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Platform for malwareanalysis

Plattform for skadevareanalyse

Bachelor's project in IT-Drift og Informasjonssikkerhet
Supervisor: Eigil Obrestad

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Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Information Security and Communication Technology



Sammendrag av Bacheloroppgaven

Tittel:	Plattform For Skadevareanalyse
Dato:	14.01.2019
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Sammendrag:	<p>I en moderne verden er det viktig å være oppdatert og kunne lære mer om skadevare. NTNU SOC presenterte et ønske om å lage en plattform som kunne analysere skadevare og som kunne brukes i produksjons-, utviklings-, og testmiljøer. Det var et ønske om at plattformen kunne installeres automatisk i forbindelse med bruk i undervisningsscenarioer, men også fordi den skulle være lett å vedlikeholde og videreutvikle. Det var også ønskelig at plattformen skulle benytte seg av Cuckoo Sandbox, med tett integrering av simulerte nettverkstjenester som The Onion Router(TOR), Virtual Private Network(VPN), og InetSim. Installasjonen av Cuckoo Sandbox ble automatisert ved hjelp av Ansible, et verktøy som brukes av server administratorer verden rundt. Med dette prosjektet har vi levert en løsning som innfyller ønskene til oppdragsgiveren, NTNU SOC, og som etter kort tid vil bli tatt i bruk som en del av NTNU SOC sitt daglige arbeid i å beskytte både studenter og ansatte ved NTNU. Prosjektgruppen har hatt fokus på profesjonell arbeidsmetodikk, ved for eksempel en agil tilnærming av Waterfall-metoden i løpet av utviklings perioden, og har brukt Kanban som hjelp til å skrive denne rapporten.</p>
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Summary of Graduate Project

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Authors:	Daniel Krohn Siqveland Stian Rønningen Nestor Gerardo Fortique
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Abstract: In the modern world, it is essential to be up-to-date and to learn more about malware. NTNU SOC presented a wish to create a platform that could analyze malware samples and which could be used in production, development, and testing environments. There was a wish that the platform could be installed automatically in combination with use in teaching scenarios, but also because it should be easy to maintain and develop. It was also desirable that the platform was built around Cuckoo Sandbox, with close integration of simulated network services such as The Onion Router (TOR), Virtual Private Network (VPN), and InetSim. The installation of Cuckoo Sandbox was automated using Ansible, a tool used by server administrators around the world. With this project, we have delivered a solution that fulfills the wishes of the employer, NTNU SOC, and which after a short time will be used as part of NTNU SOC's daily work in protecting both students and employees at NTNU. The project team has focused on professional work methodology, for example, by an agile approach to the Waterfall method during the development period, and has used Kanban to help write this report.

Preface

This is a bachelor thesis in IT-Operations and Information Security written and performed by the following students:

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First of all the group would like to thank NTNU SOC for giving us such an interesting and challenging project to work on. The group would also like to thank our employer, Christoffer Vargtass Hallstensen, and our supervisor, Eigil Obrestad, for guiding, helping and inspiring us throughout the whole project. Thanks to Frode Haug and Tom Røise for helping the group with great presentations about report writing and project planning. Last but not least the group would like to thank the Digital Security Section and the [Institutt for informasjonssikkerhet og kommunikasjonsteknologi \(IIK\)](#) for lending us the equipment necessary to make this project a reality.

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Acronyms

- API** Application Programming Interface. [23](#)
- Bash** Bourne again shell. [xiv](#)
- Bionic Beaver** Ubuntu 18.04 LTS. [2](#), [9](#), [19](#), [20](#), [23](#), [42](#), [46](#)
- DHCP** Dynamic Host Configuration Protocol. [xv](#)
- DNS** Domain Name Server. [xv](#), [9](#), [38](#)
- IDS** Intrusion Detection System. [2](#), [9](#), [57](#)
- IIK** Institutt for informasjonssikkerhet og kommunikasjonsteknologi. [iii](#)
- IPS** Intrusion Prevention System. [9](#)
- LAN** Local Area Network. [18](#)
- NAT** Network Address Translation. [xvi](#), [19](#), [20](#)
- NIC** Network Interface Card. [x](#), [25](#), [26](#), [34](#), [35](#)
- NSM** Network Security Monitoring. [9](#)
- NTNU** Norges Teknisk-Naturvitenskapelige Universitet. [1–4](#), [12](#), [13](#), [48](#)
- OS** Operating System. [6](#), [40](#), [43](#), [46](#), [48](#)
- PCAP** Packet Capture. [9](#)
- PID** Process Identifier Number. [21](#), [36](#)
- PPA** Personal Package Archives. [xvii](#)
- SOC** Security Operations Center. [1](#), [2](#), [4](#), [43](#), [48](#)
- SSH** Secure Shell. [11](#), [23](#)
- SSL** Secure Sockets Layer. [30](#)
- TLS** Transport Layer Security. [30](#)
- TOR** The Onion Router. [13](#)
- UAC** User Account Control. [21](#)

URL Uniform Resource Locator. [39](#)

VCSA vCenter Server Appliance. [12](#), [17](#), [18](#), [23](#), [31](#), [42](#), [69](#)

VPN Virtual Private Network. [1](#), [10](#), [13](#), [18](#), [20](#)

Xenial Xerus Ubuntu 16.04 LTS. [2](#), [19](#), [42](#)

Glossary

Android A smartphone [Operating System](#) developed by Google and used by many smartphone manufacturers worldwide, one of which is Samsung. [xvi](#), [2](#), [8](#), [21](#), [28](#), [32](#), [45](#), [46](#), [56](#), [63](#)

Ansible Ansible is an open-source IT automation engine with which you can provision, configure, manage and deploy machines. [2](#), [11](#), [14–16](#), [22–24](#), [26](#), [46](#), [48](#), [57](#), [61](#), [63](#)

API A software intermediary that allows two applications to talk to each other. Each time you use an app like Facebook, send an instant message, or check the weather on your phone, you're using an API. [8](#)

Backlog Product backlog is a list of tasks that is not yet started on. [16](#)

Bash [Bourne again shell \(Bash\)](#) is a command process that typically runs in a text window where the user types in commands that cause actions. [23](#)

Bitbucket Bitbucket is a version management solution designed for professional teams. It is a central place to manage git repositories, collaborate on source code and it helps making the development flow smoother. [20](#)

Botnet A botnet is a group of computers connected in a coordinated fashion for malicious purposes. Each computer in a botnet is called a bot. These bots form a network of compromised computers, which is controlled by a third party and used to transmit malware or spam, or to launch attacks. [1](#)

Configuration Files Configuration files are files used to configure the parameters and initial settings for some computer programs. [8](#), [19](#), [21](#)

Container A container is a software package that contains everything the software needs to run. The package includes the executable program as well as system tools, libraries, and settings. Containers are not installed like traditional software programs, which allows them to be isolated from the other software and the operating system itself. [43](#), [46](#), [56](#)

Cuckoo Cuckoo is an open source automated malware analysis program that allows you to throw any virus in it and it will give you a detailed report on what the virus is trying to do. [viii](#), [xviii](#), [1–4](#), [8](#), [10](#), [12–16](#), [18–26](#), [28–34](#), [36–43](#), [45](#), [46](#), [48](#), [63](#), [64](#), [69](#)

Cuckoo Rooter Rooter helps Cuckoo out with running network-related commands in order to provide per-analysis routing options. [10](#), [14](#), [21](#), [22](#), [36](#), [39](#)

- Debugging** Debugging is the routine process of locating and removing computer program bugs, errors or abnormalities, which is methodically handled by software programmers via debugging tools. [45](#)
- DevOps** Devops is a software developing practice made to reduce the time of development of software while delivering features, fixes, and updates frequently. [57](#)
- DHCP** [Dynamic Host Configuration Protocol \(DHCP\)](#) is a network management protocol used on UDP/IP networks whereby a DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks. [13, 21](#)
- Digitalocean** Digital Ocean is a company where both private and enterprise actors can buy servers online to deploy and deliver their application to the masses. [19, 20, 26](#)
- DNS** [Domain Name Server \(DNS\)](#) is a protocol that translates domain names to IP addresses so browsers can load Internet resources. [13, 29](#)
- Docker** Docker is a program designed to facilitate the use of containers, making it easier to create, deploy, and run applications. [43, 46, 56, 61, 63](#)
- Elasticsearch** Elasticsearch is an open source, broadly distributable, readily scalable search engine. Accessible through an extensive and elaborate API, Elasticsearch can power extremely fast searches that support your data discovery applications. [14, 15, 19, 20, 46](#)
- Environment** The set of facilities, such as operating system, windows management, database, etc., that is available to a program when it is being executed by a processor, in this project when the group refers to environment. [6–8, 10–12, 17, 18, 46, 60](#)
- ESXI** VMware ESXi is an enterprise-class, type-1 hypervisor developed by VMware for deploying and serving virtual computers. [6, 12, 17, 18, 20, 23, 28, 31, 42](#)
- Firewall** A firewall is software used to maintain the security of a private network. Firewalls block unauthorized access to or from private networks and are often employed to prevent unauthorized Web users or illicit software from gaining access to private networks connected to the Internet. [21](#)
- Gantt Diagram** A Gantt diagram is an illustration of a projects schedule, and it shows all the phases of the project. When those phases are due to start, when the phases end, and which of those phases are running at the same time. [16, 61](#)
- Guest** The virtual machine running inside the [Host](#). [6](#)
- Home Directory** A directory where the user stores all personal information and files as well as user information. [19](#)
- Host** A server which runs virtual machines inside itself. [xv, 6, 7, 18](#)

- HTTP** HTTP or Hypertext Transfer Protocol is a set of rules for transferring files (text, images, sound, video, and other multimedia files) on the World Wide Web. 9
- Hypervisor** A hypervisor is a process that creates and runs virtual machines (VMs). A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, like memory and processing [1]. 2, 6, 11, 12, 14, 18, 20, 23, 28, 30, 42
- INetSim** INetSim is a software suite for simulating common internet services in a lab environment, e.g. for analyzing the network behaviour of unknown malware samples. 8, 10, 11, 14, 28, 40
- Infected computer** A computer that is or has been affected by a virus in any way. 6, 8
- interface** The layout or design of the interactive elements of a computer program, an online service, or an electronic device. 8, 20
- iOS** Apples smartphone implementation of [Operating System](#) running on phones developed by Apple, for example the iPhone X. 63
- IP-address** Identifies each computer using the Internet Protocol to communicate over a network. 9–11, 23, 26, 29–36
- Kernel** The kernel is a program that constitutes the central core of a computer operating system. It has complete control over everything that occurs in the system. 45
- Linux** Linux is a free open source [Operating System](#) based on UNIX that was created in 1991 by Linus Torvalds. Users can modify and create variations of the source code, known as distributions, for computers and other devices. It is also the base [Operating System](#) for [Android](#). xviii, 8, 46
- MacOS** Apples implementation of [Operating System](#) running on computers made by Apple. 2, 8, 21, 45, 46, 56, 63
- Malware** Short for malicious software, is any software intentionally designed to cause damage to a computer, server, client, or computer network. 1–4, 6–8, 10, 11, 13, 14, 16, 32, 39, 43, 45, 48, 56, 57, 61, 63
- Moloch** Moloch is an open source piece of software that can be used to index very large PCAP files into Elasticsearch. 15, 19, 37, 46
- NAT** [Network Address Translation \(NAT\)](#) is the process where a network device, usually a firewall, assigns a public address to a computer (or group of computers) inside a private network. 13
- OpenVPN** OpenVPN is both a VPN protocol and a software that uses VPN techniques to secure point-to-point and site-to-site connections. 12, 18, 20, 22, 26, 27
- Operating System** An operating system is a huge program that whose purpose is to provide the user with a clean interface towards hardware. xiv, xvi, xix, 8, 63, 64

- pcap** Pcap consists of an application programming interface for capturing network traffic. [9](#)
- pfSense** Firewall, VPN, and router functionality for a fraction of the cost of proprietary alternatives. [12–14](#), [18](#), [20](#)
- Pillow** Pillow is a fork of the python image library that will help the group by taking screenshots of the processes happening in the sandboxes. [21](#)
- Playbook** Playbooks are Ansible’s configuration, deployment, and orchestration language. They can describe a policy you want your remote systems to enforce, or a set of steps in a general IT process. [11](#), [14–16](#), [19](#), [20](#), [22–24](#), [26](#), [28](#), [30–32](#), [36](#), [37](#), [42–46](#), [48](#), [63](#)
- Repository** Often referred to as a [Personal Package Archives \(PPA\)](#). A repository is a private collection of prebuilt packages for Linux systems that users can add to their system to install the latest version of a package. When using a repository the user will not have to compile the program from source code. [19](#)
- Risk** According to ISO 31000, risk is the “effect of uncertainty on objectives” and an effect is a positive or negative deviation from what is expected. Risk = Likelihood * Impact. [7](#), [58](#), [59](#)
- Routing** Routing refers to establishing the routes that data packets take on their way to a particular destination. [8](#), [10](#), [13](#), [39](#), [40](#)
- Sandbox** In computer security, a sandbox is a security mechanism for separating running programs. It is often used to execute untested code, or untrusted programs from unverified third parties, suppliers, untrusted users and untrusted websites. The sandbox typically provides a tightly controlled set of resources for guest programs to run in, such as scratch space on disk and memory. Network access, the ability to inspect the host system or read from input devices are usually disallowed or heavily restricted. [xviii](#), [1](#), [2](#), [7](#), [12–16](#), [18](#), [20](#), [21](#), [25](#), [29–31](#), [38–40](#), [42](#), [43](#), [45](#), [56](#)
- Script** A script is a lightweight, quickly constructed and possibly single-use tool programming language. [14](#), [20](#), [40](#), [60](#)
- Security Operations Center** A unit that deals with security issues on an organizational and technical level. [8](#)
- Signature** A signature is any detection method that relies on distinctive characteristics being present in an exploit. These signatures are specifically designed to detect known exploits as they contain a specific set of characteristics. [7](#), [8](#), [57](#)
- Snapshot** A snapshot of a virtual machine is a file-based representation of the state of the virtual machine at a given time. It includes disk data and configuration data of the VM. With a snapshot you can restore a machine to a previous state. [14](#), [23](#), [30](#), [37](#), [43](#)

- Spoof** Spoofing is the act of disguising a communication from an unknown source as being from a known, trusted source to attempt to gain access to something they should have access to. [1](#), [13](#), [14](#), [56](#)
- subnet** A subnet is a logical partition of an IP network into multiple, smaller network segments. It is typically used to subdivide large networks into smaller, more efficient subnetworks. [13](#), [15](#)
- Subnet 1** The subnet that makes sure that the platform has Internet connectivity for updates and other services. [18](#), [23](#), [34](#), [35](#)
- Subnet 2** The subnet where the sandboxes reside. Used for analyzing and routing between the [Sandboxes](#) and [Cuckoo](#). [18](#), [23](#), [30](#), [31](#), [34](#), [36](#)
- Suricata** Suricata is a free and open source, mature, fast and robust network threat detection engine. The Suricata engine is capable of real time intrusion detection (IDS), inline intrusion prevention (IPS), network security monitoring (NSM) and offline pcap processing. [9](#), [15](#), [19](#), [32](#), [35](#), [46](#)
- systemd** systemd is a system and service manager for Linux. It has replaced init for startup- and servicemanagement [2]. [15](#), [19–21](#), [36](#)
- TOR** The Tor browser is a web browser that anonymises your web traffic by bouncing your communications around a distributed network of relays run by volunteers all around the world. [1](#), [10](#), [11](#), [13](#), [14](#), [18](#), [34](#), [35](#), [40](#), [56](#)
- Traceroute** Traceroute is a computer network diagnostic tool for displaying the route and measuring transit delays of packets across an Internet Protocol network. [40](#)
- Trello** Trello is a collaboration tool that organizes your projects into boards. Trello tells you what's being worked on, who's working on what, and where something is in a process. [47](#)
- Ubuntu** Ubuntu is an open-source operating system (OS) based on the Debian GNU / [Linux](#) distribution. [14](#), [19](#), [25](#)
- vCenter Server Appliance** The vCenter Server Appliance is a preconfigured [Linux](#) virtual machine, which is optimized for running VMware vCenter Server and the associated services on Linux. [18](#), [63](#)
- Version Management** In this project, Version Management, means the possibility of installing different versions based on a preset variable in Ansible. [1](#)
- Virtual Environment** At its core, the main purpose of Python virtual environments is to create an isolated environment for Python projects. The isolated environment means that each project can have its own dependencies/packages which will not be updated with system updates to avoid breakage. [20](#), [43](#)
- Virtualbox** VirtualBox is a powerful x86 and AMD64/Intel64 virtualization product for enterprise as well as home use. [45](#)

- VMWare** VMware is a virtualization and cloud computing software that allows you to run multiple virtual machines on a single physical machine. [2](#), [6](#), [12](#), [23](#), [45](#), [56](#)
- Volatility** Volatility [3] is an open collection of forensic tools that facilitate the extraction of digital artifacts from volatile memory (RAM) samples. [10](#), [15](#), [19](#), [31](#), [43](#)
- VPN** A vpn is a tool used to hide an users traffic by encrypting it. A vpn also hides the users ip-address by redirecting the users traffic through a server. [8](#), [11](#), [14](#), [19](#), [20](#), [40](#), [46](#), [56](#)
- vSphere** Connecting ESXi to vCenter Server Appliance turns it into a vSphere Server, expanding its features and allowing full memory dumps of virtual machines. [1](#), [2](#), [6](#), [12](#), [18](#), [20](#), [23](#), [28](#), [30](#), [31](#)
- WebGUI** webgui, is a Website Graphical User Interface that allows users to interact with electronic devices through graphical icons and visual indicators, instead of text-based user interfaces, typed command labels or text navigation. [20](#)
- Windows** Microsofts implementation of [Operating System](#). [1](#), [2](#), [8](#), [16](#), [21](#), [29](#), [30](#), [41–43](#), [45](#), [46](#), [48](#), [56](#), [63](#), [64](#)
- Yaml** YAML (YAML Ain't Markup Language) is a data-oriented language structure used as the input format for diverse software applications. An application user or administrator specifies data in a YAML file, which the application then can read. [11](#)
- Yara** Yara is an opensource software that classifies malware by matching it against textual or binary patterns. [8](#), [10](#), [15](#), [19](#), [43](#)

1 Introduction

Since the dawn of computers and computer networks, [Malware](#) has been in existence. Malware is created by hackers or other evil-minded to help break into computers or computer systems, through exploiting vulnerabilities in software. Today there exist hundreds of thousands of different malware. The goals of malware can vary, but the most popular ones usually turn a device into a slave of a [Botnet](#) or kidnap its files and encrypt them. Malware expands as fast as or even faster than we can protect from it. It is imperative to understand [Malware](#) by how it operates and how the mind behind the [Malware](#) think. New sophisticated methods to lure a user into downloading malware and new types of malware are discovered every day. The only way malware researchers can prepare themselves from these threats is to understand their method and structure. With this thesis, we will take a closer look at how an immutable platform is used to analyze any malware and present the results.

1.1 Problem description

This project was created by Christoffer Vargtass Hallstensen, head of Security Operations Center in [NTNU Gjøvik](#). [NTNU SOC](#) needed a service platform that could analyze potential malware quick and risk-free. Therefore, [SOC](#) made a bachelor submission, which had these factors in mind.

It is time-consuming to do malware analysis manually. There is, therefore, a need to scale up automatic [Malware](#) analysis. Scaling issues are addressed with the automation of development, testing, and production. Automatic [Malware](#) analysis is versatile but is not always accurate, so one needs to be able to do manual [Malware](#) analysis as well. Another challenge is maintaining virtual machines for both manual and automated analyses. The group solved this by using [vSphere](#) which makes maintenance of sandboxes easier and the possibility to use the same [Sandboxes](#) for both manual and automated analysis when needed, e.g., via VMware Workstation.

1.2 Goals and research question

The goal of the project will be to simplify [Malware](#) analysis by being able to use the same platform for both automatic and manual analysis. The group will automate the installation of a malware analysis lab which will be scalable and can be further developed.

1.2.1 Scope

Implementing the [Cuckoo](#) analysis platform so it can run [Malware](#) on [Windows Sandboxes](#). See appendix [A](#) for the full description of the task.

[NTNU SOC](#) wanted a platform that had a configuration component that allowed for [Version Management](#) and had integration towards systems for threat intelligence. Another requirement from the employer was the implementation of different network services such as [TOR](#) and [Virtual Private Network \(VPN\)](#) to [Spoof](#) the location of the ana-

lyzer and lure the attacker into unleashing the full potential of the [Malware](#) for better analysis.

The environment will be built in a [VMWare vSphere Hypervisor](#). Every other machine run in the same environment will be virtual machines. The virtual machines the group will use are [Sandboxes](#) for [Malware](#) testing, and a [Ubuntu 18.04 LTS](#) server for running [Cuckoo](#). Network-based [Intrusion Detection System](#) systems will be installed alongside [Cuckoo](#) to ensure that traffic generated by the malware is captured and inspected. [Cuckoo](#) installation will be automated using [Ansible](#).

1.2.2 Limitation of scope

The original plan was to install the platform on a [Ubuntu 16.04 LTS \(Xenial Xerus\)](#) server (hereby referred to as [Xenial Xerus](#)). Since Canonical ¹ will no longer be offering updates to [Xenial Xerus](#) after April 2021, [4] the students have decided to change the operating system of the [Cuckoo](#) host to [Ubuntu 18.04 LTS \(Bionic Beaver\)](#) (hereby referred to as [Bionic Beaver](#)), which is supported until April 2023.

The implementation of containers proved to be more challenging than helpful. Therefore the students, together with the employer, excluded containers during the midterm review which can be read in appendix D.

The employer and the students decided to focus on the implementation of a platform for analyzing [Windows](#). The implementation for [MacOS](#) and [Android](#) would be optional and put at future work.

1.3 Motivation

The group has a common interest in [Malware](#), and they like practical challenges. The group agreed that the bachelor thesis should include practical work, such as networking, virtualization, and advanced server implementations. When "platform for skadevareanalyse" had the presentation about the subject and the task, the group knew right away, this would be a perfect challenge.

In previous subjects, the students learned the basics of automation, infrastructure and [Malware](#) so this would be an excellent opportunity to improve the groups' knowledge in these areas. [Ansible](#) and [Cuckoo](#) were entirely new for the students, and the group knew right away it would be fun in a challenging way to learn new tools and applications.

1.4 Roles

This section will give the reader a better idea of who the authors are, who the employer is, and who the supervisor is.

1.4.1 Employer

Christoffer Vargtass Hallstensen, head of [Security Operations Center](#) at [Norges Teknisk-Naturvitenskapelige Universitet](#) in Gjøvik, provided the task. The students had progress meetings with the employer every time the group deemed it necessary. In these progress meetings, the group discussed the scope of the project, asked for technical advice regarding the project and showed him some demos of [Cuckoo Malware](#) analysis in action.

¹The Company behind Ubuntu: <https://www.canonical.com/>

1.4.2 Supervisor

The groups supervisor is Egil Obrestad, an assistant professor at [NTNU](#). The group had progress meetings with him nearly every Monday. In these meetings the group discussed everything from different infrastructures for [Cuckoo](#) and how to write the thesis.

1.4.3 Authors

The authors of this thesis are Daniel Emil Krohn Siqveland, Nestor Gerardo Fortique, and Stian Rønningen. All of whom study IT-Operations and Information Security at [NTNU Gjøvik](#). The group initially received a different project from an external employer, but the group decided that this project was much more interesting and felt they could learn more from this project.

1.5 Students experience

All of the members of the group have a passion for IT-security, and that is why it was an easy decision to take on this project. All of the group members have experience in coding and are familiar with automating infrastructure with the help of Puppet.

Before this thesis, none of the students had any previous experience with [Malware](#) analysis, nor had they ever heard of [Cuckoo](#) before. The students had to read up on both subjects. Equally none of the group members had written a report of this proportion before, meaning that the group had a lot to learn.

1.5.1 Previous competence

The projects participants have previous experiences from the subjects taken during three years of studying before writing this thesis. Among many subjects, the ones the group felt most relevant for this project can be seen in table 1.

Code	Name	Relevance
IMT2006	Computer Networks	Subnetting
IMT2007	Network Security	VPN, Firewall, Routing
IMT2008	ITSM, Security and Risk Management	Risk Management
IMT2243	Software Engineering	Software development models
IMT2571	Data Modelling and Database Systems	Database administration and Security
IMT2282	Operating Systems	Virtualization, Access Control and Malware, Bash
IMT3003	Service Architecture Operations	Automation, Databases and Web Applications, Architecture
IMT3004	Incident Response, Ethical Hacking and Forensics	Internet and Network Forensics
IMT3005	Infrastructure as Code	Logging, Monitoring and Auditioning/Testing, Configuration Management, Rapid Deployments

Table 1: Previous Competence - Subjects

1.6 About the report

The report is written in Latex, and will have clickable links in PDF-format. The reader will be able to follow links to references, sources, glossaries and acronyms throughout the report. There will also be lists of figures, tables, listings and a table of contents, all clickable. For bibliography, the document is using JabRef to Cite with BibLaTeX [5]. A more thorough list of tools used in the making of this thesis can be seen in table 2.

1.6.1 Project period

The project will start on 10.01.2019 and it will end 20.05.2019. A presentation of the thesis will be held 04.06.2019.

1.7 Target audience

The target audience for this project is mainly our employer [NTNU SOC](#), but it can also be an interesting read for other [SOC](#) analysts, [Malware](#) researchers, academics, digital forensics investigators, incident responders, and students that need a dynamic and agile lab environment for malware analysis and research.

1.8 Thesis structure

This section will describe how the thesis is structured.

Introduction

Chapter 1 gives an overview of the thesis, including the description of the task and the protagonists. It will also tell the reader about what the students have learned from a project of this size, and what experience the group had from previous projects.

Background

Chapter 2 provides the necessary background information for the reader to be able to understand the different types of malware analysis and tools/services that will be used in this thesis. The analysis software uses a variety of services that will be briefly described.

Design

Chapter 3 explains more accurately how the architecture and services are connected, and its use in this environment and platform.

Implementation

Chapter 4 will introduce the methodology, together with the technologies used and how the implementation process of the architecture design was configured and conducted.

Automation

Chapter 5 covers the documentation of the automation installation of [Cuckoo](#).

Testing and Verification

Chapter 6 points out errors that occurred during the implementation with examples and how the troubleshooting was conducted. Additionally, the chapter covers how the different tool's functionality was verified.

Discussion

Chapter 7 will discuss the project from the groups' perspective. The reader will make sense of what obstacles the students faced along the way; the alternative approaches that could have been taken with suggestions for future work, and a critical view on the execution of the task — lastly, evaluation of the groups' effort.

Conclusion

Chapter 8 concludes this thesis. It will discuss the project results, the groups' achievements, and a closing statement from the students.

Bibliography

Displays a list of sources used in this thesis.

Appendix

Short content description of the appendix:

Appendix A: Task description.

Appendix B: Project agreement.

Appendix C: The students plan regarding the embodiment of the thesis.

Appendix D: Midterm review with the employer.

Appendix E: Code for route.py.

Appendix F: OpenVPN Systemd integration.

Appendix G: Cuckoo Systemd integration.

Appendix H: Code for vsphere.py.

Appendix I: Code sample of vsphere.conf.

Appendix J: Cuckoo Web GUI options in an analysis.

Appendix K: Ansible directory structure.

2 Background

To build the malware analysis platform, the group used a lot of different tools and concepts; in this chapter, those tools and concepts will be explained in detail. Giving the readers the necessary information to fully comprehend the rest of the thesis.

The purpose of malware analysis is usually to provide the information one needs to respond to a network intrusion. The goal will be to determine precisely what happened and ensure all of the [Infected computer](#) machines and files have been located. When analyzing suspected malware, the key is to find out exactly what a particular suspect binary can do, how to detect it on your network, and how to measure and contain its damage [6]. In these evolving times, detecting and removing malware artifacts is not enough; it is vitally important to understand how they operate to understand the context, the motivations, and the goals of a breach.

2.1 Virtual machine

A virtual machine can be thought of as a computer inside a computer. The machine which runs the virtual machine is often referred to as a [Host](#), while the virtual machine itself is often referred to as a [Guest](#). The host shares its resources with the guest, meaning memory, CPU, Disk, and I/O will be allocated between the two.

To be able to run a virtual machine, the [Host](#) needs to have a [Hypervisor](#) software installed. There are many variants of [Hypervisors](#), including ones that can be installed as its own [Operating System](#) ([VMWare ESXI](#)) and others that can be run on top an [OS](#) ([VMWare Workstation](#)). The [Hypervisor](#) the group chose to use in this project is [VMWare vSphere](#). [vSphere](#) can be thought of as an extension to [VMWare ESXI](#) which allows an administrator to manage multiple [ESXI Hosts](#) with one installation of [vSphere](#), in addition to adding more features to the standard [ESXI](#) installation.

The [Guests](#) running on the [Host](#) is considered to be in a safe [Environment](#), where one use case is using this [Environment](#) as a platform to test and analyze malware.

2.2 Malware

Malicious software, often referred to as [Malware](#), plays a part in most computer intrusion and security incidents. [Malware](#) is often designed to steal sensitive information, or otherwise harm a computer or a network causing downtime. During the last years there has been a significant increase in new malware samples [7], thus increasing the need to analyze and learn how to protect against these threats.

2.2.1 Malware analysis

[Malware](#) analysis is the art of dissecting malware to understand how it operates, what it does to the infected system, how to identify it, and how to mitigate or eliminate the damage it may cause. The purpose of malware analysis is to study and determine the functionality, origin, and impact of a given sample.

With millions of malicious software on the Internet and new types of malware being encountered every day, malware analysis is critical for anyone who responds to computer security incidents. There are many ways to gather information from malware; one of these is by performing an analysis on a given malware; this provides a unique [Signature](#) for that malware. The [Signature](#) can then be added to an anti-virus [Signature](#) scan to be able to detect this specific malware. While using signatures to detect malware is a great technique, it is a weakness with anti-virus programs, since most anti-viruses will only look for known signatures provided by its developer [8] meaning the anti-virus can often be classified as outdated. The best way to detect the existence of a new malware signature is to use a [Sandbox](#) feature that includes analysis tools.

It is recommended to set up a safe [Environment](#) before running an analysis on a [Malware](#) sample. Samples of [Malware](#) can be full of surprises, and if run in a production [Environment](#), it can quickly spread to other computers on the network and be very difficult to contain and remove. A safe [Environment](#) will allow investigation of the malware without exposing other computers on the network to unexpected and unnecessary [Risk](#) [9]. Therefore it is preferred to use virtual machines because these machines are isolated from the [Host](#) so it does not infect other components than intended. The methods to analyze malware usually fall under two categories, dynamic- and static malware analysis [10].

Static malware analysis

Static or code analysis is usually performed by dissecting the different resources of the binary file without executing it and studying each component. Static analysis can confirm whether a file is malicious, provide information about its functionality, and sometimes provide information which allows the production of simple network [Signatures](#). Basic static analysis is straightforward and can be quick, but it is mostly ineffective against sophisticated [Malware](#) and can miss important behaviors [11].

An advanced static analysis consists of reverse-engineering the [Malware's](#) internals by loading the executable into a disassembler and looking at the [Malwares](#) hardware instructions. The CPU executes the instructions, so advanced static analysis tells you exactly what the [Malware](#) does [11].

Static [Malware](#) analysis is very similar to manual [Malware](#) analysis, because it uses the same techniques to understand how a [Malware](#) operates.

Dynamic malware analysis

Dynamic analysis techniques involve running the [Malware](#) and observing its behavior on the system in order to remove the infection, produce effective [Signatures](#), or both. Basic dynamic analysis techniques can be used by most people without deep programming knowledge, but they will not be effective with all malware and can miss important functionality [11].

Advanced dynamic analysis uses a debugger to examine the internal state of a running malicious executable. Advanced dynamic analysis techniques provide another way to extract detailed information from an executable. These techniques are most useful when the goal is to obtain information that is difficult to gather with the other techniques[11].

A weakness of dynamic analysis is while testing the malware there is no way of being 100% sure if all of the executable paths of the malware have been successfully tested

and mapped [12].

Automation of Analysis

Automation is the use of various control systems for operating and controlling a process or procedure without human assistance. The project's thesis will involve the setup of a [Malware](#) analysis platform that is going to be automated. It exists a wide variety of software that will analyze many aspects of what a malware can do - intercept network traffic, changes in file structure and requests to the [Operating System](#). To solve the issue of downloading, installing and linking the software together is where automation becomes handy, with only a few changes in [Configuration Files](#) the software can be customized for each specific need.

2.3 Cuckoo Sandbox

This section will give the reader an idea about the main tool and how it is used in this thesis.

2.3.1 What is Cuckoo

Cuckoo Sandbox is the leading open source automated [Malware](#) analysis system. In a matter of minutes, Cuckoo will provide a detailed report outlining the behavior of the file when executed inside a realistic but isolated [Environment](#). [13]

Cuckoo Sandbox is free software that automated the task of analyzing any malicious file under [Windows](#), [MacOS](#), [Linux](#), and [Android](#).

2.3.2 What can Cuckoo do

[Cuckoo](#) Sandbox is an advanced, extremely modular, and 100% open source automated [Malware](#) analysis platform with countless application opportunities.

According to [Cuckoo's](#) homepage ¹, Cuckoo is able to:

- Analyze many different malicious files (executables, office documents, pdf files, emails, etc) as well as malicious websites under [Windows](#), [Linux](#), [MacOS](#), and [Android](#) virtualized [Environment](#).
- Trace [API](#) calls and general behavior of the file and distill this into high level information and [Signatures](#) comprehensible by anyone working in a [Security Operations Center](#) or anyone interested in malware analysis.
- Dump and analyze network traffic, even when encrypted with SSL/TLS. With native network [Routing](#) support to drop all traffic or route it through [INetSim](#), a network [interface](#), or a [VPN](#).
- Perform advanced memory analysis of the [Infected computer](#) virtualized system through Volatility as well as on a process memory granularity using [Yara](#).

2.3.3 Tools

This section will present some of the important tools that [Cuckoo](#) uses when analyzing a file. Each of these tools have an independent purpose, and [Cuckoo](#) can take advantage of all of them.

¹<https://cuckoosandbox.org/>

Suricata

Suricata is a free and open source, mature, fast and robust network threat detection engine. The Suricata engine is capable of real time [Intrusion Detection System \(IDS\)](#), inline [Intrusion Prevention System \(IPS\)](#), [Network Security Monitoring \(NSM\)](#) and of-line [PCAP](#) processing. In this project, Suricata is used to intercept traffic in the form of a [pcap-file](#).

Moloch

Moloch is a standalone open source full packet capture system with meta data parsing and searching. Moloch can present intercepted network traffic in a graphical chart in the form of a webpage. Moloch is used as a supplement to [Suricata](#) to provide more visibility by indexing the network traffic from the PCAP file into Elasticsearch.

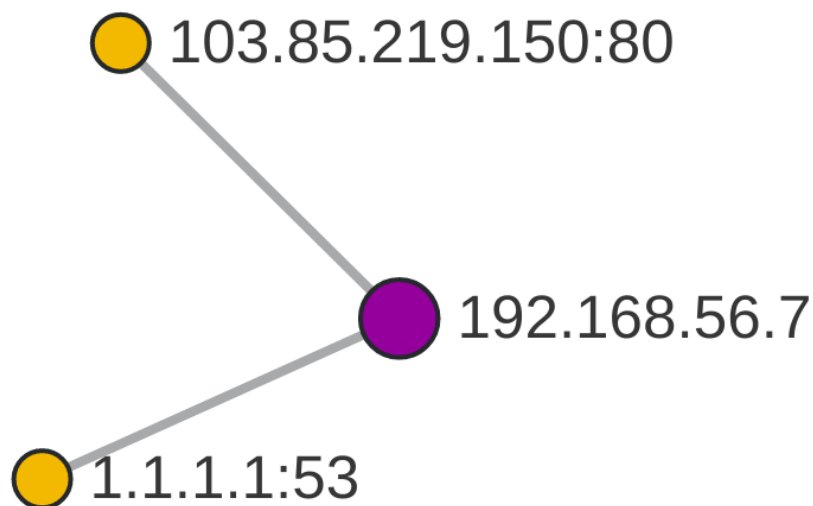


Figure 1: Moloch active connections

Figure 1 shows active connections from [IP-address](#) 192.168.56.7. One can see that it contacts 1.1.1.1 with a [DNS](#) request(port 53). After resolving the given [DNS](#) name, it contacts 103.85.219.150 with a [HTTP](#) request(port 80).

Elasticsearch

Elasticsearch is a really fast search and analytics engine and database. Figure 2.1 depicts a working Elasticsearch installation by running `curl localhost:9200` on [Bionic Beaver](#).

```
{
  "name" : "xvJNENk",
  "cluster_name" : "elasticsearch",
  "cluster_uuid" : "VNtGOIx1THCMQb8XR_he6w",
  "version" : {
```



```

    "number" : "5.6.16",
    "build_hash" : "3a740d1",
    "build_date" : "2019-03-13T15:33:36.565Z",
    "build_snapshot" : false,
    "lucene_version" : "6.6.1"
  },
  "tagline" : "You Know, for Search"
}

```

Listing 2.1: Elasticsearch

Yara

[Yara](#) [14] is a tool that will help an analyst by detecting what the malware is doing and matching it up with a set of rules based on textual or binary patterns so [Yara](#) can classify it.

Besides categorizing [Malware](#), [Yara](#) [14] can also help the analyst in different ways, one of them is that [Yara](#) can detect if the [Malware](#) checks if it runs in a virtual [Environment](#).

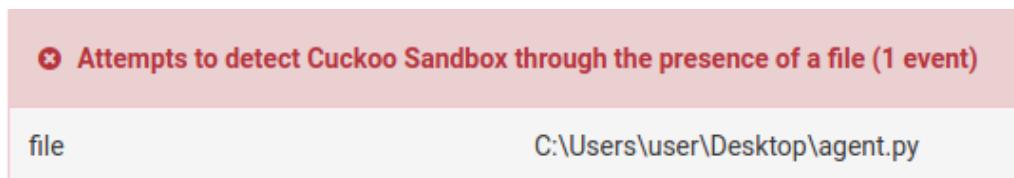


Figure 2: Yara rule matching

Volatility

[Volatility](#) [3] is an open collection of forensic tools that facilitate the extraction of digital artifacts from volatile memory (RAM) samples. With [Volatility](#) integrated into [Cuckoo](#) it can analyze memory dumps after running a [Malware](#) analysis.

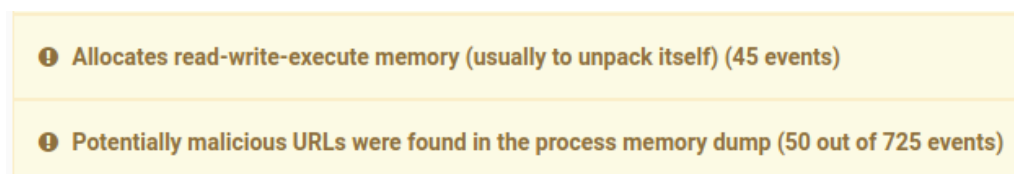


Figure 3: Volatility warnings

2.3.4 Networking

[Cuckoo](#) offers a wide variety of options when it comes to [Routing](#). To do this [Cuckoo](#) uses a routing service called [Cuckoo Rooter](#). [Cuckoo Rooter](#) supports direct Internet connection, [VPN](#) connections, [TOR](#), simulated network services and the default drop all routing.

[TOR](#) and [VPN](#) are both tools the group will use to hide the location from where the testing is taking place from the [Malware](#). If the malware detects that the traffic is coming from a university network, it might execute differently than if it is coming from an unknown [IP-address](#). [INetSim](#) will be used as a service to fake real Internet access from the [Malware](#).

[TOR \[15\]](#) is a routing service that anonymizes its user's traffic by bouncing it around in a distributed network of relays run by volunteers all around the world.

A [VPN \[16\]](#) is a tool that anonymizes the user's traffic by encrypting it, and it also hides its users [IP-address](#) by redirecting the traffic from the user through a server.

[INetSim \[17\]](#) is a software suite for simulating common internet services in a lab [Environment](#), e.g. for analyzing the network behavior of unknown [Malware](#) samples.

2.4 Ansible

[Ansible](#) is an automation tool, developed by Red Hat Inc., capable of administrating multiple hosts at the same time over the [Secure Shell \(SSH\)](#) protocol. Ansible uses human-readable [Yaml](#) templates so that users can program repetitive tasks to occur automatically, without learning an advanced language. Ansible can install an entire set of webservers and its backend in a matter of minutes. [Ansible](#) is capable of administrating virtual machines and [Hypervisors](#). [Ansible Playbook](#) is a collection of different roles put together to allow installation of an entire platform on a single or multiple host simultaneously.

2.4.1 Playbook

The [playbook](#) is the core component of any [Ansible](#) configuration. An [Ansible Playbook](#) contains one or multiple tasks, each of which define the work to be done for a configuration on a managed server.

3 Design

This chapter will describe how the architecture is designed by connecting all the tools in chapter 2 together.

3.1 Architecture

The architecture runs on a [VMWare ESXi Hypervisor](#). The [Hypervisor](#) needs to run all of the virtualized [Sandboxes](#) for [Cuckoo](#) to work. Connecting a [vCenter Server Appliance \(VCSA\)](#) to the [ESXI](#) host turns the architecture into a [vSphere Environment](#). Figure 4 describes how the architecture is designed.

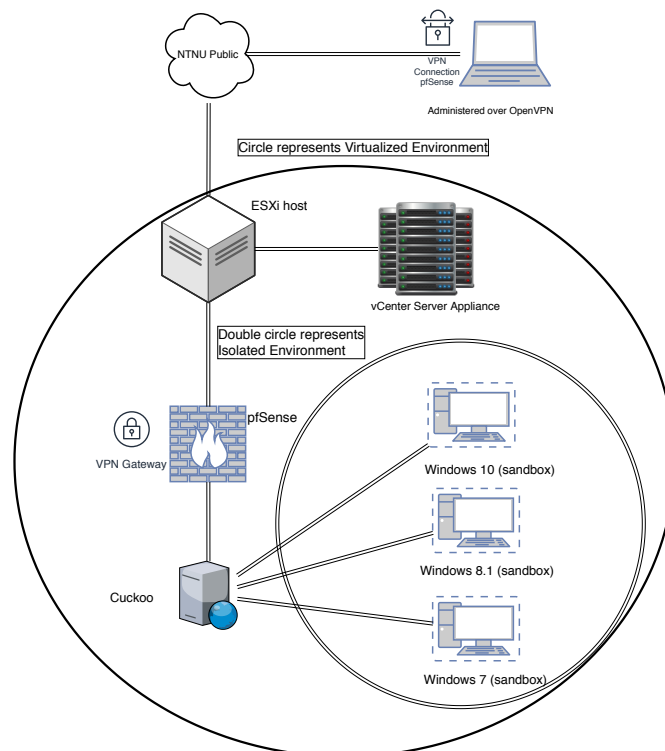


Figure 4: Architecture design

3.2 PfSense

[Cuckoo](#) does not have a password protected login and is therefore vulnerable to anyone, if connected [NTNU Public](#) directly. [pfSense](#) is needed to protect [Cuckoo](#) from fraudulent use, and will have an active [OpenVPN](#) server which makes it is possible to work on the platform remotely.

3.2.1 Networking

In addition to protecting [Cuckoo](#) from NTNU public, [pfSense](#) handles [Routing](#), [DHCP](#), [DNS](#) and [NAT](#). The architecture needs to have two separate [subnets](#). One subnet in which [Cuckoo](#) resides, and one subnet in which the [Sandboxes](#) reside. [Figure 5](#) describes the network design in better detail.

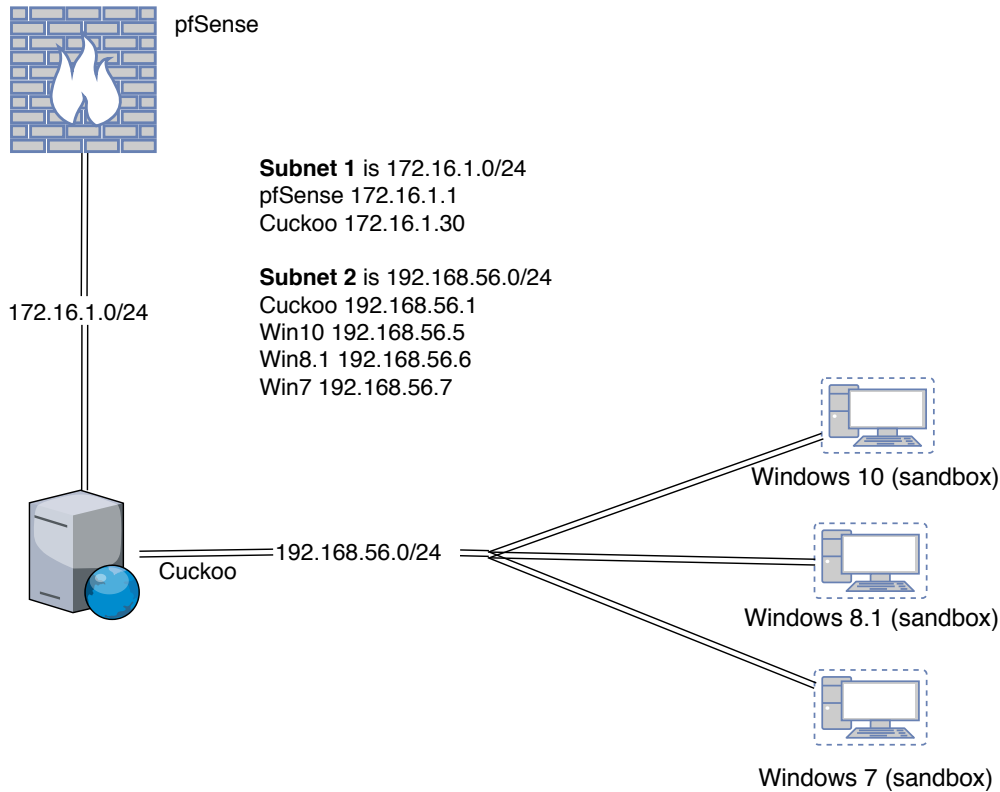


Figure 5: Subnet design

Some [Malwares](#) need internet access to reach full potential. Some malware checks the IP-address from where it is executed and may stop when it is from a research center. The next sections describe the routing options for [Cuckoo](#) to help an analyzer conceal the location from where the [Malware](#) is executed.

The Onion Router - Tor

The [Onion Router \(TOR\)](#) will [Spoof](#) the traffic from a [Sandbox](#) by distributing the traffic among different [TOR](#) nodes. Additionally, Tor encrypts the traffic [15]. Bouncing the encrypted traffic through nodes, ensures that it is nearly impossible for a [Malware](#) to know it is being analyzed from [NTNU](#).

Virtual Private Network - VPN

[Virtual Private Network \(VPN\)](#) initiates an encrypted tunneled connection to a remote server [16], which [Spoofs](#) the location of the analyzer.

INetSim

INetSim simulates Internet by [Spoofing](#) website requests to analyze network behavior of unknown [Malware](#) samples [17].

3.3 Cuckoo

Cuckoo needs to run on a [Ubuntu](#) server. Everything needed to start and run Cuckoo will be installed by an [Ansible Playbook](#). Cuckoo interacts with the [Hypervisor](#) to start, shutdown and restore [Snapshots](#) of the [Sandboxes](#). Cuckoo will act as a router between the sandboxes and [pfSense](#) to intercept and analyze network traffic generated by the [Sandboxes](#). Using [Cuckoo Rooter](#), Cuckoo is also able to route traffic over internet, [TOR](#), [VPN](#) or [INetSim](#). Cuckoo hosts a few databases, including [MongoDB](#), [PostgreSQL](#) and [Elasticsearch](#), all set up and ready to use by the [Ansible Playbook](#).

3.3.1 Sandboxes

This architecture includes three different [Sandboxes](#). The [Sandboxes](#) will be used to check if the [Malware](#) operates differently on different distributions. The sandboxes have direct contact with Cuckoo by running a python [Script](#), allowing the [Sandboxes](#) and Cuckoo to interact to each other.

3.3.2 Tools

Cuckoo uses a variety of tools to perform analysis mentioned in chapter 2, in section 2.3.3. Figure 6 depicts the applications needed.

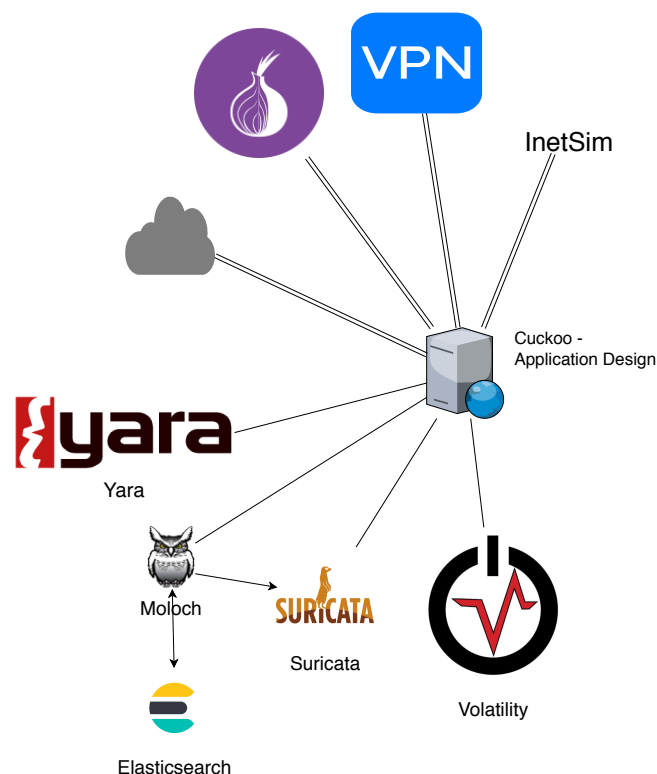


Figure 6: Application design

The tools are dependent on each other to work with the exception of [Yara](#) and [Volatility](#) which will be detailed better in chapter 4. [Suricata](#) must be in place to capture-, intercept- and analyze network traffic generated by the [Sandboxes](#) in [subnet 2](#). [Elasticsearch](#) and [Moloch](#) are both dependent on [Suricata](#) to operate.

3.3.3 Systemd

A requirement from the employer was to implement [Cuckoo](#)'s services to [systemd](#), which is explained in deeper detail in chapter 4.5.6.

3.4 Ansible

The implementation of [Ansible](#), will follow best practice on how to organize the [Playbook](#) from the documentation of [Ansible](#) [18] and will be further detailed in chapter 5.

4 Implementation

This chapter will explain how the implementation process of the architecture design was conducted and the methods used in both writing the thesis and workflow. The virtualization platform was the first implementation in this assignment after the foundation was made; the next step was an analyzing server. [Cuckoo](#) was firstly implemented manually to understand the concept, then later set up with the help of an [Ansible Playbook](#). The last implementation needed to be hosts for the [Malware](#), which is where [Windows](#) was introduced as [Sandboxes](#).

4.1 Methodology

As a development methodology, the students used waterfall, as mentioned in appendix [C.5.1](#). Each sequence or phase in the waterfall methodology must be complete before the next can be started. The waterfall method makes it easy to understand and follow when the project has clear objectives and requirements [19]. Traditionally there is no process for going back, but because of changes in the requirements, some exceptions were made. For the students, the waterfall methodology made it user-friendly to follow the [Gantt Diagram](#) flow; when one sequence was done, the students started on a new. As seen in figure [C.6.1](#) implementation has four sub-phases that were worked on in parallel. Waterfall worked great as a development methodology for this project, but for writing the report, the students used a more agile approach.

The students used the Kanban methodology when writing the thesis. The students started by making a Kanban board with a product [Backlog](#) in Trello, as seen in figure 7. Trello is a flexible and visual way to manage projects workflow [20]. Using Trello allowed the group to have a better overview of what needed to be done as well as what was left. Trello became the primary tool to arrange the workflow systematically. The Kanban board is to allow team members to track the progress of work through its workflow visually [21].

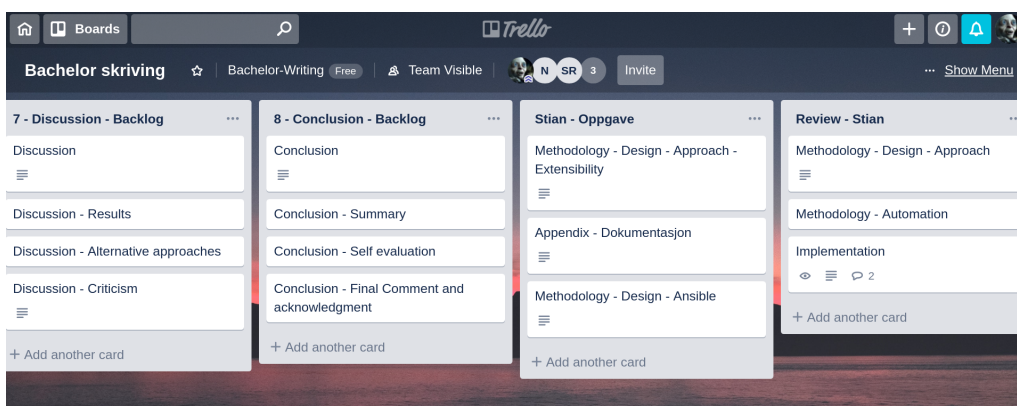


Figure 7: Trello

4.1.1 Technologies

Name	Type	Area of application
Trello	Web-based project management application	Project control
Overleaf	Online LaTeX compiler	Thesis document
Bitbucket and Github	Web-based hosting service for version control using Git	Version control
Draw.io	Flowchart Maker and Online Diagram Software	Diagrams and figures
Google Drive	File storage and synchronization service	Document and file storage
Digitalocean	Cloud infrastructure provider	OpenVPN - Cuckoo
pfSense	Firewall/router computer software	OpenVPN - Users
Jabref	Bibliography reference manager	Bibliography
Atom	Text and source code editor	Code editor
Master PDF Editor	Edit PDF files	PDF files
LaTeX Table Generator	Online table generator for LaTeX	Tables

Table 2: Technologies and applications used in the project

Table 2 shows which applications/technologies have been used in the making of this project. These tools helped the group save time by making it easy to review each other's work and also making the report writing process more streamlined.

4.2 Virtualization environment

At the start of the implementation phase as seen in figure C.6.1, the group needed a virtualization [Environment](#), and tried setting up an [ESXI](#) server on their personal computers. Installing ESXi on a personal computer did not work, due to the infrastructure requiring more computer resources than what a laptop could handle. The students had to figure out a solution to run [ESXI](#).

After a meeting with the employer, it was concluded that the infrastructure had to be run on a server dedicated to run [ESXI](#). With the assistance of Lars-Erik Pedersen, a senior engineer of NTNU's IT-Department, the group was able to loan a server from the IT-Department. While setting up [ESXI](#) on the server, it would not run as intended. After reading the documentation on [ESXI](#), the students learned the server was not compatible with the newest version(6.7) of [ESXI](#). The implementation was put on hold while the server was replaced with a compatible one.

With a new compatible server, the group was able to install [ESXI](#) along with [vCenter Server Appliance \(VCSA\)](#) as a virtual machine. With a working server installed running

[ESXI](#) and [VCSA](#), it was possible to access more functions like incorporate memory dumping from [vCenter Server Appliance](#) and simulating human interaction with the [Sandboxes](#). At this point, the group had a working [vSphere Host](#) by allowing [VCSA](#) to control and administer the [ESXI Hypervisor](#).

Once the virtualization [Environment](#) was working as intended, a server that would monitor and analyze network traffic and perform different analyzes on the sandboxes was next in line.

4.3 Networking

Having set up the [Hypervisor](#), the group needed to implement some subnets in order for the implementation to look like the design in figure 5.

The group set up three virtual network cards on the [vSphere](#) host to account for this which can be seen in table 3

Name	Virtual Machines	Subnet	vCenter
Bridge - Internett	2	128.39.142.0/24	128.39.142.137
pfMonitor	2	172.16.1.0/24	128.39.142.137
viruslan	4	192.168.56.0/24	128.39.142.137

Table 3: vSphere Networking

Bridge-Internet makes sure that some of the virtual machines are indirectly connected to the Internet through NTNU Public. Even though these machines are not directly connected to the Internet, it means that other students at NTNU can reach them by using their IP addresses. If [Cuckoo](#) used NTNU public, it would mean that users of the network could access Cuckoo and use it by running analysis and filling up the disk space on the [vSphere](#) host. [pfSense](#) is implemented to protect Cuckoo from direct exposure to NTNU Public. The second virtual machine running with a network card using this virtual switch is [vCenter Server Appliance \(VCSA\)](#). The group decided it would be best to put the [VCSA](#) in the same subnet as the [ESXI](#) host to avoid having communication problems between the two. The administration of [VCSA](#) is also password protected, meaning that the group was willing to take the risk of exposing it in NTNU's public subnet, while also being able to reach it without having to run a [VPN](#). Being able to reach the [vCenter Server Appliance](#) server without running a [VPN](#), caused the group to become more flexible in case of [pfSense](#) failure which would render the [VPN](#) connection useless.

pfMonitor(referred to as [Subnet 1](#) in this thesis) is the [Local Area Network \(LAN\)](#) behind [pfSense](#). The two virtual machines that use this subnet are [pfSense](#) and [Cuckoo](#). [pfSense](#) routes traffic for [Cuckoo](#). [pfSense](#) acts as the gateway for [Cuckoo](#).

viruslan(referred to as [Subnet 2](#) in this thesis) is the [Local Area Network \(LAN\)](#) behind [Cuckoo](#) where all of the sandboxes reside. [Cuckoo](#) is set up as a gateway for the sandboxes traffic to the Internet, [OpenVPN](#), or [TOR](#).

Name	IP Address	Guest OS
Cuckoo18.04	172.16.1.30 192.168.56.1	Ubuntu 18.04 64-bit
pfSense	128.39.142.158 172.16.1.1	FreeBSD 12 64-bit
vCenter Server Appliance	128.39.142.137	Proton Linux
Win10	192.168.56.5	Windows 10 64-bit
Win8.1	192.168.56.6	Windows 8.1 64-bit
Win7	192.168.56.7	Windows 7 64-bit

Table 4: Network Configuration Virtual Machines

4.4 Software

The first successful [Cuckoo](#) installation was done manually following Cuckoo's own documentation [22] on an [Ubuntu 16.04 LTS \(Xenial Xerus\)](#). In Cuckoo's documentation, there are plenty of references to additional software needed to make the most out of Cuckoo's analysis. Such as [Yara](#), [Volatility](#), [Moloch](#) and [Elasticsearch](#) [23]. [Yara](#) and [Volatility](#) had to be downloaded and installed by compiling them. However, after upgrading the server to [Bionic Beaver](#), [Volatility](#)'s latest version was already compiled and ready to install from [Ubuntu](#)'s official repositories. The only application that had to be installed by compiling it from source code was [Yara](#). The manual installation went almost seamlessly, and there were some challenges with the version compatibility of some packages; nevertheless, it worked in the end.

Having upgraded to [Bionic Beaver](#), the group was able to install [Suricata](#) by adding a [Repository](#) which also gave the group the latest version of [Suricata](#) [24]. [Moloch](#) was installed by heading over to [moloch](#)'s download page [25], downloading and installing the latest prebuilt version for [Bionic Beaver](#). The configuration of [Cuckoo](#) will be described in the next section.

4.5 Configuration

This section will look into how the platform was configured in this project and will include some of the more important subsections to the configuration of the [Playbook](#), [Cuckoo](#) and connecting to the [VPN](#) at [Digitalocean](#).

4.5.1 Cuckoo

By default, the [Playbook](#) will create a user named [cuckoo](#), and a [Home Directory](#) for that user. The [Playbook](#) distributes the [Configuration Files](#) in this home directory for [Cuckoo](#) to use as a working directory. Every time [Cuckoo](#) starts up its services, it will read from the configuration files from this home directory. That means, every single time a configuration file has changed, [Cuckoo](#) will have to be restarted to reflect these changes. When running the [Playbook](#), [Cuckoo](#) will be installed as a [systemd](#) service[2]. A [systemd](#) service makes it fairly easy to reload new changes to [Cuckoo](#) by simply restarting the [Cuckoo systemd](#) services, instead of restarting the whole server.

The server is also set up to do basic router functionality, along with [Network Address](#)

Translation (NAT). The server is configured with two network cards. One of the network cards sits in the [pfSense](#) network, to give the server the Internet connection it needs. The second network card sits in the [Sandbox](#) network, where it can reach the sandboxes. The reason the group decided to do this was to make sure all network traffic generated by the sandboxes was intercepted by [Cuckoo](#), and therefore readable.

Due to compatibility issues with [Cuckoo](#) and [Elasticsearch](#) version 6 [26], the group had to install an older version, namely [Elasticsearch](#) version 5. The group downloaded the latest version of [Elasticsearch](#) 5, version number 5.6.16, and was able to integrate it with [Cuckoo](#). [27]

4.5.2 Virtual Environment

A **Virtual Environment** is a directory on the harddrive which installs the packages needed for an application to work. The application in this case, is [Cuckoo](#). In the virtualenv, the administrator can install a specific version of a software to needed to run [Cuckoo](#). In this case, the specific software is python 2.7 and pip 9.0.3.

In addition to installing specific software to the virtualenv, these packets are not updated with the rest of the system, meaning that the application running in this virtualenv is less likely to break because of newer package versions that could stop the app working. The group implemented the virtual environment to the [Playbook](#) to future proof the platform, and also to resolve the issues with [Cuckoo](#) not being able to run correctly with newer versions of different kinds of software.

4.5.3 OpenVPN

The [Playbook](#) will by default include an [OpenVPN](#) installation. [OpenVPN](#) routes traffic from the sandboxes through a [VPN](#) connection to conceal the analyzers location. The [OpenVPN](#) server used for this purpose was set up by one of the group members, and it is hosted by [Digitalocean](#)[28].

Since this server was only used to test the [OpenVPN](#) connection, it is included in a private repo on [Bitbucket](#), because this configuration contains everything needed to connect to the [OpenVPN](#) hosted at [Digitalocean](#).

It is set up to create a [tun0 interface](#) on the server hosting [Cuckoo](#), so by choosing to route through over [VPN](#) in [Cuckoo's WebGUI](#), the [Sandboxes](#) will appear to be in France when running analysis. To make this work when connecting to the [VPN](#), the group had to search around for similar issues of how [Cuckoo](#) deals with this. A similar issue is described, and the solution was to run a [VPN](#) with additional arguments together with the [route.py Script](#) (see appendix E and source [29]). The script, along with the complete command, can be found in the source above, by reading [doomedraven's](#) 8th comment. Using the same command, the group was able to implement the [VPN](#) as a [systemd](#) service that starts automatically each time the [Bionic Beaver](#) server has been restarted (see appendix F).

4.5.4 Hypervisor

The [Hypervisor](#) supported by this [Playbook](#) is [ESXI](#) and [vSphere](#). Only basic configuration of the [ESXI](#) has been done, by creating a datacenter for containment of the virtual machines running, and three network cards. One for Internet connectivity, one for [pfSense](#) network, and one for [Sandbox](#) network.

4.5.5 Sandboxes

Three different versions of [Windows](#) (7 64-bit, 8.1 64-bit, and 10 64-bit) were installed as virtual machines that would become the [Sandboxes](#). Together with the employer, it was decided to start with only windows hosts to make sure the concept was working. If there were spare time, in the end, the platform would include [Android](#) and [MacOS](#). Inside each [Sandbox](#) the group installed a couple of programs that were essential for [Cuckoo](#) to be able to analyze them. These programs were Python 2.7, [Pillow](#), and an agent for communicating with [Cuckoo](#) called agent.py. In order for [Cuckoo](#) to be able to communicate with the sandboxes, [User Account Control \(UAC\)](#) and the [Windows Firewall](#) was disabled. Additionally, the sandboxes were configured with a static IP configuration, because [Cuckoo](#) is known not to be able to communicate with the sandboxes if configured with [DHCP](#). [30]. Figure 6 shows a sample network configuration on one of the sandboxes used in the project.

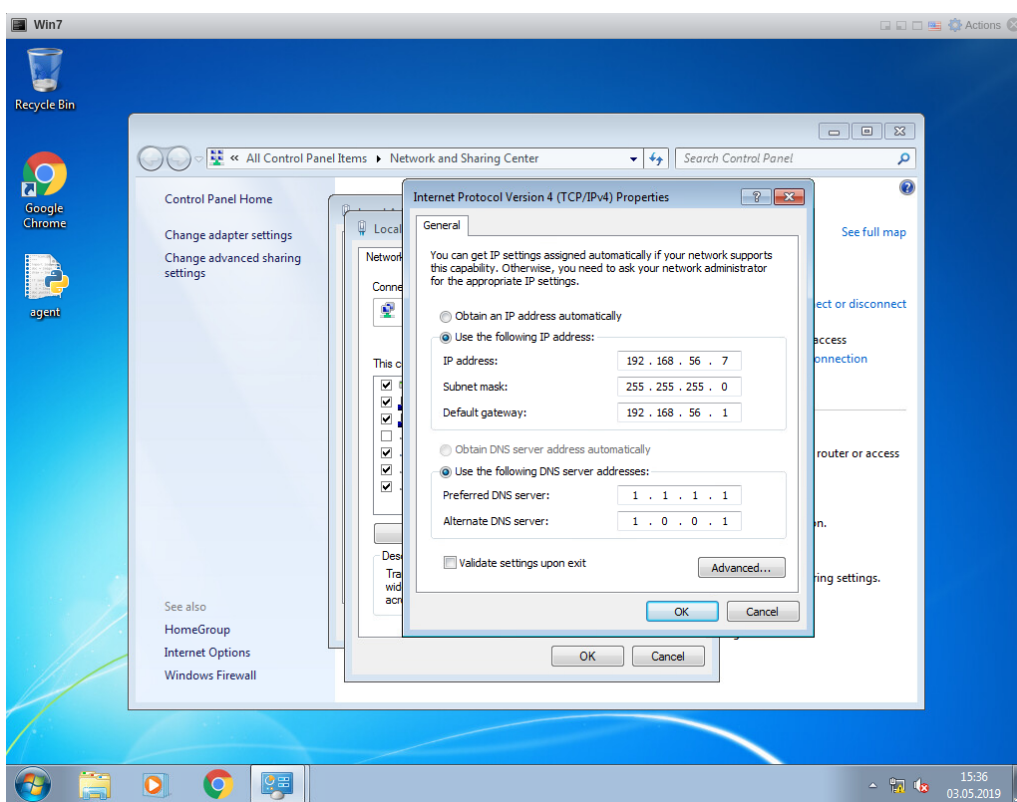


Figure 8: Network configuration sandboxes

4.5.6 Systemd

The need to implement [Cuckoo](#) as a [systemd](#) service quickly surfaced as an issue for the group after having installed [Cuckoo](#) and needing to restart its services after changing some of the [Configuration Files](#). As such, it was understandable that the employer wanted it implemented as a [systemd](#) service, as it became very tedious to restart the server or to kill the [PID](#)'s every time a change had happened.

[Cuckoo Router](#) is very special in that it needs every network service to be started

beforehand, otherwise it will fail to start. As seen in appendix F and G.1, [Cuckoo Rooter](#) needs the [OpenVPN](#) service to be started before the [Cuckoo Rooter](#) starts, otherwise [Cuckoo](#) and all will fail to start. Figure 9 describes the order in which [Cuckoo](#)'s services and dependencies are started.

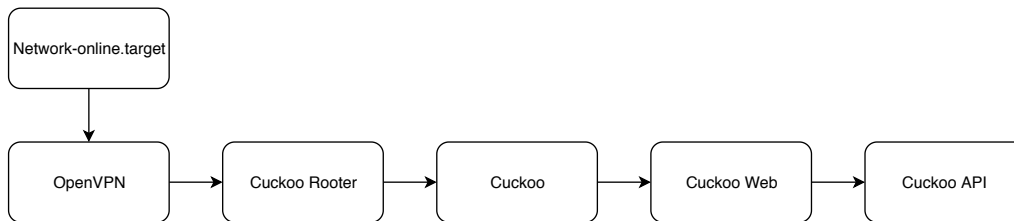


Figure 9: Systemd startup order

4.6 Ansible

When [Cuckoo](#) worked as intended after the manual installation, it was time to make the installation process automated with the help of [Ansible](#). The group started reading up on documentation of [Ansible](#) and found out that the best way to implement an automatic installation of the platform was to use [Playbooks](#) [31]. The reason for using [Playbooks](#) is that the designer can include multiple roles to install many applications one by one without requiring any user interaction, thus making the installation process automated.

Note: The [Playbook](#) used in creating this platform is based on a similar [Playbook](#) that the group found on GitHub. The playbook was over a year old, and very outdated. Having installed [Cuckoo](#) manually, the group could implement the steps taken during the manual installation and rewrite the [Playbook](#) found on Github. The playbook needed replacement of the old software with newer software versions, also adding new roles to the playbook itself. Because of all the details, and different ways to set up the platform, the group decided to make an entire chapter describing the [Playbook](#) and all the different configuration setups in chapter 5.

5 Automation

This chapter covers the documentation of the installation process of [Cuckoo](#). The platform has been successfully installed using the [Ansible Playbook](#) developed by the group during this project. The platform runs on an [Ubuntu 18.04 LTS \(Bionic Beaver\)](#) with the latest updates.

5.1 Prerequisites

Some physical host running [ESXI 6.7](#), managed by [vCenter Server Appliance \(VCSA\) 6.7](#). Managing the [ESXI](#) with [VCSA](#) effectively turns the [ESXI](#) into [vSphere](#). [vSphere](#) is necessary because it allows [Cuckoo](#) to retrieve full memory dumps of the virtual machine analyzing a given virus, while also being able to simulate user interactivity. The minimum licence required to run [Cuckoo](#) on a [VMWare vSphere](#) environment is [vSphere Standard](#). Using the [vSphere Essentials](#) licence, which is free of charge, does not include the [API](#) support needed by [Cuckoo](#) to interact with and control the virtual machines on the [vSphere Hypervisor](#).

During the project, the students found that the server running [Cuckoo](#) should have at least 8GB of Ram and 25GB hard drive space. The server also needs to have two Network cards - [Subnet 1](#) (Internet connectivity) and one for [Subnet 2](#) (Analyzing only).

Do take note that when running [Cuckoo](#) with full memory analysis, the disk space needed will increase drastically. The memory dumps are very big in size, and [Cuckoo](#) will download these [Snapshot](#) memory dumps from the [vSphere](#) host itself. The more disk space, the better. An option to delete the memory dumps after processing them can be used to preserve disk space. Using the option to delete the memory dumps will be detailed in section [5.5.6](#).

5.1.1 Software

Before the installation process begins, make sure that the server is fully updated, and that Python 2.7 is installed. [Cuckoo](#) relies heavily on Python 2.7, and will not run with Python 3. Also, make sure that the machine running [Ansible](#) has the latest version of [Ansible](#) installed or the [Playbook](#) might not work.

Before the [Playbook](#) can be run, it is vital that some of the files in the [Playbook](#) is configured to match the [IP-addresses](#) used in the environment. Depending on if its a local installation on a server, or a remote one, two different files can be changed to suit the environment and will be detailed in section [5.2.1](#) and [5.2.2](#).

NOTE: All the commands in section [5.2](#) and onwards are executed in a [Bash](#) shell either locally or remotely (through [Secure Shell \(SSH\)](#)) on the [Ubuntu 18.04 LTS \(Bionic Beaver\)](#) server which will be used as a base to install the platform.

5.1.2 Network configuration

The server running [Cuckoo](#) needs to have two network cards. The server needs to be configured with a static IP configuration on both network cards in order for [Cuckoo](#) to

work. In listing 5.1, an example configuration can be seen, and is also the groups network configuration of the server running **Cuckoo** (etc/netplan/50-cloud-init.yaml):

```
network:
  ethernets:
    ens160:
      addresses:
        - 172.16.1.30/24
      gateway4: 172.16.1.1
      nameservers:
        addresses:
          - 1.1.1.1
          - 1.0.0.1
    ens192:
      addresses:
        - 192.168.56.1/24
      nameservers: {}
  version: 2
```

Listing 5.1: Network Configuration

5.2 Installation of the Platform

To install the platform, make sure to clone the repository from Github [32]. The group has provided a bash script that adds the **Ansible** repository to the machine used with **Ansible**. The bash script is only supported on debian-based distributions(e.g. Ubuntu or Linux Mint). Having added the repository and installed **Ansible**, the **Playbook** can be configured to the environment. The first file to note is **site.yml** in the directory:

```
cuckoo-playbook/
```

site.yml holds all the roles needed to install **Cuckoo**.

```
1 ---
2 - hosts: all
3   gather_facts: false
4   roles:
5     - python
6     - cuckoo_user
7     - build_directory
8     - ubuntu_packages
9     - python_packages
10    - postgresql
11    - elasticsearch
12    - cuckoo
13    - yara
14    - volatility
15    - suricata
16    - moloch
17    - tor
18    - inetsim
19    - openvpn
20    - network
21    - start_up_cuckoo
```

Listing 5.2: site.yml

The roles described in **site.yml**(5.2) refer to each folder inside of

```
cuckoo-playbook/roles
```

and the name of each role is case-sensitive.

5.2.1 Local installation

Make sure to have git installed on the server that is going to run **Cuckoo**, and that the repository [32] is cloned somewhere on that servers' disk. There are a few files that need to be changed in order for the local installation to work.

Step 1

Head into

```
cd cuckoo-playbook/inventories/staging/
```

and open the **hosts** file. Edit the variable **ansible_sudo_pass** to the password of the user, that allows the use **sudo** as depicted in listing 5.3.

```
1 [all]
2 localhost ansible_connection=local ansible_sudo_pass=
   password
```

Listing 5.3: Staging hosts

Save and exit the file.

Step 2

Head into

```
cd cuckoo-playbook/inventories/staging/group_vars/
```

and open the **all** file. The **all** file includes variables that are used throughout the entire playbook. The only thing that should need to change here is the variables that hold the names of the **Network Interface Cards**. Using **ifconfig** or **ip addr** under **Ubuntu** will tell you the names of each network card. Change them accordingly as depicted in listing 5.4. **nic** is the interface for internet connectivity, and **ananic** is used for the subnet that the **Sandboxes** reside in.

```
15 ### Network cards ###
16 nic: ens160
17 ananic: ens192
```

Listing 5.4: Staging network cards

Save and exit the file.

5.2.2 Remote installation

There are a few files that needs to be changed for the remote installation to work.

Step 1

Head into

```
cd cuckoo-playbook/inventories/production/
```

and open the **hosts** file. The **ansible_host** variable is the [IP-address](#) of the server you wish to install the platform to. The **ansible_ssh_user** variable is the user that [Ansible](#) will use to log into the target server. The only requirement for this user, is that it has sudo rights. The **ansible_ssh_pass** variable is the password to the **ansible_ssh_user**. Edit them accordingly, and save and exit the file when done. Listing 5.5 depicts an example where the variables have been filled in.

```
15 [all]
16 remotehost ansible_host= ansible_ssh_user=user
    ansible_ssh_pass=password ansible_sudo_pass=
    sudoPassword
```

Listing 5.5: Production host

Note: Some Linux distributions allows a user to use a different password for elevating to and running commands as **sudo**. With a standard installation of Ubuntu server, the password used to log in as a given user, is the same as the password used to elevate **sudo** rights.

Step 2

Head into

```
cd cuckoo-playbook/inventories/production/group_vars
```

and open **all** file. As with the local installation, the only variable that needs to be edited is the network card variables. Make sure they reflect the names the of network cards on the server used to install the platform onto. Example [Network Interface Cards](#) can be seen in figure 5.6.

```
15 ### Network cards ###
16 nic: ens160
17 ananic: ens192
```

Listing 5.6: Production network cards

Save and exit the file.

5.3 OpenVPN

This section will include the steps needed to be taken when either disabling 5.3.1 or enabling 5.3.2 [OpenVPN](#) role. Note that it is required to have a working external [OpenVPN](#) server for this role to work. To be able to fully test the functionality of the [OpenVPN](#), one of the group members bought a server at [Digitalocean](#) [33].

NOTE: To be able to start [Cuckoo](#) after the [Playbook](#) has installed the platform, some steps need to be considered whether or not the [Playbook](#) should be installed. The [Playbook](#) is installed in such a way that it requires an [OpenVPN](#) to be running before [Cuckoo](#) can even start its services. The steps needed to both enable and disable the role completely will be better explained in sections 5.3.1 and 5.3.2.

5.3.1 Disabling the role

A side note when disabling the [OpenVPN](#) role, some more work needs to be done to fully disable it from the setup. Commenting it out in `site.yml` is not enough.

Step one

Head into

```
cd cuckoo-playbook/roles/start_up_cuckoo/files/
```

in this folder, open the `cuckoo_router.service` file, and remove `openvpnclient.service` on line 3.

```
1 [Unit]
2 Description=Cuckoo Rooter Service
3 After=network.target openvpnclient.service
```

Listing 5.7: `cuckoo_router.service`

Save the file and exit.

Step two

Head into

```
cd /cuckoo-playbook/roles/cuckoo/files
```

In this folder, open the `routing.conf` file, and change `enabled=yes` to `enabled=no` on line 61 as seen in listing 5.8.

```
59 [VPN]
60 # Are VPNs enabled?
61 enable = yes
```

Listing 5.8: `routing.conf`

Save the file and exit.

5.3.2 Enabling the role

The role is by default enabled for installation, but it will still require you to change some files around to make it fit your setup. Head into

```
cd cuckoo-playbook/roles/openvpn/files/
```

and open the `openvpn.conf` file. The easiest way to do this, is to replace the contents in this file with the contents of an `ovpn` file that is already in your possession (assuming you have a working openvpn server already). The only vital part about this, is that the interface created by running the configuration file, **must** be named `tun0` as depicted in listing 5.9. More on this in a later section.

```
23 ;dev tap
24 dev tun0
```

Listing 5.9: `openvpn.conf`

NOTE: In the configuration file used in this project, the exact line number is 24, but it could be different depending on the [OpenVPN](#) server configuration.

5.4 InetSim

If using an alternative to, and therefore do not want to install [INetSim](#) to the platform, simply comment out the `inetsim` line from `site.yml`, and no additional configuration will be needed for [INetSim](#) to be disabled upon running the [Playbook](#).

5.5 Cuckoo

This section will cover every file used by [Cuckoo](#) that will have to be edited before running the [Playbook](#). Do note that these files can be edited after the platform has been installed, but editing them beforehand saves a little bit of hassle.

This section will not go into detail about every single one of these files, but only the ones used in the making of this project. The files not detailed are used for either VirtualBox (`virtualbox.conf`), KVM (`kvm.conf`), XenServer (`xenserver.conf`), and QEMU (`qemu.conf`) as alternative [Hypervisors](#) to [ESXI](#) or [vSphere](#). Other files not detailed are `avd.conf` (Used for configuration of [Android](#) emulator) and configuration of analyzes on physical machines(`physical.conf`).

5.5.1 cuckoo.conf

This section will look at some important variables inside the `cuckoo.conf` file found in:

```
cd cuckoo-playbook/roles/cuckoo/files/
```

Listing 5.10: cuckoo.conf directory

All of the files that needs to be edited can be found in the directory shown in listing [5.10](#).

Machinery

In the `cuckoo.conf` file is where one specifies which [Hypervisor](#) one would like to use, along with other options like memory dumps. Depending on whether one want to use [ESXI](#) or [vSphere](#), go to the line depicted in listing [5.11](#)

```
20 machinery = vsphere
```

Listing 5.11: cuckoo.conf - Machinery

Simply changing `vsphere` to `esx` changes the chosen [Hypervisor](#) to [ESXI](#) from [vSphere](#). Machinery is by default set to `vsphere`.

Refer to [5.5.2](#) for more information on `vsphere.conf`. If one want to use [ESXI](#) instead, refer to [5.5.3](#).

Line 25 allows one to choose whether or not one wants to enable memory dumps, by downloading the memory dumps from the [Hypervisor](#) after the analysis is done. Refer to listing [5.12](#).

```
25 memory_dump = yes
```

Listing 5.12: cuckoo.conf - Memory dumps

Simply changing the value to 'no' turns off memory dumps. Memory dumps can still be turned on in the WebGUI when running an analysis. The options available can be seen in appendix [J](#).

Resultserver

The variable on line 87 describes which [IP-address](#) the sandboxes should interact with. In this case, it will be the same IP-address as the platform running [Cuckoo](#) as seen in figure 5.

```
87 ip = 192.168.56.1
```

Listing 5.13: cuckoo.conf - Resultserver IP Address

Processing

Line 108 allows the analyst to resolve [DNS](#) lookups performed by the [Sandboxes](#) during analysis.

```
107 resolve_dns = yes
```

Listing 5.14: cuckoo.conf - Processing

The resolved DNS lookups can be seen in figure 14.

Database

Line 122 through 127 includes the configuration of which databases to use for analysis. Cuckoo will by default use a PostgreSQL database to store analyzed results. However, [Cuckoo](#) supports multiple databases. Listing 5.15 shows some examples of which databases that are supported.

```
122 # Examples, see documentation for more:
123 # sqlite:///foo.db
124 # postgresql://foo:bar@localhost:5432/mydatabase
125 # mysql://foo:bar@localhost/mydatabase
126 # If empty, defaults to a SQLite3 database at $CWD/
   # cuckoo.db.
127 connection = postgresql://cuckoo:cuckoo@localhost
   :5432/cuckoo
```

Listing 5.15: cuckoo.conf - Databases

Using PostgreSQL, allows [Cuckoo](#) to do multiple analysis simultaneously, and it is therefore default here.

Remote control

While the analysis is running, one can choose to remotely control the [Sandboxes](#) with a tool called [Guacd](#). [Guacd](#) is installed by the `ubuntu_packages` role, and is enabled by default in `cuckoo.conf`. Lines 145 through 153 include the configuration of this service in listing 5.16. **NOTE:** To be able to remote control [Windows Sandboxes](#), [VNC](#) will have to be installed on them, otherwise it will not work.

```
145 [Remote Control]
146 # Enable for remote control of analysis machines
   # inside the web interface.
147 enabled = yes
148
149 # Set host of the running guacd service.
150 guacd_host = 192.168.56.1
```

```

151
152 # Set port of the running guacd service.
153 guacd_port = 4822

```

Listing 5.16: cuckoo.conf - Remote control

The `guacd_host` variable(line 150) must be set to the same [IP-address](#) as [Cuckoo](#) has in [Subnet 2](#) as seen in [figure 5](#).

5.5.2 vsphere.conf

The first lines one need to look at here are the lines 14 through 17. These lines hold the configuration parameters to [vSphere](#) through the use of an [IP-address](#), a username and a password.

```

14 host = ip.address.to.vcsa
15 port = 443
16 user = username@some.domain
17 pwd = Passw0rd

```

Listing 5.17: vsphere.conf - Connection

Unfortunately, these parameters are not enough to make sure [Cuckoo](#) is able to interact with the [vSphere](#) server. The parameters are not enough because in later versions of python(developed after the last version of [Cuckoo](#)), it has enabled [SSL/TLS](#) connections(PEP-0476) by default because of a security issue described here [34]. [Appendix H](#) describes how the group managed to work around this issue by using [SSL](#) instead of [TLS](#). The patched version of `vsphere.py` is installed by the [Playbook](#), so that the connection between [vSphere](#) and [Cuckoo](#) works after the installation has finished. Do note that this should only be necessary when using a self-signed certificate specified at line 32 in [listing 5.18](#):

```

32 unverified_ssl = yes

```

Listing 5.18: vsphere.conf - Certificate

Moving on with the configuration file, the [Sandboxes](#) that are hosted by the [vSphere](#) can be defined. Line 22 describes this in further detail, but names in this file must match the names of the virtual machines specified on the [vSphere](#) host. [Listing 5.19](#) shows the groups configuration.

```

22 machines = Win10, Win81, Win7

```

Listing 5.19: vsphere.conf - Sandboxes

The configuration of the [Windows 7 Sandbox](#) which the group used for most of its testing can be seen in [appendix I](#). The configuration of [Windows 8.1](#) and [Windows 10](#) is identical to the sample, except for `ip =` and `osprofile =`. Both of these variables are found at lines 107 and 117, respectively, in the sample configuration. The `snapshot =` variable can be somewhat confusing. What it means is that it wants the name of the [Snapshot](#)(on the [Hypervisor](#)) of the virtual machine when the agent is running. The group used `clean_agent` as a reference to the rightful state of the virtual machine, but you can use any name that makes sense to you.

Lastly, line 27 specifies the name of the network card on the [Cuckoo](#) server that is connected to [Subnet 2](#) and is used for intercepting network traffic generated by the [Sandboxes](#). The name of this network card will be the same as the one described in section [5.2.2 \(ananic\)](#).

```
27 interface = ens192
```

Listing 5.20: vsphere.conf - Network card

Save the file and exit.

5.5.3 esx.conf

Very similar to [vsphere.conf](#), but the [IP-address](#), username and password will have to be different, because [vSphere/VCSA](#) is a different server than the [ESXI](#) server. Defines [Sandboxes](#) the same way as done in [vsphere.conf](#).

5.5.4 limits.conf and sysctl.conf

Running multiple analysis at once, might cause [Cuckoo](#) to stop and crash because it has reached the limit of too many open files at once. To avoid this, two files need to be edited in order to increase the open file limit. The group included a way to increase the open file limit to the [Playbook](#). **NOTE:** The group never actually hit the open file limit once during the testing of the platform, but was done to future proof the platform for the employer. The issue is described here [\[35\]](#).

The fix was implemented by appending some lines of configuration to both [/etc/security/limits.conf](#) ([5.21](#)) and [/etc/sysctl.conf](#) ([5.22](#)) [\[36\]](#). Both of these files have been included to the [Playbook](#) and will be installed by default by the [cuckoo](#) role.

limits.conf

Looking at the [limits.conf](#) file, line 56 through 59 was implemented to overcome this issue.

```
56 *          hard    nofile    500000
57 *          soft    nofile    500000
58 root       hard    nofile    500000
59 root       soft    nofile    500000
```

Listing 5.21: limits.conf - Open file limit

sysctl.conf

Line 63 of [sysctl.conf](#) is the line that was implemented to fix the issue.

```
63 fs.file-max = 2097152
```

Listing 5.22: sysctl.conf - Open file limit

5.5.5 memory.conf

[memory.conf](#) handles all the tuning options for [Volatility](#). [memory.conf](#) is the kind of file where you would want to enable some parameters by changing **enabled = no** to **enabled = yes**.

One very useful option for environments that does not have much harddrive space is to enable the option to delete memory dumps after processing.

```

3 # Basic settings
4 [basic]
5 # Profile to avoid wasting time identifying it
6 guest_profile = WinXPSP2x86
7 # Delete memory dump after volatility processing.
8 # Change this to yes to avoid running out of space
9 delete_memdump = no

```

Listing 5.23: memory.conf - File processing

Other than that, the options that are enabled in **memory.conf** already, are what provided the group with the best results during testing and is therefore enabled by default when installing the [Playbook](#).

5.5.6 processing.conf

Processing.conf handles everything from behavior analysis to hits of [Malware](#) signature on VirusTotal.

Most of the sections here are self-explanatory, while some will have to be explained in deeper detail. Among the few that do, is **[procmemory]**. **[procmemory]**'s section creates process memory dumps for each analyzed process, right before they terminate themselves or right before the analysis finishes. The group enabled it for better analysis, and an extra option here is to delete the process memory dump after analysis to save disk space. On low hard drive systems, this is recommended, because this quickly eats up disk space. Memory dump can be enabled on line 87 of **processing.conf**:

```

86 # Delete process memory dumps after analysis to save
    disk space.
87 dump_delete = no

```

Listing 5.24: processing.conf - Process memory dumps

Other options include testing **apk**'s. **APK**'s is the file-extension of every Android app that exists out there. Since [Android](#) will not be tested here, it is therefore disabled by default. The option to use [Suricata](#) is also enabled here. Lines 122 through 142 includes options for Suricata. Since [Suricata](#) is only setup to listen in on traffic, and later used to analyze the traffic, none of these options need to change from this project to deployment on yours. It is possible to setup [Cuckoo](#) to increase performance here by letting [Cuckoo](#) talk directly to the [Suricata](#) socket, which can be found at line 142.

```

142 socket =

```

Listing 5.25: processing.conf - Suricata

5.5.7 reporting.conf

This configuration file holds all the necessary [IP-addresses](#) for each component that runs alongside [Cuckoo](#). These components include things like MongoDB, Moloch and Elastic-search.

Lines 34 through 43 hold the configuration for MongoDB:

```

34 [mongodb]
35 enabled = yes
36 host = 127.0.0.1
37 port = 27017
38 db = cuckoo
39 store_memdump = yes
40 paginate = 100
41 # MongoDB authentication (optional).
42 username =
43 password =

```

Listing 5.26: reporting.conf - MongoDB

Elasticsearch can be configured on lines 45 through 60. The free version of Elasticsearch is wide open, so there is no option here to configure a username or a password:

```

45 [elasticsearch]
46 enabled = yes
47 # Comma-separated list of Elasticsearch hosts. The
   # format is IP:PORT, if the port is
48 # missing the default port is used.
49 # Example: hosts = 127.0.0.1:9200, 192.168.1.1:80
50 hosts = localhost:9200
51 # Increase default timeout from 10 seconds, required
   # when indexing larger
52 # analysis documents.
53 timeout = 300
54 # Set to yes if we want to be able to search every API
   # call instead of just
55 # through the behavioral summary.
56 calls = no
57 # Index of this Cuckoo instance. If multiple Cuckoo
   # instances connect to the
58 # same Elasticsearch host, then this index (in Moloch
   # called "instance") should
59 # be unique for each Cuckoo instance.
60 index = cuckoo

```

Listing 5.27: reporting.conf - Elasticsearch

Running Elasticsearch on the same server as [Cuckoo](#) will require no changing of parameters. Elasticsearch will work as-is, if one wants to run Elasticsearch on a different server, it is required to change line 50 of **reporting.conf**. Change it from **localhost:9200** to whatever [IP-address](#) it runs on, but do not forget the **:9200** at the end.

Lines 71 through 78 cover Moloch's installation:

```

71 [moloch]
72 enabled = yes
73 # If the Moloch web interface is hosted on a different
   # IP address than the
74 # Cuckoo Web Interface then you'll want to override
   # the IP address here.
75 host = 172.16.1.30

```



```

76 # If you wish to run Moloch in http (insecure) versus
    #     https (secure) mode,
77 # set insecure to yes.
78 insecure = yes

```

Listing 5.28: reporting.conf - Moloch

The host in this section is the same host as [Cuckoo](#) and will therefore have its [IP-address](#) set to the same as the one mentioned in [Subnet 1](#) and in figure 5.

5.5.8 routing.conf

This file is a big one, and you are able to configure all the routing by [Cuckoo](#) here. There are a few small variables that need to change in this file. The first one is the configuration of **InetSim**, depending on your network setup:

```

48 [inetsim]
49 enabled = yes
50 server = 192.168.56.1

```

Listing 5.29: routing.conf - Inetsim

Change the variable **server** to the [IP-address](#) you need it to be. Make sure that it matches the configuration of your network setup, use figure 5 as a reference point, but remember that this [IP-address](#) needs to be in [Subnet 2](#).

The second variable is the name of the network card handling the **Internet** routing. The variable is located at line 19:

```

19 internet = ens160

```

Listing 5.30: routing.conf - Network Interface Card (NIC)

This should be changed to be the same network card that as used in [Subnet 1](#).

TOR can also be somewhat configured in this file, but **TOR** is also configured in **torrc**, which we will return to in section 5.8. A few lines still needs to be mentioned here, because it is imperative that it matches the configuration in **torrc**:

```

52 [tor]
53 # Route a VM through Tor, requires a local setup of
    #     Tor (please refer to our
54 #     documentation).
55 enabled = yes
56 dnsport = 5353
57 proxyport = 9040

```

Listing 5.31: routing.conf - TOR routing

The ports configured in line 56 and 57 must match the ports in **torrc**.

5.6 Elasticsearch

The Elasticsearch role is a rather simple one and only requires you to change an [IP-address](#) in its configuration file in order to work properly. The configuration file in question is **elasticsearch.yml**, and is found under.

```

cuckoo-playbook/roles/elasticsearch/files/

```

The line we need to edit is found in the yml file at line 55:

```
55 network.host: 172.16.1.30
```

Listing 5.32: elasticsearch.yml

Make sure that this [IP-address](#) matches the one in [Subnet 1](#). Use listing [5.1.2](#) as a reference.

5.7 Suricata

This section covers all of [Suricata](#)'s files that need to be edited depending on your network configuration. All files are located under

```
cuckoo-playbook/roles/suricata/files/
```

5.7.1 suricata

This file has only one line that needs to be changed, and is once again dependant on [Network Interface Card \(NIC\)](#) naming policy of the linux kernel. The line we need to change is 19 as listing [5.33](#) describes further:

```
18 IFACE=ens192
```

Listing 5.33: suricata

5.7.2 suricata.yaml

The last file to edit for [Suricata](#) to be fully functional is **suricata.yaml**. On line 15, [IP-address](#) for address groups is required for better performance and accuracy:

```
13 # more specific is better for alert accuracy and
    performance
14 address-groups:
15   #HOME_NET:
    "[192.168.0.0/16,10.0.0.0/8,172.16.0.0/12]"
16   HOME_NET: "[192.168.56.0/32]"
```

Listing 5.34: suricata.yaml

Make sure the address groups fits subnet's correctly.

5.8 Tor

torrc is a file that is used by [TOR](#) for its configuration and is located in:

```
cuckoo-playbook/roles/tor/files/
```

For this project and its features, it is enough for the group to look at lines 15 and 16 of the file:

```
15 TransPort 192.168.56.1:9040
16 DNSPort 192.168.56.1:5353
```

Listing 5.35: torrc

Make sure that the [IP-address](#) here matches the one configured at ens192 in listing [5.1](#). Also do make sure that the port number is the same as mentioned in listing [5.31](#). Otherwise will not work.

5.9 Cuckoo Startup

This role is a rather simple one. All it does is copy four preconfigured `systemd` files to `/etc/systemd/system`. The idea with this is that you can restart `Cuckoo`'s services (router, cuckoo itself, web and api) without having to restart the entire server or kill the services with `PID`'s every time you change a configuration file. Each one of the `systemd` services can be more thoroughly viewed through appendixes [G.1](#), [G.2](#), [G.3](#) and [G.4](#). These also be started in the correct order for `Cuckoo` to work. For example, if running a VPN, the `Cuckoo Router` must be the first service to start. But the `Cuckoo Router` also handles Internet routing, Tor and InetSim as well. Which is why the `openvpnclient.service` (appendix [F](#)) MUST be disabled in `cuckoo_router.service` before running the `Playbook` to avoid any start up issues.

Note: Appendixes [G.3](#) and [G.4](#) also have `IP-addresses` in them. Change these addresses to reflect your configuration.

5.10 Running the playbook

After having completed the previous steps, the playbook may be run with the following command from the terminal inside the `cuckoo-playbook` directory:

```
ansible-playbook -i inventories/production site.yml
```

Listing 5.36: Running the Playbook

Depending on whether the `Playbook` is run on a remote or a local server, replace *production* with *staging*.

5.11 Final thoughts

Most of the steps described in the previous sections can be omitted if `Cuckoo`'s `Subnet 2` is defined with the same `IP-addresss` the group used. The `IP-addresss` of a production environment might not be the same as the ones the group used, and will therefore have to be changed.

To avoid manually changing all of these `IP-addresss`, the group has included a section in chapter [7](#) under alternative approaches and future work ([7.2.4](#)) which would make installation more automated.

6 Testing and verification

Testing is an essential step to point out errors made during the implementation phase and to deliver a quality project. That is why the group focused on making tests that made sure everything worked as intended before it was delivered to the employer.

6.1 Automation

To ensure that the [Playbook](#) worked without any input from the user, the group ran the playbook on a fresh server after each test by reverting the server to an earlier [Snapshot](#). When an error occurred, the students would analyze the error message and correct the issue in the [Playbook](#) as seen in figure 10. The group repeated this test until there were no errors in the [Playbook](#)'s installation process, as shown in figure 11.

```
TASK [ubuntu_packages : Install libssl-dev package] *****
fatal: [remotehost]: FAILED! => {"changed": false, "msg": "No package matching '
libssl-dev9999' is available"}
    to retry, use: --limit @/home/stianr/Bachelor/Plattform/Ansible-Cuckoo-g
ithub/cuckoo-playbook/site.retry

PLAY RECAP *****
remotehost : ok=11  changed=6  unreachable=0  failed=1
```

Figure 10: Ansible test with errors

```
TASK [start_up_cuckoo : Set up done] *****
ok: [remotehost] => {
    "msg": "Set up is done, and Cuckoo is now started. Enjoy!"
}

PLAY RECAP *****
remotehost : ok=180  changed=158  unreachable=0  failed=0
```

Figure 11: Ansible test without errors

While the group was testing the playbook, it came to the group's attention that [Moloch](#) stopped the installation of the playbook, requiring input from the user for the [Playbook](#) to continue installing the platform. After discussing this issue with the group's employer, it was agreed that this needed to be changed. To remedy this issue, the group added a configuration file that adds a few parameters which result in [Moloch](#) not requiring user input.

6.2 Cuckoo

To test if [Cuckoo](#) was configured correctly the group ran `./cuckoo -d` as shown in figure 12. Running [Cuckoo](#) with its debug parameter, the group was able to find any configuration problems by using the error messages. Moreover, fixing all the errors from [Cuckoo](#)'s output, allowed [Cuckoo](#) to start and wait for an analysis to be submitted, a demonstration can be seen in figure 13.

```

Terminal - cuckoo@cuckoo: /opt/cuckoo/bin
File Edit View Terminal Tabs Help
cuckoo@cuckoo:/opt/cuckoo/bin$ ./cuckoo -d

Cuckoo Sandbox?
OH NOES!

Cuckoo Sandbox 2.0.6
www.cuckoosandbox.org
Copyright (c) 2010-2018

2019-05-09 11:39:33,734 [cuckoo] CRITICAL: CuckooConfigurationError: The configuration value '/var/run/suricata/cuckoo.socket' found for processing:suricata:socket is invalid. Please update your configuration!
cuckoo@cuckoo:/opt/cuckoo/bin$

```

Figure 12: Cuckoo test with errors

```

Terminal - cuckoo@cuckoo: /opt/cuckoo/bin
File Edit View Terminal Tabs Help
2019-05-09 11:52:53,178 [cuckoo.core.startup] DEBUG: |-- scripts powershell_
empire.yar
2019-05-09 11:52:53,178 [cuckoo.core.startup] DEBUG: |-- scripts powershell_
meterpreter.yar
2019-05-09 11:52:53,178 [cuckoo.core.startup] DEBUG: |-- scripts powershell_
txt_c2.yar
2019-05-09 11:52:53,178 [cuckoo.core.startup] DEBUG: |-- scripts powershell_
unicorn.yar
2019-05-09 11:52:53,179 [cuckoo.core.startup] DEBUG: |-- scripts powerworm.y
ar
2019-05-09 11:52:53,179 [cuckoo.core.startup] DEBUG: |-- shellcode metasploit.yar
2019-05-09 11:52:53,180 [cuckoo.core.startup] DEBUG: |-- office dde.yar
2019-05-09 11:52:53,180 [cuckoo.core.startup] DEBUG: |-- office ole.yar
2019-05-09 11:52:53,224 [cuckoo.core.resultserver] DEBUG: ResultServer running on 192.168.56.1:2042.
2019-05-09 11:52:53,225 [cuckoo.core.scheduler] INFO: Using "vsphere" as machine manager
2019-05-09 11:52:53,303 [cuckoo.machinery.vsphere] WARNING: Turning off SSL certificate verification!
2019-05-09 11:52:54,268 [cuckoo.core.scheduler] INFO: Loaded 3 machine/s
2019-05-09 11:52:54,311 [cuckoo.core.scheduler] INFO: Waiting for analysis tasks

```

Figure 13: Cuckoo test without errors

The message *INFO: waiting for analysis tasks* in figure 13 means that all the modules were loaded successfully and Cuckoo is just waiting for the user to submit malware for analysis.

When an analysis has completed, Cuckoo is set up to resolve all DNS requests made by the Sandboxes. Figure 14 shows how this looks like in Cuckoo's report in the WebGUI:

senseofsecurity.club	A → 103.85.219.150
----------------------	--------------------

Figure 14: Resolved DNS requests done by Cuckoo

6.3 Malware

To test [Cuckoo](#)'s functionality, the group ran a variety of different [Malware](#). The different malware was tested so [Cuckoo](#) could analyze them, and then the group could see if the results from the [Cuckoo](#) analysis matched the expected outcome.

Signatures
Queries for the computername (3 events)
Checks if process is being debugged by a debugger (2 events)
Collects information to fingerprint the system (MachineGuid, DigitalProductId, SystemBiosDate) (1 event)
Tries to locate where the browsers are installed (1 event)
Checks amount of memory in system, this can be used to detect virtual machines that have a low amount of memory available (1 event)
One or more processes crashed (1 event)
Allocates read-write-execute memory (usually to unpack itself) (44 events)
Checks whether any human activity is being performed by constantly checking whether the foreground window changed
Creates a shortcut to an executable file (14 events)
File has been identified by one AntiVirus engine on VirusTotal as malicious (1 event)
Checks for the Locally Unique Identifier on the system for a suspicious privilege (9 events)
Potentially malicious URLs were found in the process memory dump (50 out of 554 events)
Attempts to detect Cuckoo Sandbox through the presence of a file (1 event)

Figure 15: Signatures of Trojan.Heur.FU.dmW@a8VPjLb tested in [Cuckoo](#)

After having tested a [Malware](#) and [Cuckoo](#) presented the results, it did not seem like a test had happened; therefore, the group suspected something was wrong at some point in the analyzing process. With [Cuckoo](#) reporting no suspicious activity, it could be an indicator that one or more of the applications did not work as intended. [Cuckoo](#) displays screenshot from the events on the [Sandboxes](#) with the help of Pillow, and the issue was often found when the group into them. If the screenshots did not provide any useful information, then the log files would.

6.4 Network

To test if the [Sandboxes](#) had internet access without having to log into each one and trying to reach a website with every routing options, the group used [Cuckoo](#)'s [Routing](#) tool [Cuckoo Rooter](#). When writing a website [URL](#) in the "SUBMIT URLS/HASHES" field (see figure 16) cuckoo tries to connect to the website from each sandbox. Cuckoo will

not only start the browser but will also attempt to actively instrument it in order to extract interesting results such as executed Javascript, iframe URLs, etc[22]. The test was executed with each routing option [VPN](#), [TOR](#), [INetSim](#) and Internet. These options can be seen in appendix J.

Cuckoo

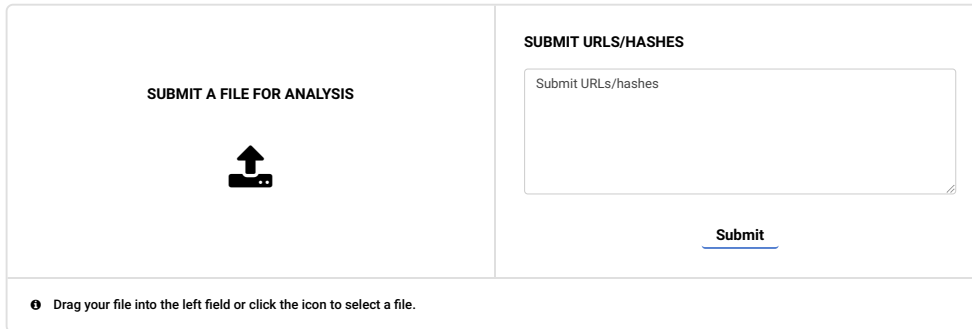
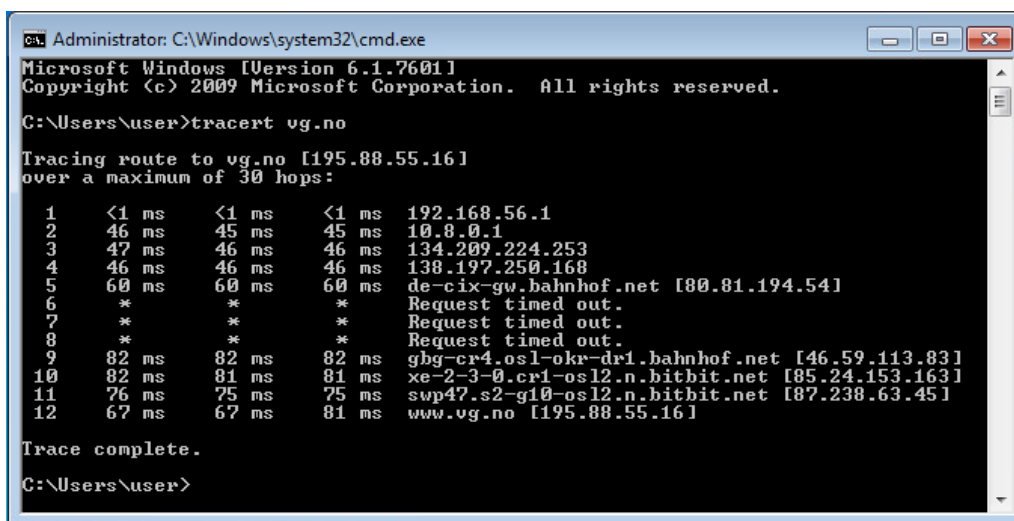


Figure 16: Cuckoo Web GUI

In order to test if [Cuckoo](#) is [Routing](#) the data packets correctly the group made a [Traceroute Script](#). Submitting this file for analysis and choosing a network service to route through(Internet, VPN). The [Traceroute](#) script traces what path the data packets took towards the Internet and helped the group fix routing issues too.



```

Administrator: C:\Windows\system32\cmd.exe
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. All rights reserved.

C:\Users\user>tracert vg.no

Tracing route to vg.no [195.88.55.161]
over a maximum of 30 hops:
  0  <1 ms    <1 ms    <1 ms    192.168.56.1
  1  46 ms    45 ms    45 ms    10.8.0.1
  2  47 ms    46 ms    46 ms    134.209.224.253
  3  46 ms    46 ms    46 ms    138.197.250.168
  4  60 ms    60 ms    60 ms    de-cix-gw.bahnhof.net [80.81.194.54]
  5  *        *        *        Request timed out.
  6  *        *        *        Request timed out.
  7  *        *        *        Request timed out.
  8  82 ms    82 ms    82 ms    gbg-cr4.osl-okr-dr1.bahnhof.net [46.59.113.83]
  9  82 ms    81 ms    81 ms    xe-2-3-0.cr1-os12.n.bitbit.net [85.24.153.163]
 10  76 ms    75 ms    75 ms    swp47.s2-g10-os12.n.bitbit.net [87.238.63.45]
 11  67 ms    67 ms    81 ms    www.vg.no [195.88.55.161]

Trace complete.

C:\Users\user>

```

Figure 17: Traceroute script over VPN

6.5 Sandbox

To test the compatibility between Cuckoo and the [Operating System \(OS\)](#)'s running in the different sandboxes. The group tested the same malware on the three different sandboxes(win7,win8.1, and win 10). The results of the analysis were different in all three instances; this could be because as cuckoos own documentation states[37], Windows 7 is the recommended OS for the [Sandbox](#). Since Windows 7 is older than both Windows

8.1 and Windows 10, it is believed that it does not possess all of the security mechanisms newer versions of windows have [38]. Another reason for the difference in results in these analyses could be that [Cuckoo](#) is more compatible with [Windows 7](#).

7 Discussion

In this chapter, the reader will make sense of the difficulties for the students along the way. The group will discuss alternative approaches that also could be used for future work. In the end, the group will present self-criticism then evaluate the groups' effort.

7.1 Obstacles

This section will describe the issues encountered and how the group resolved these issues.

7.1.1 Playbook

The [Playbook](#) the group used to successfully install [Cuckoo](#) the first time, was based on a [Playbook](#) that the group found on GitHub. [39]. The [Playbook](#) was used as a backbone, because at the point of its creation it installed [Cuckoo](#) successfully on an [Ubuntu 16.04 LTS \(Xenial Xerus\)](#) server. Due to the [Playbook](#) being over a year old, the group updated it to work with packages that were newer and compatible.

During a meeting with the employer, the group discussed the matter of running the platform on [Ubuntu 16.04 LTS](#). The employer suggested and wanted that the platform should be updated to run on [Ubuntu 18.04 LTS](#). Updating the platform to [Ubuntu 18.04 LTS](#) meant that the group had to rework the [Playbook](#). After doing some research on updating the [Playbook](#), the group quickly realized that most of the packages that the [Playbook](#) previously had downloaded and compiled from scratch were no longer needed, because the official [Bionic Beaver](#) repositories already had most of the prior compiled packages. Some of the roles had to be rewritten to reflect that some of the software did not have to be downloaded, compiled, which made it easier to install the given packages. The group used an evening to rewrite the [Playbook](#) to make it work on [Bionic Beaver](#).

7.1.2 vCenter Server Appliance (VCSA)

During one of the meetings where the group had prepared a demo for the employer, it became clear that the virtual machine running [vCenter Server Appliance \(VCSA\)](#) had crashed. The crash caused the group not to be able to show a demo to the employer.

After some research, the group found out that the version of [vCenter Server Appliance \(VCSA\)](#) had the wrong compatibility with [ESXI](#), which caused [VCSA](#) to crash. The version of [VCSA](#) had been running version 6.5, while the [ESXI](#) was running version 6.7. The group quickly decided to download and install a compatible version of [VCSA](#) to match the [ESXI Hypervisor](#) to solve this issue permanently. Having reinstalled [VCSA](#) to run version 6.7 it has been stable, and not a single crash has occurred ever since.

7.1.3 Sandboxes

In addition to [VCSA](#), the group had additional difficulties regarding the [Sandboxes](#). During the execution of an analysis on either [Windows 8.1](#) or [Windows 10](#), [Cuckoo's](#) agent stopped communicating with [Cuckoo](#). The group never really found the root issue of

[Cuckoo](#)'s agent stopping to communicate with [Windows](#) 8.1 and 10. Restarting the agent, creating a new [Snapshot](#) and running a further analysis only provides a temporary solution, because the issue reappears after running one analysis on those two [Sandboxes](#).

7.1.4 Cuckoo

During the early testing of the platform, the group quickly encountered an error with python's package manager called [pip](#). After upgrading [pip](#) to its latest version at the time of this writing (19.1.1), [Cuckoo](#) would stop working. [Cuckoo](#) is reliant on [pip](#) version 9.0.3 to run and work properly. In addition to [pip](#), [Cuckoo](#) does not support python version higher than 2.7.

All of these version checks have been implemented to the [Playbook](#), and in addition to using version checks, the [Playbook](#) installs [Cuckoo](#) into python's [Virtual Environment](#).

7.2 Alternative approaches and future work

The group will discuss alternative approaches to the project and the platform, which could be implemented in future work.

7.2.1 Docker

A big decision was to exclude [Docker Containers](#), which is mentioned in appendix [D](#). The decision to exclude [Docker](#) was to be certain that the group would deliver a working product. The employer was like-minded on the issue and wanted the group to focus on deploying a functional product. Additionally, the platform would not have much performance difference compared to using containers, and may even be easier to troubleshoot with its current implementation.

7.2.2 Development methodology

When it comes to the development methodology, there were plenty of possibilities. Scrum could have worked better when considering the sprints and have a more detailed visual view of what needs to get done during a sprint. The choice of development method does not mean the students choose the wrong development methodology, because the waterfall methodology gave the group a good overview, they knew what needed to be done during a phase and executed that well.

7.2.3 Cuckoo Sandbox

Like mentioned earlier in the thesis, [Cuckoo](#) is extremely modular. Additionally, the tuning of [Cuckoo](#) is something to take into consideration. By tuning [Cuckoo](#), the group means that the results of the analysis can vary, based on the options enabled/disabled by changing the configuration files, changing memory profiles used by [Volatility](#) or using custom made [Yara](#) rules. Tuning [Cuckoo](#) was mentioned in chapter [5.5](#), but the tuning of [Cuckoo](#) could potentially be different based on which sandboxes are run in the environment. Even though the options the group used provided the best test results for [Windows](#), might not be the case in other environments running other [OS](#)'s than [Windows](#).

It might prove beneficial to create different [Cuckoo](#) servers to test different [OS](#)'s, this way the [Malware](#) researcher/[SOC](#) analyst can customize the [Cuckoo](#) servers to better analyze the type of [Malware](#) made for the given [OS](#).

7.2.4 Automation

Even though the installation of the platform is very automated as is, there are a few more changes that could have been implemented to automate the installation process fully. Making the platform even more automated involves adding a new role which makes use of regular expressions [40] to edit a line directly in a file that has already been copied over to the server by the [Playbook](#). By using regular expressions in the [Playbook](#) installation, one could avoid having to follow most of the steps in chapter 5.

```

22 - network
23 - ip_addresses # <-- New Role
24 - start_up_cuckoo

```

Listing 7.1: Role added to site.yml

Additionally, this would allow the new role to use variables in

```

cuckoo-playbook/inventories/(production/staging)/all/
group_vars

```

```

15 ### Network cards ###
16 nic: ens160
17 ananic: ens192
18
19 ### IP Addresses ###
20 ipnic: 172.16.1.30 # <-- new variable
21 ipananic: 192.168.56.1 # <-- new variable

```

Listing 7.2: group_vars file

Listing 7.3 shows an example of how the file could look like:

```

1 ---
2 - name: Setting correct IP Address to cuckoo.conf [ 1
  / 2 ]
3   become: true
4   become_method: "{{_cuckoo_user_}}"
5   lineinfile:
6     dest: /home/cuckoo/.cuckoo.conf/cuckoo.conf
7     state: present
8     regexp: '^ip ='
9     line: 'ip = "{{_ipananic_}}"'
10
11 - name: Setting correct IP Address to cuckoo.conf [ 2
  / 2 ]
12   become: true
13   become_method: "{{_cuckoo_user_}}"
14   lineinfile:
15     dest: /home/cuckoo/.cuckoo.conf/cuckoo.conf
16     state: present
17     regexp: '^guacd_host'
18     line: 'guacd_host = "{{_ipananic_}}"'

```

Listing 7.3: main.yml for ip_address role

It would be necessary to add more sections to main.yml in the ip_adress role by using regular expressions to edit the IP addresses of the files that need to change. Adding regular expressions would only require some initial editing of files and the [Playbook](#) would install perfectly. The group did not implement regular expressions, due to time limitations. Using regular expressions became clear for the students as a solution to automate the environment even further, but was realized too late into the project period.

Note: The listings above are only an example of how the group would implement this additional role, and is only meant reference of how the [Playbook](#) could have been written differently.

7.2.5 Sandboxes

Unfortunately, due to time constraints the group was only able to implement [Windows](#) based [Sandboxes](#). In future work, the project should be updated with support for sandboxes with [MacOS](#) and [Android](#). In [Cuckoos](#) documentation, it was mentioned [Android](#) analysis may not work as expected due to becoming a Cuckoo Package [41]. Cuckoo states it is possible to use [MacOS](#), but have no documentation on how it is done. A variety of [Sandboxes](#) were implemented to run analysis to see how [Malware](#) reacts to different operating systems.

Another adjustment that hopefully could be implemented in the future is the installation of more software in the [Sandboxes](#), for example, different versions of Microsoft Office, this is so the platform can provide better test results for a given [Malware](#). In addition to installing more software to the [Sandboxes](#), kernel debugging is an option that has to be done manually. Still, it is reasonably easy to implement, by adding a COM-port to the virtual machine, and then connecting to this COM-port with [VMWare](#) Workstation.

Kernel debugging

Something the group would like to see be implemented in the future is [Kernel Debugging](#) for the [Sandboxes](#). Kernel debugging can be done to further analyze a malware, by directly connecting to the [Windows Kernel](#), and by attaching the debugger to a given process, an analyst can see what code the malware executes relative to the [Kernel](#) [42].

7.2.6 Software

In the future, the group would also like for [VMCloak](#) to be implemented into the platform [43]. [VMCloak](#) is a program that hides/cloaks virtual machines by making it harder [Malware](#) to detect it is being run in a virtual environment. The group did not implement [VMCloak](#) due to the lack of documentation when it comes to setting it up with [VMWare](#) infrastructure. Before successfully implementing [VMCloak](#), it would mean the group would have had to go through a lot more trial and error to get an effective integration.

[VMCloak](#)'s documentation is based on [Virtualbox](#). A possible solution to installing [VMCloak](#) on [VMWare](#), would be to create the virtual machine in [Virtualbox](#) first, and export/import it to [VMWare](#). The group did not have the time to test the implementation of [VMCloak](#) but should work in theory.

7.2.7 Environment

There are also a few infrastructure changes that could be made to the platform in the future. One of them could be to adjust the projects [Playbook](#) by moving different parts of the platform into different dedicated servers, thereby allowing the infrastructure of the platform to not depend on one server, and be more redundant to failure. Distributing the infrastructure should be done to avoid losing data when upgrading the server, potentially installing a package that would otherwise harm or break the platform.

In the group's experience, [Cuckoo](#) can sometimes stop routing correctly, which causes Internet and [VPN](#) routing to stop working. Without Internet routing, the malware analysis results may be affected negatively. Due to time limitations, the group found that rolling the [Bionic Beaver](#) server back to its fresh state, install updates and then run the [Playbook](#) again would solve these issues. To avoid spending too much time, in the end, troubleshooting the routing issues. Having dedicated servers for PostgreSQL, [Elasticsearch](#) and [Moloch](#), along with [Suricata](#), the installation of the platform could be reduced to less than three minutes making it a better choice rather than having to install it all again.

As stated previously in section [7.2.1](#) the group chose to abstain from implementing [Docker Containers](#) in the projects infrastructure, nevertheless it would be beneficial to implement it in the future because it allows the infrastructure to be used in any [Environment](#) and it also helps with redundancy by separating the platform's tasks. Implementing containers will not entirely remove the need for virtual machines, because a windows container can not be run under [Linux](#) and vice versa. Since this platform is almost entirely built on linux, the need for windows virtual machines would still be needed even if implementing docker [Containers](#).

7.3 Criticism

One of the main lessons the group learned during the assignment is that writing from the beginning is very important. Since the group did not document too much in the beginning, the report writing took longer than anticipated.

The group could have documented more in the early stages. Due to the lack of documentation, the group had to go back to reproduce some of the errors and setups during the implementation and install [Cuckoo](#) through [Ansible](#). Due to lack of documentation, this was done to get the necessary and relevant screenshots of the installation process.

The group also discovered that meeting and working together at the university proved to be more productive than working alone from home. As a result, the group held most meetings at the university.

Having read [Cuckoo](#)'s documentation, the group should have dropped implementing [Windows](#) 8.1 and 10, because these [OS](#)'s are poorly documented and badly supported by [Cuckoo](#). The group should have used their time implementing [Android](#) and [MacOS](#) instead, which is something the group regrets not having implemented since [Android](#) and [MacOS](#) was a wanted functionality by the employer.

7.4 Evaluation of the groups work

The group worked together very well, the group held meetings constantly and worked hard in each of them. The students helped each other whenever they were stuck with

a given task, which helped keep the standards for the project high by reviewing each others work and motivated each other throughout the project.

By using [Trello](#), the group could see what the other members of the group were working on, and also assist them if they were stuck with the task they were given. Trello helped keep the standards for the project high, by reviewing each other's work and motivating each other throughout the project. The group has worked a lot on the report, and it has been re-manufactured many times to find the correct layout, and so the chapters and its contents made sense to one another. The group feels like they have delivered a good report that reflects the subject and the task they have been given very well.

8 Conclusion

This chapter concludes this thesis; it presents the results achieved in this project, followed by the students' opinions. Lastly, the students give their closing statement.

8.1 Results

NTNU SOC wanted a platform for malware analysis, which was configurable and installed through the use of [Ansible](#). Implementation of the platform was accomplished, although not every functionality described in the task description was fulfilled. The students and the employer had regular contact throughout the thesis. Regular communication with the employer was massively appreciated and used when issues or uncertainties occurred.

The employer was satisfied with the finished product. Additionally, the students felt their job was well executed; this is why the students think the task was accomplished.

An [Ansible Playbook](#) was created to implement a fully working [Cuckoo](#) analysis platform, integrated with additional tools for thorough malware analysis. Cuckoo is optimized to work together with [Windows OS](#), but works best on Windows 7 as described in chapter testing and verification under the sandbox section [6.5](#).

By following chapter [5](#), it is possible to get a complete walk-through of the setup used in this thesis.

8.1.1 Group achievements

This project was a tremendous learning experience; the group learned a lot about [Malware](#) analysis, the different tools, and technologies used in this project, how those technologies interact with each other and most importantly how to work as a team.

At the end of the project, the group delivered a functional platform for [Malware](#) analysis and managed to implement most of what the employer required in the task description. The group is pleased with everything achieved and learned during this project. That being said if the group had more time, the group would have loved to implement the technologies named in future work.

8.2 Closing statement

The students learned a lot of valuable lessons throughout this project that we will carry with us for the rest of our lives. We hope [NTNU SOC](#) will find our platform useful and we would like to thank Christoffer Vargtass and [NTNU SOC](#) for trusting us with such an interesting and relevant project to work with and learn from. Furthermore, [NTNU SOC](#) has many possibilities for how they want to use this project for both production and development environments. The code used in the making of the automation of [Cuckoo](#) is on an open repository on GitHub and is therefore free for anyone to use. Finally, we would like to thank our supervisor, Eigil Obrestad, for giving us critical feedback throughout the project, pushing us to write a better report and developing a better project.

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A Task Description



Oppdragsgiver

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Plattform for skadevareanalyse

NTNU SOC er en operativ digital beredskapsfunksjon i seksjon for digital sikkerhet og har hovedansvaret for å detektere trusler mot NTNU, utføre sikkerhetsanalyse og respondere til truslene i form av preventive tiltak eller hendelsehåndtering. NTNU SOC må daglig gjøre skadevareanalyse for å best kunne beskytte NTNUs brukere og systemer.

Oppgave

Design og implementere et komplett, agilt system for automatisk skadevareanalyse for å støtte automatisk og manuell sikkerhetsanalyse ved NTNU SOC. Konfigurasjon og utrulling av komponentene i systemet må automatiseres slik at systemet kan gjenskapes i utvikling, test og produksjon.

Ønsket funksjonalitet:

- Konfigurasjonsstyringssystem med versjonshåndtering
- Bruk av kontainer teknologi for smidig utvikling, test og produksjon av komponenter
- Integrasjon mot systemer og tjenester for trusseletteretning
- Støtte for dynamisk og statisk analyse
- Støtte for automatisk og manuell analyse
- Støtte for sandkasser av Windows, MacOS og Android
- Støtte for VPN, Tor og simulerte nettverkstjenester
- Støtte for IDS
- Distribuert arkitektur
- Dokumentasjon / Wiki

Funksjonaliteten beskrevet over er ikke en nødvendigvis en fullstendig liste og begrensende, det er muligheter for å utvide funksjonalitet og da spesielt i retning av utvikling.


Utvikling

Dette prosjektet er hovedsakelig et implementasjon og driftsprosjekt, og det er forventet at sluttproduktet er et tilnærmet produksjonsklart system. **Prosjektet passer for en gruppe på 2-5 studenter avhengig av funksjonalitet og dybde.** I Prosjektet kan studentene forvente å tilegne seg kunnskap innen:

- Agile metoder, automasjon og DevOps metodikk
- Virtualisering, containere og sandkaseteknologi
- Nettverk og sikkerhetsmodeller
- Verktøy og metodikk for enkel skadevareanalyse

Figure 18: Task Description

B Project Agreement

 NTNU	Vår dato	Vår referanse	1 av 3
Norges teknisk-naturvitenskapelige universitet			
<h3>Prosjektavtale</h3>			
mellom NTNU Fakultet for informasjonsteknologi og elektroteknikk (IE) på Gjøvik (utdanningsinstitusjon), og			
<hr/> <i>Christopher Hallstensen</i> (oppdragsgiver), og			
<hr/> <i>Nestor Fortique</i>			
<hr/> <i>Daniel Sivveland</i>			
<hr/> <i>Stian Rønningem</i> (student(er))			
Avtalen angir avtalepartenes plikter vedrørende gjennomføring av prosjektet og rettigheter til anvendelse av de resultater som prosjektet frembringer:			
1. Studenten(e) skal gjennomføre prosjektet i perioden fra <i>10/1/2019</i> til <i>20/5/2019</i>			
Studentene skal i denne perioden følge en oppsatt fremdriftsplan der NTNU IE på Gjøvik yter veiledning. Oppdragsgiver yter avtalt prosjektbistand til fastsatte tider. Oppdragsgiver stiller til rådighet kunnskap og materiale som er nødvendig for å få gjennomført prosjektet. Det forutsettes at de gitte problemstillinger det arbeides med er aktuelle og på et nivå tilpasset studentenes faglige kunnskaper. Oppdragsgiver plikter på forespørsel fra NTNU å gi en vurdering av prosjektet vederlagsfritt.			
2. Kostnadene ved gjennomføringen av prosjektet dekkes på følgende måte: <ul style="list-style-type: none"> • Oppdragsgiver dekker selv gjennomføring av prosjektet når det gjelder f.eks. materiell, telefon/fax, reiser og nødvendig overnatting på steder langt fra NTNU på Gjøvik. Studentene dekker utgifter for ferdigstillelse av prosjektmateriell. • Eiendomsretten til eventuell prototyp tilfaller den som har betalt komponenter og materiell mv. som er brukt til prototypen. Dersom det er nødvendig med større og/eller spesielle investeringer for å få gjennomført prosjektet, må det gjøres en egen avtale mellom partene om eventuell kostnadsfordeling og eiendomsrett. 			
3. NTNU IE på Gjøvik står ikke som garantist for at det oppdragsgiver har bestilt fungerer etter hensikten, ei heller at prosjektet blir fullført. Prosjektet må anses som en eksamensrelatert oppgave som blir bedømt av intern og ekstern sensor. Likevel er det en forpliktelse for utøverne av prosjektet å fullføre dette til avtalte spesifikasjoner, funksjonsnivå og tider.			

Norges teknisk-naturvitenskapelige universitet
Fakultet for informasjonsteknologi og elektroteknikk

4. Alle bacheloroppgaver som ikke er klausulert og hvor forfatteren(e) har gitt sitt samtykke til publisering, kan gjøres tilgjengelig via NTNUs institusjonelle arkiv hvis de har skriftlig karakter A, B eller C.

Tilgjengeliggjøring i det åpne arkivet forutsetter avtale om delvis overdragelse av opphavsrett, se «avtale om publisering» (jfr Lov om opphavsrett). Oppdragsgiver og veileder godtar slik offentliggjøring når de signerer denne prosjektavtalen, og må evt. gi skriftlig melding til studenter og instituttleder/fagenhetsleder om de i løpet av prosjektet endrer syn på slik offentliggjøring.

Den totale besvarelsen med tegninger, modeller og apparatur så vel som programlisting, kildekode mv. som inngår som del av eller vedlegg til besvarelsen, kan vederlagsfritt benyttes til undervisnings- og forskningsformål. Besvarelsen, eller vedlegg til den, må ikke nyttes av NTNU til andre formål, og ikke overlates til utenforstående uten etter avtale med de øvrige parter i denne avtalen. Dette gjelder også firmaer hvor ansatte ved NTNU og/eller studenter har interesser.


5. Besvarelsens spesifikasjoner og resultat kan anvendes i oppdragsgivers egen virksomhet. Gjør studenten(e) i sin besvarelse, eller under arbeidet med den, en patentbar oppfinnelse, gjelder i forholdet mellom oppdragsgiver og student(er) bestemmelsene i Lov om retten til oppfinnelser av 17. april 1970, §§ 4-10.
6. Ut over den offentliggjøring som er nevnt i punkt 4 har studenten(e) ikke rett til å publisere sin besvarelse, det være seg helt eller delvis eller som del i annet arbeide, uten samtykke fra oppdragsgiver. Tilsvarende samtykke må foreligge i forholdet mellom student(er) og faglærer/veileder for det materialet som faglærer/veileder stiller til disposisjon.
7. Studenten(e) leverer oppgavebesvarelsen med vedlegg (pdf) i NTNUs elektroniske eksamenssystem. I tillegg leveres ett eksemplar til oppdragsgiver.
8. Denne avtalen utferdiges med ett eksemplar til hver av partene. På vegne av NTNU, IE er det instituttleder/faggruppeleder som godkjenner avtalen.
9. I det enkelte tilfelle kan det inngås egen avtale mellom oppdragsgiver, student(er) og NTNU som regulerer nærmere forhold vedrørende bl.a. eiendomsrett, videre bruk, konfidensialitet, kostnadsdekning og økonomisk utnyttelse av resultatene. Dersom oppdragsgiver og student(er) ønsker en videre eller ny avtale med oppdragsgiver, skjer dette uten NTNU som partner.
10. Når NTNU også opptre som oppdragsgiver, treer NTNU inn i kontrakten både som utdanningsinstitusjon og som oppdragsgiver.
11. Eventuell uenighet vedrørende forståelse av denne avtale løses ved forhandlinger avtalepartene imellom. Dersom det ikke oppnås enighet, er partene enige om at tvisten løses av voldgift, etter bestemmelsene i tvistemålsloven av 13.8.1915 nr. 6, kapittel 32.


Norges teknisk-naturvitenskapelige universitet
Fakultet for informasjonsteknologi og elektroteknikk

12. Deltakende personer ved prosjektgjennomføringen:

NTNUs veileder (navn): Eigil Obrestad

Oppdragsgivers kontaktperson (navn): Christoffer Hallstensen

Student(er) (signatur):  dato 21/1/2019
Donil Siveland dato 21/1/2019
Stian Remington dato 21/1/2019
 _____ dato _____

Oppdragsgiver (signatur):  dato 30.1.2019

*Signert avtale leveres digitalt i Blackboard, rom for bacheloroppgaven.
Godkjennes digitalt av instituttleder/faggruppeleder.*

*Om papirversjon med signatur er ønskelig, må papirversjon leveres til instituttet i tillegg.
Plass for evt sign:*

Instituttleder/faggruppeleder (signatur): _____ dato _____

3

Figure 19: Task Description

C Project Plan

C.1 Introduction

In these evolving times, detecting and removing [Malware](#) artifacts is not enough: it is vitally important to understand how they operate in order to understand the context, the motivations, and the goals of a breach.

C.2 Goals and Scope

C.2.1 Project's goals

Design and implement a complete and agile platform automatic [Malware](#) analysis. The project aims to assist NTNU SOC in its daily work by detecting threats against NTNU and analyzing these threats.

Result goals

- Automated configuration and deployment of system components
- Immutable platform for use in development, test and production
- Platform for simple malware analysis

Effect goals

- Automatic and manual security analysis of malware
- Analyze new types of malware, as well as existing ones
- Used in context of lectures in the future

C.2.2 Project's scope

Brief description of the project

This project aims to create a platform for [Malware](#) analysis by using a handful of tools to automate and administrate the installation process along with operating the system when it is finished. The main focus will be [Windows](#)(100% implementation and malware analysis) and if time allows it, the project will include [Android](#) and [MacOS](#).

Timeframe

The project period will be from 10.01.2019-20.05.2019. After the final date, the work on the project will cease regardless of the project's state unless arrangements are made.

Employer's scope

Requirements / limitations for project and final report:

The employer wants a platform that is mostly built on [Containers](#). The platform must have a configuration component that allows for version management and has integration towards systems for threat intelligence. It is required that there is an implementation of different network services such as [TOR](#) and/or [VPN](#) to [Spoof](#) the analyzers location and lure the attacker into unleashing the full potential of the [Malware](#) for better analysis. The platform will be built upon [VMWare](#) and containers will be built using [Docker](#). [Sandboxes](#) will be run in [VMWare](#), while Cuckoo will be used for malware analysis. The

entire platform will be administrated through the use of [Ansible](#). Network [Intrusion Detection System \(IDS\)](#) systems will be used to ensure that malware is detected by the use of [Signatures](#) and to help analysts identify the signature set a specific malware sample triggers.

Student's scope

The following requirements/limitations the students has to deliver/do for this project:

Write a project plan containing scheduling of the different phases during the project (Delivered to the supervisor). Design and implement a complete agile system for automatic and manual analysis of [Malware](#). The configuration and deployment of components in the system with [DevOps](#) in mind. (A final report to be graduated in Bachelor in IT-Operations and Information Security at NTNU Gjøvik (Delivered to NTNU Gjøvik). Finally have a presentation of the thesis.

C.3 Organization

C.3.1 Organizational structure

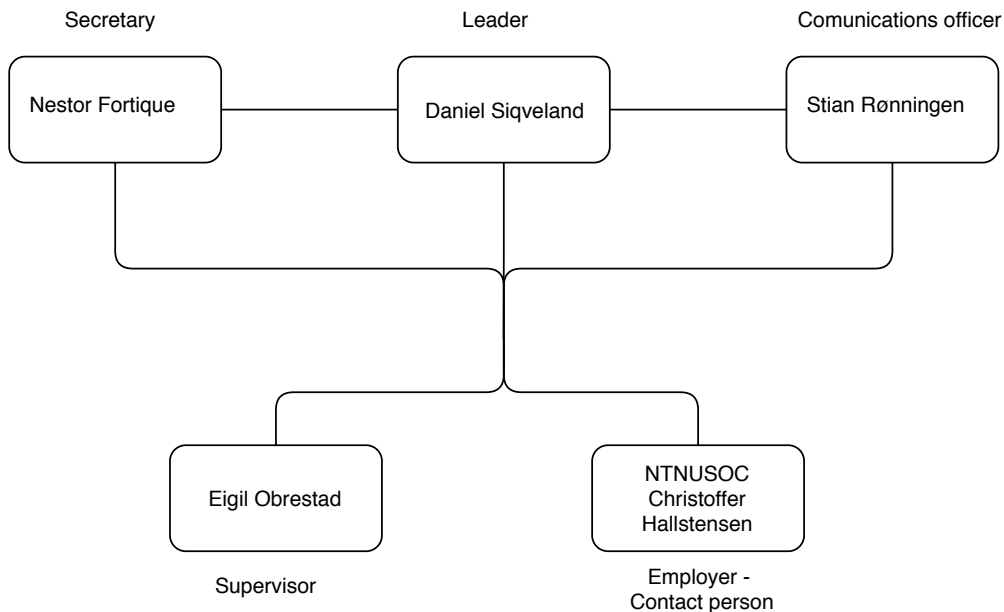


Figure 20: The organizational structure of this project

C.3.2 Roles

The following roles have been specified for this project:

- **Employer & Product Owner** - Christoffer Vargtass Hallstensen representing NTNU SOC
 - Ensure the quality of the student's works and proof that it matches the wished requirements.
 - Provide the needed information about systems for the students during the defined period.
- **Supervisor** - Eigil Obrestad
 - Follow the student's working process.
 - Provide feedback, and ensure that the students is *on track*.
- **Students & task performers** - Daniel E. Krohn Siqveland, Nestor Gerrardo Fortique & Stian Rønningen
 - Daniel, as the chosen leader of the group, will set time and dates for when the group meets.
 - Nestor will be the secretary, responsible of writing summaries of meetings.
 - Stian will be the one in charge for sending mails and arranging meetings with the supervisor and the employer.
 - Responsible for project's time management and delivering the requirements of the project within the deadlines.

C.3.3 Time management and meetings

During this project, the students work Monday-Friday and sometimes during weekends. The students are also responsible of maintaining the communication with their employer. A meeting between the employer and the students is defined by dropping by the office or arranging meetings by email if needed, and could be changed later according to the process and time management. Additionally, the students are responsible for the meetings between the supervisor and the students. It is already defined to be once each week on Mondays.

C.4 Risk Management

This section will contain the **Risks** that could appear during this project. Each risk will be evaluated relative to it's likelihood to happen and consequence if a risk occurs. In the risk analysis subsection under, it's defined the likelihood and consequence on a scale from one (1) to five (5). Where one is defined as *None Critical* and five is considered *Critical*.

C.4.1 Risk analysis

Nr#	Risk	Likelihood	Consequence	Countermeasure
1	The project is not completed before the deadline or delivery delay. Reasons could be Backup lost, poor estimate of points in activities.	2	5	Yes
2	Major changes in requirements specifications from employer.	1	4	No
3	Loss of resources (data or report).	2	5	Yes
4	Project shutdown	1	5	No
5	The final product does not match the requirements of the employer.	1	4	Yes

Table 5: Project's risks

C.4.2 Countermeasures

To ensure the quality of the student's work in the project, a list of countermeasures for the mentioned [Risks](#) is listed in the table below.

Nr#	Risk Countermeasures
1	The students will be using a more agile version of the waterfall development model. So, both the quality of the work and the delivery should be matching the requirements.
3	The data and the report of the project is vulnerable to be lost. Therefore, it should be stored and protected. Also, a back-up of data will be often during the project period. The report is hosted in Overleaf cloud storage and a back-up will happen periodically.
5	The students should organize the work and share the process with the supervisor and employer to ensure that they are following the right track.

Table 6: Project's risk countermeasures

C.5 Planning & Report

C.5.1 Working process

Due to the task requirements from the employer, the project is divided into four phases. The project will go through comprehensive testing, setup of tools and [Scripts](#) to make the end product as simple as possible along with having included the requirements from the employer.

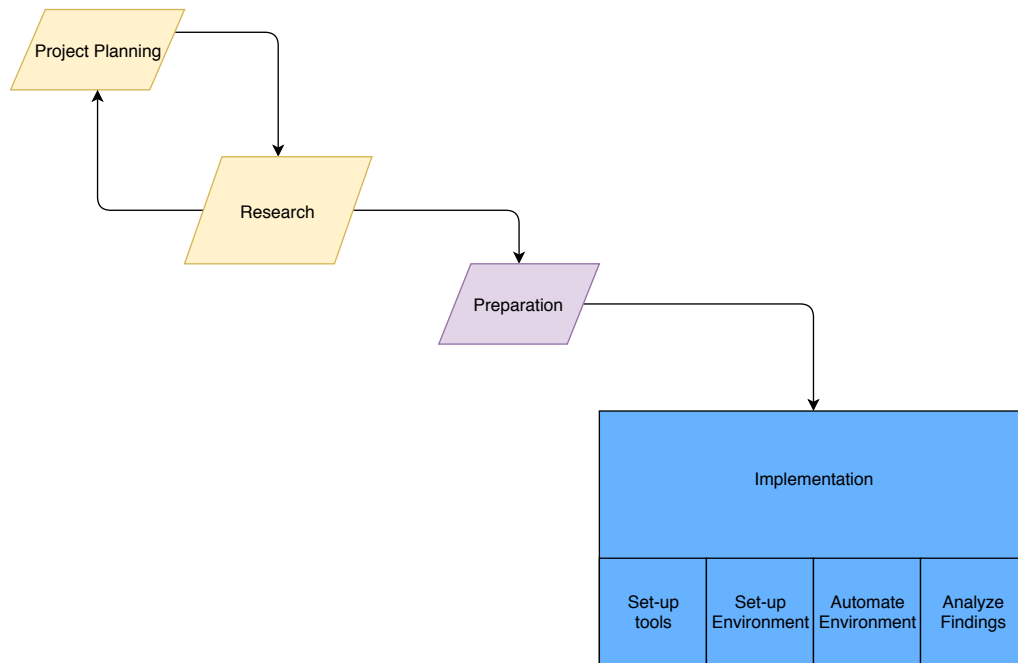


Figure 21: Working process during the project

- **Phase 1 - Project planning**
 - Define the goals of the project.
 - Set up a plan of the working process.
 - Establish communications with the supervisor and the employer.
- **Phase 2 - Research**
 - The students use the period to obtain the relevant information for the project, by learning and reading about the different tools based on documentations.
 - It is possible that during this phase the predefined project plan will change if needed.
- **Phase 3 - Preparation**
 - The students use this time to prepare for the experiment by preparing and learning the tools for the project. This includes preparing to deploy the [Environment](#) based on *best practices*.
- **Phase 4 - Implementation**
 - The implementation phase contains 4 sub-phases that should run in parallel:

- Phase 4.1 - Set up the required tools
- Phase 4.2 - Set up environment
- Phase 4.3 - Automate environment
- Phase 4.4 - Analyze findings

The report (thesis) will be written in parallel with all phases as the students are starting to see a working product.

C.5.2 Experiment's Notes

The reason for running all the sub-phases at the same time under the experiment is to ensure the quality of the environment. What is likely to happen the first time is that the students set up the environment manually and then automate with [Ansible](#) and [Docker](#) from there to create an agile environment that can be used in later situations. NTNU's IT-department has been very kind to lend the students a few servers to run the environment on, because the students laptops were not up to the task of running the environment.

C.6 Schedule

C.6.1 Gantt diagram

The figure below is a [Gantt Diagram](#) that shows how the mentioned phases in [C.5.1](#) are divided over 18 weeks and four days as mentioned in [C.2.2](#).

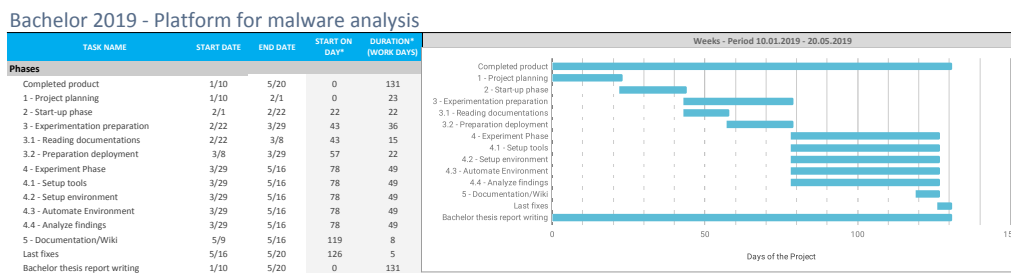


Figure 22: Gantt chart of the project flow and phases timing

Planning is taking a part of this thesis from the start, and it is estimated to take three weeks of work. During the planning, the students will use the time to obtain knowledge about the assignment.

The next phase in line is the start-up phase. The students will start learning and reading about the tools - what the best practices are, how to implement them and why they should be implemented. Estimated time for this phase will be roughly three weeks.

After getting the basics, the project will enter the preparation-for-experimentation phase. This is the phase where tools are tested for the first time, getting the hands-on experience. Since some of the tools can be very overwhelming, the time frame for this phase is set to three weeks.

The students will use five weeks of the project to implement the environment by automating installation of components. This is also the phase where everything will be tested, including testing [Malware](#) in the environment and analyzing the system thoroughly.

Even though the thesis will be written in parallel with all the phases, the project

will have four weeks at the end where all of the time will be dedicated to writing and polishing the thesis.

D Midterm review

This section presents the the midterm review, where the students met with their employer. The meeting took place 8th of October and lasted one hour.

D.1 Status of the project before the meeting

The students had a working step by step guide to install, configure and run [Cuckoo](#), but not a working [Ansible Playbook](#) that downloads and installs everything necessary to run [Cuckoo](#). The Gantt-diagram in [C.6.1](#) was followed and the students where on schedule, with focus on the technical solution. This resulted in less writing the thesis than originally planned. In preparation to the meeting the students had prepared a demo run with an [Malware](#) that would show how [Cuckoo](#) worked. Also prepared a few questions that would help with clarifying the process ahead.

D.2 Summary of the meeting

The employer answered questions regarding how much of the setup was to be automated with [Ansible](#). The students got an impression that the employer was more than happy with the environment so [Cuckoo](#) could run smoothly. When it was time to present the demo to the employer there was an issue with [vCenter Server Appliance](#) resulting in the demo not working, but luckily the students where able to present the results of an earlier analysis performed prior to the meeting.

The following two main factors were discussed during the meeting:

1. Clarification

During the meeting the students got clarification on what to automate. The wanted functionality from the employer was that the installation process of [Cuckoo](#) would be automated. Support for more [Operating System](#) than [Windows](#) was also discussed.

2. Docker

During the Planning Phase (see [Appendix C](#)) the students mentioned [Docker](#) to be used as a way to run [Cuckoo](#). This proved to be more challenging than helpful. The students then chose to abandon the docker implementation of [Cuckoo](#) and rather focus on getting a manual installation of it working. This resulted in a much cleaner approach to the installation process itself by allowing easier automation with [Ansible](#). Following this approach will also leave the installation with a larger backlog of earlier analyzes, restricted only by harddrive space.

D.3 The student's decision

Due to time constraints, the students chose to only implement and test the platform on a [Windows](#) environment. If time allows it, implementation of [MacOS](#), [iOS](#) and [Android](#) will be included in the platform. All of the [Operating System](#)'s mentioned in this section are supported by [Cuckoo](#), but not yet tested in this project.

D.4 Modifying the topic

In order to modify the original topic to a new one, several elements has been taken into consideration, such as:

- **The predefined project's motivation, goals and research question.**

The employer wish was to have as many [Operating System](#) as possible, but due to time constraints, the students and the employer agreed on fully implementing [Windows](#) as the primary goal.

- **Time constraints**

The manual installation and troubleshooting took way longer than the students anticipated. Additionally [Cuckoo](#)'s configuration opportunities and documentation were hard to familiarize and learn. As a result there wasn't much time to write on the thesis, the students focused more on providing a working prototype to show the employer, also gathering enough knowledge about the environment to get more specific questions.

E Route.py

```
1 #!/usr/bin/python
2 import os
3 import subprocess
4
5 IP_ROUTE_TABLES='/etc/iproute2/rt_tables'
6
7 if __name__ == '__main__':
8     config_name = os.environ.get('config')
9     local_ip = os.environ.get('ifconfig_local')
10    vpn_gateway = os.environ.get('route_vpn_gateway')
11    common_name = os.environ.get('common_name')
12    dev = os.environ.get('dev')
13    ip_table = common_name
14    print 'ip_rule_add_from_{ }_table_{ }'.format(
15        local_ip, ip_table)
16    print 'ip_route_add_default_via_{ }_dev_{ }_table_{ }
17        '.format(vpn_gateway, dev, ip_table)
18    subprocess.call(['ip', 'rule', 'add', 'from',
19        local_ip, 'table', ip_table])
20    subprocess.call(['ip', 'route', 'add', 'default',
21        'via', vpn_gateway, 'dev', dev, 'table',
22        ip_table])
```


F OpenVPN Systemd

```
1 [Unit]
2 Description=Openvpn Client Service
3 After=network-online.target
4 Wants=network-online.target
5
6 [Service]
7 ExecStart=/usr/sbin/openvpn --config openvpn.conf --
      script-security 2 --route-noexec --route-up route.
      py
8 Restart=on-failure
9 User=root
10 Group=root
11 WorkingDirectory=/etc/openvpn/client
12
13 [Install]
14 WantedBy=multi-user.target
```

G Cuckoo Systemd

G.1 Cuckoo Rooter

```
1 [Unit]
2 Description=Cuckoo Rooter Service
3 After=network.target openvpnclient.service
4
5 [Service]
6 ExecStart=/opt/cuckoo/bin/cuckoo rooter
7 Restart=on-failure
8 User=root
9 Group=root
10 WorkingDirectory=/home/cuckoo/.cuckoo
11
12 [Install]
13 WantedBy=multi-user.target
```

G.2 Cuckoo

```
1 [Unit]
2 Description=Cuckoo Sandbox Service
3 After=network.target cuckoo_rooter.service
4
5 [Service]
6 ExecStart=/opt/cuckoo/bin/cuckoo
7 Restart=on-failure
8 User=cuckoo
9 Group=cuckoo
10 WorkingDirectory=/home/cuckoo/.cuckoo
11
12 [Install]
13 WantedBy=multi-user.target
```

G.3 Cuckoo Web

```
1 [Unit]
2 Description=Cuckoo Web Service
3 After=network.target cuckoo.service
4
5 [Service]
6 ExecStart=/opt/cuckoo/bin/cuckoo web runserver
7     172.16.1.30:8880
8 Restart=on-failure
9 User=cuckoo
10 Group=cuckoo
11 WorkingDirectory=/home/cuckoo/.cuckoo
12
13 [Install]
14 WantedBy=multi-user.target
```

G.4 Cuckoo API

```
1 [Unit]
2 Description=Cuckoo API Service
3 After=network.target cuckoo_web.service
4
5 [Service]
6 ExecStart=/opt/cuckoo/bin/cuckoo api --host
7     172.16.1.30 --port 8881
8 Restart=on-failure
9 User=cuckoo
10 Group=cuckoo
11 WorkingDirectory=/home/cuckoo/.cuckoo
12
13 [Install]
14 WantedBy=multi-user.target
```

H vsphere.py

This is the version that [Cuckoo](#) installs by default

```
97     # Workaround for PEP-0476 issues in recent
98     Python versions
99     if self.options.vsphere.unverified_ssl:
100         sslContext = ssl.SSLContext(ssl.
101             PROTOCOL_TLSv1)
102         sslContext.verify_mode = ssl.CERT_NONE
103         self.connect_opts["sslContext"] =
104             sslContext
105         log.warn("Turning off SSL certificate
106             verification!")
```


This is the patched version that works when [Cuckoo](#) interacts with [VCSA](#). Notice that line 99 has changed from `ssl.PROTOCOL_TLSv1` to `ssl.PROTOCOL_v23`.


```
97     # Workaround for PEP-0476 issues in recent
98     Python versions
99     if self.options.vsphere.unverified_ssl:
100         sslContext = ssl.SSLContext(ssl.
101             PROTOCOL_SSLv23)
102         sslContext.verify_mode=ssl.CERT_NONE
103         self.connect_opts["sslContext"] =
104             sslContext
105         log.warn("Turning off SSL certificate
106             verification!")
```

I Sample Virtual Machine config - vsphere.conf


```
91 [Win7]
92 # Specify the label name of the current machine as
   # specified on your
93 # vSphere host.
94 label = Win7
95
96 # Specify the operating system platform used by
   # current machine
97 # [windows/darwin/linux].
98 platform = windows
99
100 # Please specify the name of the snapshot. This
   # snapshot should be taken
101 # while the machine is running and the agent started.
102 snapshot = clean_agent
103
104 # Specify the IP address of the current virtual
   # machine. Make sure that the
105 # IP address is valid and that the host machine is
   # able to reach it. If not,
106 # the analysis will fail.
107 ip = 192.168.56.7
108
109 # (Optional) Specify the OS profile to be used by
   # volatility for this
110 # virtual machine. This will override the
   # guest_profile variable in
111 # memory.conf which solves the problem of having
   # multiple types of VMs
112 # and properly determining which profile to use.
113 # Profiles defined by Volatility, see link below for
   # more information
114 # https://github.com/volatilityfoundation/volatility/
   # wiki/2.6-Win-Profiles
115 # Windows profiles only. Linux and Mac OS profiles can
   # be found in the link below
116 # https://github.com/volatilityfoundation/profiles
117 osprofile = Win7SP1x64_23418
```

J Cuckoo Web GUI options


 Configure your Analysis


 **Global Advanced Options**

Options you change here are globally persisted to all files in your selection.

Network Routing 
<https://cuckoo.sh/docs/installation/host/routing.html>

NONE	DROP	INTERNET	INETSIM	TOR
				TOR

VPN via 

Package  Priority

LOW	MEDIUM	HIGH
LOW	MEDIUM	HIGH

Timeout

SHORT	MEDIUM	LONG	...	SECONDS
60	120	300	...	

Options

Remote Control
Enables Guacamole UI for VM

Enable Injection
Enable behavioral analysis.

Process Memory Dump

Full Memory Dump
If Volatility has been enabled, process an entire VM memory dump with it.

Enforce Timeout

Enable Simulated Human Interaction
Disable this feature for a better experience when using Remote Control

EXTRA OPTIONS What can I use?
(<https://cuckoo.sh/docs/usage/packages.html>)

NAME	VALUE
name	value

To add a new option, type the option name + value and hit enter. It will add itself to the list. Remove an item by clicking the right remove icon.

Machine


Win7 

Figure 23: Cuckoo Web GUI options

K Ansible directory structure

```
Ansible-Cuckoo/
|-- cuckoo-playbook
|   |-- inventories
|   |   |-- production
|   |   |   |-- group_vars
|   |   |   |   --- all
|   |   |   --- hosts
|   |   --- staging
|   |       |-- group_vars
|   |       |   --- all
|   |       --- hosts
|   |-- roles
|   |   |-- build_directory
|   |   |   --- tasks
|   |   |       main.yml
|   |   |-- cuckoo
|   |   |   |-- files
|   |   |   |   |-- auxiliary.conf
|   |   |   |   |-- avd.conf
|   |   |   |   |-- cuckoo.conf
|   |   |   |   |-- esx.conf
|   |   |   |   |-- kvm.conf
|   |   |   |   |-- limits.conf
|   |   |   |   |-- memory.conf
|   |   |   |   |-- physical.conf
|   |   |   |   |-- processing.conf
|   |   |   |   |-- qemu.conf
|   |   |   |   |-- reporting.conf
|   |   |   |   |-- routing.conf
|   |   |   |   |-- sysctl.conf
|   |   |   |   |-- virtualbox.conf
|   |   |   |   |-- vmware.conf
|   |   |   |   |-- vsphere.conf
|   |   |   |   |-- vsphere.py
|   |   |   |   --- xenserver.conf
|   |   |   --- tasks
|   |   |       --- main.yml
|   |   |-- cuckoo_user
|   |   |   --- tasks
|   |   |       --- main.yml
|   |   |-- elasticsearch
|   |   |   |-- files
|   |   |   |   --- elasticsearch.yml
|   |   |   --- tasks
|   |   |       --- main.yml
|   |   |-- inetsim
|   |   |   |-- files
```

```
| | | | |-- inetsim
| | | |   --- inetsim.conf
| | | |   --- tasks
| | | |     --- main.yml
| | |-- moloch
| | | |-- files
| | | | |-- Configure
| | | | |-- molochcapture.service
| | | | |-- molochviewer.service
| | | | --- tasks
| | | |   --- main.yml
| | |-- network
| | | --- tasks
| | |   --- main.yml
| | |-- openvpn
| | | |-- files
| | | | |-- openvpnclient.service
| | | | |-- openvpn.conf
| | | | |-- route.py
| | | | |-- rt_tables
| | | | --- tasks
| | | |   --- main.yml
| | |-- postgresql
| | | --- tasks
| | |   --- main.yml
| | |-- python
| | | --- tasks
| | |   --- main.yml
| | |-- python_packages
| | | --- tasks
| | |   --- main.yml
| | |-- start_up_cuckoo
| | | |-- files
| | | | |-- cuckoo_api.service
| | | | |-- cuckoo_router.service
| | | | |-- cuckoo.service
| | | | |-- cuckoo_web.service
| | | | --- tasks
| | | |   --- main.yml
| | |-- suricata
| | | |-- files
| | | | |-- oinkmaster.conf
| | | | |-- suricata
| | | | |-- suricata.log
| | | | |-- suricata.yaml
| | | | --- tasks
| | | |   --- main.yml
| | |-- tor
| | | |-- files
| | | | --- torrc
| | | | --- tasks
| | | |   --- main.yml
| | |-- ubuntu_packages
```



```
| | | --- tasks
| | |     --- main.yml
| | |-- volatility
| | | --- tasks
| | |     --- main.yml
| | --- yara
| |     --- tasks
| |     --- main.yml
| --- site.yml
|-- install_ansible.sh
|-- LICENSE.md
--- README.md

49 directories, 62 files
```

Listing K.1: Ansible directory structure

