Digital forensics

Handbook, Document for teachers

September 2013

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Acknowledgements

ENISA wants to thank all institutions and persons who contributed to this document. A special "Thank You" goes to the following contributors:

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Main Objective	Present the trainees with the principles of digital forensics and evidence gathering. Establish a common knowledge of the requirements regarding evidence admissibility in the court of law. Show a server-centric approach to evidence gathering as a valuable source for further legal proceedings as well as for establishing patterns of malicious activity. The patterns are then used to quickly identify similar events from the past in the future as they take place. The exercise also gives an overview of popular malware characteristics, methods of identification and tools that may be used at the scene.	
Targeted Audience	The exercise is intended for CERT staff involved in the process of early fraud investigations to establish mechanisms of fast response to future events and detect similar actions in other archived data. It applies especially to events when there is a possibility of further legal actions.	
Total Duration	5.5 hours	
Time Schedule	Introduction to the exercise	0.5 hours
	Task1: Identify characteristics in HTTP session of fraud	1.5 hours
	Task 2: Identify other attacked customers based on these characteristics	1.0 hours
	Task 3: Hands-on analysis of memory process dump	2.0 hours
	Summary of the exercise	0.5 hours
Frequency	It is advised to organise the exercise once a year or when new people join the CSIRT/CERT team.	

1 General Description

The main goal of this exercise is to provide the trainees with technical knowledge of tools and reasoning used in digital forensics. Trainees are required to focus on details during the examination of system data as they craft a script to detect similar events throughout the evidence. They get insights into network monitoring as well, learning that information gathered from logging systems and IDS sensors is crucial in any investigation as well as in regular incident handling practices.

The course scenario is based on a common scheme of an electronic banking fraud, when the evidence may only be gathered on the bank side. Only a small percentage of such cases include examining evidence at the client side, especially in a situation where the case is not supported by Law Enforcement Agencies or gains the support late in the investigation.

This exercise also presents the trainees with basic principles of evidence. At all times the trainees should be aware of the documentary characteristics of the gathering process, and principles stated in the exercise introduction must be applied.

The exercise consists of 3 components:

1. Identifying the pattern of the malicious activity,
2. Identifying other cases with the same pattern,
3. Analysing collected malware. [1]

[1] *ENISA CERT Exercises – 'Identification and handling of electronic evidence' -* https://www.enisa.europa.eu/activities/cert/support/exercise

2 Introduction

Having a code of laws is one of the rudiments of any modern civilisation. Along with the developments in law, law enforcement units were created. A court of law has the final word on whether someone's act was lawful or not. To make that judgement a court of law has to rely on 'evidence' presented to it.

Evidence is any of the material items or assertions of fact that may be submitted to a competent tribunal as a means of ascertaining the truth of any alleged matter of fact under investigation before it[2].

Traditionally evidence was gathered in physical form. After the invention of photography it became common practice to take photographs at the crime scene and present the photographs along with other evidence. With the digital revolution and following usage of electronic devices in almost all aspects of life it became necessary to allow evidence extracted from electronic devices, especially with electronic storage capacity, for use in judicial proceedings. We call such evidence 'electronic evidence'.

In modern judicial practice electronic evidence is no different from traditional evidence, so it is mandatory that the party introducing it into legal proceedings is able to demonstrate the evidence was left intact from the moment it was collected – including the collecting process.

It must be stressed that electronic evidence, being usually much easier to manipulate than traditional forms of data, require great care when handled to be admissible in a court of law. The seizure, custody, control, transfer, analysis and disposition of the evidence must be chronologically documented in a proper way constituting a 'Chain of custody' (CoC). [3]

Proper handling of any evidence, including electronic evidence, requires following some general guidelines:

Handling by specialists	Each device has its characteristics and handling procedures must adhere to them. Electronic devices are particularly sensitive to unintentional changes to their state, which along with other dangers may lead to rejecting the evidence by the court of law.
Rapid evolution	Rapid evolution of electronic evidence sources requires constant improvement in forensic techniques and procedures.
Use of proper procedures, techniques and tools.	Use of proper procedures, techniques and tools. Along with expert knowledge of forensic engineers, each task requires following procedures while applying proper techniques with adequate tools. Each forensic investigation must be traceable and repeatable by other forensic specialists with the same final conclusion.
Admissibility	Since the ultimate goal is to present the evidence to support a case in a court of law, the evidence must be obtained in compliance with existing law. It must be stressed that laws vary between countries however, in all cases due professional care must be applied.
Authenticity	It must be certifiable to tie the evidence to the case under investigation.
Completeness	It must cover the case completely regardless of the perspective.
Reliability	There must be no doubt about how the evidence was collected and handled that could raise questions about its authenticity and veracity.

[2] *Encyclopedia Britannica – http://www.britannica.com/EBchecked/topic/197308/evidence*
[3] *Wikipedia – https://en.wikipedia.org/wiki/Chain_of_custody*

Credibility	It must be understandable and believable to the court.
Proportionality	The whole process of investigation must be adequate and appropriate, i.e. the benefits gained by a specific action must outweigh the harms for the parties affected by the action.

However, we must remember some unique characteristics of digital evidence:

It's invisible to the untrained eye. Electronic evidence is often retrieved from places known or accessible only to experts.
It may need to be interpreted by a specialist. In many cases information gained requires thorough analysis to uncover properties assuring the information is valid from judicial point of view.
It's highly volatile. A powered electronic device modifies its state every time a specific event happens. Lack of power or a system overwriting old data with new data requires us to preserve electronic evidence as soon as possible.
It may be altered or destroyed through normal use. Devices constantly change the state of memory – allocating it for programs automatically, swapping it to disk or writing chunks of it to a disk file on user request. This characteristic calls for using appropriate tools and techniques from the very moment of identification the evidence as relevant for an investigation.
It can be copied without limits. This property allows many specialists work on the same evidence at the same time in different places. It also enables the possibility of presenting the evidence as-is in the court of law along with the specialist witness report.

The branch of forensic science that focuses on the identifying, acquiring, processing, analysing and reporting of evidence that is stored on computer systems, digital devices and other storage media with the aim of admissibility in court is called Digital Forensics.

There are 5 main principles that establish a basis for all dealings with electronic evidence. These principles were adopted as part of European Union and the Council of Europe project to develop a 'seizure of e-evidence' guide. As stated before, while laws regarding admissibility of evidence differ between countries, using these principles is considered appropriate as they are common internationally. [4]

2.1.1 Principle 1 – Data Integrity

No action taken should change electronic devices or media, which may subsequently be relied upon in court.

- When handling electronic devices and data, they must not be changed, either in relation to hardware or software. The person in charge is responsible for the integrity of the material recovered from the scene and thus for initiating a forensic chain of custody.
- There are circumstances where a decision will be made to access the data on a 'live' computer system to avoid the loss of potential evidence. This must be undertaken in a manner which causes the least impact on the data and by a person qualified to do so.

[4] *This is excerpt from the 'Electronic evidence guide', version 1.0, created as part of CyberCrime@IPA, EU/COE Joint Project on Regional Cooperation against Cybercrime.*

2.1.2 Principle 2 – Audit Trail

An audit trail or other record of all actions taken when handling electronic evidence should be created and preserved. An independent third party should be able to examine those actions and achieve the same result.

- It is imperative to accurately record all activities to enable a third party to reconstruct the first responder's actions at the scene in order to ensure probative value in court. All activity relating to the seizure, access, storage or transfer of electronic evidence must be fully documented, preserved and available for review.

2.1.3 Principle 3 – Specialist Support

If it is assumed that electronic evidence may be found in the course of an operation, the person in charge should notify specialists/external advisers in time.

- For investigations involving search and seizure of electronic evidence it may be necessary to consult external specialists. All external specialists should be familiar with the principles laid down in this or similar relevant documents. A specialist should have:
  - Necessary specialist expertise and experience in the field,
  - Necessary investigative knowledge,
  - Necessary knowledge of the matter at hand,
  - Necessary legal knowledge,
  - Appropriate communication skills (for both oral and written explanations)
  - Necessary appropriate language skills.

2.1.4 Principle 4 – Appropriate Training

First responders must be appropriately trained to be able to search for and seize electronic evidence if no experts are available at the scene.

- In exceptional circumstances where it is necessary that a first responder collects electronic evidence and/or accesses original data held on an electronic device or digital storage media, the first responder must be trained to do it properly and to explain the relevance and implications of his/her actions.

2.1.5 Principle 5 – Legality

The person and agency in charge of the case are responsible for ensuring that the law, the general forensic and procedural principles, and the above listed principles are adhered to. This applies to the possession of and access to electronic evidence. Each Member State should take its own legal documents and regulations into consideration when interpreting the measures proposed in this document.

- One of the internationally important legal documents, the Convention on Cybercrime by the Council of Europe, is currently open for signature by the Member States and the states, which have participated in its elaboration, and for accession by other states.

In the last few years we have witnessed a great change in the banking sector. It has undergone a full transition from a completely closed environment with strict perimeter protection, leased data links and no Internet access even for its employees, to an open world where almost any electronic device can play the role of a banker's workstation. Lack of control over consumer devices is one of the biggest problems in ensuring full security of e-banking environments. As we cannot completely prevent the misuse of e-banking systems, we must build the ability to react and respond to security incidents. This response should always lead to better prevention and detection measures, as well as to legal actions when necessary.

3 Scenario

Present the trainees with the following narrative; they should have the same story in their materials:

A bank customer has recently made a complaint about a transfer of money to an account that was unknown and never used before. According to the customer declaration, the transfer was made at a time when the he/she was not using the electronic banking system.

However, the customer admitted during the call to the Bank hotline that he/she found a text message with the authorisation code for the transfer in question. He/she remembers also playing a bank quiz game for mobile phones. The customer did not notice anything suspicious; he/she declares using only one computer for electronic banking with the same Internet browser all the time.

As a precautionary measure, the customer's password was changed during the call.

You are CSIRT/CERT members in a financial institution. You have just received a notification from your fraud detection system team, that there's been a fraud action with a set of characteristics previously unknown to their systems.

Your task is to help establish a pattern that would allow for finding other transactions that may need further investigation.

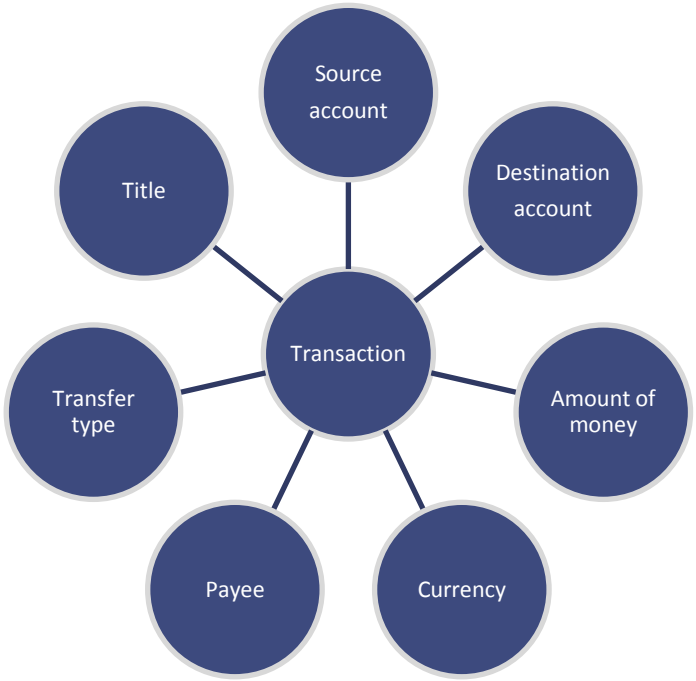
At first, the customer denies access to his/her computer and mobile phone data, so you must utilize any technical means available on the bank's side to find clues about fraudulent transactions. Find data related to the unauthorized transaction.

After the narrative is known, present the participants with some basic information about money transfer data.

We can divide data normally available at a banking system into two main categories:

1. Directly linked to transactions made
2. Additional data, related to the technology used behind the scenes

Information directly linked to the transactions includes:



1. Source and destination account numbers – one of them is typically a local account in the banking system analysed, the other can be local or an account in different bank.
2. Amount of money in the transaction
3. The transaction currency
4. Payee
5. Transfer type (standard, fast, SWIFT and others)
6. Title or description put on the order

Additional data include information specific to the electronic banking system such as:

1. Data regarding user login:
    a. IP address of the far end (user)
    b. Status of the login attempt (success, failure)
2. HTTP session data:
    a. Headers: User-Agent, Accepted-Languages, Accept-Encoding
    b. Cookies
3. Some additional data can be retrieved from external data sources, such as GeoIP database when fed with logged data (IP address in this case)
4. Now discuss with the participants the sources of the information described above.
5. Information about bank transfers must be obtained from a database or a data warehouse used for banking transactions. This source is considered highly reliable; there are numerous teams in every bank working hard to ensure the quality of the data.
6. Electronic banking services are normally configured to collect and store information about users logging in and out to the system. They also log any transactions made and/or authorized by a user to assure non-repudiation. Such information can be obtained from a database similar to the transaction database. Note, that this database supposedly contains only some sort of transaction identifiers or hashes that allow for matching electronic banking information with the transaction information.
7. Now, before the first hands-on task, remind the trainees of the timeline concept and proper evidence evaluation. All the information used must have a valid time stamp, as well as be uniquely identifiable with the electronic banking user. Valid time stamps also mean that the system time is in some way controlled and can be verified to be exact now and in any time in the past.

4 Task 1 – Identify characteristics in the HTTP session of fraud

The main goal of Task 1 is to find the differences between normal and fraudulent HTTP sessions and to identify characteristics of the fraudulent session to be used in next tasks.

Trainees will work with collected log files and use the following tools to extract information from them to achieve the goal:

1) Standard command lines utilities (bash, grep, sort, cut, etc.)
2) GeoIP DB
3) Python/Perl to implement more advanced logic

Although storing data about bank transfers and electronic banking logins is routine, gathering technical information on user sessions (cookies, headers) is rare in web servers' configuration. We can work around this issue by having logged network traffic information into a pcap file for the purpose of incident handling.

We can use scripts or a tool such as BroIDS to generate access_log files from the pcap dump with the content we require for a successful investigation. In our case we will use the *tshark* utility, a terminal version of Wireshark, a well-recognized tool used to dump and analyse network traffic:

tshark -nn -r tcpdump.pcap -T fields -E separator='|' –R 'http.request' -e ip.src -e frame.time -e http.request.uri –e http.user_agent -e http.cookie > tshark.log

To make it handy we've redirected the output to *tshark.log* file

You have collected log files from your transaction environment:

1) access_log from HTTP server, Apache
2) pcap file (tcpdump.pcap) to identify characteristics which are not present in the access_log files
3) syslog.log file containing the log of initiated user sessions, containing cookie information, extracted from pcap file
4) client.csv file containing information about users and their online sessions identified by cookie information

These are stored in /home/enisa/enisa/forensic directory on the virtual machine. You may also want to access publicly available databases such as:

1) GeoIP database
2) 'bad IP' database

To accomplish the task trainees have to find the anomalistic characteristics of the fraudulent session. In this case they need to compare carefully a normal session with the questioned one. The session narrative contains some clues. Allow the groups to search through the data.

Arrange a discussion on the value of gathered information and what to look for in the transaction history of our customer.

Which fields are of interest? Why?

- Source account number – although electronic banking systems encourage people to have more than one account, most commonly only one account is used. But we have to use this information as a reference for other cases of unauthorised transfers.
- Destination account number – might be a local account or an account in another bank. Except in the easiest of cases, it's unlikely this is the ultimate account of the criminal; it may be the first in a chain of accounts, where the length of the chain makes it difficult to reverse the effects of the fraud. It may be another compromised account, local or in yet another bank.

- Amount – the range or a set of sums transferred may be another clue; some banks have different verification policies based on the amount transferred. A criminal may take advantage of this fact.
- Currency – may suggest that money is to be transferred abroad.
- Payee – a common name or a common pattern may lead us to uncovering more suspicious transactions.
- Transfer type – the faster the transfer is the harder it is to withdraw it. A criminal may benefit from this.
- Transfer title – same as regarding payee.

Now, arrange a similar discussion regarding data collected from electronic banking logins. What should be looked for in the login history for this particular login?

- Source IP address – might have been used more than once. Is it different than in legitimate sessions? If it was the same, the customer's computer may be compromised, or the customer is lying.
- Unsuccessful login attempts – did somebody tried to access the account before? Or maybe after user's password was changed?

Maybe GeoIP for source IP address can give us any clues? Were these login attempts coming from a particular region or country?

We know from the Fraud Detection Unit, that the customer questioning has ID **client94777** and the compliant was made by him on 21st August at 17:30 of local time. We know that the user had a legitimate session open during the bank call centre and the customer claimed to have been online with the banking application for around 15 minutes at that time.

Let's search quickly through the collected files to find something about the user. As we've seen looking through the files, the only log to have bank customer information is the user session file client.csv, we should start our search there:

grep client94777 client.csv
client94777,gohlohyigheidoochiezueshoopeiceeche
client94777,ichaewupugohciasahchohwaethohfooquo

There are two sessions found for this user, but we know only the cookies of these sessions. We have to look through system log to see when the two sessions started. We could look into the tshark.log instead of syslog as both files are extracted from a pcap; this one is more readable however:

grep *gohlohyigheidoochiezueshoopeiceeche syslog.log*
Aug 21 15:52:19 debian bank: 62.182.152.59 gohlohyigheidoochiezueshoopeiceeche
grep ichaewupugohciasahchohwaethohfooquo syslog.log
Aug 21 17:16:00 debian bank: 91.226.251.216 ichaewupugohciasahchohwaethohfooquo

We found two sessions as expected, the second one matches the time of a bank call and is a confirmed one. We want to see the details of this session, so we try to find it in webserver access log. The access log however doesn't include cookie information, we have to find it either by date (which normally is impractical with many accesses every second) or by IP address (which is much better unless it's an IP address for a large network proxy):

grep 91.226.251.216 access.log
91.226.251.216 - - [21/Aug/2013:17:16:00 +0200] "GET /login.php HTTP/1.1" 200 291 "-" "Opera/9.80 (X11; Linux x86_64; U; pl) Presto/2.10.229 Version/11.61"

This is a default access log for an Apache webserver, and therefore most commonly encountered. It gives us the information about accessing IP, date (note, it's local time: UTC+2), type of request (GET), requested URI and protocol used(/login.php HTTP/1.1), status code + extended status code (200 291 – codes with a digit 2 in front are generally success codes), referrer (the page user came from, empty in this case), and so called User-Agent – name and the type of the browser (Opera) it's version (9.80) along with information about the system used, type of encoding, extensions and/or html engine used. All this information is provided to 'enhance browsing experience' which means: to be able to modify web content according to browser capabilities and user preferences. In this case a content-rich web service would provide the user with Polish version (note 'pl' in language) of the contents in Unicode (U) but perhaps using HTML instead of ActiveX controls, as this is a connection coming from a Linux box, not a Windows one.

It must be noted however, that the User-Agent string can be easily modified by the user, most browsers can be configured to present themselves as others.

So what can we tell about the other session?

grep 62.182.152.59 access.log
62.182.152.59 - - [21/Aug/2013:15:52:19 +0200] "GET /login.php HTTP/1.1" 200 291 "-" "'Mozilla/5.0 (Linux; U; Android 4.2.2; ru; Nexus 7 Build/JDQ39) AppleWebKit/534.30 (KHTML, like Gecko) Version/4.0 Safari/534.30'"

The session was started at 15:52:19 local time, the IP is different so is the user agent.

Remember from the narrative – the user claimed to use the same computer for all electronic banking activities. Apparently, there's a trace the system is different. It presents as Mozilla with preferred language ru (Russian). Of course both IPs are different, we've searched for them, but did we use all the information we have? What about geolocation of both cases:

geoiplookup 91.226.251.216
GeoIP Country Edition: PL, Poland
geoiplookup 62.182.152.59
GeoIP Country Edition: UA, Ukraine

The browser asked for Russian language, but apparently the connection came from Ukraine. Is there any other clue? Well, the User-Agent field is actually malformed, there is another pair of apostrophes (' ') inside double apostrophes (" "). It does not happen normally. Usually it means the string was manipulated, possibly from a script. However, it doesn't mean this is bad by itself.

Now, after the case is solved, present the trainees with an alternative http server config and the access log generated by this configuration. In that case pcap files wouldn't have been needed, all the information is logged directly by http server. We consider it a good practice to configure a web server in this way for increasing incident handling capabilities.

An example of custom log configuration for Apache webserver is presented below:

CustomLog ${APACHE_LOG_DIR}/access.log "%h %l %u %t \"%r\" %>s %b \"%{Referer}i\" \"%{User-agent}i\" \"%{Accept-Language}i\" \"%{Cookie}i\""

Identified factors:
Identifying that fraudulent session was connected from Ukraine
The web browser identified itself as Mozilla while the user normally connected from Opera
Preferred language was set to Russian
The user agent string was malformed (double quotes used)
A record of information analysed, tools and methods used is maintained

5 Task 2 – Identify other attacked customers based on these characteristics

After the trainees successfully identified a pattern characteristic of the fraudulent session, the next task is to quickly identify other possible victims.

The teams are to prepare a list of customers that have recorded transactions that follow the same pattern. The list will be passed on to the Fraud Detection Team to perform phone verification with listed customers.

Arrange a discussion what details should be included on that list to be useful and complete in phone verification.

Let's play with the search for a while and look for all the small characteristics one by one:

grep Mozilla access.log | wc –l
2429
grep ' ru;' access.log | wc –l
299
grep \"\' access.log | wc –l
155
for i in `cat access.log | cut –f 1 –d ' ' `; do geoiplookup $i; done | grep Ukraine | wc –l
232
for i in `cat access.log | cut –f 1 –d ' ' `; do geoiplookup $i; done | sort | uniq | wc –l
73
cat access.log | wc –l
3252

This demonstration was an example of the importance of matching many small factors together. As we can see there were 2429 connections from Mozilla browser (wc –l counts the lines of input), 299 times the preferred language was Russian, even the malformed header occurred 155 times. There were 232 connections from Ukraine and a total of 3252 connections were initiated from 73 countries, the most exotic ones being A2 Satellite Provider or Trinidad and Tobago.

In the mass of all events registered at a large bank a single property for a connection is not very useful, except for statistics. We have to apply all the information we have at hand to start with the most probable cases:

grep Mozilla access.log | grep ' ru;' | grep \"\'
62.182.152.59 - - [21/Aug/2013:15:52:19 +0200] "GET /login.php HTTP/1.1" 200 291 "-" "'Mozilla/5.0 (Linux; U; Android 4.2.2; ru; Nexus 7 Build/JDQ39) AppleWebKit/534.30 (KHTML, like Gecko) Version/4.0 Safari/534.30'" *212.9.224.171 - - [21/Aug/2013:16:02:14 +0200] "GET /login.php HTTP/1.1" 200 291 "-" "'Mozilla/5.0 (Linux; U; Android 4.1.1; ru; GT-P3110 Build/JRO03C) AppleWebKit/534.30 (KHTML, like Gecko) Version/4.0 Safari/534.30'"* *91.198.140.87 - - [21/Aug/2013:17:08:26 +0200] "GET /login.php HTTP/1.1" 200 291 "-" "'Mozilla/5.0 (Linux; U; Android 2.3.5; ru; HTC_WildfireS_A510e Build/GRJ90) AppleWebKit/533.1 (KHTML, like Gecko) Version/4.0 Mobile Safari/533.1'"* *178.213.184.202 - - [21/Aug/2013:17:14:39 +0200] "GET /login.php HTTP/1.1" 200 291 "-"*

"'Mozilla/5.0 (Linux; U; Android 2.2; ru; HTC Desire Build/FRF91) AppleWebKit/533.1 (KHTML, like Gecko) Version/4.0 Mobile Safari/533.1'"
geoiplookup 62.182.152.59
GeoIP Country Edition: UA, Ukraine
geoiplookup 212.9.224.171
GeoIP Country Edition: UA, Ukraine
geoiplookup 91.198.140.87
GeoIP Country Edition: UA, Ukraine
geoiplookup 178.213.184.202
GeoIP Country Edition: UA, Ukraine

Note the last information, connection from Ukraine was redundant – all connections matching the first three conditions matched the fourth and no further selection occurred. We have to match the connections to real users. Again, as we haven't got cookie information in the access log we must use sources derived from pcap file:

for i in `egrep '62.182.152.59|212.9.224.171|91.198.140.87|178.213.184.202' tshark.log | cut -f 5 -d '|' | cut -f 2 -d '=' `; do grep $i client.csv; done
client94777,gohlohyigheidoochiezueshoopeiceeche
client96707,eidoovoabucoophohzauchahquaiqueeshu
client93597,aethaeghaevishuveechaishohhoojaedii
client98079,zarozaemoshumeigeughoovauthuziezuxe

We've found four bank customers that had the same connection; of course we've found our original customer that complained about the transactions. That's a very good thing of course. We've found three more customers, and the cases should be verified quickly.

Bring to the attention of all trainees that, even if in this example there was a 1:1 match between data sets, we do not need that match in every case to issue an alert. Any money transfer to the same account that follows a fraudulent pattern is suspicious. Every login with a match with a strong connection pattern is suspicious even if there was no transfer of money, it might just have failed for a number of reasons. If all but one suspicious connection were from a single country, VPN or Tor network might have been used.

Success factors:

- Three more suspicious transfers were found

Task summary:

By gaining new but verifiable fraud indicators we can analyse our data sets again. It may allow us to find other clients who were hit by a fraud act but previously undetected.

As we have an established and verified set of fraud indicators we can now build an early detection algorithm.

6 Task 3 – Hands-on analysis of memory process dump

Now we will work on material that was collected by a CERT team, from a workstation of a customer hit by the fraud. The customer agreed to provide you with the information stored on his/her computer. We will verify that the information gathered really contains malware, extract its type, version and verify it's configured to target your bank.

We will use the following tools

1) Standard command lines utilities (bash, grep, sort, cut, etc.)
2) Volatility Framework ver. 2.0 [5] with zeusscan plugins [6]
3) Custom-crafted script decrypting malware config file

We will be working on a memory dump from the infected workstation.

Refer to ENISA Exercise 'Identifying and handling of electronic evidence' for more information about the malware extraction process and first evaluation of gathered data.

Remind the trainees that all actions should be properly documented, as all actions taken must be repeatable by other experts and lead to the same conclusions.

Examinations done previously by the other team, suggest the computer was infected with one of the ZeuS variants. Gathered evidence contains traces of one type of malicious activity (one unknown server, suspected to be a botnet C&C server is contacted).

We follow the path by examining the memory dump with zeusscan, a Volatility Framework (VF) plugin for detecting processes infected with ZeuS malware, versions 1.x and 2.x. Issue the following commands:

cd /home/enisa/enisa/forensic
vol20.py –f memdump.raw zeusscan1
vol20.py –f memdump.raw zeusscan2

While zeusscan1 reports no data, zeusscan2 detected a group of processes that has ZeuS code injected:

[5] *See: https://www.volatilesystems.com/default/volatility and https://code.google.com/p/volatility/wiki/CommandReference22*
[6] *By Michael Hale Ligh http://mnin.blogspot.com/2011/09/abstract-memory-analysis-zeus.html*

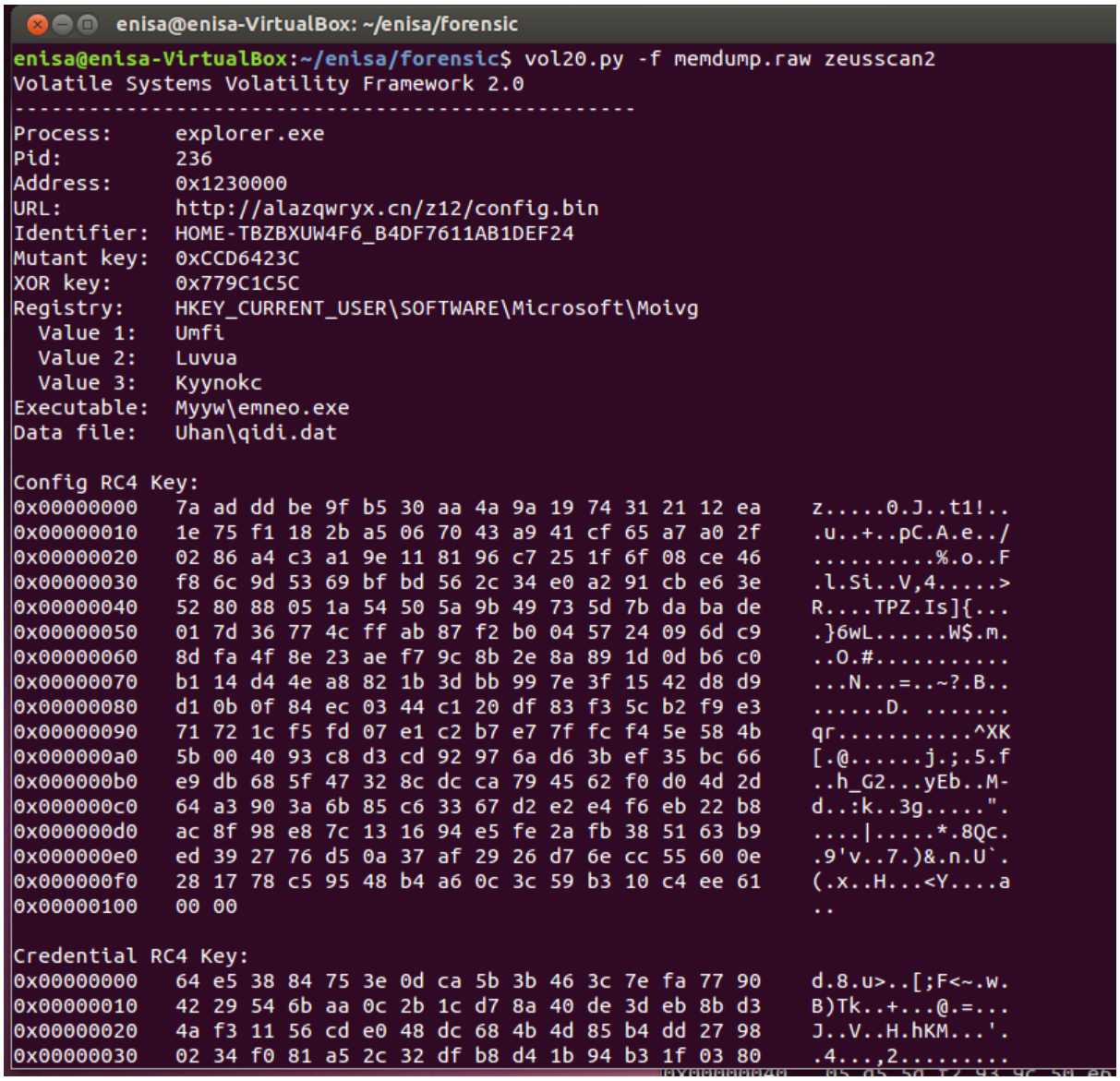


Figure 1: Zeusscan

From the script used we derive a conclusion the station is actually infected with ZeuS version 2.x, we will examine it in more detail soon.

For each infected process the zeusscan scripts returns an RC4 script used for decrypting the ZeuS config file, along with some more information: binary file path, datafile path, windows registry keys and the config file location. We can see that all the keys are the same, so we've got only one instance of ZeuS malware on this computer.

We need to access the config file data so we need to decrypt it first. We copy the config file and save it in data/key.txt file:

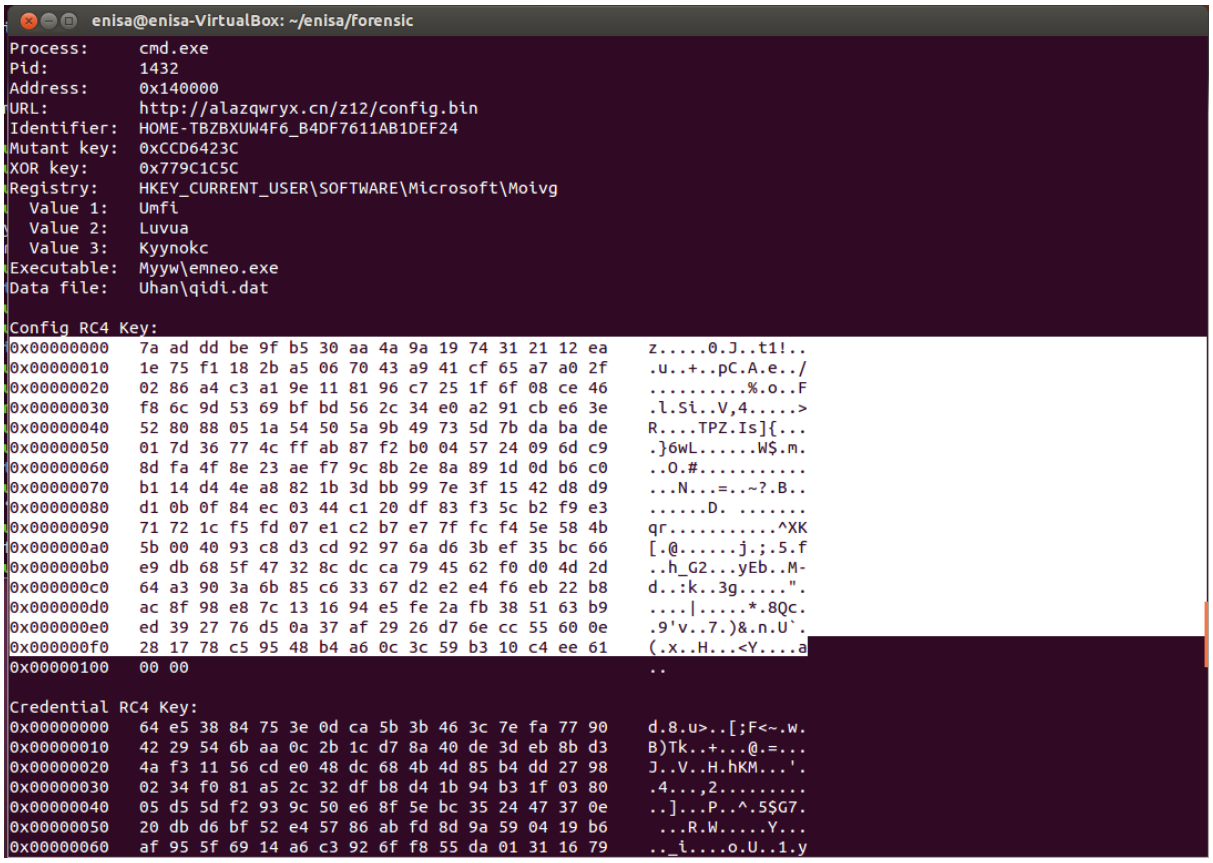


Figure 2: Zeusscan copy action

We may achieve it with a text editor of choice or use basic UNIX console mechanisms:

cd data
cat >key.txt

Now paste the data (middle mouse button can be used) and press Ctrl-D at the end.

We verify the contents of the file:

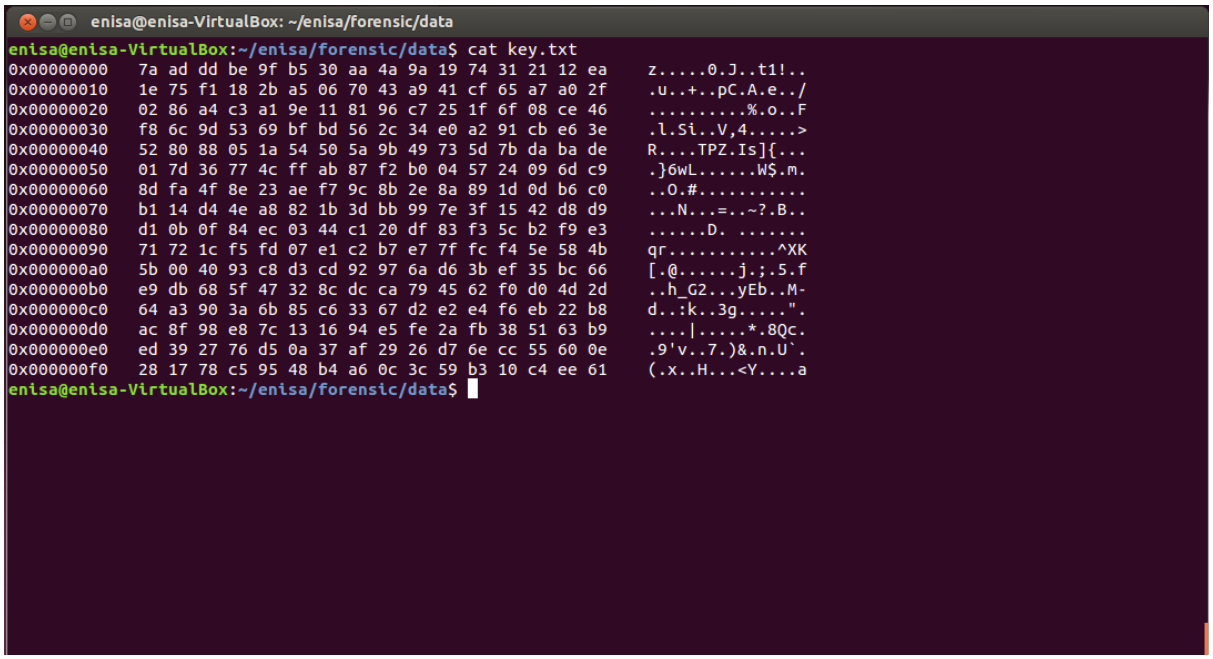


Figure 3: Decryption key

All data was copied correctly, but the file has a 'hexdump' format, which is unsuitable for processing. We need to convert it to a binary format, which can be achieved with a simple one-line script:

```
cat key.txt | cut -d ' ' -f 4-19 | xxd -r -p > key.bin
```

This script first extracts the middle column (the one with a list of character pairs) and then converts the pairs (hexadecimal values) to corresponding byte values.

To verify that the copy & paste executed correctly and the conversion succeeded we verify cryptographic sums, they must match the values in the Figure 4.

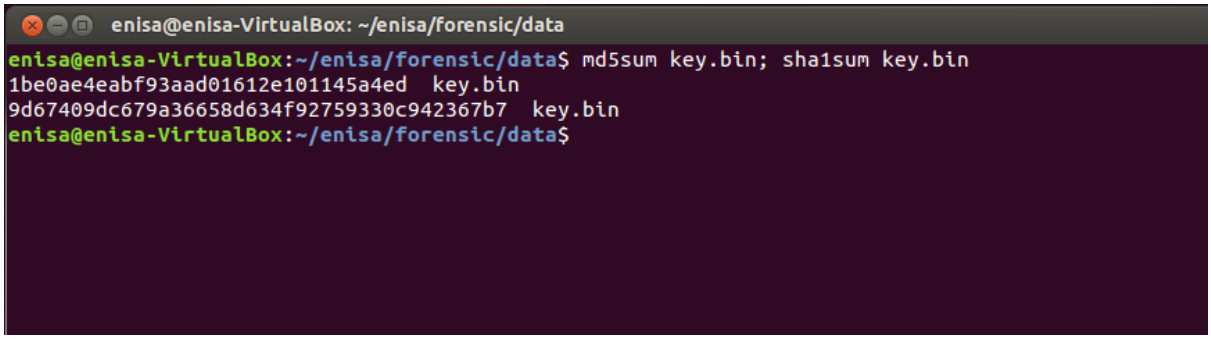


Figure 4: Calculating hash sums

At this time we've got an RC4 key which we use to decrypt the config file. All we need is a config file.

Now ask the trainees where we can get the config from. Can we use the online version if the botnet is still active? What guarantees there are the config is the same as the one used for fraud?

We may want to extract the config file from a memory dump, but we'll use a simpler technique and extract the file from the network dump, a pcap file taken from the scene by fellow team. This approach has one more advantage; we use the less poisoned evidence, taken before the team started altering the source system by issuing commands. Note that an even better source for that particular reason would be the disk dump if the malware stored the config file on disk.

We open the network.pcap file in Wireshark and enter the 'http' filter in the Filter field (and click Apply button):

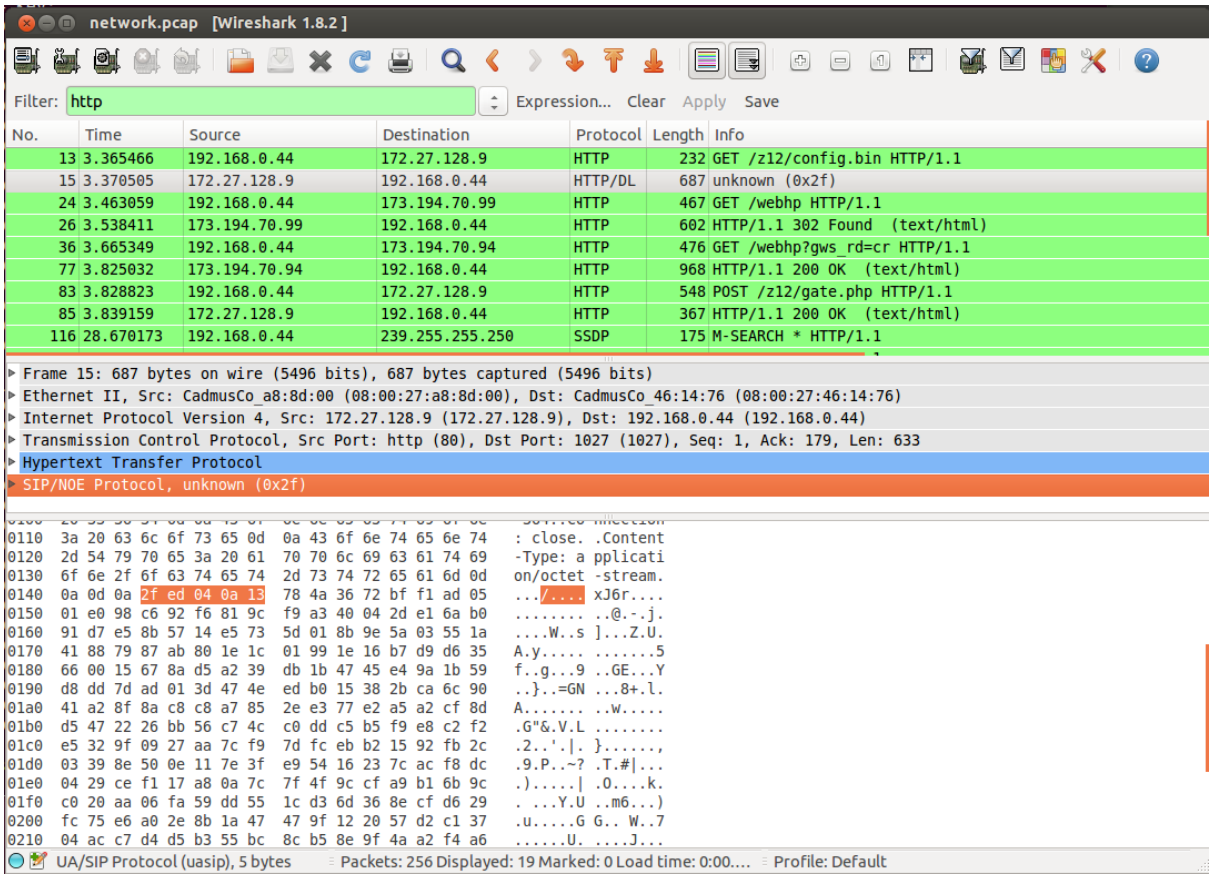


Figure 5: Wireshark communication

As we can see on the screen and in Figure 5 there was an http request for /z12/config.bin in frame 13. Frame 15 contains server's reply.

Unfortunately the Wireshark version shipped with our distribution misinterprets the http server reply from the C&C server. Fortunately the http headers show there's no encoding or encryption in this case, so we can work around the issue by accessing the frame directly and search for all the contents beginning with 0x2fed040a13 (highlighted in Figure 5) to the end of frame.

To achieve this we select the frame and press Ctrl-H or use File->Export Selected Packet Bytes from the Wireshark menu:

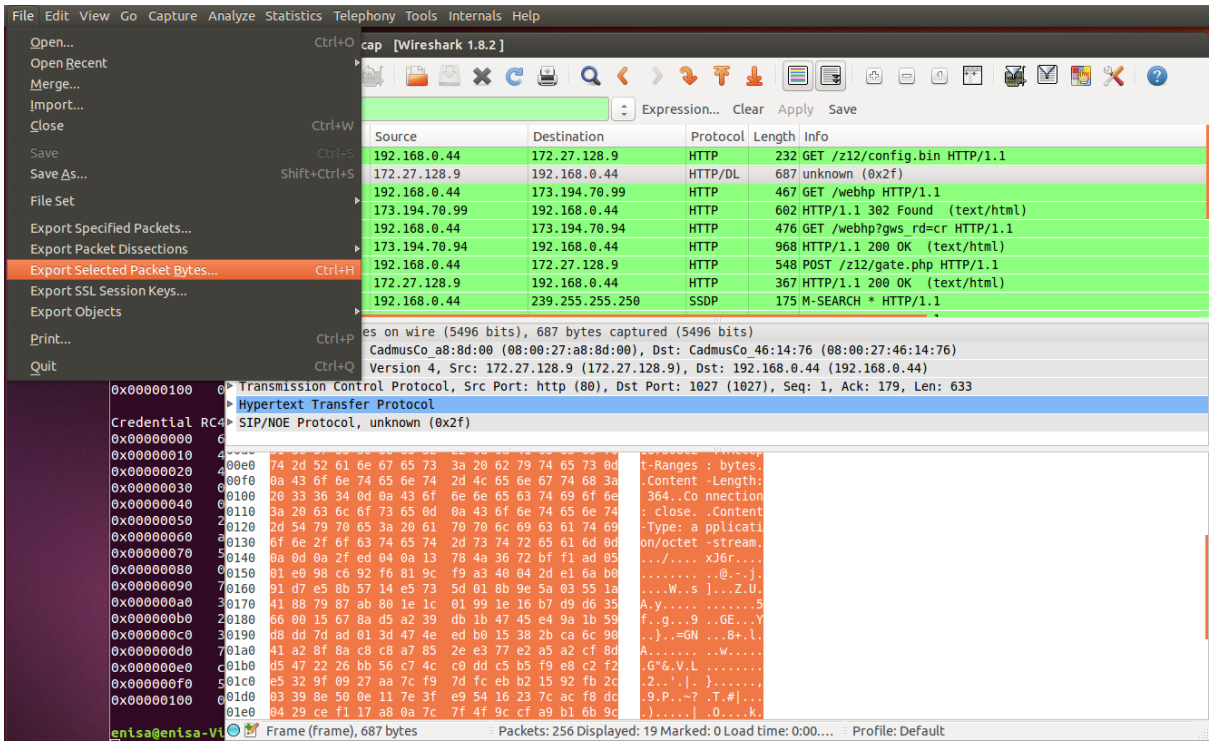


Figure 6: Copying bytes from traffic

We save the exported data to /home/enisa/enisa/data/config.bin. As we exported the whole frame, not only the response payload we have to remove everything before the 0x2FED040A13 bytes. We use a hex editor, GHex:

ghex config.bin

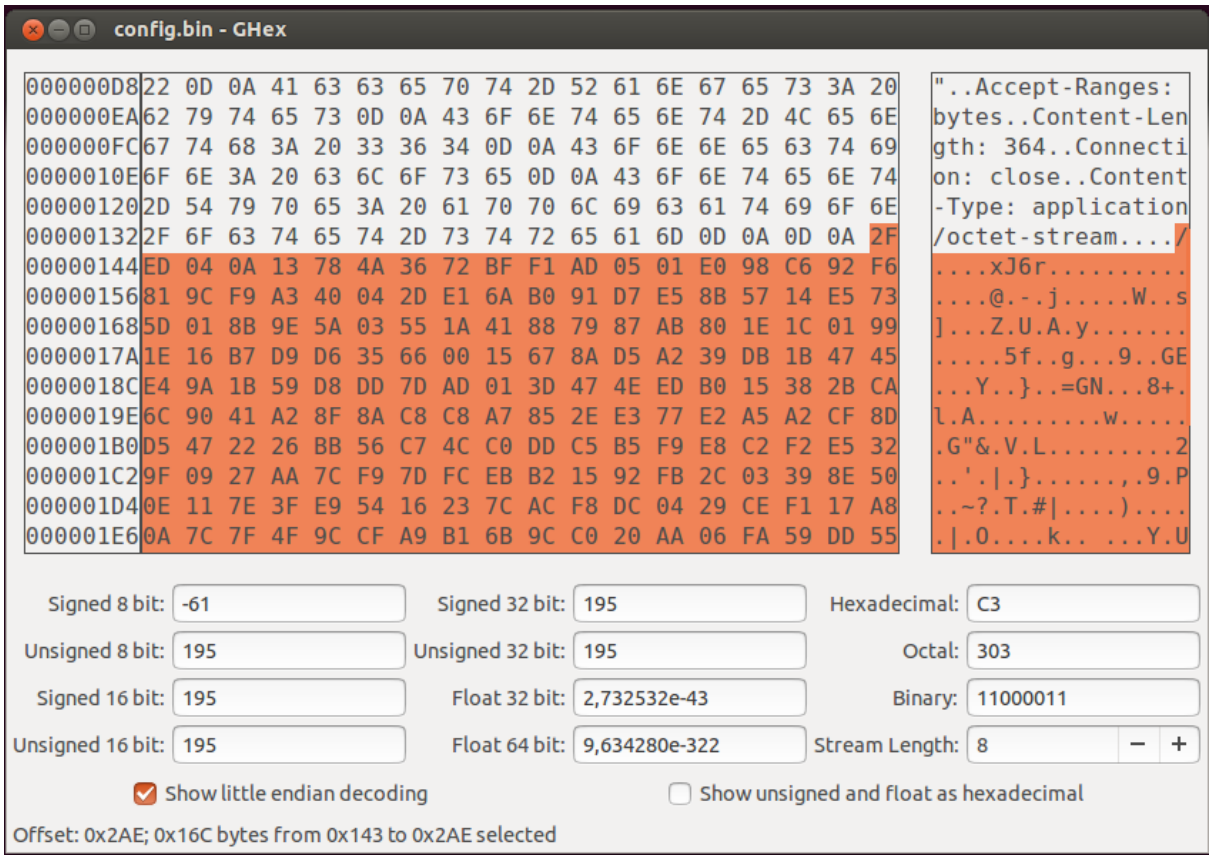


Figure 7: Editing config file in hex-editor

We remove all the bytes preceding the highlighted area, save the file and compute cryptographic sums to verify our work. MD5 and SHA1 sums should match these in Figure 8.

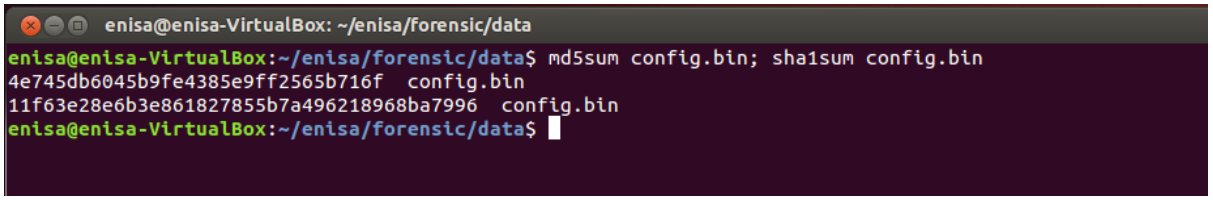


Figure 8: Calculating hashes sum

Now we can look into the config file. We remember it's encrypted with an RC4 file, in this case the file in key.bin file. We've crafted a script for that case, based on leaked ZeuS source code and documentation, zdecrypt.py:

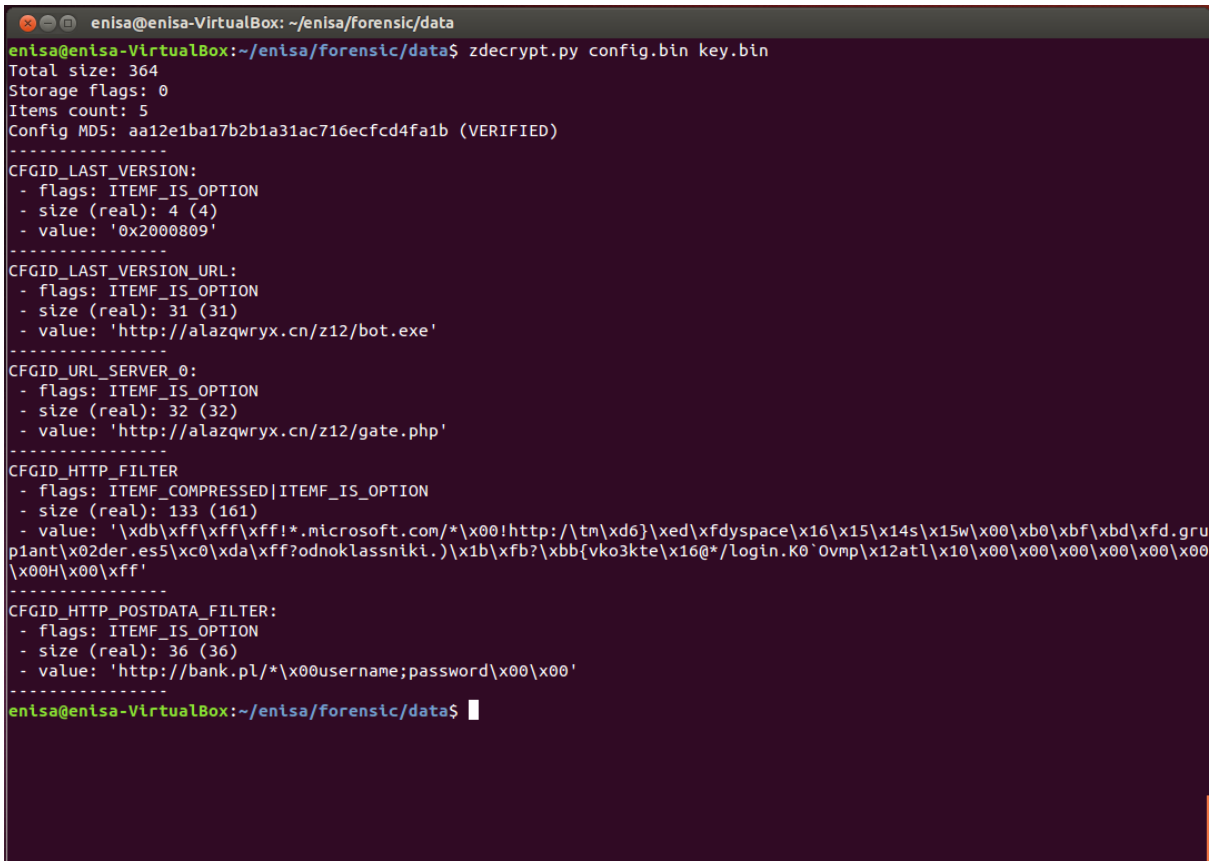


Figure 9: Decrypting Zeus config file

As we can see (Figure 9) the configuration file contains 5 sections.

In the first section, CFGID_LAST_VERSION there's the information about the bot version. In this case the value reads 0x02000809, which we interpret as 2.0.8.9 version.

In the two sections following we can see the URL addresses to the bot binary file (bot.exe) and the reporting location (gate.php). The former address is used by malware to report to the C&C and send any data stolen from infected systems.

Note however, that this interpretation is based not on reverse engineering this exact binary, it's based on our expert knowledge of ZeuS source code and documentation.

The fourth section of the config file contains compressed contents (note the ITEMF_COMPRESSED flag), which is not supported by the zdecrypt script – we still can read some of the URLs stored there. This section lists the pages ZeuS is supposed to inject its code to. For us, the most interesting section however is the fifth section – containing instruction what data should be stolen from one of websites. Website address is anything beginning with 'http://bank.pl/' and there are two fields to be captured whenever they occur within the system: username and password.

We now are sure, that this piece of malware is a ZeuS variant, version 2.0.8.9 and its configured specifically to target our bank (bank.pl) and capture usernames and passwords of the users.

7 Summary of the exercise

In this exercise we performed server-side analysis of a bank fraud case. Trainees learned basic principles of evidence collection. At the end you should discuss the Chain of Custody documented by the trainees.

The trainees learned how evidence can be extracted from system logs, what to expect from the extracted logs and that logs may become a more valuable source of information if configured with incident response in mind. The process of identifying suspicious activity by careful log examination and correlation is now one of the most basic forensic processes in any financial institution, telecommunication company or a cloud/hosting provider. Systems used for log collection and correlation are of paramount importance given the amount of information that must be gathered to assure compliance with the law.

The trainees should also become aware that attention to details is key factor while conducting forensic procedures, and evidence can be extracted also from the lack of data or from raw data formatting. They should understand the need for looking for data in outside sources, like GeoIP databases, keeping in mind however, that information quality in such databases cannot be usually guaranteed.

In the last task the trainees got some hand-on experience in malware analysis and learned basic principles of malware characteristics such as online configuration files and their encryption or online data submission.

The trainees should now be aware of the complexity of forensic proceedings and understand the legal aspects that drive the requirements.

8 References

1. Council of Europe – Electronic evidence guide version 1.0, 2013, (http://www.coe.int/t/dghl/cooperation/economiccrime/cybercrime/Documents/Electronic%20Evidence%20Guide/default_en.asp)
2. ENISA – Give and Take – Good Practice Guide for Addressing Network and Information Security Aspects of Cybercrime, 2012 (https://www.enisa.europa.eu/activities/cert/support/fight-against-cybercrime/good-practice-guide-for-addressing-network-and-information-security-aspects-of-cybercrime)
3. ENISA – Tools for Gathering evidence (https://www.enisa.europa.eu/activities/cert/support/chiht/gathering-evidence)

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