Mag. iur. Dr. techn. Michael Sonntag

# Web-browsing history

Institute for Information Processing and
Microprocessor Technology (FIM)
Johannes Kepler University Linz, Austria

E-Mail: sonntag@fim.uni-linz.ac.at
http://www.fim.uni-linz.ac.at/staff/sonntag.htm

# 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
- 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 (“no-cache” headers)
  - → Provides the full content of what was seen, e.g. (in theory!) webmail content
    - » More exactly: What was delivered by the server to the client

# 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 ads (no one sees them intentionally ☺)!
  - → Password protected pages?
    - » But images/JavaScript can easily supply passwords as well when opening a URL!
- Investigation of other files/trying it out/content inspection/… are needed to verify, whether a page that was visited, was actually intended to be visited (“intentionality”)
  - → Usually this should not be a problem:
    - » Logging in to the mail account
    - » 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 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!
    - » This has no influence on what proxies on transmission path do!

# 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!
      - – See also swap file/partition, hibernation file

# 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
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

Page, not Cookie!

"Do not cache this response"

# 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 OS version/language!
  - → <User profile>\Local Settings\Temporary Internet Files\Content.IE5 ← Also later versions of IE (This is the version of the file format, not of the software)!
    - » Cache (webpages, images, applets, flash-files, …)
    - » Win 7: <User profile>\AppData\Local\Microsoft\Windows\Temporary Internet Files
  - → <User profile>\Local Settings\History
    - » Where the user had been (URLs);
    - » Subdirectories for various time spans
    - » Win 7: <User profile>\AppData\Local\Microsoft\Windows\History
  - → <User profile>\Cookies
    - » Win 7: <User profile>\AppData\Roaming\Microsoft\Windows\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; format as above)
  * 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: Newer versions

- Additional information can be found under <User Profile>\AppData\Roaming\Microsoft\Windows
  - → IECompatCache, IECompatUACache: Sites to be shown in compatibility view
    - » Independent kind of “history”
  - → IEDownloadHistory: Download history
    - » Obviously interesting!
  - → PrivacIE: **NOT** InPrivate browsing sessions! These are things blocked during InPrivate brwosing sessions to prevent third-party tracking (→ InPrivate Filtering).
    - » Usually not interesting → Site X (=interesting) references content on site Y → Y might be in here (but Y might be referenced on A, B, C, … as well!)
  - → IETldCache: Help file for colouring TLD (esp. second level)
    - » Forensically probably not very useful

# Internet Explorer: index.dat structure (1)

- This structure is the same for cookies, cache, history etc.
- 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 (Possibly: Cache entry deleted, but file couldn't be deleted)
    - » 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

# Internet Explorer: URL records

- Attention: Not all URLs are “real” URLs
  - → Depending on the file various other “URLs” exist!
- Examples:
  - → ietld: Top-Level-Domain coloring
  - → download:{…..}: Downloads
  - → iecompat: Website to be shown in compatibility view
- These are actually correct URLs, they just have a “strange” protocol instead of the normal “http:”!
- Forensic conclusion:
  - → This does not necessarily mean this “URL” was visited. The interpretation depends on both the protocol and the file it has been found in!

# 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
    - » See above: file couldn't be deleted (open in browser/editor)
- Not all records are necessarily present in the hash table
  - → When deleted, sometimes a record remains and only the hash entry is removed
    - » "Delete history" → Mark as deleted in hashtable
  - → As all records are block-sized (see before), "undelete" is possible without too many problems!
    - – A kind of file system within a file ☺ !
    - » 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 |

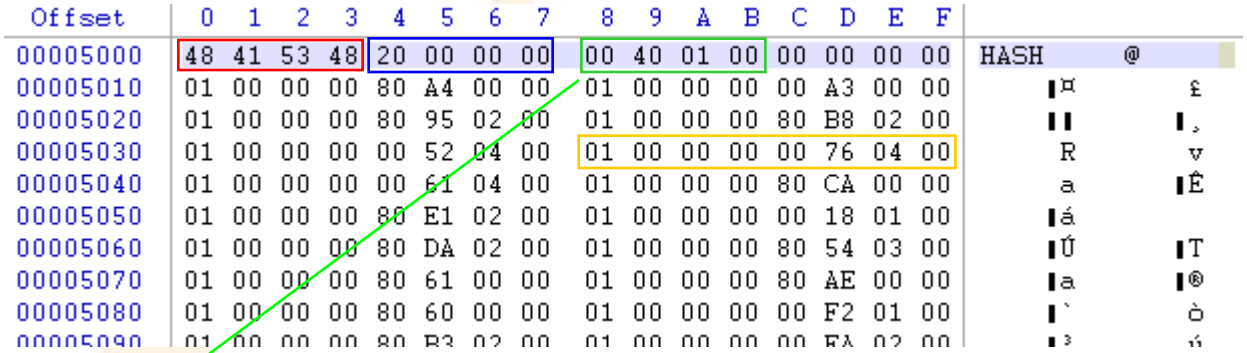
- Magic "number"
- File size (0x000B0000 = 704 kB)
- Hash table offset (0x00005000)

Note byte order!

- Cache directory names

# Internet Explorer: index.dat example

- Screenshot of (start of) hash table :



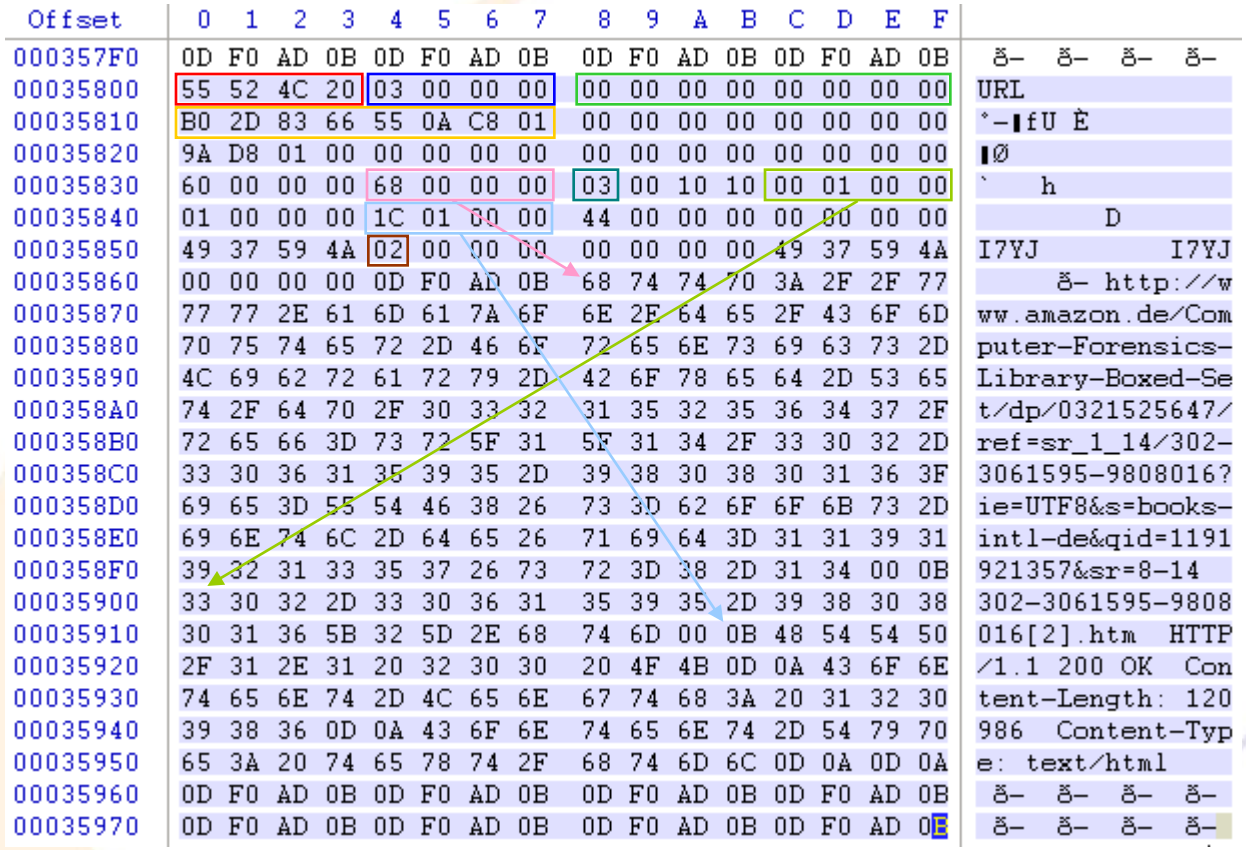
| Offset | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00005000 | 48 | 41 | 53 | 48 | 20 | 00 | 00 | 00 | 00 | 40 | 01 | 00 | 00 | 00 | 00 | 00 | HASH @ |
| 00005010 | 01 | 00 | 00 | 00 | 80 | A4 | 00 | 00 | 01 | 00 | 00 | 00 | 00 | A3 | 00 | 00 | ▮¤ £ |
| 00005020 | 01 | 00 | 00 | 00 | 80 | 95 | 02 | 00 | 01 | 00 | 00 | 00 | 80 | B8 | 02 | 00 | ▮▮ ▮¸ |
| 00005030 | 01 | 00 | 00 | 00 | 00 | 52 | 04 | 00 | 01 | 00 | 00 | 00 | 00 | 76 | 04 | 00 | R v |
| 00005040 | 01 | 00 | 00 | 00 | 00 | 61 | 04 | 00 | 01 | 00 | 00 | 00 | 80 | CA | 00 | 00 | a ▮Ê |
| 00005050 | 01 | 00 | 00 | 00 | 80 | E1 | 02 | 00 | 01 | 00 | 00 | 00 | 00 | 18 | 01 | 00 | ▮á |
| 00005060 | 01 | 00 | 00 | 00 | 80 | DA | 02 | 00 | 01 | 00 | 00 | 00 | 80 | 54 | 03 | 00 | ▮Ú ▮T |
| 00005070 | 01 | 00 | 00 | 00 | 80 | 61 | 00 | 00 | 01 | 00 | 00 | 00 | 80 | AE | 00 | 00 | ▮a ▮® |
| 00005080 | 01 | 00 | 00 | 00 | 80 | 60 | 00 | 00 | 01 | 00 | 00 | 00 | 00 | F2 | 01 | 00 | ▮` ò |
| 00005090 | 01 | 00 | 00 | 00 | 80 | B3 | 02 | 00 | 01 | 00 | 00 | 00 | 00 | FA | 02 | 00 | ▮³ ú |

- Magic "number"
- Table length (0x0000020 → 32*128 Byte = 4096 Bytes long)
- Next hash table offset (0x00014000; absolute from start of file!)
- Cache entry (example)

- Note: Hash table is usually not interesting
  - → Extraction software will ignore it anyway

# 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 (3*128B)
- Last modified time
- Last access time
- URL offset
- Filename offset
- Cache directory index
  - 3 → BRNONATM
  - Missing; non-cacheable!
- HTTP header offset
- Hit count

# 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?

Nice tool: http://www.digital-detective.co.uk/freetools/decode.asp

# 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 and delta

- Time zone issues:
  - → Identify time zone from installation
    - » Alternative: Geographical area of usage of the system
- 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)

# Sidetrack: Date/time formats Daylight Saving Time (DST)

- Attention: Summer time ("daylight saving time", "DST")!
  - → Sometimes its UTC+1, but at the other dates it's UTC+2 !
    - » Austria: 29.3.2009-25.10.2009 → 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, …
    - » Usually defined by certain weekends, not dates!
      - – Current AT: Last Sunday in March to last Sunday in October
  - → Does the system account for this?
    - » Timestamp stored as UTC or local time?
      - – NTFS: UTC; but FAT: Local time

# 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!

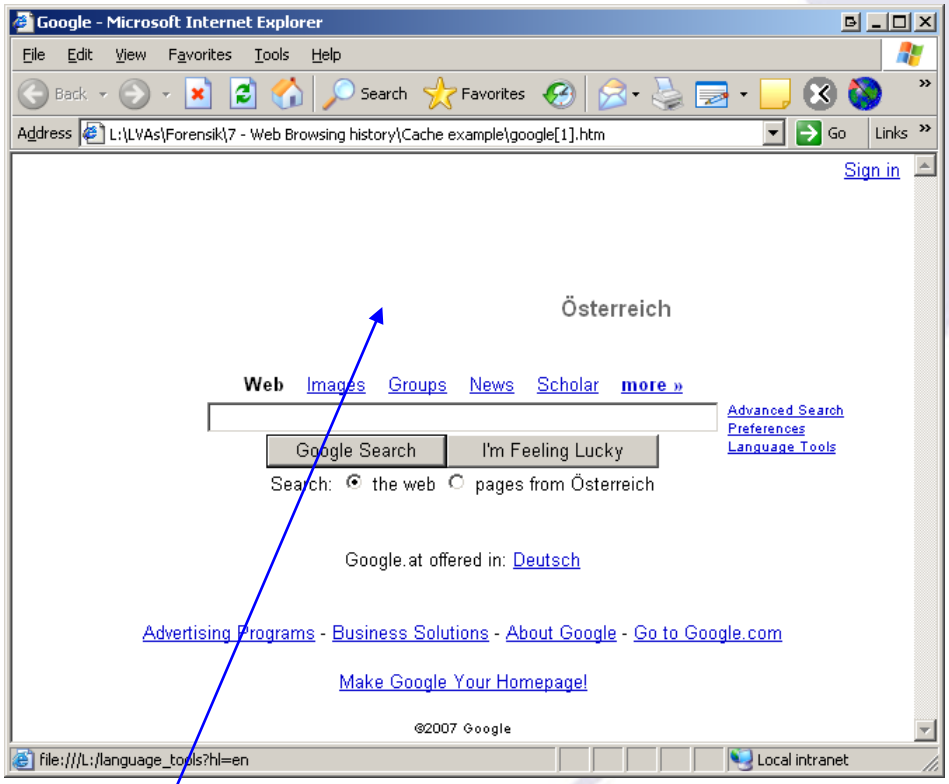
http://www.hotel.de/Booking.aspx?h_rooms=1&h_fbrs=1&h_step=3&h_departure=9/1/2007&h_arrival=8/26/2007&h_rmod=0&h_sbl=/Search.aspx?hs_arrival=8/26/2007&hs_destination=Lübeck&hs_circum=0&hs_landisoa3=DEU&hs_locationnr=37547&hs=2&hs_departure=9/1/2007&hs_ltype=1&hs_validate=2&hs_llat=53,86626&lng=EN&hs_llong=10,67468&lng=EN&h_persons=1&h_validate=1&h_hmid=50727&h_p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

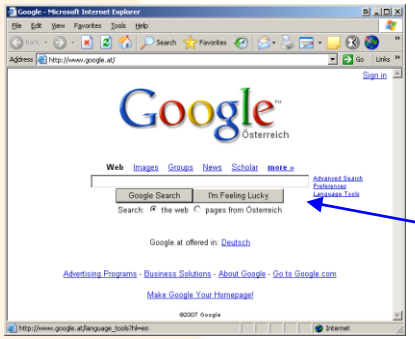
Booking a hotel for one person in Lübeck (Germany) from 26.8.2007 till 1.9.2007

# Internet Explorer: Cache directory example

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

    LEAK record: Some binary data



Webpage

Directly opened as a file in the cache directory

Note: Images are missing because of modified file names (original ones in index.dat)!

# 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"); 2.x (>=3.x → SQLite!)
    - » 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
  - → Replaced in version 3 with a real DB (SQLite)!
    - » Examination quite simple: SQL queries!
- V2: 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 timezone of dates!

http://www.forensicswiki.org/wiki/Mozilla_Firefox_3_History_File_Format

# 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 filename 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
      bMDEpJi1JPF9xN0JINkUyQkExJSIhJxweJBkeGyAvLjcsLDQpKzJCSzElliEnHB8dGRwcIC83Ny8tNC0uMktBMSMtSzksIh0gGw==
      - – 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 shown 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
      - – Depending on the server, not the version of Internet Explorer!
  - → So webmail is not necessarily recoverable, but perhaps in some instances
- Note: The cache only contains, what is sent to the computer
  - → Locally drafted E-Mail is "form input" which is **never** cached!

# 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

# Privacy mode: IE 8 "InPrivate Browsing"

- Allows Browsing without leaving traces (but see below!)
- Additional feature: Prevent Sites from sending data to other sites (InPrivate Filtering)
  - → IE traces third party content; if it appears on more than 10 (can be modified from 3 to 30) sites visited, it is blocked in InPrivate Browsing mode (“Ads” or similar)
    - » Must be activated manually each time (works per-session)!
    - » Can also be activated in non-private browsing mode
  - → Complete blocking (no third-party content) can be set manually; exceptions can be configured as well
- InPrivate Browsing does not store:
  - → New cookies (existing can still be read!), history entries, form data, passwords, typed URLs, search queries, visited links
  - → Toolbars and extensions are disabled
- Will keep: Bookmarks, downloaded files, Flash cookies

# Privacy mode: IE 8 "InPrivate Browsing"

- InPrivate Browsing still stores files in the cache on the disk, but deletes them when closing the window
  - → This means, traces **WILL** remain on the disk!
  - → Which can be found through careful investigation
- Data might remain on disk because of swapped memory too
- Reconstructing the history:
  - → Not available directly (not stored!)
    - » Article unclear about this; some parts might remain
  - → But possible through the cache, which contains the last access time of every stored element!
- No advantage regarding:
  - → Eavesdropping: ISP, NSA, … can still copy the connection
  - → Servers: May even be able to identify that this mode is used

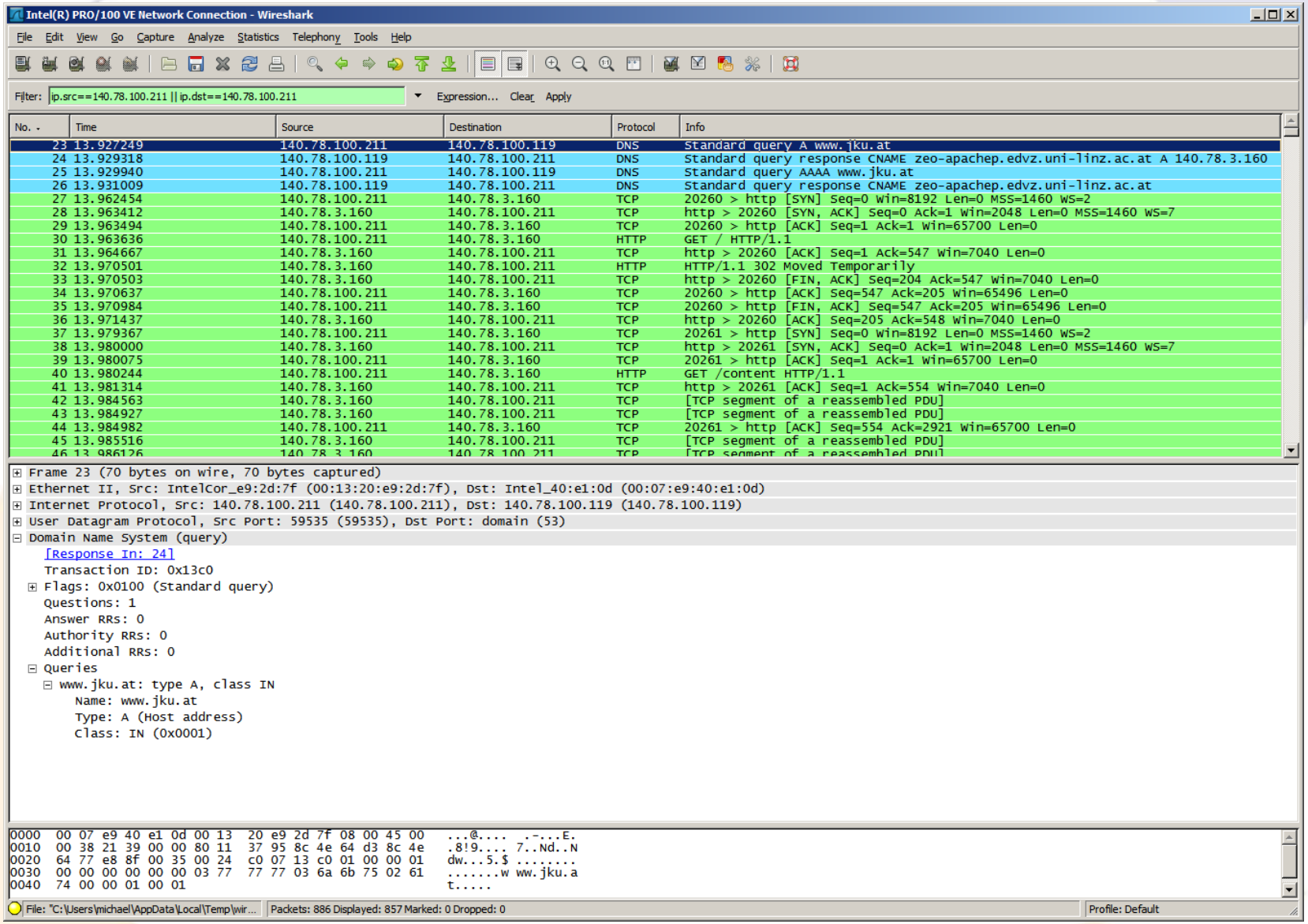
# Privacy mode: Firefox 3

- Firefox does not store
  - → History entries (incl. intelligent address bar), search queries, download history, form data, cookies, cache, typed URLs, passwords, visited links
- Will keep: Bookmarks, downloaded files, Flash cookies
- Same features as IE8
  - → Except third party elements
    - » Cookies can be filtered
    - » Images too, but not through the UI!
      - – about:config → permissions.default.image=3 (no third party images)
    - » Scripts etc.: NoScript or other extensions
- Extensions remain active!
  - → Configuration (e.g. third party images) is the same

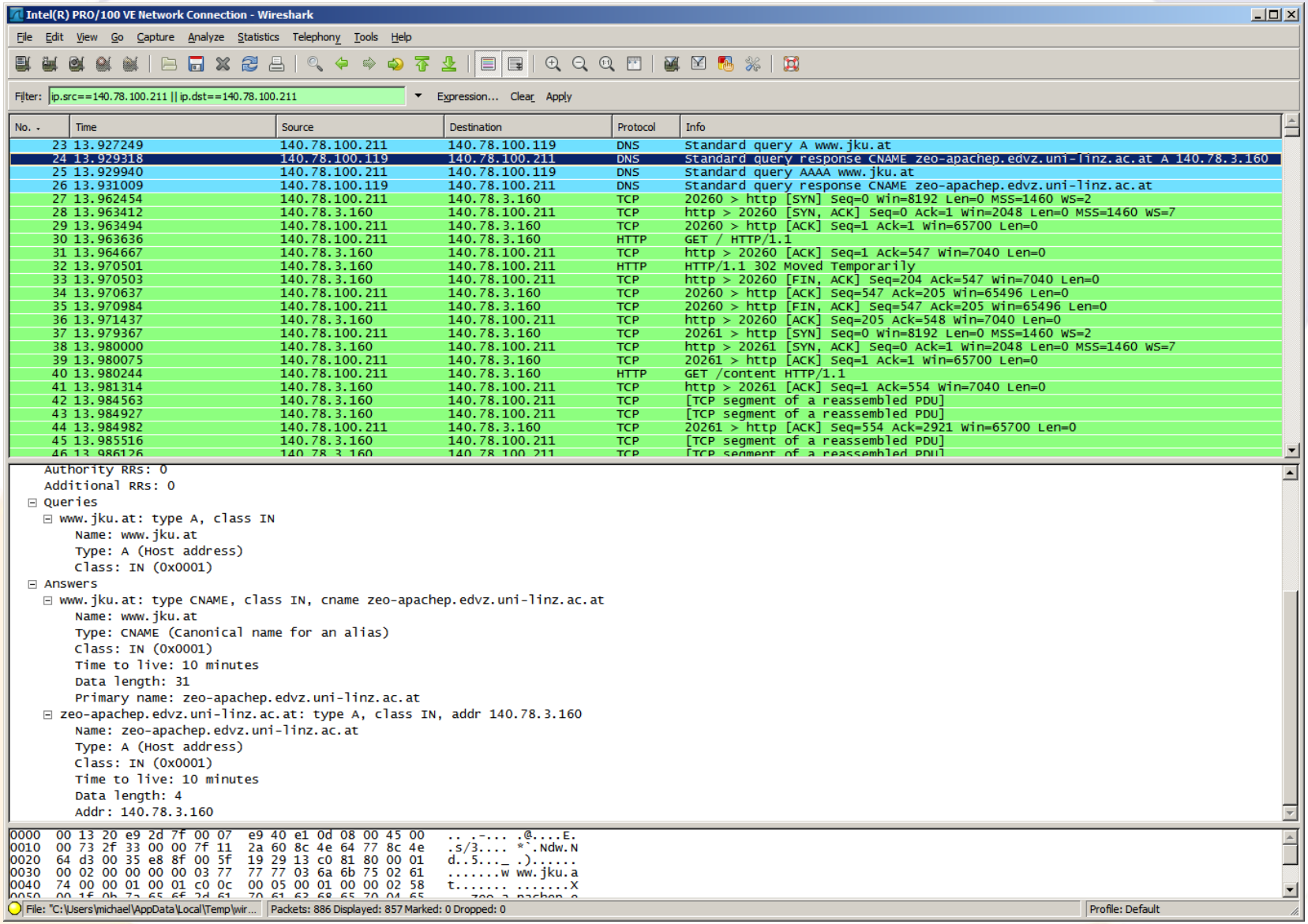
# Alternative: Network forensics

- Copying the network traffic allows reconstructing the page
  - → This requires live access on a router, intercept station etc. at the moment the user browses the web
    - » Wiretapping → Very difficult to do legally!
  - → Only very limited usability!
- Result: Trace of the individual packets
- Requires:
  - → Reassembly of the TCP connection (difficult → tool needed!)
  - → Splitting into the individual requests (HTTP 1.1 pipelining!)
  - → Manual reassembly to a “viewable” local page
    - » Inspection of the HTML code is quite simple
- Following pages: Wireshark example
  - → Left out: IPv6 DNS query, redirect to actual homepage, detailed analysis of the individual packets (not interesting!)

# Web page request trace (www.jku.at) DNS query



# Web page request trace (www.jku.at) DNS response



# Web page request trace (www.jku.at) HTTP query

Intel(R) PRO/100 VE Network Connection - Wireshark

File Edit View Go Capture Analyze Statistics Telephony Tools Help

Filter: ip.src==140.78.100.211 || ip.dst==140.78.100.211 Expression... Clear Apply

| No. | Time | Source | Destination | Protocol | Info |
|---|---|---|---|---|---|
| 23 | 13.927249 | 140.78.100.211 | 140.78.100.119 | DNS | Standard query A www.jku.at |
| 24 | 13.929318 | 140.78.100.119 | 140.78.100.211 | DNS | Standard query response CNAME zeo-apachep.edvz.uni-linz.ac.at A 140.78.3.160 |
| 25 | 13.929940 | 140.78.100.211 | 140.78.100.119 | DNS | Standard query AAAA www.jku.at |
| 26 | 13.931009 | 140.78.100.119 | 140.78.100.211 | DNS | Standard query response CNAME zeo-apachep.edvz.uni-linz.ac.at |
| 27 | 13.962454 | 140.78.100.211 | 140.78.3.160 | TCP | 20260 > http [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=2 |
| 28 | 13.963412 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20260 [SYN, ACK] Seq=0 Ack=1 Win=2048 Len=0 MSS=1460 WS=7 |
| 29 | 13.963494 | 140.78.100.211 | 140.78.3.160 | TCP | 20260 > http [ACK] Seq=1 Ack=1 Win=65700 Len=0 |
| 30 | 13.963636 | 140.78.100.211 | 140.78.3.160 | HTTP | GET / HTTP/1.1 |
| 31 | 13.964667 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20260 [ACK] Seq=1 Ack=547 Win=7040 Len=0 |
| 32 | 13.970501 | 140.78.3.160 | 140.78.100.211 | HTTP | HTTP/1.1 302 Moved Temporarily |
| 33 | 13.970503 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20260 [FIN, ACK] Seq=204 Ack=547 Win=7040 Len=0 |
| 34 | 13.970637 | 140.78.100.211 | 140.78.3.160 | TCP | 20260 > http [ACK] Seq=547 Ack=205 Win=65496 Len=0 |
| 35 | 13.970984 | 140.78.100.211 | 140.78.3.160 | TCP | 20260 > http [FIN, ACK] Seq=547 Ack=205 Win=65496 Len=0 |
| 36 | 13.971437 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20260 [ACK] Seq=205 Ack=548 Win=7040 Len=0 |
| 37 | 13.979367 | 140.78.100.211 | 140.78.3.160 | TCP | 20261 > http [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=2 |
| 38 | 13.980000 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20261 [SYN, ACK] Seq=0 Ack=1 Win=2048 Len=0 MSS=1460 WS=7 |
| 39 | 13.980075 | 140.78.100.211 | 140.78.3.160 | TCP | 20261 > http [ACK] Seq=1 Ack=1 Win=65700 Len=0 |
| 40 | 13.980244 | 140.78.100.211 | 140.78.3.160 | HTTP | GET /content HTTP/1.1 |
| 41 | 13.981314 | 140.78.3.160 | 140.78.100.211 | TCP | http > 20261 [ACK] Seq=1 Ack=554 Win=7040 Len=0 |
| 42 | 13.984563 | 140.78.3.160 | 140.78.100.211 | TCP | [TCP segment of a reassembled PDU] |
| 43 | 13.984927 | 140.78.3.160 | 140.78.100.211 | TCP | [TCP segment of a reassembled PDU] |
| 44 | 13.984982 | 140.78.100.211 | 140.78.3.160 | TCP | 20261 > http [ACK] Seq=554 Ack=2921 Win=65700 Len=0 |
| 45 | 13.985516 | 140.78.3.160 | 140.78.100.211 | TCP | [TCP segment of a reassembled PDU] |
| 46 | 13.986126 | 140.78.3.160 | 140.78.100.211 | TCP | [TCP segment of a reassembled PDU] |

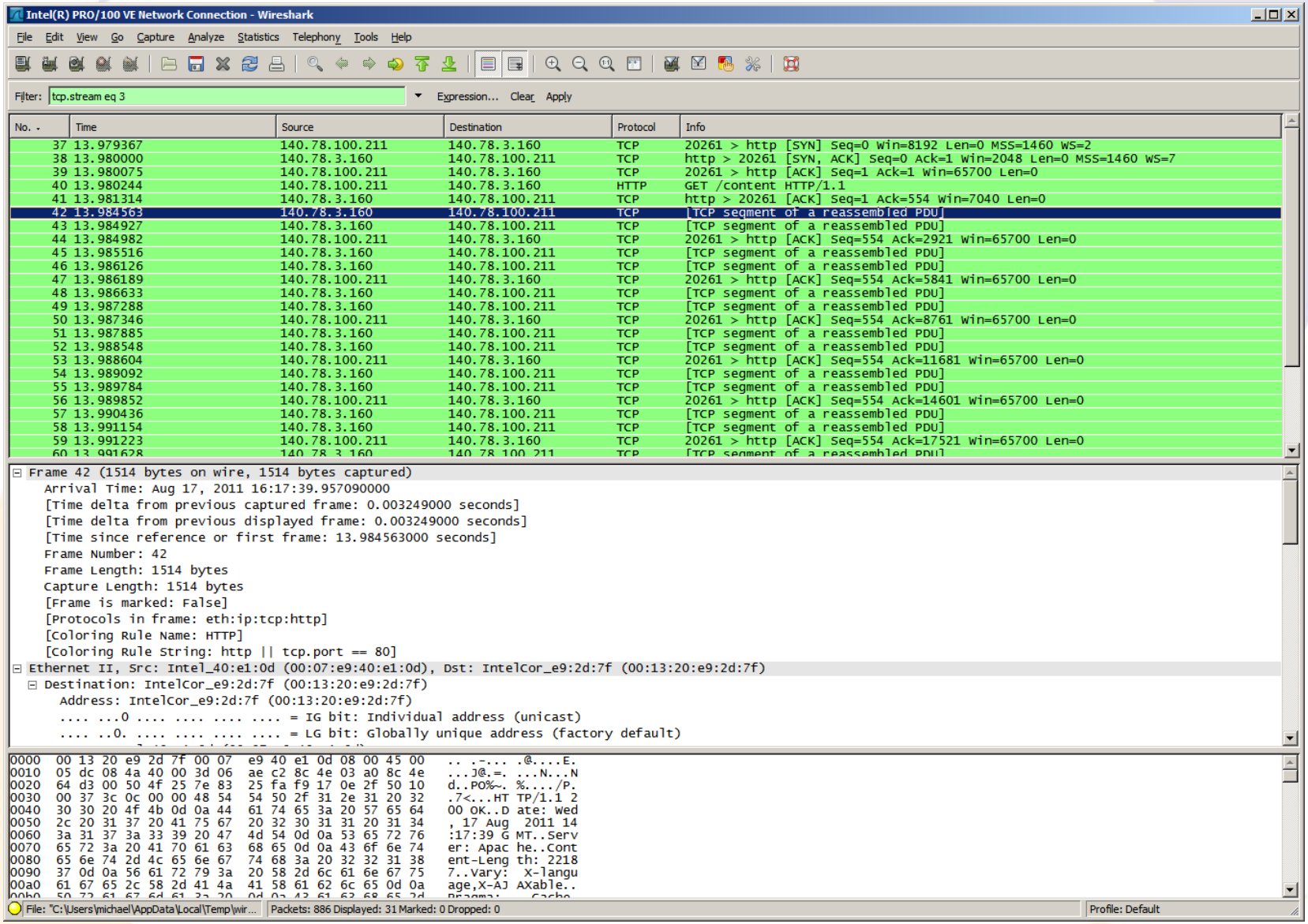
```
Frame 30 (600 bytes on wire, 600 bytes captured)
Ethernet II, Src: IntelCor_e9:2d:7f (00:13:20:e9:2d:7f), Dst: Intel_40:e1:0d (00:07:e9:40:e1:0d)
Internet Protocol, Src: 140.78.100.211 (140.78.100.211), Dst: 140.78.3.160 (140.78.3.160)
Transmission Control Protocol, Src Port: 20260 (20260), Dst Port: http (80), Seq: 1, Ack: 1, Len: 546
Hypertext Transfer Protocol
  GET / HTTP/1.1\r\n
  Host: www.jku.at\r\n
  User-Agent: Mozilla/5.0 (Windows; U; Windows NT 6.1; de; rv:1.9.2.18) Gecko/20110614 Firefox/3.6.18\r\n
  Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\n
  Accept-Language: de-de,de;q=0.8,en-us;q=0.5,en;q=0.3\r\n
  Accept-Encoding: gzip,deflate\r\n
  Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\n
  Keep-Alive: 115\r\n
  Cookie: sselect=people; jku_query_config=%7B%22pagesize%22%3A5%2C%22history%22%3A%5B%223%3Awildling%22%2C%221%3Airrgeher%22%2C%221%3Anussbaumer%22%5D%7D\r\n
  DNT: 1\r\n
  Connection: keep-alive\r\n
  \r\n
```

DNT = Do Not Track (Mozilla version of „X-Do-Not-Track")

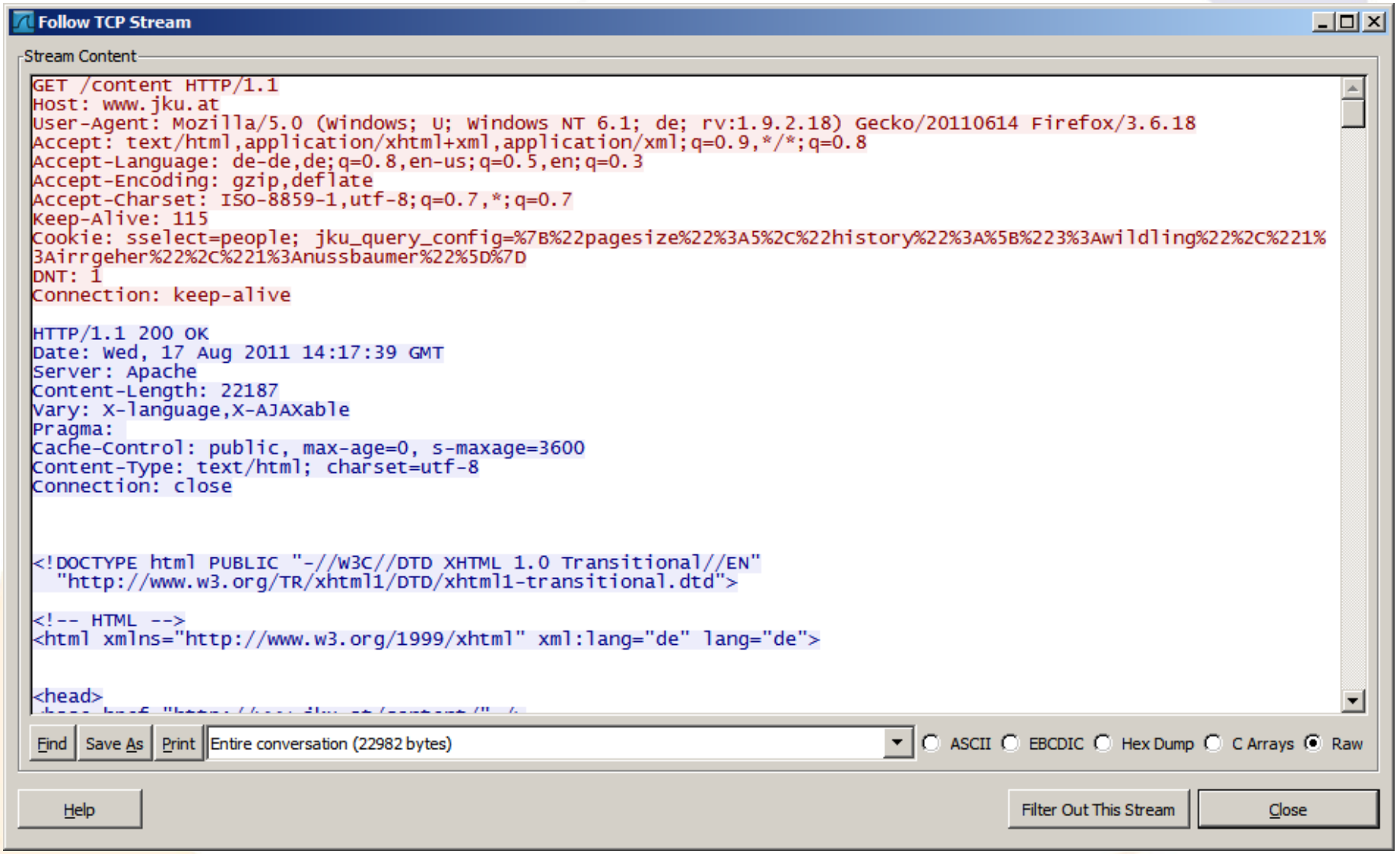
```
0000  00 07 e9 40 e1 0d 00 13  20 e9 2d 7f 08 00 45 00   ...@.... .-...E.
0010  02 4a 21 3d 40 00 80 06  56 61 8c 4e 64 d3 8c 4e   .J!=@... Va.Nd..N
0020  03 a0 4f 24 00 50 3a 67  b5 9d 7e 28 2d dc 50 18   ..O$.P:g ..~(-.P.
0030  40 29 6f 28 00 00 47 45  54 20 2f 20 48 54 54 50   @)o(..GE T / HTTP
0040  2f 31 2e 31 0d 0a 48 6f  73 74 3a 20 77 77 77 2e   /1.1..Ho st: www.
0050  6a 6b 75 2e 61 74 0d 0a  55 73 65 72 2d 41 67 65   jku.at.. User-Age
0060  6e 74 3a 20 4d 6f 7a 69  6c 6c 61 2f 35 2e 30 20   nt: Mozi lla/5.0
0070  28 57 69 6e 64 6f 77 73  3b 20 55 3b 20 57 69 6e   (Windows ; U; Win
0080  64 6f 77 73 20 4e 54 20  36 2e 31 3b 20 64 65 3b   dows NT  6.1; de;
0090  20 72 76 3a 31 2e 39 2e  32 2e 31 38 29 20 47 65    rv:1.9. 2.18) Ge
00a0  63 6b 6f 2f 32 30 31 31  30 36 31 34 20 46 69 72   cko/2011 0614 Fir
00b0  65 66 6f 78 2f 33 2e 36  2e 31 38 0d 0a 41 63 63   efox/3.6 .18..Acc
```

File: "C:\Users\michael\AppData\Local\Temp\wir... Packets: 886 Displayed: 857 Marked: 0 Dropped: 0 Profile: Default

# Web page request trace (www.jku.at)
# HTTP response (start)



# Web page request trace (www.jku.at)
# HTTP response (TCP stream)



# 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 these files
  - → Few of them are free
  - → File formats are often not at all/badly documented
- Timestamps are very important, but many formats exist
  - → 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)