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Web-browsing history

Computer forensics

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Agenda

- The elements of web-browsing history and intentionality
- HTTP – Hypertext Transfer Protocol
  - → Cookies
- Internet Explorer
  - → File locations
  - → The index.dat file format
  - → Example
- Date/Time formats
- Firefox
  - → File locations
  - → Cookies, history, cache
- Webmail reconstruction example

The elements of web-browsing history

- History
  - → The list of URLs visited (at which time, …)
  - → Provides general information on time and location of activity
    - » URL's may also contain information: GET requests
      - – Example: Google searches
- Cookies
  - → Which websites were visited when + additional information
  - → May allow determining whether the user was logged in
  - → Can survive much longer than the history
    - » Depends on the expiry date of the Cookie and the configuration
- Cache
  - → The content of the pages visited
    - » Incomplete: E.g. ad's will rarely be cached
    - » See e.g. HTML headers to prevent caching
  - → Provides the full content of what was seen, e.g. Webmail

Web-browsing history: Intentionality

- Did the user visit the webpage intentionally?
  - → In general: If it's in the cache/history/cookie file: Yes
  - → See also: Bookmarks!
- BUT:
  - → What about pop-ups?
    - » E.g.: Pornography advertisements!
  - → Password protected pages?
    - » But images/JavaScript can easily supply passwords as well when opening a file!
- Investigation of other files, trying it out, content inspection … needed to verify, whether a page that was visited was actually intended to be visited
  - → Usually this should not be a problem:
    - » Logging in to the mail
    - » Visiting a website after entering log-ins
    - » Downloading files

Web browsing procedure

1. User enters the URL
2. Browser determines the IP address for the host part
3. Browser connect to the IP address (+port if specified)
4. Sends request
   - → With additional information, e.g. what compression is allowed
   - → May contain cookie(s)
5. Retrieves response
   - → Headers and actual content
     - » Header may contain cookie
   - → Saved to memory (and perhaps the disk in the cache file)
     - » Depends on headers, settings, …
6. Connection is closed
   - → Note: HTTP 1.1 may keep the connection open for further requests (incl. pipelining). This e.g. is especially useful for images from the same site!

The HTTP protocol

- Basis of HTTP is a reliable stream protocol (usually TCP)
- The HTTP state diagram is very simple
  - » With some exceptions, e.g. authorization
  - → There is only a single request
  - → There is only a single response
- HTTP request methods:
  - → GET: Retrieve some content
    - » Should never change the state on the server!
      - – Especially important if caching takes place somewhere
    - » Parameters (optional) are encoded in the URL
  - → POST: Send data for processing and retrieve result
    - » To be used for requests changing the server state!
    - » Parameters are sent in the request body
  - → HEAD, PUT, DELETE, TRACE, OPTIONS, CONNECT
    - » Of less importance

The HTTP protocol

- The response always includes a status code
  - → 1xx Informational
  - → 2xx Success
  - → 3xx Redirection (request should be sent again differently)
  - → 4xx Client side error (e.g. incorrect request, not existing)
  - → 5xx Server side error (should not be retried)
- Caching of HTTP: Commonly performed through proxies
  - → Must either be validated with the source
  - → Or it is "fresh enough" according to client, server, and cache
  - → Note: Browsers often ignore this
    - » E.g. IE can be configured to never check for a newer version even if the cached page is already expired!

The HTTP protocol

- Local (=browser) caches
  - → If a page is expired, it is not necessarily deleted from the local cache → It might remain there for much longer
  - → Can store even pages marked as "no-cache" and "no-store"
    - » "no-cache": Should not be cached for future requests
      - – But might still be written to disk (e.g. Mozilla)
    - » "no-store": Should only be held in memory
      - – Users are still allowed to use "Save As"!
  - → This cache can be very large and contain very old files
    - » Very important for computer forensics!
    - » Manual deletion or cleaner programs are simple and effective
      - – But must be used every time after surfing
      - – Attention: Many such programs just delete the files, only the more serious ones overwrite them securely!
      - – Also, fragments of files might remain in unused areas, so all free sectors and slack spaces would have to be cleaned every time!

The HTTP protocol example:

http://elearning.fim.uni-linz.ac.at/cms/elearn_ebiz.phtml

GET /cms/elearn_ebiz.phtml HTTP/1.1
Host: elearning.fim.uni-linz.ac.at
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.8.1.7) Gecko/20070914 Firefox/2.0.0.7
Accept: text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5
Accept-Language: en-us,en;q=0.7,de-at;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive

HTTP/1.1 200 OK
Date: Mon, 08 Oct 2007 13:36:22 GMT
Server: Apache/1.3.34 (Debian)
Set-Cookie: hashID=22d68c8b5698827d57f071f43d818456; path=/
Expires: Thu, 19 Nov 1981 08:52:00 GMT ← Page, not Cookie!
Cache-Control: no-store, no-cache, must-revalidate, post-check=0, pre-check=0
Pragma: no-cache
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
Transfer-Encoding: chunked
Content-Type: text/html; charset=iso-8859-1

Cookies

- What is a "cookie"?
  - → Small (max. 4 kB) text file with information
    - » Originates form the server
    - » Stored locally
    - » Transmitted back to server on "matching" requests
  - → Content (with exemplary data):
    - » Name: "session-id"
    - » Value: "303-1195544-4348244"
    - » Domain: ".amazon.de"
    - » Website path: "/"

    } Sent to all requests ("/") of subdomains of ".amazon.de"
    - » Expiry date and time: 15.10.2007, 00:02:22 — None → Till browser is closed ("session cookie")
    - » Secure(https): * — Will be sent also on non-HTTPS connections
- The data may have any meaning
  - → Very rarely this is some "plain-text data"
  - → Some part of it might be the IP address or the user name
  - → But usually it is just a (more or less!) random unique number

Internet Explorer: Interesting files/locations

- Where can we find information on what users did with IE?
  - » Att.: Locations change slightly with operating system version!
  - → <User profile>\Local Settings\Temporary Internet Files\Content.IE5
    - » Cache (webpages, images, applets, flash-files, …)
  - → <User profile>\Local Settings\History
    - » Where the user had been (URLs);
    - » Subdirectories for various time spans
  - → <User profile>\Cookies
    - » Cookies
- Note: Data is deleted from these locations independently!
  - → What is (was) present in one, is not necessarily available any more in the other locations
    - » We must search all three locations and assemble the results

Internet Explorer: Cookie file structure

- Each cookie file contains all cookies for a single domain
  - → The information is stored line-by-line; 9 lines = 1 cookie
- Example:

```
__utma                                  Name
36557369.378120483.1187701792.1189418701.1190710388.4   Value
hotel.at/                               Domain
1088                                    Flags
2350186496  }
32111674    }  Expiration time (UTC; LoVal","HiVal)
2116717664  }
29884241    }  Creation time (UTC)
*           Secure (here: False)
__utmb
...
```

- Note: Additional information on the cookies is in the index.dat file in the same directory!
  - → Number of hits, suspected as advertisement

Internet Explorer: index.dat structure (1)

- This structure is the same for cookies, cache, and history
- Overall structure:
  - » Remember: File has bytes in reverse order (little endian)!
  - → Header: Magic number (text), file size, hash table offset, subdirectory names (cache only)
    - » Subdirectory names are referred to by index (0 = first)
  - → Hash table: Length of table, pointer to next hash table, 8-byte hash entries
    - » Entries: 4 bytes flags, 4 bytes record offset
  - → Activity records: Type, length, data (dependent on type)
    - » Type can be REDR, URL, or LEAK
      - – URL: Website visit
      - – REDR: Redirection to another URL
      - – LEAK: Purpose unknown
    - » Each record is a multiple of 128 bytes long

Source: http://odessa.sourceforge.net/

Internet Explorer: index.dat structure (2)

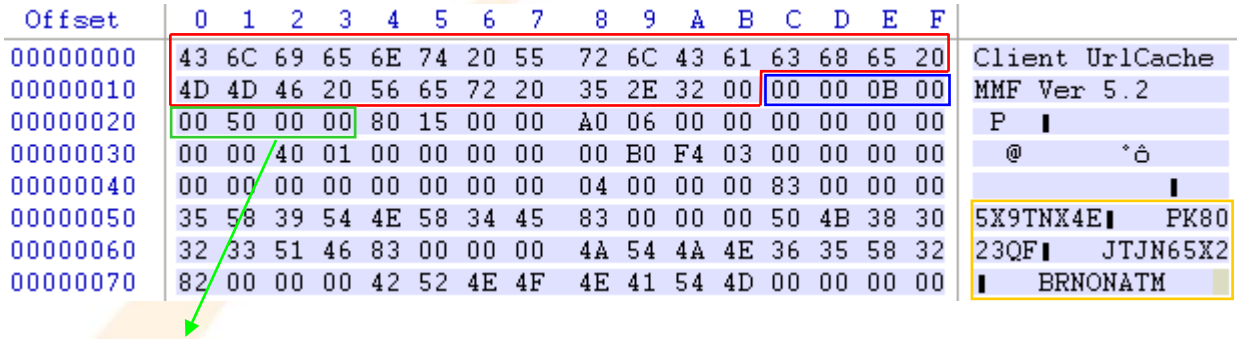
- URL records
  - → Last modified time: When the information was modified on the web server
    - » Filetime format; All zero if unknown
  - → Last access time: When the URL was visited
    - » Filetime format!
  - → URL offset
    - » URL itself is Null-terminated; no Unicode – ASCII only!
  - → Filename offset
    - » The name in the cache directory
  - → Cache directory index
    - » In which cache directory the file is stored (index; 0 = first dir!)
  - → HTTP header offset
    - » The response headers only; not always present
  - → Hit count: How often visited (location unknown)

Internet Explorer: index.dat structure (3)

- REDR records
  - → Flags: Exact meaning unknown
  - → URL offset
    - » Null-terminated
- LEAK records
  - → Structure similar to URL record
  - → Purpose unknown
- Not all records are necessarily present in the hash table
  - → When deleted, sometimes a record remains, and only the hash entry is removed
  - → As all records are block-sized (see before), "undelete" is possible without too many problems!
    - » Especially as each record starts with the type, and destroyed records are filled with well-known values (0x0BADF00D)

Internet Explorer: index.dat example

- Screenshot of header:

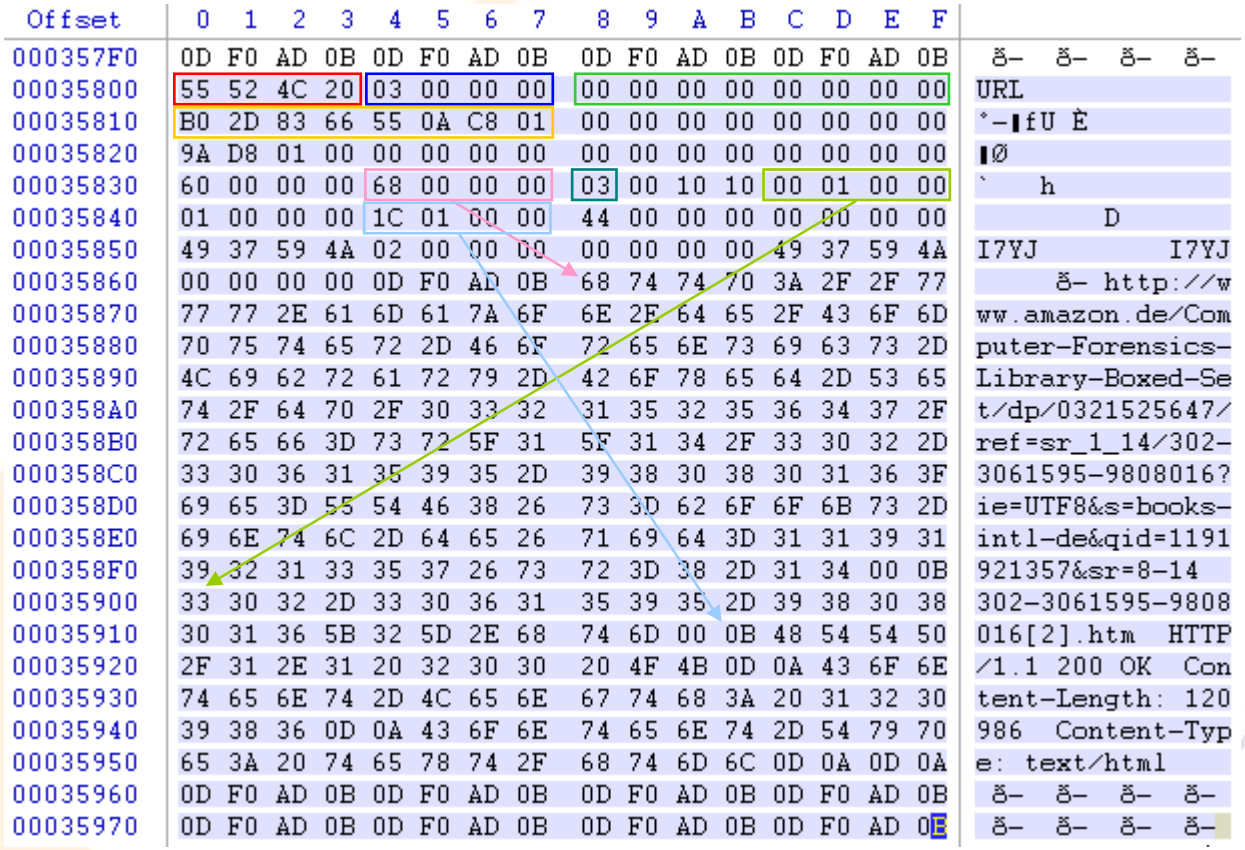


Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
00000000	43	6C	69	65	6E	74	20	55	72	6C	43	61	63	68	65	20	Client UrlCache
00000010	4D	4D	46	20	56	65	72	20	35	2E	32	00	00	00	0B	00	MMF Ver 5.2
00000020	00	50	00	00	80	15	00	00	A0	06	00	00	00	00	00	00	P ▌
00000030	00	00	40	01	00	00	00	00	00	B0	F4	03	00	00	00	00	@ °ô
00000040	00	00	00	00	00	00	00	00	04	00	00	00	83	00	00	00	▌
00000050	35	58	39	54	4E	58	34	45	83	00	00	00	50	4B	38	30	5X9TNX4E▌ PK80
00000060	32	33	51	46	83	00	00	00	4A	54	4A	4E	36	35	58	32	23QF▌ JTJN65X2
00000070	82	00	00	00	42	52	4E	4F	4E	41	54	4D	00	00	00	00	▌ BRNONATM

- Magic "number"
- File size (0x000B0000 = 704 kB)
- Hash table offset (0x00005000)
- Cache directory names

Internet Explorer: index.dat example

- Screenshot of detail record:



Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
000357F0	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	ð– ð– ð– ð–
00035800	55	52	4C	20	03	00	00	00	00	00	00	00	00	00	00	00	URL
00035810	B0	2D	83	66	55	0A	C8	01	00	00	00	00	00	00	00	00	°-▮fU È
00035820	9A	D8	01	00	00	00	00	00	00	00	00	00	00	00	00	00	▮Ø
00035830	60	00	00	00	68	00	00	00	03	00	10	10	00	01	00	00	` h
00035840	01	00	00	00	1C	01	00	00	44	00	00	00	00	00	00	00	D
00035850	49	37	59	4A	02	00	00	00	00	00	00	00	49	37	59	4A	I7YJ I7YJ
00035860	00	00	00	00	0D	F0	AD	0B	68	74	74	70	3A	2F	2F	77	ð– http://w
00035870	77	77	2E	61	6D	61	7A	6F	6E	2E	64	65	2F	43	6F	6D	ww.amazon.de/Com
00035880	70	75	74	65	72	2D	46	6F	72	65	6E	73	69	63	73	2D	puter-Forensics-
00035890	4C	69	62	72	61	72	79	2D	42	6F	78	65	64	2D	53	65	Library-Boxed-Se
000358A0	74	2F	64	70	2F	30	33	32	31	35	32	35	36	34	37	2F	t/dp/0321525647/
000358B0	72	65	66	3D	73	72	5F	31	5F	31	34	2F	33	30	32	2D	ref=sr_1_14/302-
000358C0	33	30	36	31	35	39	35	2D	39	38	30	38	30	31	36	3F	3061595-9808016?
000358D0	69	65	3D	55	54	46	38	26	73	3D	62	6F	6F	6B	73	2D	ie=UTF8&s=books-
000358E0	69	6E	74	6C	2D	64	65	26	71	69	64	3D	31	31	39	31	intl-de&qid=1191
000358F0	39	32	31	33	35	37	26	73	72	3D	38	2D	31	34	00	0B	921357&sr=8-14
00035900	33	30	32	2D	33	30	36	31	35	39	35	2D	39	38	30	38	302-3061595-9808
00035910	30	31	36	5B	32	5D	2E	68	74	6D	00	0B	48	54	54	50	016[2].htm HTTP
00035920	2F	31	2E	31	20	32	30	30	20	4F	4B	0D	0A	43	6F	6E	/1.1 200 OK Con
00035930	74	65	6E	74	2D	4C	65	6E	67	74	68	3A	20	31	32	30	tent-Length: 120
00035940	39	38	36	0D	0A	43	6F	6E	74	65	6E	74	2D	54	79	70	986 Content-Typ
00035950	65	3A	20	74	65	78	74	2F	68	74	6D	6C	0D	0A	0D	0A	e: text/html
00035960	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	ð– ð– ð– ð–
00035970	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	0D	F0	AD	0B	ð– ð– ð– ð–

- Type
- Record length
- Last modified time
- Last access time
- URL offset
- Filename offset
- Cache directory index
  - 3 →BRNONATM
  - Missing; non-cacheable!
- HTTP header offset

Internet Explorer: index.dat example

- Output from Pasco:
  - → Type: URL
  - → URL: http://www.amazon.de/Computer-Forensics-Library-Boxed-Set/dp/0321525647/ref=sr_1_14/302-3061595-9808016?ie=UTF8&s=books-intl-de&qid=1191921357&sr=8-14
  - → Modified time: <Not present in file>
  - → Last accessed time: 10/09/2007 11:18:48 9.10.2007, 9:18:48 UTC
  - → Filename: 302-3061595-9808016[2].htm
  - → Directory: BRNONATM
  - → HTTP headers:
    HTTP/1.1 200 OK
    Content-Length: 120986
    Content-Type: text/html
- Other data:
  - → Record length: 3 (=3*128 = 384 bytes = 0x180)
    - » From 0x035800 to 0x35980

Sidetrack: Date/time formats

- Filetime: Number of ticks since 1.1.1601
  - → UTC; 100 ns resolution
  - → Usually stored as 8 hexadecimal numbers
- Unix time: Number of ticks since 1.1.1970
  - → UTC, 1 s resolution
  - → May appear as hexadecimal or decimal value (take care!)
    - » Hex: 9940F039
    - » Dec: 971815414
- Attention:
  - → Big endian or little endian?
  - → UTC or a different time zone? Which?
    - » Windows NT stores everything as GMT (according to its own time zone as configured)
  - → Difference of system time to actual time?

Sidetrack: Date/time formats Examples

- index.dat example: Filetime – Little endian
  - → B02D8366550AC801 = Tue, 09 October 2007 09:18:48 UTC
    - » Actually: Di, 09 Oktober 2007 11:18:48 +0200
- Cookie example (expiration time; Windows Cookie time):
  - → 2350186496,32111674 = 25.9.2007 08:53:07 UTC
- Firefox cookie (Unix numeric timestamp):
  - → 1192658552 = 17.10.2007 22:02:32 UTC

Sidetrack: Date/time formats
Time zone, DST, and delta

- Time zone issues:
  - → Identify time zone from installation
    - » Alternative: Geographical area of usage of the system
- Attention: Summer time ("daylight saving time", "DST")!
  - → Now its UTC+1, but at some dates it's UTC+2 !
    - – Austria: 25.3.2007-28.10.2007 → UTC+2; Rest of year: UTC+1
    - » Note: Dates of start/end changed over the years
      - – Was the corresponding patch applied to the computer? When?
      - – Windows: Registry stores start/end date, …
  - → Does the system account for this?
    - » Timestamp stored as UTC or local time?
      - – NTFS: UTC; but FAT: Local time
- Delta: Identify delta between computer time and UTC
  - → Attention: This might not necessarily be the same delta as when the timestamp was created!
    - » Manual corrections, time drift (important for longer timespans)

Internet Explorer: Cache information

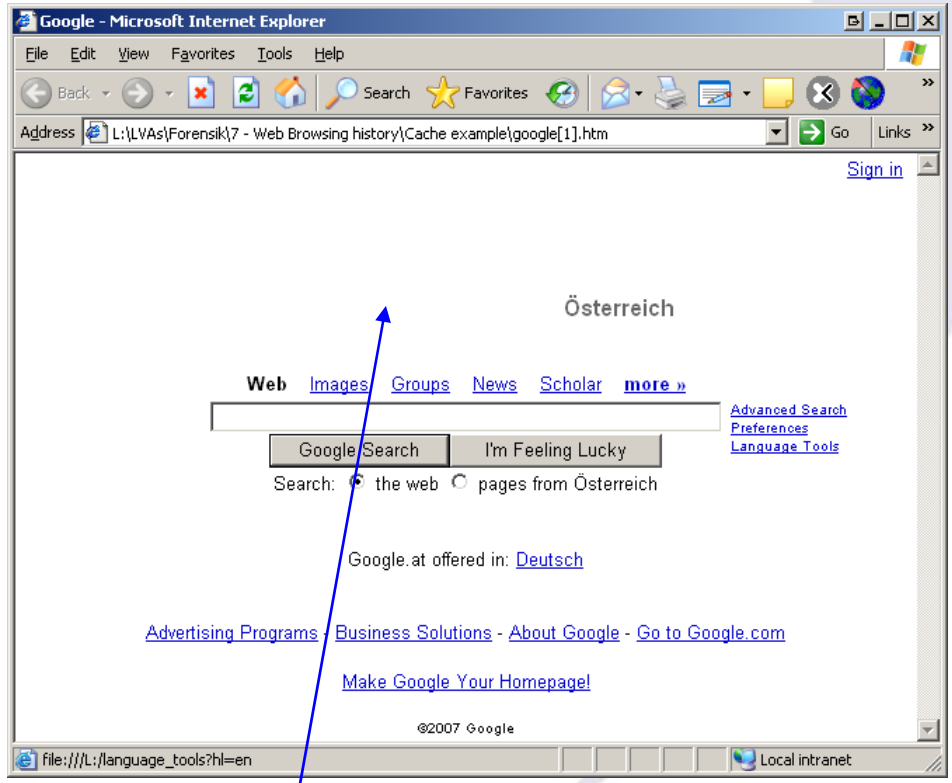
- Information is stored in the file "index.dat"
  - → File format see before!
  - → Again: Content is not necessarily the same as in other files
- Additionally: Several subdirectories for the actual files
  - → Note: These receive "random" filenames to avoid collisions
    - » Typically with "[1]", "[2"], … added at the end
    - » The files itself are NOT modified; URL's are kept the same!
      - – Recreating pages: Must "load" the URLs from the cache too
      - – "Transparent proxy" is needed
- The URL also contains GET parameters
  - → These might also be interesting!

http://www.hotel.de/Booking.aspx?h_rooms=1&h_fbrs=1&h_step=3&h_departure=9/1/2007&h_arrival=8/26/2007&h_rmod=0&h_sbl=/Search.aspx?hs_arrival=8/26/2007&hs_destination=Lübeck&hs_circum=0&hs_landisoa3=DEU&hs_locationnr=37547&hs=2&hs_departure=9/1/2007&hs_ltype=1&hs_validate=2&hs_llat=53,86626&lng=EN&hs_llong=10,67468&lng=EN&h_persons=1&h_validate=1&h_hmid=50727&h_persons_total=1

Booking a hotel for one person in Lübeck (Germany) from 26.8.2007 till 1.9.2007

Internet Explorer: Cache directory example

- Directory 5X9TNX4E:
  - → nav_logo3[1].png
- Directory BRNONATM:
  - → google[1].htm
  - → logo_plain[1].png
  - → google[1]



Webpage

Directly opened as a file in the cache directory

Note: Images are missing!

Firefox: Interesting files/locations

- Where can we find data on what users did with Firefox?
  - » Profile ID is a random string generated once
  - → <User profile>\Local Settings\Application Data\Mozilla\Firefox\Profiles\<Profile ID>\ Cache
    - » Cache (webpages, images, applets, flash-files, …)
  - → <User profile>\Application Data\Mozilla\Firefox\Profiles\<Profile ID>\ history.dat
    - » **Extremely** strange file format ("Mork")
    - » There does exist an exporter ("Dork")
  - → <User profile>\Application Data\Mozilla\Firefox\Profiles\<Profile ID>\ cookies.txt
    - » Cookies; Tab-delimited text file
- Easy cache access: URL "about:cache"
  - → Also extensions available for directly viewing cached files
    - » Should only be used on write-protected disks/images!
  - → Firefox has two caches: In-memory and on disk

Firefox: Cookie file

- Simple text file with tab-delimiters: Single line per cookie
- Format:
  - → Domain: ".amazon.de"
  - → Domain access: "TRUE"
    - » Probably a security setting
  - → Path: "/"
  - → Secure : "FALSE" (= Sent over any type of connection)
  - → Timestamp: 1192658552 (=17.10.2007 22:02:32 UTC)
    - – Local time: Do, 18 Oktober 2007 00:02:32 +0200 (Sommerzeit!)
    - » Format: Unix numeric value
  - → Name: "session-id"
  - → Value: " 302-0868837-0800841"
- Example:
  - → .amazon.de TRUE / FALSE 1192658552 session-id 302-0868837-0800841

Firefox: History file

- Stored in a "strange" format, a kind of database
  - → To be probably replaced in version 3 with a real DB!
- Currently: Very difficult to parse, except through Firefox
  - → But there is an exporter, generating a tab-delimited file
- Example:
  - → C7D0D 3 2007-10-08 14:44:44 2007-10-08 14:47:07 http://www.amazon.de/ref=rd_www_amazon_at/?site-redirect=at
  - → ID of the visit: C7D0D
  - → Visit count: 3
  - → First visit date: 2007-10-08 14:44:44
  - → Last visit date: 2007-10-08 14:47:07
  - → URL: http://www.amazon.de/.....
  - → Take care of time zone of dates!

Firefox: Cache

- The cache consists of 4 files plus the data files
  - → 1 cache map: Hash table for entries ("_CACHE_MAP_")
    - » Header plus 8192 records of cached elements
      - – Record: Hash number, eviction rank, data / metadata location
    - » Data may be saved within cache block file (below) or separately
  - → 3 cache block files ("_CACHE_00?_")
    - » Bitmap header and some cache content and/or metadata
    - » Varying block sizes: cache 1 = 256, 2 = 512, 3 = 1024 Bytes
      - – Maximum block count per data: 3 (→ up to 3072 Bytes)
  - → Data files: If the content doesn't fit into the cache blocks
    - » Filename = <Hash number><type><generation number>
      - – Type: d = cache, m = metadata (rare!)
      - – Generation number: Lowest byte of location
    - » No extension! → Filename doesn't tell file type!
      - – If known → Rename → Original file

IE-Example: Reconstructing a Webmail message

- Cookies:
  - → www.gmx.net/de/
    - » Visits 1
    - » moveinBrowser
      new%20MoveinData%28%29%2Eunpickle%28%7B%22viewed%22%3A%201%2C%20%22closed%22%3A%20false%2C%20%22latest%22%3A%20new%20Date%28119217422571 8%29%7D%29
      - – Decoded: new MoveinData().unpickle({"viewed": 1, "closed": false, "latest": new Date(119217422571 8)})
      - – Decoded date (Unix): Fr, 12 October 2007 07:30:25 UTC
  - → gmx.net/
    - » GUD
      bMDEpJi1JPF9xN0JINkUyQkExJSIhJxweJBkeGyAvLjcsLDQpKzJCSzElliEnHB8dGRwcIC83Ny8tNC0uMkt BMSMtSzksIh0gGw==
      - – Mime encoded, but is just a binary value
      - – Probably a unique ID for session handling
  - → logout.gmx.net/
    - » POPUPCHECK 1192260804812

Sa, 13 Oktober 2007 07:33:24 UTC

IE-Example: Reconstructing a Webmail message

- History (pasco; adjusts for local time zone!): = 12.10.2007 7:30-7:33 UTC!
  - → Modified/access time: 10/12/2007 09:30 until 09:33
    - » Local time of event: Western European DST (=+2)
      - – But done according to the time zone set at the moment of the analysis; physically stored as UTC time!
- URLs (selection):
  - → sonntag@http://www.gmx.net/de
    - » User visited GMX homepage
  - → sonntag@http://service.gmx.net/de/cgi/login
    - » User logged in to GMX
  - → sonntag@http://service.gmx.net/de/cgi/g.fcgi/mail/index?CUSTOMERNO=10333901&t=de1690301692.1192174366.c35ea10d&FOLDER=inbox
    - » User visited his inbox
  - → sonntag@http://service.gmx.net/de/cgi/derefer?TYPE=2&DEST=http%3A%2F%2Fwww.gmxattachments.net%2Fde%2Fcgi%2Fg.fcgi%2Fmail%2Fprint%2Fattachment%3Fmid%3Dbabgehj.1192174412.25124.s9vnnjbfon.74%26uid%3DKxs5Dm8bQEVsw%252FqY9HVpw45KNTg2NcIR%26frame%3Ddownload
    - » User opened an attachment
  - → sonntag@http://www.gmxattachments.net/de/cgi/g.fcgi/mail/print/attachment:/filename/Lebenslauf.doc?mid=babgehj.1192174412.25124.s9vnnjbfon.74&uid=Kxs5Dm8bQEVsw%2FqY9HVpw45KNTg2NcIR&frame=attachment
    - » User downloaded an attachment called "Lebenslauf.doc"

IE-Example: Reconstructing a Webmail message

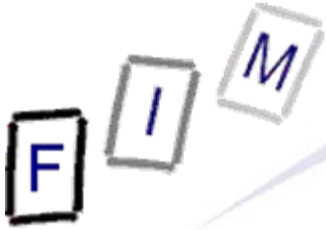
- Cache:
  - → 282 entries
    - » Images (GIF, JPG)
    - » Stylesheets (CSS)
    - » JavaScript (JS)
    - » HTML files (HTML)
      - – Only static files, login screen, etc.!
- What is missing are the actual E-Mails
  - → These are not cached on disk
    - » In previous versions they might have been cached
      - – Probably depending on server, not version of Internet Explorer!
  - → So webmail is not necessarily recoverable, but perhaps

Other information: Careful interpretation necessary!

- Typed URLS: Visited sites
- Form history and stored passwords
  - → For identifying visited sites and accessing them
  - → Often encrypted, but decryption programs exist
- Search history: What was the person looking for?
- Blocked sites: If the popup-host of a site was blocked, the site itself was probably visited!
  - → Manually unblocked sites obviously interesting!
- Certificate store: To identify secured sites visited often
  - → Might include client certificates, which act as a kind of key
- Download history: What file(names) were downloaded
  - → And where they were stored locally (name; for searching)
- Installed add-ons (browser controls)
- Language preferences and all other configuration options

Conclusions

- What a user did with a web browser can usually be reconstructed quite good
  - → Especially Internet Explorer: Deleting the index.dat files is almost impossible
    - » Dedicated "cleaner" programs are needed
    - » Information may be stored multiple times
- Reconstructing the content of web-based E-Mail is difficult
  - → That, which, … can be done
  - → But content is typically not cached and therefore unavailable
- A variety of programs exist to investigate the files
  - → Few of them are free
  - → File formats are often not at all/badly documented
- Timestamps are very important, but many formats occur
  - → Identifying delta and timezone are paramount!



Questions?

Thank you for your attention!

Links

- Anderson, Keith: Firefox history exporter: https://bugzilla.mozilla.org/show_bug.cgi?id=241438
  (Entry at 2006-03-17 09:10:47 PDT)