Digital forensics

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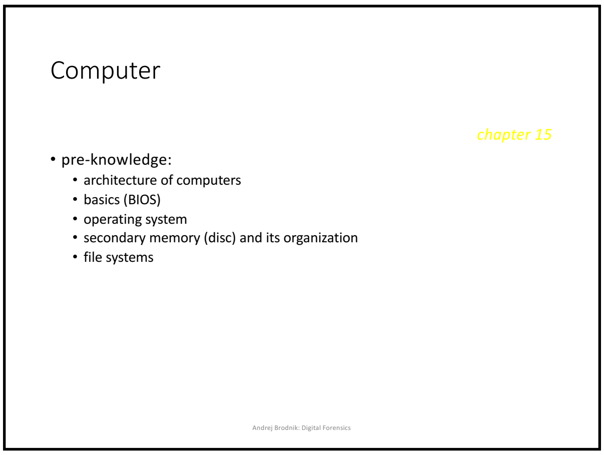
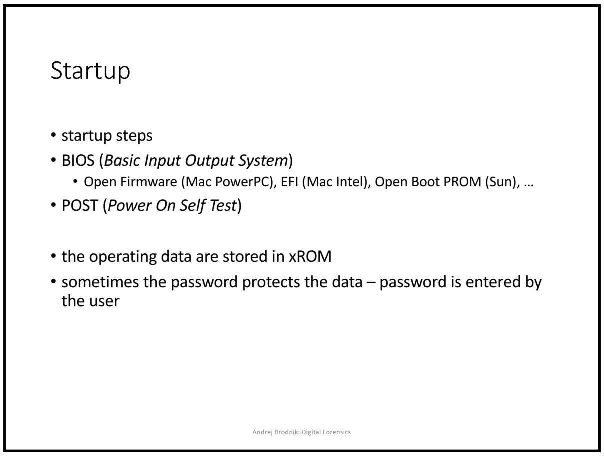


Computer

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

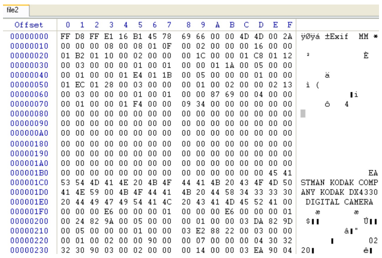
- how the data is encrypted
  - ASCII, …
  - Little / big endian
- What happens if you take disc to another computer

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



```
 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   $▮▮         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

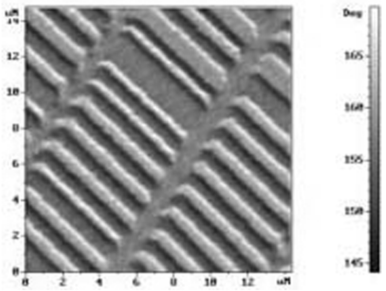
- Challenge: Embed one file in the another file and publish that on the forum. The other colleagues should find the embedded file and extract it using tools like dd or some other tools motioned it the previous slides.
- Challenge: Divide the file into more pieces and insert each one into another file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

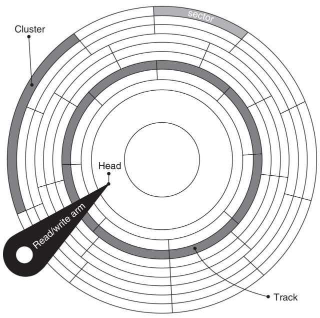
Data storage and hiding

- 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?

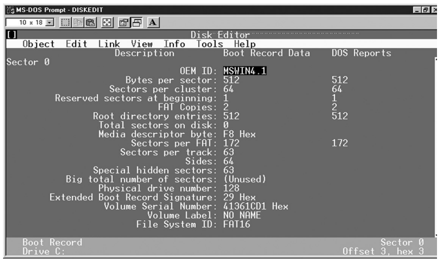


Data storage and hiding

- 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

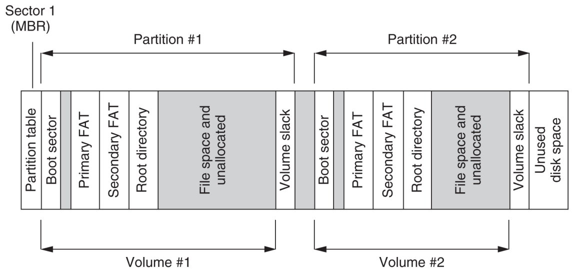
- look at the Windows 95 boot sector with the Norton Disk Utils tool



```
                         Disk Editor
   Object  Edit  Link  View  Info  Tools  Help
                    Description          Boot Record Data    DOS Reports
Sector 0
                            OEM ID: MSWIN4.1
                  Bytes per sector: 512                 512
               Sectors per cluster: 64                  64
     Reserved sectors at beginning: 1                   1
                        FAT Copies: 2                   2
            Root directory entries: 512                 512
             Total sectors on disk: 0
             Media descriptor byte: F8 Hex
                   Sectors per FAT: 172                 172
                 Sectors per track: 63
                             Sides: 64
            Special hidden sectors: 63
       Big total number of sectors: (Unused)
             Physical drive number: 128
    Extended Boot Record Signature: 29 Hex
              Volume Serial Number: 41361CD1 Hex
                      Volume Label: NO NAME
                    File System ID: FAT16
   Boot Record                                                  Sector 0
   Drive C:                                               Offset 3, hex 3
```

Data storage and hiding

- simplified organization of the disk with the FAT file system



Data storage and hiding

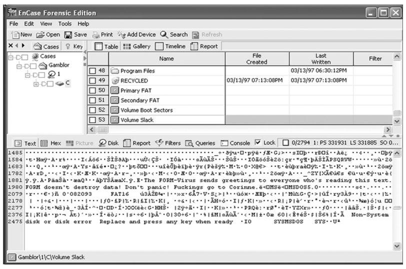
- partition, volume, sector
- inside the file system
- can also be without the file system

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)


EnCase Forensic Edition
File Edit View Tools Help
New Open Save Print Add Device Search Refresh
Cases Key
Table Gallery Timeline Report
Cases
Gamblor
1
C
Text Hex Picture Disk Report Filters Queries Console
☑ Lock
0/2794 1: PS 331931 LS 331885 SO 0...

	Name	File Created	Last Written	Filter
□ 48	Program Files		03/13/97 06:30:12PM	
□ 49	RECYCLED	03/13/97 07:13:08PM	03/13/97 07:13:08PM	
□ 50	Primary FAT			
□ 51	Secondary FAT			
□ 52	Volume Boot Sectors			
□ 53	Volume Slack			

```
1485 ·······················································_÷·ðÿu·□·pÿë·ƒÆ·G;>··sI□þ··rÐ□î··Aë¿ ··¢··¸··□þÿ
1584 ·t·Hœÿ·A·r¾····I‹Áö6··ŠÌŠðAþ···uÙ‹ÇŠ· ·IÓà····sÃùÃŠ···ŠûŠ···IOãöóŠè2ö:çr·*ç¶·þÃŠÌÃPSQRVW······»ù·2ö
1683 ¹··Q¸··¹··œÿ·A·Ys·âïé•·□¿?··þtõ□□···uíèÕþèïþè·ÿr(PèšÿЖ·M·ж·0·X@€> ··t·èùþraè□ÿЖ·I·ж·K·¸··»ù·¹··2öœÿ
1782 ·A·rD¸··‹·I·‹·K·Æ·K··œÿ·A·r–¸··»þ·‹·M·‹·0·Æ·0··œÿ·A·r·èbþ»ù·¸··¹··2öœÿ·A···_^ZY[XÃ€ú€s €ü·u·€ÿ·u·è(
1881 ÿ.ÿ.A·PäaŠà··æaQ¹··âþYŠÃæaX.ÿ.E·The FORM-Virus sends greetings to everyone who's reading this text.
1980 FORM doesn't destroy data! Don't panic! Fuckings go to Corinne.ë<□MSë<□MSDOS5.0··········s¢·.···.··
2079 ·r···€·)ñ 0'082093     FAT16   ú3ÀŽÐ¼·|··»x·6Å7·V·S¿>|¹··üó¤··ÆEþ·‹··|^MùЖG·Ç·>|ûÍ·ry3À9··|t·‹··|Ж·
2178  | ·|÷&·|···|···|···|ƒ0·£P|Ж·R|£I|Ж·K|¸ ·÷&·|‹··|·ÃH÷ó··I|ƒ·K|·»··‹·R|;P|è´·r·*·è¬·r·‹û¹··¾æ)ó¦u □□
2277  ¹··ó¦t·¾Ž)è_·3ÀÍ·^·□·□D·Í·XXXëè‹G·HHŠ· |2ÿ÷ã··I|··K|»··¹··PRQè:·rØ*·èT·YZXr»···ƒ0····|âãŠ.·|Š·$|‹·
2376 I|;K|ê··p·¬ Åt)´·»··Í·ëò;··|s·÷6·|þÅ^·0|30÷6·|^·$|£M|sÃùÃ´·‹·M|±·0æ 60|‹Ê†éŠ·$|Š6$|Í·Ã  Non-System
2475 disk or disk error  Replace and press any key when ready  ·IO      SYSMSDOS   SYS··Uª
```

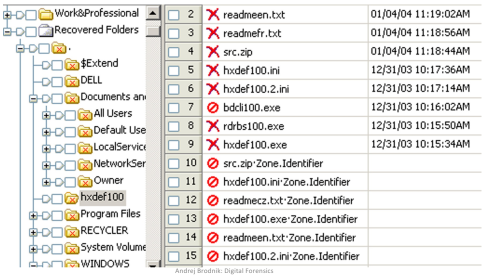
Gamblor\1\C\Volume Slack

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



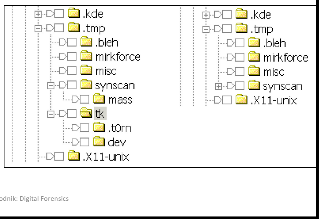
□	2	✗ readmeen.txt	01/04/04 11:19:02AM
□	3	✗ readmefr.txt	01/04/04 11:18:56AM
□	4	✗ src.zip	01/04/04 11:18:44AM
□	5	✗ hxdef100.ini	12/31/03 10:17:36AM
□	6	✗ hxdef100.2.ini	12/31/03 10:17:14AM
□	7	⊘ bdcli100.exe	12/31/03 10:16:02AM
□	8	✗ rdrbs100.exe	12/31/03 10:15:50AM
□	9	✗ hxdef100.exe	12/31/03 10:15:34AM
□	10	⊘ src.zip·Zone.Identifier	
□	11	⊘ hxdef100.ini·Zone.Identifier	
□	12	⊘ readmecz.txt·Zone.Identifier	
□	13	⊘ hxdef100.exe·Zone.Identifier	
□	14	⊘ readmeen.txt·Zone.Identifier	
□	15	⊘ hxdef100.2.ini·Zone.Identifier	

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

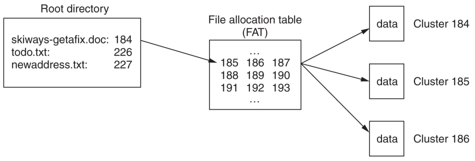
chapter 17

- 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



Root directory

skiways-getafix.doc: 184
todo.txt: 226
newaddress.txt: 227

File allocation table (FAT)

…
185 186 187
188 189 190
191 192 193
…

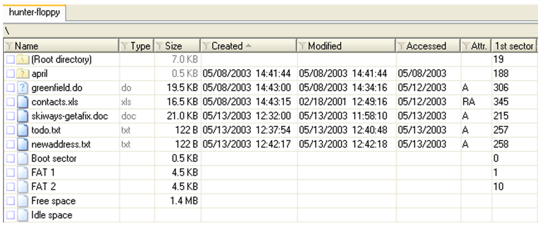
data Cluster 184

data Cluster 185

data Cluster 186

- 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

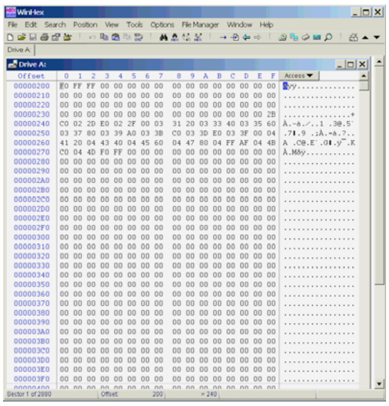
File system FAT



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



```
  Offset   0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F
00000200  F0 FF FF 00 00 00 00 00  00 00 00 00 00 00 00 00  ðÿÿ.............
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  À.-à./..1 .3@.5`
00000250  03 37 80 03 39 A0 03 3B  C0 03 3D E0 03 3F 00 04  .7€.9 .;À.=à.?..
00000260  41 20 04 43 40 04 45 60  04 47 80 04 FF AF 04 4B  A .C@.E`.G€.ÿ¯.K
00000270  C0 04 4D F0 FF 00 00 00  00 00 00 00 00 00 00 00  À.Mðÿ...........
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  ................
00000400  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
Sector 1 of 2880        Offset:        200        = 240
```

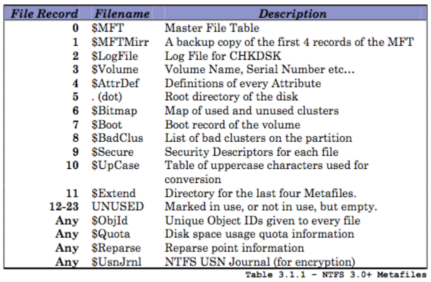
File system FAT

- *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)

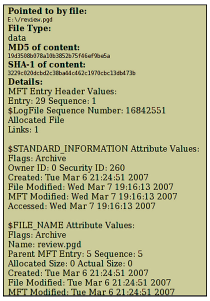
Table 3.1.1 – NTFS 3.0+ Metafiles

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



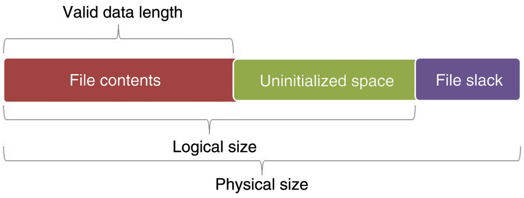
Pointed to by file:
E:\/review.pgd
File Type:
data
MD5 of content:
19d3508b078a10b3852b75f46ef9be5a
SHA-1 of content:
3229c020dcbd2c38ba44c462c1970cbc13db473b
Details:
MFT Entry Header Values:
Entry: 29 Sequence: 1
$LogFile Sequence Number: 16842551
Allocated File
Links: 1

$STANDARD_INFORMATION Attribute Values:
Flags: Archive
Owner ID: 0 Security ID: 260
Created: Tue Mar 6 21:24:51 2007
File Modified: Wed Mar 7 19:16:13 2007
MFT Modified: Wed Mar 7 19:16:13 2007
Accessed: Wed Mar 7 19:16:13 2007

$FILE_NAME Attribute Values:
Flags: Archive
Name: review.pgd
Parent MFT Entry: 5 Sequence: 5
Allocated Size: 0 Actual Size: 0
Created: Tue Mar 6 21:24:51 2007
File Modified: Tue Mar 6 21:24:51 2007
MFT Modified: Tue Mar 6 21:24:51 2007

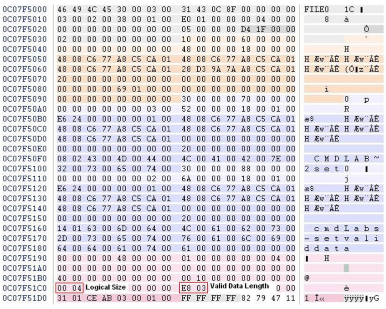
NTFS - search for data

- 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



```
0C07F5000  46 49 4C 45 30 00 03 00  31 43 0C 8F 00 00 00 00  FILE0   1C ▮
0C07F5010  03 00 02 00 38 00 01 00  E0 01 00 00 00 04 00 00     8  à
0C07F5020  00 00 00 00 00 00 00 00  05 00 00 00 D4 1F 00 00             Ô
0C07F5030  02 00 00 00 00 00 00 00  10 00 00 00 60 00 00 00             `
0C07F5040  00 00 00 00 00 00 00 00  48 00 00 00 18 00 00 00          H
0C07F5050  48 08 C6 77 A8 C5 CA 01  48 08 C6 77 A8 C5 CA 01  H Æw¨ÅÊ H Æw¨ÅÊ
0C07F5060  48 08 C6 77 A8 C5 CA 01  28 D3 9A 7A A8 C5 CA 01  H Æw¨ÅÊ (Ó▮z¨ÅÊ
0C07F5070  20 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0C07F5080  00 00 00 00 69 01 00 00  00 00 00 00 00 00 00 00      i
0C07F5090  00 00 00 00 00 00 00 00  30 00 00 00 70 00 00 00          0   p
0C07F50A0  00 00 00 00 00 00 03 00  52 00 00 00 18 00 01 00          R
0C07F50B0  E6 24 00 00 00 00 01 00  48 08 C6 77 A8 C5 CA 01  æ$      H Æw¨ÅÊ
0C07F50C0  48 08 C6 77 A8 C5 CA 01  48 08 C6 77 A8 C5 CA 01  H Æw¨ÅÊ H Æw¨ÅÊ
0C07F50D0  48 08 C6 77 A8 C5 CA 01  00 00 00 00 00 00 00 00  H Æw¨ÅÊ
0C07F50E0  00 00 00 00 00 00 00 00  20 00 00 00 00 00 00 00
0C07F50F0  08 02 43 00 4D 00 44 00  4C 00 41 00 42 00 7E 00    C M D L A B ~
0C07F5100  32 00 73 00 65 00 74 00  30 00 00 00 88 00 00 00  2 s e t 0   ▮
0C07F5110  00 00 00 00 00 00 02 00  6A 00 00 00 18 00 01 00          j
0C07F5120  E6 24 00 00 00 00 01 00  48 08 C6 77 A8 C5 CA 01  æ$      H Æw¨ÅÊ
0C07F5130  48 08 C6 77 A8 C5 CA 01  48 08 C6 77 A8 C5 CA 01  H Æw¨ÅÊ H Æw¨ÅÊ
0C07F5140  48 08 C6 77 A8 C5 CA 01  00 00 00 00 00 00 00 00  H Æw¨ÅÊ
0C07F5150  00 00 00 00 00 00 00 00  20 00 00 00 00 00 00 00
0C07F5160  14 01 63 00 6D 00 64 00  4C 00 61 00 62 00 73 00    c m d L a b s
0C07F5170  2D 00 73 00 65 00 74 00  76 00 61 00 6C 00 69 00  - s e t v a l i
0C07F5180  64 00 64 00 61 00 74 00  61 00 00 00 00 00 00 00  d d a t a
0C07F5190  80 00 00 00 48 00 00 00  01 00 00 00 00 00 04 00  ▮   H
0C07F51A0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0C07F51B0  40 00 00 00 00 00 00 00  00 10 00 00 00 00 00 00  @
0C07F51C0  00 04 Logical Size 00 00 00  E8 03 Valid Data Length 0 00          è
0C07F51D0  31 01 CE AB 03 00 01 00  FF FF FF FF 82 79 47 11  1 Î«    ÿÿÿÿ▮yG
```

NTFS - search for data

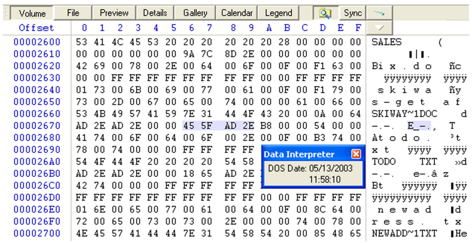
- In one directory we can have multiple files with the same name

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

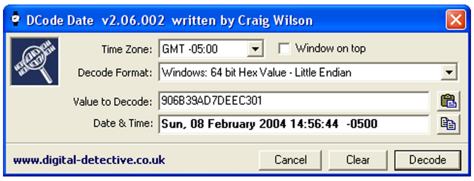


```
Offset    0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F
00002600  53 41 4C 45 53 20 20 20  20 20 20 28 00 00 00 00  SALES      (
00002610  00 00 00 00 00 00 9A 7C  8D 2E 00 00 00 00 00 00        ▌|▌.
00002620  42 69 00 78 00 2E 00 64  00 6F 00 0F 00 F1 63 00  Bi x . d o   ñc
00002630  00 00 FF FF FF FF FF FF  FF FF 00 00 FF FF FF FF    ÿÿÿÿÿÿÿÿ  ÿÿÿÿ
00002640  01 73 00 6B 00 69 00 77  00 61 00 0F 00 F1 79 00   s k i w a   ñy
00002650  73 00 2D 00 67 00 65 00  74 00 00 00 61 00 66 00  s - g e t   a f
00002660  53 4B 49 57 41 59 7E 31  44 4F 43 20 00 0A 00 64  SKIWAY~1DOC    d
00002670  AD 2E AD 2E 00 00 45 5F  AD 2E B8 00 00 54 00 00  -.-.  E_-.,  T
00002680  41 74 00 6F 00 64 00 6F  00 2E 00 0F 00 B3 74 00  At o d o .   ³t
00002690  78 00 74 00 00 00 FF FF  FF FF                    x t   ÿÿÿÿ  ÿÿÿÿ
000026A0  54 4F 44 4F 20 20 20 20  54 58                    TODO    TXT   »d
000026B0  AD 2E AD 2E 00 00 18 65  AD 2E                    -.-.  e-.â z
000026C0  42 74 00 00 00 FF FF FF  FF FF                    Bt   ÿÿÿÿÿ  ▌ÿÿ
000026D0  FF FF FF FF FF FF FF FF  FF FF 00 00 FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿ  ÿÿÿÿ
000026E0  01 6E 00 65 00 77 00 61  00 64 00 0F 00 8C 64 00   n e w a d   ▌d
000026F0  72 00 65 00 73 00 73 00  2E 00 00 00 74 00 78 00  r e s s .   t x
00002700  4E 45 57 41 44 44 7E 31  54 58 54 20 00 85 48 65  NEWADD~1TXT  ▌He
```

DOS Date: 05/13/2003 11:58:10

Time coding for files

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



DCode Date v2.06.002 written by Craig Wilson

Time Zone: GMT -05:00

□ Window on top

Decode Format: Windows: 64 bit Hex Value - Little Endian

Value to Decode: 906B39AD7DEEC301

Date & Time: Sun, 08 February 2004 14:56:44 -0500

www.digital-detective.co.uk

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.

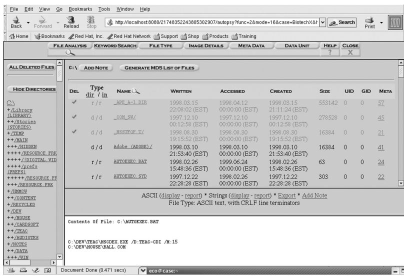
NTFS - tracks files ...

- *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/)


File Edit View Go Bookmarks Tools Window Help
Back Forward Reload Stop
http://localhost:8080/21748352243805302907/autopsy?func=2&mode=16&case=BiotechX&
Search
Print
Home Bookmarks Red Hat, Inc. Red Hat Network Support Shop Products Training
File Analysis Keyword Search File Type Image Details Meta Data Data Unit Help Close
?
X
All Deleted Files
Hide Directories
C:\ Add Note Generate MD5 List of Files
Document: Done (0.471 secs)
eco@case:~

C:\
+/Library (LIBRARY)
++/Stories (STORIES)
+/TEMP
++/MAIN
+++/HIDDEN
++++/RESOURCE.FRK
++++/!DIGITAL.VID
++++/prefs (PREFS)
+++++/RESOURCE.FR
+++/RESOURCE.FRK
+/HMMCW
++/CONTENT
+/RECYCLED
+/DEV
++/MOUSE
++/CARDSOFT
++/TEAC
++/AUDIOTES
+/NOTES
++/DATA
+++/WIN

Del	Type dir / in	Name	Written	Accessed	Created	Size	UID	GID	Meta
✓	r / r	_APE_A~1.DIR	1998.03.15 22:08:02 (EST)	1998.04.12 00:00:00 (EST)	1998.03.15 21:11:24 (EST)	553142	0	0	57
✓	d / d	_COM_SW/	1997.12.10 00:12:58 (EST)	1997.12.10 00:00:00 (EST)	1997.12.10 00:12:58 (EST)	278528	0	0	45
✓	d / d	_MSSTFOF.T/	1998.08.30 19:15:52 (EST)	1998.08.30 00:00:00 (EST)	1998.08.30 19:15:52 (EST)	16384	0	0	21
	d / d	Adobe (ADOBE)/	1998.03.10 21:53:40 (EST)	1998.03.10 00:00:00 (EST)	1998.03.10 21:53:40 (EST)	16384	0	0	41
	r / r	AUTOEXEC.BAT	1998.02.26 15:48:36 (EST)	1999.06.24 00:00:00 (EST)	1998.02.26 15:48:36 (EST)	63	0	0	24
	r / r	AUTOEXEC.SYD	1997.12.22 22:28:28 (EST)	1998.02.26 00:00:00 (EST)	1997.12.22 22:28:28 (EST)	303	0	0	22

ASCII (display - report) * Strings (display - report) * Export * Add Note
File Type: ASCII text, with CRLF line terminators

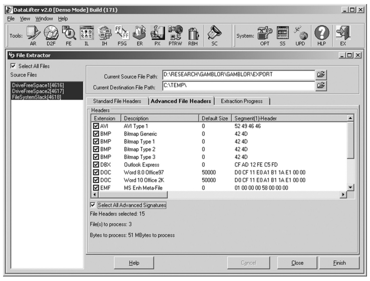
```
Contents Of File: C:\AUTOEXEC.BAT


C:\DEV\TEAC\MSCDEX.EXE /D:TEAC-CDI /M:15
C:\DEV\MOUSE\BALL.COM
```

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



DataLifter v2.0 [Demo Mode] Build (171)

☑ Select All Files

Source Files

DriveFreeSpace1[4616]
DriveFreeSpace2[4617]
FileSystemSlack[4618]

Current Source File Path: D:\RESEARCH\GAMBLOR\GAMBLOR\EXPORT

Current Destination File Path: C:\TEMP\

Headers

Extension	Description	Default Size	Segment(1)-Header
☑ AVI	AVI Type 1	0	52 49 46 46
☑ BMP	Bitmap Generic	0	42 4D
☑ BMP	Bitmap Type 1	0	42 4D
☑ BMP	Bitmap Type 2	0	42 4D
☑ BMP	Bitmap Type 3	0	42 4D
☑ DBX	Outlook Express	0	CF AD 12 FE C5 FD
☑ DOC	Word 8.0 Office97	50000	D0 CF 11 E0 A1 B1 1A E1 00 00
☑ DOC	Word 10 Office 2K	50000	D0 CF 11 E0 A1 B1 1A E1 00 00
☑ EMF	MS Enh Meta-File	0	01 00 00 00 58 00 00 00

☑ Select All Advanced Signatures

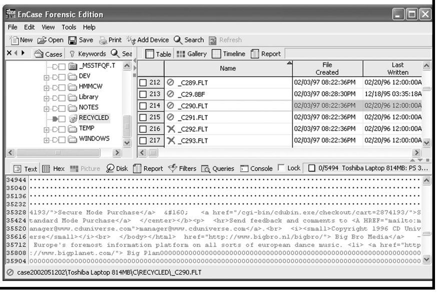
File Headers selected: 15

File(s) to process: 3

Bytes to process: 51 MBytes to process

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



EnCase Forensic Edition

File Edit View Tools Help
New Open Save Print Add Device Search Refresh
Cases Keywords Sea
Table Gallery Timeline Report
_MSSTFQF.T
DEV
HMMCW
Library
NOTES
RECYCLED
TEMP
WINDOWS
Text Hex Picture Disk Report Filters Queries Console Lock
0/5494 Toshiba Laptop 814MB: PS 3...

	Name	File Created	Last Written
□ 212	_C289.FLT	02/03/97 08:22:36PM	02/20/96 12:00:00A
□ 213	_C29.8BF	02/03/97 08:28:30PM	12/18/95 03:35:18A
□ 214	_C290.FLT	02/03/97 08:22:36PM	02/20/96 12:00:00A
□ 215	_C291.FLT	02/03/97 08:22:36PM	02/20/96 12:00:00A
□ 216	_C292.FLT	02/03/97 08:22:36PM	02/20/96 12:00:00A
□ 217	_C293.FLT	02/03/97 08:22:36PM	02/20/96 12:00:00A

```
34944 ................................................................................
35040 ................................................................................
35136 ................................................................................
35232 ................................................................................
35328 4193/">Secure Mode Purchase</a>  &#160;   <a href="/cgi-bin/cdubin.exe/checkout/cart=2874193/">S
35424 tandard Mode Purchase</a>  </center></b><p>  <hr>Send feedback and comments to <A HREF="mailto:m
35520 anager@www.cduniverse.com">manager@www.cduniverse.com</a>.<br>  <i><small>Copyright 1996 CD Univ
35616 erse</small></i><br>  </body></html>  href="http://www.bigbro.nl/bigbro/"> Big Bro Media</a>   -
35712  Europe's foremost information platform on all sorts of european dance music. <li> <a href="http
35808 ://www.bigplanet.com/"> Big Plan0000000000000000000000000000000000000000000000000000000000000
35904 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

case2002051202\Toshiba Laptop 814MB\C\RECYCLED_C290.FLT

Log 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

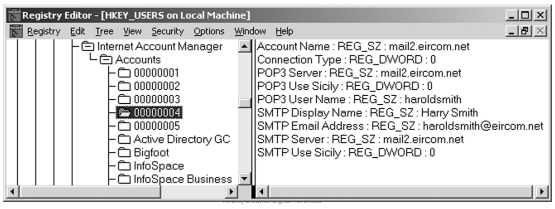
- In Windows OS, the process environment variables are defined in the registers
- actually, the data is stored in the files (hives) in the system directory *%systemroot%\system32\config*
  - *ntuser.dat for each user account*
- files can be viewed with the Windows tool regedt32 (EnCase, FTK, ...)

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, …



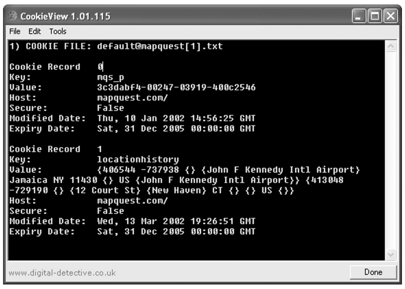
```
Account Name : REG_SZ : mail2.eircom.net
Connection Type : REG_DWORD : 0
POP3 Server : REG_SZ : mail2.eircom.net
POP3 Use Sicily : REG_DWORD : 0
POP3 User Name : REG_SZ : haroldsmith
SMTP Display Name : REG_SZ : Harry Smith
SMTP Email Address : REG_SZ : haroldsmith@eircom.net
SMTP Server : REG_SZ : mail2.eircom.net
SMTP Use Sicily : REG_DWORD : 0
```

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)



```
1) COOKIE FILE: default@mapquest[1].txt

Cookie Record   0
Key:            mqs_p
Value:          3c3dabf4-00247-03919-400c2546
Host:           mapquest.com/
Secure:         False
Modified Date:  Thu, 10 Jan 2002 14:56:25 GMT
Expiry Date:    Sat, 31 Dec 2005 00:00:00 GMT

Cookie Record   1
Key:            locationhistory
Value:          {406544 -737938 {} {John F Kennedy Intl Airport}
Jamaica NY 11430 {} US {John F Kennedy Intl Airport}} {413048
-729190 {} {12 Court St} {New Haven} CT {} {} US {}}
Host:           mapquest.com/
Secure:         False
Modified Date:  Wed, 13 Mar 2002 19:26:51 GMT
Expiry Date:    Sat, 31 Dec 2005 00:00:00 GMT
```

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

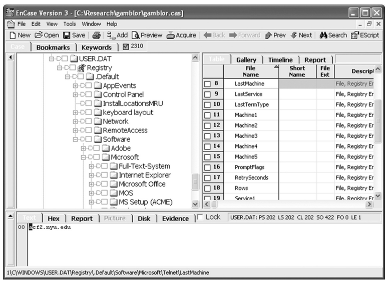
- Traces depend on the mail agent we use
  - sent and received mails
  - summary of IMAP mailbox
- content that is interesting
  - text mails only
  - attachments (!) – MIME format

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



EnCase Version 3 - [C:\Research\gamblor\gamblor.cas]
File Edit View Tools Window Help
New Open Save Add Preview Acquire Back Forward Prev Next Search EScript
Case Bookmarks Keywords 2310
USER.DAT
Registry
.Default
AppEvents
Control Panel
InstallLocationsMRU
keyboard layout
Network
RemoteAccess
Software
Adobe
Microsoft
Full-Text-System
Internet Explorer
Microsoft Office
MOS
MS Setup (ACME)
Table Gallery Timeline Report
Text Hex Report Picture Disk Evidence
Lock

	File Name	Short Name	File Ext	Descript
□ 8	LastMachine			File, Registry Er
□ 9	LastService			File, Registry Er
□ 10	LastTermType			File, Registry Er
□ 11	Machine1			File, Registry Er
□ 12	Machine2			File, Registry Er
□ 13	Machine3			File, Registry Er
□ 14	Machine4			File, Registry Er
□ 15	Machine5			File, Registry Er
□ 16	PromptFlags			File, Registry Er
□ 17	RetrySeconds			File, Registry Er
□ 18	Rows			File, Registry Er
□ 19	Service1			File, Registry Er

USER.DAT: PS 202 LS 202 CL 202 SO 422 FO 0 LE 1

```
00 acf2.nyu.edu
```

1\C\WINDOWS\USER.DAT\Registry\.Default\Software\Microsoft\Telnet\LastMachine

Andrej Brodnik: Digital Forensics