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**Report**

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# Sniff Hynesim

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# Contents

# Abstract

This project consist in elaborate the cyber defense of a system virtualize on Hynesim. I had to detect all attacks against my system. During this project, Justin Bouroux achieve attacks. The project try to know the state of the system and analyze it with model to know if there is an attack.

# Introduction

Cyber security is one of the major threats of the 21st century, and attackers use increasingly sophisticated techniques. So one of the most important aims for cyber security engineers is to find a way to detect and stop attacks. To do that effectively cyber engineers need to analyze cyber attacks to find a way to detect them. One solution is to use simulators of network and information systems to reproduce scenario of attacks. Simulators permit to achieve attacks in a closed space with a huge agility. To do so, ENSTA Bretagne has decided as Thales and the DGA (French Procurement Agency) to use Hynesim[1].

The aim of this project is to elaborate a system of alert on Hynesim. This system need to analyze network events and applications events. To do that, I have to install an IDS[2] to analyze network traffic and implement an SIEM[3] to aggregate alerts. Then, with all these events the SIEM may establish the state of the system. If we consider that we are able to know all possible states of systems via model checking, the SIEM may know if the system is on a attacked state.

To begin, I will achieve a bibliographic study which will present Hynesim, IDS and SIEM. Then, I am going to present the subject, the choices made to answer the topic, and the organization set up in this project. And to finish, I will explain how I installed the tools available to me, how I achieved the other tools that I needed, and the results of the project.

[1] This software is presented in the chapter 1

[2] Intrusion detection system

[3] Security information and event management

# Part I

# Bibliographic study

CHAPTER 1

# Hynesim

Firstly, I will present Hynesim. In fact, I will use this tool to create our network and test our solution so it is important to introduce it.

## 1.1 Presentation

Figure 1.1: Hynesim logo

**Definition 1.1 :** *Hynesim*
Means HYbrid NEtwork SIMulation, is a distribution platform of simulation of information systems developed by Diateam. [3]

The platform was initially developed by Diateam for DGA[1] MI (Maitrise de l'information) to create virtual networks. But now is a major project to develop information systems and automatize cyber security attacks. This project has two version, an open source version and a professional version. The open source version has less options, but I will use this version for this project.

## 1.2 Architecture

In order to work, Hynesim needs a server with on it the main software. This software is the virtualization part. It manages virtual machines and networks.

Moreover, to see virtual machine and interact with them, users needed to have a client interface. This interface can be installed on a simple computer.

To add a virtual machine to Hynesim, I need to create it on Virtual Box[2] or VMWare[3] and then import them on Hynesim.

[1] French Procurement Agency
[2] More information here: `https://www.virtualbox.org/`
[3] More information here: `https://www.vmware.com/`

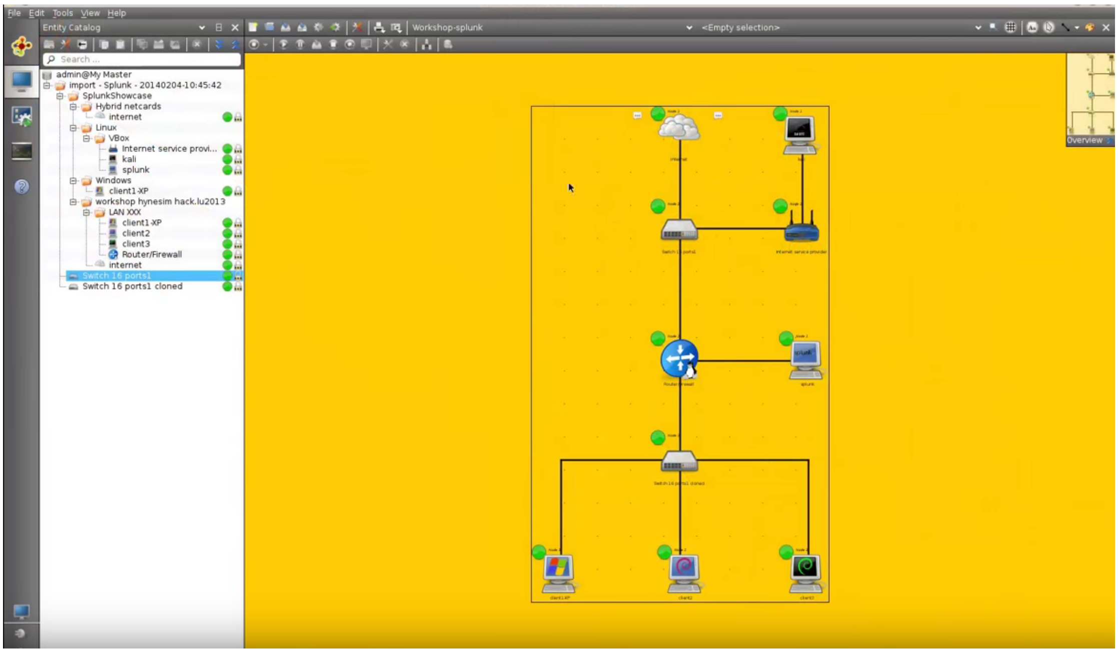


Figure 1.2: An example of a client Hynesim interface

CHAPTER 2

# IDS

In this subject, a probe will be created to detect attacks. It is the aim of IDS that I are going to introduce.

## 2.1 Presentation

**Definition 2.1 :** *IDS*
An intrusion detection system (IDS) inspects all inbound and outbound network activity and identifies suspicious patterns that may indicate a network or system attack from someone attempting to break into or compromise a system. [2]

There are many type of IDS:

- NIDS, network IDS. They listen and analyze the network and detect attacks from network packets. They are the most interesting for our subject, so this document will focus primarily on this type of IDS.
- HIDS, host IDS. These IDS are on a system and they detect intrusion within it.
- Hybrid IDS. They are composed of NIDS and HIDS.
- IPS. They are NIDS with active functions which help to stop attackers.
- KIDS/KIPS, kernel IDS. They are types of HIDS. They are on the system kernel. They are more effective and slower than HIDS.

In the following document I will talk about NIDS. But to detect attacks there is also many methods.

To be efficient IDS should have a good balance between some features.

- **Speed:** In fact an IDS should analyze packets as fast as possible, otherwise, it will behind the network traffic.
- **False alarm:** An IDS raises an alert when it detect attacks. But it could raise alarm during a normal utilization, a false alarm. It is one of the most important features, because at every alarm a system administrator needs to analyze the alert. So in company, every alarm cost time and money.
- **Probability of detection:** For an IDS, the capacity of detecting attacks. The higher the probability the more the IDS will raise false alarms. In some sensitive systems, I prefer to detect every attack and raise many false alarms. That depends on the system.

## 2.2 Detection methods

### 2.2.1 Misuse detection

This technique is the simplest. It uses attack signature to raise alerts. In fact, all attacks have a particularity, if I detect this particularity I can detect the attackers. There are three sub methods.

#### Pattern matching

In this technique I have a base of signature and the IDS looks for the pattern. If the pattern matches perfectly, this IDS raises an alert.

The problem is, only attacks which are in our base can be detected. So if there is a new attack (zero day), or if the attack is not perfectly the same, it cannot be detected.

However, this method is much used because it is high-performance, and with this method the IDS don't raise a lot of false alerts

#### Dynamic pattern matching

In this techniques the IDS is also based on signature but this data base is dynamic. In other words, the IDS has the faculty of adaptation and learning. The IDS improve its data base of signature automatically.

#### Protocol analysis

The last sub method I will present is the protocol analysis. This technique is based on the verification of protocol. The IDS will check if flows are compliant with RFC[1] standards. It will verify parameters of packets and fields. An IDS can check many protocols such as FTP, HTTP, ICMP, . . .

The advantages of this method is that I can detect unknown attacks contrary to pattern matching. However, software publishers don't often respect RFC so this technique is not always very efficient.

### 2.2.2 Anomaly detection

This technique consists in detecting an intrusion through the analysis of the user's past behavior. So the IDS should create a profile of users from his use and raises alerts when there is an event outside this profile. To create a profile the IDS could use machine learning.

| Advantages | Drawbacks |
|---|---|
| The IDS should be able to detect every type of attack even unknown (zero days) attacks. | This method is not reliable. Every alteration of the use creates an alert |
| The IDS is autonomous | This method needs a learning period. In fact, this method needs to learn the habit of users, so I need a period without attacks |
|  | Hackers can need only time. In fact, if the attacker creates a new profile after many month with his attacks, he could attack silently |

[1] Requests for Comments, is a type of publication from the Internet Engineering Task Force (IETF) and the Internet Society (ISOC), the principal technical development and standards-setting bodies for the Internet.

**Probabilistic method**

Bayésien network is a learning machine based on probability. The IDS will create a probabilistic model and will raise an alert if the user don't respect this model.

For example, I know that in 90% of cases in an HTTP request the first parameter is GET after a connection to the port 80.

## 2.3 Main IDS

There are many IDS on the market. The most popular open source solutions are Snort, Suricata, Bro, Fail2Ban, ACARM ... There are also some tools «all in one». It is usually OS[2] with an IDS, a tool to analyze alert, a tool to create rules,... The most popular are SELKS and ELKS. A description of SELKS is available page 30.

[2] Operating system

Chapter 3

# SIEM

## 3.1 Description

**Definition 3.1 :** *SIEM*

In the field of computer security, security information and event management (SIEM) software products and services combine security information management (SIM) and security event management (SEM). They provide real-time analysis of security alerts generated by network hardware and applications.[11]

So SIEM are software which aggregate all security information, analyze them, and display them for user.

## 3.2 Capabilities

- **Data aggregation** aggregate data from many sources: network, IDS, log, applications, etc. . .
- **Correlation** Analyze alerts and events to correlate them to spot an attack.
- **Reporting and alerting** Create alert and reporting more clear.
- **Visualization** SIEM permit visualization of all event with for example dashboard.
- **Log management** Store all log in a central location. This permit to do forensic many month after events.

## 3.3 Main SIEM

There is many SIEM on the market. The most popular open source solutions are Prelude, OSSIM, and Cyberoram.

# Part II

# Presentation of the topic

CHAPTER 4

# Presentation of the subject

After this bibliographic study, I will present the subject of my work and the aim of it. My work supposed that a model checking was done, so I will firstly explain that.

## 4.1 Model checking

Since few years, we are able to realize model to represent systems. These models permit to simulate systems. To do these models, there is many languages UML, SysML, Fiacre,. . . The figure 4.1 represents an example of a complex system.

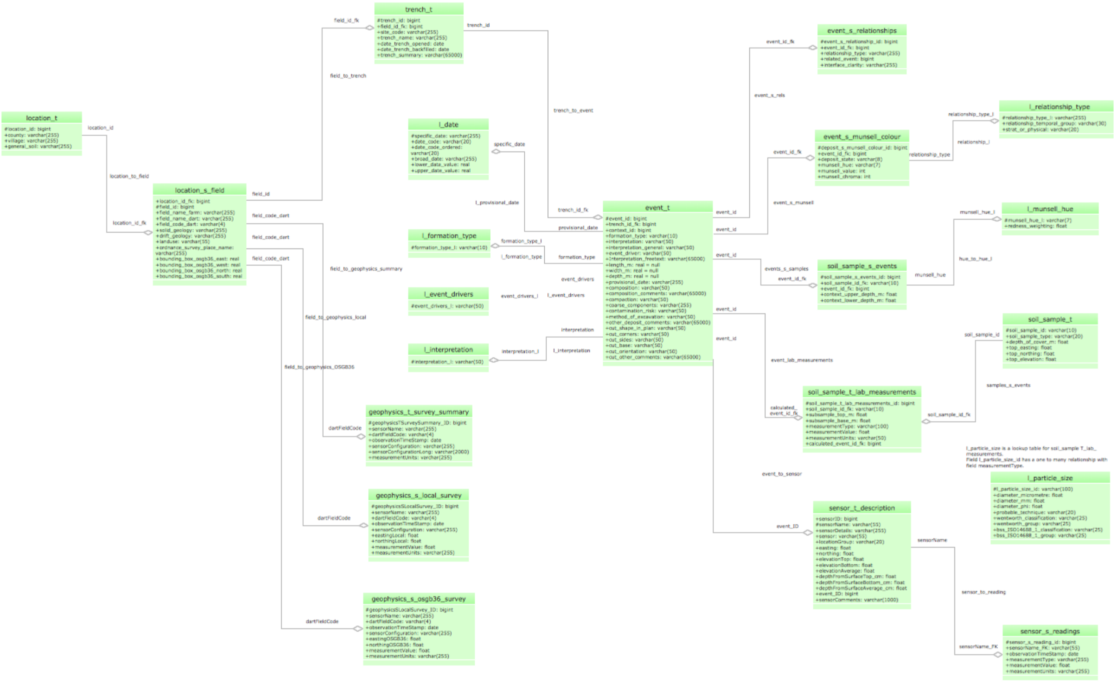


Figure 4.1: Complex model in UML

Then with the simulation of these systems, we can imagine that we are able to find all possible states of our system. So we know that if we are not in a valid state of the system, the system was potentially hacked.

## 4.2 Position of my project

So for my project, I guess I have all possible states of my system and I will check these possible states with the current status of the system. To do so, I have to find the state of applications and the state of the network, and analyze them. Of course, a system is composed by specific applications that I well known because I can do model checking.

I choose to use an IDS to have the status of the network. In fact, an IDS can raise alert when there is particular message, so I will raise event when I sniff particular message. To have a status of an application, I choose to implement probe in applications, or if it is possible use the log of these applications. Then, the SIEM will correlate all these messages and alerts to find the status of our system and it will compare it with all previous possible status.

The figure 4.2 represent the position of our project.

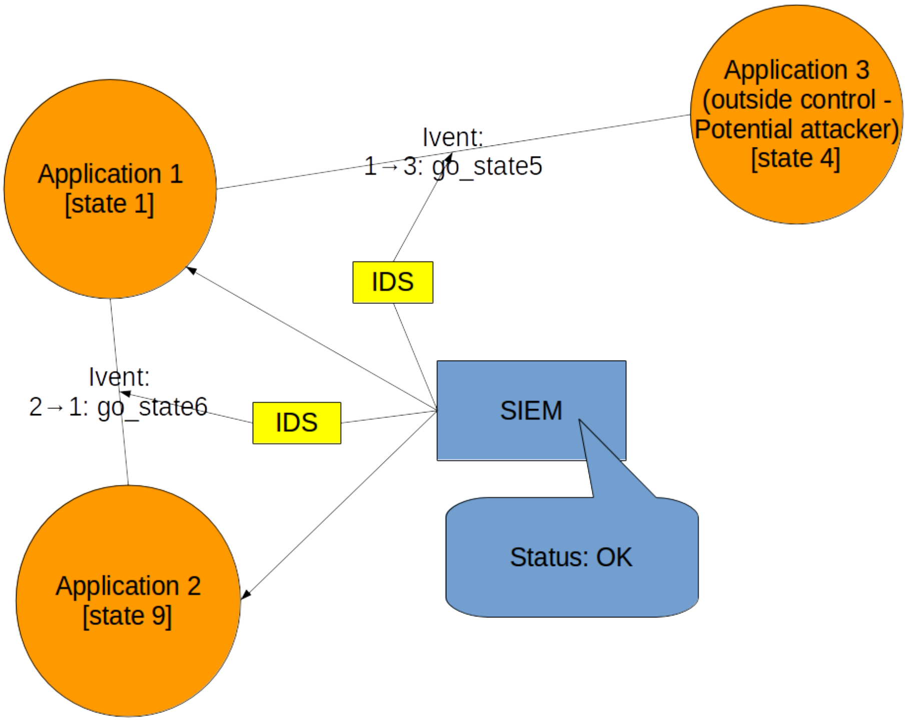


Figure 4.2: Position of my project

CHAPTER 5

# Technical choice

## 5.1 Application created for test

As it was explain before, I have to protect specific applications. To do my tests, and prove the concept of my work, I choose to create a simple application. I plan to add some security issue to be more realistic.

This application has three states, and two parts. Firstly, there is an admin interface which contains the state admin. This interface is connected on the port 9000. Only one specific known computer can access to this interface. Of course, the aim of attackers is to arrive in this state.

Then there is the main interface. It is connected to the port 9124, and everyone can connect to it. There is two states ping and pong. If the application is in the state ping and the user send «topong» the application go to state pong, and if the application is in the state pong and the user send «toping» the application go to the state ping. There is also an unknown backdoor, if the user is in the state ping for the third time and he send «admin», the application go to the admin interface.

The figure 5.1 represents a model of our application.

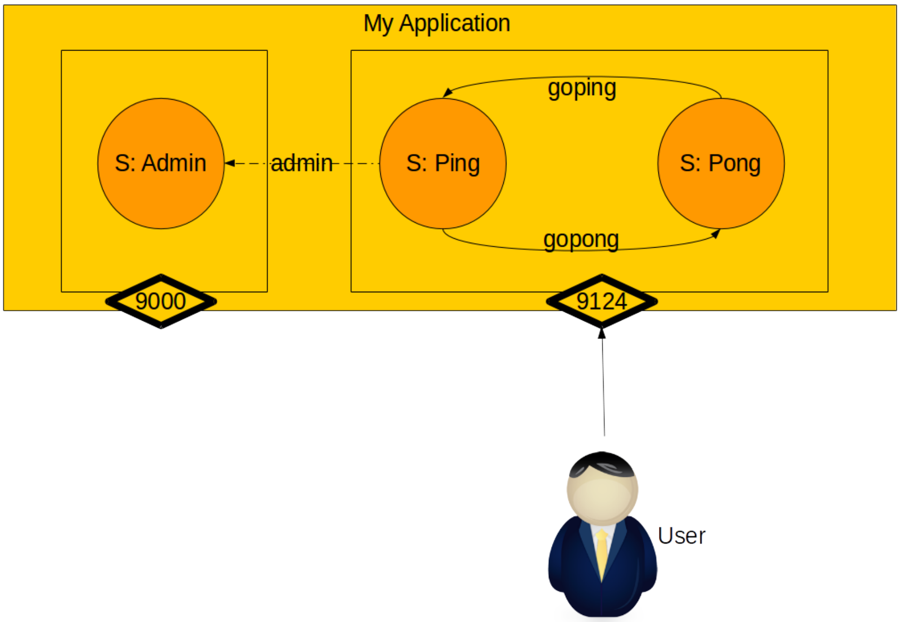


Figure 5.1: Model of the application

## 5.2 IDS

To monitor the network between my applications, I have to install an IDS. In this project, my IDS only need to check network packets and send alerts when it detects patterns. So I choose to use an IDS which use a misuse detection.

Moreover, my IDS only need to raise alert and save them. It is possible to find on the market of open source software many IDS which do that. So I choose one of the most popular open source IDS, SELKS.

## 5.3 SIEM

Then, for the SIEM I had to made a choice: use an open source solution of SIEM, or implement my own solution. The table 5.1 lists advantages and drawback of the two solutions.

| **Prelude** | |
|---|---|
| Advantages | Drawbacks |
| Already implemented | Need to connect it to SELKS |
| More modular | Not adapted to my problem |
| | Need to configure it |
| | Heavy solution |

| **My SIEM** | |
|---|---|
| Advantages | Drawbacks |
| Well adapted for my problem | Need time to implement it |
| Less heavy | Only adapted for my problem |

Table 5.1: Prelude vs my SIEM

For all the reasons cited on the previous table, I choose to implement my own SIEM.

Chapter 6

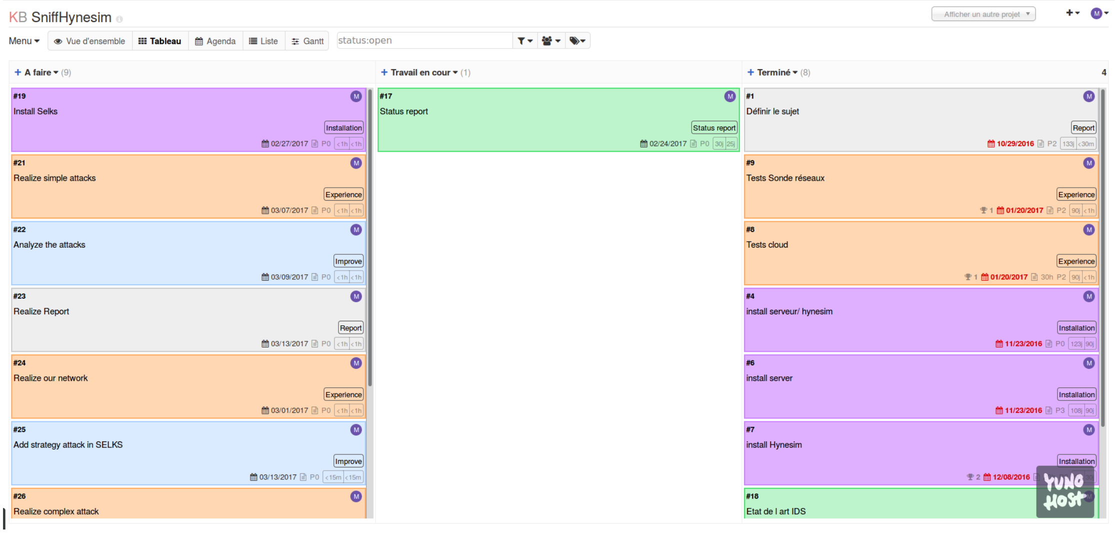
# Forecasting organization

## 6.1 Kanban

To achieve this project, we decided to use some tools to arrange our work. First of all, we decided to use an agile technique of management which name Kanban.

**Definition 6.1 :** *Kanban*
Kanban is a new technique for managing a software development process in a highly efficient way. Kanban underpins Toyota's "just-in-time" (JIT) production system. The kanban system consists of a big board on the wall with cards or sticky notes placed in columns with numbers at the top [9]

Kanban is an inventory-control system to control the supply chain. It uses a board with columns. Each column represents a status, for example: to do, doing, done. In each column we put «notes» which represent a task. Moreover, each column has a maximum number of notes authorized.



A faire (9)

- #19 Install Selks — Installation — 02/27/2017 P0 <1h <1h
- #21 Realize simple attacks — Experience — 03/07/2017 P0 <1h <1h
- #22 Analyze the attacks — Improve — 03/09/2017 P0 <1h <1h
- #23 Realize Report — Report — 03/13/2017 P0 <1h <1h
- #24 Realize our network — Experience — 03/01/2017 P0 <1h <1h
- #25 Add strategy attack in SELKS — Improve — 03/13/2017 P0 <15m <15m
- #26 Realize complex attack

Travail en cour (1)

- #17 Status report — Status report — 02/24/2017 P0 30j 25j

Terminé (8) 4

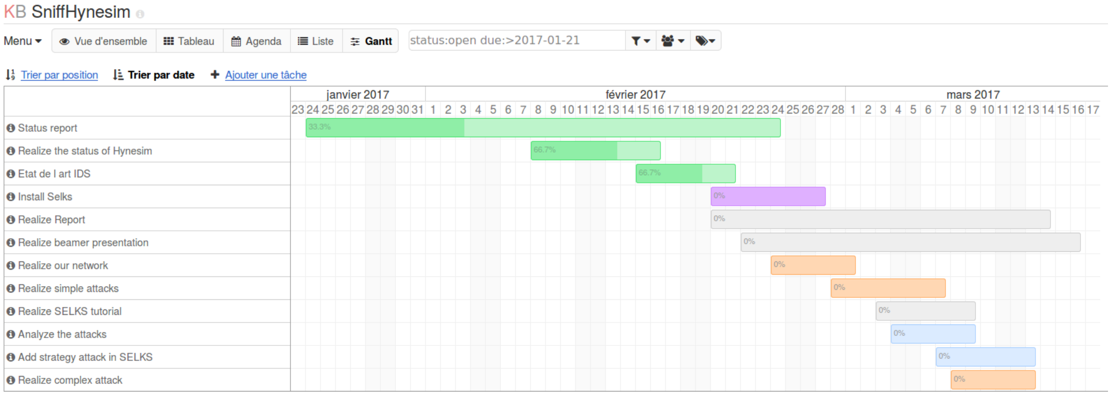
- #1 Définir le sujet — Report — 10/29/2016 P2 133j <30m
- #9 Tests Sonde réseaux — Experience — 1 01/20/2017 P2 90j <1h
- #8 Tests cloud — Experience — 1 01/20/2017 30h P2 90j <1h
- #4 install serveur/ hynesim — Installation — 11/23/2016 P0 123j 90j
- #6 install server — Installation — 11/23/2016 P3 108j 90j
- #7 install Hynesim — Installation — 2 12/08/2016
- #18 Etat de l art IDS

Figure 6.1: Kanboard of this project

Limiting the amount of tasks, at each step in the process, prevents overproduction and reveals bottlenecks dynamically. In fact, with this technique it is possible to have a better overview of the project and control it dynamically.

For this project, we use Kanboard[5] self-hosted on our own Yunohost server.[1]. You can see in the figure 6.1 the kanboard of this project. Each color represent a category of tasks: blue: improvement , purple: installation, red : experience, green: status report, and grey: report.

With this tool, it is also possible to see tasks as a Gantt diagram. The figure 6.2 presents our Gantt diagram.



status:open due:>2017-01-21

- Status report
- Realize the status of Hynesim
- Etat de l art IDS
- Install Selks
- Realize Report
- Realize beamer presentation
- Realize our network
- Realize simple attacks
- Realize SELKS tutorial
- Analyze the attacks
- Add strategy attack in SELKS
- Realize complex attack

Figure 6.2: Gantt diagram of the project

## 6.2 Github

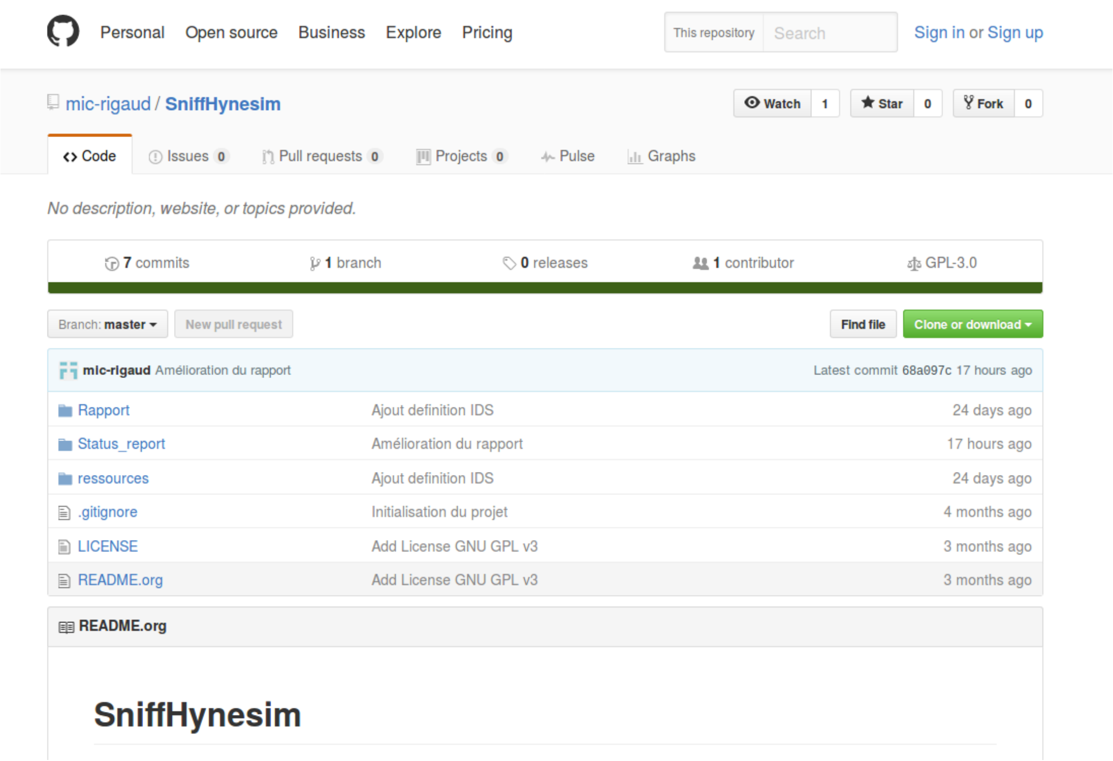
To achieve this project, we also decided to use Git and Github as a Git server.

**Definition 6.2 :** *Git*

Git is a version control system for tracking changes in computer files and coordinating work on those files among multiple people.

Git enables me to control version of our work and obtain a real showcase of it for our tutor. The figure 6.3 is a screenshot of our Github server.

[1] It is possible to see our kanboard at this link: `https://mic-rigaud.fr/kanboard/?controller=BoardViewController&action=readonly&token=10ea65eca908023dbcd8bc8dce75791c7a14d67912627dafaa5b71033222`



No description, website, or topics provided.

mic-rigaud Amélioration du rapport — Latest commit 68a097c 17 hours ago

| | | |
|---|---|---|
| Rapport | Ajout definition IDS | 24 days ago |
| Status_report | Amélioration du rapport | 17 hours ago |
| ressources | Ajout definition IDS | 24 days ago |
| .gitignore | Initialisation du projet | 4 months ago |
| LICENSE | Add License GNU GPL v3 | 3 months ago |
| README.org | Add License GNU GPL v3 | 3 months ago |

README.org

SniffHynesim

Figure 6.3: Github server

# Part III

# Technical study

CHAPTER 7

# Installation

## 7.1 Hynesim

### 7.1.1 Requirement

To use Hynesim, Justin and I had to install the open source version of Hynesim server. To do so, M Champeau give us a computer with 16G of RAM. I installed Debian 8 on this machine. Them I installed the hynesim server with the basics networks equipment. I follow the instructions write on the Hynesim web-page.

Then, Justin configure Hynesim to be accessible with the client. I will not detail this part, if you want more information you can read his report.

### 7.1.2 Import of virtual machines

Hynesim works with many virtual software as qemu, virtualbox, and vmware. For this project I use qemu because it is the most suitable for hynesim. To create virtual computer on hynesim, I firstly created the machine on virtualbox, then I converted it to a qemu virtual machine and to finish I import this machine to hynesim.

Hynesim is also provided with some virtual equipment: a switch, and an inter topology link.

An important detail, on the hynesim network machines haven't access to the internet. So I had to do update, and install before they are imported.

I created the left part of the network represented on the figure 7.1.

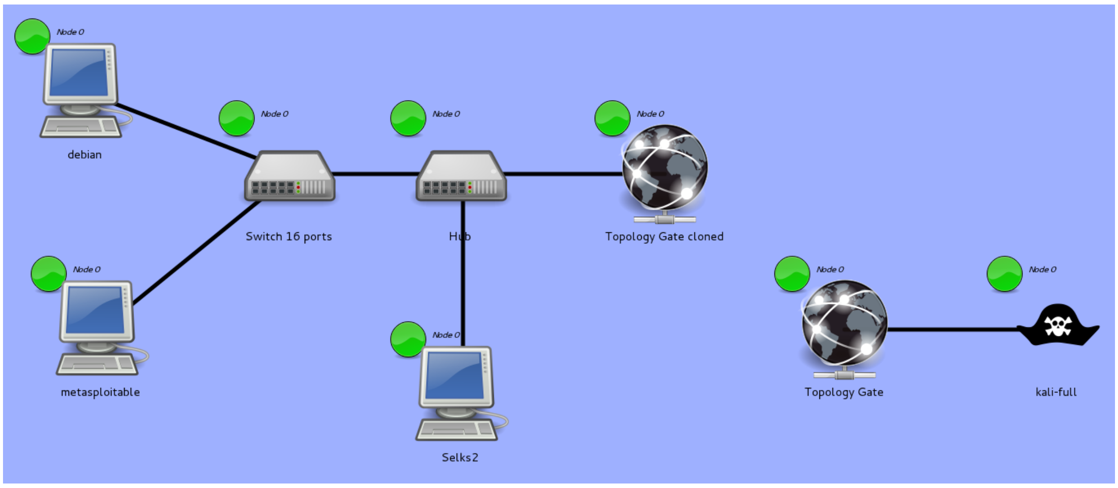


Figure 7.1: Network infrastructure

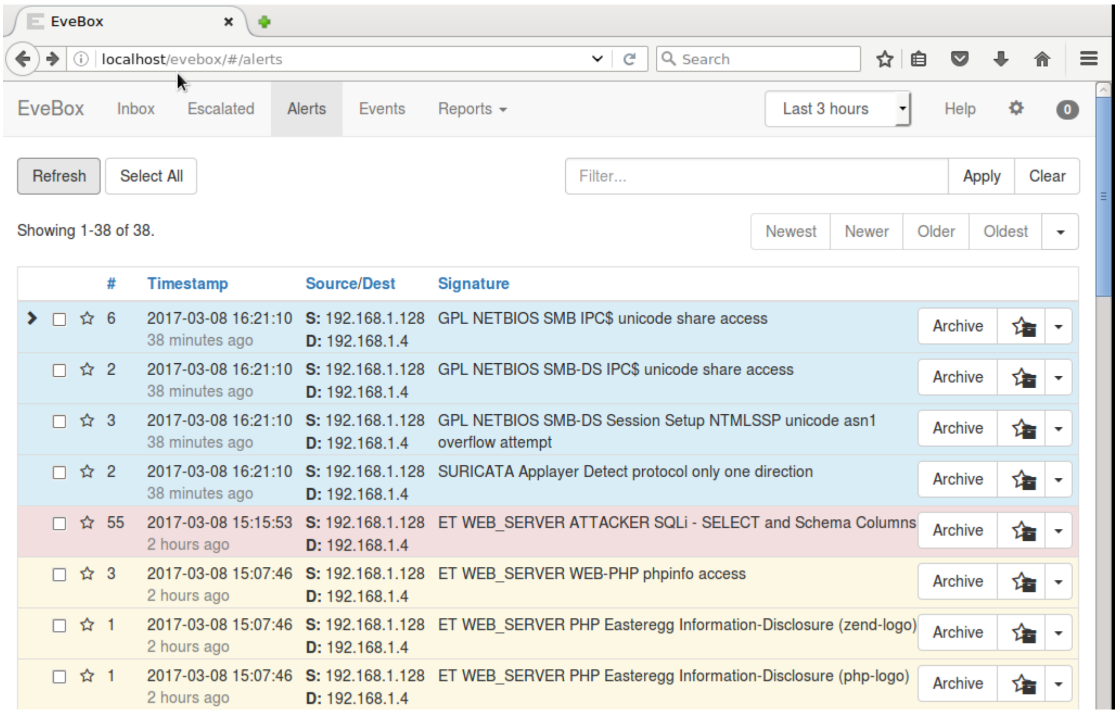
## 7.2 Selks

As it was explain on the previous section, before importing the machine I had to create an virtual machine. To do so, I use an ISO available on the Stamus web page [10] and I create a virtual machine with it. Then, before it was imported, I have set up important libraries for the realization of the SIEM[1].

The ISO is a key in hand version. So Suricata, Elasticsearch, Logstash, Kibana, Scirius, and Evebox are already installed and connected.[2] However, I had to configure some particularity and take in charge the system.

The only particularity that I have to configure during the installation was the network. In fact, on the hynesim network there is no DHCP, so I had to configure by hand the IP of the machines. Moreover, I had to configure on Suricata the private address domain. In fact, Suricata doesn't pay so much attention to networks packets from the private network.

Then, I tested my IDS with basic attacks[3]. The can see on the figure 7.2 the evebox interface which permit to visualize alerts raised by Suricata.



Showing 1-38 of 38.

| | # | Timestamp | Source/Dest | Signature |
|---|---|---|---|---|
| › ☐ ☆ | 6 | 2017-03-08 16:21:10<br>38 minutes ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | GPL NETBIOS SMB IPC$ unicode share access |
| ☐ ☆ | 2 | 2017-03-08 16:21:10<br>38 minutes ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | GPL NETBIOS SMB-DS IPC$ unicode share access |
| ☐ ☆ | 3 | 2017-03-08 16:21:10<br>38 minutes ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | GPL NETBIOS SMB-DS Session Setup NTMLSSP unicode asn1 overflow attempt |
| ☐ ☆ | 2 | 2017-03-08 16:21:10<br>38 minutes ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | SURICATA Applayer Detect protocol only one direction |
| ☐ ☆ | 55 | 2017-03-08 15:15:53<br>2 hours ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | ET WEB_SERVER ATTACKER SQLi - SELECT and Schema Columns |
| ☐ ☆ | 3 | 2017-03-08 15:07:46<br>2 hours ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | ET WEB_SERVER WEB-PHP phpinfo access |
| ☐ ☆ | 1 | 2017-03-08 15:07:46<br>2 hours ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | ET WEB_SERVER PHP Easteregg Information-Disclosure (zend-logo) |
| ☐ ☆ | 1 | 2017-03-08 15:07:46<br>2 hours ago | **S:** 192.168.1.128<br>**D:** 192.168.1.4 | ET WEB_SERVER PHP Easteregg Information-Disclosure (php-logo) |

Figure 7.2: Example of alerts

[1] More information on the chapter 8.3

[2] For more information you can can read the annex A

[3] These attacks were achieve by Justin Bouroux

# Chapter 8

# Implementation

In this chapter, I will explain how I implemented my solution.

## 8.1 Application

First of all, I implemented the application for the tests. I choose to implement this application in python and it is hosted on the computer named Dedian (cf figure 7.1). As it was explain in the chapter 5, this application has three state: Ping, Pong and Admin.

Considering I have to implement the defense of this application, I have to delimit the sensitive space. It is obvious for this application, the sensitive state is the admin state. So I have to send many event when the user try to access to the admin interface. In this way I could know if somebody try without success to access to the admin interface, this person is doubtless an attacker.

To raise event, I send messages to a particular Logstask instance which is on SELKS. These messages contain the time and the state of the application. I will explain after, how the Logstash instance work.

| | |
|---|---|
| Hosted | Debian |
| Language | Python |
| States | Ping, Pong, Admin |
| Sensitive state | Admin |
| Port open | 9124, 9000 |
| Outdoor communication | Selks to port 5000 |
| Port 9124 accept communication from | Everybody |
| Port 9000 accept communication from | Metasploitable only |

Table 8.1: Features of the application

## 8.2 Probe

### 8.2.1 Network probe

I already explain that I use SELKS as IDS, but I had to configure it to adapt it to my application. So I had rules on the Suricata ruleset. To add rules, I use the scirius interface which permit to administrate suricata's ruleset. I added the next rules:

```
alert tcp any any -> any 9124 (msg:"Action␣goping"; \
content:"goping"; sid:501; rev:5000;)

alert tcp any any -> any 9124 (msg:"Action␣gopong"; \
content:"gopong"; sid:502; rev:5001;)

alert tcp any any -> any 9000 (msg:"Connexion␣vers␣l␣interface␣admin"; \
flow:established,to_server sid:504; rev:5002;)
```

### 8.2.2 Application probe

As it was explain before, to have the status of the application, it sends to Logstash its status. Then, Logstash filter these messages and write them on the Elasticsearch data base.

On the SELKS computer, there is a Logstash implemented with a filter adapted for Suricata but not for our application. So I write a filter to Logstash adapted for this application, and I run a new instance of Logstash with this configuration on SELKS. By this way, both instance of Logstash do their job without interaction.

The filter implemented, convert plain text message send by my application as json event readable by Elasticsearch. Moreover, the filter add some tag on this events facilitate the research on the data base. These tags are added on the label «alert_signature_id».

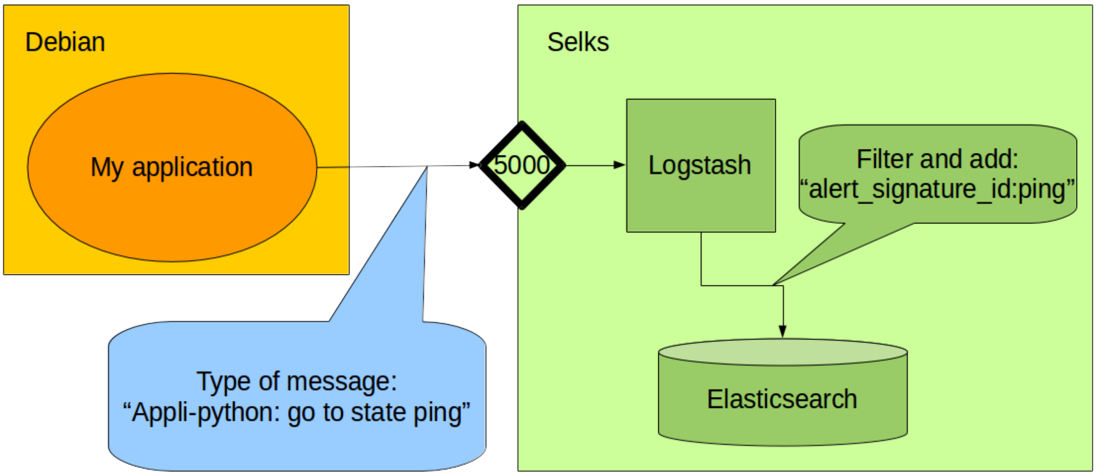
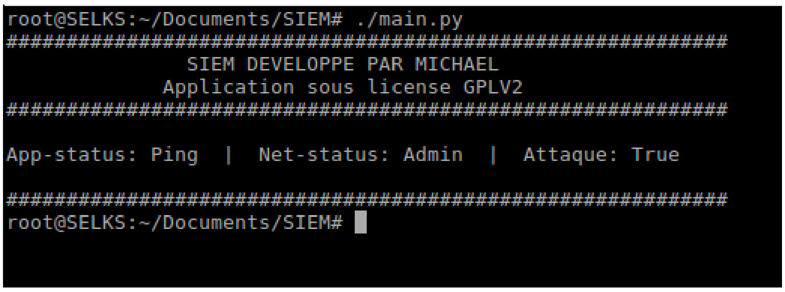


Figure 8.1: Data processing

## 8.3 SIEM

I also achieve to implement a SIEM. To do so, I used the «elasticsearch» library for python. With it I can make request to the data base easily. I collect the last events, I refresh the interface with these information, and analyze its. After analysis, I am able to say if the application is under attack.

The figure 8.2 represent the interface of the SIEM implemented.



```
root@SELKS:~/Documents/SIEM# ./main.py
############################################################
               SIEM DEVELOPPE PAR MICHAEL
             Application sous license GPLV2
############################################################

App-status: Ping  |  Net-status: Admin  |  Attaque: True

############################################################
root@SELKS:~/Documents/SIEM# 
```

Figure 8.2: My siem interface

## 8.4 Summary

The next figure represents a summary of the infrastructure of our system.

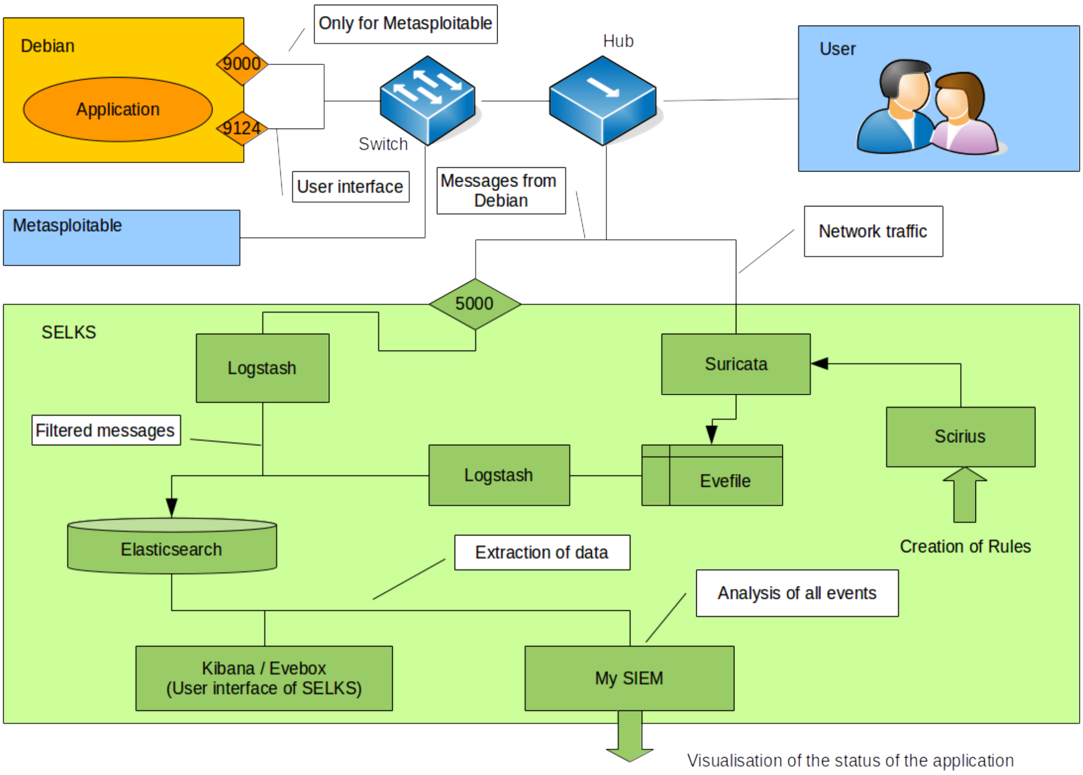


Figure 8.3: Summary of the situation

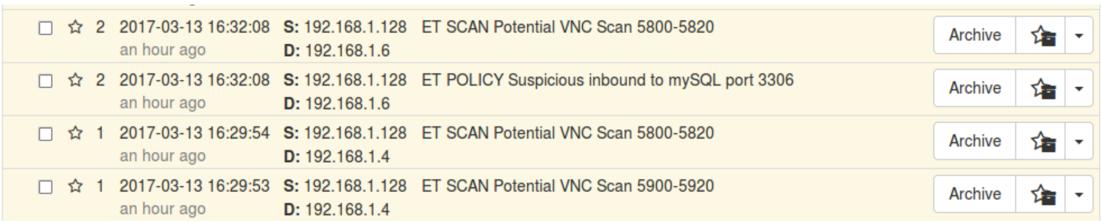
CHAPTER **9**

# Analysis of results

## 9.1 Results

In the system represented before, I represent the cyber defense. On the same system, Justin Bouroux achieved attacks and tried to penetrate the system. Of course, it was designed to have some security issues, but the most important for my system is the detection of its attacks. In fact, all system have security issue even the most secure[1], but if we can detect an intrusion we are able to ensure the service. If you want more information about attacks carried out, you can read the Justin's report.

To begin, when an hacker want to attack a system he always tries to scan the ports. We can notice that my system was able to detect the scan of ports. You can see on the next figure that Suricata raised some warnings during the scan. This warnings represent a possible attacks. It is very important to detect that because it is often the synonym that someone want to attack your system.



□ ☆ 2 2017-03-13 16:32:08 an hour ago S: 192.168.1.128 D: 192.168.1.6 ET SCAN Potential VNC Scan 5800-5820

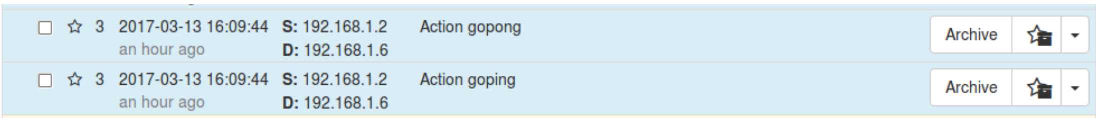
□ ☆ 2 2017-03-13 16:32:08 an hour ago S: 192.168.1.128 D: 192.168.1.6 ET POLICY Suspicious inbound to mySQL port 3306

□ ☆ 1 2017-03-13 16:29:54 an hour ago S: 192.168.1.128 D: 192.168.1.4 ET SCAN Potential VNC Scan 5800-5820

□ ☆ 1 2017-03-13 16:29:53 an hour ago S: 192.168.1.128 D: 192.168.1.4 ET SCAN Potential VNC Scan 5900-5920

Figure 9.1: Events raised during the scan

Then, he has tested the application «ping-pong». On the next figure, it is possible to see the messages «go_ping» and «go_pong» catch by the IDS. The events are raised because I had the rules described on the section 8.2.1.



□ ☆ 3 2017-03-13 16:09:44 an hour ago S: 192.168.1.2 D: 192.168.1.6 Action gopong

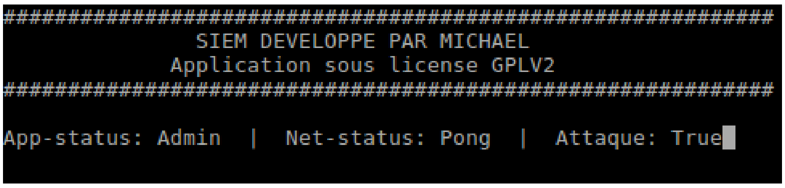
□ ☆ 3 2017-03-13 16:09:44 an hour ago S: 192.168.1.2 D: 192.168.1.6 Action goping

Figure 9.2: Events goping and gopong

Justin, also try to access to the admin interface with the combination of «to_ping», «to_pong», and «admin». It is possible to notice, that my system of detection is able to

[1] A minimum of «zero day»

detect this attack. On the network the attack seems invisible because he isn't logged in the port 9000, but the application send the event «appli-python: go to admin state». So, my SIEM understand that the user has access to the admin interface without using the good interface, so there is a problem: our system is under attack.

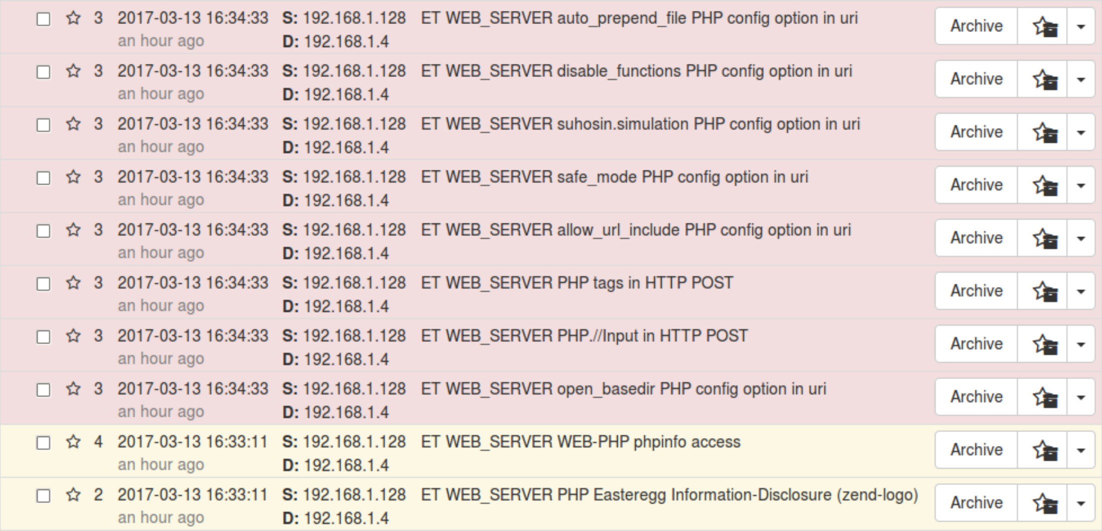


```
##################################################################
               SIEM DEVELOPPE PAR MICHAEL
             Application sous license GPLV2
##################################################################

App-status: Admin  |  Net-status: Pong  |  Attaque: True
```

Figure 9.3: SIEM interface

And to finish, Justin hacked the metasploitable computer to have access to the admin interface on the port 9000. After his attack, my system of detection raise a lot of alert. Firstly, because the IDS has detected his attack against the metasploitable. Secondly, because the application has raised event when he arrived on the admin interface. So, I am able to identify his attack against the metasploitable and connect it to the access of the admin interface.



| | | | | | | |
|---|---|---|---|---|---|---|
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER auto_prepend_file PHP config option in uri | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER disable_functions PHP config option in uri | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER suhosin.simulation PHP config option in uri | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER safe_mode PHP config option in uri | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER allow_url_include PHP config option in uri | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER PHP tags in HTTP POST | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER PHP.//Input in HTTP POST | Archive | |
| □ | ☆ 3 | 2017-03-13 16:34:33<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER open_basedir PHP config option in uri | Archive | |
| □ | ☆ 4 | 2017-03-13 16:33:11<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER WEB-PHP phpinfo access | Archive | |
| □ | ☆ 2 | 2017-03-13 16:33:11<br>an hour ago | S: 192.168.1.128<br>D: 192.168.1.4 | ET WEB_SERVER PHP Easteregg Information-Disclosure (zend-logo) | Archive | |

Figure 9.4: Alerts during metasploitable attacks

A demonstration video will be presented during the presentation.

## 9.2 Way of improve

To summarize, during this test phase I was able to detect all attacks. However, I had some issue. In fact, the Suricata IDS sometimes raises event later. Sometimes 5 minutes after the real event. It is not a problem for a normal IDS, but for our utilization it is. We want to know the states of our system without delay to analyze them. Even if I think the problem can be solved with computer more efficient, it is a real issue.

Moreover, I didn't protect my detector system because of the lack of time, so it is possible to attack it. For example, it is possible to send false messages to the SIEM to hide attacks. It would be necessary to add an authenticity on the messages send by the application to the SIEM.

Finally, we can notice that my system is very huge and very complex. So the transition to scale could be very hard. So the system need some improvements in this direction as well.

# Conclusion

At the end of this study, I succeeded in implementing a detection system. My system of detection uses information extracted from the applications and the network studied. With this information my system is able to determine the status of the system protected. Then, it compare this with the possible states and can know if our system is under attack. For this project, I protected a simple application name «ping-pong».

Our system of detection is a complex system based on an IDS named SELKS and a SIEM adapted for the system protected. It is possible to notice that our system detected during the tests all the attacks envisaged. But it is also possible to underline that it is possible to improve this system of detection. Firstly by improving the speed of the IDS. Secondly by improving the security of our system of detection. And thirdly by improving the modularity of our system.

To conclude, I achieve a complex system of detection which need some improvements. However, this system prove that it is possible to retrieve all the states of an observed system. And if we could model this observed system to determine all possible states via model checking, we could compare this possible states with the current state of the system and thus detect attacks.

So it is a prove of contest of the possibility to use model checking to implement the security rules of an application.

# Annex

# APPENDIX A

# SELKS

**Definition A.1 :** *SELKS*

SELKS is a free and open source Debian (with LXDE X-window manager) based IDS/IPS platform released under GPLv3 from Stamus Networks (https://www.stamus-networks.com/).[10]

The SELKS ISO is both Live and Installable ISO in one. Once installed it is ready to use out of the box solution.

SELKS is comprised of the following major components:

**S** Suricata IDPS - http://suricata-ids.org/

**E** Elasticsearch - http://www.elasticsearch.org/overview/

**L** Logstash - http://www.elasticsearch.org/overview/

**K** Kibana - http://www.elasticsearch.org/overview/

**S** Scirius - https://github.com/StamusNetworks/scirius

So SELKS is an OS which contains many softwares. Firstly there is Suricata which is the network analyzer which raise alerts. Alerts produce by Suricata are written in a EVE file. Then Logstash traduce this file into a JSON file readable by Elasticsearch. Elasticsearch is a data base. It keep all event and permit a navigation into many millions of events almost instantaneous. And to finish Kibana and Evebox propose a User interface for this data base. The figure A.2 represents this architecture.[1]

You can see on figure A.3, an example of the interface of kibana which give an overview of alerts. This image was extract from the Twitter of Stamus Networks.

Figure A.1: screenshot of SELKS desktop

[1] SIEM (security information and event management) which are not developed here, are software to analyze and display event of every security tools.

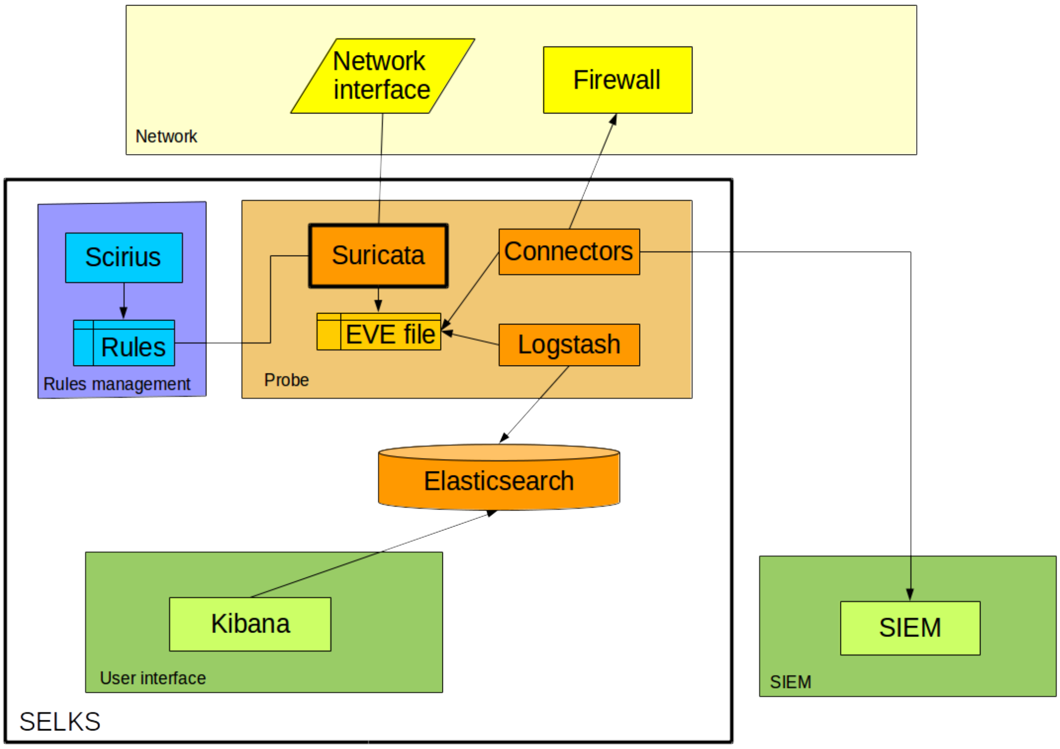
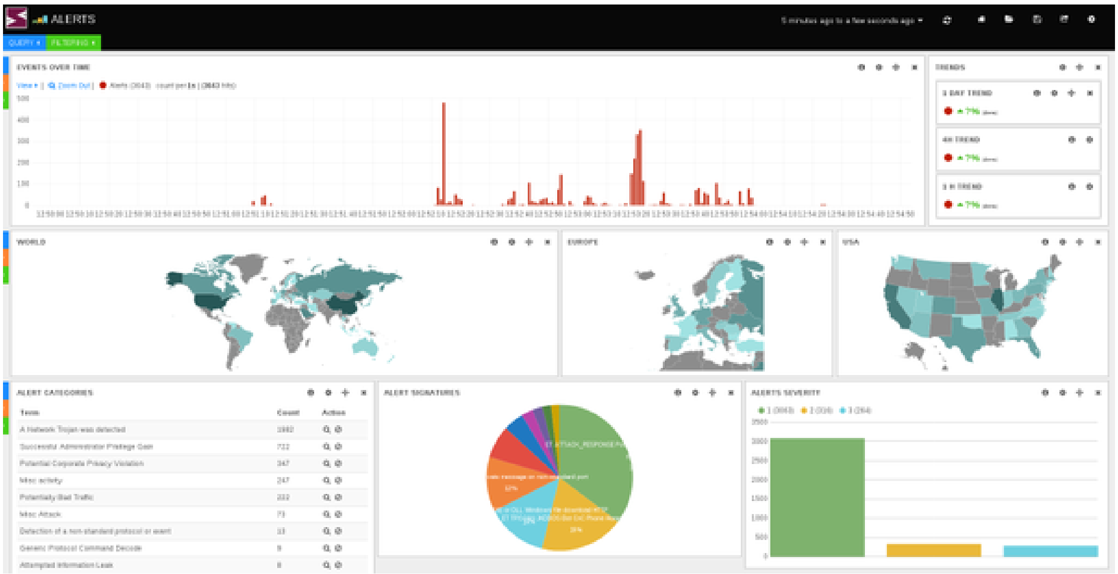


Figure A.2: Selks architecture



| Term | Count | Action |
|---|---|---|
| A Network Trojan was detected | 1982 | |
| Successful Administrator Privilege Gain | 722 | |
| Potential Corporate Privacy Violation | 347 | |
| Misc activity | 247 | |
| Potentially Bad Traffic | 222 | |
| Misc Attack | 73 | |
| Detection of a non-standard protocol or event | 13 | |
| Generic Protocol Command Decode | 9 | |
| Attempted Information Leak | 8 | |

Figure A.3: Kibana interface

# List of Figures

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