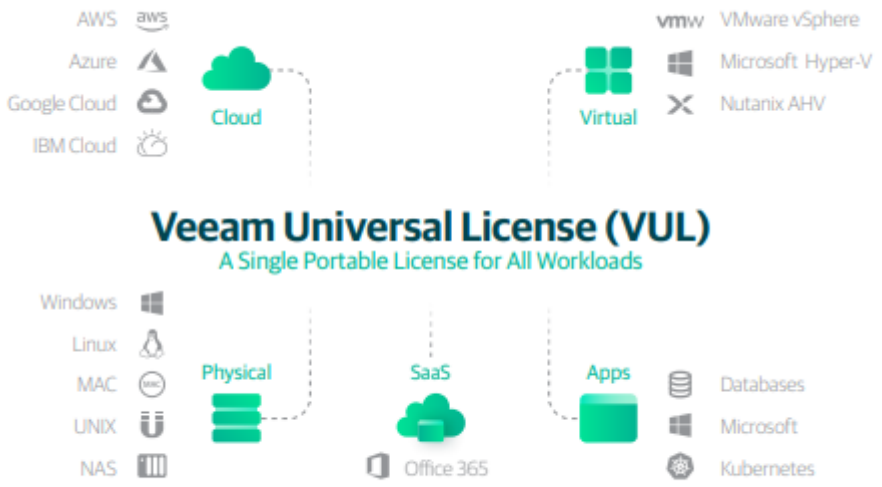


Figure 20. Veeam backup & replication possibilities.

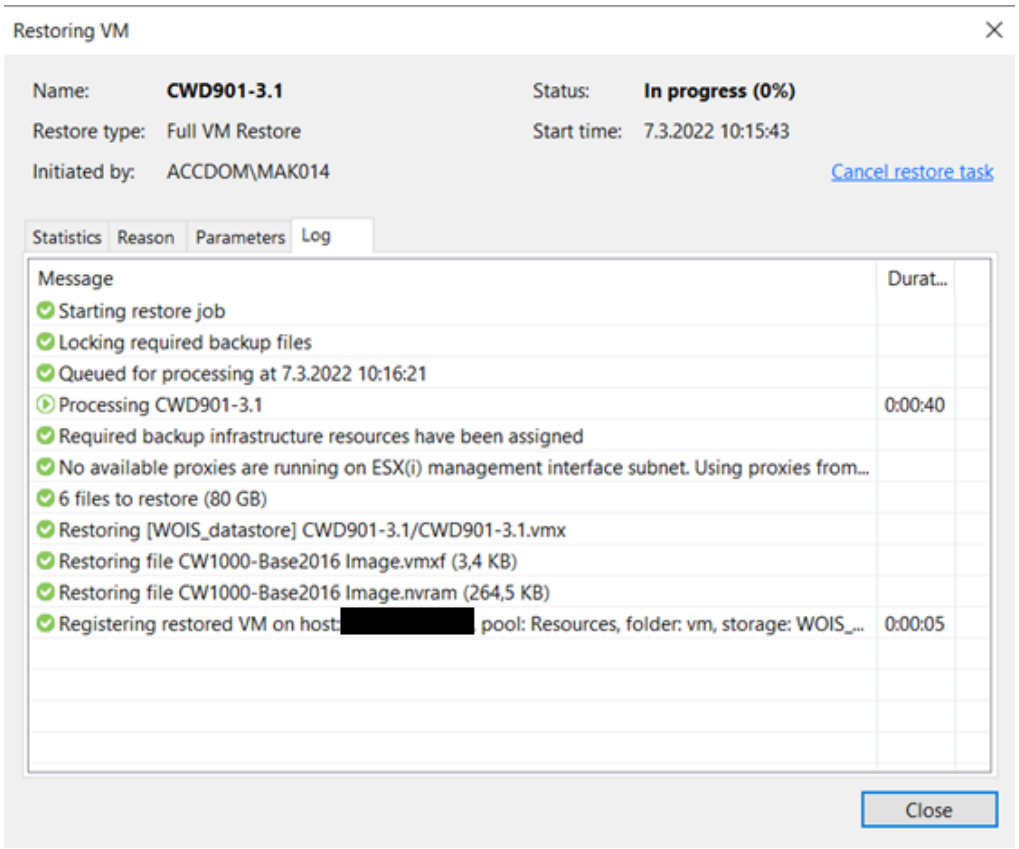


Figure 21. Veeam Backup &replication restore test.

8.3 VMware vCenter Converter Standalone Client

vCenter Converter supports many sources of physical machines, including Windows and Linux desktop and server editions (vmware, n.d.). It also supports the conversion of third-party virtual machines like Hyper-V and KVM (figure 22).

In our test vCenter Converter was the most suitable option for converting the backup to a virtual machine if the virtual machine was supposed to transfer to own computer or external hard drive. It is good to remember that in a WOIS computer (CWA90X) there is usually reserved 500Gb for the data size, so it needs quite a lot of space from the hard drive (figure 23). Naturally WOIS virtual machine is running much slower on an external hard drive than in a server computer.

vCenter Converter was very easy to use because its user interface was user friendly, it had clear menus and the program always told what was being done (figure 23). The only minus was that the server must be switched off before taking a backup. This may cause problems for ships if the servers are shut down for an hour. An external hard drive needs to have big memory size if there have to be three TB reserved for historian data. It is not possible to take the real data size that is inside a historian computer. VMware vCenter Converter Standalone Client always wants to take a full backup of a computer, including reserved data.

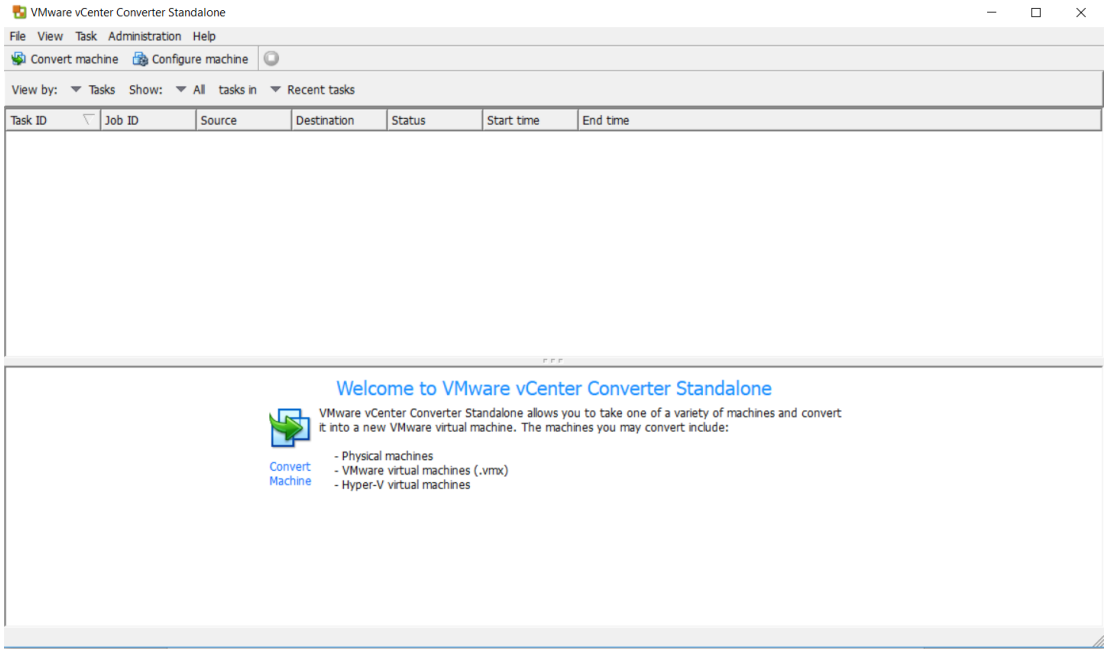


Figure 22. Main screen from VMware vCenter Converter Standalone

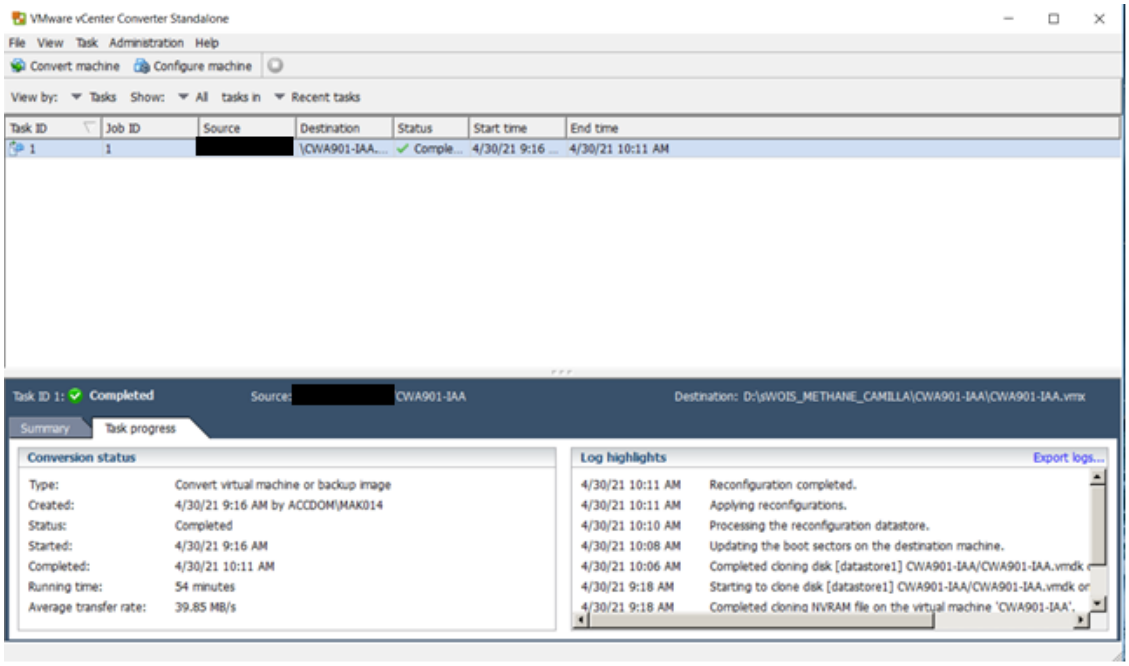


Figure 23. Backup image converted to virtual machine using vCenter Converter Standalone

8.4 NAKIVO Backup & Replication

Developed specifically for VMware vSphere, NAKIVO Backup & Replication delivers complete data protection for vCenter-managed and standalone ESXi workloads (NAKIVO, n.d.). With enterprise-grade functionality, the software solution provides efficient backups and ensures that your VMs, applications and data are recoverable within minutes. NAKIVO Backup & Replication fulfils all the requirements of today's agile IT infrastructures by simplifying vSphere data protection, improving VM backup performance and ensuring data recovery.

In our test NAKIVO proved to be a bad choice for taking backups from sWOIS. NAKIVO interface was quite OK but NAKIVO reserved always 500gb from your computer so that needs lots of space (figure 24). Another thing is that it is not possible to take and save backup for your external hard drive, only copying to a cloud server or the computer's own hard drive is allowed.

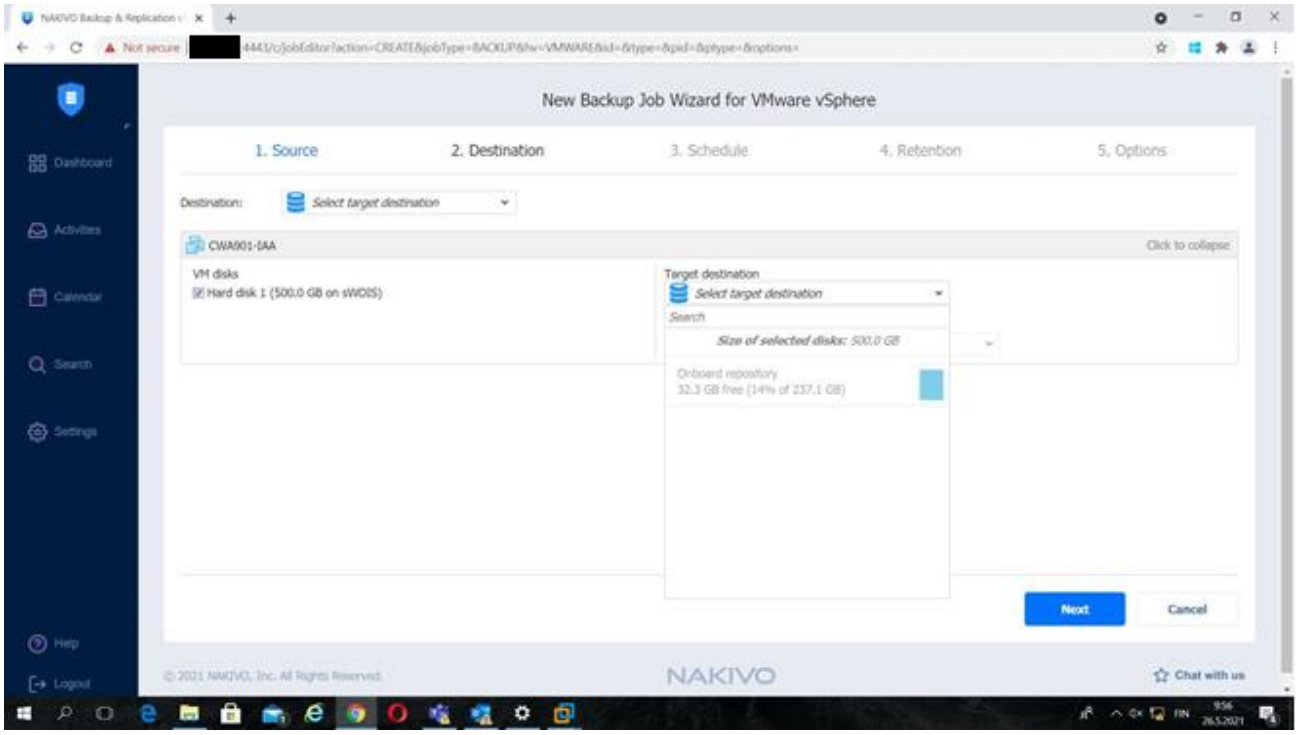


Figure 24. NAKIVO Backup & Replication test.

9 Conclusions

9.1 Positive findings

Veeam Backup & Replication was the best software for all pieces of software that were tested. There is a feature for getting backup in a thin mode which only takes the real used data size. In the historian server the reserved data size can be over 3TB, but the real size is 30Gb. Veeam is very user friendly to use and it provides clear information for all icons and functions. In addition, Veeam is more and more common among field service engineers at sWOIS installations which are nowadays included in standard deliveries.

It is more useful to take a backup for an SSD hard drive and transfer virtual machines to the server, where the amount of memory is huge. For monitoring a virtual machine plant an automation team instructs service engineers to take remote control of the server via VPN. VMware vCenter Converter Standalone Client is good if a plant or ship is using a redundant sWOIS server and one server can be shut down while taking backup from another server.

9.2 Negative findings

Virtualization needs a lot of space from a computer, and also the reserved data size can be over 3 Tb when backups are coming from bigger power plants. The latest backup that was restored was 3Tb. It was reserved for a historian virtual machine. There is a solution for getting the data size smaller by taking backup in thin mode which took the real data size of the virtual machine that was actually in use.

At the sites people are using their own laptops so it is not practical to take backups for one’s own computer hard drive. Besides, a virtual machine is rather slow to run on a laptop and it needs a lot of memory.

Acronis Cyber Backup 12.5 Standard was not a good choice to continue testing backup restoring because sometimes backup restoring failed for no reason. This kind of unreliability is not acceptable if the size of backup is big and restoring takes 2-6 hours.

VMware vCenter Converter Standalone Client was a good choice for taking backups and restoring them but it is necessary to always shut down the server to be able to take a backup. This may, however, cause problems in powerplants and ships if engines must be shut down for 1-6 hours while taking backups.

NAKIVO backup & replication got some problems too. When taking a backup in the NAKIVO backup & replication it always reserves 500Gb from the computer. And it is not possible to take the backup to your external hard drive, only for the cloud or one's own computer hard drive. NAKIVO is more useful in a server safety backup system where you can program backup jobs into a calendar so that you know when to make full or incremental backups from the server.

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