Forensic Introduction

CIRCL
Computer Incident
Response Center
Luxembourg

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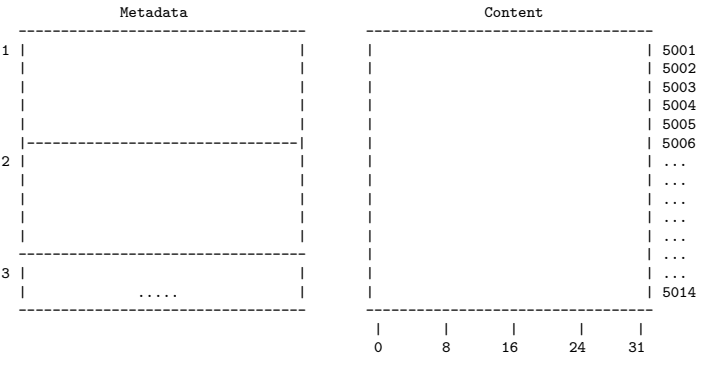
Overview

- ~~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*)

4. File System Analysis

4.1 Organizing data in files

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



Allocation table:

4.1 Organizing data in files

- Organizing data on a volume
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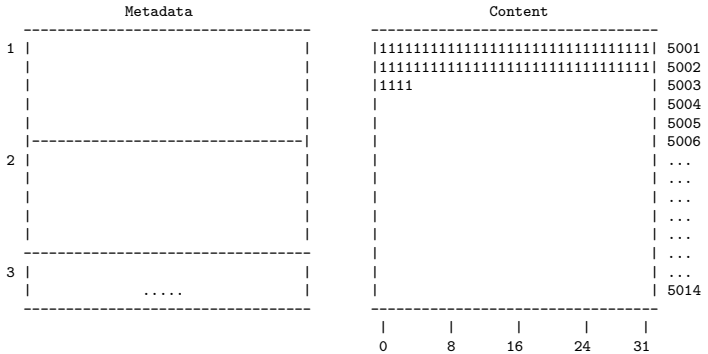

Allocation table:

4.1 Organizing data in files

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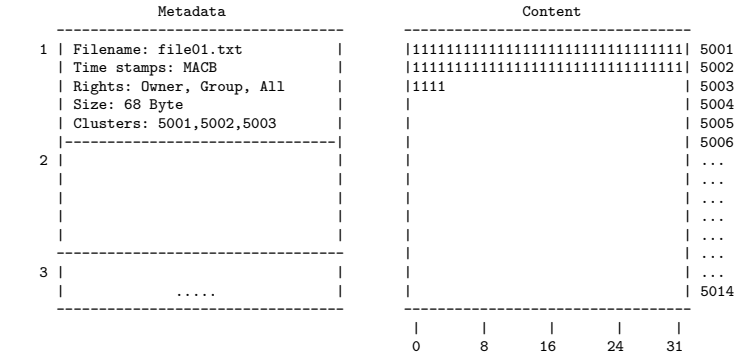
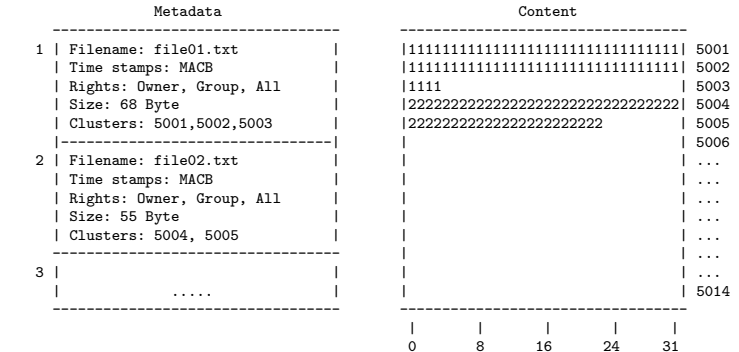


Allocation table: 5001, 5002, 5003

4.1 Organizing data in files

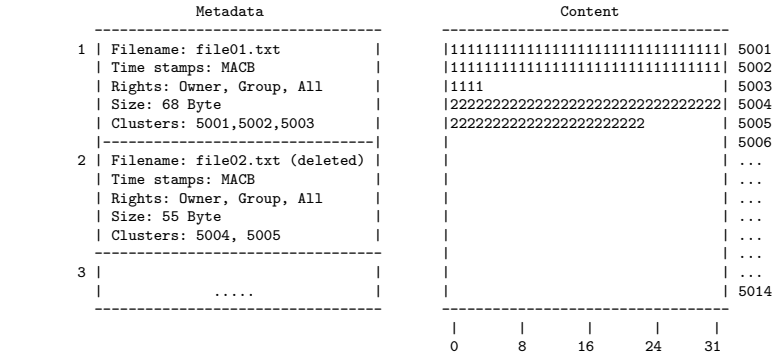
- Organizing data on a volume
- Maintain file related meta data
- Maintain allocation status of clusters



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

4.2 Deleting a file

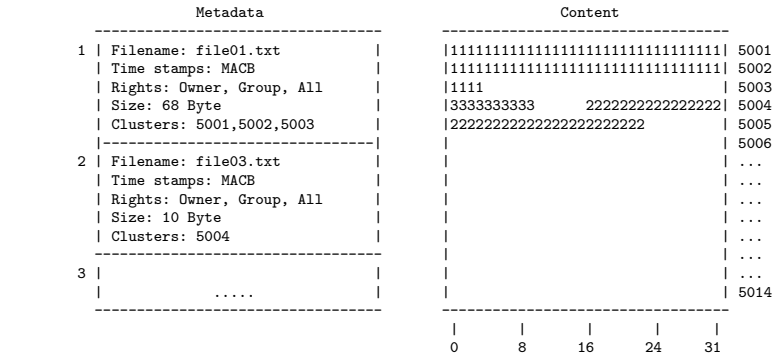
- Organizing data on a volume
- Maintain file related meta data
- Maintain allocation status of clusters



Allocation table: 5001, 5002, 5003

4.3 Slack space - FileSlack

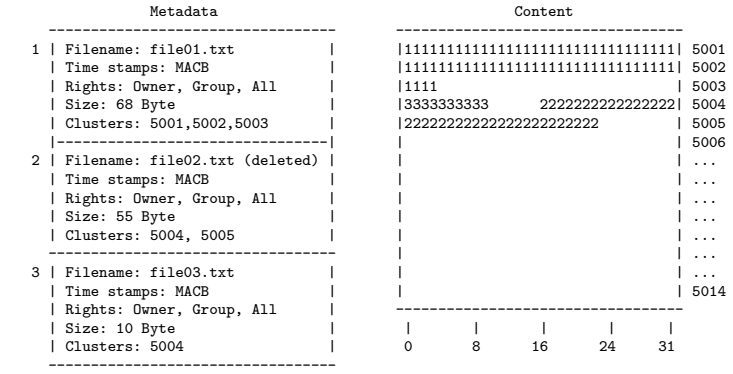
- Metadata: Case 1: Re-Use Metadata
- Content: End of sector: Filled with zeros (RAM slack)
- Content: End of cluter: Don't touch (File slack)



Allocation table: 5001, 5002, 5003, 5004

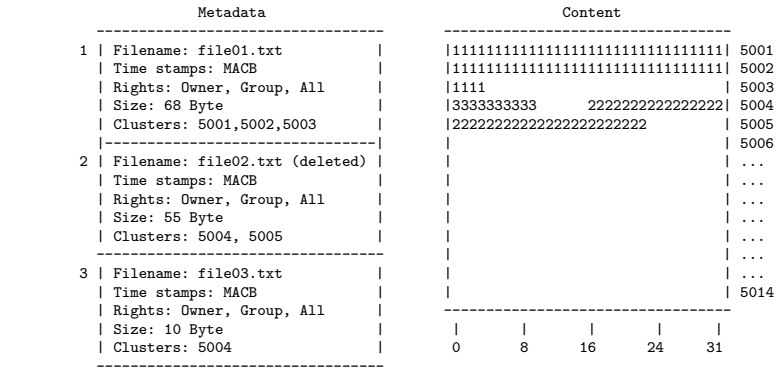
4.3 Slack space - FileSlack

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



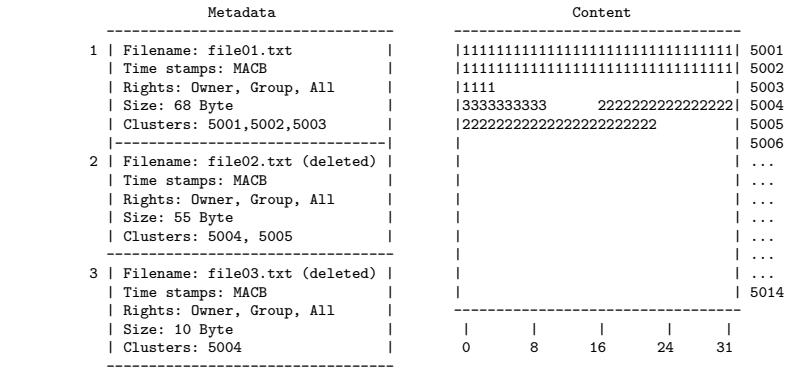
4.4 Data Recovery

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



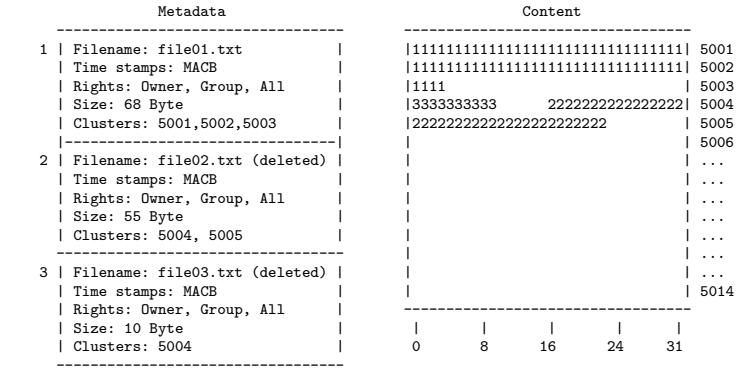
4.4 Data Recovery

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



4.4 Data Recovery

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



4.5 The Sleuth Kit

```
mmstat  # Volume system information
mmls        # List partition table
mmcat       # 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
....
```

4.5 The Sleuth Kit: Exercise

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

```
# File system information
$
```

```
# List files
$
```

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

4.5 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
$
$
$
```

4.5 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
$
$
```

4.5 The Sleuth Kit: Exercise

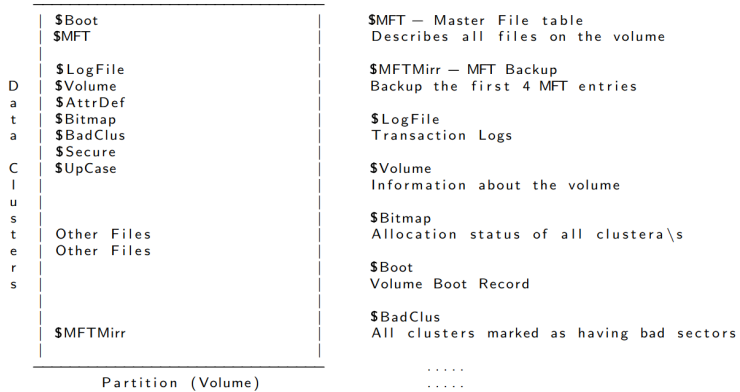
Recover deleted files from `/carving/deleted.dd`

```
# 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
```

5. NTFS

5.1 File system structure

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



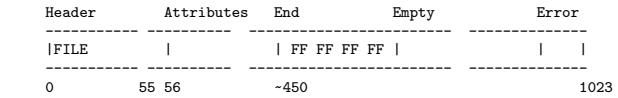
5.2 Volume Boot Record

```
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  otable floppy an
  .....
000001e0: 0000 0000 0000 0000 0000 0000 0000 0000  ................
000001f0: 0000 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	fff7 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

5.3 Master File Table

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




```
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 Recort: FF FF FF FF
Empty (Resident Data)
Error Check Sequence
```

5.3 MFT

```
$ 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
```

5.4 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

5.4 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-  ................
```

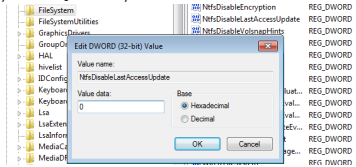
offset:	size:	value:	description:
0010	2	2	Record sequence number
0012	2	0	Link count
0016	2	0	Record flag: 0000 = file deleted 0100 = file in use 0200 = dir deleted 0300 = dir in use
0030	2	1400	FixUp values
03fe	2	1400	CRC

6. File System Time Line

6.1 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 mofidied
  - MACB times
    - M time: Content last Modified
    - A time: Content last Accessed
    - C time: MFT record last Changed
    - B time: File created (Born)

6.2 Last Access Time

- Updated in memory, writen to disk after $\approx$ 1h
- 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

6.3 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
```

6.3 Time Line: Exercise - What could we reproduce Yes/No

```
01.txt
      1. 12:23:08 01.txt ...b -> new create                          Yes
      6. 12:29:07 01.txt m.c. -> modified content                      No
      7. 12:33:50 01.txt m.c. -> 2nd modification                    Yes

02.txt
      2. 12:24:20 02.txt m.cb -> new create                          Yes
      8. 12:29:50 02.txt .a.. -> open/access file                      No
      9. 12:30:01 02.txt .a.. -> close                                 No

03.txt, 03 - Copy.txt
      3. 12:25:24 03.txt m.cb -> new create                          Yes
     10. 13:07:52 03.txt .acb -> copy to 03 - Copy.txt               Yes/No

44.txt
      4. 12:26:05 04.txt m..b -> new create                          Yes
     11. 13:10:36 04.txt ..c. -> rename to 44.txt                    Yes/No

05.txt
      5. 12:27:00 05.txt macb -> new create                          Yes
     14. 13:58:07 05.txt macb -> delete file                          No

06.txt
     12. 13:14:20 06.txt m... -> new created on other drive          Yes/No
     13. 13:56:30 06.txt .acb -> copy to local drive                 Yes
```

6.4 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
```

6.4 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?
-----------------------
```

6.4 Create a Time line

```
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
```

7. Carving and String Search

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
00000000: 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
- Scalpel
  - Based on Foremost
- 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

- Work on `circl-dfir/carving/formated.dd`
- Try `fls`
- `sudo apt install foremost`
- `https://www.cgsecurity.org/wiki/TestDisk_Download`

7.4 Exercise: Recover data from 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 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 ot other banking details
  - Email addresses or URLs
- Search through all the blocks
  - Allocated and non allocated blocks
  - File slack and outside partition boundaries
- Goal
  - Proof that the data was there once
  - Identify interesting data that are close

7.6 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

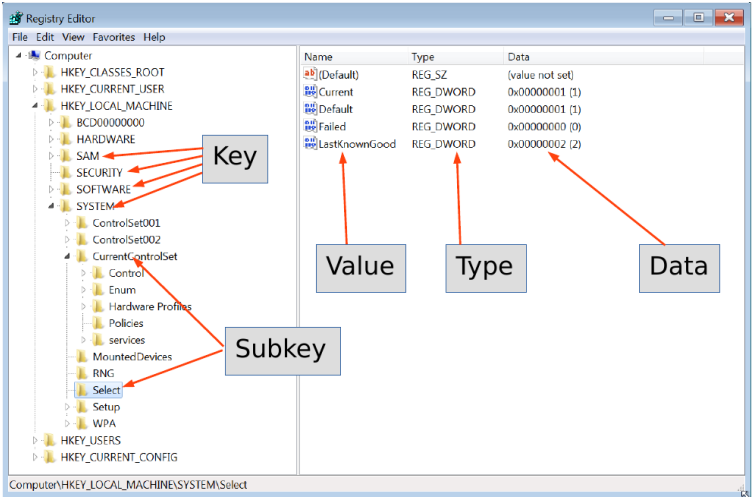
8. Windows Registry

8.1 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

8.1 About Windows Registry



8.1 About Windows Registry

- Hive files location:
  - `%SystemRoot%\system32\config`
    → SAM, SECURITY, SYSTEM, SOFTWARE
  - `%UserProfile%\NTUSER.DAT`
  - `%UserProfile%\AppData\Local\Microsoft\Windows\UsrClass.dat`

8.2 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

8.2 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)

8.3 RegRipper

- Installation:
  - `sudo apt install regripper`
    or
  - Install wine
  - Clone https://github.com/keydet89/RegRipper3.0
  - Use rip.exe with wine

8.3 RegRipper

```
$ 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 pl$ | wc -l
    249
```

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

8.3 RegRipper - Exercise

- `circl-dfir/case_02/registry`
- Use regripper to find:
  - Computer name
  - Software that run when a user logs on
  - Informations on Windows
  - Network cards
  - List of uninstaller
  - Ips
  - List of users
  - Shutdown
  - Timezone

8.3 RegRipper - Solution

- Computer name:

```
regripper -p compname -r system
```

- Software that run when a user logs on:

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

- Informations on Windows:

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

- Network cards:

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

8.3 RegRipper - Solution

- List of uninstaller:

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

- Ips:

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

- List of users:

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

- Shutdown:

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

- Timezone:

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

8.4 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
```

8.4 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
```

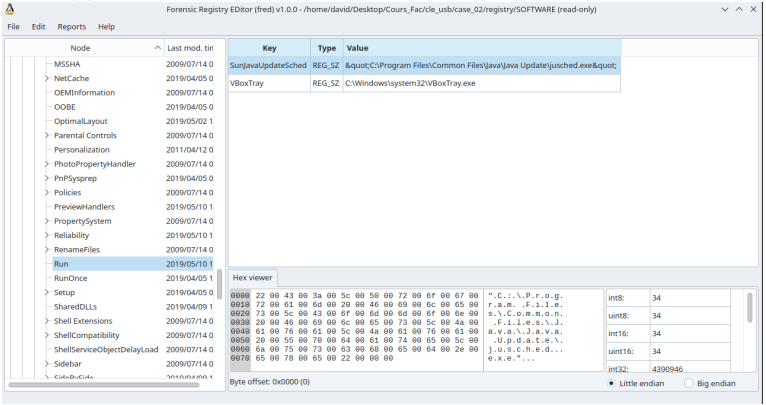
  - MountPoints

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

- https://www.sans.org/posters/windows-forensic-analysis/

8.5 Fred

https://code.sits.lu/foss/fred



9. Windows Event Logs

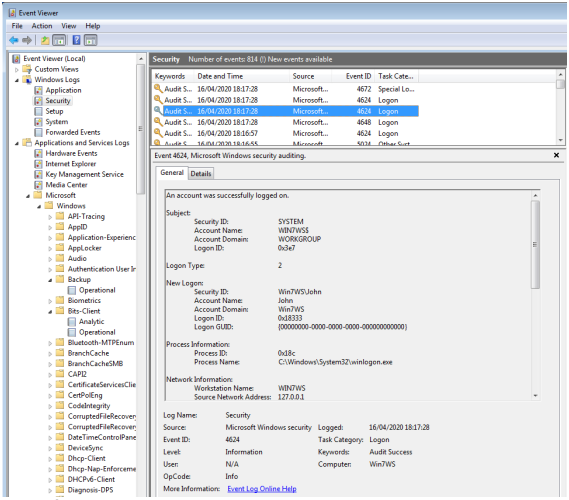
9.1 About Windows Event Logs

- Up to Windows XP
  - Mainly 3 .evt files:
    - Security: secevent.evt
    - System: sysevent.evt
    - Application: appevent.evt
  - 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

9.1 About Windows Event Logs

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

9.1 Windows Event Logs



9.1 Windows Event Logs

- Review logging policies

```
$ regripper -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
.....
```

9.2 Parsing

```
sudo apt install libevt-utils
sudo apt install libevtx-utils

evtinfo evtx/AppEvent.Evt
evtinfo evtx/SecEvent.Evt
evtinfo evtx/SysEvent.Evt

evtexport AppEvent.Evt | less
evtexport SysEvent.Evt | less

evtxexport Security.evtx | less
```

- Search for:
  - 4624
  - 4625

9.3 Other tools

- Chainsaw
  - https://github.com/WithSecureLabs/chainsaw
- Hayabusa
  - https://github.com/Yamato-Security/hayabusa

10 Other Windows artifacts

10.1 Recycle Bin

- 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`

10.1 Recycle Bin - Life-Investigate

- Play Script: TextFile.txt
  - Moved with mouse into Recycle Bin
  - 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

10.1 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
- 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'.
    .....
```

10.1 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
```

10.2 LNK Files

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

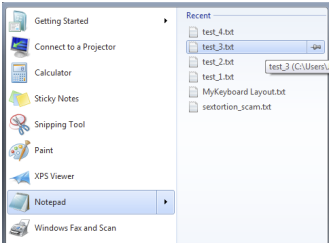
10.2 LNK Files

- 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
```

10.3 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`

10.3 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 6824f4a902c78fbd.automaticDestinations-ms
10/04/2020  14:12             9 216 7e4dca80246863e3.automaticDestinations-ms
```

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

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

10.3 Jump Lists

- Exercise: Identify applications

```
cd JumpLists/AutomaticDestinations/
ls -l

    1b4dd67f29cb1962.automaticDestinations-ms -->
    28c8b86deab549a1.automaticDestinations-ms -->
    6824f4a902c78fbd.automaticDestinations-ms -->
    7e4dca80246863e3.automaticDestinations-ms -->
    918e0ecb43d17e23.automaticDestinations-ms -->
    b74736c2bd8cc8a5.automaticDestinations-ms -->
    de48a32edcbe79e4.automaticDestinations-ms -->
```

10.3 Jump Lists

- Exercise: Identify applications

```
cd JumpLists/AutomaticDestinations/
ls -l

    1b4dd67f29cb1962.automaticDestinations-ms --> Windows Explorer
    28c8b86deab549a1.automaticDestinations-ms --> Internet Explorer 8
    6824f4a902c78fbd.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
```

10.4 Prefetch Files

- Application prefetching since XP
  - Monitor an application when it starts
  - Collect information about resources needed
  - Wait 10sec after application started $\rightarrow$ Know where to find the resources $\rightarrow$ Better performance: App launch faster $\rightarrow$ 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
  - ...

10.4 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
- Information found inside a Prefetch file:
  - Run count: How often application run
  - Last time executed
  - Application name incl. parameter
  - Path to application and resources

10.4 Prefetch Files

- Parsing a Prefetch file

```
prefetch_parser.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

10.5 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
```

10.5 VSS - Configuration & Analysis

`HKEY LOCAL MACHINE/SYSTEM/CurrentControlSet/services/VSS`

`HKEY LOCAL MACHINE/SYSTEM/CurrentControlSet/Control/BackupRestore`

- Analyze disk image:
  `vshadowinfo -o offset disk_image`
- Mount VSS:
  `vshadowmount -o offset disk_image mount_point`

Contact and Reference

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