Forensic Introduction

CIRCL
Computer Incident
Response Center
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Me

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Overview

- 1. Introduction - (*Course 1*)
- 2. Understand disk - (*Course 1*)
- 3. Imaging / Cloning and Mounting - (*Course 1*)
- 4. File system analysis - (*Course 2*)
- 5. NTFS - (*Course 2*)
- 6. File System Time Line - (*Course 2*)
- 7. Carving and String Search - (*Course 2*)
- 8. Windows Registry - (*Course 2*)
- 9. Windows Event Logs - (*Course 2*)
- 10. Other Windows Artifacts - (*Course 2*)
- 11. Introduction to Flowintel - (*Course 3*)
- 12. The Exercise - (*Course 3*)

1. Introduction

1.1 Incident reponse

- Someone call for an incident
- Compromised server
- Strange connection from PC of John
- Multiple disks are collected

1.1 Incident reponse - 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

1.1 Incident reponse - Basic problem: Admin

- 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) Anti virus
  - Apply updates for OS and Apps
    → Create big noise
    → Overwrite evidences

→ Negative impact on forensics

1.2 Preservation of evidences

- Legal case:
  - → Collect & safe evidences
  - → Witness testimony for court
- Use cryptographic hash function
  - → Ensure integrity of the evidences
- Make copy of evidences
- Write blocker

1.3 Order of Volatility (OOV)

- 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

1.4 Forensic Science

- Write down everything you see, hear, smell and do
- Scope of the analysis
- Chain of custody
  - A process that tracks the movement of evidence through its collection, safeguarding, and analysis lifecycle by documenting each person who handled the evidence, the date/time it was collected or transferred, and the purpose for any transfers.

→ https://www.nist.gov/document/sample-chain-custody-formdocx

1.5 Forensic Disciplines

- Post-mortem Analysis
- Memory Forensics
- Reverse Engineering
- Code-Deobfuscation
- Network Forensics
- Mobile Forensics
- Cloud Forensics

1.6 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
    $\rightarrow$ Chain of custody
  - Mouse jiggler
- Talk with people; Take notes
- Identify potential evidences (Computer, devices, paper, ...)

1.6 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
  - 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

1.6 First Responder: Live Response

- 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 !!!

1.6 First Responder: Live Response

- Isolate system from (WiFi) network
- Perform memory dump
- Shutdown and do disk image (If possible)
- Logical image of live system (Possible issues)

1.7 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. Understand disk

2.1 Some history

- Magnetic storage
  - Tapes
  - Floppy disks
  - Hard disks
- Optical storage
  - Compact disks - CD
  - Digital versatile disk - DVD
  - Blu-ray disk
- Non-volatile memory
  - USB flash drive
  - Solid state drive
  - Flash memory cards

2.2 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 manufactur
  - Diagnostics and recovery tools
- ATA-6: DCO - Device Configuration Overlay
  - Supports manufacturs with a layer of abstraction
    - Use standard parts
      → To build different products
      → Example: Disks reports uniq amount of sectors
- ATA-7: Serial ATA

2.3 Hidden Sectors

- 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
```

2.3 Hidden Sectors

- Create partition and format

```
$ dmesg
    sd 1:0:0:0: [sdb] 3000000000 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.
```

2.3 Hidden Sectors

- 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.
```

2.3 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

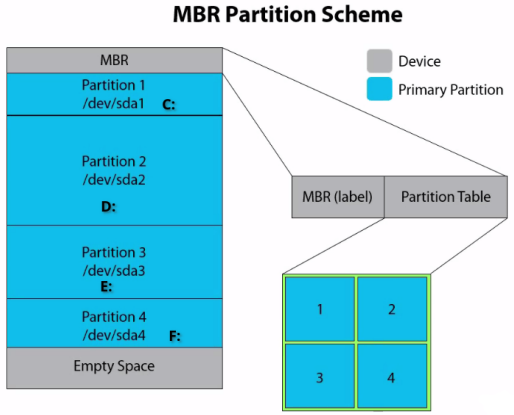
```
$ hdparm -N /dev/sdb
    max sectors   = 3000000000/3907029168, ACCESSIBLE MAX ADDRESS enabled

$ 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
```

2.3 Hidden Sectors

- Recover hidden message

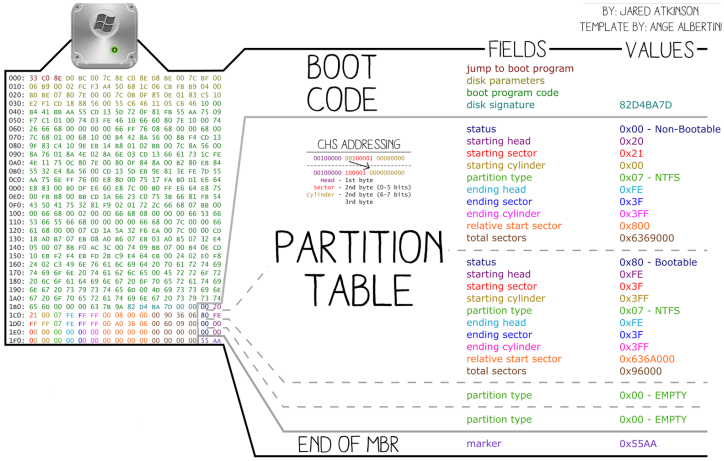
```
$ dd if=/dev/sdb skip=3500000000 count=1 status=none
    00000000: 4d79 5365 6372 6574 2031 3233 3435 3600  MySecret 123456.
```

2.4 Disk structure



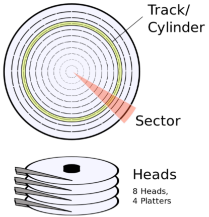
https://www.golinuxhub.com/2014/11/understanding-partition-scheme-mbr-vs/

2.4.1 MBR



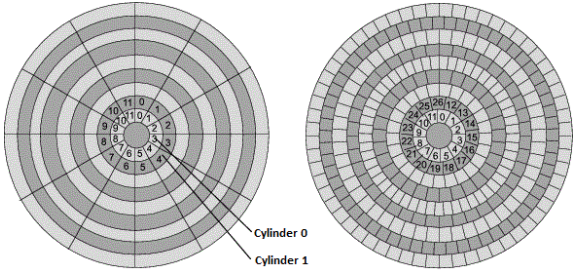
http://www.invoke-ir.com/2015/05/ontheforensictrail-part2.html?m=0

2.4.2 CHS



- C -> Cylinder, [0, 1023]
- H -> Head, [0, 254]
- S -> Sector, [1, 63]
- 1024*255*63*512 = 8,422,686,720 bytes $\rightarrow$ 8G

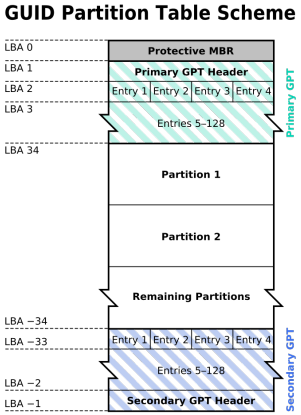
2.4.3 CHS vs LBA



https://benkixmiller.com/2023/10/08/chs-vs-lba-addressing/

- $((2^32 * 512 / 1024^3)) == 2 TByte
- 48 bits -> 144,000,000 GB -> 144 000 TB

2.4.4 GPT



2.4.4 GPT

GPT HEADER

```
200 45 46 49 20 50 41 52 54 00 00 01 00 5C 00 00 00
210 F3 73 9F 97                  01 00 00 00 00 00 00 00
220 FF FF 3F 01 00 00 00 00 22 00 00 00 00 00 00 00
230 DE FF 3F 01 00 00 00 00 10 E1 13 F9 35 08 F1 4C
240 96 C7 38 08 5D B4 A4 2D 02 00 00 00 00 00 00 00
250 80 00 00 00 80 00 00 00 3B 04 A4 F8
```

signature	EFI PART
revision	1.0
header size	92
header CRC32	979F73F3
my LBA	1
alternate LBA	20971519
first usable LBA	34
last usable LBA	20971486
disk guid	f913e110-0835-4cf1-96c7-380b5db4a42d
partition entry LBA	2 (sector containing of partition table)
# of partition entries	128
size of partition entry	128
partition entry array CRC32	F8A4043B

PARITION ARRAY

```
400 16 E3 C9 E3 5C 0B B8 4D 81 7D F9 2D F0 02 15 AE
410 47 8A 1A FF F8 0B A8 43 B4 10 53 69 7F 0B 23 23
420 22 00 00 00 00 00 00 00 21 00 01 00 00 00 00 00
430 00 00 00 00 00 00 00 00 4D 00 69 00 63 00 72 00
440 6F 00 73 00 6F 00 66 00 74 00 20 00 72 00 65 00
450 73 00 65 00 72 00 76 00 65 00 64 00 20 00 70 00
460 61 00 72 00 74 00 69 00 74 00 69 00 6F 00 6E 00
470 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

480 A2 A0 D0 EB E5 B9 33 44 87 C0 68 B6 B7 26 99 C7
490 42 AE 76 6D C1 B6 BE 4F 8D 42 20 CD 36 60 26 B4
4A0 00 08 01 00 00 00 00 00 FF 07 00 00 00 00 00 00
4B0 00 00 00 00 00 00 00 00 42 00 61 00 73 00 69 00
4C0 63 00 20 00 64 00 61 00 74 00 61 00 20 00 70 00
4D0 61 00 72 00 74 00 69 00 74 00 69 00 6F 00 6E 00
4E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
4F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

500 A2 A0 D0 EB E5 B9 33 44 87 C0 68 B6 B7 26 99 C7
510 3A 5C 79 D6 4D 8A B4 4F 91 A0 48 88 12 CC E0 27
520 00 08 00 00 00 00 00 00 FF 07 41 00 00 00 00 00
530 00 00 00 00 00 00 00 00 42 00 61 00 73 00 69 00
540 63 00 20 00 64 00 61 00 74 00 61 00 20 00 70 00
550 61 00 72 00 74 00 69 00 74 00 69 00 6F 00 6E 00
560 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
570 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

partition type guid	e3c9e316-0b5c-4db8-817d-f92df00215ae
unique partition guid	ff1a8a47-08f8-43ab-b410-536970fb2323
starting LBA	34
ending LBA	65569
attributes	0
partition name	Microsoft reserved partition

partition type guid	ebd0a0a2-b9e5-4433-87c0-68b6b72699c7
unique partition guid	6d76ae42-b6c1-4fbe-8d42-20cd366026b4
starting LBA	67584
ending LBA	2164735
attributes	0
partition name	Basic data partition

partition type guid	ebd0a0a2-b9e5-4433-87c0-68b6b72699c7
unique partition guid	d6795c3a-8a4d-4fb4-91a0-488812cce027
starting LBA	2164736
ending LBA	4261887
attributes	0
partition name	Basic data partition

http://www.invoke-ir.com/2015/06/ontheforensictrail-part3.html

3. Imaging / Cloning and Mounting

3.1 Disk Imaging / Cloning

- Clone disk-2-disk
  - Different sizes
  - This will 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

3.2 dd - disk imaging rudimentary

- Copy files from usb stick using dd:

```
$ dd if=img_1.txt of=out_1.txt bs=512

  <input file>   <output file>  <block size>
3+0 records in
3+0 records out
1536 bytes (1.5 kB) copied, 0.000126 s, 12.2 MB/s
```

- 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
```

3.2 dd - disk imaging rudimentary

- Play with bs, skip and count option

```
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
```

- Exercice: Find the secret password behind sector 3

3.2 dd - disk imaging rudimentary

- Exercise: Continue an interrupted imaging process

3.2 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

||      img_2.txt  ..... 1591 Aug 13 14:40 img_2.txt*
||      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
```

3.2 dd - disk imaging rudimentary - Tools

- dd
- ddrescue, gddrescue, dd_rescue
- dc3dd - Department of Defense Cyber Crime Center
- dcfldd - Defense Computer Forensic Labs
- rdd-copy, netcat, socat, ssh
- Guymager

3.3 Connecting devices

- List all disk

```
sudo lsblk -o NAME,FSTYPE,SIZE,MOUNTPOINT,LABEL
```

- Where there are mount:
  - /dev/sd* # SCSI, SATA
    - /dev/sda1 # Partition 1 on disk 1
    - /dev/sda2 # Partition 2 on disk 1
    - ...
  - /dev/hd* # IDE. EIDE
  - /dev/md* # RAID
  - /dev/nvme*n* # NVME devices

3.3 Connecting devices

- 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 /dev/sda

```
Disk /dev/sda: 7.62 GiB, 8178892800 bytes, 15974400 sectors
Disk model: Flash Disk
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x223f3288

Device     Boot Start      End  Sectors Size Id Type
/dev/sda1        2048 10485759 10483712   ?  7 HPFS/NTFS/exFAT
```

3.3 Connecting devices

- fdisk -l /dev/sda

```
Disk /dev/sda: 7.62 GiB, 8178892800 bytes, 15974400 sectors
Disk model: Flash Disk
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x223f3288

Device     Boot Start      End  Sectors Size Id Type
/dev/sda1        2048 10485759 10483712   5G  7 HPFS/NTFS/exFAT
```

3.4 Imaging devices

- Image your usb stick
- What are the steps ?

3.4 Imaging devices

```
dd if=/dev/sda of=circl_dfir.dd bs=512
dd if=/dev/sda of=/home/david/Desktop/circl_dfir_ntfs.dd skip=2048
dd if=/dev/sda1 of=/home/david/Desktop/circl_dfir_ntfs_2.dd
```

3.5 Mounting

- Basiscs

```
mkdir /mnt/ntfs                                  # Create mount point
mount /dev/sda1 /mnt/ntfs                        # Mounting

mount -o ro,remount /dev/sda1 /mnt/ntfs          # Re-mounting

umount /mnt/ntfs                                 # Un-mounting
umount /dev/sda1                                 # Also un-mounting
```

3.5 Mounting

- More Advanced:

```
# Mounting readonly, no journaling, no executable
mount -o ro,noload,noexec /dev/sda1 /mnt/ntfs
mount -o ro,noload,noexec,remount /dev/sda1 /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
```

3.5 Mounting

```
dd if=/dev/sda of=circl_dfir.dd bs=512
dd if=/dev/sda of=/home/david/Desktop/circl_dfir_ntfs.dd skip=2048
dd if=/dev/sda1 of=/home/david/Desktop/circl_dfir_ntfs_2.dd

mount -o offset=$((512*2048)) circl_dfir.dd mnt_pt
mount circl_dfir.dd mnt_pt
mount circl_dfir.dd mnt_pt
```

Contact and Reference

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