# TOR BROWSER FORENSICS ON WINDOWS OS

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DEFTCON 2015

ROMA, 17 APRILE

# REAL CASE

- Management salaries of a private company were **published on a Blog**
- Through an analysis of the internal network, we found a possible suspect because he accessed the Excel file containing the salaries the day before the publication
- Company asked us to analyze the employee laptop
- We **found evidences that confirm that the Excel file was opened [LNK, Jumplist, ShellBags]**
- But **no traces** were found **in browsing history** about the publishing activity on the blog…

# PREVIOUS RESEARCH

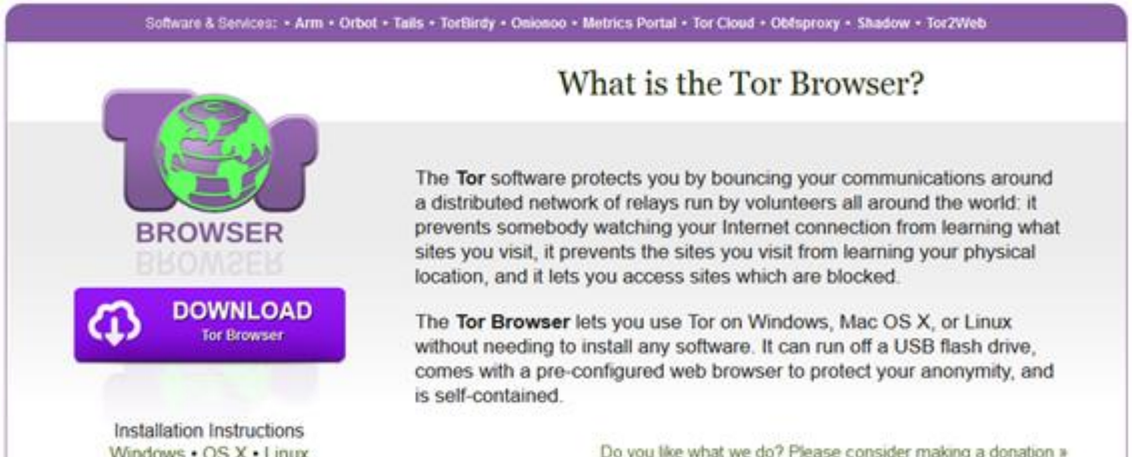
- An interesting research by Runa Sandvik is available at

  **Forensic Analysis of the Tor Browser Bundle on OS X, Linux, and Windows**

  https://research.torproject.org/techreports/tbb-forensic-analysis-2013-06-28.pdf

- We started from her work to find other interesting artifacts

# TOR BROWSER – MICROSOFT WINDOWS



Software & Services: • Arm • Orbot • Tails • TorBirdy • Onionoo • Metrics Portal • Tor Cloud • Obfsproxy • Shadow • Tor2Web
BROWSER
DOWNLOAD
Tor Browser

## What is the Tor Browser?

The **Tor** software protects you by bouncing your communications around a distributed network of relays run by volunteers all around the world: it prevents somebody watching your Internet connection from learning what sites you visit, it prevents the sites you visit from learning your physical location, and it lets you access sites which are blocked.

The **Tor Browser** lets you use Tor on Windows, Mac OS X, or Linux without needing to install any software. It can run off a USB flash drive, comes with a pre-configured web browser to protect your anonymity, and is self-contained.

Installation Instructions
Windows • OS X • Linux

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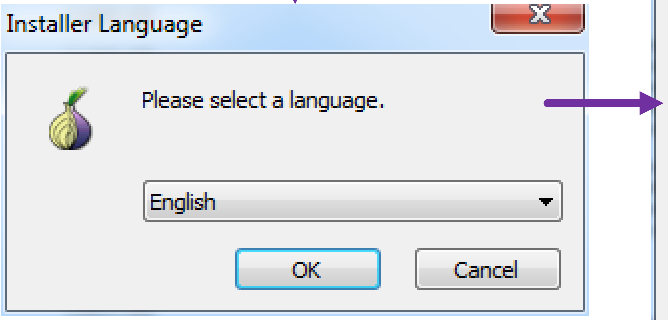
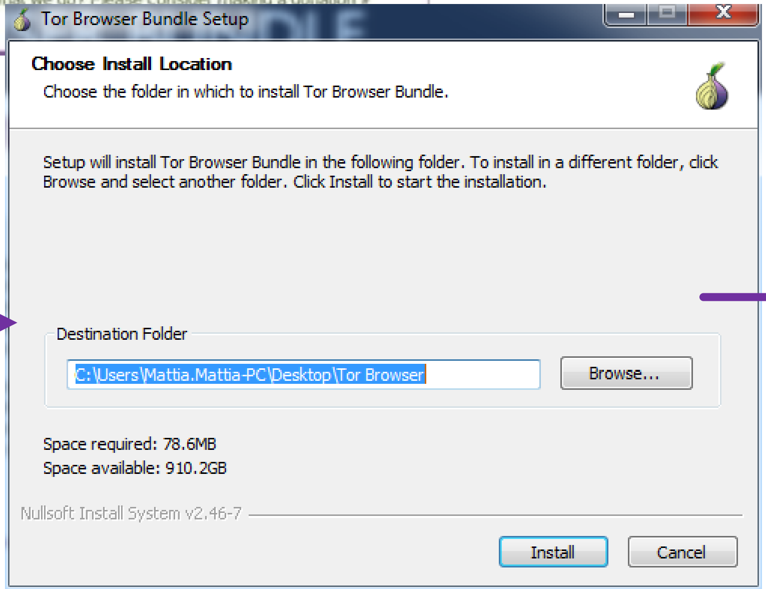


Installer Language

Please select a language.

English



Tor Browser Bundle Setup

**Choose Install Location**

Choose the folder in which to install Tor Browser Bundle.

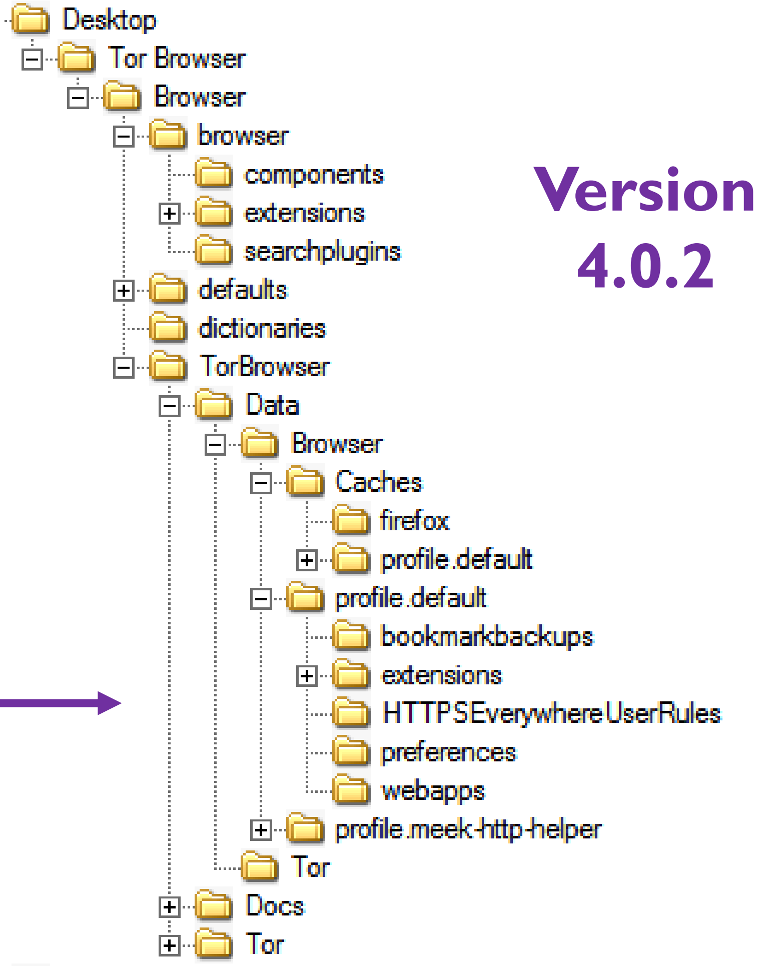
Setup will install Tor Browser Bundle in the following folder. To install in a different folder, click Browse and select another folder. Click Install to start the installation.

Destination Folder

C:\Users\Mattia.Mattia-PC\Desktop\Tor Browser

Space required: 78.6MB
Space available: 910.2GB

Nullsoft Install System v2.46-7



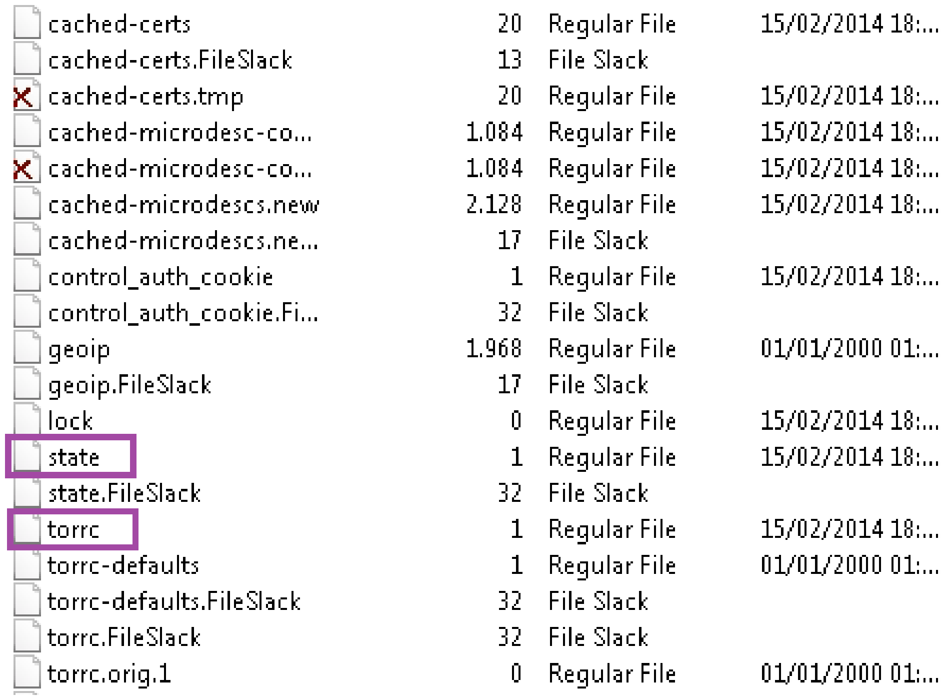
```
Desktop
  Tor Browser
    Browser
      browser
        components
        extensions
        searchplugins
      defaults
      dictionaries
      TorBrowser
        Data
          Browser
            Caches
              firefox
              profile.default
            profile.default
              bookmarkbackups
              extensions
              HTTPSEverywhereUserRules
              preferences
              webapps
            profile.meek-http-helper
          Tor
        Docs
        Tor
```

**Version 4.0.2**

# TOR BROWSER FOLDER

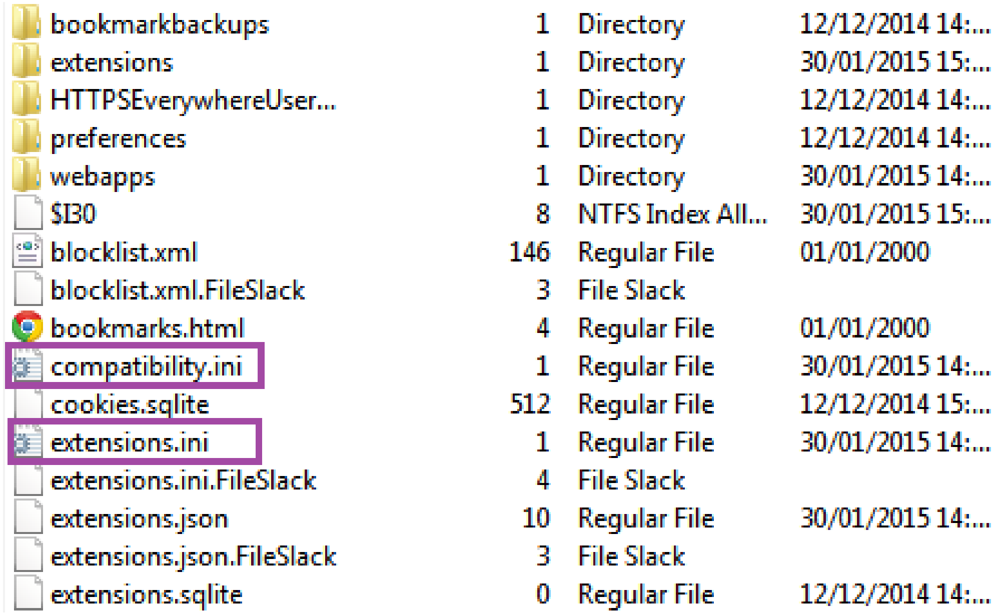
- The most interesting folders are located in **\Tor Browser\Browser\Tor Browser**:

## \Data\Tor



| | | | |
|---|---|---|---|
| cached-certs | 20 | Regular File | 15/02/2014 18:... |
| cached-certs.FileSlack | 13 | File Slack | |
| cached-certs.tmp | 20 | Regular File | 15/02/2014 18:... |
| cached-microdesc-co... | 1.084 | Regular File | 15/02/2014 18:... |
| cached-microdesc-co... | 1.084 | Regular File | 15/02/2014 18:... |
| cached-microdescs.new | 2.128 | Regular File | 15/02/2014 18:... |
| cached-microdescs.ne... | 17 | File Slack | |
| control_auth_cookie | 1 | Regular File | 15/02/2014 18:... |
| control_auth_cookie.Fi... | 32 | File Slack | |
| geoip | 1.968 | Regular File | 01/01/2000 01:... |
| geoip.FileSlack | 17 | File Slack | |
| lock | 0 | Regular File | 15/02/2014 18:... |
| state | 1 | Regular File | 15/02/2014 18:... |
| state.FileSlack | 32 | File Slack | |
| torrc | 1 | Regular File | 15/02/2014 18:... |
| torrc-defaults | 1 | Regular File | 01/01/2000 01:... |
| torrc-defaults.FileSlack | 32 | File Slack | |
| torrc.FileSlack | 32 | File Slack | |
| torrc.orig.1 | 0 | Regular File | 01/01/2000 01:... |

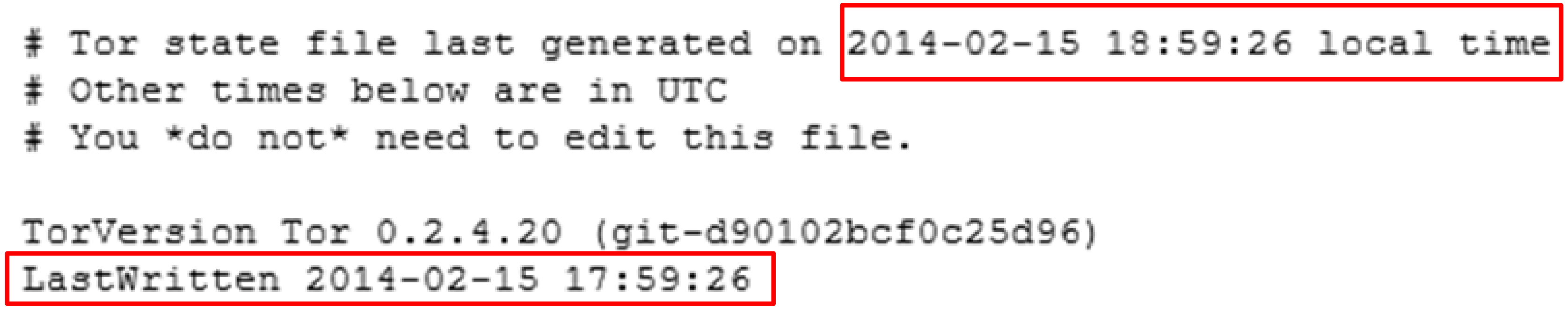
## \Data\Browser\profile.default



| | | | |
|---|---|---|---|
| bookmarkbackups | 1 | Directory | 12/12/2014 14:... |
| extensions | 1 | Directory | 30/01/2015 15:... |
| HTTPSEverywhereUser... | 1 | Directory | 12/12/2014 14:... |
| preferences | 1 | Directory | 12/12/2014 14:... |
| webapps | 1 | Directory | 30/01/2015 14:... |
| $I30 | 8 | NTFS Index All... | 30/01/2015 15:... |
| blocklist.xml | 146 | Regular File | 01/01/2000 |
| blocklist.xml.FileSlack | 3 | File Slack | |
| bookmarks.html | 4 | Regular File | 01/01/2000 |
| compatibility.ini | 1 | Regular File | 30/01/2015 14:... |
| cookies.sqlite | 512 | Regular File | 12/12/2014 15:... |
| extensions.ini | 1 | Regular File | 30/01/2015 14:... |
| extensions.ini.FileSlack | 4 | File Slack | |
| extensions.json | 10 | Regular File | 30/01/2015 14:... |
| extensions.json.FileSlack | 3 | File Slack | |
| extensions.sqlite | 0 | Regular File | 12/12/2014 14:... |

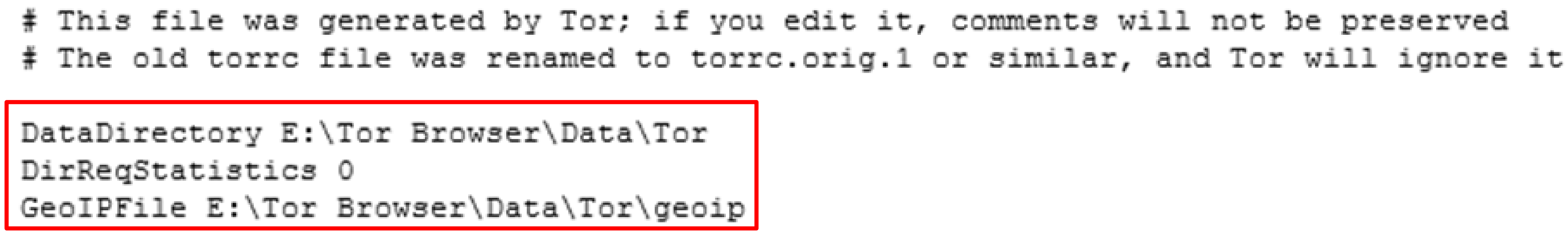
# FOLDER DATA\TOR

- **State**: it contains the **last execution date**



```
# Tor state file last generated on 2014-02-15 18:59:26 local time
# Other times below are in UTC
# You *do not* need to edit this file.

TorVersion Tor 0.2.4.20 (git-d90102bcf0c25d96)
LastWritten 2014-02-15 17:59:26
```

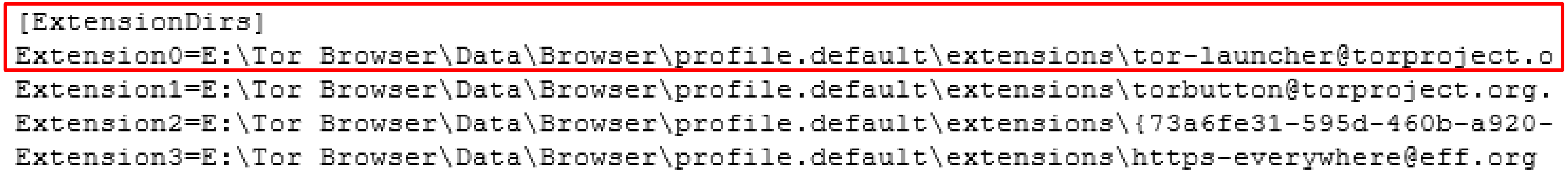
- **Torrc:** it contains the **path from where the Tor Browser was launched** with the drive letter



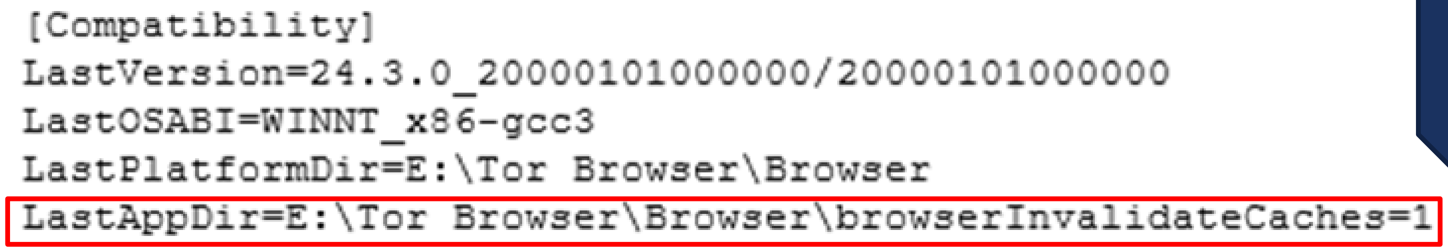
```
# This file was generated by Tor; if you edit it, comments will not be preserved
# The old torrc file was renamed to torrc.orig.1 or similar, and Tor will ignore it

DataDirectory E:\Tor Browser\Data\Tor
DirReqStatistics 0
GeoIPFile E:\Tor Browser\Data\Tor\geoip
```

# FOLDER \DATA\BROWSER\PROFILE.DEFAULT

- The traditional *Firefox folder* containing the user profile **without usage traces**
- The most interesting files:
  - ❑ **Compatibility.ini**
  - ❑ **Extension.ini**



```
[ExtensionDirs]
Extension0=E:\Tor Browser\Data\Browser\profile.default\extensions\tor-launcher@torproject.o
Extension1=E:\Tor Browser\Data\Browser\profile.default\extensions\torbutton@torproject.org.
Extension2=E:\Tor Browser\Data\Browser\profile.default\extensions\{73a6fe31-595d-460b-a920-
Extension3=E:\Tor Browser\Data\Browser\profile.default\extensions\https-everywhere@eff.org
```



```
[Compatibility]
LastVersion=24.3.0_20000101000000/20000101000000
LastOSABI=WINNT_x86-gcc3
LastPlatformDir=E:\Tor Browser\Browser
LastAppDir=E:\Tor Browser\Browser\browserInvalidateCaches=1
```

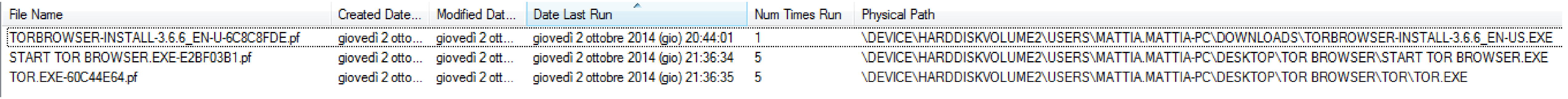
- **Browser execution path**
- **Date Created → First execution**
- **Date Modified → Last execution**

# OS ARTIFACTS ANALYSIS

- Evidence of TOR usage can be found (mainly) in:
  - ❑ Prefetch file **TORBROWSERINSTALL-<VERSION>-<PATH-HASH>.pf**
  - ❑ Prefetch file **TOR.EXE-<PATH-HASH>.pf**
  - ❑ Prefetch file **FIREFOX.EXE-<PATH-HASH>.pf**
  - ❑ Prefetch file **START TOR BROWSER.EXE-<PATH-HASH>.pf** *(old version < 4.0.2)*
  - ❑ NTUSER.DAT registry hive → **User Assist** key
  - ❑ Windows Search Database
  - ❑ Thumbnail cache

# PREFETCH FILES

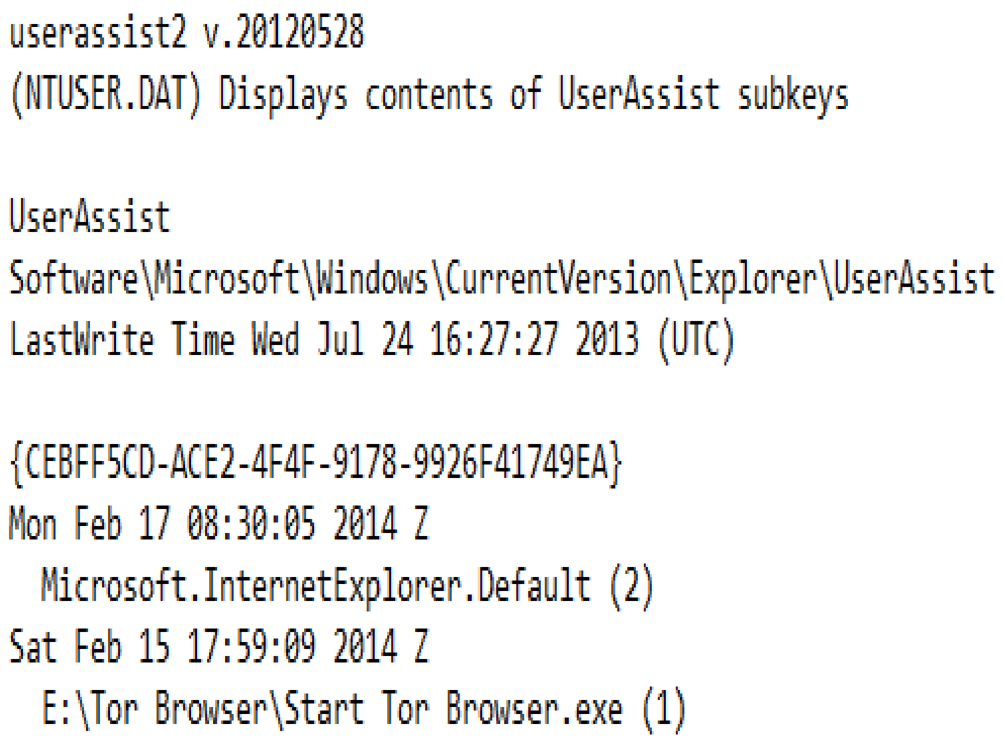
- We can recover:
  - **First execution date**
  - **Last execution date**
    - **In Windows 8/8.1 → Last 8 executions**
  - **Number of executions**
  - **Execution Path**
  - **Install date (from Tor Browser Install prefetch file)**
  - **Tor Browser version (from Tor Browser Install prefetch file)**



| File Name | Created Date... | Modified Dat... | Date Last Run | Num Times Run | Physical Path |
|---|---|---|---|---|---|
| TORBROWSER-INSTALL-3.6.6_EN-U-6C8C8FDE.pf | giovedì 2 otto... | giovedì 2 ott... | giovedì 2 ottobre 2014 (gio) 20:44:01 | 1 | \DEVICE\HARDDISKVOLUME2\USERS\MATTIA.MATTIA-PC\DOWNLOADS\TORBROWSER-INSTALL-3.6.6_EN-US.EXE |
| START TOR BROWSER.EXE-E2BF03B1.pf | giovedì 2 otto... | giovedì 2 ott... | giovedì 2 ottobre 2014 (gio) 21:36:34 | 5 | \DEVICE\HARDDISKVOLUME2\USERS\MATTIA.MATTIA-PC\DESKTOP\TOR BROWSER\START TOR BROWSER.EXE |
| TOR.EXE-60C44E64.pf | giovedì 2 otto... | giovedì 2 ott... | giovedì 2 ottobre 2014 (gio) 21:36:35 | 5 | \DEVICE\HARDDISKVOLUME2\USERS\MATTIA.MATTIA-PC\DESKTOP\TOR BROWSER\TOR\TOR.EXE |

# USER ASSIST

- We can recover:
  - **Last execution date**
  - **Number of executions**
  - **Execution path**
- By analyzing various NTUSER.DAT from VSS we can **identify the number and time of execution in a period of interest**



```
userassist2 v.20120528
(NTUSER.DAT) Displays contents of UserAssist subkeys

UserAssist
Software\Microsoft\Windows\CurrentVersion\Explorer\UserAssist
LastWrite Time Wed Jul 24 16:27:27 2013 (UTC)

{CEBFF5CD-ACE2-4F4F-9178-9926F41749EA}
Mon Feb 17 08:30:05 2014 Z
  Microsoft.InternetExplorer.Default (2)
Sat Feb 15 17:59:09 2014 Z
  E:\Tor Browser\Start Tor Browser.exe (1)
```

# OTHER ARTIFACTS ON THE HARD DRIVE

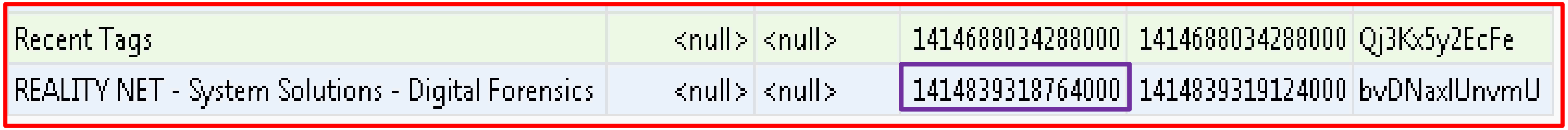
- Other files noted:
  - **Thumbnail Cache**
    - It contains the TOR Browser icon
  - **Windows Search Database**
    - Tor Browser files and folders path

# BROWSING ACTIVITIES

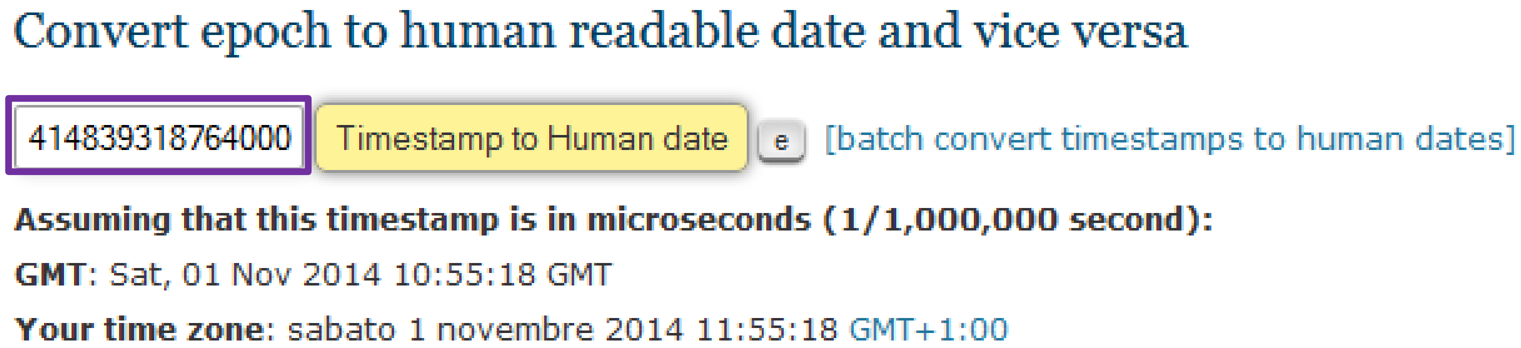
- Evidence of browsing activities can be found in:
  - □ Bookmarks (places.sqlite database)
  - □ Pagefile.sys
  - □ Memory Dump / Hiberfil.sys

# BOOKMARKS

User saved bookmarks:



| | | | | | |
|---|---|---|---|---|---|
| Recent Tags | <null> | <null> | 1414688034288000 | 1414688034288000 | Qj3Kx5y2EcFe |
| REALITY NET - System Solutions - Digital Forensics | <null> | <null> | 1414839318764000 | 1414839319124000 | bvDNaxlUnvmU |



Convert epoch to human readable date and vice versa

414839318764000

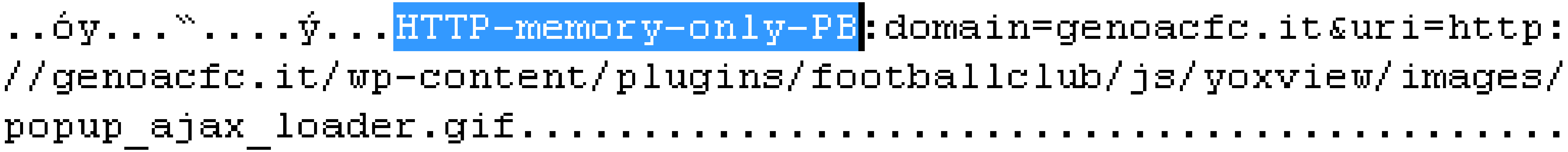
**Assuming that this timestamp is in microseconds (1/1,000,000 second):**

**GMT**: Sat, 01 Nov 2014 10:55:18 GMT

**Your time zone**: sabato 1 novembre 2014 11:55:18 GMT+1:00

# PAGEFILE.SYS

- **Information about visited websites**
- Search for the keyword **HTTP-memory-only-PB**

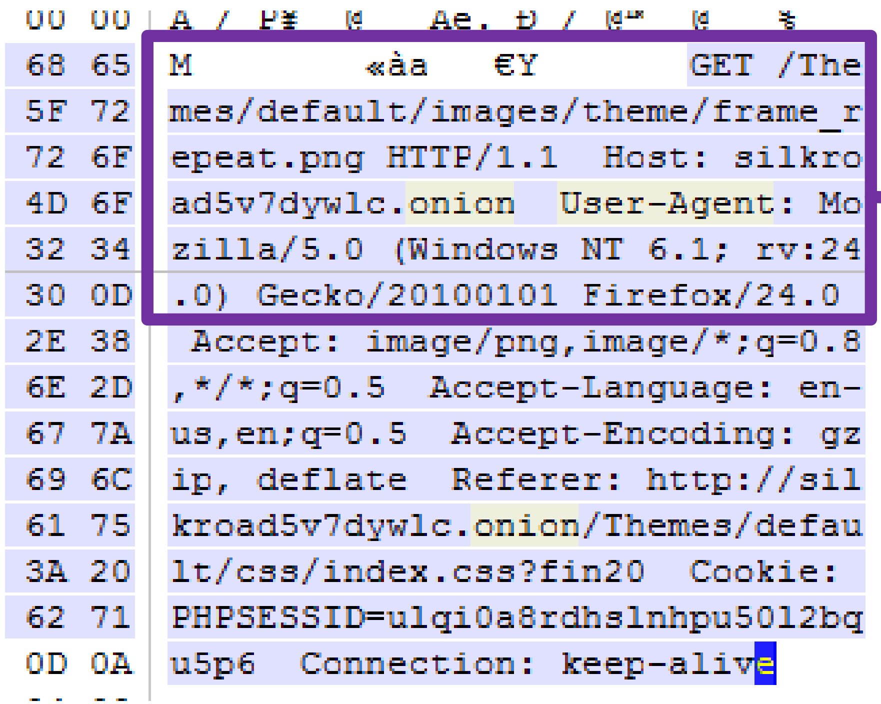


```
..óy...“....ý...HTTP-memory-only-PB:domain=genoacfc.it&uri=http:
//genoacfc.it/wp-content/plugins/footballclub/js/yoxview/images/
popup_ajax_loader.gif...........................................
```

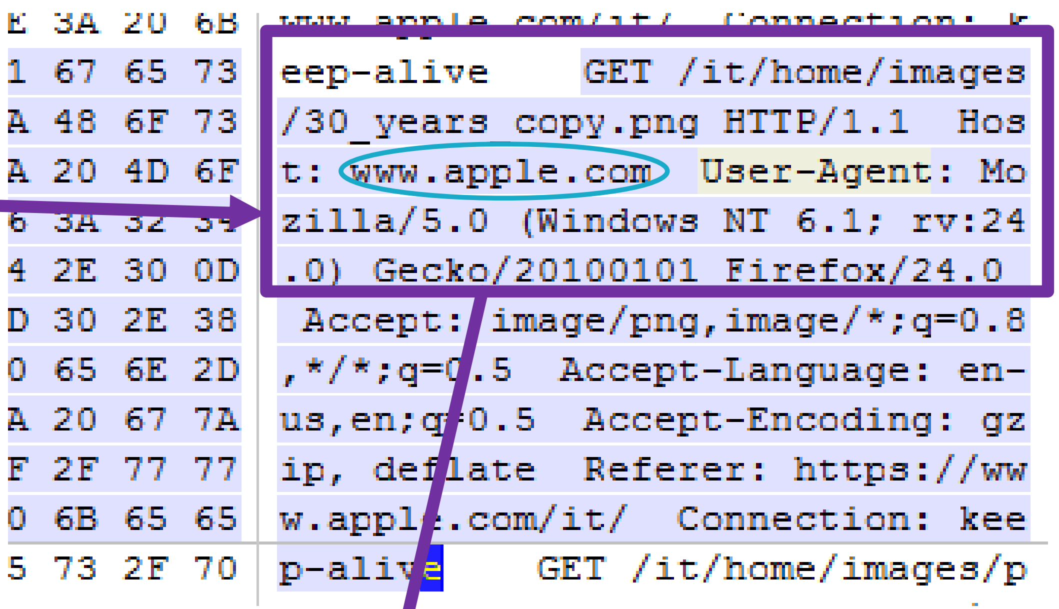
# HTTP-MEMORY-ONLY-PB

- A function used by Mozilla Firefox for Private Browsing (**not saving cache data on the hard drive**)
- **Tor Browser uses the Private Browsing** feature of Mozilla Firefox
- But Tor Browser typically **uses an old Firefox version, based on Firefox ESR**
- To distinguish if the browsing activity was made with Mozilla Firefox or with Tor Browser:
  - Check if Firefox is installed
  - If it is installed, verify the actual version

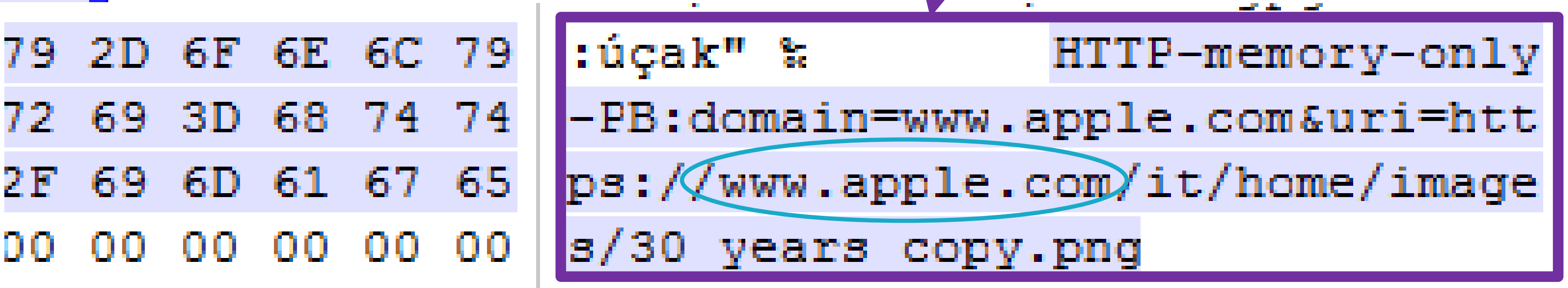
# PAGEFILE.SYS - EXAMPLE



```
00 00 | A / Þ¥  @   Ae. Đ / @ª  @   %
68 65 | M          «àa   €Y        GET /The
5F 72 | mes/default/images/theme/frame_r
72 6F | epeat.png HTTP/1.1  Host: silkro
4D 6F | ad5v7dywlc.onion  User-Agent: Mo
32 34 | zilla/5.0 (Windows NT 6.1; rv:24
30 0D | .0) Gecko/20100101 Firefox/24.0
2E 38 |  Accept: image/png,image/*;q=0.8
6E 2D | ,*/*;q=0.5  Accept-Language: en-
67 7A | us,en;q=0.5  Accept-Encoding: gz
69 6C | ip, deflate  Referer: http://sil
61 75 | kroad5v7dywlc.onion/Themes/defau
3A 20 | lt/css/index.css?fin20  Cookie:
62 71 | PHPSESSID=ulqi0a8rdhslnhpu5012bq
0D 0A | u5p6  Connection: keep-alive
```



```
E 3A 20 6B | www.apple.com/it/  Connection: k
1 67 65 73 | eep-alive    GET /it/home/images
A 48 6F 73 | /30_years copy.png HTTP/1.1  Hos
A 20 4D 6F | t: www.apple.com  User-Agent: Mo
6 3A 32 34 | zilla/5.0 (Windows NT 6.1; rv:24
4 2E 30 0D | .0) Gecko/20100101 Firefox/24.0
D 30 2E 38 |  Accept: image/png,image/*;q=0.8
0 65 6E 2D | ,*/*;q=0.5  Accept-Language: en-
A 20 67 7A | us,en;q=0.5  Accept-Encoding: gz
F 2F 77 77 | ip, deflate  Referer: https://ww
0 6B 65 65 | w.apple.com/it/  Connection: kee
5 73 2F 70 | p-alive    GET /it/home/images/p
```



```
79 2D 6F 6E 6C 79 | :úçak"  %        HTTP-memory-only
72 69 3D 68 74 74 | -PB:domain=www.apple.com&uri=htt
2F 69 6D 61 67 65 | ps://www.apple.com/it/home/image
00 00 00 00 00 00 | s/30 years copy.png
```

# ANALYSIS METHODOLOGY

### Prefetch files

- Install date
- First execution date
- Last execution date(s)
- Number of executions
- Tor Browser version

### NTUSER\UserAssist key

- Execution path
- Last execution date
- Total number of executions
- Verify the history of execution through the Volume Shadow Copies

### Other possible artifacts

- Thumbnail Cache
- Windows Search Database

### Tor Browser Files

- State
- Torrc
- Compatibility.ini
- Extension.ini
- Places.sqlite [Bookmarks]

### Pagefile.sys
### (keywords search)

- HTTP-memory-only-PB
- Torproject
- Tor
- Torrc
- Geoip
- Torbutton
- Tor-launcher

### Hiberfil.sys

- Convert to a memory dump
- Analyze through
  - Volatility
  - Keywords search

# REAL CASE

- We indexed the hard drive and searched for the blog URL
- We found some **interesting URLs in the pagefile**, indicating the access to the **Blog Admin page** (*http://www. blognameblabla.com/wp-admin/*)

# REAL CASE

- All the URLs were **preceded by the string HTTP-MEMORY-ONLY-PB** and Firefox is not installed on the laptop
- We found that the **TOR Browser was downloaded with Google Chrome** the night in which the file was published on the blog
- By analyzing the OS artifacts we found that **it was installed and only executed once, 3 minutes before the publish date and time on the blog**

# ACTIVE RESEARCHES

- Memory Dump  with Volatility and Rekall
- Can we find any temporal reference for browsing activities?
- Can we correlate Tor Browser cache entries to carved files from pagefile/hiberfil/memory dump?
- Tor Browser on Mac OS X
- Tor Browser on Linux
- Orbot on Android

# Q&A?

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| Blog | **http://blog.digital-forensics.it** |
| | **http://mattiaep.blogspot.it** |