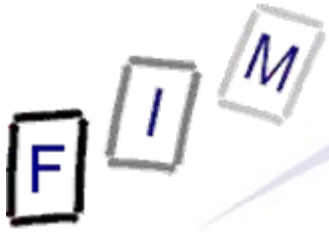

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Filesystem investigation

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Agenda

- Install the software:
  - → OSFMount
  - → Cygwin
  - → Optional (can be run from CD): WinHex, HxD
- Search for deleted files and reconstruct them
  - → WinHex: Deleted file (FAT)
  - → Reconstruct: If possible
- Discovering hidden files: Wrong extension
  - → Cygwin: "file" command
- Windows ADS
  - → LADS – Find the picture hidden in an ADS
- Timestamps
  - → WinHex: Analyze timestamps and convert them
- Running time of your Windows computer
  - → Analyze the event log

Scenario

❶

❷

❷

❸

Images

- Source of images: http://dftt.sourceforge.net/
  - → ❶ 6-undel-fat.zip
    - » FAT image
  - → ❷ 8-jpeg-search.zip
    - » NTFS image
  - → ❸ 5-fat-daylight.zip
    - » FAT image
- Attention: Copy the files to a local disk and remove the "Read-only" attribute → Else you cannot mount them RW!
- Requirements:
  - → Operating System: Windows (XP, Vista; NT, 2K, 7: ???)
  - → Harddisk space:
    - » Scenarios: 17 MB
    - » Cygwin: A lot; approx. 700 MB!
    - » Other software: A few MB

Software installation

- OSFMount: Mounting disk images as drives under Windows
  - → Requires Administrator access
- Install "Winhex"
  - → Not really needed; can be run directly from CD!
    - » Copy to harddisk for faster start if desired
    - » Need to use "Run as Administrator" (or configure this in properties) to fully work on Windows 7 (Vista: Probably too)
- Install "HxD"
  - → Not really needed; can be run directly from CD!

Software installation

- Install "Cygwin"
  - → Linux-like environment (and programs) under windows
  - → Procedure:
    - » Execute "setup.exe" and choose to install from local path
      - – Select the subdirectory starting with "ftp…" in it as install source
        - » E.g.: “E:\Software\Source”
      - – No spaces in the path of destination directory allowed!
        E.g. **not** C:\Program Files\...
    - » Change selection to "install" on the "All" selection
      - – Click on the "circular arrows" icons repeatedly (once should suffice)
  - → Add the binary directory to the path
    - » XP: Control panel – System – Advanced – Environment Variables → Add the complete path to the user variables, e.g. add ";C:\Cygwin\bin“ to the end
    - » Win 7: Control panel – System and Security – System – Advanced System Settings – Environment Variables

Search for deleted files: FAT

- Find and recover the deleted files in image ❶!
- Your task:
  - → Find out, which files did at some time exist in the image
    - » Investigate through HxD
      - – Note Windows 7: Normal user → Cannot see mounted disk
        Admin → Sees & opens mounted disk
    - » Recovery through WinHex!
      - – Manual recovery in WinHex not possible due to evaluation version limitations
  - → Recover these files
    - » Check their MD5 values
- Document your actions through a log and screen shots!
- Hints:
  - → FAT1 starts at offset 0x1000, FAT2 (=copy) at 0x4000
  - → Root directory is at offset 0x7000

Search for deleted files: FAT

- MD5 table of correctly recovered files

Filename	File size	MD5 value
\SING.DAT	780	59B20779F69FF9F0AC5FCD2C38835A79
\MULT1.DAT	3801	FFD27BD782BDCE67750B6B9EE069D2EF
\FRAG1.DAT	1584	7A3BC5B763BEF201202108F4BA128149
\FRAG2.DAT	3873	0E80AB84EF0087E60DFC67B88A1CF13E
\DIR1\		
MULT2.DAT	1715	59CF0E9CD107BC1E75AFB7374F6E05BB
DIR2\		
FRAG3.DAT	2027	21121699487F3FBBDB9A4B3391B6D3E0

Search for deleted files: FAT

- Mount the image ❶ as readonly (6-fat-undel.dd)
- Look at the image directly (cmd.exe)
  - → There is not a single file there!
- Examine it using a Hex editor
  - → Find the FAT and the root directory (see also later)
  - → Root dir: Starts at offset 0x7000 (=sector 56)
    - » Note: The first directory entry is not a file, but the volume label!
- Root dir content:
  - → ?RAG1.DAT, ?RAG2.DAT, ?ING.DAT, ?ULT1.DAT, ?YSTEM~1 ("System Volume Information"; long filename)
    - » 0xE5 → This file has been deleted
  - → ?IR1: Deleted directory
    - » Difference file vs. directory? Byte 0x0B, Bit 4 (here: 0x10)!

Search for deleted files: FAT

- Manual undelete of ?ING.DAT
  - → Overwrite first byte (0xE5) with something else (e.g. 0x53 = S)
    - » Note: You have to change into edit mode with F6!
    - » But writing to the disk does not work in the evaluation version!
      - – Default edit mode gives an error message, but in-place mode just silently ignores all changes you make!
  - → Right-click on the file and then "Recover/Copy…"
  - → Copy the files to your hard disk and calculate their MD5 sum
    - – Example: "md5sum _ING.DAT"
    - » Note, that the MD5 for ?ING.DAT and ?ULT1.DAT are correct, but those for ?RAG1.DAT and ?RAG2.DAT are not
    - » Why? Examine the FAT table at offset 0x1000 (or 0x4000)!
    - » The FAT has been completely cleared, except for the first sector
      - – This is the sector of the root directory!
  - → Automatic undelete has therefore the problem, that it cannot know which sectors belong to a file if fragmentation occurs!
    - » File carving needed!

Search for deleted files: FAT

- → Result: Start at first (=known) sector and copy consecutive number of bytes till the file size has been reached
- → Possible chance at detection (but not solution!): The sector is marked as "in use" by another directory entry
  - » However, this is marked as deleted as well, so which one was the later one cannot really be determined either!
    - – MAC dates might help here to some degree

- Deleted directory: Only the directory is marked as deleted
  - → The files/directory inside are only implicitly deleted!
  - → Their first character still exists: MULT2.DAT and subdir DIR2
  - → \DIR1\DIR2: FRAG3.DAT
  - → MULT2.DAT can be recovered, FRAG3.DAT is again a fragmented file and cannot be recovered
    - » Although extracted without **any** warning or error message!

Discovering hidden files: Wrong extensions

- Find out, which of all the files in image ❷ are jpg pictures!
- Your task:
  - → Collect all files, except those in archives
    - » How many are these?
  - → Identify their file type
    - » Do this manually (Winhex/HxD)
      - – Check first in the internet: How to recognize a JPG file
    - » Use the command "file"
      - – Inspect the "magic" file and find the description for JPG files
    - » Use command "strings" (file1.jpg, file4.jpg, file12.doc, cmd.exe)
  - → Identify the file type of the archives
- Document your actions through a log and screen shots!

Wrong extensions: Exemplary solution – Manual check

- Mount the image ❷ as readonly (8-jpeg-search.dd)
- Collect all files
  - → alloc\file1.jpg, alloc\file2.dat, \invalid\file3.jpg, \invalid\file4.jpg, \invalid\file5.rtf, misc\file11.dat, misc\file12.doc, misc\file13.dll
  - → In total 8 files (+3 archives)
- Search the Internet for recognizing JPEG files
  - → E.g. search Google for "JPEG magic number"
    - » See http://en.wikipedia.org/wiki/Magic_number_(programming)
    - » JPEG start with 0xFFD8 and end with 0xFFD9
      - – Most (JPEG/JFIF type) also contain "JFIF\0"!
- Identify files manually
  - → Open alloc\file1.jpg in Winhex
    - » Both start and end match, and "JFIF" is found at offset 0x06
  - → This also applies to alloc\file2.dat → Wrong extension!

Wrong extensions: Exemplary solution – Manual check

- → invalid\file3.jpg has a different start (0x4865) and end (0x300A)
- → invalid\file4.jpg claims to be a JPEG, but has only a header
  - » The footer is 0x9F32; additionally there is no "JFIF"
    - – Only "JF", and that at index 0x02AB90!
- → invalid\file5.rtf has neither header nor footer and no "JFIF"
  - » But signature occurs several times within, e.g. 0x2CF3, 0x4094!
  - » Only "JF" at 0x013062 (no "JFI" or "JFIF"!)
- → misc\file11.dat has a wrong header, but a correct footer
  - » Additionally, "JFIF" occurs at 0x062A
  - » At 0x0624 there is the correct header signature
  - » This could be a JPEG with some other data at the beginning
    - – Extract it with WinHex (in 2 parts, e.g. to 0x31FFF; eval. limit)
    - – Concatenate with "copy /b part1.bin + part2.bin file11.jpg"
  - » We have recovered a new picture ("I Am Picture #8")!

Wrong extensions: Exemplary solution – Manual check

- misc\file12.doc is similar to file11.dat, but the end of the picture is not the end of the file
  - Do the same as above
  - Actually, this is a valid MS Word document with an embedded JPEG; these are not necessarily always stored as "plain“ data!
  - Extract from 0x1348 until 0x1C26C (inclusive)
    - 0x1348-0xFFFF and 0x010000-0x1C26C; Concatenate
  - We have recovered "I Am Picture #9"!
- misc\file13.dll: Header and footer wrong, no "JFIF"
  - This is no picture!
  - It looks more like random data

Wrong extensions: Exemplary solution – "file" command

- The file command uses a table of "magic values" to identify file types according to their content
  - → These rules can be very simple, but also complex
- Where is the file: %CYGWIN%\usr\share\misc\magic.mgc
  - → JPEG now in separate file (here a compiled version!)
    - » Note: "JFIF" occurs already before, but those are movie files!
  - → As can be seen, only the start of the file is checked!
    - » Starts with 0xFFD8
    - » At exactly the position 0x06 the string "JFIF" must occur
      - – The ">" is a continuation marker, **not** an index modifier!
- Identify file types:
  - → alloc/file1.jpg: JPEG image data, JFIF standard 1.01
  - → alloc/file2.dat: JPEG image data, JFIF standard 1.01
  - → /invalid/file3.jpg: ASCII English text
    - » Actually, the file only starts with ASCII English text. But as only the start is checked, the rest is ignored!

Wrong extensions: Exemplary solution – "file" command

- \invalid\file4.jpg: JPEG image data
  - » Note: No "JFIF" and "version ?.?"!
    - – Identified, as only the (correct) header is checked, but not the footer
    - – The missing "JFIF" should be a warning sign here!
- \invalid\file5.rtf: data
  - » Could not be identified; actually it is just random data
- misc\file11.dat: data
  - » As only the start is checked, the picture later on is **not** found!
- misc\file12.doc: CDF V2 Document
  - » This is a "Microsoft Office Document"
    - – The type of Microsoft office files is often hard to identify because of the complex file format
      - » Actually a kind of archive with several streams
- misc\file13.dll: data
  - » Just random data, correctly identified

Wrong extensions: Exemplary solution – "strings" command

- Only as an example: The "strings" command
  - → More useful for investigating executables
    - » What text do they contain
    - » If a debug version → what methods do they call, messages etc.
- Examine alloc\file1.jpg
  - → strings file1.jpg | more
    - » All strings, first one is "JFIF"
  - → strings file1.jpg | grep "JFIF"
    - » Select only those lines containing the specific string
- Examine invalid\file4.jpg
  - → strings file4.jpg | grep "JFIF"
    - » Returns nothing → no JPEG
      - – Actually, just not a JPEG/JFIF!

Wrong extensions: Exemplary solution – "strings" command

- Examine misc\file12.doc
  - → Finds "JFIF" very early, but not as the first string
  - → The end is more interesting: The document properties!
    - » We can find out that some "Brian Carrier" is somehow involved with this document
      - – Detailed investigation: This is the author (of document and image)
    - » We can also see that it was created by Microsoft Word 10.1
      - – What version is this really? From when is it?
        - » MS MacWord 10.1 (=“Office X”) from 2001
- Examine %SYSTEMROOT%\system32\cmd.exe
  - → Lots of Windows functions
    - » E.g. MessageBeep, CopyFileExW, RegEnumKeyW, _wcslwr
  - → At least one message "CMD Internal Error %s"
  - → Win XP: Some "ASCII art" (probably icon information)
  - → Win 7: Some XML (Assembly/security information)

Wrong extensions: Exemplary solution – Archives

- Check the file type of the archives with the "file" command
  - → file8.zip: Zip archive data, at least v2.0 to extract
    - » "unzip file8.zip –d C:\temp"
      - – file8.jpg + random8.dat (some random data)
    - » file8.jpg is "I Am Picture #5"
  - → file9.boo: Zip archive data, at least v2.0 to extract
    - » Unzip as before → file9.jpg + random9.dat
    - » file9.jpg is "I Am picture #6"
  - → file10.tar.gz: gzip compressed data, from Unix
    - » "file –z file10.tar.gz" → Identifies a TAR inside a ZIP
    - » "gzip –d file10.tar.gz –c > C:\temp\file10.tar"
  - → file10.tar: POSIX tar archive (GNU)
      - – A file archive (several files; not compressed!)
    - » "tar –xvf file10.tar"
      - – file10.jpg + random10.dat (some random data)
    - » file10.jpg is "I Am Picture #7"

Search for deleted files: Bonus example - NTFS

- Search for deleted files in this image
- Recover them if possible
  - → In del1 a deleted JPEG can be recovered (file6.jpg)
  - → In del2 another file could theoretically be recovered completely (file7.hmm)
    - » Not actually because of the WinHex evaluation version size limit!
    - » Or recover it manually in two parts and combine them
- Note that this is not a FAT, but a NTFS volume!

Windows ADS

- Find the hidden picture!
- In the image ❷ there is an additional picture hidden
  - → This is located within an alternate data stream
- Your task:
  - → Find the location of the hidden picture
  - → Extract the picture into a separate "normal" file
  - → Add the picture to another file and to a directory
    - » Not "into" the directory, but to the directory entry itself!
    - » Name the ADS "new*picture"
      - – Could you create a normal file with this name?
- Document your actions through a log and screen shots!

Windows ADS: Exemplary solution

- Mount the image ❷ as **read-write** (8-jpeg-search.dd)
- Run lads for every directory
  - → Or use the parameter "/s" on the root directory
- Look at the result: The file "**?**:\misc\file13.dll" contains an ADS with the name "here"
  - → "**?**:\misc\file13.dll:here"
- Extract the ADS through "more"
  - → "more < **?**:\misc\file13.dll:here >here.jpg"
  - → Examine the file: Is it really a picture?
  - → Check the MD5: It should be 9b787e63e3b64562730c5aecaab1e1f8!
    - » The result is different! Why?
  - → Open the file in Winhex and compare it to another JPEG file from the same drive
    - » It seems, that "more" does some textual translation, outputting 0x0D0A instead of 0x00 (translation to plain text!)

Windows ADS: Exemplary solution

- Extract through "cp" (Cygwin!)
  - → "cp **?**:\misc\file13.dll:here here.jpg“
    - » **NOT WORKING** with current cygwin version anymore!
  - → Check the file with a hex editor: Is it a picture? Yes!
  - → Calculate the MD5 value and check it
    - » Now it is OK!
- View the picture: Just open it (double-click) or use Paint
  - → It shows a green puzzle tile and the text "I Am Picture #10"

Timestamps

- Find out when the two files in image ❸ were actually created
- Your task:
  - → Check the date through the Windows command line
    - » Would changing the local time zone influence the output?
    - » Compare this to your OS drive (hint: FAT ⇔ NTFS/EXT3!)
  - → Find out where the creation time is located on the disk
    - » Don't use the WinHex UI; first think and calculate, then verify!
  - → Manually calculate the creation time from the hex values
    - » Search the internet for the exact format
  - → Use DCode to decode the creation time
  - → When were the files created in UTC?
- Document your actions through a log and screen shots!

Timestamps: Exemplary solution

- Mount the image ❸ as readonly (daylight.dd)
- Check dates through command line
  - → Result:
    - » Winter.txt: 1.1.2004 14:00
    - » Summer.txt: 1.6.2004 15:00
  - → Changing the local time zone would not change the output!
    - » FAT stores date/time according to the local time of the computer at the moment the action occurs
    - » Therefore it is not "recalculated" according to the local time zone
      - – As for example NTFS dates are: These are stored as UTC!
      - – File shows 14:26 in TZ Austria (+1), but 13:26 in TZ London (=UTC)!
- Where is the FAT on a FAT-disk?
  - → Offset 0x0e in first sector: Number of reserved sectors (=1)
  - → FAT therefore starts immediately after the boot sector
    - » This is address 0x0200 (1 sector = 512 bytes)

Timestamps: Exemplary solution

- → Root directory starts immediately after the FAT-copy
  - » Length of FAT: Offset 0x16 = 9
  - » Boot + FAT1 + FAT2 = 1+9+9 = 19 sectors = 0x2600
- → One directory entry = 32 bytes
- → Creation time: 0x0D-0x11
  - » Modification: 0x16-0x19 (2s resolution only)
  - » Access: 0x12-0x13 (date only)

- Manual calculation from the hex values
  - » See http://en.wikipedia.org/wiki/File_Allocation_Table for details
- → Value: 0x8600702130
  - » Fine time: 0x86 = 134*10ms = 1.34 s
  - » Time: 0x7000 = 14 hours, 0 minutes, 0*2 seconds
    - – Little endian, therefore to be converted as 0x7000 and not the 0x0070 as found on the disk!
  - » Date: 0x3021 = 24+1980 years, month 1 (=January), day 1
  - » Result: 1.1.2004, 14:00:01.34

Timestamps: Exemplary solution

- Use DCode to decode the date and time
  - → Note: DCode only can convert 4-Byte times!
  - → Use "MS-DOS: 32 bit Hex Value"
  - → To enter: 00702130 (omit first byte; little endian!)
  - → Result: 1/Jan/2004 14:0:0 Local
- When were the files created in UTC?
  - → This we cannot say, as the date/time is always stored in local time only. Unless we know the time zone where the file was created, we simply cannot determine it!

Windows Startup/Shutdown time

- Investigate your own computer:
  - → When was it turned on and off during the last week?
    - » Investigate in the Internet which events are logged when!
  - → Draw a timeline to visualize your results!

Windows Startup/Shutdown time: Exemplary solution

- The Startup/shutdown time is logged in the event log
  - → These are part of the "System" log
  - → See http://support.microsoft.com/kb/196452
  - → Date and time of the event are logged as well
    - » Note: Local time!
- Event-IDs:
  - → 6009: Startup (OS version, …)
  - → 6005: Event log service started
  - → …
  - → 6006: Clean shutdown/Event log service stopped
  - → 6008: Dirty shutdown
    - » Unexpected, e.g. through power failure

Windows Startup/Shutdown time: Exemplary solution

- To ease the gathering, use "View – Filter…" to only show events with specific IDs
- Exemplary results:
  - → No 6008 events!

Type	Date	Time	Source	Category	Event
Information	14.01.2008	07:39:35	eventlog	None	6009
Information	11.01.2008	07:42:02	eventlog	None	6009
Information	10.01.2008	07:42:36	eventlog	None	6009
Information	09.01.2008	07:52:19	eventlog	None	6009
Information	08.01.2008	07:52:27	eventlog	None	6009
Information	07.01.2008	07:48:25	eventlog	None	6009
Information	04.01.2008	08:44:11	eventlog	None	6009
Information	03.01.2008	08:46:04	eventlog	None	6009
Information	02.01.2008	08:41:38	eventlog	None	6009
Information	21.12.2007	08:38:17	eventlog	None	6009
Information	20.12.2007	08:42:55	eventlog	None	6009

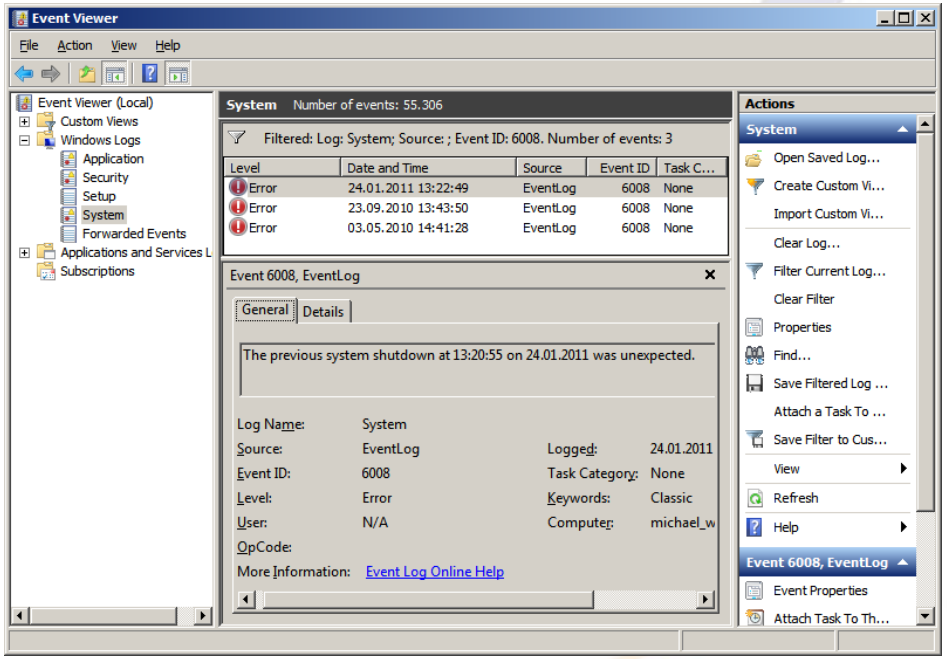
Type	Date	Time	Source	Category	Event
Information	11.01.2008	18:00:31	eventlog	None	6006
Information	10.01.2008	17:37:32	eventlog	None	6006
Information	09.01.2008	20:11:26	eventlog	None	6006
Information	09.01.2008	07:51:18	eventlog	None	6006
Information	07.01.2008	17:11:09	eventlog	None	6006
Information	04.01.2008	17:13:34	eventlog	None	6006
Information	03.01.2008	17:05:44	eventlog	None	6006
Information	02.01.2008	16:20:33	eventlog	None	6006
Information	19.12.2007	22:54:01	eventlog	None	6006

Windows Startup/Shutdown time: Exemplary solution

- Result:
  - → Monday 7.1.2008: 7:48-17:11
  - → Tuesday 8.1.2008: 7:52- 7:51 (next day!)
  - → Wednesday 9.1.2008: 7:52-20:11
  - → Thursday 10.1.2008: 7:42-17:37
  - → Friday 11.1.2008: 7:42-18:00
- Extraordinary period on night of 8.1. to 9.1.
  - → Further investigation: Some updates occurred at 5 o'clock in the night, so the computer was actually running
  - → It seems, it was just not turned off
  - → Whether it was in actual use cannot be decided!
    - » But as no other events occurred during that time, this is unlikely
      - – Windows update is automatic → No user needed to be there!

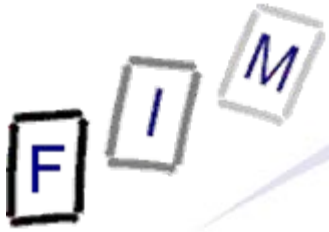
Windows Startup/Shutdown time: Windows 7

- Control Panel – System and Security - Administrative tools
  - → Select System log click under actions “Filter current log…”
  - → Enter the ID “6008” in the form, or write the filter manually:
    - » <QueryList>
      <Query Id="0" Path="System">
      <Select Path="System">*[System[(EventID=6008)]]</Select>
      </Query>
      </QueryList>
  - → Events can also be shown as native XML
  - → Practical:
    - » 6006
    - » 6009



Conclusions

- Undelete is quite simple on FAT
  - → But complex/impossible on NTFS/EXT3!
  - → "Plain text" search will still work unless actually overwritten
- Hiding files is quite simple: Wrong extensions and ADS
  - → Found only with good knowledge and additional tools
    - » But **VERY** difficult to **REALLY** hide information!
- Even with very simple means a lot of information can be extracted, if it is exactly known where to look for it
  - → But also its limitations must be known!
- Timestamps (or timing issues) are an important aspect for every forensic investigation
  - → The time zone is very important there
    - » Is the data stored in local or UTC (or …) time?
    - » What is the difference to UTC now (and what was it then?)



Questions?

Thank you for your attention!