Digital forensics

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Computer

chapter 15

- pre-knowledge:
  - architecture of computers
  - basics (BIOS)
  - operating system
  - secondary memory (disc) and its organization
  - file systems

Startup

- startup steps
- BIOS (*Basic Input Output System*)
  - Open Firmware (Mac PowerPC), EFI (Mac Intel), Open Boot PROM (Sun), …
- POST (*Power On Self Test*)

- the operating data are stored in xROM
- sometimes the password protects the data – password is entered by the user

Startup…

- example *Moussawi*:

> The computer has been shut down for a very long time and the battery on the motherboard has been emptied

- how the data is encrypted
  - ASCII, …
  - Little / big endian
- What happens if you take disc to another computer

File format

- at the beginning all files have their unique signatures (www.garykessler.net/library/file_sigs.html)
- jpg: *FF D8 FF E0* or *FF D8 FF E3*
- gif: *47 49 46 38 37 61* or *47 49 46 38 39 61*
- doc: *D0 CF 11 E0 A1 B1 1A E1*

File format - example

- jpeg encoded exif (*Exchangeable image file format*) file

file2

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
00000000	FF	D8	FF	E1	16	B1	45	78	69	66	00	00	4D	4D	00	2A	ÿØÿá ±Exif MM *
00000010	00	00	00	08	00	08	01	0F	00	02	00	00	00	16	00	00	
00000020	01	B2	01	10	00	02	00	00	00	1C	00	00	01	C8	01	12	² È
00000030	00	03	00	00	00	01	00	01	00	00	01	1A	00	05	00	00	
00000040	00	01	00	00	01	E4	01	1B	00	05	00	00	00	01	00	00	ä
00000050	01	EC	01	28	00	03	00	00	00	01	00	02	00	00	02	13	ì (
00000060	00	03	00	00	00	01	00	01	00	00	87	69	00	04	00	00	‡i
00000070	00	01	00	00	01	F4	00	00	09	34	00	00	00	00	00	00	ô 4
00000080	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00000090	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
000000A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00000180	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
00000190	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
000001A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
000001B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	45	41	EA
000001C0	53	54	4D	41	4E	20	4B	4F	44	41	4B	20	43	4F	4D	50	STMAN KODAK COMP
000001D0	41	4E	59	00	4B	4F	44	41	4B	20	44	58	34	33	33	30	ANY KODAK DX4330
000001E0	20	44	49	47	49	54	41	4C	20	43	41	4D	45	52	41	00	DIGITAL CAMERA
000001F0	00	00	00	E6	00	00	00	01	00	00	00	E6	00	00	00	01	æ æ
00000200	00	24	82	9A	00	05	00	00	00	01	00	00	03	DA	82	9D	$‚š Ú‚
00000210	00	05	00	00	00	01	00	00	03	E2	88	22	00	03	00	00	â‰"
00000220	00	01	00	02	00	00	90	00	00	07	00	00	00	04	30	32	‘ 02
00000230	32	30	90	03	00	02	00	00	00	14	00	00	03	EA	90	04	20‘ ê‘

File format

- the file can be embedded in another file
  - find the file
  - it can be labeled and copied (*copy-paste*)
  - or use tool **`dd`**
- this procedure is called *carving*
- other tools:
  - scalpel (http://www.digitalforensicssolutions.com/Scalpel/), DataLifter (http://www.datalifter.com/)
  - EnCase (http://www.guidancesoftware.com/forensic.htm), FTK (Forensic Toolkit, http://accessdata.com/products/computer-forensics/ftk), X-Ways (http://www.x-ways.net/)

Curving

- in the end, we only get content and not metadata from the directory
- The other problem is that the data can be scattered through the disk
  - Adroit (http://digital-assembly.com/products/adroit-photo-forensics/)

File format - challenge

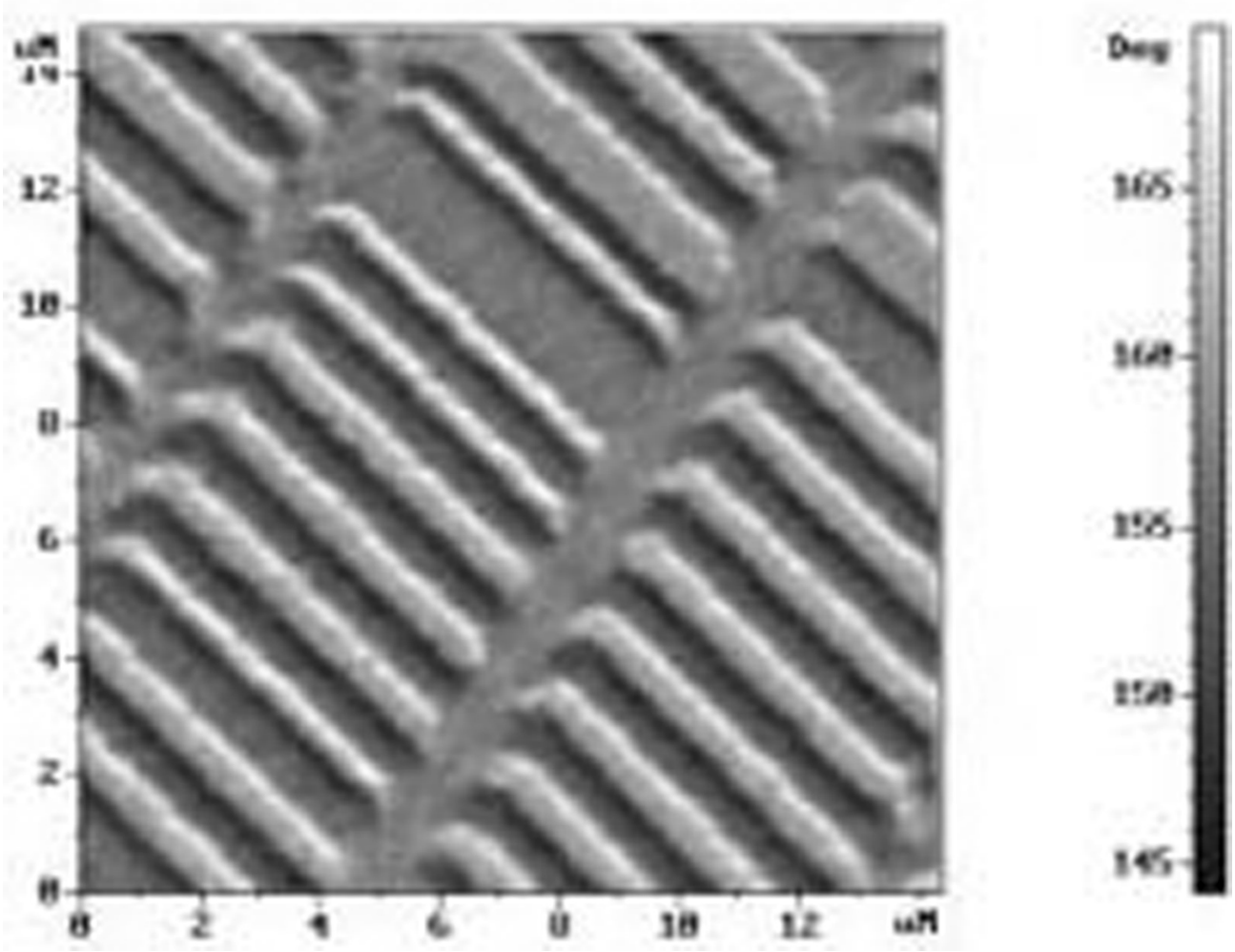
- Challenge: Embed one file in the another file and publish that on the forum. The other colleagues should find the embedded file and extract it using tools like dd or some other tools motioned it the previous slides.
- Challenge: Divide the file into more pieces and insert each one into another file and post it all in the forum. Let your colleagues reconstruct your distributed pieces.

Data storage and hiding

- the I / O units are connected to the computer via:
  - bas (IDE, ATA, SATA; SCSI, firewire)
  - interface (*controller*)
- the interfaces can also be smart
  - SMART (*Self-Monitoring, Analysis, and Reporting Technology*)
  - keep access statistics and other similar data
  - usually are not relevant for forensic research

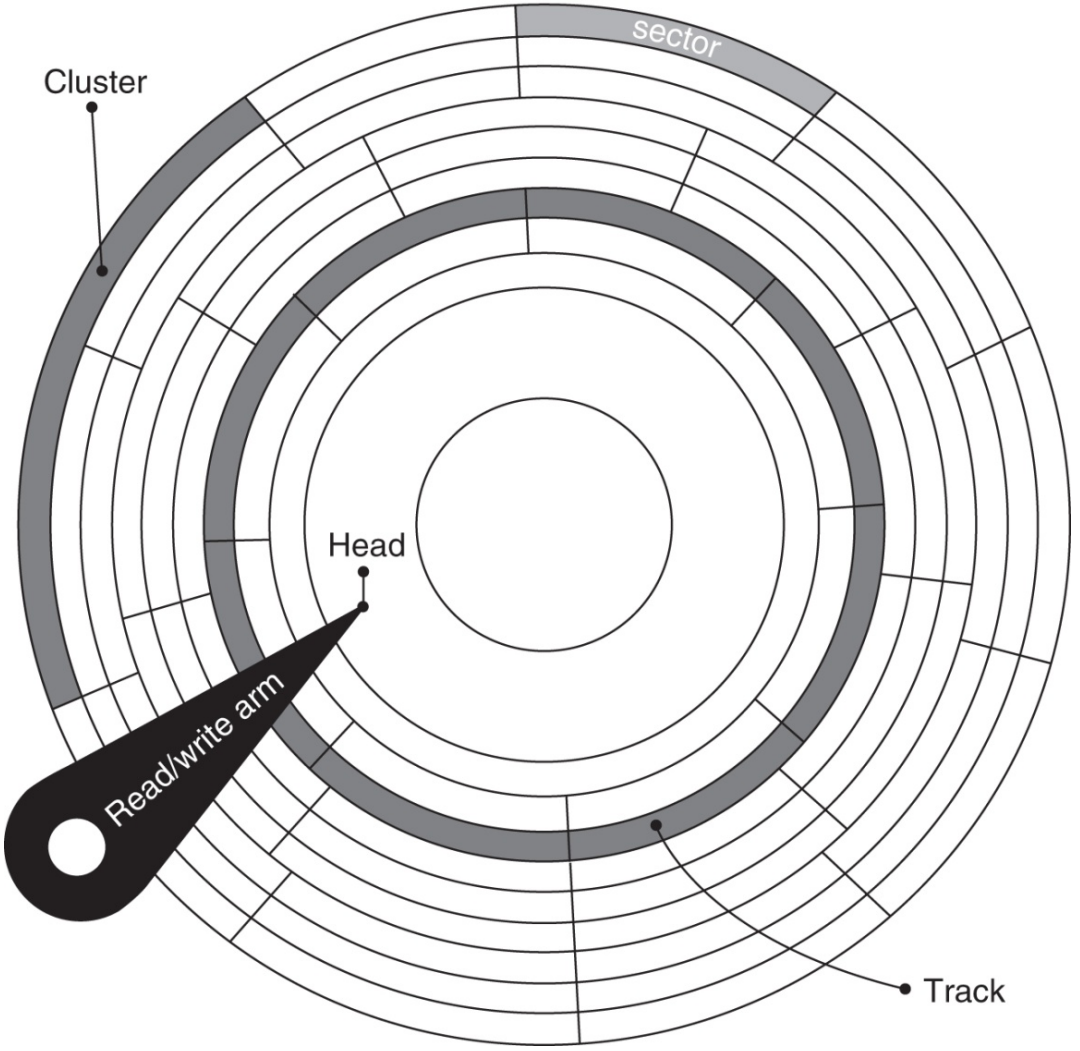
Data storage and hiding

- usually we store data permanently on a disk
- What does the hard drive look like?



Data storage and hiding

- how is the disk organized?
  - spindle, platter, cylinders, tracks, sectors, cluster
- at the first sector are control data (MBR, *master boot record*)
  - size (geometry), blocks, partitions, ...
- what organization in SSD looks like?



Data storage and hiding

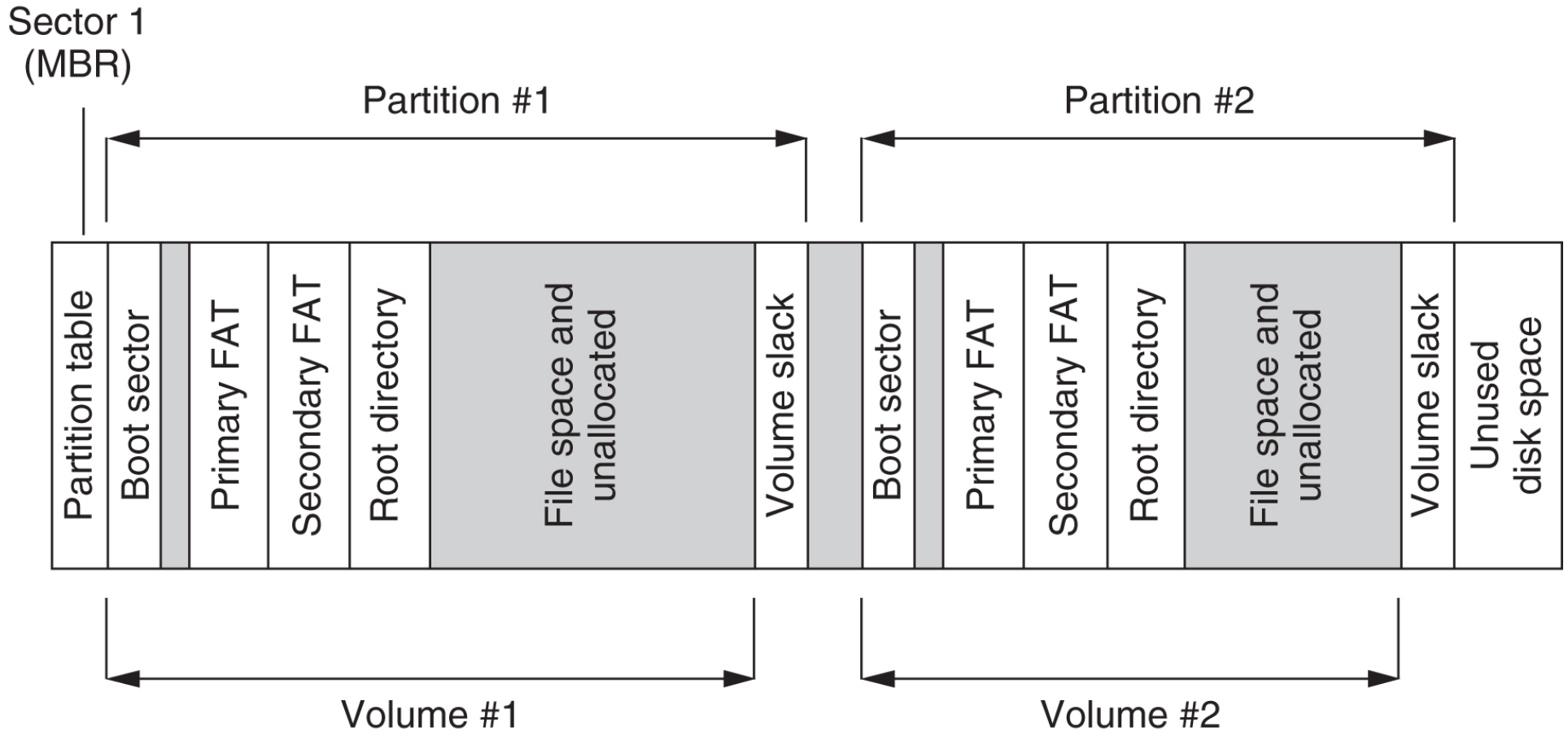
- *Challenge: find the anadisk tool and see what it knows and can do.*
- *Challenge: what is the MBR structure? Build your MBR and post it in the forum..*

Data storage and hiding

- look at the Windows 95 boot sector with the Norton Disk Utils tool

Data storage and hiding

- simplified organization of the disk with the FAT file system



Data storage and hiding

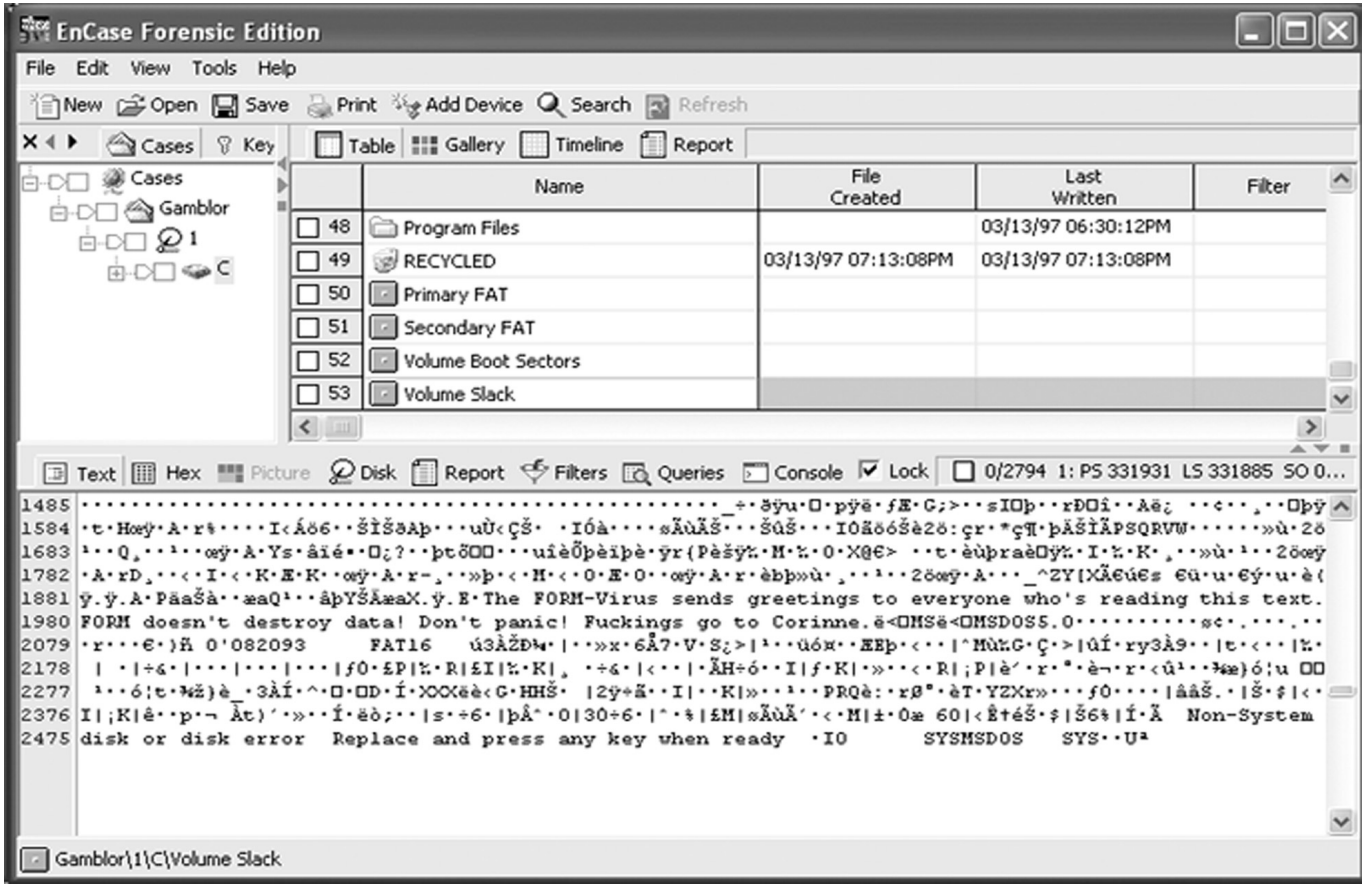
- partition, volume, sector
- inside the file system
- can also be without the file system

Data storage and hiding

- hiding data due to internal and external fragmentation:
  - hiding within a cluster
  - hiding within the partition (partitions usually begin at the beginning of the trace)
  - hiding partition
- partition encryption
- service data: DCO (*Drive/device configuration overlay*) and HPA (*Host/hidden protected area*) – http://www.forensicswiki.org/wiki/DCO_and_HPA

Data storage and hiding

- the virus is hidden in the empty partition volume (volume slack)

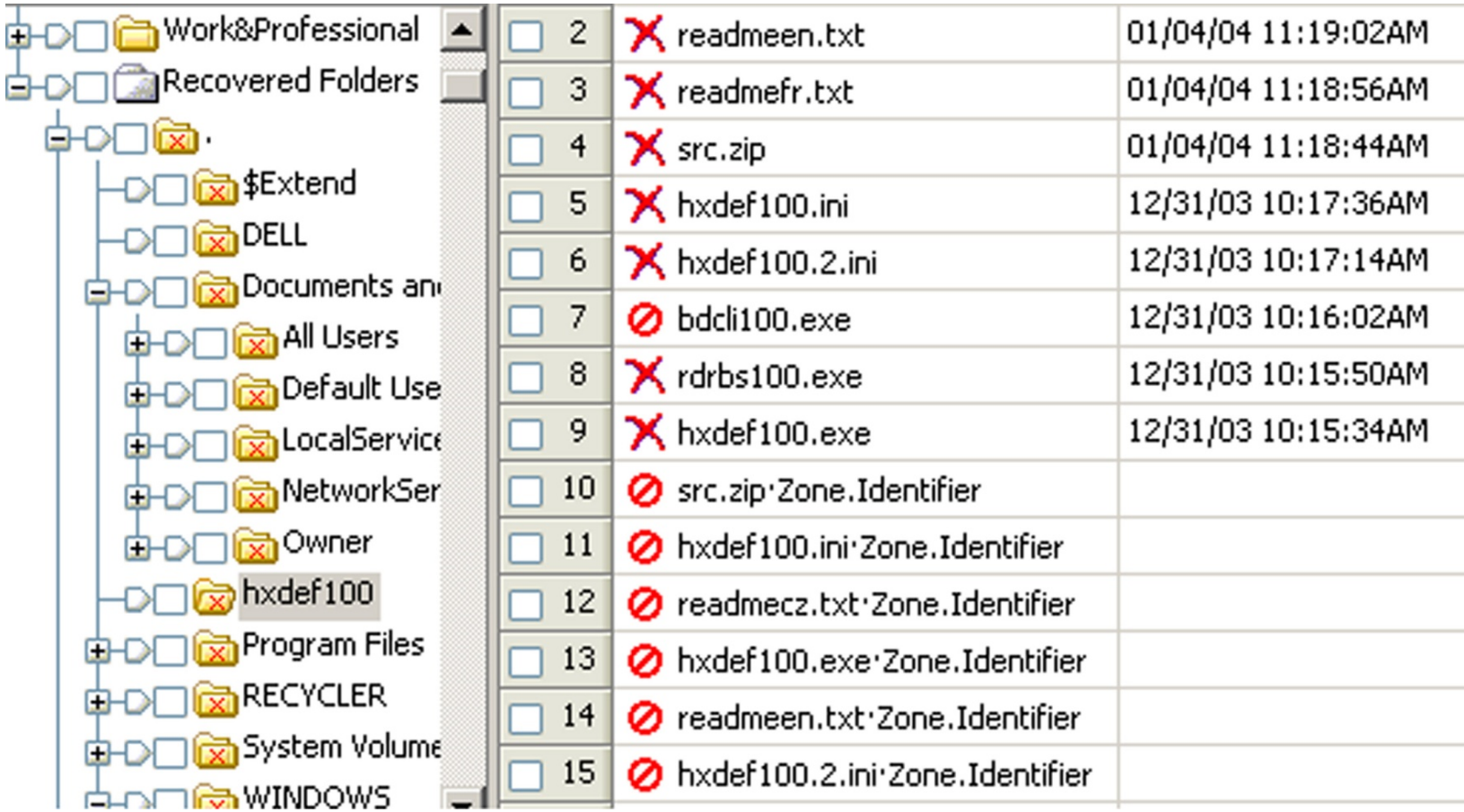


Data storage and hiding

- when file is deleted, data does not disappear
- even when we format the disk, the data does not disappear
  - take a look at the tool **`fdisk`**
- the result of both operations is correct file system and a cluster of empty blocks
- tools: **`sleuthkit`** (http://www.sleuthkit.org/), Norton DiskEdit, …

Data storage and hiding

- An example of the reconstruction of files on a freshly formatted disk with the EnCase tool

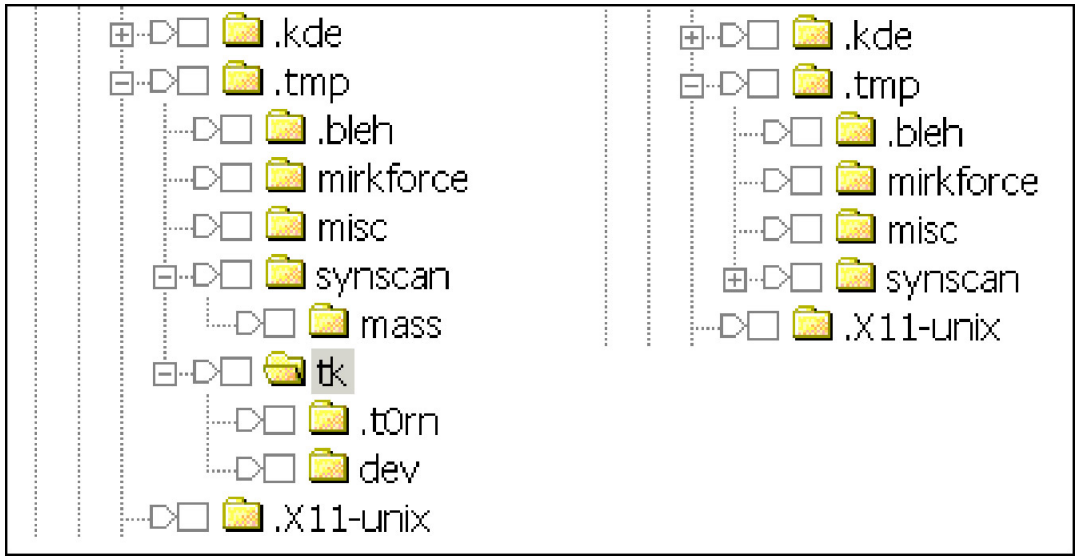


Data storage and hiding

- *Challenge: See what the MBR and boot sector on your computer looks like with an appropriate tool. Report about this on the forum.*
- *Challenge: Check the configuration of your drive.*

Data storage and hiding

- hiding partitions
  - tool Test Disk (http://www.cgsecurity.org/)
- at file level
  - hiding files: e.g. MS Windows: *attrib +H* in *dir/AH*
  - parlament.jpg -> test.exe
  - picture in .ppt pres.
- the latest tools



Passwords and encryption

- tools for breaking and searching passwords
  - Password Recovery Tool – PRTK in Distributed Network Attack – DNA (http://accessdata.com/products/computer-forensics/decryption)
  - John the Ripper (www.openwall.com/john/)
  - Cain and Abel (www.oxid.it/cain.html)
  - Advanced Archive Password Recovery (www.elcomsoft.com/azpr.html)

Passwords and encryption

- more about encryption and cryptography later
- some examples
  - tools caesar, rot13
  - support for the PGP
  - tool crypt

OS Windows

chapter 17

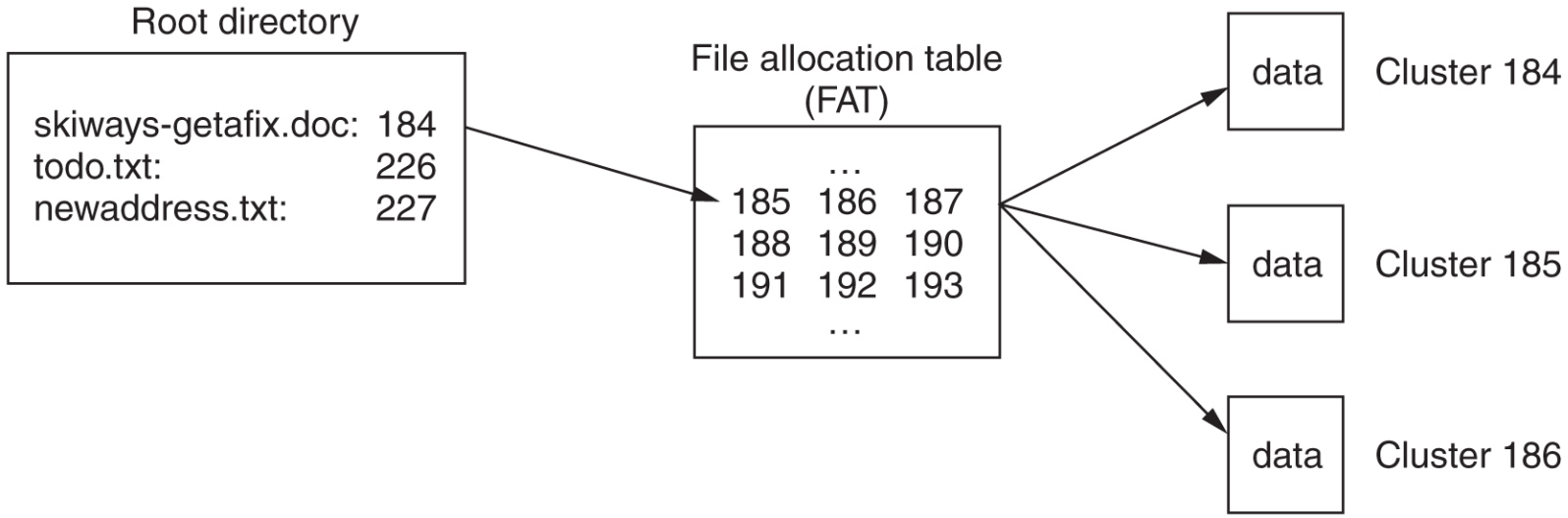
- file systems
- data recovery
- notes (log files)
- register
- communication trails

OS Windows –file system

- two basic file systems FAT (*File Allocation Table*) in NTFS (*New Technology File System*)

- FAT
  - developed first for hard disks (floppy disks)
  - FAT12, FAT16, FAT32

File system FAT



- FATxx is a list of index clusters in which each file is stored
- xx means the number of bits used for the index
- 12 = 2^{12} = 4096, 16 = 2^{16} = 65.536, 32 = 2^{28} = 268.435.456

File system FAT

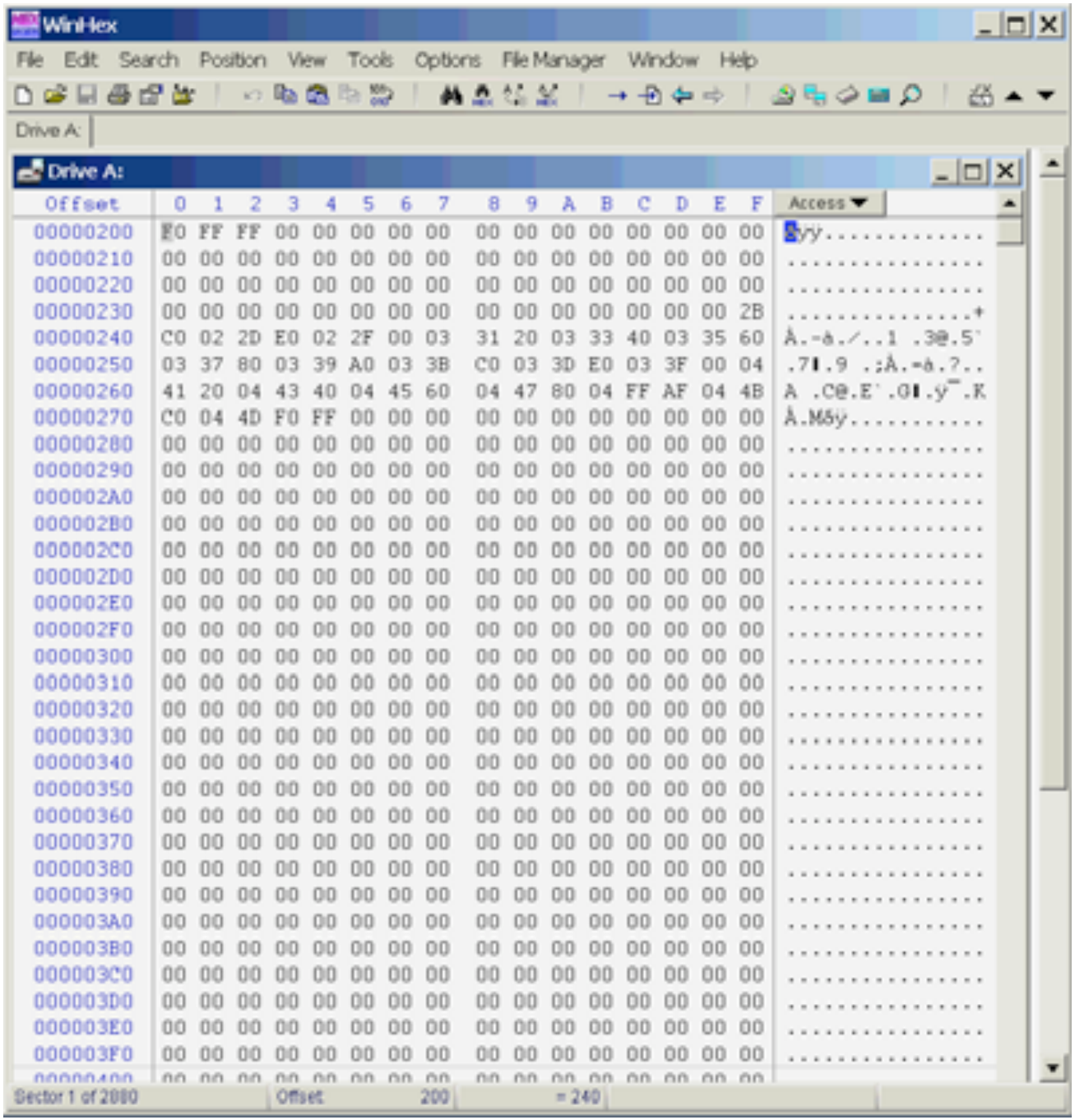
hunter-floppy

\

Name	Type	Size	Created	Modified	Accessed	Attr.	1st sector
(Root directory)		7.0 KB					19
april		0.5 KB	05/08/2003 14:41:44	05/08/2003 14:41:44	05/08/2003		188
greenfield.do	do	19.5 KB	05/08/2003 14:43:00	05/08/2003 14:34:16	05/12/2003	A	306
contacts.xls	xls	16.5 KB	05/08/2003 14:43:15	02/18/2001 12:49:16	05/12/2003	RA	345
skiways-getafix.doc	doc	21.0 KB	05/13/2003 12:32:00	05/13/2003 11:58:10	05/13/2003	A	215
todo.txt	txt	122 B	05/13/2003 12:37:54	05/13/2003 12:40:48	05/13/2003	A	257
newaddress.txt	txt	122 B	05/13/2003 12:42:17	05/13/2003 12:42:18	05/13/2003	A	258
Boot sector		0.5 KB					0
FAT 1		4.5 KB					1
FAT 2		4.5 KB					10
Free space		1.4 MB					
Idle space							

- view the root of the file system on the hard disk using the X-Ways program
- keeps the creation time and last changes but only the last access date

FAT


WinHex
File Edit Search Position View Tools Options File Manager Window Help
Drive A:
Drive A:
Offset 0 1 2 3 4 5 6 7 8 9 A B C D E F Access
00000200 E0 FF FF 00 00 00 00 00 00 00 00 00 00 00 00 00
00000210 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000220 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000230 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 2B
00000240 C0 02 2D E0 02 2F 00 03 31 20 03 33 40 03 35 60
00000250 03 37 80 03 39 A0 03 3B C0 03 3D E0 03 3F 00 04
00000260 41 20 04 43 40 04 45 60 04 47 80 04 FF AF 04 4B
00000270 C0 04 4D F0 FF 00 00 00 00 00 00 00 00 00 00 00
00000280 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000290 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000002F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000300 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000310 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000320 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000330 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000340 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000350 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000360 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000370 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000380 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000390 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003A0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003B0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003E0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
000003F0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Sector 1 of 2880
Offset 200 = 240

File system FAT

- *Challenge: See for yourself what the FAT looks like on your disk. Look in particular for those clusters that are empty - they are not part of any file system.*

File system NTFS

- a more modern file system
  - everything is in files
  - the file information is stored in the system file $MFT
  - directory is only a file (B tree structure)
  - is journal and stores transactions over a file in the system file $LogFile
- supports multiple file functionality
  - *ACL (Access Control List*)
- better protected, since it stores copies of file system data in multiple locations ($MFTMirr)

File system NTFS

File Record	Filename	Description
0	$MFT	Master File Table
1	$MFTMirr	A backup copy of the first 4 records of the MFT
2	$LogFile	Log File for CHKDSK
3	$Volume	Volume Name, Serial Number etc...
4	$AttrDef	Definitions of every Attribute
5	. (dot)	Root directory of the disk
6	$Bitmap	Map of used and unused clusters
7	$Boot	Boot record of the volume
8	$BadClus	List of bad clusters on the partition
9	$Secure	Security Descriptors for each file
10	$UpCase	Table of uppercase characters used for conversion
11	$Extend	Directory for the last four Metafiles.
12-23	UNUSED	Marked in use, or not in use, but empty.
Any	$ObjId	Unique Object IDs given to every file
Any	$Quota	Disk space usage quota information
Any	$Reparse	Reparse point information
Any	$UsnJrnl	NTFS USN Journal (for encryption)

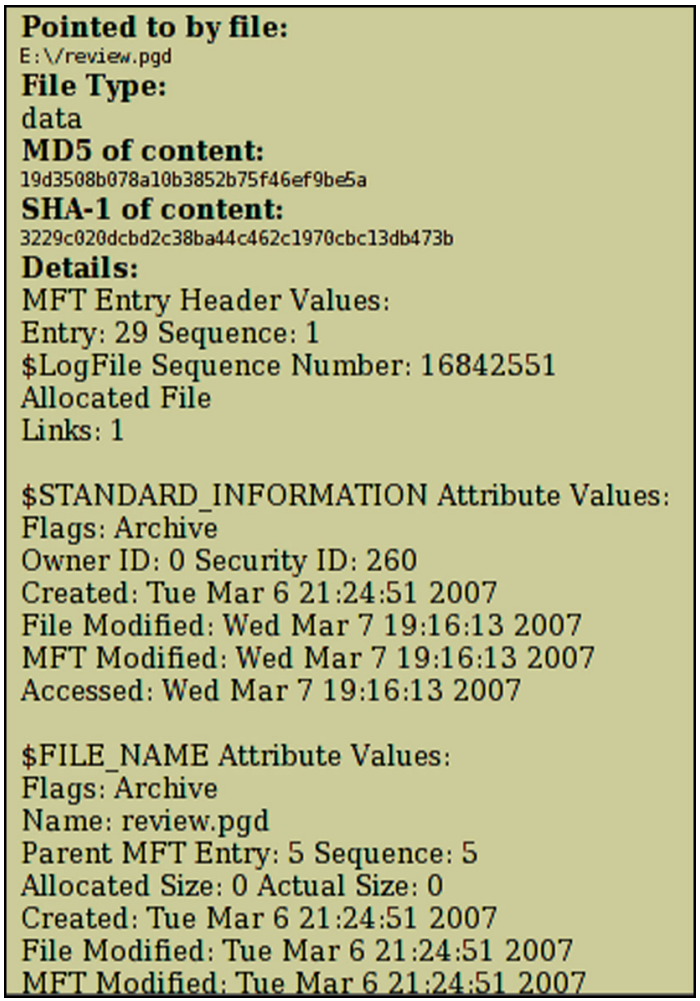
Table 3.1.1 - NTFS 3.0+ Metafiles

File system NTFS

- *Challenge: look for journals in your NTFS journals that are empty (unused) and then look at their content.*

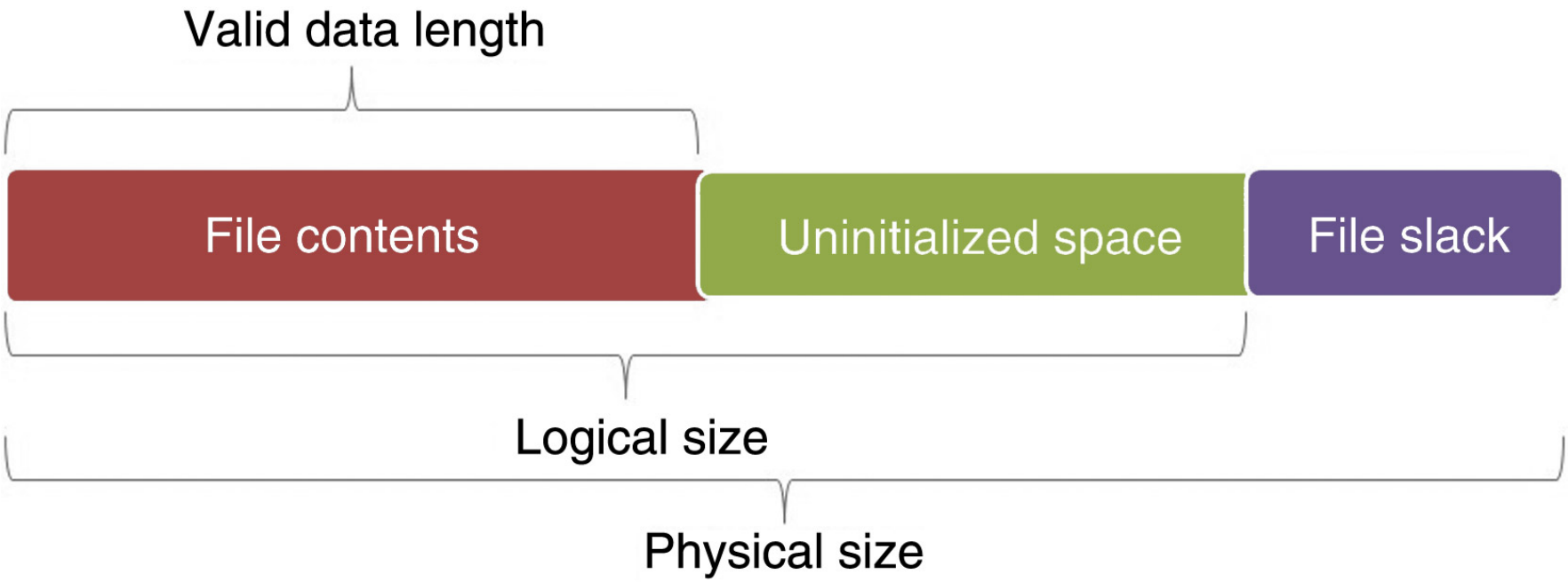
NTFS – $MFT

- example of one record in $MFT
- the record consists of attributes, the record is the size of the 1kB
- if the file is small, it is stored in the record
- when the flag is deleted, then the record is reused



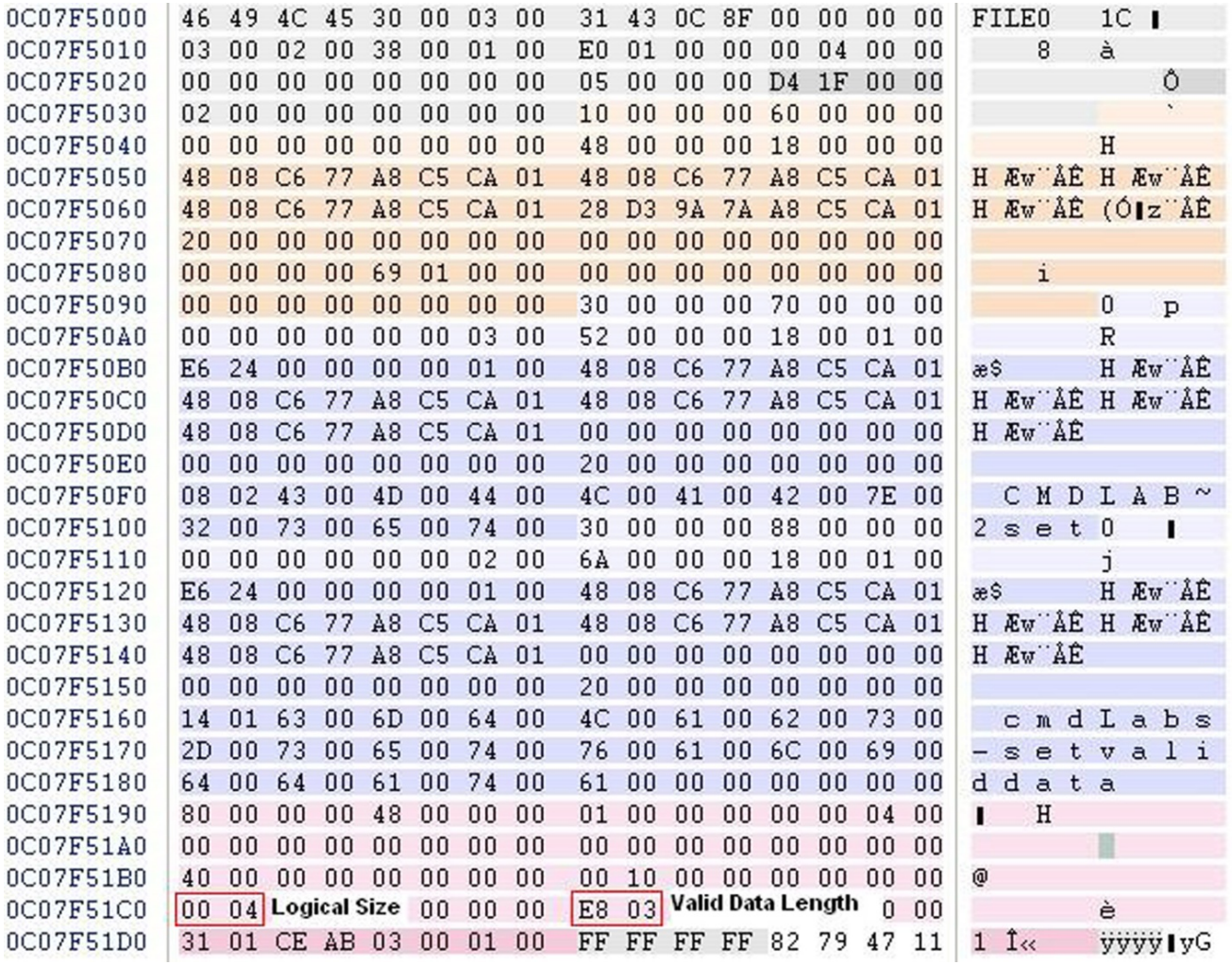
NTFS - search for data

- there is a physical file size (cluster), logical size (directory entry) and the end of the file (EOF)



NTFS – MFT record

- MFT record and the difference between sizes



NTFS - search for data

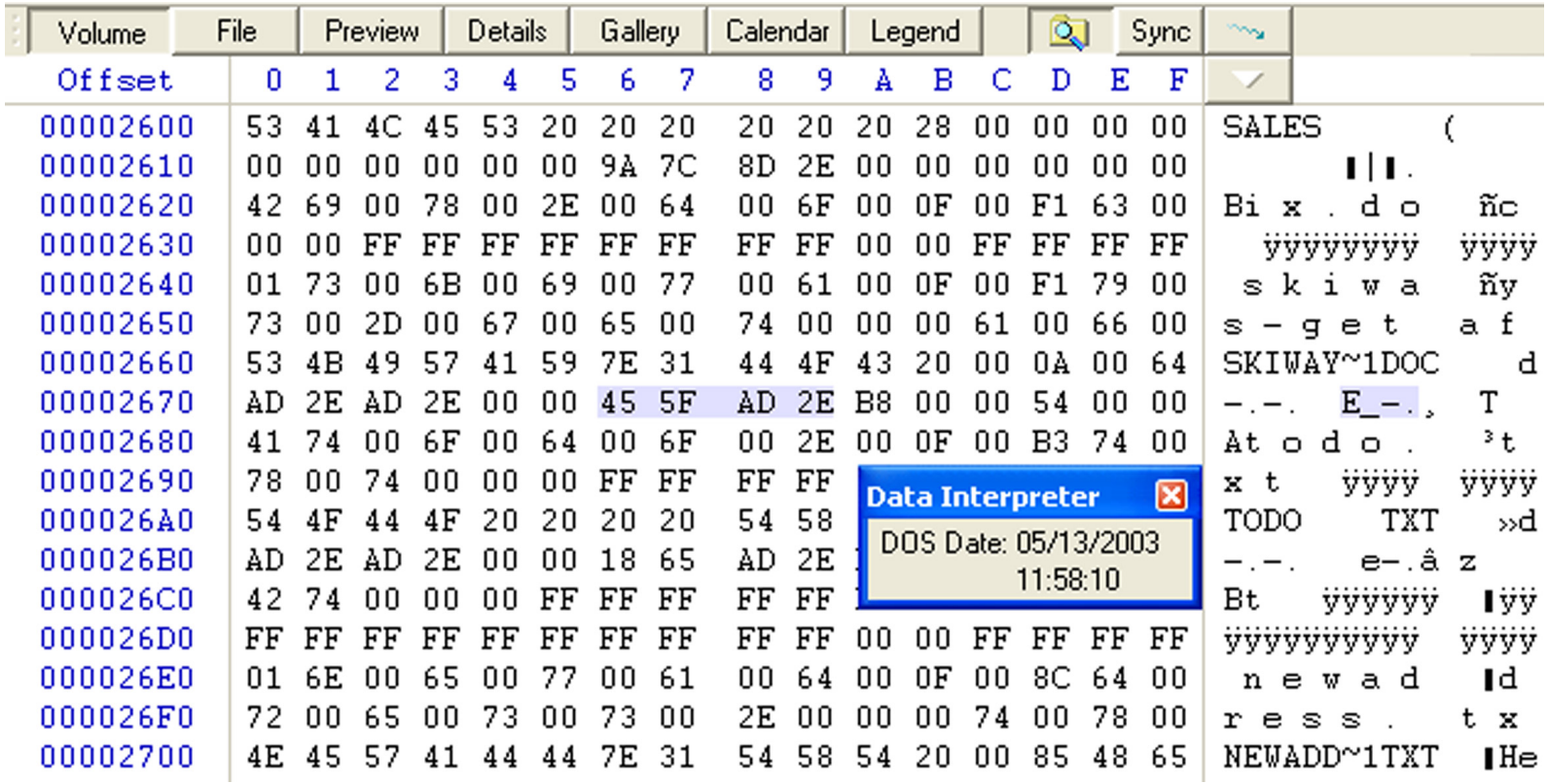
- In one directory we can have multiple files with the same name

File system NTFS

- *Challenge: Which Clusters Compose Your File?*
- *Challenge: Find a busy but unused part of your file (on which clusters) and what's in it.*
- *Challenge: What happens if we make 1000 files, then we delete 1000 and work on it?*

Time coding for files

- FAT: 1.1.1980 + LLLLLLLM MMMDDDDD hhhhhmmm mmmsssss



Time coding for files

- FILETIME
- 64 bit record
  - value = 1.1.1600 + number * 100ns

NTFS - tracks files

- various operations have a different impact on the recorded times in the directory (creation - CR, last access - LA, last change - LC, record changed (NTFS) - RC):
  - moving the file into a directory: it does not affect anything
  - moving the file to another directory: CR, LA, RC
  - copy file (target file): CR, LA, RC
  - copy/paste: LA(*)
  - *drag&drop*: LA(*)
  - delete: LA, RC
- special features:
  - file on a stick, can be via scp/...: CR > LC
  - when deleting a directory, file information does not change

NTFS - tracks files ...

- the content of office files contains metadata from the directory
  - *Save as: if an existing file is picked, the data in the file is overwritten and no new file is created in the directory*
- printing first copies the file to a special directory and then prints it
  - *C:\Windows\Spool\Printers*, *C:\WinNT\System32\Spool\Printers*
  - even when we print online content, etc.

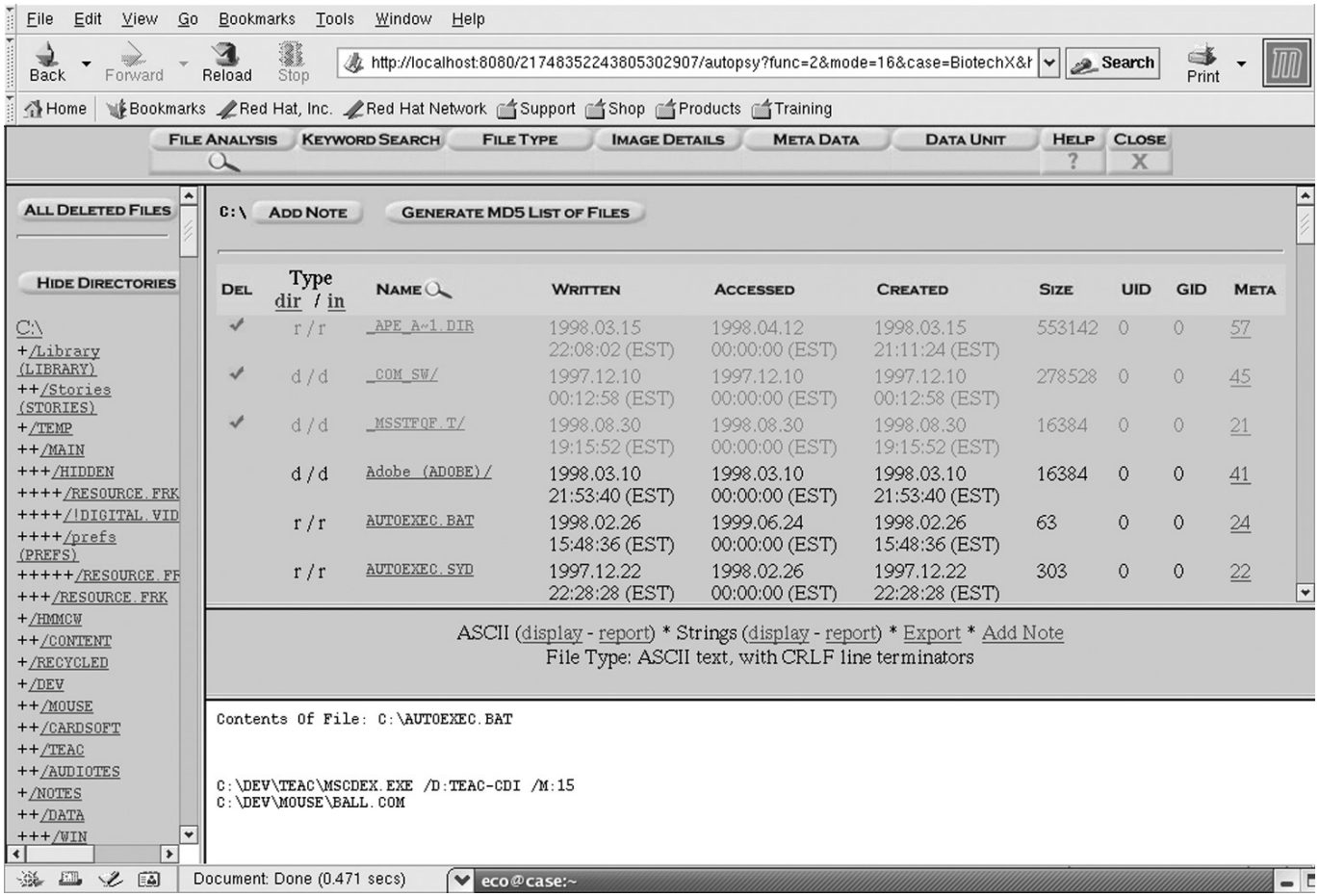
NTFS - tracks files ...

- *Challenge: Find a file that has a creation time greater than the time of the last change*.
- Challenge: What can you say, is there such a file on the system that has the last access time same at he time of the creation?
- Challenge: What is the EMF printing method ? What is stored in the print file (spooler)?

Data recovery

- recover deleted files
  - various tools that can run on WinOS

- SleuthKit combined with Autopsy Browser can even browse through the browser (http://www.sleuthkit.org/autopsy/)



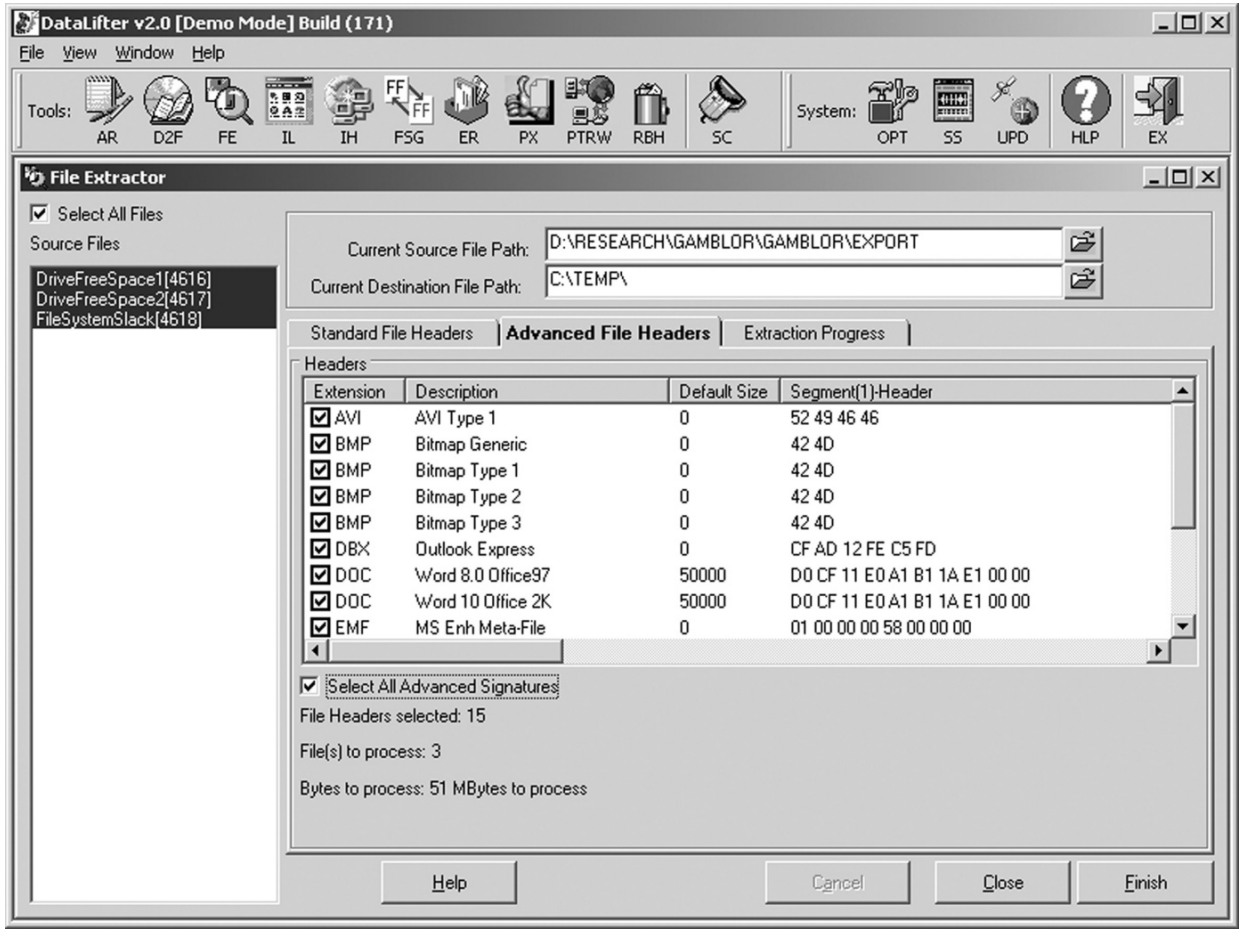
Data recovery …

- *Challenge: install sleuthkit and Autopsy Browser and find the lost files.*

Data recovery …

- searching for lost files from a large unformed mound
  - same as curving files

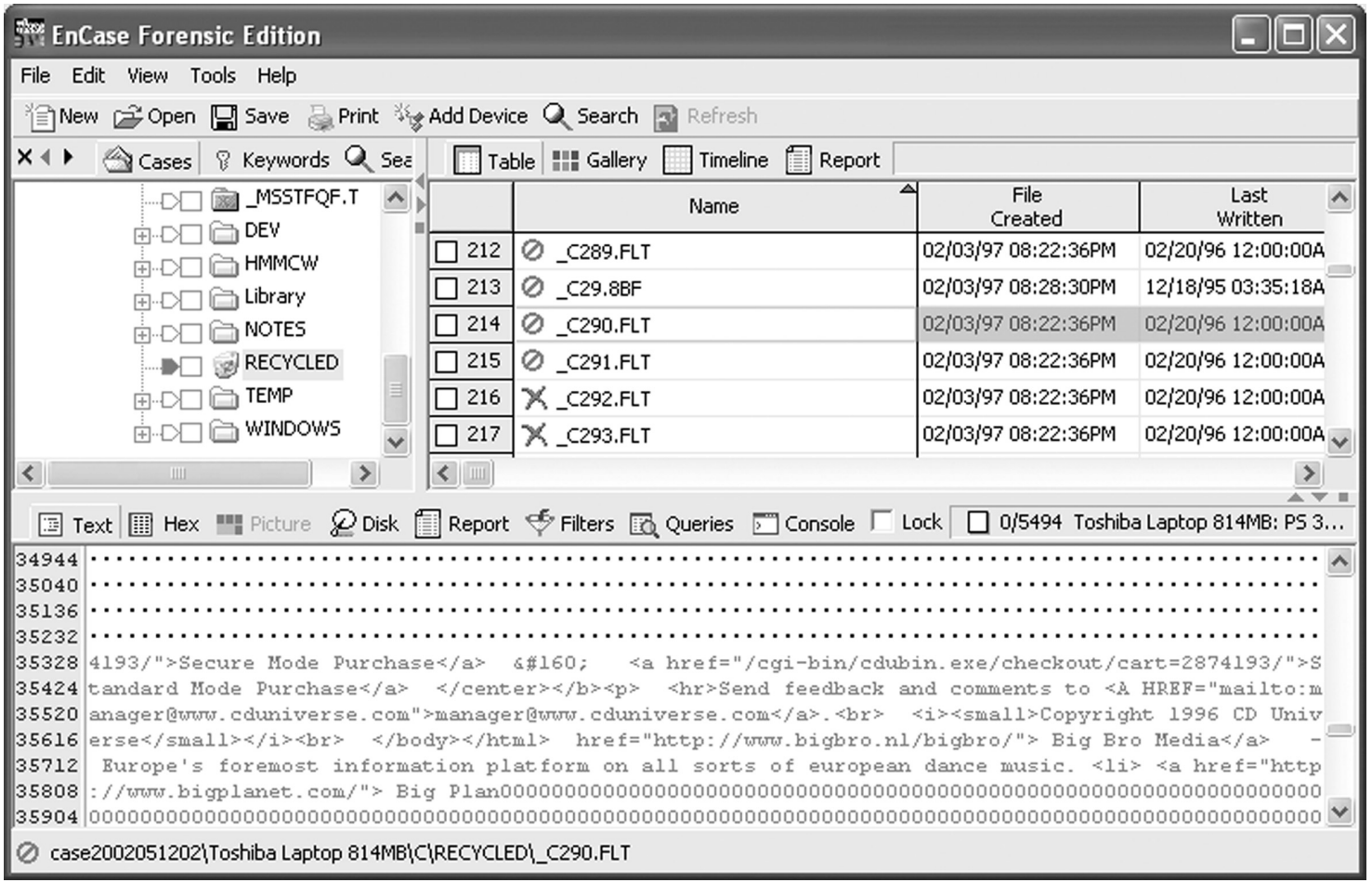
- tool DataLifter: looks for a lost file from two empty spaces and one of the rest of the file system



Data recovery …

- if a small file overwrites larger one, we can reconstruct most of the larger files

- enCase: an example of a shopping cart in the CD Universe, found in the rest of the file space



L*og files*

- the operating system (depending on the settings) records
  - access to resources
  - appearance and deletion of resources,
  - errors, etc.
- saved on *%systemroot%\system32\config* (*c:\winnt\...*)
  - different notes in different files: *Appevent.evt*, *Secevent.evt*, *Sysevent.evt*

Log *files*

- Challenge: check the format of the evt file and check what is in them and when did you logged in to the system.

Register

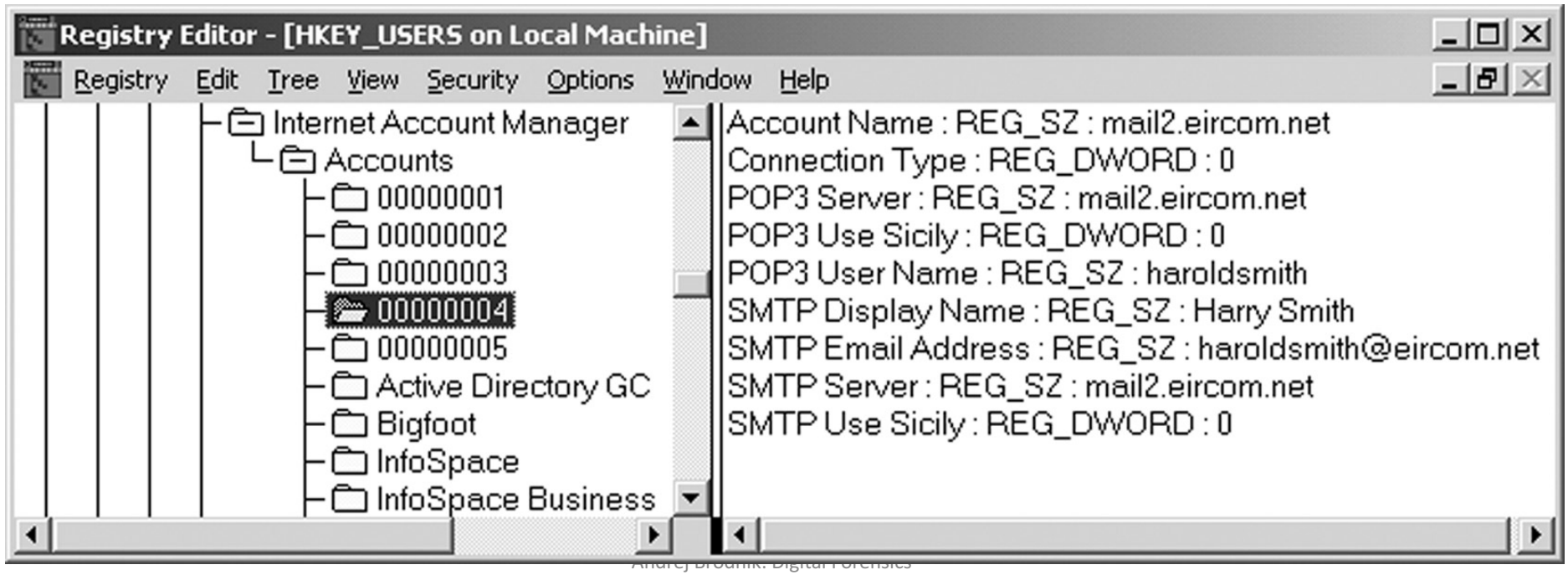
- In Windows OS, the process environment variables are defined in the registers
- actually, the data is stored in the files (hives) in the system directory *%systemroot%\system32\config*
  - *ntuser.dat for each user account*
- files can be viewed with the Windows tool regedt32 (EnCase, FTK, ...)

Register

- *Challenge: examine the forensic value of the data in the registry.*

Network tracking

- sometimes from the system environment
  - when connecting, ...
- mostly comes directly from application
  - browsers, mail agents, ...

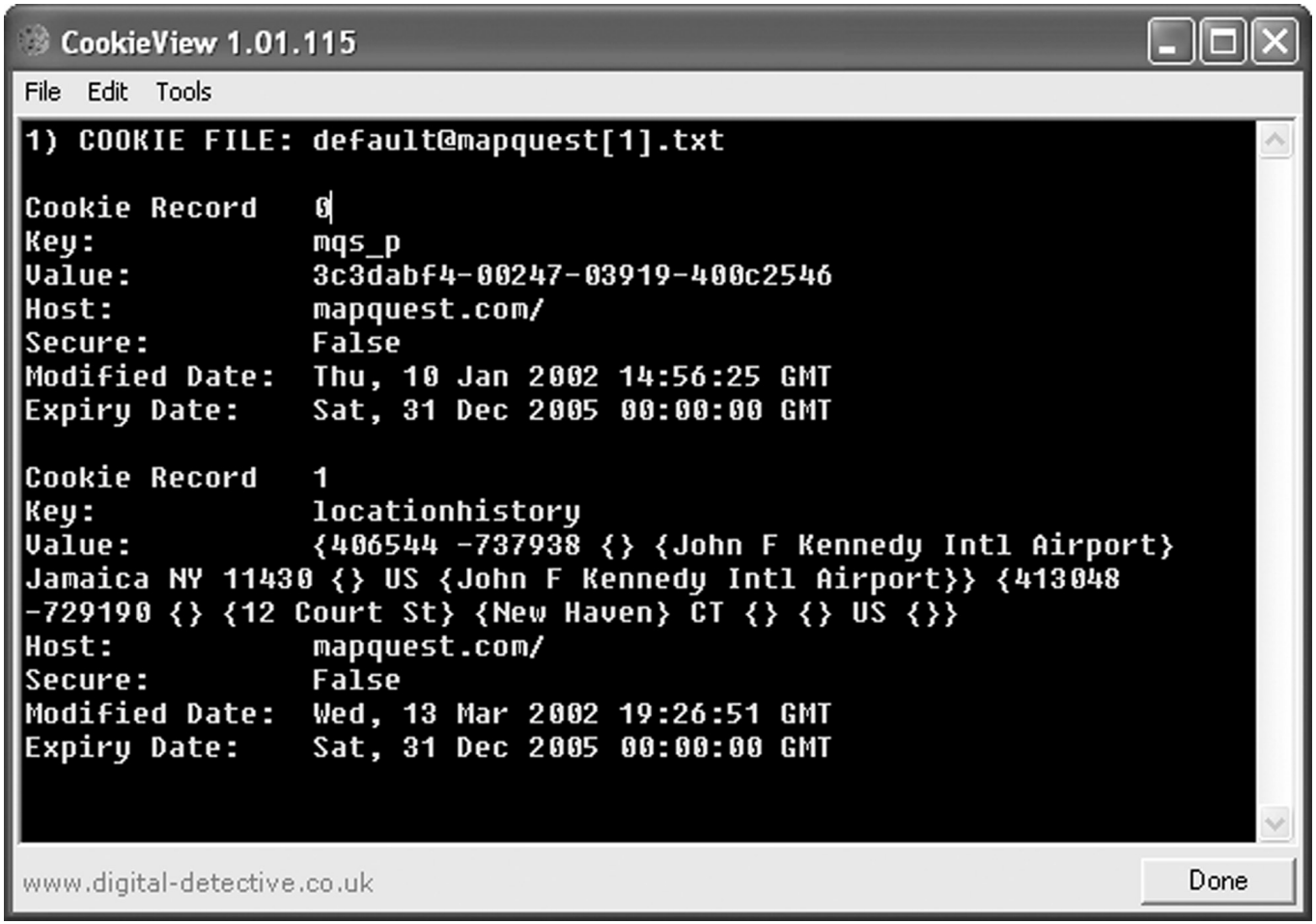


Network Tracking - Browsers

- history:
  - firefox-3 is storing history in the sqlite databases *Places.sqlite*
  - Internet Explorer stores history in the file *index.dat*
  - tools that are available to search through these databases: *Oddesa* (www.odessa.sourceforge.net)
- local cache
- cookies

Browsers - Cookies

- example of cookies inspection in CookieView (www.digitaldetective.co.uk)



Browsers

- *Challenge: Find out what leftovers you do have in your cache and check with your browsing history.*
- *Challenge: Get a file from your friend's browser history and disassemble it.*
- *Challenge: Check out what kind of traces are left behind by the IE browser, what kind by the Mozilla and what kind by the Opera.*

E-mail

- Traces depend on the mail agent we use
  - sent and received mails
  - summary of IMAP mailbox
- content that is interesting
  - text mails only
  - attachments (!) – MIME format

Other programs

- different programs leave different traces
- network software
  - access to other systems
  - allow other systems to access in our system
- system programs leave traces in the registry

Network access tracking

- telnet access to acf2.nyu.edu