# Forensic analysis

## Local Incident Response

## Handbook, Document for teachers

1.0

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# About ENISA

The European Union Agency for Network and Information Security (ENISA) is a centre of network and information security expertise for the EU, its member states, the private sector and Europe's citizens. ENISA works with these groups to develop advice and recommendations on good practice in information security. It assists EU member states in implementing relevant EU legislation and works to improve the resilience of Europe's critical information infrastructure and networks. ENISA seeks to enhance existing expertise in EU member states by supporting the development of cross-border communities committed to improving network and information security throughout the EU. More information about ENISA and its work can be found at www.enisa.europa.eu.

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# 1. Foreword

This three-day training module will follow the tracks of an incident handler and investigator, teaching best practices and covering both sides of the breach. It is technical in nature and has the aim to provide a guided training for both incident handlers and investigators while providing lifelike conditions. Training material mainly uses open source and free tools.

## 1.1 Forensic process

This exercise and the two following ones demonstrate the technical side of a forensic process. However, it is absolutely necessary to understand and follow the principles, which are fundamental for the successful delivery of forensic services. It is strongly recommended to read the introductory part of the ENISA 'Digital Forensics' exercise[1], where the principles are explained in more detail.

For the technical part of the forensic process, two principles are of utmost importance.

- Data integrity – electronic evidence must not be modified in any way during the forensic process, including the initial data capture
- Audit trail – a record of all actions taken when handling digital evidence must be created and preserved.

The whole forensic process at all stages must be chronologically documented constituting a 'Chain of Custody'[2]. The main purpose of a Chain of Custody is to provide a proof to the court, that at no point in time the evidence could had been tampered with.

There is however a practical issue directly related to the first of the two principles. There are situations, when the investigators need to make a decision to alter some evidence to extract some other pieces of evidence, otherwise unavailable. The best example illustrating that need is taking a memory dump of a running system. To be able to dump the system's memory the investigators need to run a specialized piece of code on that system. Running any code alters system state (memory, disk, processor registers and many more). What's more, the code has to be delivered somehow to the system (over the network, with a USB memory, etc.) which also alters the system state. There's also a possibility, that the system state is modified beyond investigators' intensions, as the delivery of binary code may introduce some malicious code. On the other hand, the old-school method – cutting the power off and taking disk images with a hardware write-blocker is no longer a viable option. Modern malware often resides in memory and leaves very little traces on disks and therefore it is important to dump memory before switching the system off. In such case it is important to document very carefully all actions taken – including any commands issued, tools run, network connections made or external media connected. The documentation must include all details such as the exact date and time, command syntax, serial numbers of media, cryptographic hashes of external tools used and so on. Another point to make is that only tools that are well documented, the investigators know well and are 'reputable' can be used.

There are two fundamental reasons for all the precautions described above. Firstly, it must be possible to distinguish traces left by forensic examiners and their actions from traces originally present in the system. This is possible only when actions are documented and tools used have predictable run patterns, including

[1] Digital forensics https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-material/documents/digital-forensics-handbook (last accessed 30.09.2016)
[2] Chain of custody https://en.wikipedia.org/wiki/Chain_of_custody (last accessed 30.09.2016)

any side effects (creating or deleting temporary files). Secondly, one of the criteria applied to a forensic analysis is its repeatability. The whole process of finding traces and making conclusions must be reproduceable by another, independent forensic expert equipped with adequate knowledge and sufficiently capable. As the reasoning process begins with the assessment of the evidence and the way it was collected, carefully written and maintained documentation is key. One must keep in mind that during judicial proceedings challenging the evidence or the way it was collected is a focal point for the opposing party.

## 1.2 Forensic report

A forensic report is (or at least should be) the final product of any forensic investigation. It is one of the least-liked aspects of an investigation and as such is often written in full, at the end of investigation. Unfortunately, this approach is completely flawed. No good report can be created without precise and comprehensive notes. For that single reason it is highly recommended to understand the requirements the report is supposed to meet. Reports differ in many ways depending on the situation – rudimentary incident response activities, internal investigation within a company, a task for the (Law Enforcement Agency) LEA or an examination for a defence attorney – all require different forms, different detail levels and some of them can be in part regulated by the legal system or internal company policies. It is beneficial for the investigator to know the requirements up front as it influences the process (how thorough the analysis should be, is there anything specific to look for, etc.). It is also very helpful, as the way notes are created throughout the investigation determines the amount of work required to put together a full report. A smart way of taking notes could allow for integrating them into the report rather than writing a report while trying to extract anything relevant from notes.[3]

[3] Report Writing Guidelines http://www.forensicmag.com/article/2012/05/report-writing-guidelines (last accessed 30.09.2016)

# 2. The story triggering incident handling and investigation processes.

*The customer's organization has found out that some of its sensitive data has been detected in an online text sharing application. Due to the legal obligations and for business continuity purposes the CSIRT team has been tasked to conduct an incident response and incident investigation to mitigate the threats.*

*The breach contains sensitive data and includes a threat notice that in a short while more data will follow. As the breach leads to a specific employee's computer then CSIRT team, tasked to investigate the incident, follows the leads.*

Below is presented a simplified overview of the training technical setup.

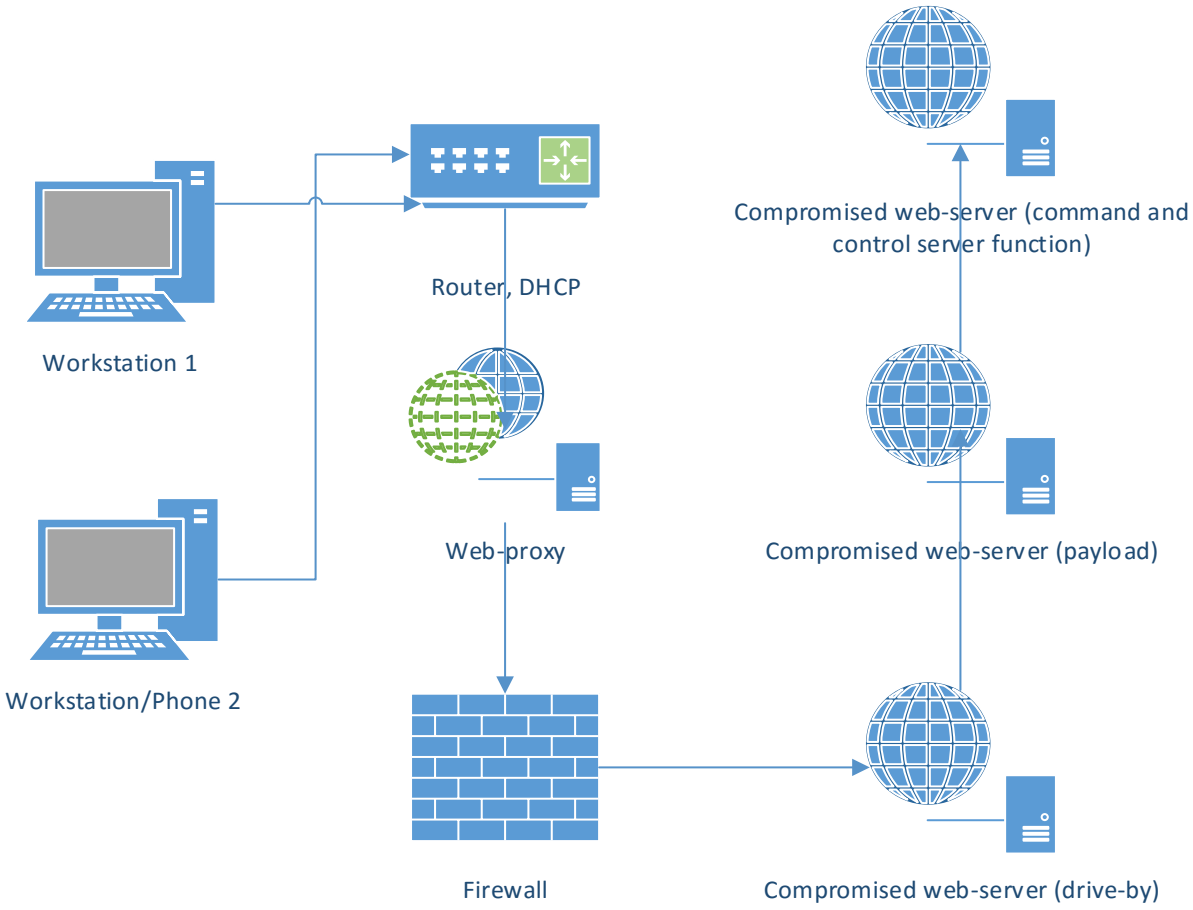



**Figure 1: Network setup**

Below is presented detailed technical setup of the whole training.

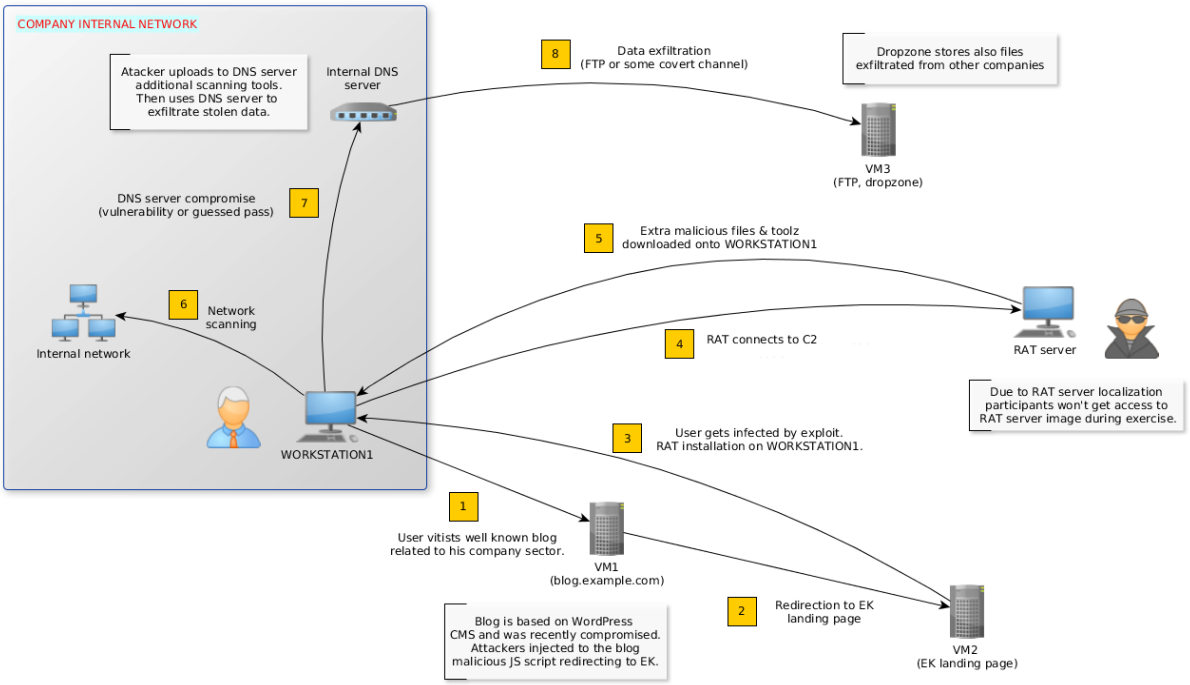



**Figure 2: Compromise scope**

# 3. Local incident response and investigation

## 3.1 Course description and goal

This scenario presents, both theoretically and practically, basic stages of the incident response and investigation process. It leads the trainees through a typical case, where a malicious action is reported and the aim is to find its source and handle the incident as a local one, limited to the workstation only.

At the beginning, emphasis is placed on proper preparation – principles, tools and techniques. A systematic approach to incident response is presented and practiced. The introduction is then followed by a simulated incident report when the response begins. After engagement conditions are met and required authorisation is given, the students start investigating the incident while maintaining a proper forensic regime. Students are given a set of web-proxy and firewall logs to find the workstation that was potentially the original source of the activity reported as security incident.

During the second part of the exercise students perform a forensic analysis of a Microsoft Windows workstation, while maintaining full audit trail of actions taken and creating timeline of events and finding Indicators of Compromise. This exercise ends up with a summary and a group discussion on further investigation, incident containment, eradication and incident reporting.

## 3.2 Course run

- PART 1: Preparing to respond – theoretical introduction to incident response methodologies with a focus on single host computer (Microsoft Windows 10) and guidelines for collecting electronic evidence.
    - References and sources of information:
- PART 2: Responding to incident – theoretical introduction to CSIRT actions in the scope of this incident– constituency, authorisation and response scope
    - References and sources of information:
- PART 3: Forensic capture
    - TASK 1: Collecting evidence: guide the trainee through evidence collection procedures and creating a forensically sound image of workstation including a memory dump.
    - Create a Microsoft Windows 10 workstation forensic image and memory dump.
        - Tools and procedures used:
        - DumpIT: http://www.moonsols.com/2011/07/18/moonsols-dumpit-goes-mainstream/ , https://zeltser.com/memory-acquisition-with-dumpit-for-dfir-2/
        - OSForensics: http://www.osforensics.com/osforensics.html
        - Belkasoft RAM Capturer: http://belkasoft.com/ram-capturer
    - Collect information from the workstation – logs, traces of activity for fast access
        - Tools and procedures used: ACPO: http://www.digital-detective.net/digital-forensics-documents/ACPO_Good_Practice_Guide_for_Digital_Evidence_v5.pdf Forensic Examination of Digital Evidence: A Guide for Law Enforcement https://www.ncjrs.gov/pdffiles1/nij/199408.pdf
        - The Enhanced Digital Investigation Process Model: http://dfrws.org/2004/day1/Tushabe_EIDIP.pdf , https://www.cerias.purdue.edu/assets/pdf/bibtex_archive/2003-29.pdf

- Categories of the Investigative process model (page 102): https://books.google.gr/books?id=WXs_rw1aR1sC&pg=PR5&source=gbs_selected_pages&cad=3#v=onepage&q&f=false
- An Extended Model of Cybercrime Investigations: https://www.utica.edu/academic/institutes/ecii/publications/articles/A0B70121-FD6C-3DBA-0EA5C3E93CC575FA.pdf
- A Hierarchical, Objectives-Based Framework for the Digital Investigations Process: https://www.dfrws.org/2004/day1/Beebe_Obj_Framework_for_DI.pdf
- FORZA – Digital forensics investigation framework that incorporate legal issues: https://www.dfrws.org/2006/proceedings/4-Ieong.pdf
- Guide to Integrating Forensic Techniques into Incident Response - NIST SP 800-86: http://csrc.nist.gov/publications/nistpubs/800-86/SP800-86.pdf
- Electronic Crime Scene Investigation: An On-the-Scene Reference for First Responders: https://www.ncjrs.gov/pdffiles1/nij/227050.pdf
- Electronic Crime Scene Investigation: A Guide for First Responders, Second Edition: https://www.ncjrs.gov/pdffiles1/nij/219941.pdf
- Digital Evidence in the Courtroom: A Guide for Law Enforcement and Prosecutors: https://www.ncjrs.gov/pdffiles1/nij/211314.pdf
- Digital Evidence Guide for First Responders: http://www.iacpcybercenter.org/wp-content/uploads/2015/04/digitalevidence-booklet-051215.pdf
- First Responders Guide to Computer Forensics: https://www.sei.cmu.edu/reports/05hb001.pdf
- Digital Evidence Field Guide: What Every Peace Officer Must know: https://www.rcfl.gov/downloads/documents/digital-evidence-field-guide
- Best Practices For Seizing Electronic Evidence v.3: A Pocket Guide for First Responders: http://www.crime-scene-investigator.net/SeizingElectronicEvidence.pdf

– PART 4: Forensic analysis
  - TASK 2: Confirm if this computer was involved in the data breach and find traces of malicious activity if present.
    - Perform disk analysis
      - Tools and procedures used:
      - AccessData FTK Imager: http://accessdata.com/product-download/digital-forensics/ftk-imager-version-3.4.2
      - WinHex: https://www.x-ways.net/winhex/
      - Forensic Posters: https://github.com/Invoke-IR/ForensicPosters
      - PowerForensics: https://github.com/Invoke-IR/PowerForensics , http://www.invoke-ir.com/2016/02/copying-locked-files-with-powerforensics_5.html
      - Bulk extractor: http://tools.kali.org/forensics/bulk-extractor , http://digitalcorpora.org/downloads/bulk_extractor/ , https://github.com/simsong/bulk_extractor
      - Browser History Viewer: http://www.nirsoft.net/utils/browsing_history_view.html
      - SQLite Database Browser: http://sqlitebrowser.org/

- Perform memory analysis
  - Tools and procedures used:
  - Volatility Framework: https://github.com/volatilityfoundation/volatility , http://www.volatilityfoundation.org/#!25/c1f29 , Web interface for the Volatility Memory Forensics Framework: https://github.com/kevthehermit/VolUtility
  - Rekall Memory Forensic Framework: https://github.com/google/rekall , http://www.rekall-forensic.com/index.html
- Analyse logs
  - Tools and procedures used:
  - Windows 10 Prefetch Parser: https://github.com/505Forensics/tools/tree/master/win10_prefetch , http://www.505forensics.com/updated-windows-10-prefetch-parser/
- Analyse registry
  - Tools and procedures used: *Windows Registry Forensics, Second Edition: Advanced Digital Forensic Analysis of the Windows Registry 2nd Edition by Harlan Carvey*
  - Registry Explorer: https://binaryforay.blogspot.gr/2015/02/introducing-registry-explorer.html , http://ericzimmerman.github.io/Software/RegistryExplorer_RECmd.zip
- Examine suspicious artefacts
  - Tools and procedures used:
  - Pestudio: https://www.winitor.com/index.html
  - IOC Finder: https://www.fireeye.com/services/freeware/ioc-finder.html
  - LOKI – Indicators Of Compromise Scanner: http://www.darknet.org.uk/2016/01/loki-indicators-compromise-scanner/ , https://github.com/Neo23x0/Loki
  - Remnux: https://remnux.org/
- Create timeline and put the leads together
  - Tools and procedures used:
    - log2timeline is a tool designed to extract timestamps from various files found on a typical computer system(s) and aggregate them https://github.com/log2timeline/plaso/wiki
- Draw conclusions

– PART 5: Reporting and follow up actions
  - TASK 3: Advise on the course of action
    - Create Indicators of Compromise
    - Create a report sketch – the most important findings
      - Report template and references: ACPO: http://www.digital-detective.net/digital-forensics-documents/ACPO_Good_Practice_Guide_for_Digital_Evidence_v5.pdf and Forensic Examination of Digital Evidence: A Guide for Law Enforcement https://www.ncjrs.gov/pdffiles1/nij/199408.pdf
    - Create recommendations of immediate actions to take

– PART 6: Exercise summary – discussion on the participants' performance and lessons learned

## 3.3 Tools and environment

- Exercise performed using Microsoft Windows 10 operating system
- Forensic tools used:
  - Windows Registry Recovery (http://www.mitec.cz/wrr.html)
  - Windows File Analyzer (http://www.mitec.cz/wfa.html)
  - Internet History Browser (http://www.mitec.cz/ihb.html)
  - RegRipper (https://github.com/keydet89/RegRipper2.8)
  - Autopsy/TSK (http://www.sleuthkit.org/autopsy/)
  - Log2Timeline (https://github.com/log2timeline/plaso/wiki)
- Malicious and attack code:
  - DarkComet / Xtremerat
  - Mimikatz https://github.com/gentilkiwi/mimikatz
  - Nmap-7.12 https://nmap.org/dist/nmap-7.12-setup.exe
  - KiTrap0D https://www.exploit-db.com/exploits/11199/
  - Pass-The-Hash Toolkit http://www.coresecurity.com/corelabs-research-special/open-source-tools/pass-hash-toolkit
  - Keimpx (build to .exe) https://github.com/inquisb/keimpx
  - Kain & Abel http://www.oxid.it/cain.html
  - fgdump http://foofus.net/goons/fizzgig/fgdump/
  - Pwdump7 http://www.tarasco.org/security/pwdump_7/
  - Proxifier https://www.proxifier.com/

**Time: 8h**

# 4. Collecting evidence

## 4.1 Memory acquisition

When acquiring memory from a live system, analysts should try to minimize the number of traces left on the system (both on disk and in the memory) as a result of the memory acquisition process.

In the analysed case USB Drive with portable version of Belkasoft Live RAM Capturer software was attached to the analysed system which then was used to dump memory image onto the same USB Drive.

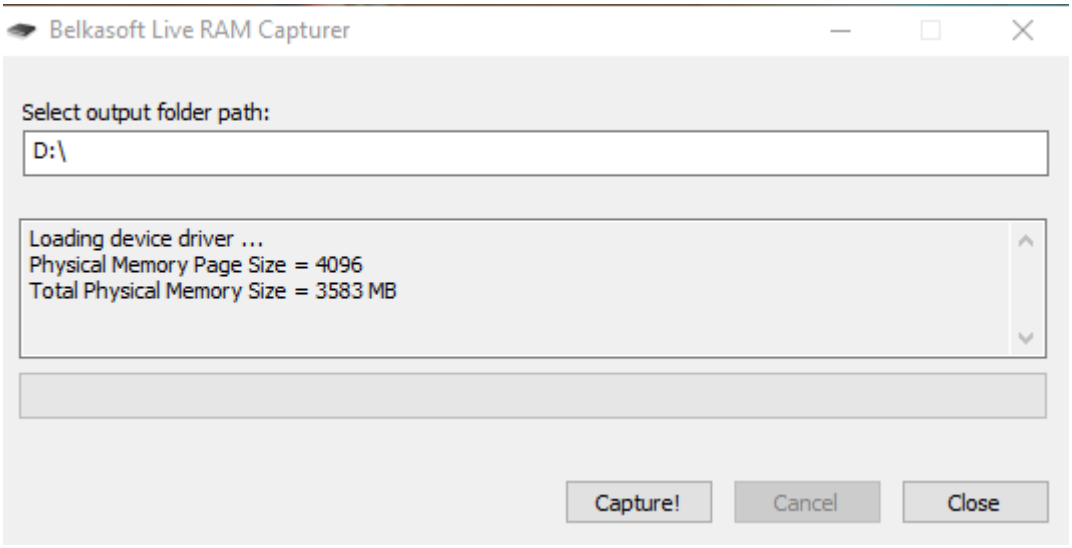



**Figure 3: Memory capture**

When collecting memory of a live system, an analyst should always note the exact time when the memory dump was taken, what tools were used and what traces were left on the analysed system as a result of the memory acquisition process.

## 4.2 Disk image acquisition

A proper way of creating a hard disk image is by using a hardware write-block device[4]. In this exercise we're dealing with virtualised hardware which cannot be imaged with hardware blockers, so we have to rely on system tools.[5]

[4] Forensic disk controller https://en.wikipedia.org/wiki/Forensic_disk_controller (last accessed 30.09.2016)
[5] Linux for computer forensic investigators: «pitfalls» of mounting file systems http://www.forensicfocus.com/linux-forensics-pitfalls-of-mounting-file-systems (last accessed 30.09.2016)

# 5. Environment preparation

All the practical exercises will be done using CAINE Linux[6]. Students should import the provided virtual machine appliance which contains additional set of scripts and all files necessary for completing the exercises. Next, the teacher should ask students to attach separate storage drive with evidence files (memory dump and disk image) – evidence.vmdk.

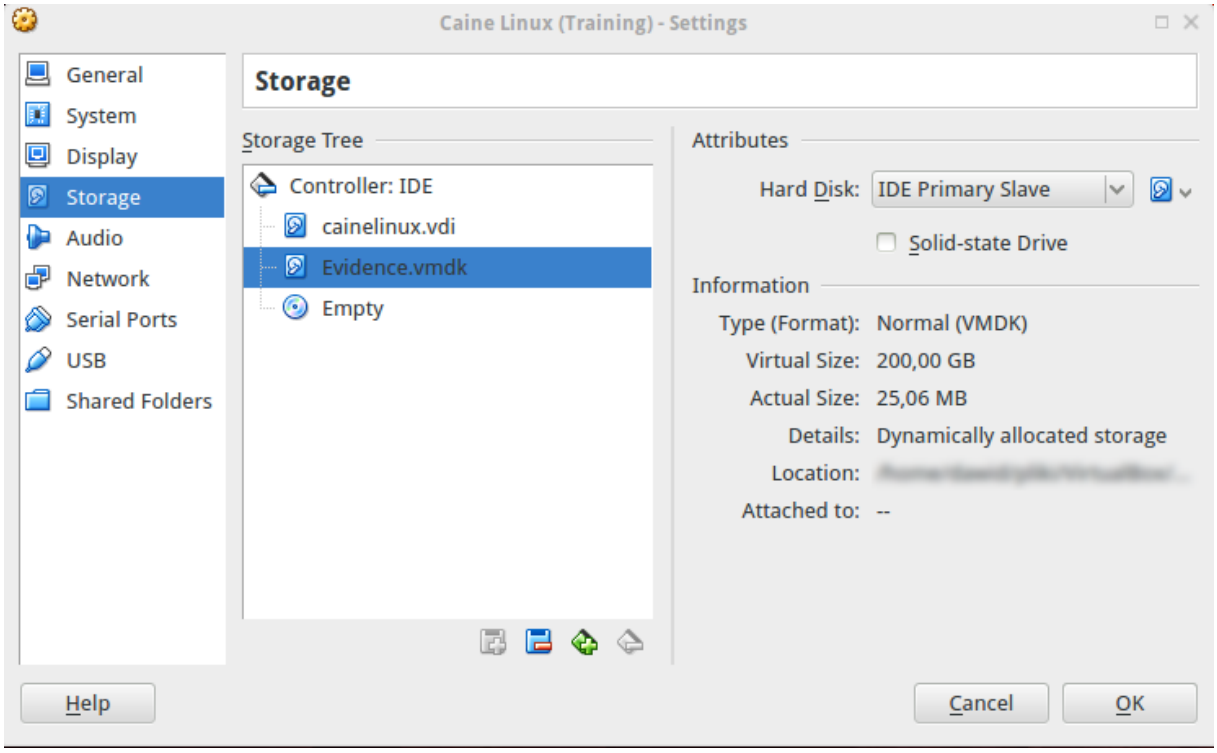



**Figure 4: Mounting the evidence**

After completing this step student should start CAINE virtual machine and try to login into the system (user: enisa, password: enisa).

By default, to prevent accidental changes to the evidence material CAINE Linux doesn't try to mount any hard drives detected at the boot time. This is especially important when CAINE Linux is used to create raw copy of the hard drive without using separate Write Blocker.

After logging into the system students should mount partition with the evidence files using read only mode. The easiest way to accomplish this is to use "Mounter" utility. "Mounter" can be started by clicking on the green hard drive icon at the bottom panel. Then student should choose partition with evidence files and click OK.

[6] CAINE (Computer Aided Investigative Environment) http://www.caine-live.net/ (last accessed 30.09.2016)

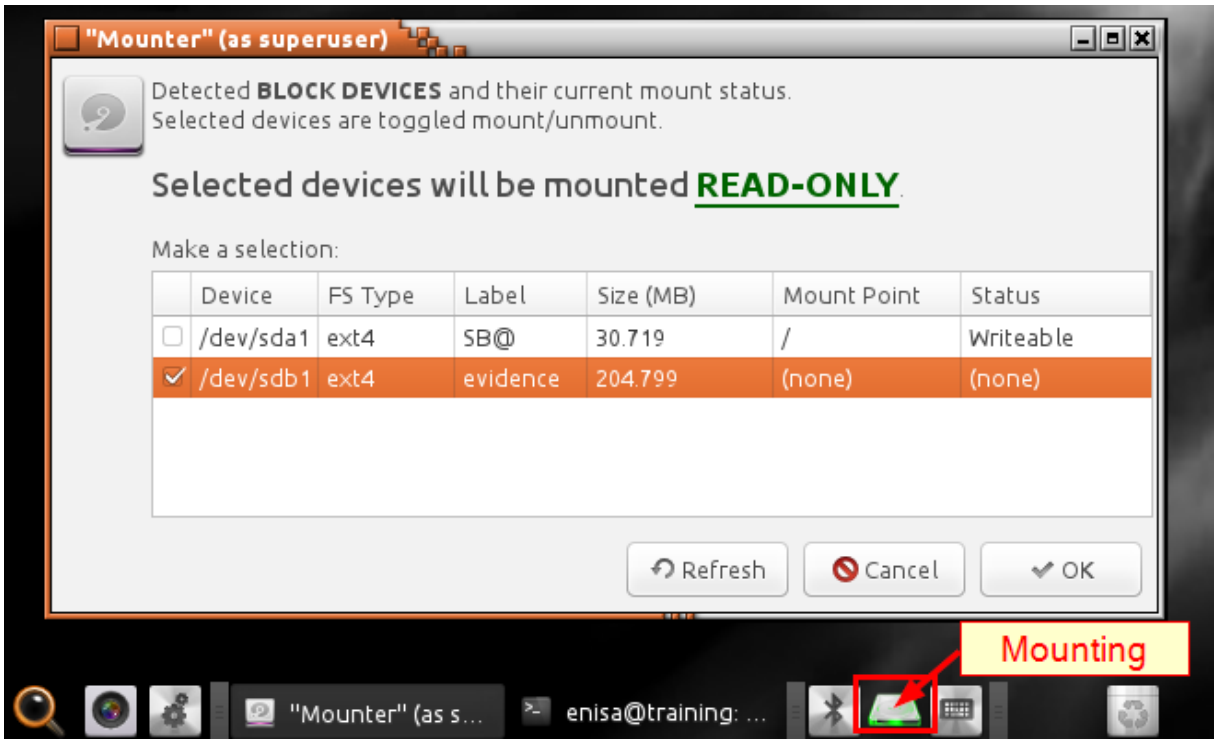



Figure 5: Mounting the evidence

After this operation evidence data should be available at the /media directory (in this case /media/sdb1).

Now, students should open terminal and go to /media/sdb1/Windows directory (or any other directory where partition with evidence files was mounted) which contains three files:

- disk.raw – raw image of Windows 10 disk (dd format);
- memory.img – dump of Windows 10 memory taken shortly after the attack;
- MD5SUMS – file with MD5 sums of disk.raw and memory.img.

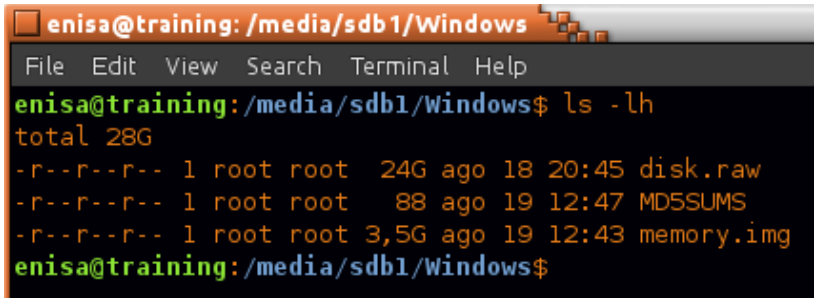



Figure 6: Evidence

The next step should be verification of MD5 checksums to make sure evidence data isn't corrupted or altered in any way. To calculate checksums students should use *md5sum* command and then compare its output with checksums stored in MD5SUMS file. Depending on the hardware and size of evidence calculating MD5 sums might take some time, though in this case it shouldn't be more than a few minutes.

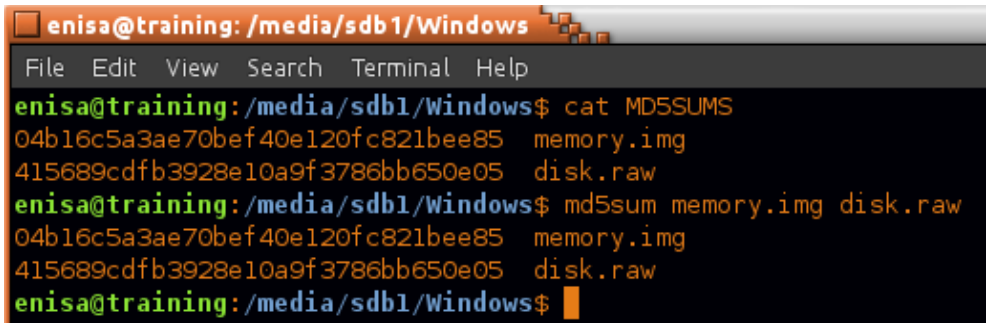



**Figure 7: Checksum**

If the checksums are correct students can proceed to the next exercises.

# 6. Memory analysis

In this exercise students will use the Volatility Framework[7] to analyse memory dump of Windows 10 (x86) system. Memory dump was taken shortly after the attack and the aim is to get preliminary assessment, possibly finding traces of malware or attacker activity.

This exercise covers only basic usage of Volatility. To get more thorough information on Volatility Framework refer to previous ENISA Advanced Artefact Analysis exercise[8].

At the time of writing this document, Windows 10 support by Volatility Framework was still considered to be in the initial phase. To make analysis of memory dump possible, additional patches were applied and special version of Volatility was put at /home/enisa/training/tools/volatility/ directory. Applied patches are expected to be merged into main Volatility repository in the near future. Note that certain Volatility plugins might still not work as expected or might be returning partially garbled results.

## 6.1 Checking memory dump file

Students should start by executing Volatility *imageinfo* command which will provide general information about dumped memory.

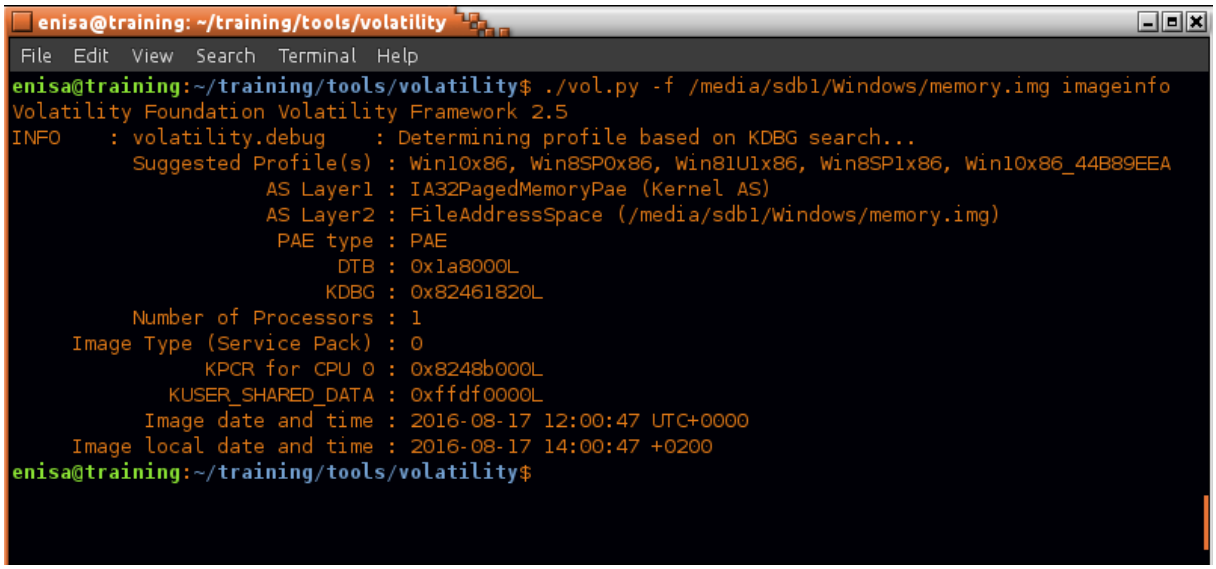



**Figure 8: Running Volatility**

From the *imageinfo* output students can read list of suggested profiles as well as addresses of DTB, KDBG and KPCR structures. Correct profile to use is Win10x86_44B89EEA[9].

[7] An advanced memory forensics framework https://github.com/volatilityfoundation/volatility (last accessed 30.09.2016)
[8] Advanced artefact analysis https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-material/documents/advanced-artifact-handling-handbook (last accessed 30.09.2016)
[9] This profile was introduced in one of the applied patches. When code is merged into main Volatility repository name of this profile might change.

From this point, all following Volatility commands should be executed with the profile explicitly set to Win10x86_44B89EEA. Additionally to make commands execute quicker students can specify addresses of DTB, KDBG and KPCR structures:

*--dtb=0x1a8000 --kdbg=0x82461820 --kpcr=0x8248b000 --profile=Win10x86_44B89EEA*

To check if everything is working students should try to list processes with the *pslist* command:

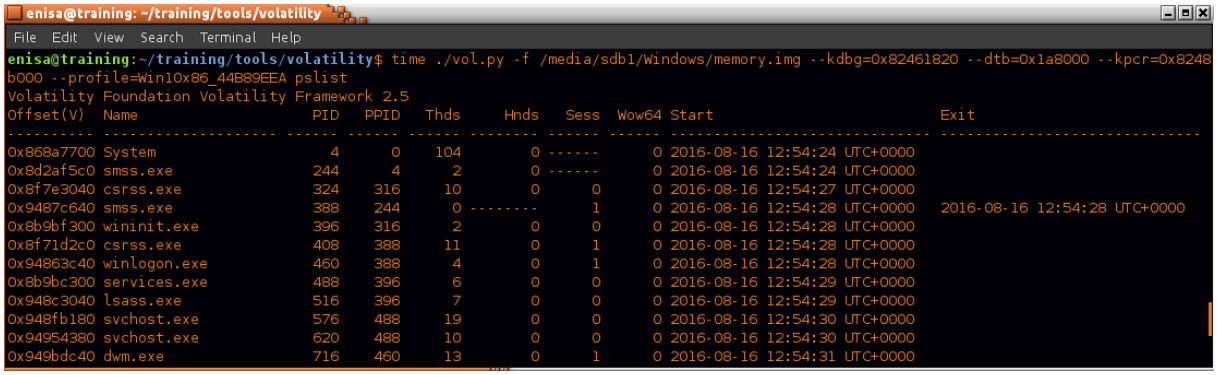



**Figure 9: Pslist command**

**Exercise:**

- Check what happens when “Win10x86” profile is used instead of “Win10x86_44B89EEA”?
- What happens if you don’t specify DTB, KDBG and KPCR addresses at the command line?

Since all following commands during Windows memory analysis will be used with the same set of parameters, for convenience students can create alias to vol.py:

vol=’/home/enisa/training/tools/volatility/vol.py -f /media/sdb1/Windows/memory.img *--dtb=0x1a8000 --kdbg=0x82461820 --kpcr=0x8248b000 --profile=Win10x86_44B89EEA*’

## 6.2 Scanning memory with Yara rules

For an initial assessment, it is worthwhile to scan the memory dump for signatures of known malware and other threats. As the source of signatures students will use Yara signatures from Yara Rules Repository[10].

Yara rules can be found at /home/enisa/training/ex1/yara-rules.

Students should start by switching to the yara-rules directory.

[10] Repository of Yara rules https://github.com/Yara-Rules/rules (last accessed 30.09.2016)

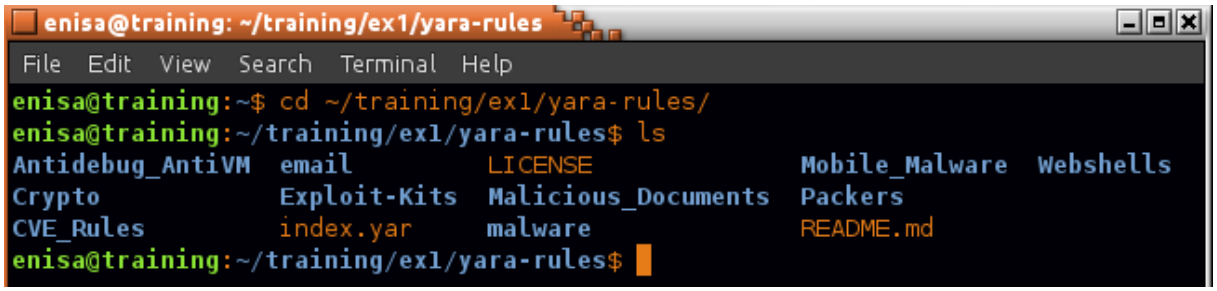



Figure 10: Yara rules

All Yara rules are contained in several *.yar files grouped into a few categories. For the general Windows memory scan it is not necessary to use all rules as some might lead to many false-positives or give low value results (e.g. a rule detecting Base64 encoding).

Students can choose which rules they want to use by creating additional *.yar file, including all other *.yar files. In this case, students will use rules from CVE_Rules, Exploit-Kits and malware directories.


Figure 11: Selecting the rules

Next, students should scan memory using yarascan plugin and the previously created rules files:

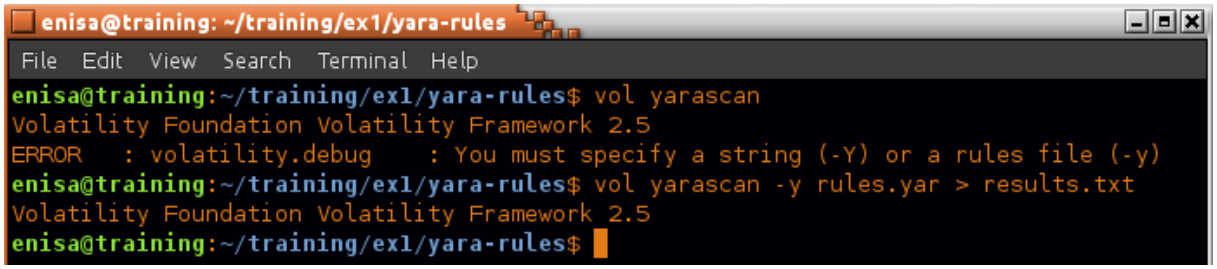



Figure 12: Yarascan

The general output format is as follows.

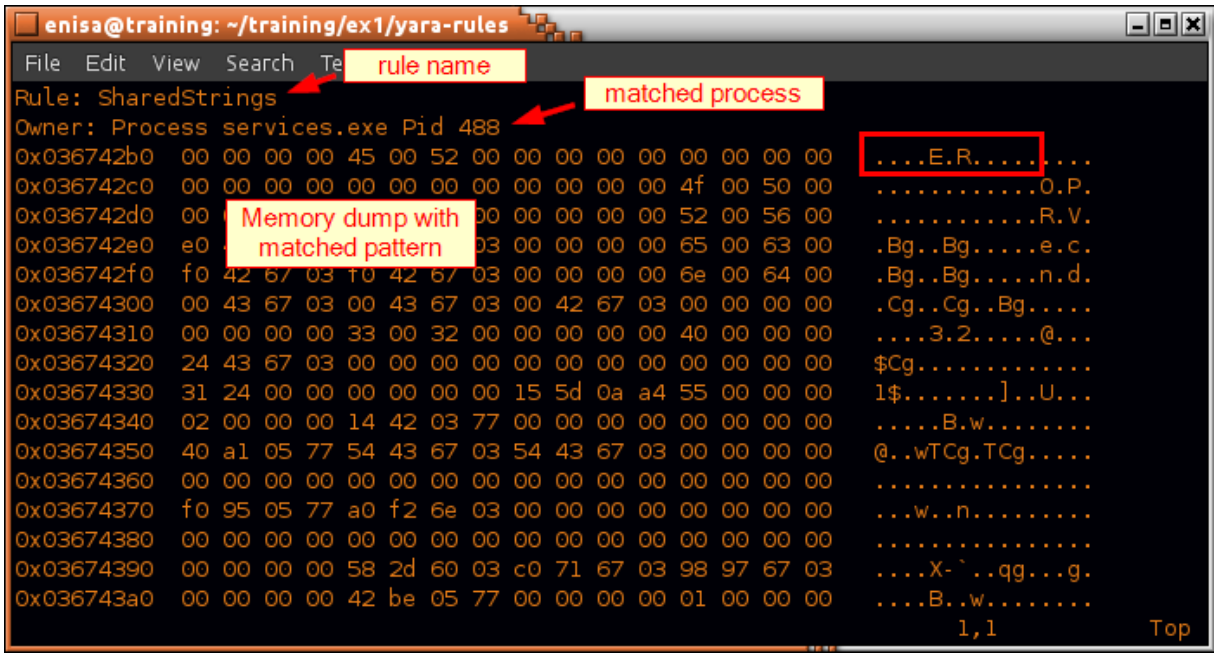


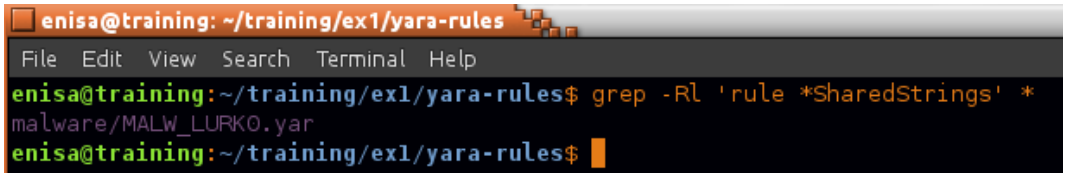

**Figure 13: Yara rules detection**

Count all distinct rules detected.

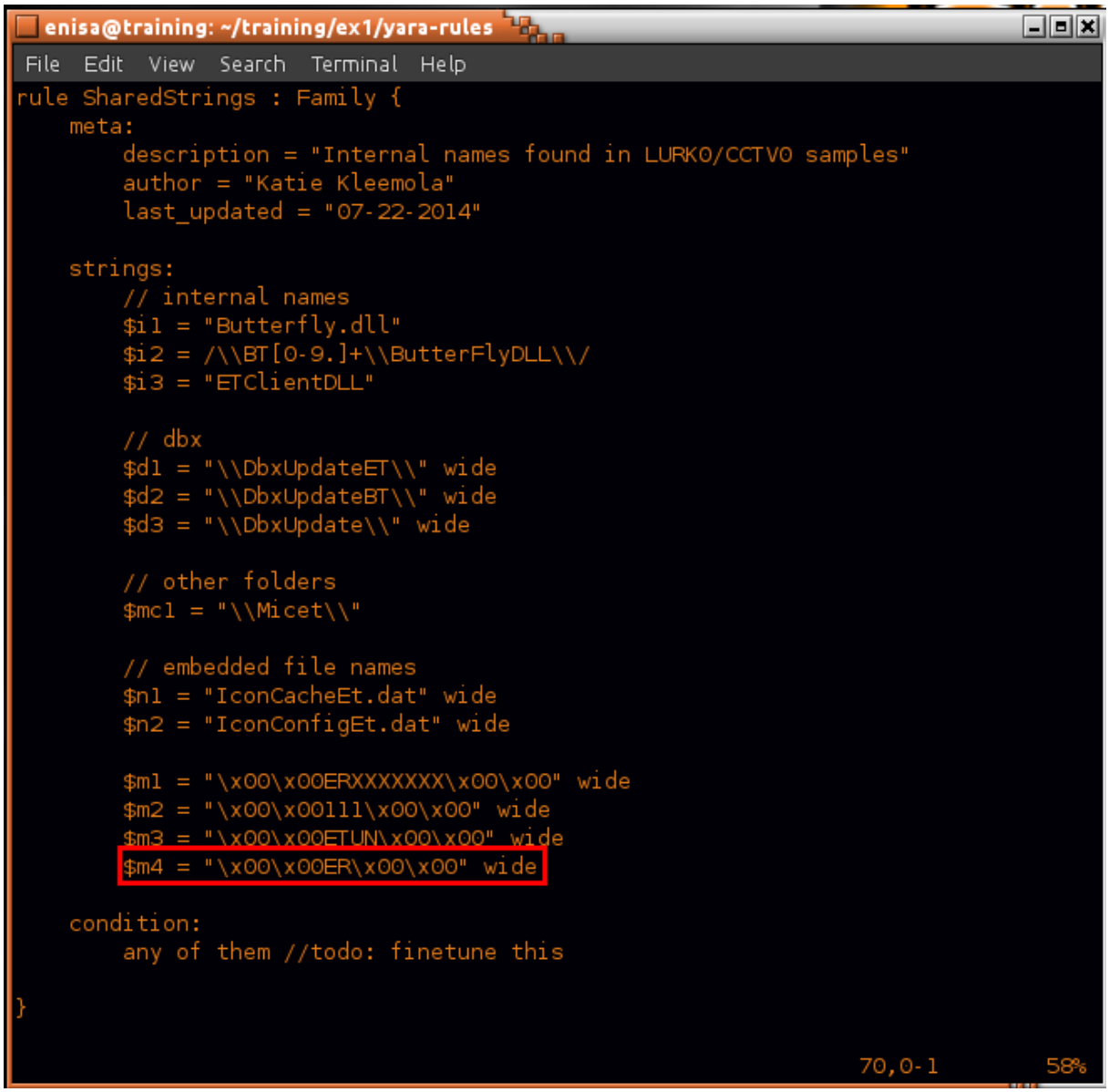

**Figure 14: Sorting detections**

As a result of the scan, several rules were detected. It is worth checking the code of each detected rule to get additional information. Some rules might turn out to be too generic and lead to false-positives in a system wide scan.

To find which rule is defined in what file, students can use *grep* tool.




SharedStrings rule in malware/MALW_LURKO.yar.




Inspection of the SharedStrings rule reveals that it will be matched if any of the defined strings are found in process memory, even a single wide string "\x00\x00ER\x00\x00" – what seems to be the case in this scenario. Since this string isn't too specific and no other strings were found, it is likely this is a false positive.

**Exercise:**

- Using results.txt and inspecting the code of each of the detected rules, try to determine which rules are worth further consideration and might be useful, and which ones are likely false positives.

  SharedStrings – likely false positive
  Spyeye_plugins – likely false positive
  UPX – generic but possibly interesting (benign processes aren't often UPX packed)
  With_Sqlite – too generic, benign processes can also use Sqlite
  Xtreme, xtreme_rat, xtremrat – interesting matches

It turns out that interesting rules are the ones related to Xtreme RAT. Students can also check that Xtreme RAT rules matched three distinct processes, the same ones in which UPX packed code was detected:

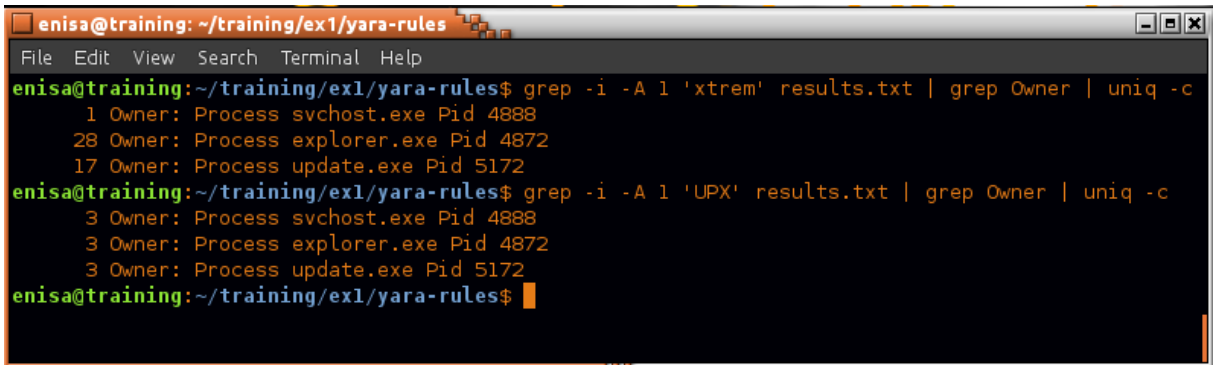



**Figure 15: Matched rules**

After completing this part students should conclude that the system is most likely infected with malware – at least Xtreme RAT. They should also note the names and Process identifiers of the processes containing malicious code.

Suspected processes:

- svchost.exe (Pid: 4888)
- explorer.exe (Pid: 4872)
- update.exe (Pid: 5172)

At the end, students should also copy the results.txt file to a separate directory as an additional piece of evidence.

## 6.3 Analysis of the process list

Students should start with listing all running processes using Volatility *pslist* plugin:

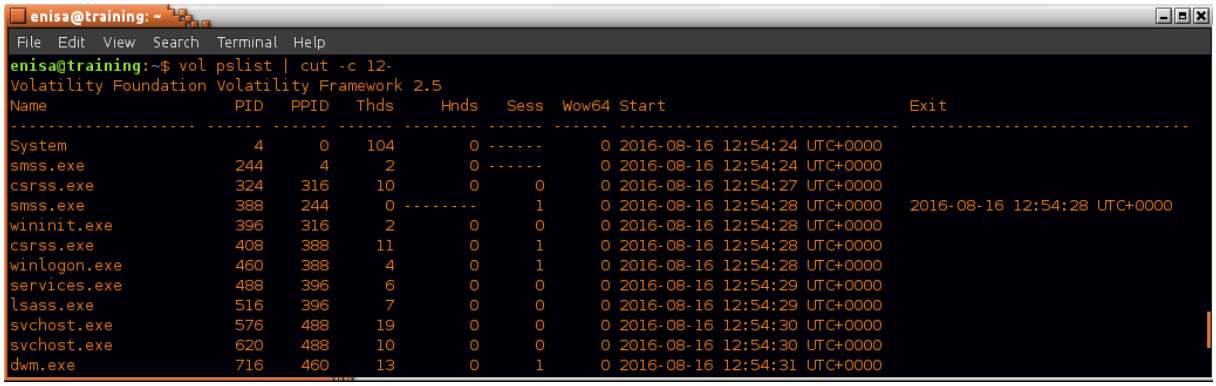



**Figure 16: Pslist plugin**

Based on *'System'* process start time students can determine that system was started at 2016-08-16 12:54:24[11]. Note that all times returned by Volatility are UTC times. Some tools might be returning times using different time zones (e.g. using local time zone of the environment where analysis is taking place or

[11] Creating a Baseline of Process Activity for Memory Forensics https://www.sans.org/reading-room/whitepapers/forensics/creating-baseline-process-activity-memory-forensics-35387 (last accessed 30.09.2016)

time zone of the environment that is being analysed). The teacher should emphasize the importance of correctly recognizing and checking the time zone used in the output of given tool.

For starters, it is worth searching the process list for the process identifiers (PIDs) of processes containing malicious code from the previous task.

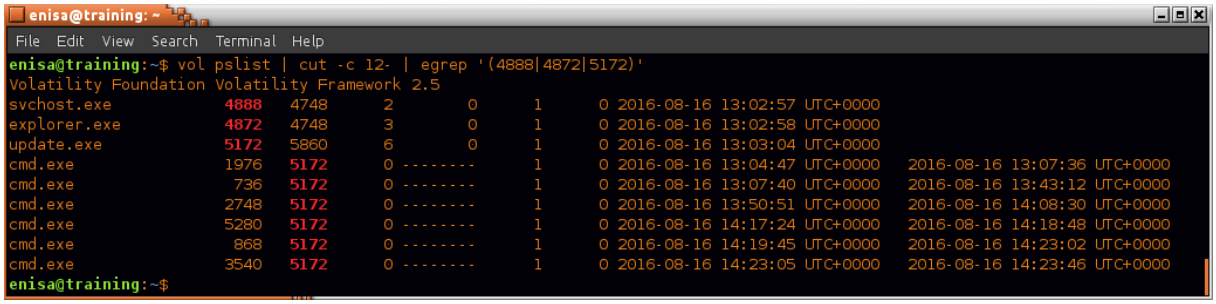



**Figure 17: Process list**

Note that process PID is presented in the second column, while the third column contains the PID of the parent process.

From this output, students can determine that processes containing malicious code were started shortly after system boot, around 13:02:57. Though at this point it is hard to tell whether this is a result of a fresh infection or the computer was infected some time ago.

Secondly, students can notice that svchost.exe (PID:4888) and explorer.exe (PID:4872) were started before update.exe. Moreover update.exe later started a few cmd.exe processes. It is worth to note timestamps when cmd.exe processes were started:

- 2016-08-16 13:07:36
- 2016-08-16 13:42:12
- 2016-08-16 14:08:30
- 2016-08-16 14:18:48
- 2016-08-16 14:23:02
- 2016-08-16 14:23:46

When searching for parent processes of explorer.exe, svchost.exe and update.exe (PIDs: 4748 and 5860) no processes with such PIDs are returned. This means that processes with those PIDs are already gone from process list.

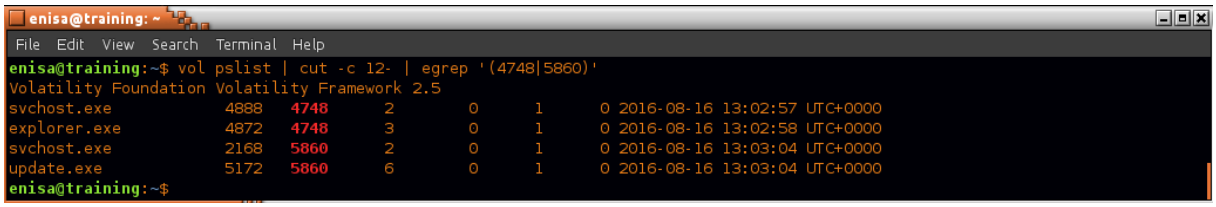



**Figure 18: Parent processes**

It is often interesting to check the command line which was used to start a given process. Students can do this using the *dlllist* plugin.

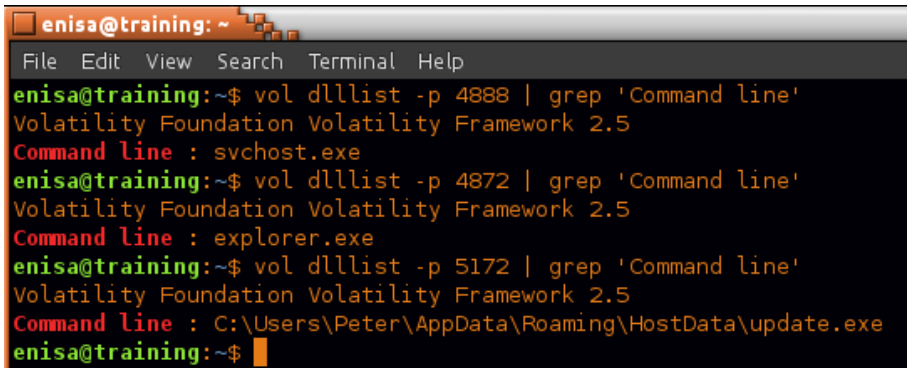



**Figure 19: Dlllist**

From this output, students can check that the update.exe executable is located at %APPDATA%\HostData\update.exe.

One more thing to notice is that there are two explorer.exe processes present in the system while normally there should be only one.

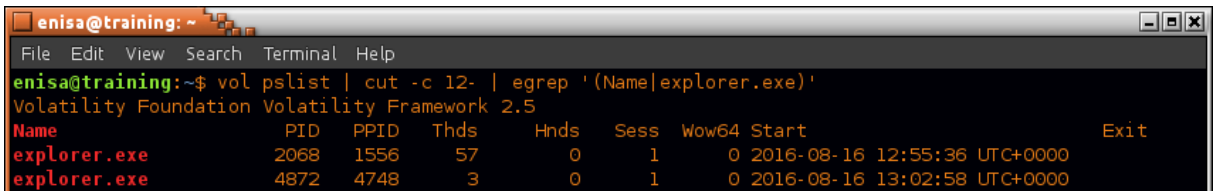



**Figure 20: Explorer.exe processes**

Explorer.exe with PID 4872 was started using the original Windows executable, though it is not the main explorer.exe process which was started when user logged in (PID:2068). This suggest that malware is using RunPE[12] technique as a form of its disguise.

## 6.4 Network artefacts analysis

To search memory for artefacts of network connections students can use the *netscan* Volatility plugin. The output of the plugin is the list of TCP and UDP endpoints, both IPv4 and IPv6.

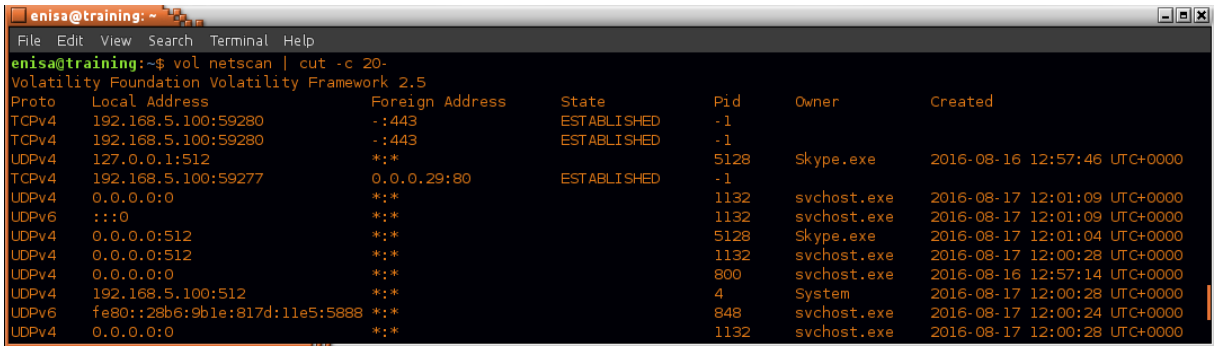



**Figure 21: Network artefacts**

[12] RunPE: How to hide code behind a legit process http://www.adlice.com/runpe-hide-code-behind-legit-process/ (last accessed 30.09.2016)

Inspection of the list can reveal a few connections to nonstandard TCP ports.

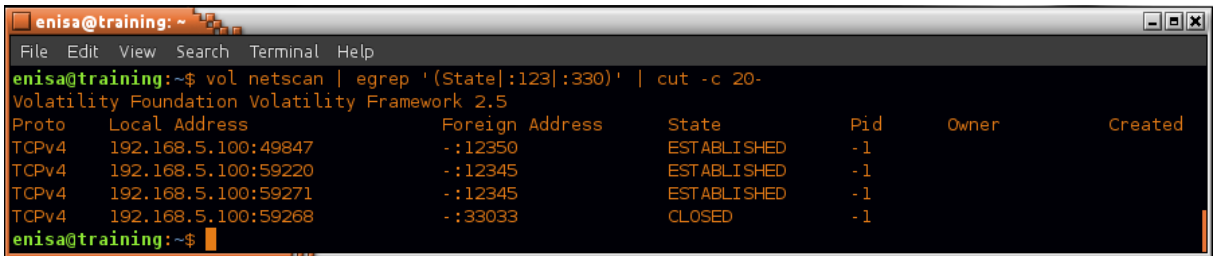



**Figure 22: Netscan**

There were also some connections to TCP /80 (HTTP) and TCP /443 (HTTPs).


**Figure 23: Netscan**

Unfortunately in neither case were any remote addresses or process IDs retrieved by Volatility. Fortunately, using a (srcip:sport, dport) tuple, it should be possible to track the destination address of some of those connections in netflow logs – assuming that the connections took place between 2016-08-16 and 2016-08-17.

## 6.5 Memory analysis summary

Based on basic memory analysis, the following was concluded.

- System was most likely infected with Xtreme RAT malware which code was found in the memory of at least three processes.
- Malware is possibly using RunPE technique to hide its presence in the system.
- Some connections to strange tcp ports were observed.
- The following paths to suspicious executables were found:
- %APPDATA%\HostData\update.exe
- The following timestamps were noted:
- 2016-08-16 13:02:57 UTC+0000 (start of svchost.exe)
- 2016-08-16 13:02:58 UTC+0000 (start of explorer.exe)
- 2016-08-16 13:03:04 UTC+0000 (start of update.exe)
- 2016-08-16 13:07:36 UTC+0000 (start of cmd.exe)
- 2016-08-16 13:42:12 UTC+0000 (start of cmd.exe)
- 2016-08-16 14:08:30 UTC+0000 (start of cmd.exe)

- 2016-08-16 14:18:48 UTC+0000 (start of cmd.exe)
- 2016-08-16 14:23:02 UTC+0000 (start of cmd.exe)
- 2016-08-16 14:23:46 UTC+0000 (start of cmd.exe)

# 7. Disk analysis

## 7.1 Mounting Windows partition and creating the timeline

When proceeding to disk analysis, it is worthwhile to use both Autopsy[13] (graphical interface to The Sleuth Kit toolkit) as well as mount analysed partitions in the local filesystem. Mounting partitions in the local filesystem allows analyst to use standard Linux tools (grep, find) when inspecting analysed filesystem.

Students should start with listing partitions present on disk image.

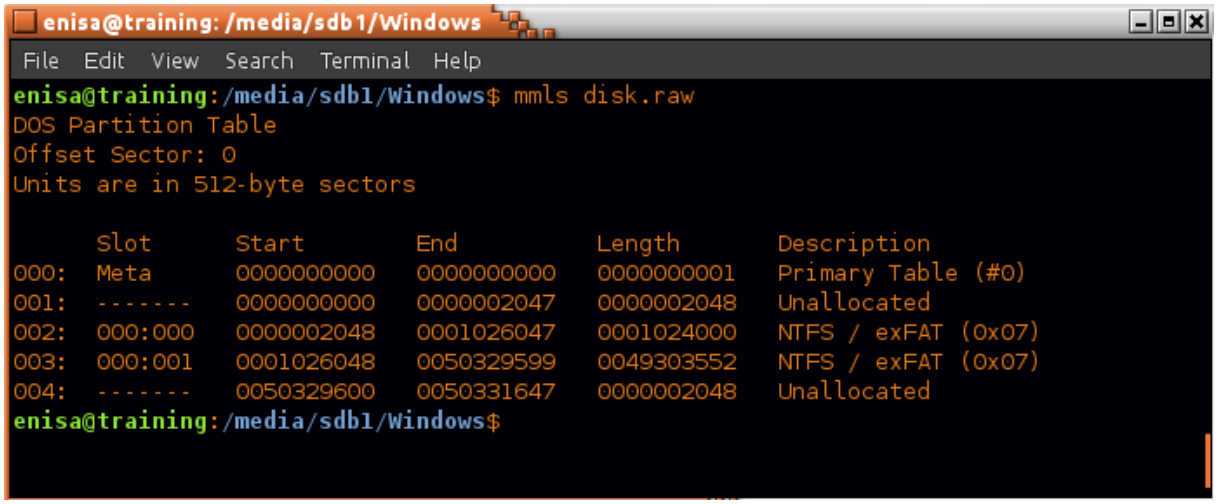



**Figure 24: Partitions**

The main Windows partition is the partition 003 starting at sector 0001026048 (byte offset = **525336576** = 1026048*512). Students should mount it at /mnt/part_c:.

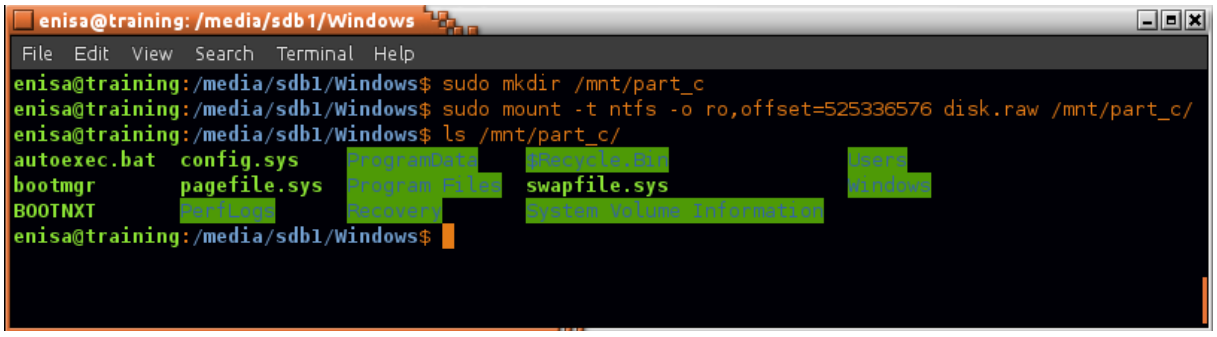



**Figure 25: Mounting**

Provided mount options specify to mount partition as read-only as well specify starting offset of the partition in disk.raw image (checked in the previous step).

[13] Digital forensics platform and graphical interface to The Sleuth Kit http://www.sleuthkit.org/autopsy/ (last accessed 30.09.2016)

Next students should start Autopsy (system menu -> Forensic Tools -> Autopsy 2.24).

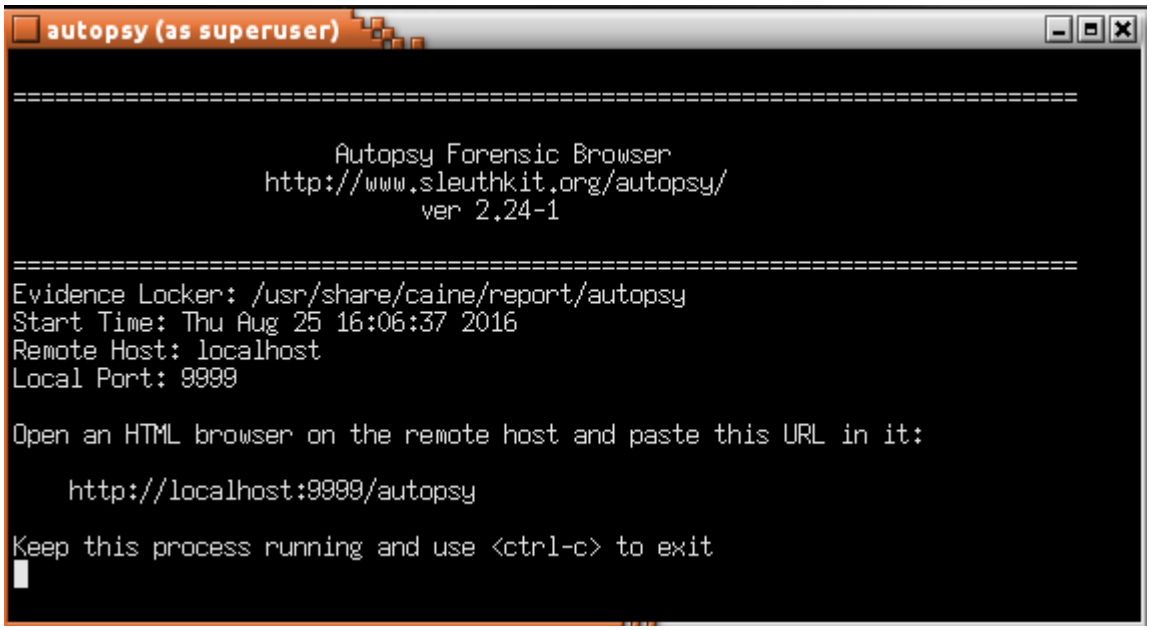



**Figure 26: Autopsy**

If the web browser wasn't yet started in the system, it should start now. Otherwise open new tab in browser and go to http://localhost:9999/autopsy.

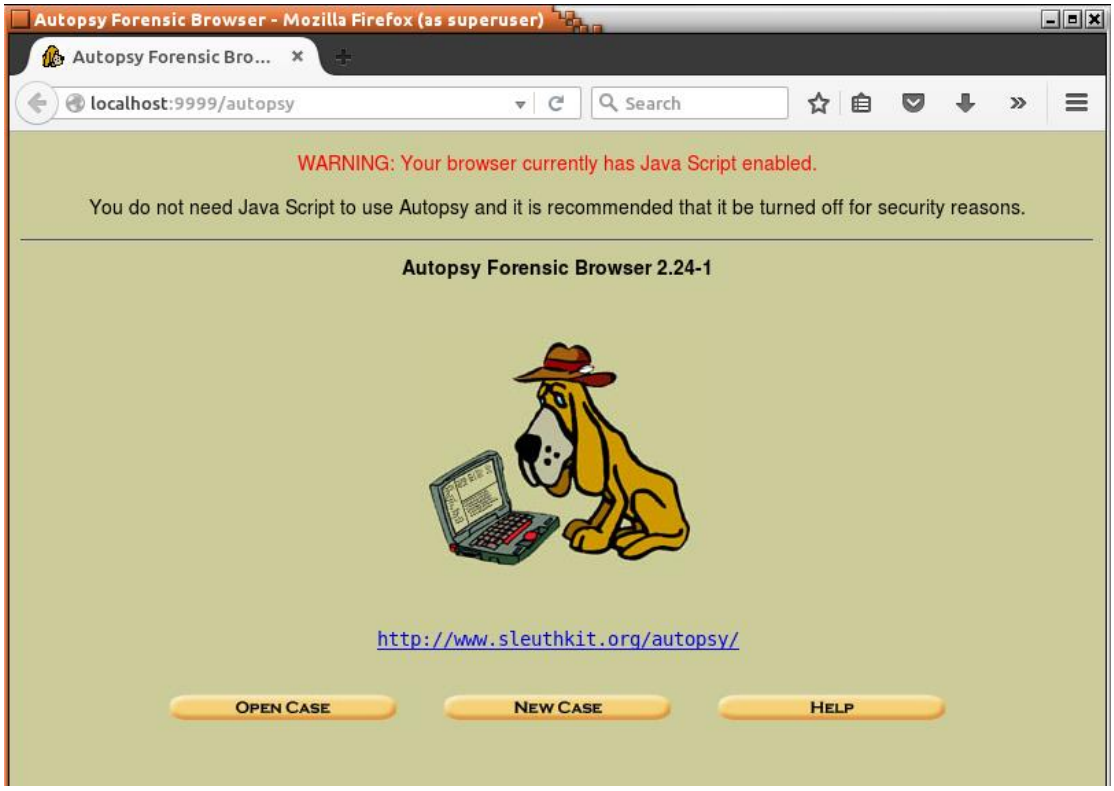



**Figure 27: Autopsy web interface**

After starting Autopsy, first thing to do should be creation of a new case. One case should be related to one incident. To create new case students should click “New Case” and fill the form on the next page. Then click “New Case” again.

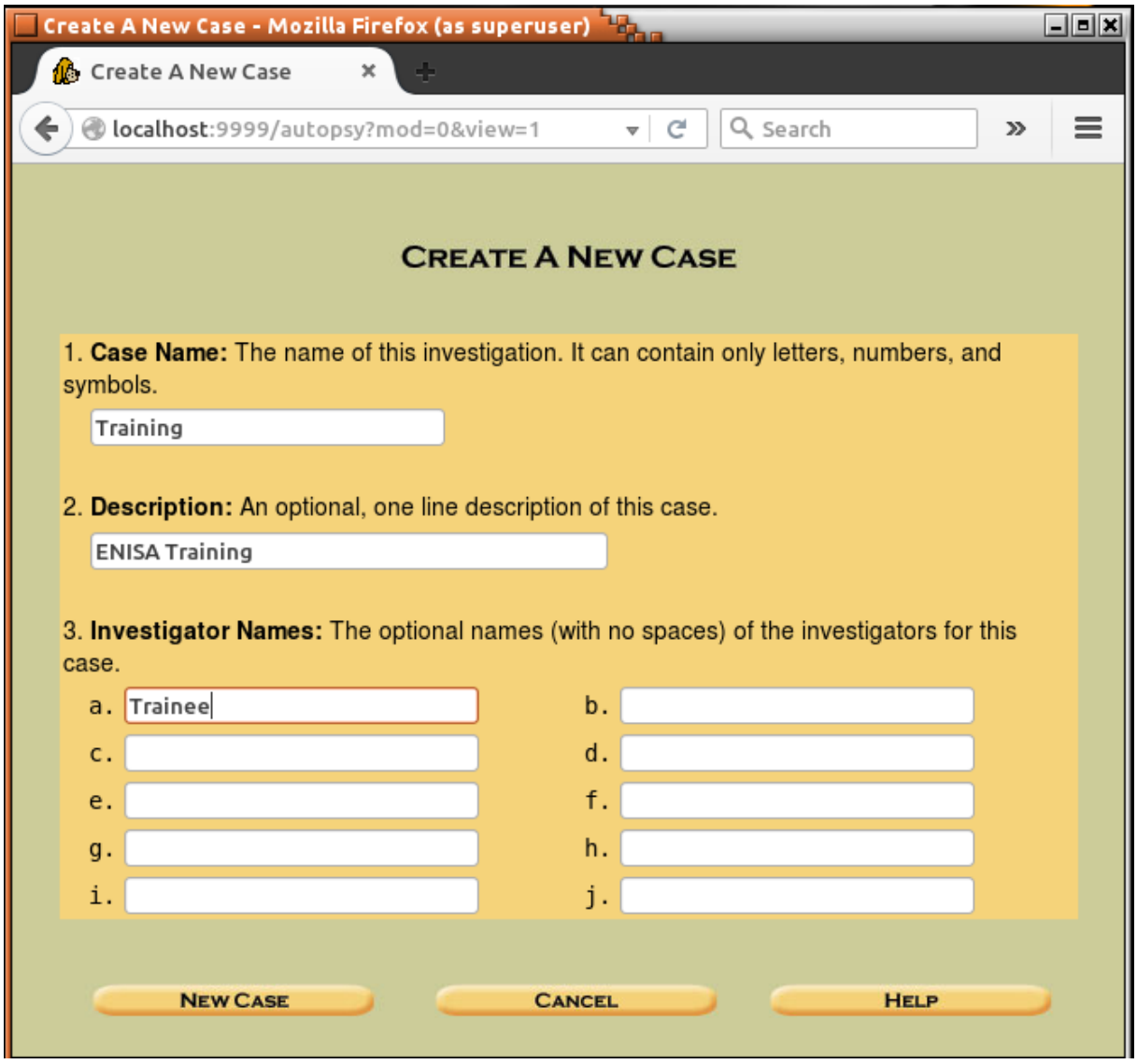



Figure 28: Creating the case

On the next page students will be informed about the path to the case files (including some intermediate results). It is worth to remember this path for later use (e.g. copying some results as an additional evidence files).


**Figure 29: Creating case**

Each forensic case in Autopsy can be related to one or many hosts. In the next step, students will add a Windows workstation host by clicking “Add Host”. On the next page, students should specify at least a Host Name and then click “Add Host”. It is also worth to specify GMT time zone to be sure that this time zone will be used for displaying times during file analysis. To list other available time zones, students can click “Help”.

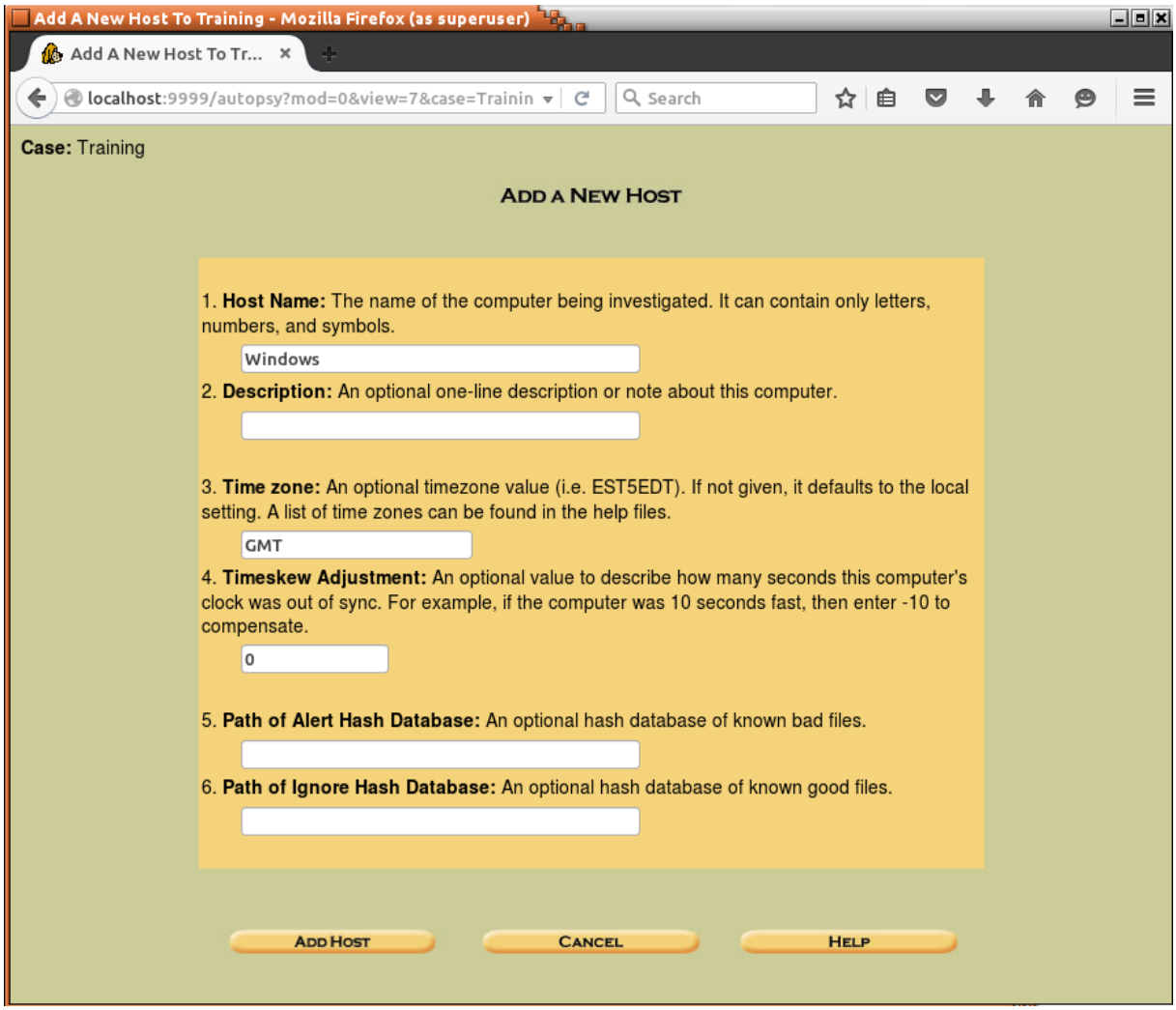



Figure 30: Adding a new host

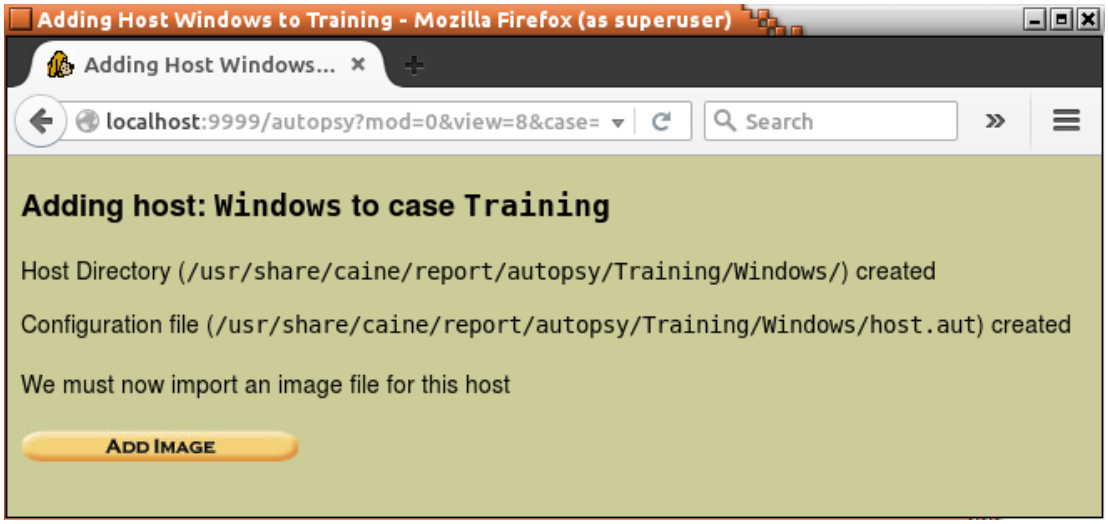



Figure 31: Importing an image

The next step will be to add evidence files consisting of whole disk images or images of single partitions. Each host can have one or more forensic images added. To add a new image click “Add Image” and then “Add Image File”.

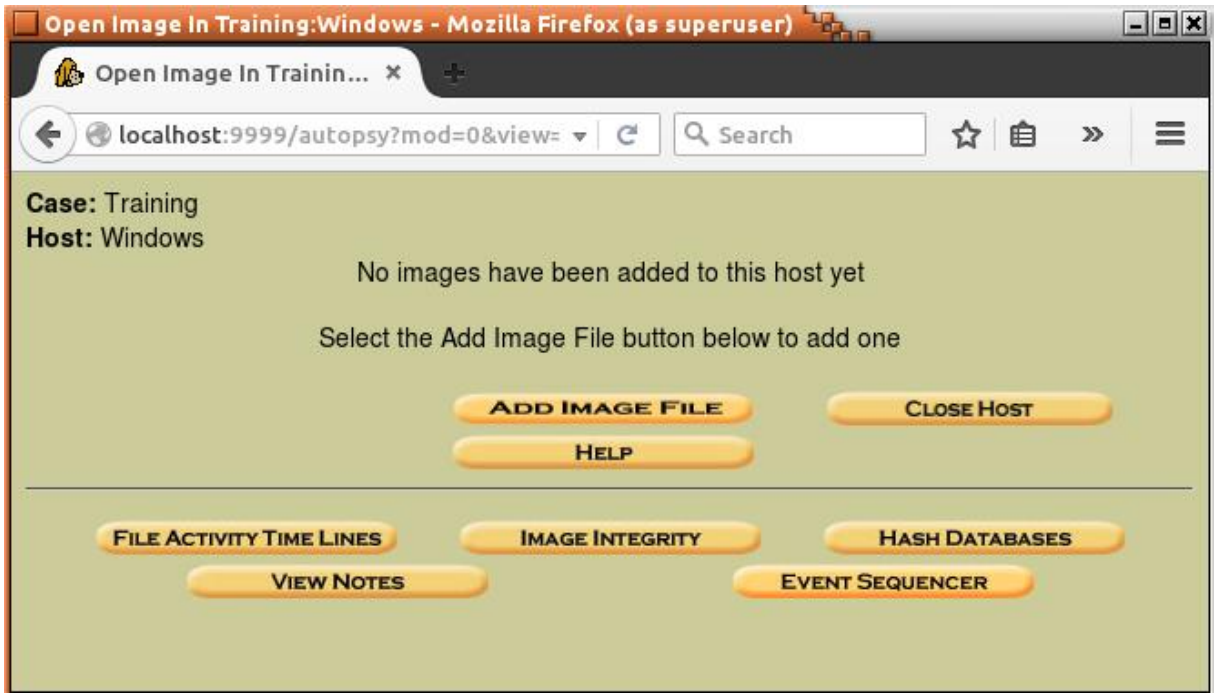



**Figure 32: Adding image file**

In the next form students should specify the path to the disk image and check if Type is set to *Disk*.

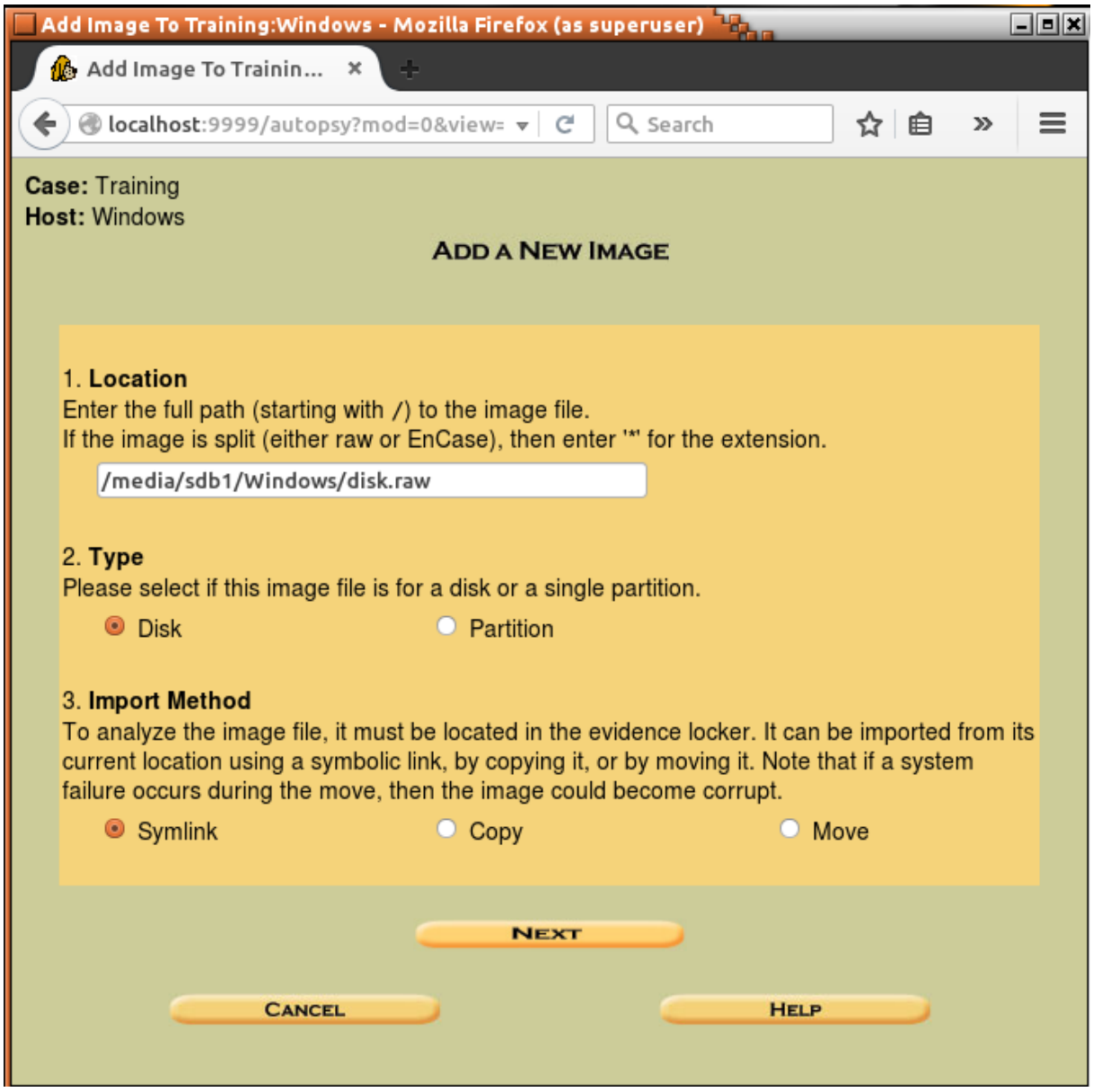



**Figure 33: Adding an image file**

Now Autopsy will analyse partition table on the provided disk image and let user decide which partitions add to the case. In this case, it should be enough to add only the main Windows partition.

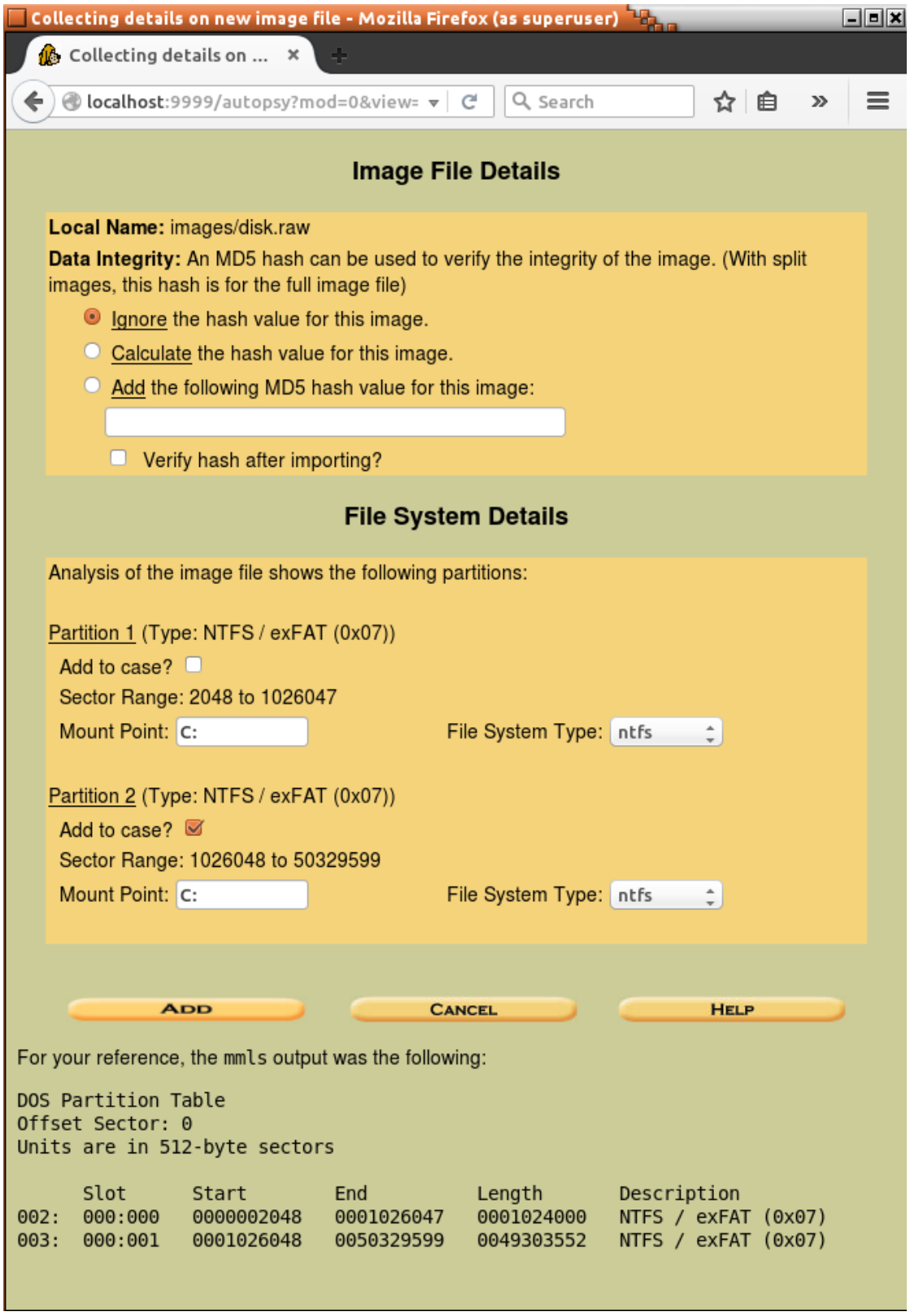



**Figure 34: Image file details**

After clicking “Add”, Autopsy will display information that a new image was added and linked with the case. At this point, the analyst can decide whether to add an additional image file or proceed with the analysis. Students should click “Ok” since there are no more evidence files to add.


**Figure 35: Adding image**

Now the main analysis panel should open. The description of each available option can be found in the help menu (“Help” button).

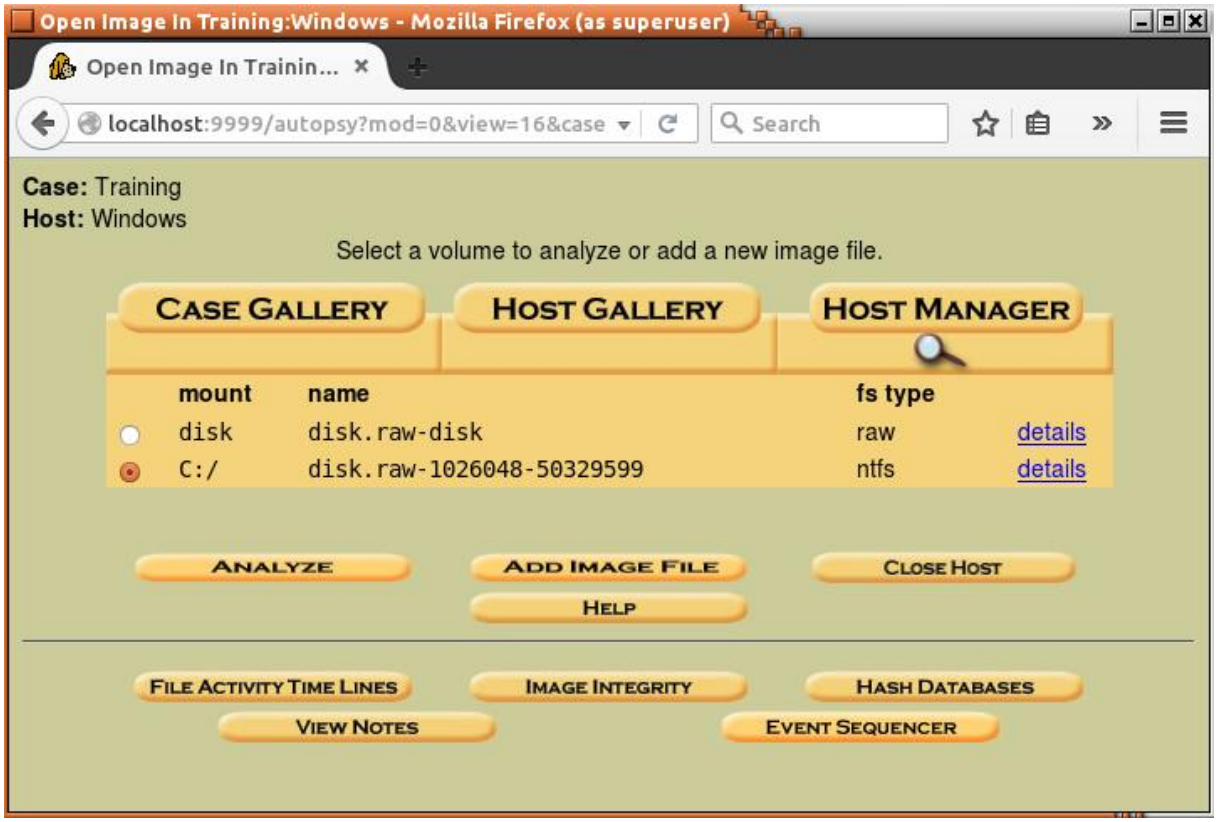



**Figure 36: Analysis panel**

As a first step, it is good to create a file activity timeline which will be quite useful during later analysis. To create a timeline, students should select partition C:\ and click “File Activity Time Lines”.

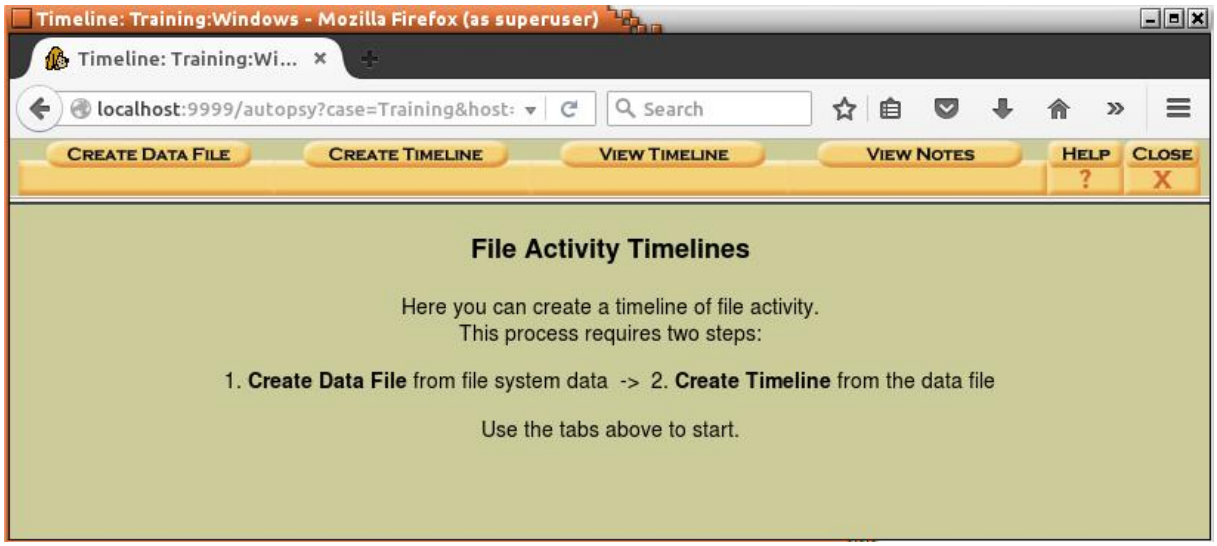



**Figure 37: Create timeline**

Select all options as presented on the screenshot below and click “Ok”:

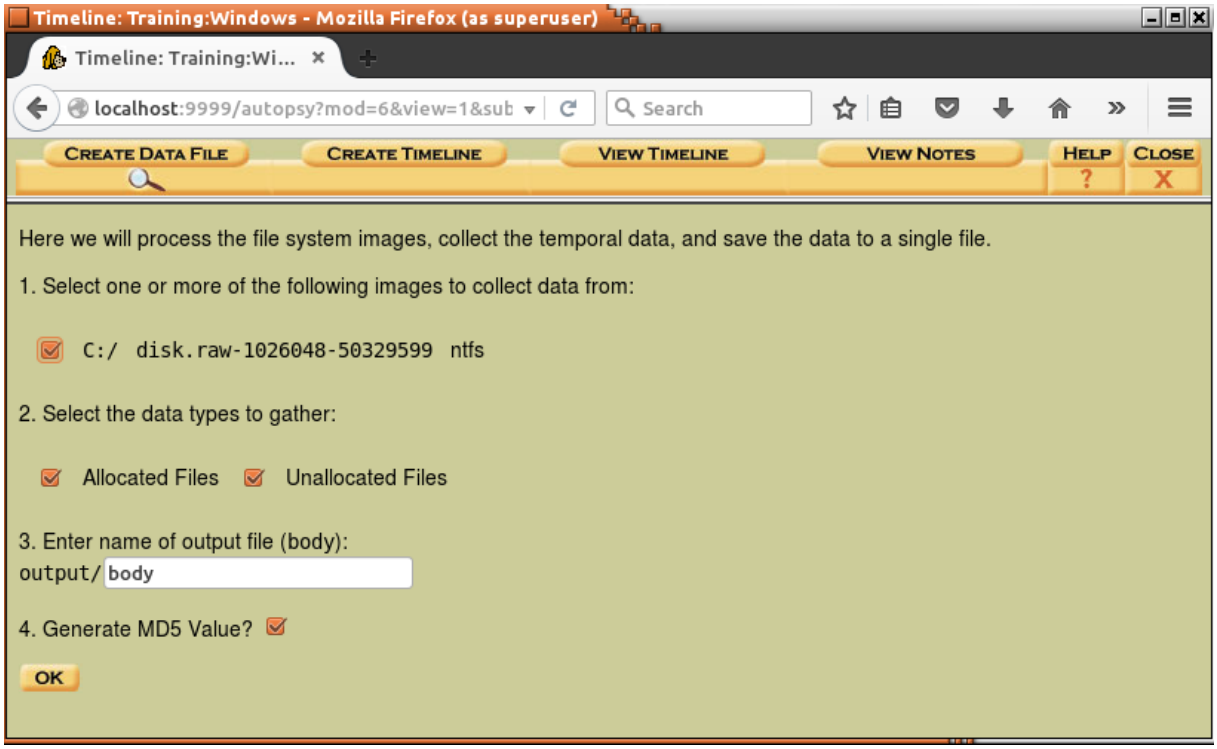



**Figure 38: Create timeline**

Now Autopsy will start the analysis of the filesystem on the C:\ partition. Depending on the partition size and number of files this might take some time.

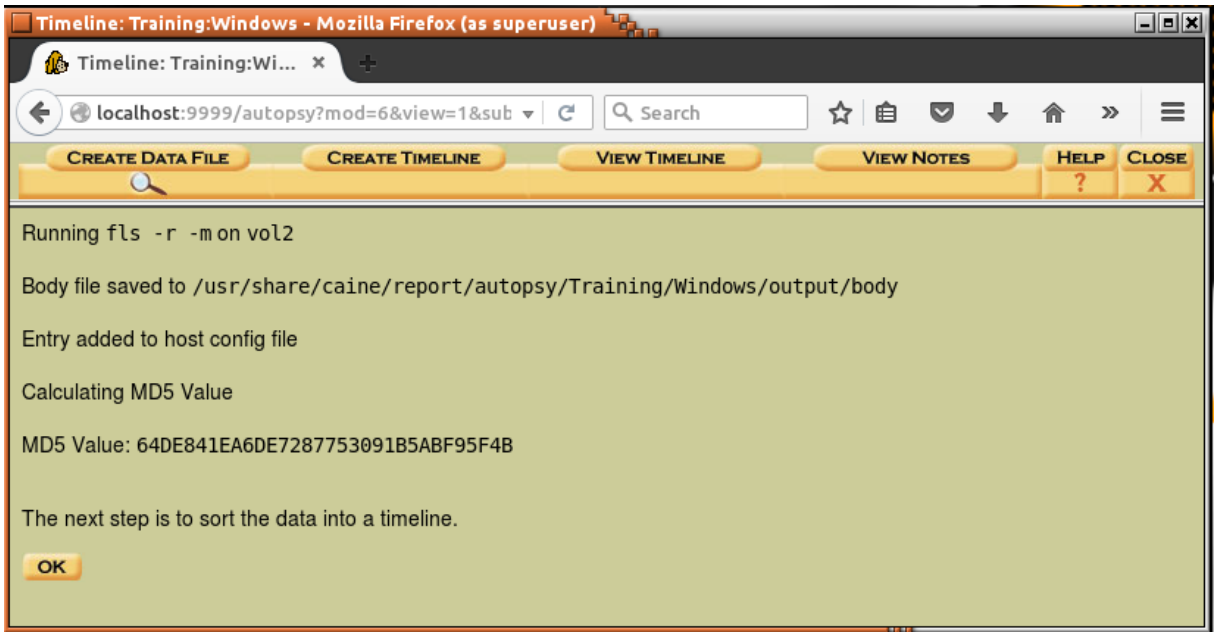



**Figure 39: Create timeline**

At the next form, students can specify a time frame of their interest and the format of the timeline file. After clicking "Ok" Autopsy will start processing the previously created body file to generate a timeline.

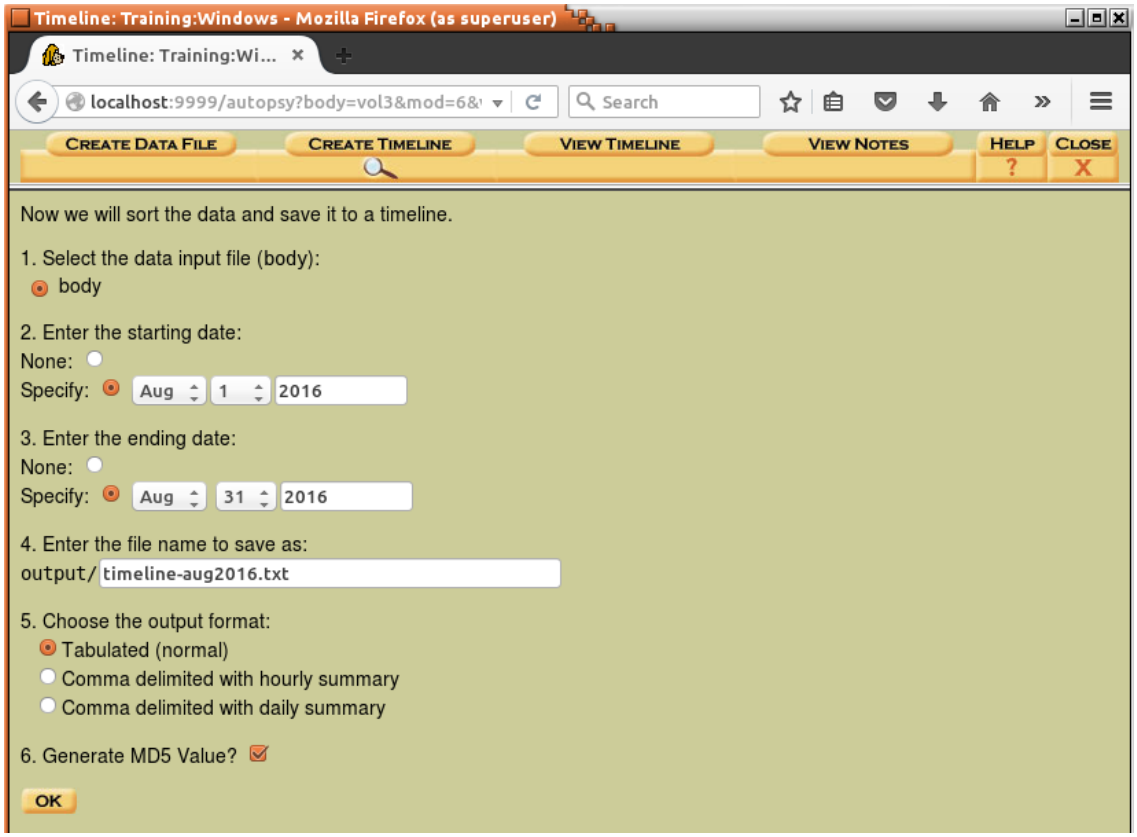



**Figure 40: Specify time frame**

As a result timeline will be created is a format of a normal text file which could be viewed in text editor or searched using grep tool. Path to this file is <case_path>/Windows/output/timeline-aug2016.txt.

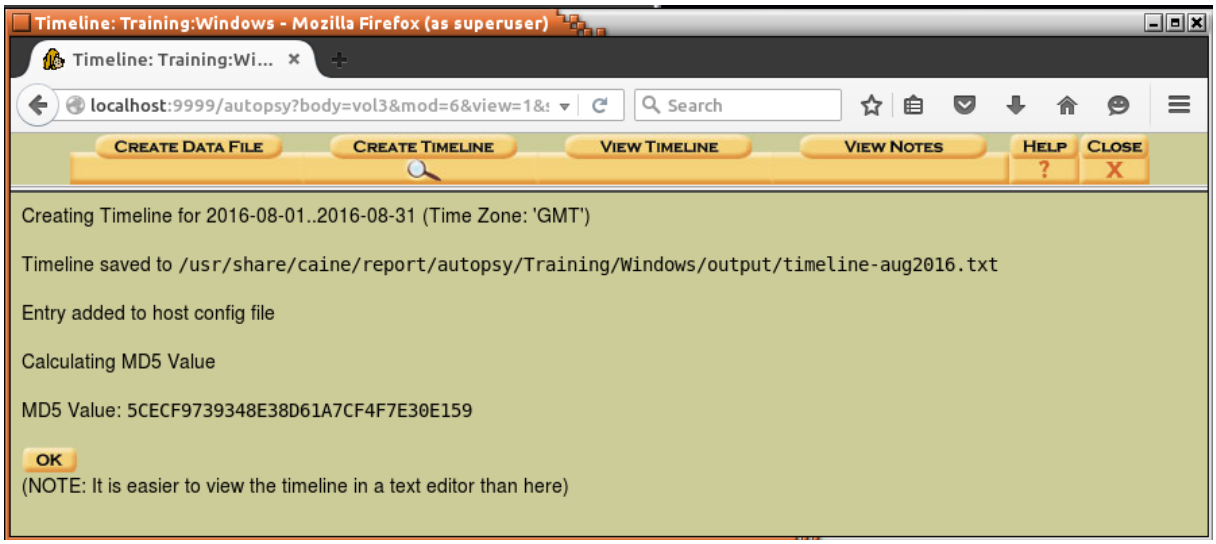



**Figure 41: Timeline created**

When students click "OK" Autopsy will open the generated timeline in the web browser. Generated timelines are usually very big and loading it in a browser can take considerable amount of time and system resources. If opening a timeline in a browser leads to a browser crash students should try opening it in a text editor (e.g. Vim, Nano).

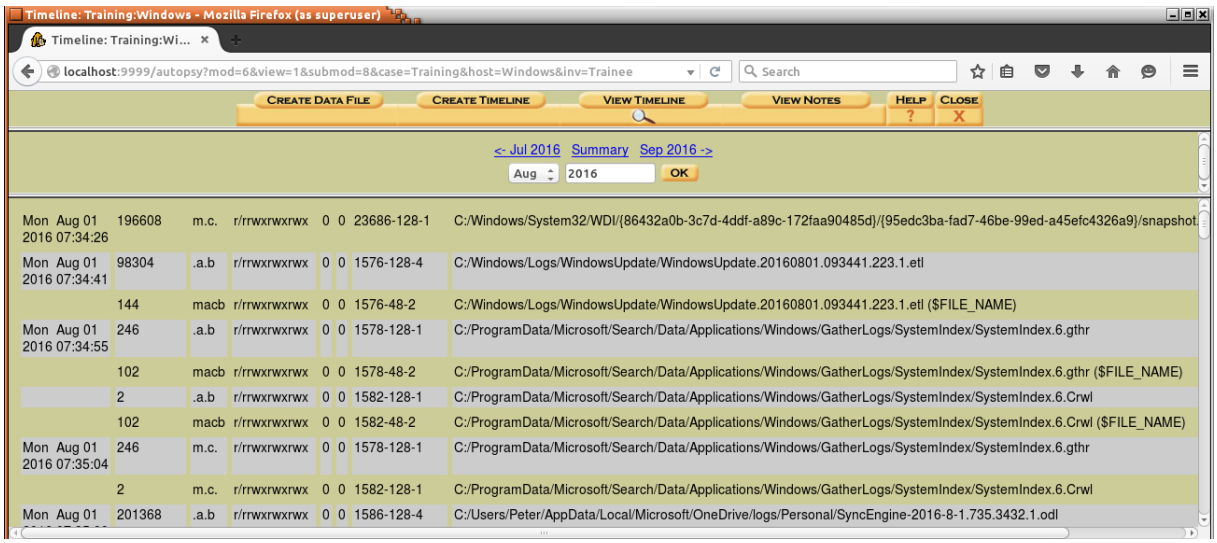



**Figure 42: Timeline**

Each row of the timeline represents some change to the file as recorded by file's MACB timestamps[14] (M – file modified, A – file access, C – metadata change, B – file born/created).

[14] Filesystem Timestamps: What Makes Them Tick? https://www.sans.org/reading-room/whitepapers/forensics/filesystem-timestamps-tick-36842 (last accessed 30.09.2016)

## 7.2 Antivirus scan

To gather additional information, perform an antivirus scan of the mounted filesystem. It might reveal information about additional files containing malicious code that should be checked later. An analyst should remember that an AV scan might not always find all malicious files and sometimes might return false positives.

In this task, students will use ClamAV antivirus to scan filesystem for well-known malware. Note that scan can be also quite memory consuming. If there is not enough memory during the scan this will result in several error messages written to the stderr.

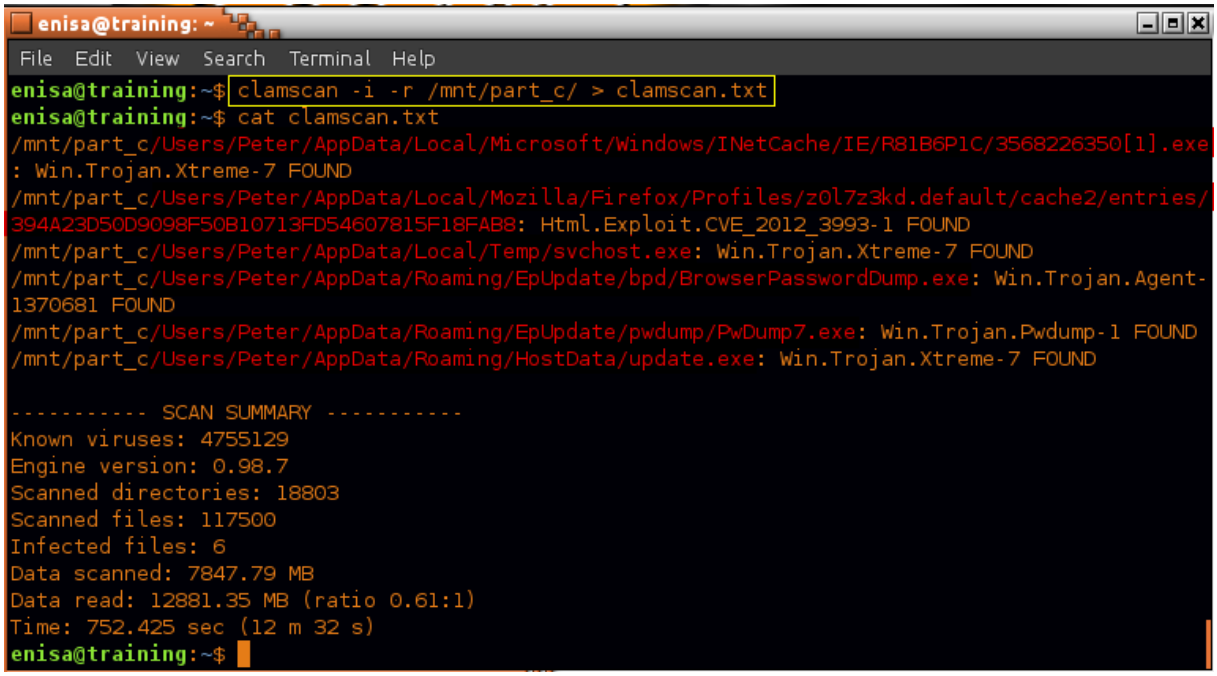



**Figure 43: Antivirus scan**

**AV scanning findings and conclusions:**

- One file in Firefox cache folder supposedly contains CVE-2012-3993 exploit code, while another file in INetCache folder (3568226350[1].exe) contains executable with Xtreme RAT. This is a pretty valuable reference as it might point to the initial attack vector.
- There is a svchost.exe executable at %TEMP%\svchost.exe likely containing copy of Xtreme RAT.
- Some suspicious executables are stored at %APPDATA\EpUpdate directory.
- ClamAV scan confirmed that previously found %APPDATA%\HostData\update.exe contains code of Xtreme RAT.

## 7.3 Filesystem analysis

In this section, students will do a preliminary filesystem analysis using a previously created timeline and browsing a mounted filesystem.

The Filesystem timeline usually consists of a huge amount of entries. Thus it is always good to have some starting point. This might be a timestamp, the name of suspicious file, a directory or estimated time frame when the incident occurred. Moreover, if we suspect that an incident is a malware-related, it is always prudent to search locations where malware commonly installs itself or stores data. Those locations are:

- %APPDATA%
- %TEMP%
- %WINDIR%

When searching those locations, an analyst should look for any suspicious executables or files modified around the time when incident took place.

It is necessary to remember that more sophisticated malware might try to hide its code in various other places like ADS (Alternative Data Streams), boot sector, hidden partitions, etc. Checking those locations isn't part of this training.

The general algorithm of filesystem analysis should look as follows:

1. For any known timestamp, check what files were created/modified/accessed around that time. What does it tell about user activity or activities taking place in the operating system?
2. For any known suspicious file, check its timestamps (MACB/MACE times on NTFS) and add them to the list of known timestamps. Repeat step 1 for those timestamps.
3. For any known suspicious directory, check what files it contains. For any suspicious file in the directory, add it to list of suspicious files and repeat step 2.

At this point students should already know from the results of memory analysis and AV scanning some suspicious files and timestamps.

Students should start by searching on the timeline (either in browser or text editor) for update.exe file which was detected during the memory analysis.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tue Aug 16 2016 13:02:57 | 61440 | ma.b | r/rrwxrwxrwx | 0 | 0 | 100775-128-3 | C:/Users/Peter/AppData/Local/Temp/svchost.exe |
| | 88 | macb | r/rrwxrwxrwx | 0 | 0 | 100775-48-2 | C:/Users/Peter/AppData/Local/Temp/svchost.exe ($FILE_NAME) |
| | 2032 | ...b | r/r--x--x--x | 0 | 0 | 101277-128-3 | C:/Users/Peter/AppData/Roaming/Microsoft/Windows/GhCtxq8t.cfg |
| | 90 | ...b | r/r--x--x--x | 0 | 0 | 101277-48-2 | C:/Users/Peter/AppData/Roaming/Microsoft/Windows/GhCtxq8t.cfg ($FILE_NAME) |
| | 61440 | m.c. | r/rrwxrwxrwx | 0 | 0 | 101285-128-4 | C:/Users/Peter/AppData/Local/Microsoft/Windows/INetCache/IE/R81B6P1C/3568226350[1].exe |
| | 82 | macb | d/d--x--x--x | 0 | 0 | 101286-48-2 | C:/Users/Peter/AppData/Roaming/HostData ($FILE_NAME) |
| | 86 | macb | r/r--x--x--x | 0 | 0 | 101287-48-2 | C:/Users/Peter/AppData/Roaming/HostData/update.exe ($FILE_NAME) |
| | 416 | ma.. | d/drwxrwxrwx | 0 | 0 | 65415-144-5 | C:/Users/Peter/AppData/Local/Microsoft/Windows/INetCache/IE/JGDRJ45O |
| Tue Aug 16 2016 13:02:58 | 61440 | ..c. | r/rrwxrwxrwx | 0 | 0 | 100775-128-3 | C:/Users/Peter/AppData/Local/Temp/svchost.exe |

**Figure 44: Analysing timeline**

As pointed by $FILE_NAME attribute[15] update.exe was referenced for the first time at 13:02:57, exactly the same time when svchost.exe was created in %TEMP% directory. Students can recall this is the same time when svchost.exe process found in memory was created.

Later at 13:03:04 according to standard $STANDARD_INFORMATION attribute, update.exe MFT entry was changed. Note that 13:03:04 is also the time when update.exe process was created according to memory analysis.

[15] NTFS $I30 Index Attributes: Evidence of Deleted and Overwritten Files https://digital-forensics.sans.org/blog/2011/09/20/ntfs-i30-index-attributes-evidence-of-deleted-and-overwritten-files (last accessed 30.09.2016)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tue Aug 16 2016 13:03:04 | 1491 | macb | r/rrwxrwxrwx | 0 | 0 | 101231-128-4 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/ |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101231-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/ |
| | 2032 | mac. | r/r--x--x--x | 0 | 0 | 101277-128-3 | C:/Users/Peter/AppData/Roaming/Microsoft/Windows/GhCtxq8t.cfg |
| | 90 | mac. | r/r--x--x--x | 0 | 0 | 101277-48-2 | C:/Users/Peter/AppData/Roaming/Microsoft/Windows/GhCtxq8t.cfg ($FILE_NAME) |
| | 61440 | ..c. | r/r--x--x--x | 0 | 0 | 101287-128-1 | C:/Users/Peter/AppData/Roaming/HostData/update.exe |
| | 1008670 | ..c. | r/rrwxrwxrwx | 0 | 0 | 101298-128-3 | C:/Users/Peter/AppData/Roaming/Microsoft/Windows/GhCtxq8t.xtr |

**Figure 45: Analysing timeline**

Students can also view detailed information about update.exe file using Autopsy Meta Data analysis. To do this students should go back to the main Autopsy panel (Trainer can suggest using browser tabs as the timeline will be needed again in a moment).

Then students should choose partition C:\ and click “Analyse”.

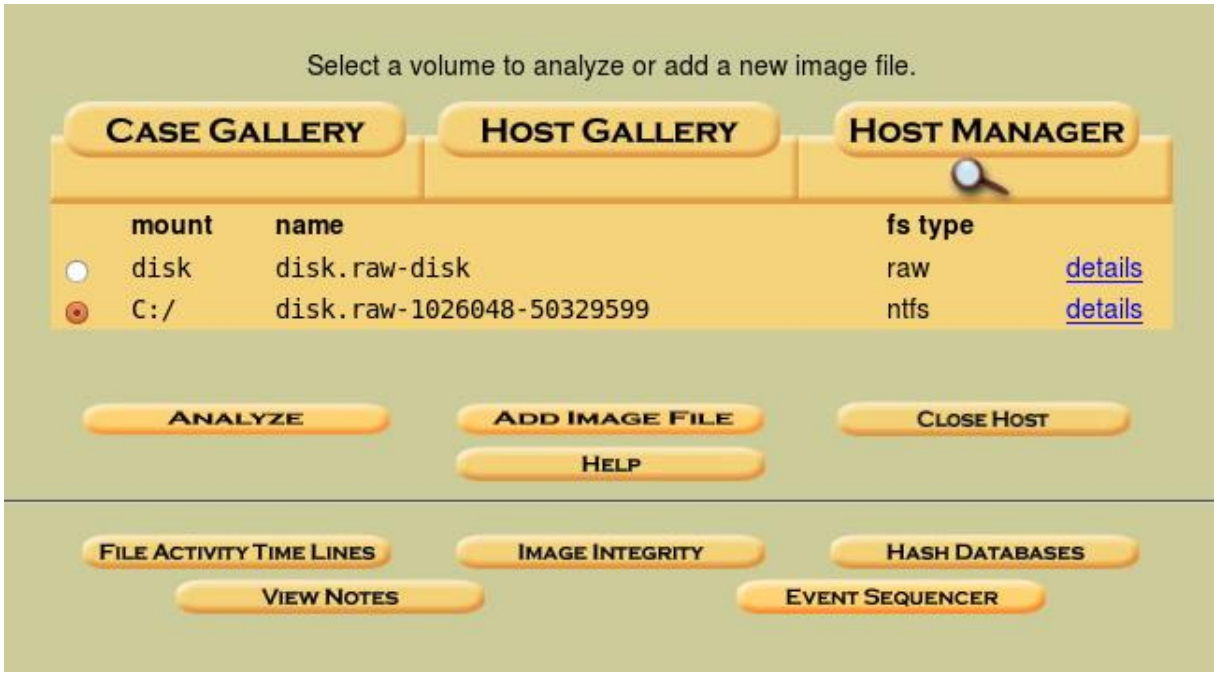



**Figure 46: Analysing partition**

On the next page students should click “Meta Data” and enter 101287 as MFT Entry Number (value can be read from timeline). After clicking “View” Autopsy should present page with detailed information about update.exe file.

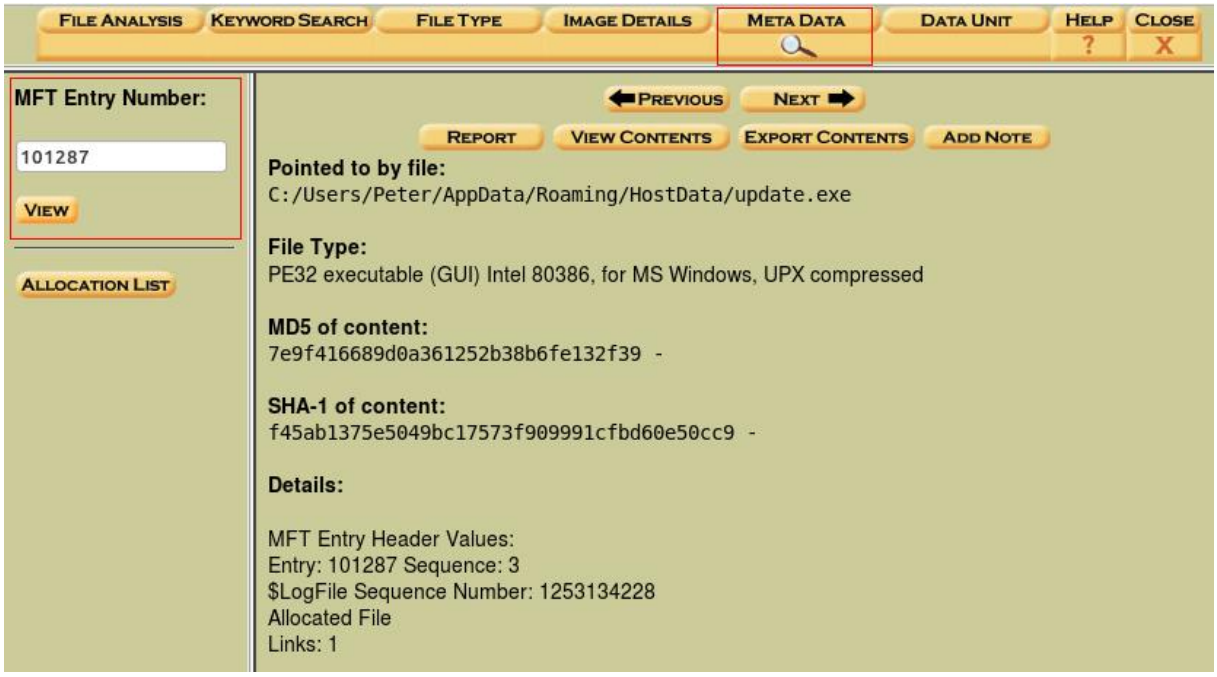



**Figure 47: Analysing metadata**

One pretty useful information for the forensic analysis that can be read from this page are MACB timestamp values as read from $STANDARD_INFORMATION and $FILE_NAME attributes.

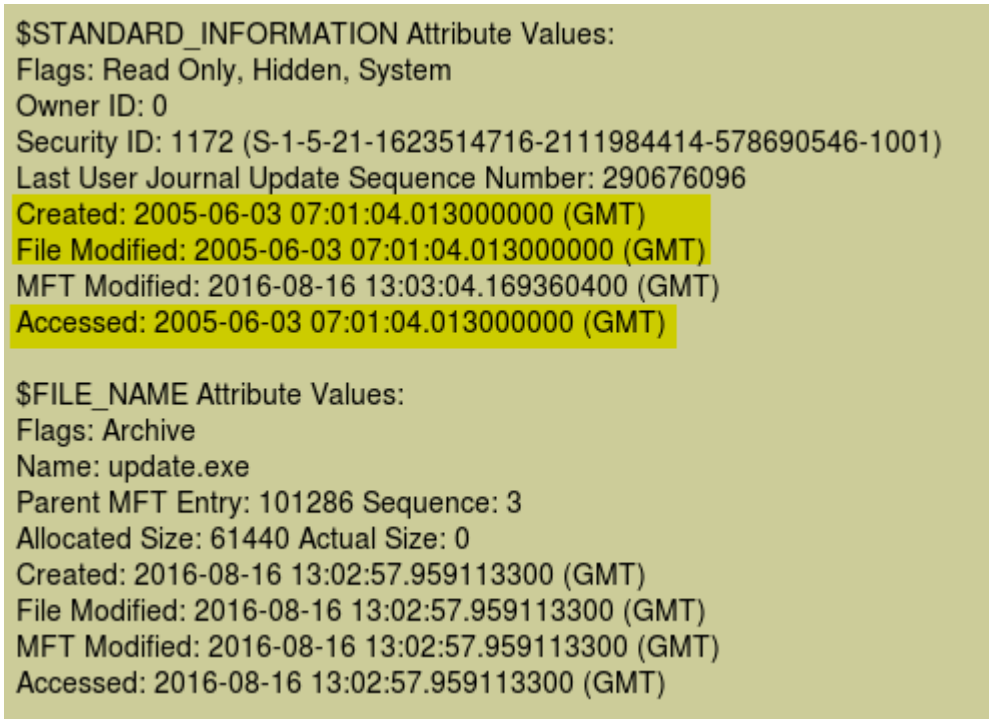



**Figure 48: Attributes**

The Trainer should point that three attributes from $STANDARD_INFORMATION are set to a time in the past. Knowing that $STANDARD_INFORMATION attributes can be changed by the process in user mode (in

opposition to $FILE_NAME attributes that can be only changed by the system), this suggests that at some point the timestamps of update.exe might have been intentionally overwritten.

Now students should go back to the timeline and check what happened shortly before 13:02:57. Quick analysis should reveal that one second before 13:02:57 file 3568226350[1].exe was created.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tue Aug 16 2016 13:02:56 | 420 | .a.b | r/rrwxrwxrwx | 0 | 0 | 101282-128-1 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/120E3605EC4A57B09C0396 |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101282-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/120E3605EC4A57B09C0396 |
| | 420 | .a.b | r/rrwxrwxrwx | 0 | 0 | 101284-128-1 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/8E3D898722819D75305BBE |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101284-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/8E3D898722819D75305BBE |
| | 61440 | .a.b | r/rrwxrwxrwx | 0 | 0 | 101285-128-4 | C:/Users/Peter/AppData/Local/Microsoft/Windows/INetCache/IE/R81B6P1C/3568226350[1].exe |
| | 100 | macb | r/rrwxrwxrwx | 0 | 0 | 101285-48-2 | C:/Users/Peter/AppData/Local/Microsoft/Windows/INetCache/IE/R81B6P1C/3568226350[1].exe ($FILE_NAME) |
| | 420 | .a.b | r/rrwxrwxrwx | 0 | 0 | 101289-128-1 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/EE63825F56120184913F54 |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101289-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/EE63825F56120184913F54 |

**Figure 49: Timeline**

Moreover shortly before that, multiple Firefox cache files were created suggesting Firefox activity. Among those files there is a file in which ClamAV detected an exploit code.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tue Aug 16 2016 13:02:53 | 1125 | macb | r/rrwxrwxrwx | 0 | 0 | 101268-128-4 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/394A23D50D9098F50B10713FD54607815F18FAB8 |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101268-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/394A23D50D9098F50B10713FD54607815F18FAB8 ($FILE_NAME) |
| | 4886 | macb | r/rrwxrwxrwx | 0 | 0 | 101269-128-4 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/B875FA5FF062E1D9C6B5550C2A338395F4815200 |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101269-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/B875FA5FF062E1D9C6B5550C2A338395F4815200 ($FILE_NAME) |
| | 9260 | macb | r/rrwxrwxrwx | 0 | 0 | 101270-128-4 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/E0FA626A10D95A9EF6C1628AAE973638AB45C3DD |
| | 146 | macb | r/rrwxrwxrwx | 0 | 0 | 101270-48-2 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/E0FA626A10D95A9EF6C1628AAE973638AB45C3DD ($FILE_NAME) |
| | 608 | macb | r/rrwxrwxrwx | 0 | 0 | 101271-128-4 | C:/Users/Peter/AppData/Local/Mozilla/Firefox/Profiles/z0l7z3kd.default/cache2/entries/6A4D4B53A8A3AC48F8B58AC492D34210E55D64BA |

**Figure 50: Timeline**

Creation of malicious files on disk preceded by Firefox activity and malicious code found in cache file is a strong indicator that some malicious website might have been used for an attack vector. To further investigate that, Firefox logs should be inspected.

Another way to browse filesystem is to use the Autopsy File Analysis utility. To do this, students should go to the main Autopsy panel and choose analysis of C:\ partition.

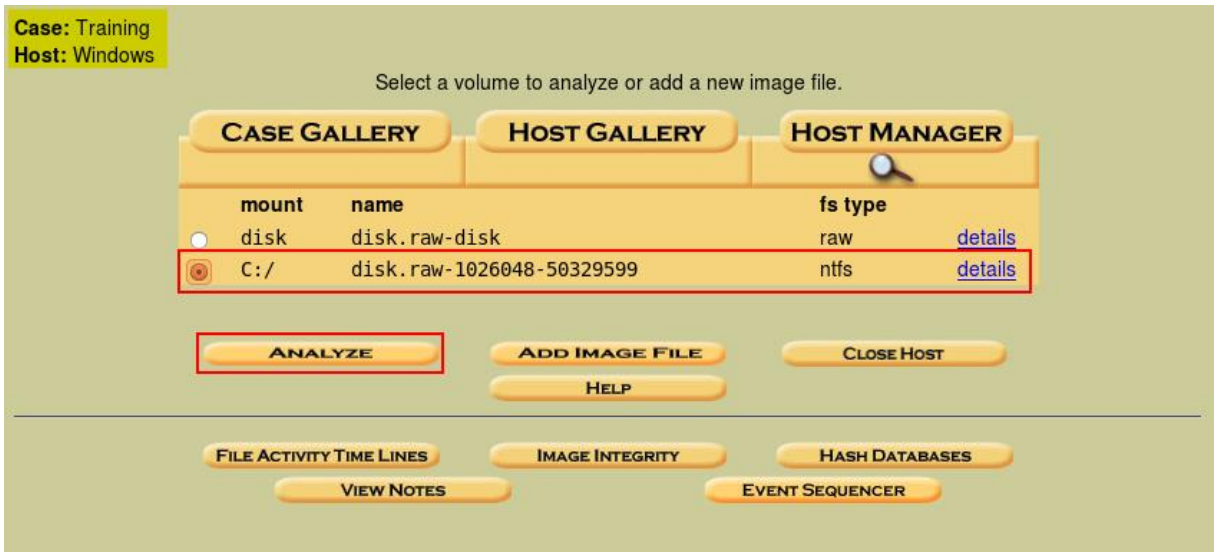



**Figure 51: Analyse files**

Next, students should navigate to C:\Users\Peter\AppData\Roaming where two suspicious directories EpUpdate and HostData are located (which were found in previous analysis).

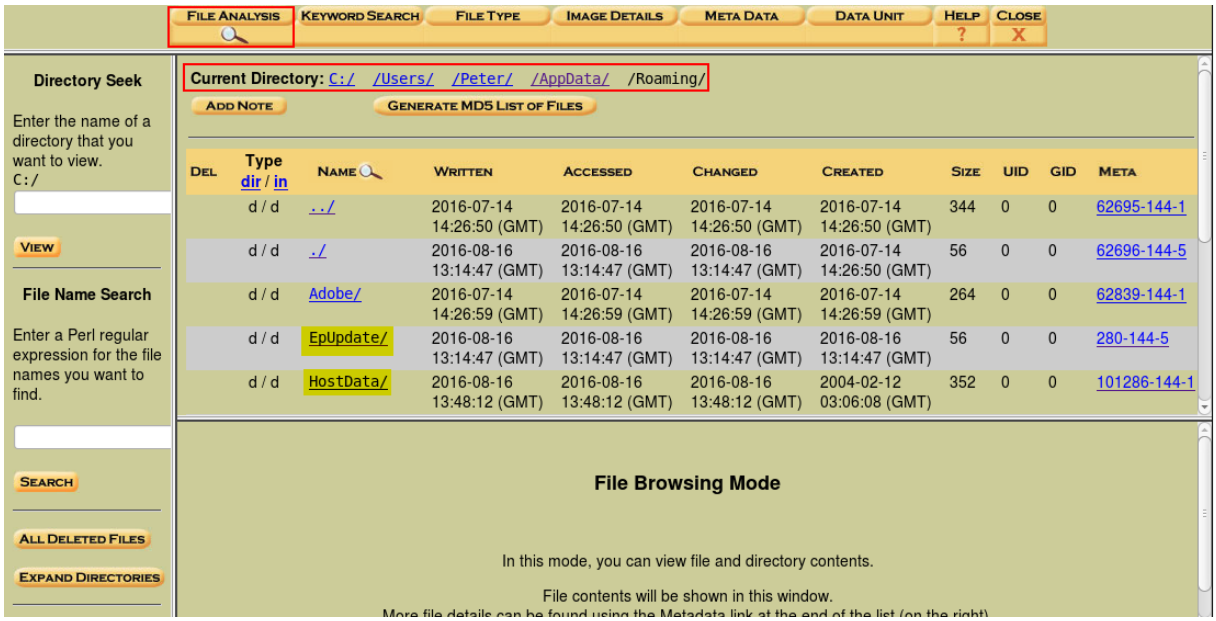



**Figure 52: File analysis**

Now students should open EpUpdate/ directory to notice it contains multiple folders and tools possibly used during the attack.

- bpd/ - BrowserPasswordDump.exe
- mmktz/ - mimikatz
- nircmd/ – NirCmd
- nmap/ - Nmap
- pwdump/ - Pwdump
- ssh/ - plink, pscp
- thc/ - THC Hydra
- passwords.txt – list of common passwords
- wdigest.reg – REG file changing UseLogonCredential value in WDigest registry subkey[16]

[16] Dumping WDigest Creds with Meterpreter Mimikatz/Kiwi in Windows 8.1 https://www.trustedsec.com/april-2015/dumping-wdigest-creds-with-meterpreter-mimikatzkiwi-in-windows-8-1/ (last accessed 30.09.2016)

Current Directory: C:/ /Users/ /Peter/ /AppData/ /Roaming/
/EpUpdate/

ADD NOTE GENERATE MD5 LIST OF FILES

| DEL | Type dir / in | NAME | WRITTEN | ACCESSED | CHANGED | CREATED | SIZE | UID | GID | META |
|---|---|---|---|---|---|---|---|---|---|---|
| | d / d | ../ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-07-14 14:26:50 (GMT) | 56 | 0 | 0 | 62696-144-5 |
| | d / d | ./ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 56 | 0 | 0 | 280-144-5 |
| | d / d | bpd/ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 288 | 0 | 0 | 286-144-1 |
| | d / d | mmktz/ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 480 | 0 | 0 | 369-144-1 |
| | d / d | nircmd/ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 256 | 0 | 0 | 566-144-1 |
| | d / d | nmap/ | 2016-08-16 13:49:24 (GMT) | 2016-08-16 13:49:24 (GMT) | 2016-08-16 13:49:24 (GMT) | 2016-08-16 13:14:47 (GMT) | 56 | 0 | 0 | 598-144-5 |
| | r / r | passwords.txt | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 3700 | 0 | 0 | 61228-128-4 |
| | d / d | pwdump/ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 264 | 0 | 0 | 61230-144-1 |
| | d / d | ssh/ | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 256 | 0 | 0 | 61377-144-1 |
| | d / d | thc/ | 2016-08-16 14:05:29 (GMT) | 2016-08-16 14:05:29 (GMT) | 2016-08-16 14:05:29 (GMT) | 2016-08-16 13:14:47 (GMT) | 176 | 0 | 0 | 61380-144-5 |
| | r / r | wdigest.reg | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 2016-08-16 13:14:47 (GMT) | 322 | 0 | 0 | 86666-128-1 |

**Figure 53: Folder with tools**

Although at this point it is uncertain whether those tools were executed, this list already gives some idea of what attacker might had in mind to do on the system.

Secondly students should notice modification time of the files in EpUpdate/ directory 13:14:47 UTC which is shortly after update.exe process was executed in the system.

Now students can check if between 13:03:00 UTC and 13:14:47 UTC were created any other executable files inside C:\Users. This time however instead of scrolling long timeline students will generate custom timeline using *mactime* utility.

Student should start by opening new terminal window and changing directory to the location of the previously generated *body* file (created by Autopsy during timeline preparation).

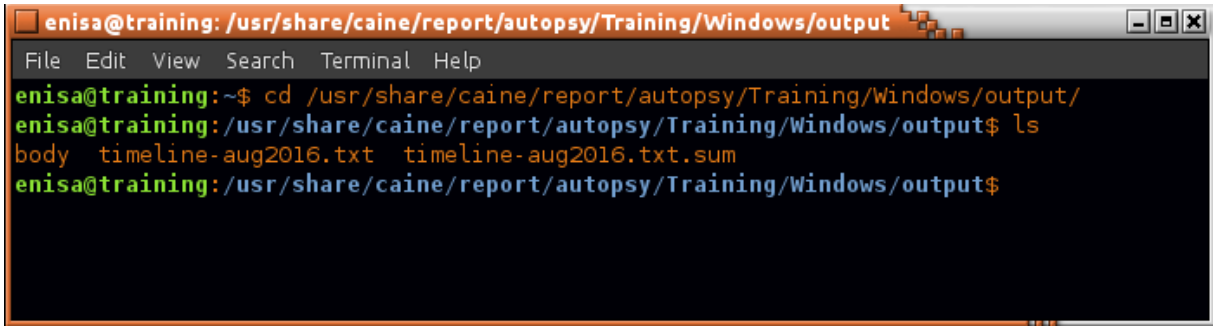



**Figure 54: Timeline location**

Next, using *mactime* tool students should generate small timeline and filter results using grep:

```
mactime -z GMT -b body -d 2016-08-16T13:03:00..2016-08-16T13:14:47 | grep 'C:/Users' | grep '\.exe'
-z – time zone specification
-b – path to body file
-d – output in comma delimited format (makes date present in each row)
```

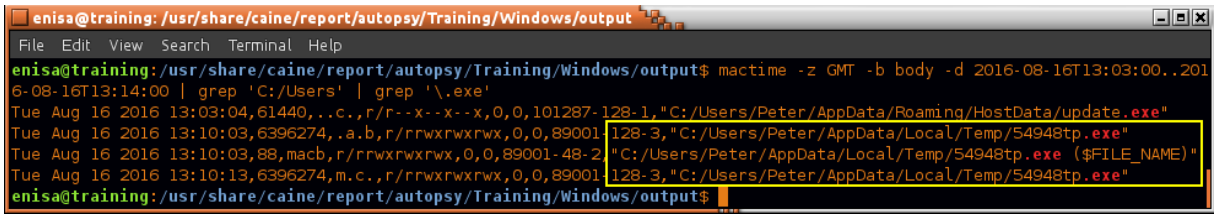



**Figure 55: Mactime output**

Students can see that at 13:10:03, suspicious executable 54948tp.exe was created inside %TEMP% folder. This executable and timestamp should be noted for later analysis.

**Filesystem analysis findings and conclusions:**

- Xtreme RAT process found in the system is likely a result of infection through a malicious website, which the user possibly visited using the Firefox web browser.
- At 13:02:57, svchost.exe executable was created inside the %TEMP% directory.
- The Update.exe executable had its timestamps overwritten.
- %APPDATA%/EpUpdate folder contains multiple tools that can be used for system and network profiling. It is unknown if any of those tools were actually executed.
- The %APPDATA%/EpUpdate folder was created at 13:14:47.
- At 13:10:03, suspicious executable 54948tp.exe was created at %TEMP% path.

## 7.4 Application logs analysis

During forensic investigation, it is often helpful to check logs created by the various applications installed in the system. For example, antivirus scan reports, web browser history, instant messenger logs or logs created by any other application related to the attack. A list of installed applications can be obtained either by browsing the filesystem (e.g. “C:\Program Files”) or from Windows Registry (presented in the later task).

In the present case, there is a strong indication that first infection occurred after the user visited a malicious website using Firefox browser. To confirm or refute this suspicion, students should analyse the Firefox browsing history and cache files created prior to the incident.

On Windows 10, the Firefox profile is located at C:\Users\<name>\AppData\Roaming\Mozilla\Firefox, while cache files can be found at C:\Users\<name>\AppData\Local\Mozilla\Firefox.

Students should start by browsing to Users/Peter/AppData/Roaming/Mozilla/Firefox.

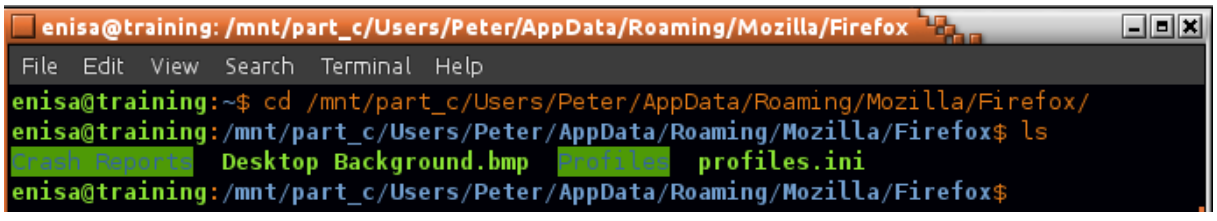



**Figure 56: AppData folder**

Inspecting the *Crash Reports* directory is a good place to begin analysis.

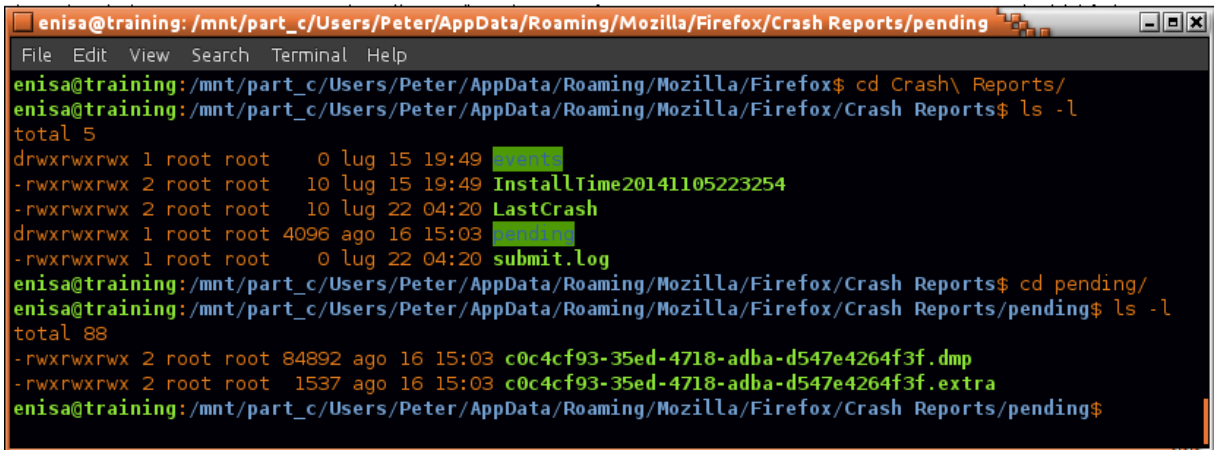



**Figure 57: Firefox crash reports**

Quickly checking in Autopsy reveals that both crash dump files were created around 13:03:16, which is around the time when first attack likely took place.

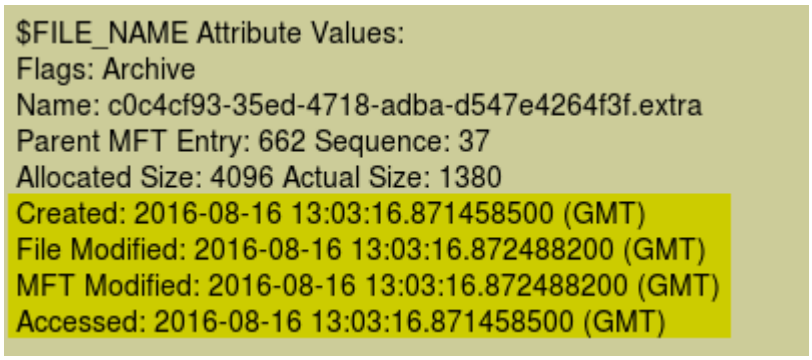



**Figure 58: File create time**

To get more details about the crash, students should open the .extra file in a text editor.

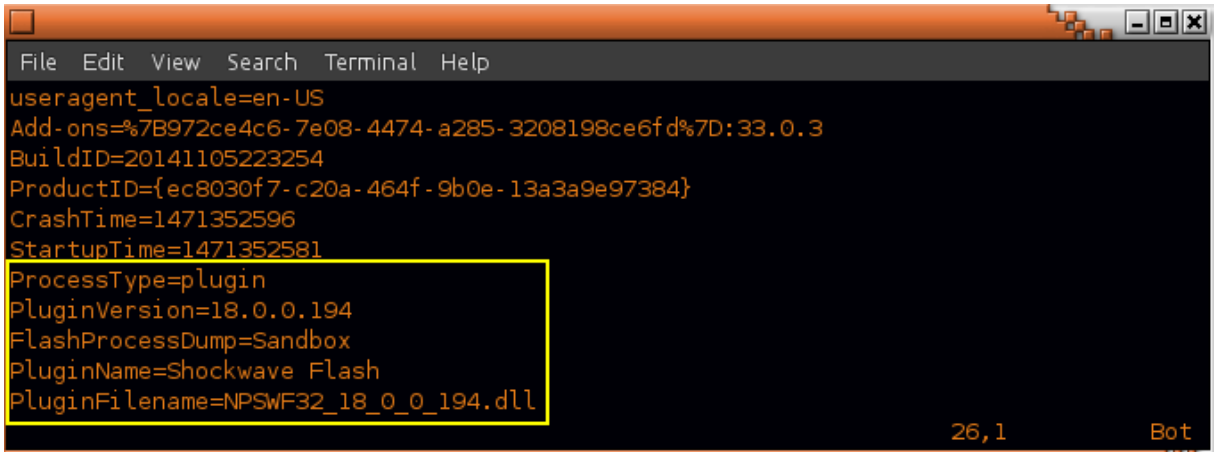



**Figure 59: Crash details**

This shows that the crash was related to the Flash plugin. Considering the circumstances, this means that the crash might have been caused by the browser trying to open a flash file containing some exploit code.

Firefox browsing history is stored in the Profiles/<profname>/places.sqlite database file. This file can be checked manually or, to make viewing easier, students can use the BrowsingHistoryView utility by NirSoft[17].

The tool can be found at ~/training/tools/BrowsingHistoryView/BrowsingHistoryView.exe. Students should start it using Wine. In the *Advanced Options* window, options should be set as shown in the screenshot below.

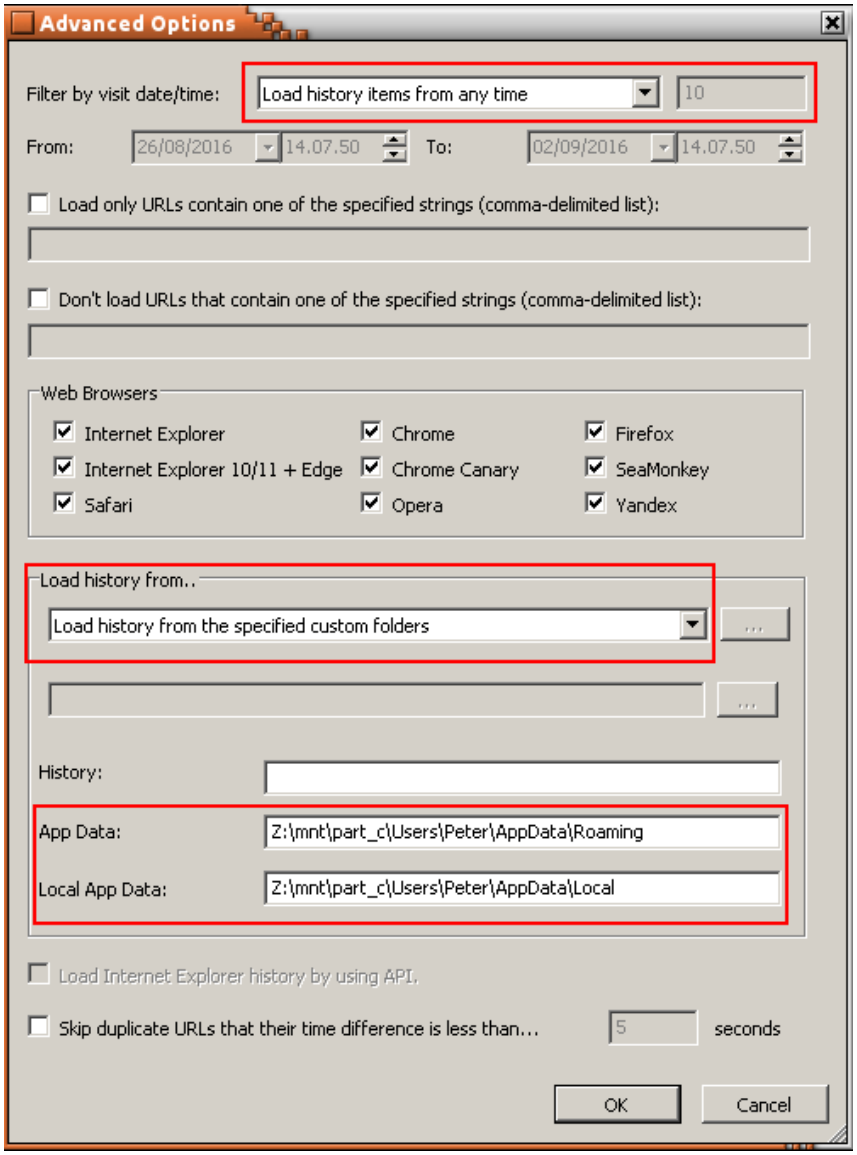



**Figure 60: Browsing history view settings**

After clicking OK, the history of visited pages should appear. If the list is empty, make sure all options in the Advanced Window were set correctly (Options -> Advanced Options).

[17] BrowsingHistoryView v1.90 http://www.nirsoft.net/utils/browsing_history_view.html (last accessed 30.09.2016)

Next it is worthwhile to set the time zone to GMT and sort list elements by the *Visit Time* column. Due to a Wine bug, students might need to scroll down and up list to refresh it to make the changes take effect.

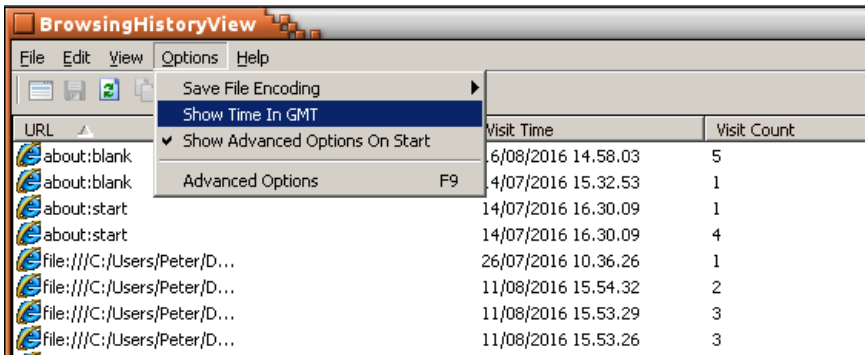



**Figure 61: Set time**

A quick inspection of the history list shows that on the day of the incident, 16/08/2016, the user was visiting Reddit and then entered some website at the address http://blog.mycompany.ex/. No other websites were visited directly by the user. Moreover it was concluded that on the day of the investigation, domain blog.mycompany.ex was resolving to 151.80.137.2.

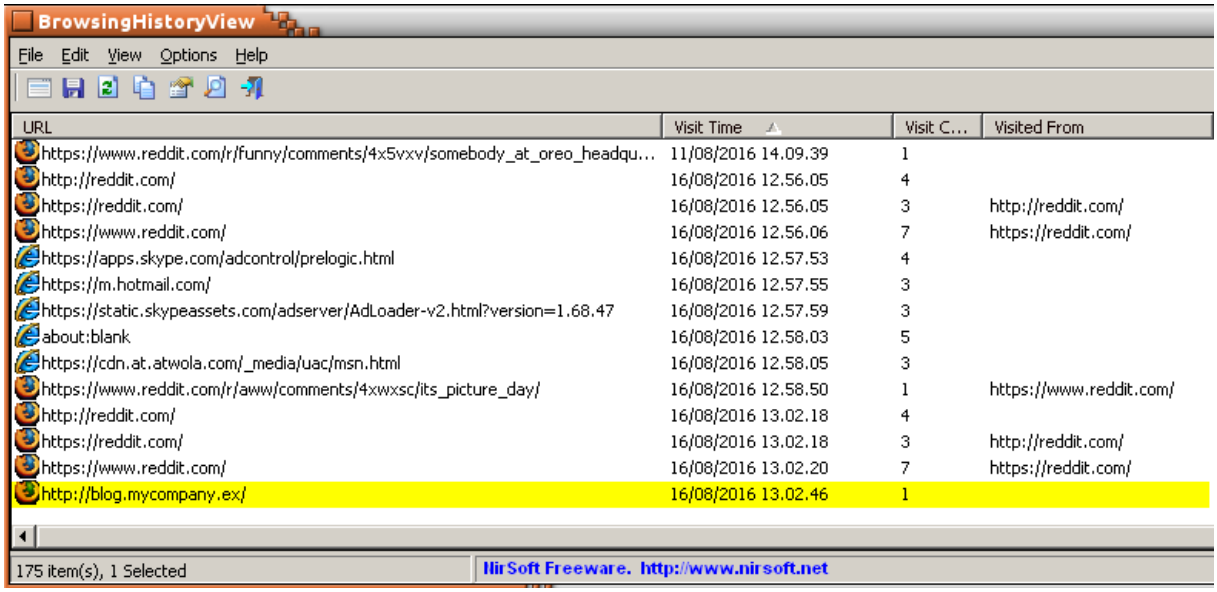



**Figure 62: Browsing history**

Browsing history reveals what websites were visited by the user, however it doesn't show what other media or scripts were indirectly downloaded by the browser as a result of visiting given website. This sort of information can be however obtained from the analysis of the browser cache files.

Mozilla Firefox cache files are located at Users\Peter\AppData\Local\Mozilla\Firefox\Profiles\<profname>\cache2.


**Figure 63: Location of cache files**

Unfortunately cache information is stored in binary format. To view it students can use MZCacheView[18]. MZCacheView is located at ~/training/tools/MozillaCacheView/ MozillaCacheView.exe and should be started using Wine.

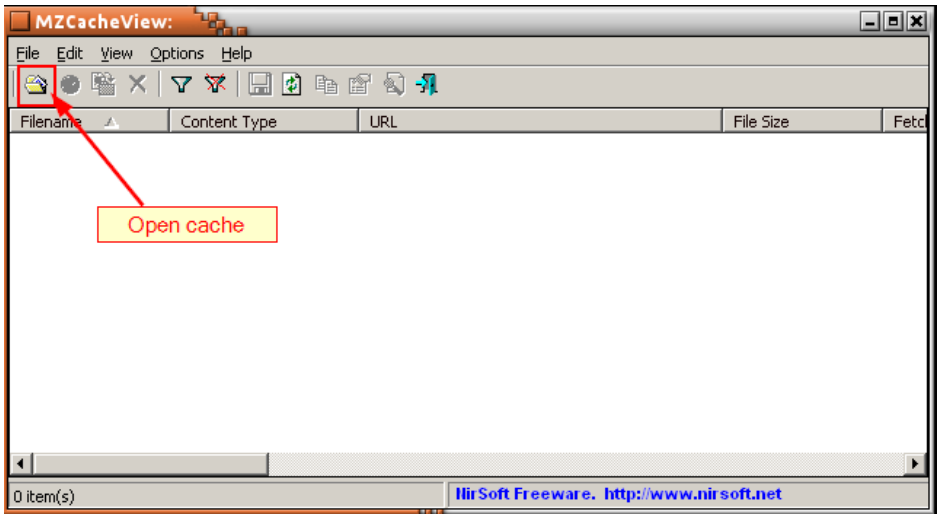



**Figure 64: MZCacheView**

In the next window, students should specify the path to the cache2 folder.

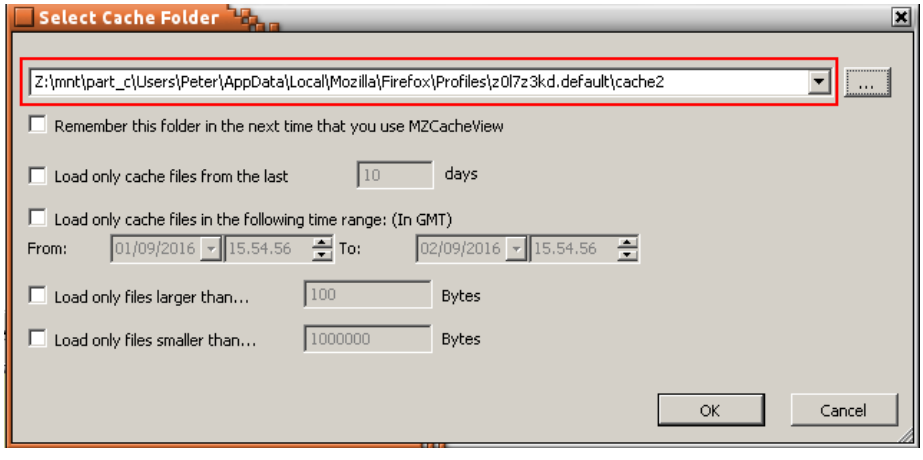



**Figure 65: MZCacheView**

[18] MZCacheView v1.69 http://www.nirsoft.net/utils/mozilla_cache_viewer.html (last accessed 30.09.2016)

After clicking OK, MZCacheView will load data from the cache files. This operation might take a short time. After the data is fully loaded, students should switch dates to GMT time zone (the same as in Browsing History View tool) and sort content by Last Modified date.

Scrolling down to the date of the incident, shortly after visiting the blog.mycompany.ex website, multiple other files were downloaded from another domain, blog.mysportclub.ex.

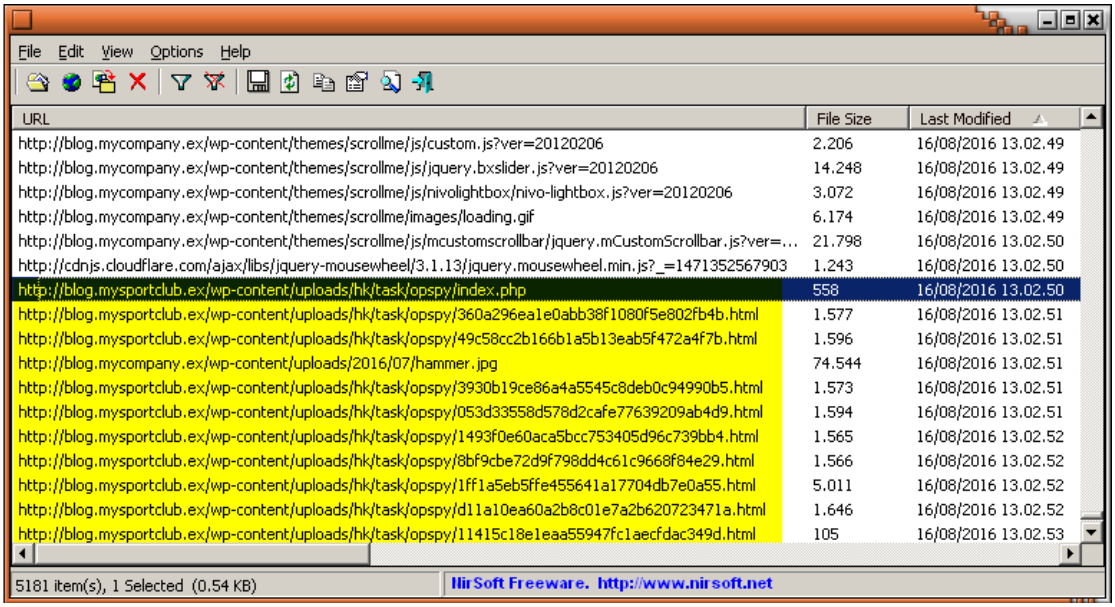



**Figure 66: MZCacheView**

The pattern of the files downloaded from blog.mysportclub.ex suggests this might be some Exploit Kit.

The next step should be to export cache files to separate directory for further analysis and to keep evidence data in one place.

To export cache data, students should select all entries related to blog.mysportclub.ex domain. Then right click on selected items and choose *"Copy Selected Cache Files To…".*

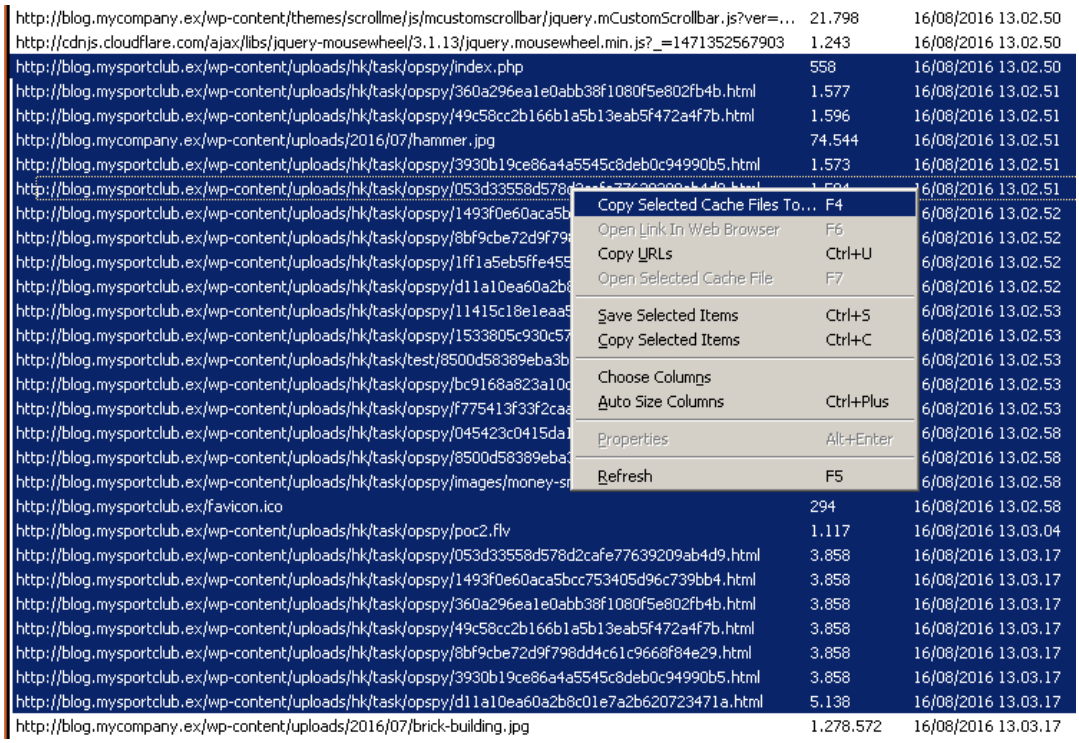



**Figure 67: Copy files**

In the next window, students should specify an output directory (if this directory doesn't exist it should be created first!).

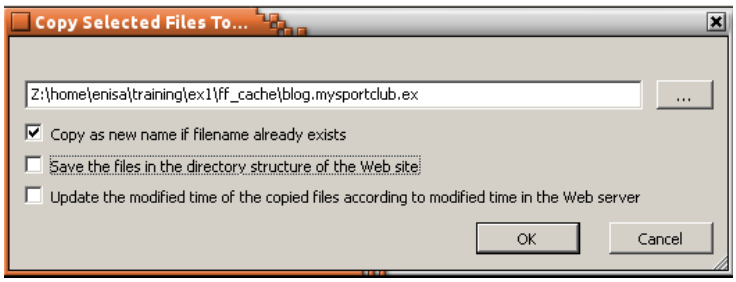



**Figure 68: Copy files**

The same should be repeated for blog.mycompany.ex domain (changing only the output directory).

Students should now perform an analysis of the exported cache files.

A good starting point would be an analysis of the index file of the blog.mycompany.ex website.

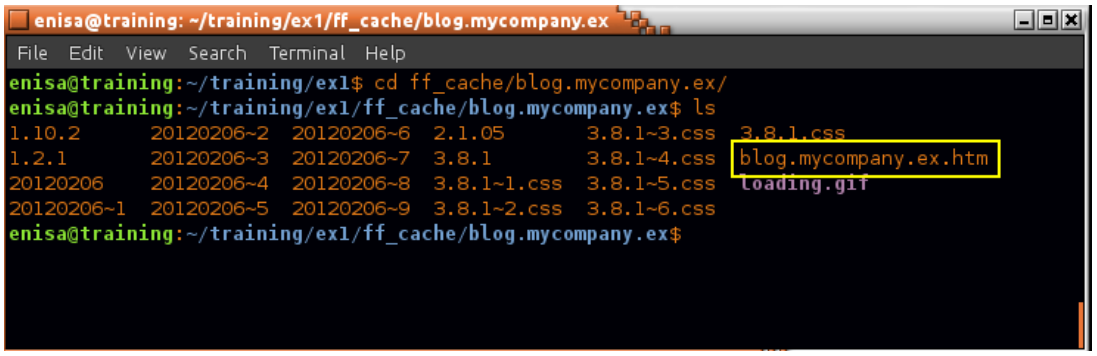



**Figure 69: Analysis of htm file**

After opening it in a text editor, students should notice strange script at line 153.

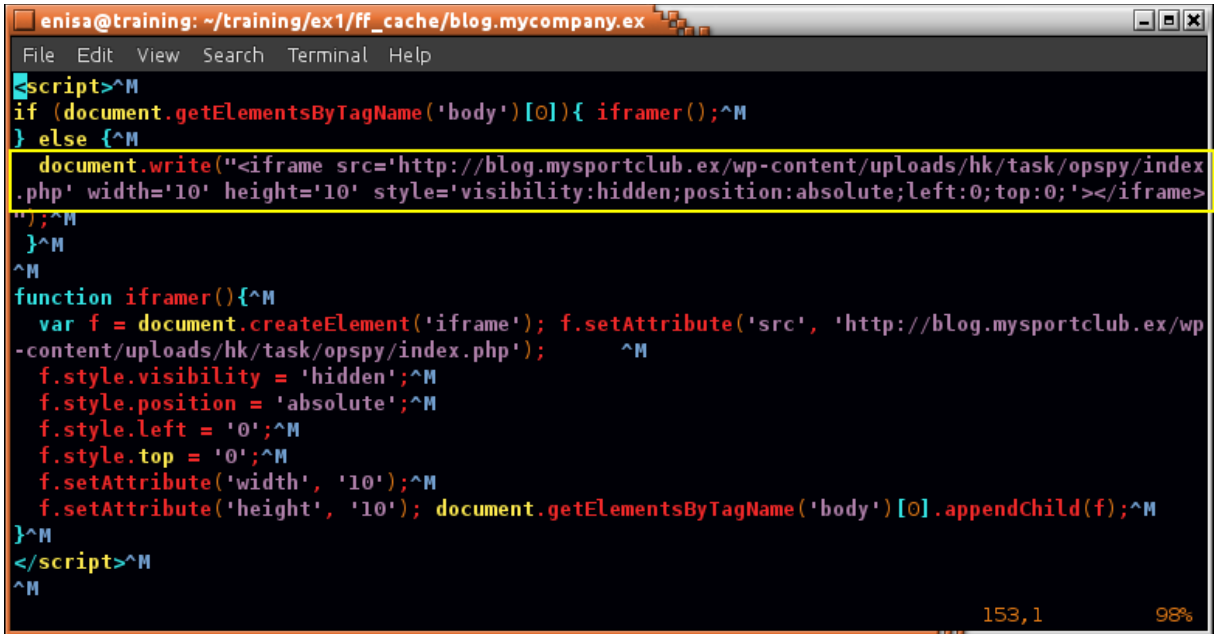



**Figure 70: Script**

What this script does is an injection of iframe element pointing to http://blog.mysportclub.ex/wp-content/uploads/hk/task/opspy/index.php. This is a very important observation because it tells us that blog.mysportclub.ex website was most likely infected with malicious code injecting iframe element redirecting to Exploit-Kit landing page.

Now switching to the analysis of cache files from blog.mysportclub.ex, students should open /wp-content/uploads/hk/task/opspy/index.php file (previously saved to blog.mysportclub.ex as index.php.htm).

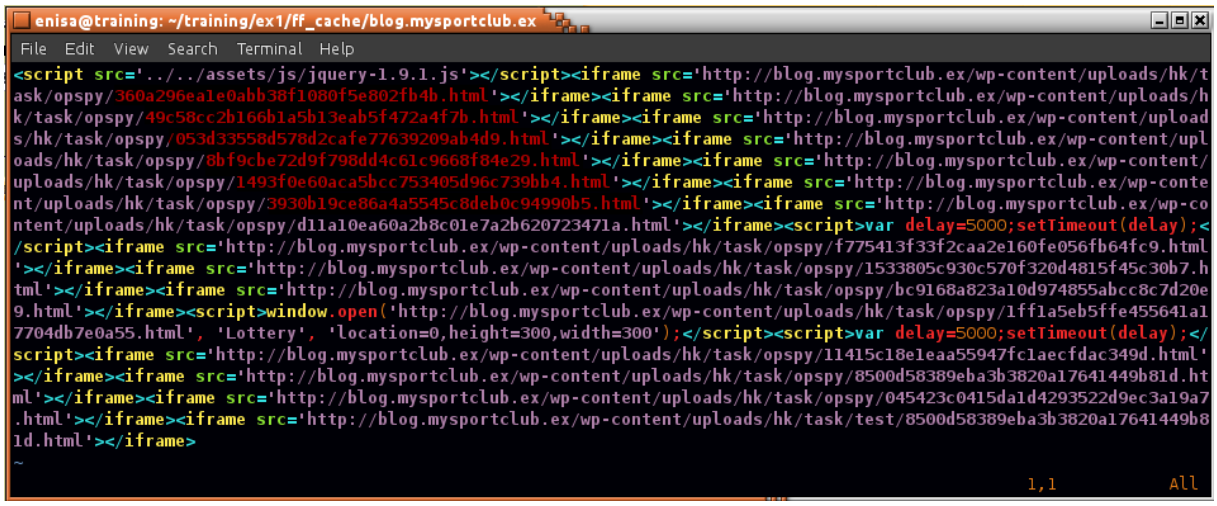



**Figure 71: Iframe**

What can be read from this file is that it contains multiple <iframe> elements, each including separate .html file from /wp-content/uploads/hk/task/opspy/ directory. Each html file contains a different exploit code trying to exploit different vulnerability.

Detailed analysis of Exploit-Kit is not part of this exercise, however students can try to search for svchost.exe occurrences in those files.

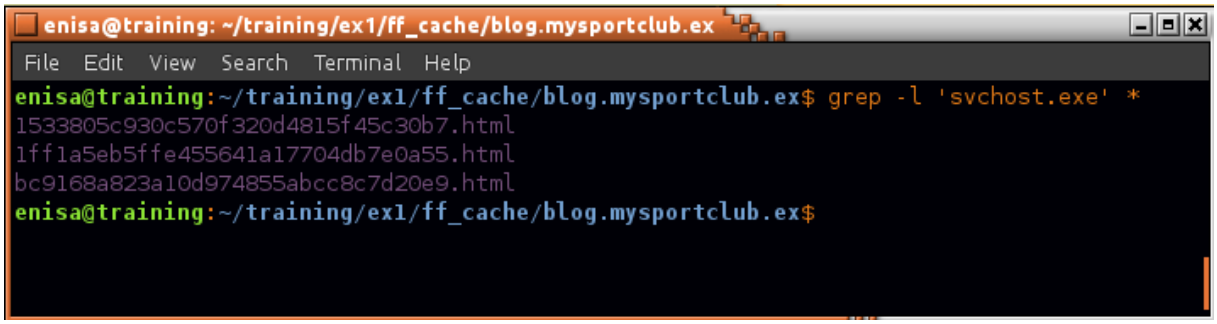



**Figure 72: Svchost.exe occurrences**

Looks like svchost.exe phrase is present in three files. Student should try to open the first file. Additionally to make viewing easier it is good to replace all '\n' phrases with actual characters of new line.

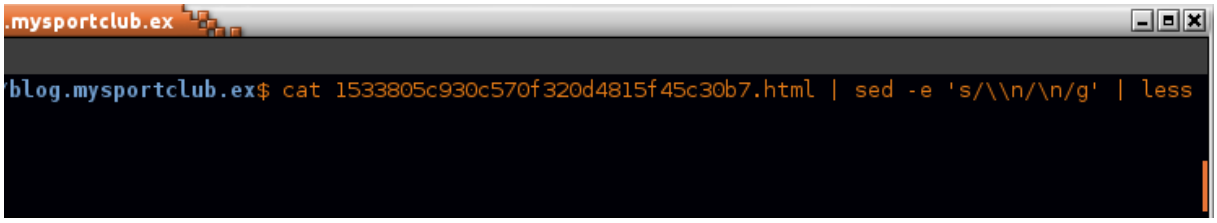



**Figure 73: View file**

In the middle of the file there should be defined *cmd* variable which contains interesting code.

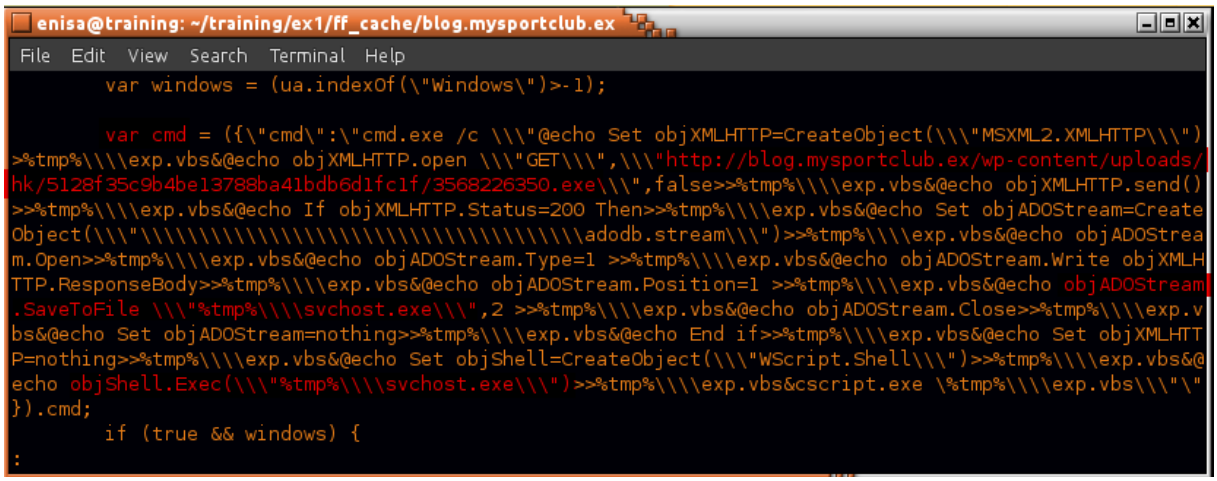



**Figure 74: Command in code**

This command downloads some executable 3568226350.exe, saves it to %TMP% folder and then executes it. Knowing from the filesystem analysis that around the same time (13:02:57) when the Exploit-Kit pages were visited, svchost.exe file was created on the filesystem confirms that one of the exploits has worked. However at this point it is uncertain which exploit has worked.

**Application logs analysis findings and conclusions:**

- At 13:03:16 a Firefox crash report related to Flash plugin was generated.
- From Firefox history it can be concluded that prior to the incident user was browsing Reddit and then visited blog.mycompany.ex website (13:02:46).
- Analysis of Firefox cache files revealed a pattern typical for Exploit-Kits – multiple similarly named .html files from blog.mysportclub.ex were downloaded after visiting blog.mycompany.ex.
- Analysis of cached blog.mycompany.ex index revealed it contains <iframe> element referring to http://blog.mysportclub.ex/wp-content/uploads/hk/task/opspy/index.php
- At least some of the .html files from http://blog.mysportclub.ex/wp-content/uploads/hk/task/opspy/ contains code downloading some executable (3568226350.exe) and saving it to %TMP%/svchost.exe – what correlates with previous finding of svchost.exe being created in the filesystem around the same time.
- Time of visit to blog.mycompany.ex correlates with the time of creation and execution of the update.exe process (Xtreme RAT).

## 7.5 Decompiling Python executable

Filesystem analysis revealed that at 13:10:03 UTC suspicious executable 54948tp.exe was created at %TEMP% path. Quick can show this file is PE32 executable most likely build from Python script using py2exe tool.

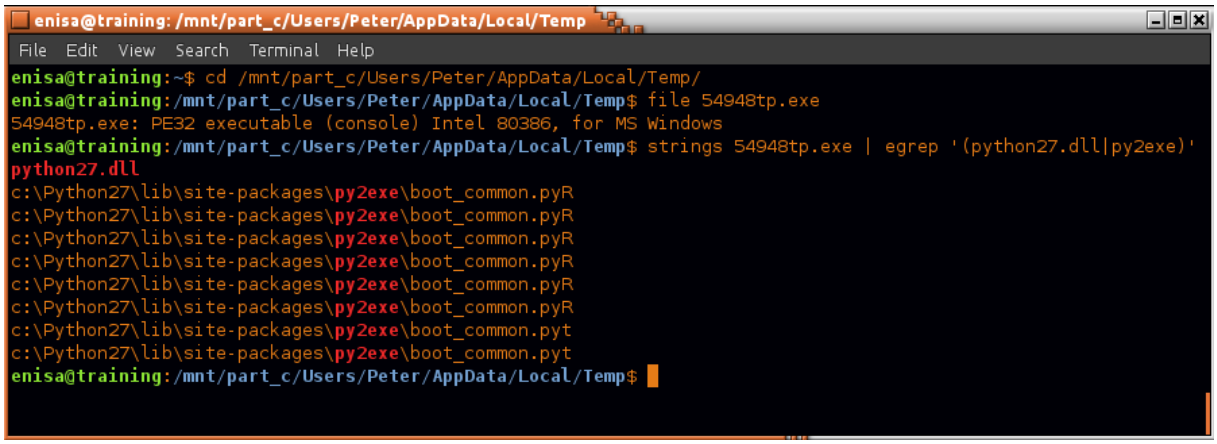



**Figure 75: File type analysis**

Students should try to extract from executable .pyc files using unpy2exe[19] script. Two .pyc files should be extracted.

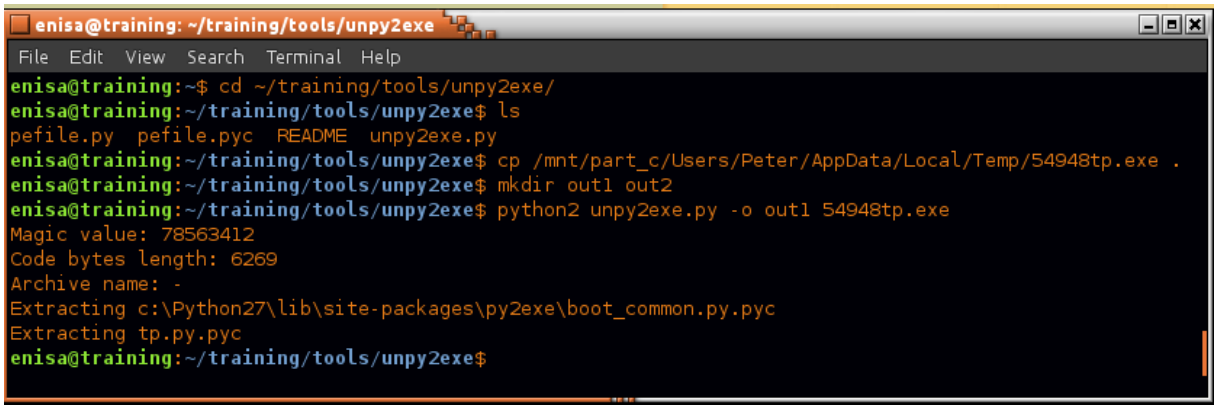



**Figure 76: Extracting files**

Next using uncompyle6[20] tool students can try decompiling the bytecode in .pyc files to the original python code.

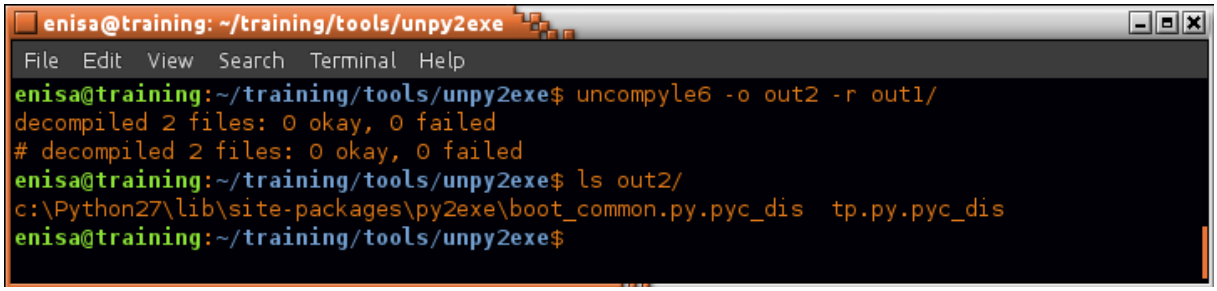



**Figure 77: Decompiling the code**

[19] Extract .pyc files from executables created with py2exe https://github.com/matiasb/unpy2exe (last accessed 30.09.2016)
[20] Uncompyle6 https://pypi.python.org/pypi/uncompyle6/ (last accessed 30.09.2016)

The most interesting code can be found in tp.py.pyc_dis. It starts with some DOWNLOAD_URL global variable pointing to data_32.bin on blog.mysportclub.ex server. Short after that there is some decryption function defined.

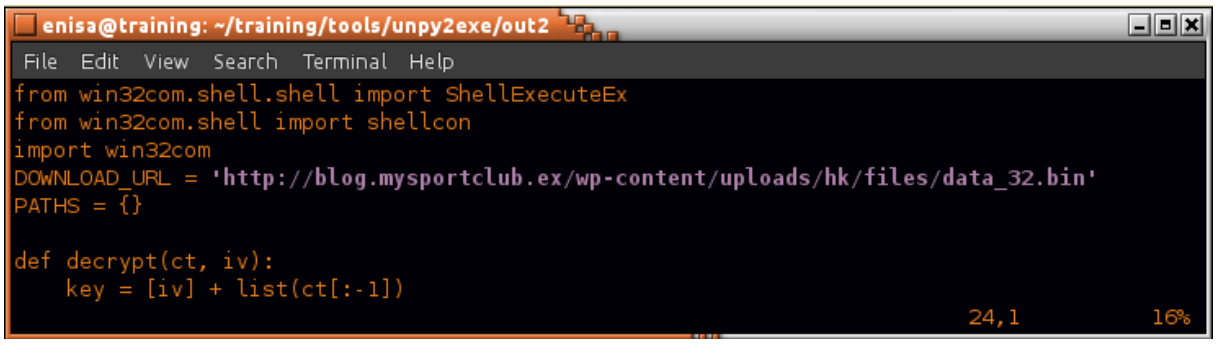



**Figure 78: Code containing URL**

In the middle of the code there is a *get_toolz* function defined (called from main function). This function first downloads the file from DOWNLOAD_URL, decrypts it and then decompresses its contents into %APPDATA%/EpUpdate directory.

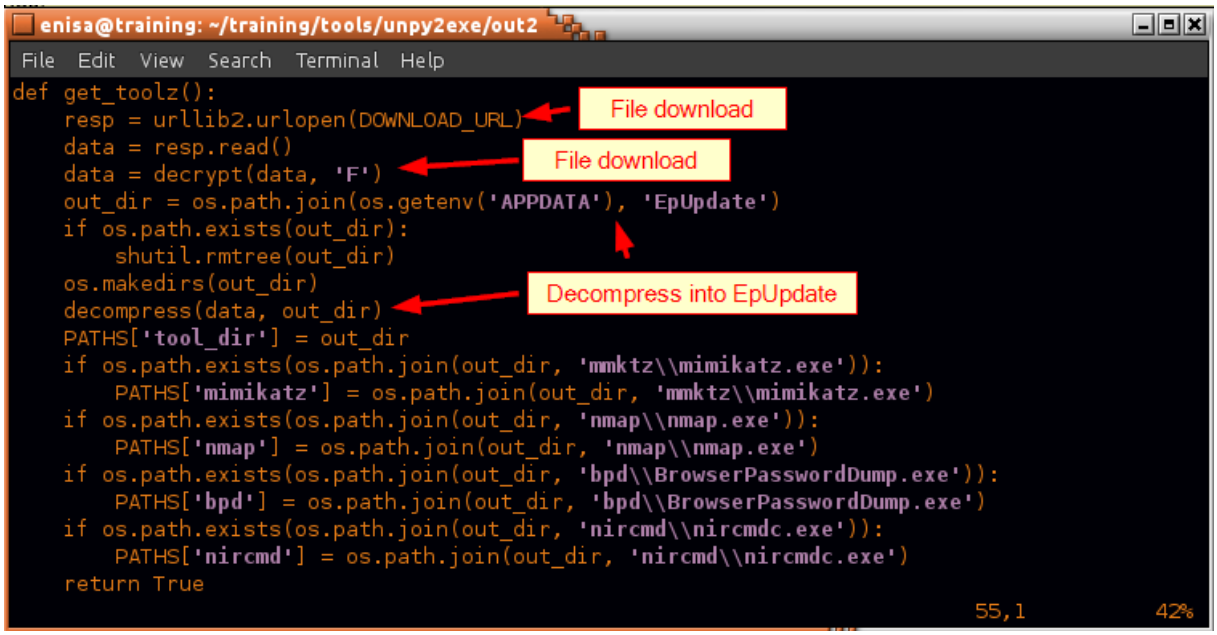



**Figure 79: Get_toolz function**

In the main function there is some SystemProfile in %TMP% directory referenced (data_dir). Then Mimikatz and Bpd tools are automatically executed.

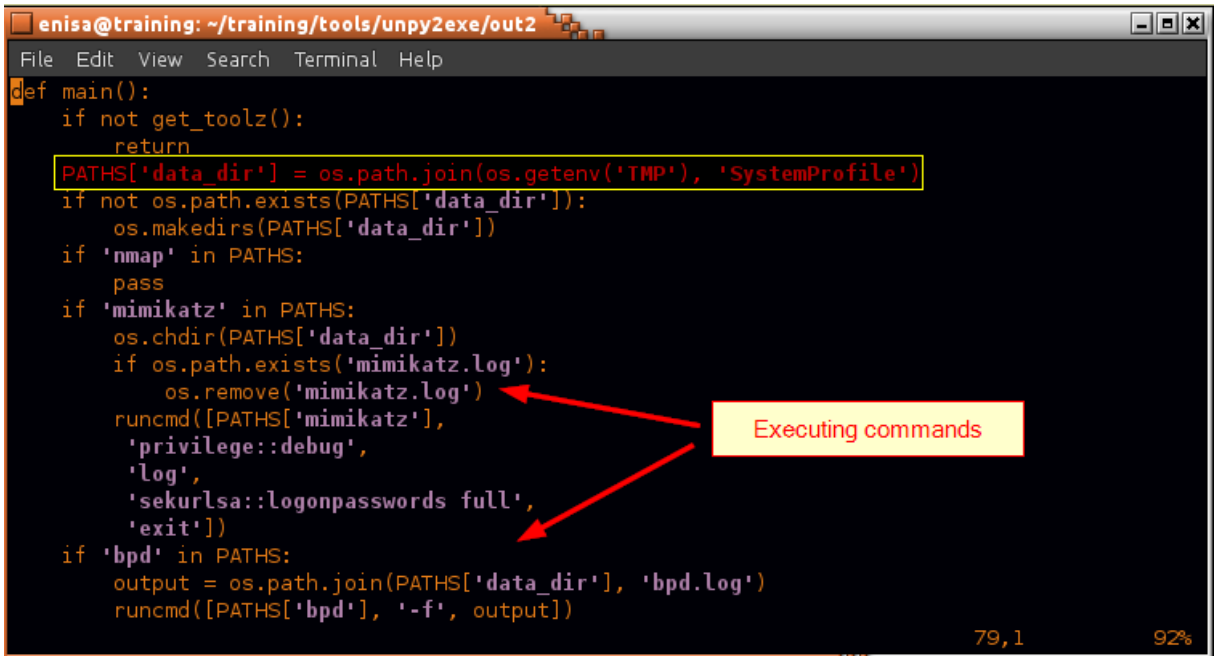
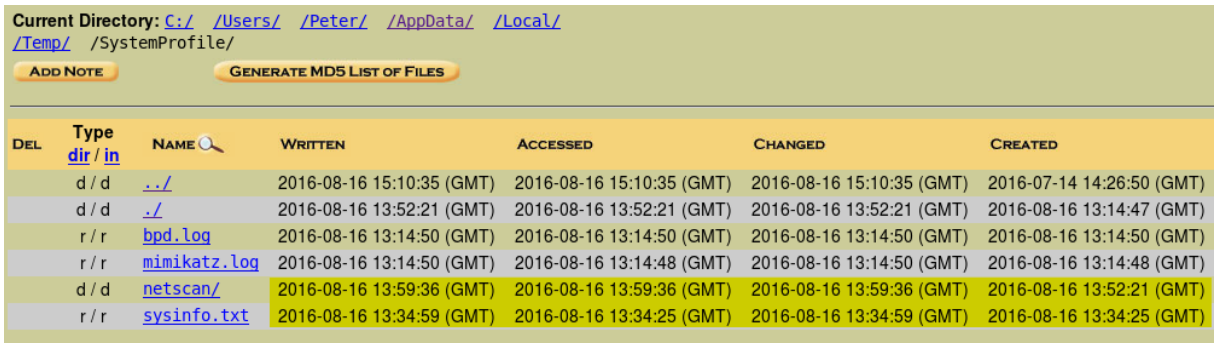



**Figure 80: Main function**

Next, students should check in Autopsy found %TMP%/*SystemProfile* directory reference. Inspection of this directory can reveal it contains a group of .log files. Beside bpd.log and mimikatz.log that were created around 13:14:48 as a result of execution of analysed Python script, there is also netscan/ directory and sysinfo.txt file. What's more, both were created several minutes after at 13:34:25 and 13:52:21.




| DEL | Type dir / in | NAME | WRITTEN | ACCESSED | CHANGED | CREATED |
|---|---|---|---|---|---|---|
| | d / d | ../ | 2016-08-16 15:10:35 (GMT) | 2016-08-16 15:10:35 (GMT) | 2016-08-16 15:10:35 (GMT) | 2016-07-14 14:26:50 (GMT) |
| | d / d | ./ | 2016-08-16 13:52:21 (GMT) | 2016-08-16 13:52:21 (GMT) | 2016-08-16 13:52:21 (GMT) | 2016-08-16 13:14:47 (GMT) |
| | r / r | bpd.log | 2016-08-16 13:14:50 (GMT) | 2016-08-16 13:14:50 (GMT) | 2016-08-16 13:14:50 (GMT) | 2016-08-16 13:14:50 (GMT) |
| | r / r | mimikatz.log | 2016-08-16 13:14:50 (GMT) | 2016-08-16 13:14:48 (GMT) | 2016-08-16 13:14:50 (GMT) | 2016-08-16 13:14:48 (GMT) |
| | d / d | netscan/ | 2016-08-16 13:59:36 (GMT) | 2016-08-16 13:59:36 (GMT) | 2016-08-16 13:59:36 (GMT) | 2016-08-16 13:52:21 (GMT) |
| | r / r | sysinfo.txt | 2016-08-16 13:34:59 (GMT) | 2016-08-16 13:34:25 (GMT) | 2016-08-16 13:34:59 (GMT) | 2016-08-16 13:34:25 (GMT) |

**Figure 81: Log files**

Inspection of sysinfo.txt file shows it contains results of several commands gathering information about local system (on routing, local users, network settings).

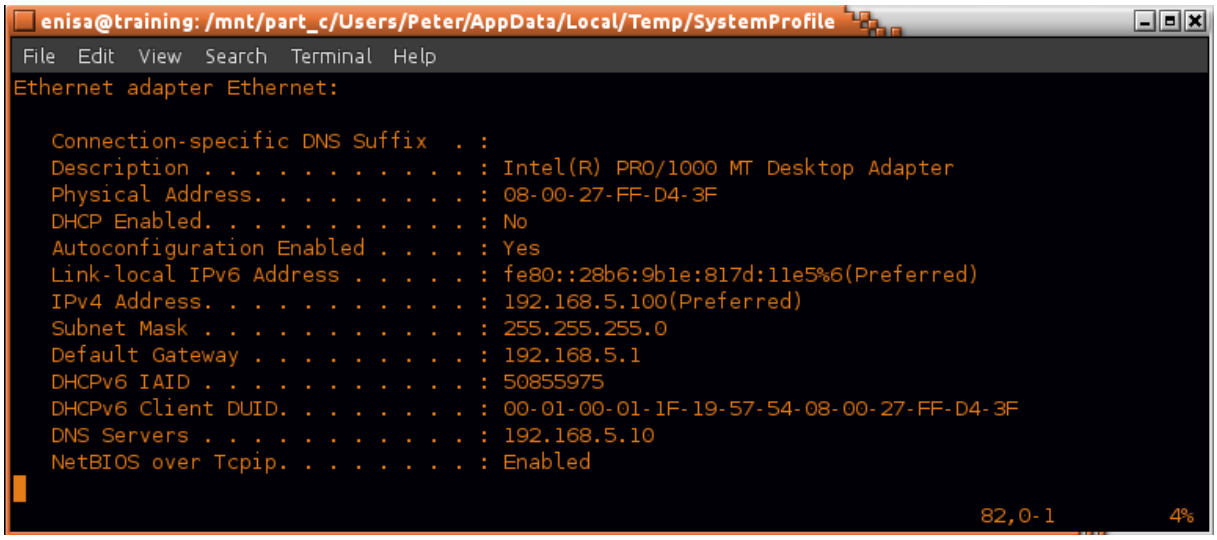



**Figure 82: Sysinfo.txt file**

Moreover netscan/ directory seems to contain port scan results of three hosts on the local network. 192.168.5.1, 192.168.5.10, 192.168.5.15.

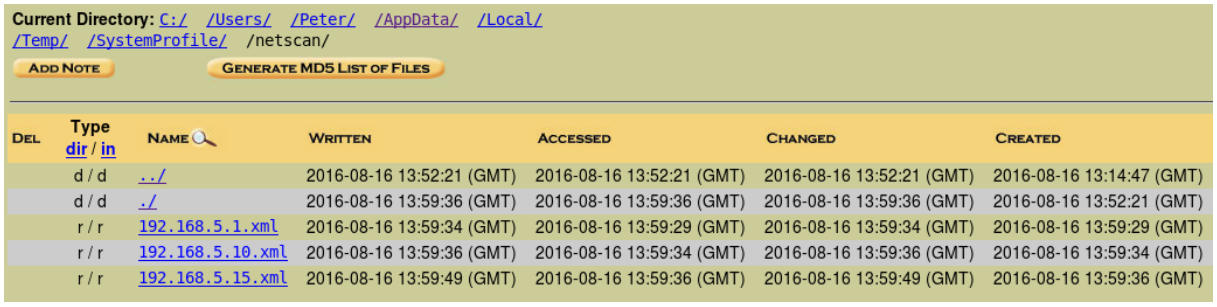



**Figure 83: Netscan directory**

From the .xml files it can be read that network scanning was done at 13:59:29, 13:59:34, and 13:59:36 using Nmap 7.12 from EpUpdate directory. Exact command used to start scanning can be also read.

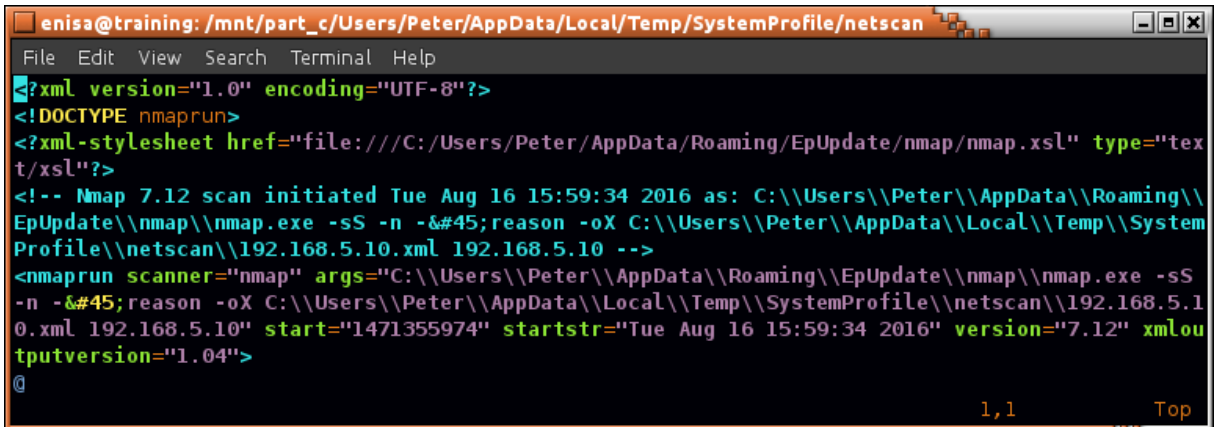



**Figure 84: Contents of XML files**

**54948tp.exe decompilation findings and conclusions:**

- 54948tp.exe is a Python script build with py2exe.
- Script downloads file from the same network location where Exploit-Kit was located (http://blog.mysportclub.ex/wp-content/uploads/hk/files/data_32.bin) and then unpacks its contents to %APPDATA%\EpUpdate. Downloaded file contains toolset later used by attacker (e.g. nmap scanner).
- 54948tp.exe was most likely executed between 13:10:03 (creation of 54948tp.exe on disk) and 13:14:47 (creation of EpUpdate directory).
- 54948tp.exe creates %TMP%\SystemProfile to which result files are saved.
- Based on log files found in SystemProfile directory analyst can assume that attacker was interested in gathering information about infected system and local network (port scans).
- Network scans were performed around 13:59:XX UTC.
- At 13:34:25 (creation time of sysinfo.txt file) possibly were executed some local commands gathering information about local system.

## 7.6 Prefetch analysis

Windows 10 prefetch files use different format than in previous Windows versions[21]. This causes some older forensic tools to incorrectly parse prefetch files while some other[22] tools/scripts need to be executed natively on Windows and doesn't work correctly under Wine.

In this task students will use 505Forensics script[23] utilizing libscca[24] library. This script can be run against single prefetch file or entire Prefetch/ directory. For the output it will produce binary name, number of executions, hash value and timestamps of last seven executions of given binary.

Script can be found at ~/training/tools/win10_prefetch/. By default it outputs data in CSV format. Students should save output to separate file and then open it in LibreOffice Calc.


**Figure 85: Prefetch script**

LibreOffice should correctly propose separating values by commas and in the Text Import window; students should just click OK.

[21] A first look at Windows 10 prefetch files http://blog.digital-forensics.it/2015/06/a-first-look-at-windows-10-prefetch.html (last accessed 30.09.2016)
[22] Parse Windows Prefetch files https://github.com/PoorBillionaire/Windows-Prefetch-Parser (last accessed 30.09.2016)
[23] Script Release: Parsing Windows 10 Prefetch Files on Linux http://www.505forensics.com/windows-10-prefetch/ (last accessed 30.09.2016)
[24] Library and tools to access the Windows Prefetch File (SCCA) format https://github.com/libyal/libscca (last accessed 30.09.2016)

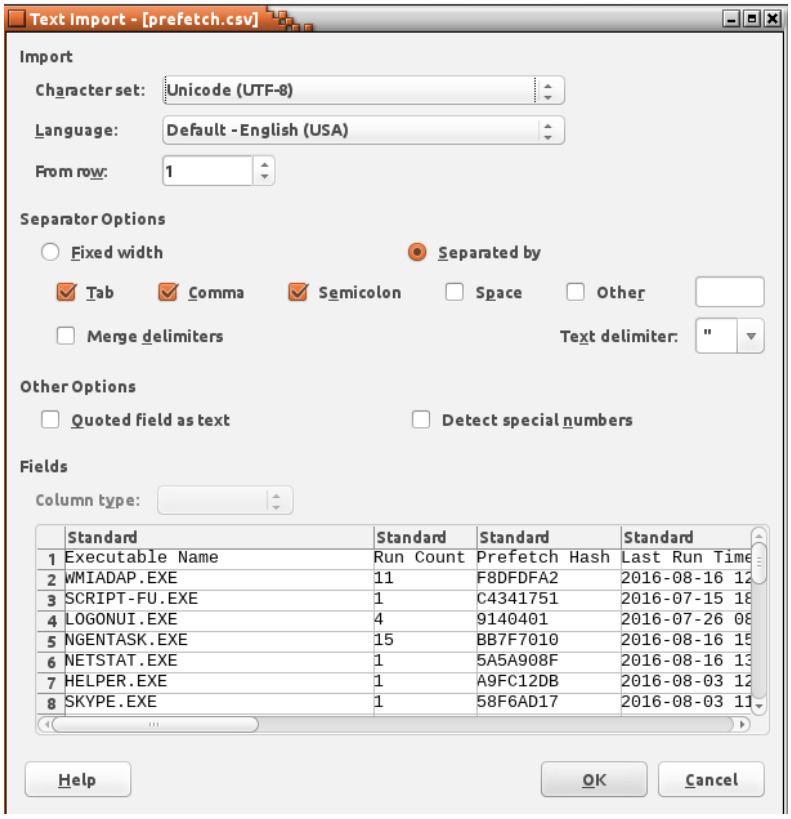



**Figure 86: LibreOffice**

Next students should select all data cells and from Data menu choose sort. Then choose column D (Last Run Time 0) for primary sort key (Sort Key 1).

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Executable Name | Run Count | Prefetch Hash | Last Run Time 0 | Last Run Time 1 | Last Run Time 2 | Last Run Time 3 | Last Run Time 4 | Last Run Time 5 | Last Run Time 6 | Last Run Time 7 |
| 2 | WMIADAP.EXE | 11 | F8DFDFA2 | 2016-08-16 12:58:38 | 2016-08-11 11:13:43 | 2016-08-03 11:43:09 | 2016-08-01 07:38:37 | 2016-07-27 11:47:05 | 2016-07-26 08:21:22 | 2016-07-19 10:35:52 | 2016-07-15 17:46:54 |
| 3 | SCRIPT-FU.EXE | 1 | C4341751 | 2016-07-15 18:01:34 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 4 | LOGONUI.EXE | 4 | 9140401 | 2016-07-26 08:07:56 | 2016-07-15 16:12:22 | 2016-07-14 14:26:57 | 2016-07-14 14:24:07 | N/A | N/A | N/A | N/A |
| 5 | NGENTASK.EXE | 15 | BB7F7010 | 2016-08-16 15:09:46 | 2016-08-16 15:06:55 | 2016-08-16 15:00:56 | 2016-08-16 15:00:57 | 2016-08-16 13:22:13 | 2016-08-11 13:28:07 | 2016-08-11 13:25:25 | 2016-08-01 09:48:47 |
| 6 | NETSTAT.EXE | 1 | 5A5A908F | 2016-08-16 13:34:50 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 7 | HELPER.EXE | 1 | A9FC12DB | 2016-08-03 12:01:32 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 8 | SKYPE.EXE | 1 | 58F6AD17 | 2016-08-03 11:52:11 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 9 | WINDOWS-KB89083 | 1 | 4C40BE8A | 2016-08-16 13:05:57 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 10 | INSTALLAGENT.EX | 29 | 2CA93386 | 2016-08-16 14:13:45 | 2016-08-16 13:00:34 | 2016-08-11 13:28:11 | 2016-08-11 11:14:51 | 2016-08-03 11:54:27 | 2016-08-03 11:44:17 | 2016-08-01 08:46:33 | 2016-08-01 07:37:41 |
| 11 | DSMUSERTASK.EX | 2 | 35CC97B6 | 2016-07-14 13:34:50 | 2016-07-14 13:34:44 | N/A | N/A | N/A | N/A | N/A | N/A |
| 12 | CONTROL.EXE | 5 | 817F8F1D | 2016-08-16 12:57:23 | 2016-07-26 08:28:01 | 2016-07-15 17:12:03 | 2016-07-15 17:04:29 | 2016-07-14 13:36:53 | N/A | N/A | N/A |
| 13 | OPENWITH.EXE | 2 | 5C93E816 | 2016-08-11 13:54:06 | 2016-07-15 17:49:06 | N/A | N/A | N/A | N/A | N/A | N/A |
| 14 | CONSENT.EXE | 18 | 531BD9EA | 2016-08-16 13:50:29 | 2016-08-16 13:03:02 | 2016-08-16 12:58:49 | 2016-08-03 11:57:54 | 2016-07-26 08:33:38 | 2016-07-15 17:53:31 | 2016-07-15 17:48:22 | 2016-07-15 17:12:06 |
| 15 | SEARCHINDEXER.E | 6 | 4A6353B9 | 2016-08-16 12:55:40 | 2016-08-03 11:39:21 | 2016-07-19 10:33:03 | 2016-07-15 17:43:09 | 2016-07-15 17:34:11 | 2016-07-15 17:01:40 | N/A | N/A |
| 16 | SIHOST.EXE | 2 | 2C4C53BA | 2016-08-16 12:55:36 | 2016-07-14 14:24:10 | N/A | N/A | N/A | N/A | N/A | N/A |
| 17 | RDSPNF.EXE | 1 | B55F4711 | 2016-07-15 17:01:44 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 18 | SPPSVC.EXE | 416 | B0F8131B | 2016-08-17 11:58:38 | 2016-08-17 11:28:38 | 2016-08-17 11:17:19 | 2016-08-17 10:58:38 | 2016-08-17 10:28:38 | 2016-08-17 09:58:38 | 2016-08-17 09:28:37 | 2016-08-17 08:58:37 |
| 19 | ARP.EXE | 1 | 2BC38967 | 2016-08-16 13:34:50 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 20 | ANTIALIAS.EXE | 1 | A08E132E | 2016-07-15 18:01:34 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

**Figure 87: Table**

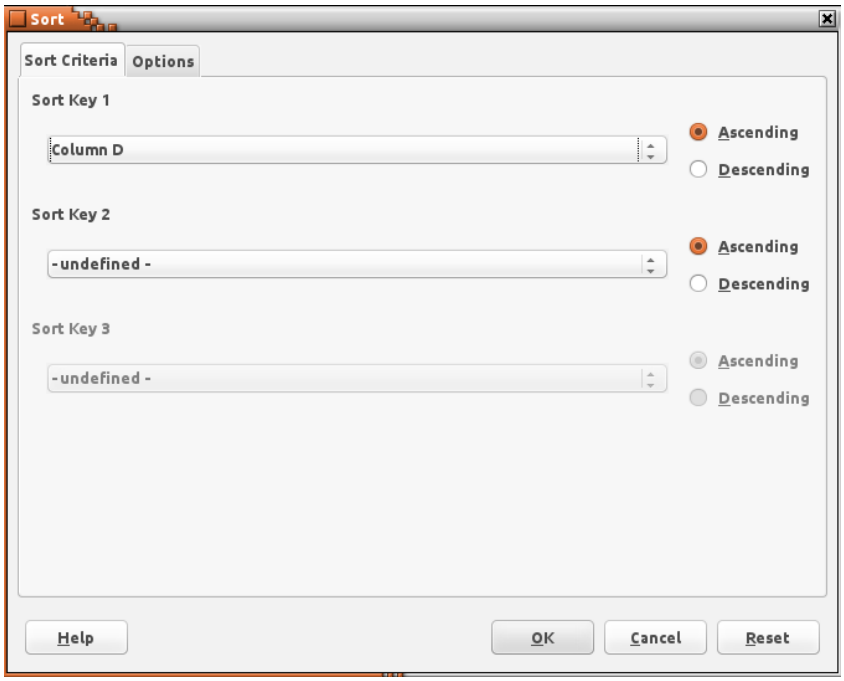



Figure 88: Sorting columns

Table data should now be sorted by last run time of the binaries.

Next scrolling down to the time of the incident, students can find that update.exe binary was run two times at 13:03:03 and 13:03:04.

| | A | B | D | E | F | G |
|---|---|---|---|---|---|---|
| 1 | Executable Name | Run Count | Last Run Time 0 | Last Run Time 1 | Last Run Time 2 | Last Run Time 3 |
| 104 | PLUGIN-CONTAINE | 15 | 2016-08-16 13:03:00 | 2016-08-16 12:56:01 | 2016-08-03 11:53:01 | 2016-08-03 11:45:16 |
| 105 | FLASHPLAYERPLU | 8 | 2016-08-16 13:03:01 | 2016-08-16 13:03:01 | 2016-07-26 08:26:43 | 2016-07-26 08:26:43 |
| 106 | UPDATE.EXE | 2 | 2016-08-16 13:03:04 | 2016-08-16 13:03:03 | N/A | N/A |
| 107 | WINDOWS-KB89083 | 1 | 2016-08-16 13:05:57 | N/A | N/A | N/A |
| 108 | MRT.EXE | 2 | 2016-08-16 13:06:18 | 2016-07-19 11:15:09 | N/A | N/A |

Figure 89: Update.exe run time

Next at 13:10:13 54948tp.exe binary was executed and shortly after that at 13:14:47 mimikatz.exe and browserprocessdump.exe were also run. This confirms that 54948tp.exe was not only created on hard disk but also executed.

| | A | B | D | E | F |
|---|---|---|---|---|---|
| 1 | Executable Name | Run Count | Last Run Time 0 | Last Run Time 1 | Last Run Time 2 |
| 110 | WMIAPSRV.EXE | 6 | 2016-08-16 13:09:32 | 2016-08-16 13:09:32 | 2016-08-16 13:07:30 |
| 111 | 54948TP.EXE | 1 | 2016-08-16 13:10:13 | N/A | N/A |
| 112 | MIMIKATZ.EXE | 1 | 2016-08-16 13:14:47 | N/A | N/A |
| 113 | BROWSERPASSWO | 1 | 2016-08-16 13:14:50 | N/A | N/A |
| 114 | WINSAT.EXE | 3 | 2016-08-16 13:21:55 | 2016-08-01 10:26:19 | 2016-07-20 02:37:28 |
| 115 | W32TM.EXE | 4 | 2016-08-16 13:26:36 | 2016-08-11 13:25:10 | 2016-08-01 09:48:49 |

Figure 90: 54948tp.exe run time

Next, between 13:34:25 and 13:34:51 multiple standard tools returning information about local system were executed. This corresponds to the creation time (13:34:25) and last write time (13:49:59) of SystemProfile\sysinfo.txt file. What's interesting is that whoami.exe and ipconfig.exe tools were also

executed earlier between 13:08:00 and 13:10:00. Students might recall that memory analysis revealed that at 13:07:36 UTC some cmd.exe process was created.

| | A | B | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| 1 | Executable Name | Run Count | Last Run Time 0 | Last Run Time 1 | Last Run Time 2 | Last Run Time 3 | Last Run Time 4 |
| 116 | PING.EXE | 9 | 2016-08-16 13:26:37 | 2016-08-16 13:26:37 | 2016-08-11 13:25:11 | 2016-08-11 13:25:11 | 2016-08-01 09:48:49 |
| 117 | WHOAMI.EXE | 11 | 2016-08-16 13:34:25 | 2016-08-16 13:09:04 | 2016-08-16 13:08:58 | 2016-08-16 13:08:58 | 2016-08-16 13:08:58 |
| 118 | NETSTAT.EXE | 1 | 2016-08-16 13:34:50 | N/A | N/A | N/A | N/A |
| 119 | ARP.EXE | 1 | 2016-08-16 13:34:50 | N/A | N/A | N/A | N/A |
| 120 | IPCONFIG.EXE | 4 | 2016-08-16 13:34:50 | 2016-08-16 13:34:49 | 2016-08-16 13:34:25 | 2016-08-16 13:09:16 | N/A |
| 121 | ROUTE.EXE | 1 | 2016-08-16 13:34:50 | N/A | N/A | N/A | N/A |
| 122 | NETSH.EXE | 3 | 2016-08-16 13:34:51 | 2016-08-16 13:34:51 | 2016-08-16 13:34:50 | N/A | N/A |
| 123 | GPRESULT.EXE | 1 | 2016-08-16 13:34:51 | N/A | N/A | N/A | N/A |
| 124 | DEFRAG.EXE | 6 | 2016-08-16 13:39:08 | 2016-08-16 13:21:58 | 2016-08-11 12:20:42 | 2016-08-01 08:46:42 | 2016-07-25 05:25:01 |
| 125 | CONSENT.EXE | 18 | 2016-08-16 13:50:29 | 2016-08-16 13:03:02 | 2016-08-16 12:58:49 | 2016-08-03 11:57:54 | 2016-07-26 08:33:38 |

**Figure 91: Applications run time**

Finally at 13:59:34 binary nmap.exe was executed for the last time. The other two executions correspond to the reported port scan times. However it should be noted that nmap was also executed earlier around 13:56:xx. Shortly after that at 14:04:44 hydra.exe, tool used for dictionary/brute force attacks against remote services, was also executed.

Finally plink.exe and pscp.exe were also executed. Plink.exe was executed six times in total: 14:10:49, 14:11:20, 14:17:45, 14:20:44, 14:22:45 and 14:23:31. Then pscp.exe was executed at 14:47:12, 14:47:54, and 14:50:09. This suggests that someone might have been trying to log in to some remote host (plink.exe) and then possibly transfer some data in/out (pscp.exe).

Sequence of the events (nmap -> hydra -> plink/pscp) suggests that attacker possibly first tried to scan local network with nmap and then used hydra to crack password to some host on the network. At this point this is however only a speculation and would need further verification with the analysis of network logs.

| | A | B | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| 1 | Executable N | un Cou | Last Run Time 0 | Last Run Time 1 | Last Run Time 2 | Last Run Time 3 | Last Run Time 4 | Last Run Time 5 |
| 130 | NS1027.TMP | 1 | 2016-08-16 13:50:39 | N/A | N/A | N/A | N/A | N/A |
| 131 | NMAP.EXE | 11 | 2016-08-16 13:59:34 | 2016-08-16 13:59:29 | 2016-08-16 13:59:26 | 2016-08-16 13:56:36 | 2016-08-16 13:56:33 | 2016-08-16 13:56:30 |
| 132 | HYDRA.EXE | 10 | 2016-08-16 14:04:44 | 2016-08-16 14:04:44 | 2016-08-16 14:04:44 | 2016-08-16 14:04:44 | 2016-08-16 14:04:44 | 2016-08-16 14:04:44 |
| 133 | INSTALLAGEN | 29 | 2016-08-16 14:13:45 | 2016-08-16 13:00:34 | 2016-08-11 13:28:11 | 2016-08-11 11:14:51 | 2016-08-03 11:54:27 | 2016-08-03 11:44:17 |
| 134 | PLINK.EXE | 6 | 2016-08-16 14:23:31 | 2016-08-16 14:22:45 | 2016-08-16 14:20:44 | 2016-08-16 14:17:45 | 2016-08-16 14:11:20 | 2016-08-16 14:10:49 |
| 135 | CMD.EXE | 18 | 2016-08-16 14:44:17 | 2016-08-16 14:23:05 | 2016-08-16 14:19:45 | 2016-08-16 14:17:24 | 2016-08-16 14:09:37 | 2016-08-16 14:02:52 |
| 136 | PSCP.EXE | 3 | 2016-08-16 14:50:09 | 2016-08-16 14:47:54 | 2016-08-16 14:47:12 | N/A | N/A | N/A |
| 137 | COMPATTELR | 12 | 2016-08-16 15:00:47 | 2016-08-16 15:00:47 | 2016-08-16 13:22:05 | 2016-08-16 13:22:05 | 2016-08-11 11:21:00 | 2016-08-11 11:21:00 |

**Figure 92: Applications run time**

**Prefetch analysis findings and conclusions:**

- Prefetch analysis confirmed some of the previous findings like execution of update.exe (Xtreme RAT) at 13:03:04 or execution of 54948tp.exe at 13:10:13.
- Between 13:34:25 and 13:34:51 a group of system commands were executed to gather information about local system.
- At 14:04:44 Hydra tool was executed. Possibly to perform some dictionary attack.
- Plink.exe tool was executed six times between 14:10:49 and 14:23:31. Possibly to login to some remote system.
- At 14:50:19 PSCP tool was executed. Possibly to download or upload some data to remote host.

## 7.7 System logs analysis

The easiest way to analyse system logs is to use Microsoft Event Viewer[25] (eventvwr.msc) utility which also allows to open log files copied from remote medium. Undoubtedly big advantage of this tool is its graphical interface allowing to easily search through often huge number of log entries or filter out uninteresting events.

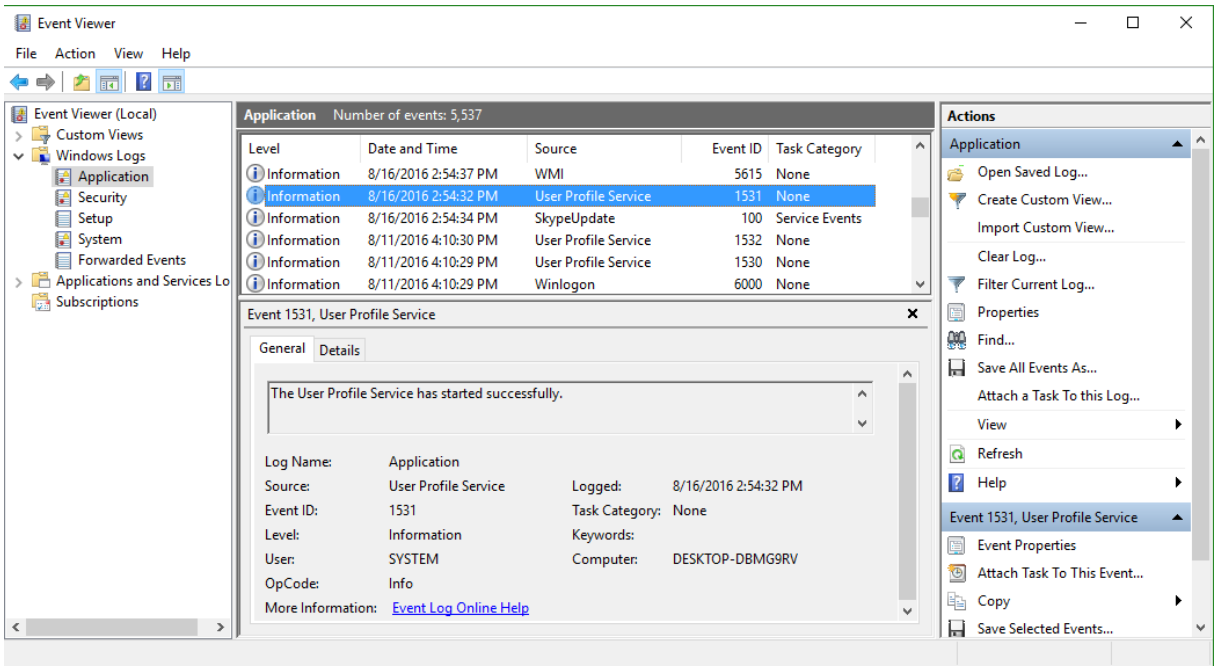



**Figure 93: Event Viewer**

Unfortunately Event Viewer can be only run under Windows operating system. Instead in this task students will use Evtx Parser[26] which is a collection of Perl scripts allowing to parse Windows logs in evtx format.

For starter students should copy all Windows logs from Windows\System32\winevt\Logs to ~/training/ex1/winevt/evtx/.

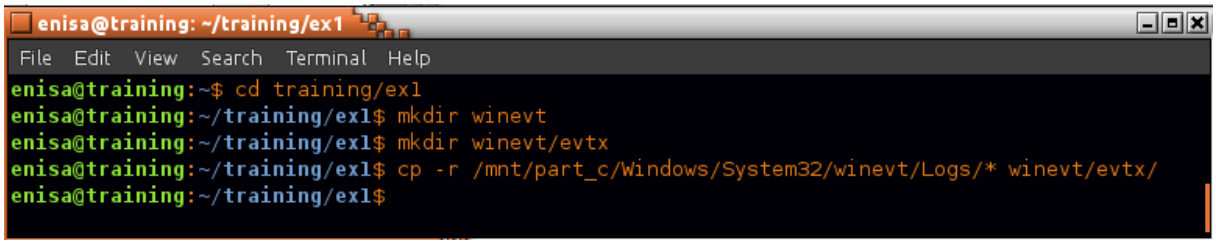



**Figure 94: Copying logs**

In the next step students should convert previously copied EVTX files to XML format using evtxdump.pl utility.

[25] Event Viewer How To https://technet.microsoft.com/en-us/library/cc749408(v=ws.11).aspx (last accessed 30.09.2016)
[26] Evtx Parser Version 1.1.1 http://computer.forensikblog.de/en/ (last accessed 30.09.2016)

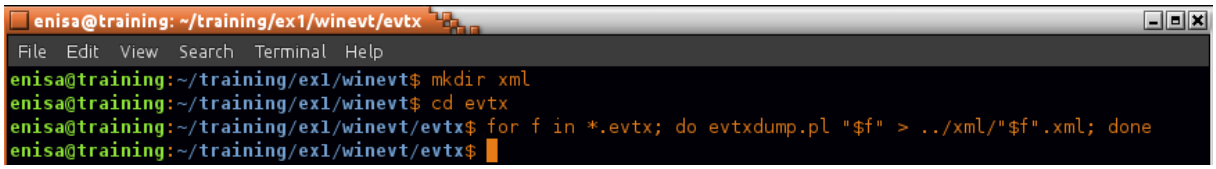



**Figure 95: Convert previously copied EVTX files to XML format**

If everything goes fine log files in XML format should now be available in xml directory. One problem with logs in this format is that they are pretty difficult to analyse manually. Moreover Windows event architecture splits all logs among multiple files. This is useful if analyst want to focus on logs from only one source but might be problematic to correlate logs from all sources.

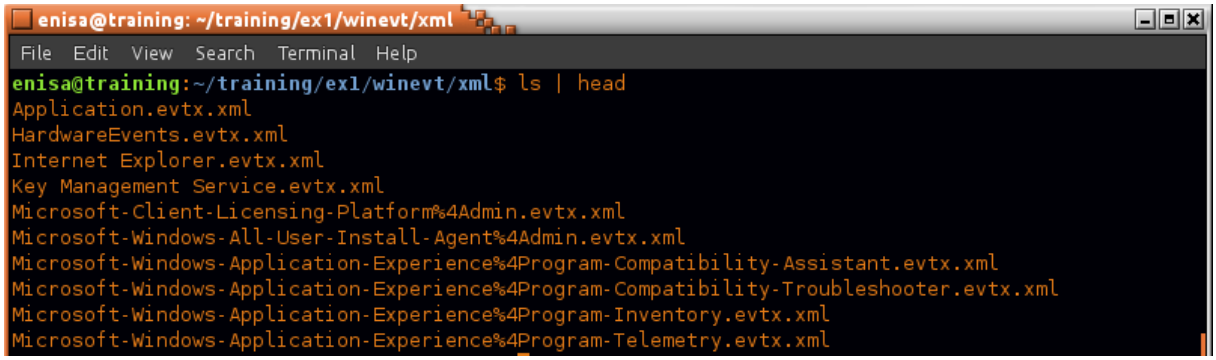



**Figure 96: log files in XML format**

Each XML file consist of multiple Event elements representing separate log entries. Each Event contains multiple child elements giving additional information about what happened[27]. Among the most interesting ones are EventID (information about type of the event), Provider with *EventSourceName* attribute (what application/subsytem reported the event), TimeCreated (when event took place), ProcessID (which process generated event). Additionally, event logs may contain EventData section with information specific to that event[28].

Event IDs are numeric values representing different types of events. When analysing logs in XML format what each event id means can be usually searched online (this is another advantage of using Microsoft Event Viewer which automatically displays event description). For example one of the websites where analyst can check event ID interpretation is Randy's Windows Security Log Encyclopaedia[29]. Moreover in most cases not all event types are of interest to an analyst.

[27] Event Properties https://technet.microsoft.com/en-us/library/cc765981(v=ws.11).aspx (last accessed 30.09.2016)
[28] Event Data https://msdn.microsoft.com/en-us/library/windows/desktop/aa363650(v=vs.85).aspx (last accessed 30.09.2016)
[29] https://www.ultimatewindowssecurity.com/securitylog/encyclopedia/default.aspx (last accessed 30.09.2016)

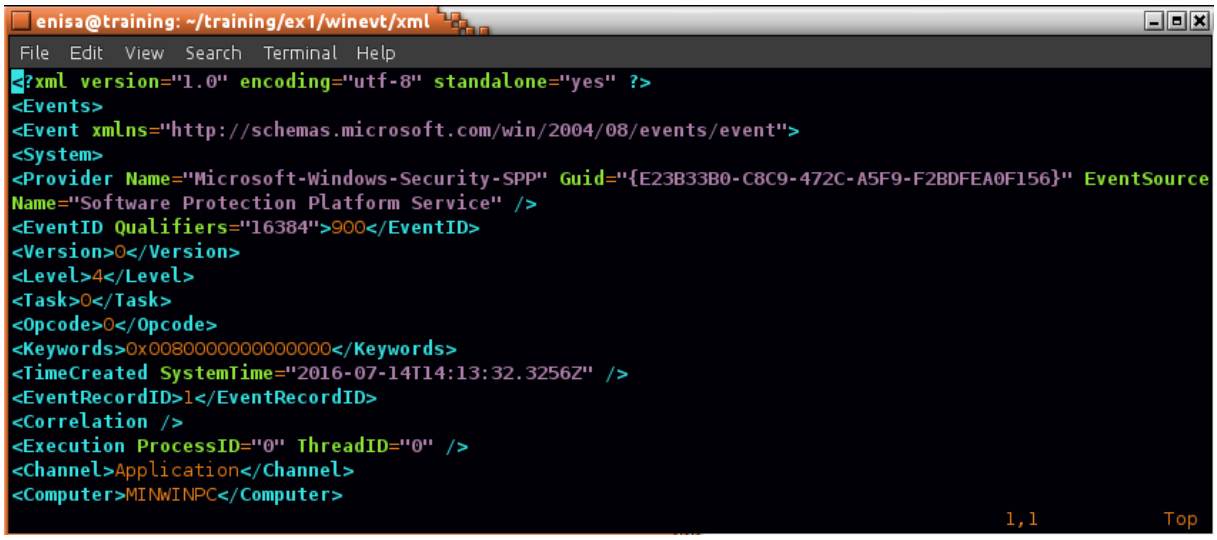



**Figure 97: Log data**

To ease event browsing and filtering there is special script, logparse.py at ~/training/tools, created for the purpose of this training. The script can receive the path to one or more .xml files as input. If the input path is a directory, it will be searched recursively for all files with .xml extension. This can be used to parse all log files at the same time and print them in time sorted order.

Additionally logparse.py allows a user to do some basic filtering using optional parameters.

- *mindate*, *maxdate* – print events from specific time period
- *ids* – comma separated list of event IDs that should be printed
- *patterns* – comma separated list of words that would be searched in the event text

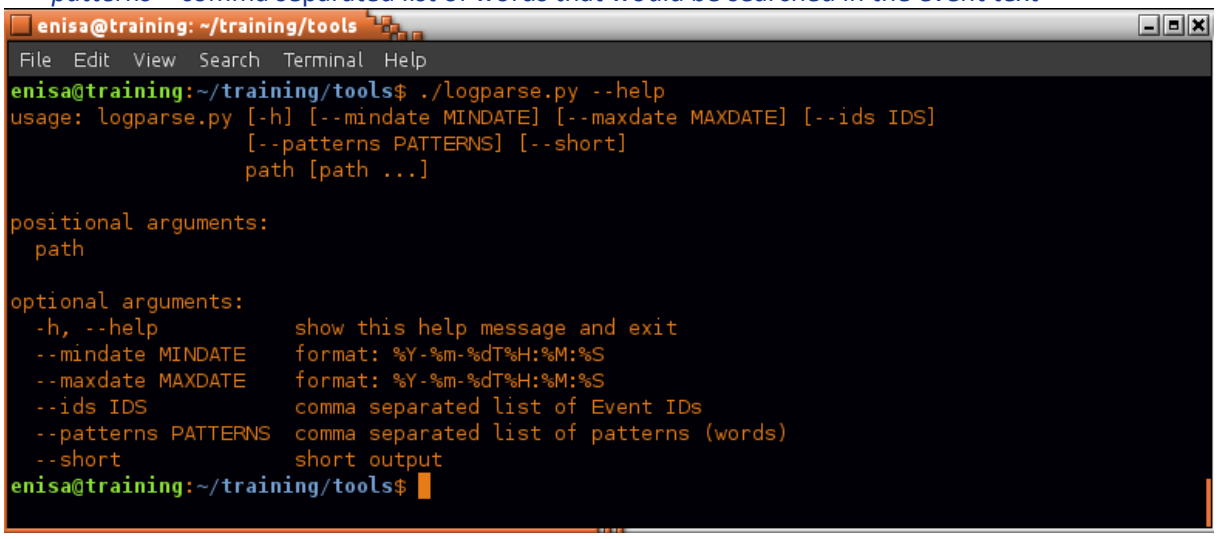



**Figure 98: Logparse.py**

To begin, students can search for all events that were logged between 14:03:00 and 14:05:00 knowing that around that time THC Hydra was executed.

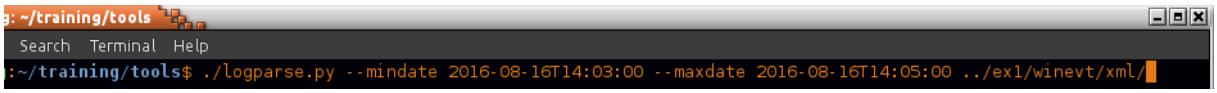



**Figure 99: Logparse.py**

Three events should be printed, two of which mentioning hydra.exe in EventData section. The EventID for both events is 4798 and they were logged respectively at 14:03:21 and 14:04:43 – that is the time when hydra.exe was executed (as found during prefetch analysis).

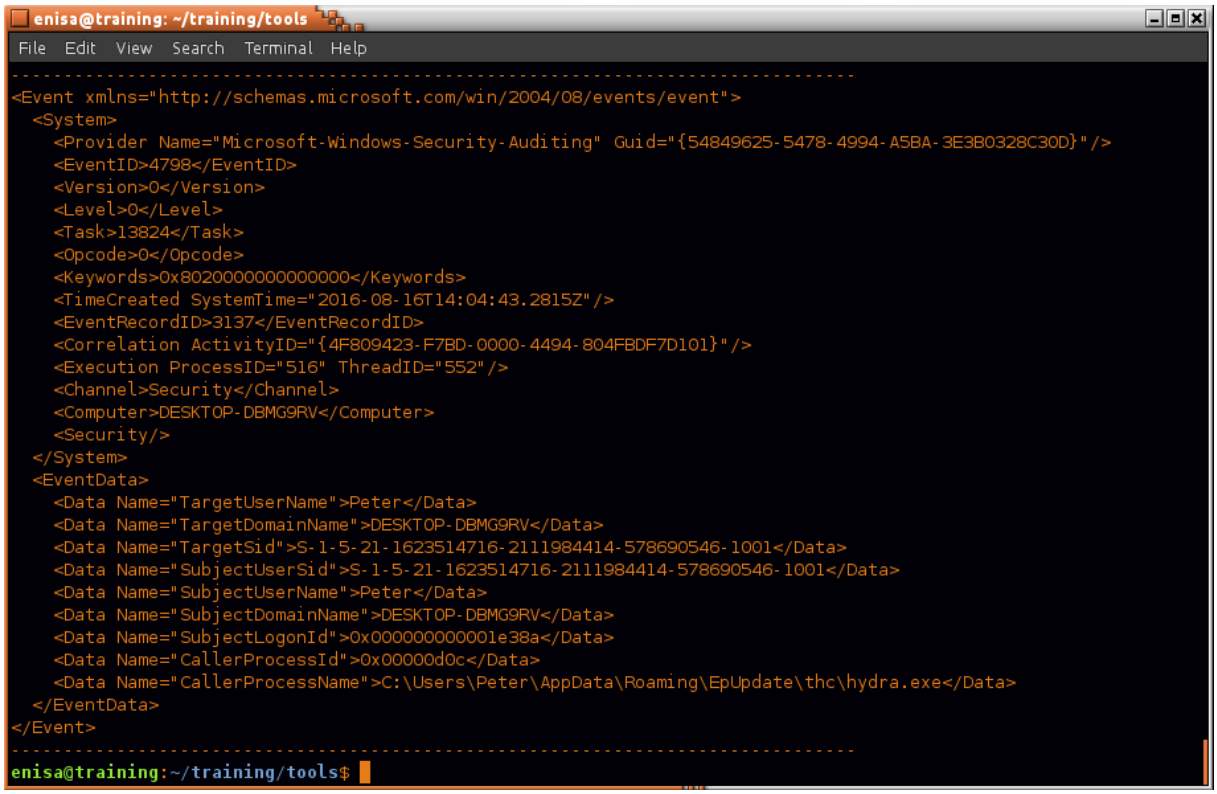
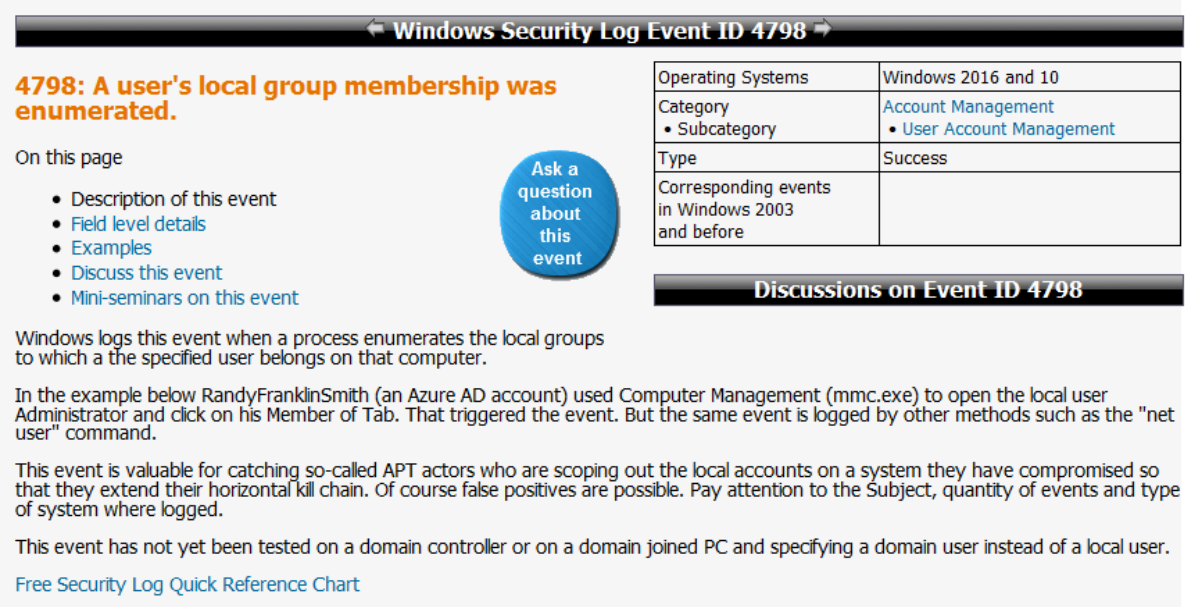



**Figure 100: Log data**

A further check online at Randy's Windows Security Log Encyclopaedia can reveal that event 4798 informs that: "A user's local group membership was enumerated":



Windows Security Log Event ID 4798

**4798: A user's local group membership was enumerated.**

| | |
|---|---|
| Operating Systems | Windows 2016 and 10 |
| Category<br>• Subcategory | Account Management<br>• User Account Management |
| Type | Success |
| Corresponding events in Windows 2003 and before | |

On this page

- Description of this event
- Field level details
- Examples
- Discuss this event
- Mini-seminars on this event

Ask a question about this event

Discussions on Event ID 4798

Windows logs this event when a process enumerates the local groups to which a the specified user belongs on that computer.

In the example below RandyFranklinSmith (an Azure AD account) used Computer Management (mmc.exe) to open the local user Administrator and click on his Member of Tab. That triggered the event. But the same event is logged by other methods such as the "net user" command.

This event is valuable for catching so-called APT actors who are scoping out the local accounts on a system they have compromised so that they extend their horizontal kill chain. Of course false positives are possible. Pay attention to the Subject, quantity of events and type of system where logged.

This event has not yet been tested on a domain controller or on a domain joined PC and specifying a domain user instead of a local user.

Free Security Log Quick Reference Chart

**Figure 101: 4798: A user's local group membership was enumerated. Source: https://www.ultimatewindowssecurity.com/securitylog/encyclopedia/event.aspx?eventid=4798**

As for the next step students might want to look for other events mentioning “hydra.exe” phrase – possibly logged at different period of time. This can be done by specifying *pattern* filter to logparse.py.

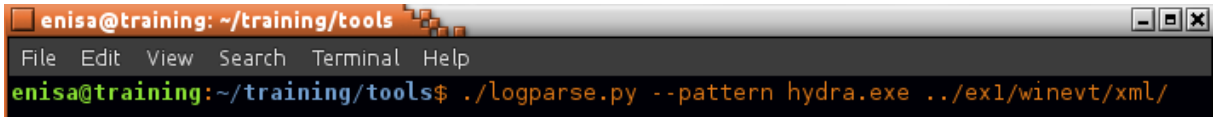



**Figure 102: Logparse.py**

One more 4798 event is found, logged at 14:02:04 – one minute before time period chosen for the first query.

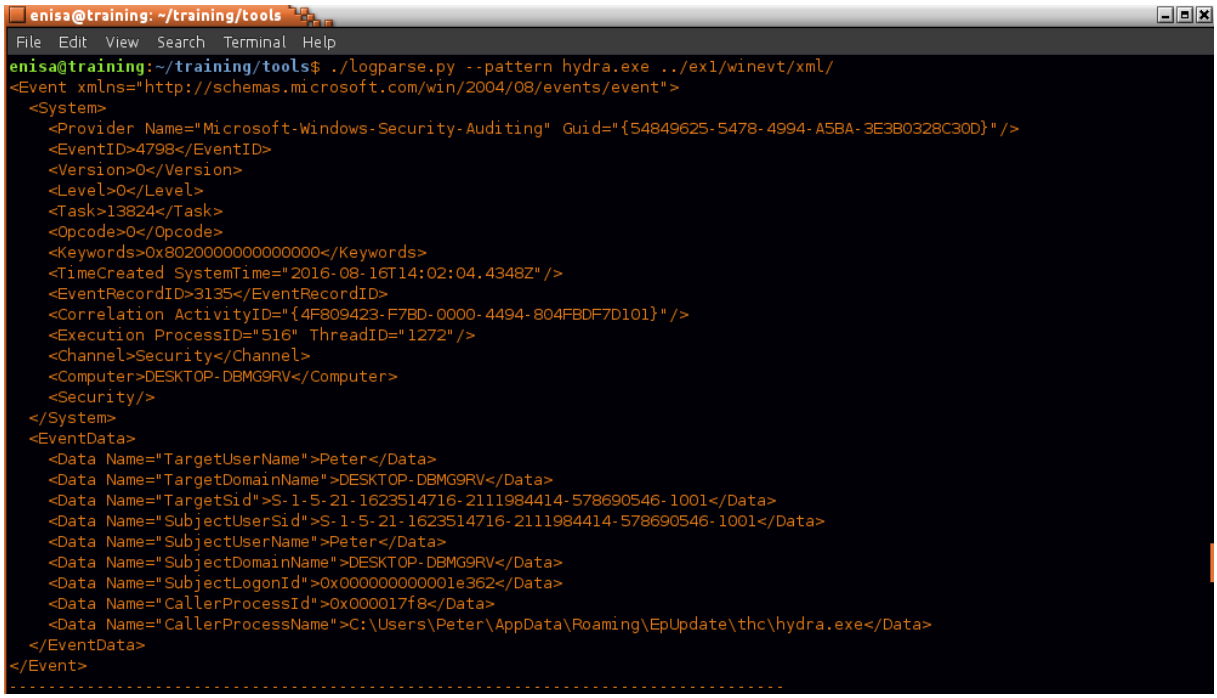



**Figure 103: Log data**

During forensic investigation there is frequently a need to determine time periods when computer was up and running. Knowing when computer was up can be very helpful when correlating logs from other sources like network logs or logs on other hosts.

One way to determine this is to search in system logs for events with IDs 6005, 6006 and 6008:

- 6005 – The Event log service was started.[30]
- 6006 – The Event log service was stopped.[31]
- 6008 – The previous system shutdown at %1 on %2 was unexpected.[32]

However analyst needs to remember that 6006 event won't be logged if computer gets suddenly shutdown or rebooted. In such situation analyst should search for last known timestamp (in event logs, system registry, filesystem timeline, etc.) before shutdown.

[30] Event ID: 6005 Explanation https://www.microsoft.com/technet/support/ee/transform.aspx?ProdName=Windows%20Operating%20System&ProdVer=10.0&EvtID=6005&EvtSrc=EventLog&LCID=1033 (last accessed 30.09.2016)

[31] Event ID: 6006 Explanation https://www.microsoft.com/technet/support/ee/transform.aspx?ProdName=Windows%20Operating%20System&ProdVer=10.0&EvtID=6006&EvtSrc=EventLog&LCID=1033 (last accessed 30.09.2016)

[32] Event ID: 6008 Explanation https://www.microsoft.com/technet/support/ee/transform.aspx?ProdName=Windows%20Operating%20System&ProdVer=10.0&EvtID=6008&EvtSrc=EventLog&LCID=1033 (last accessed 30.09.2016)

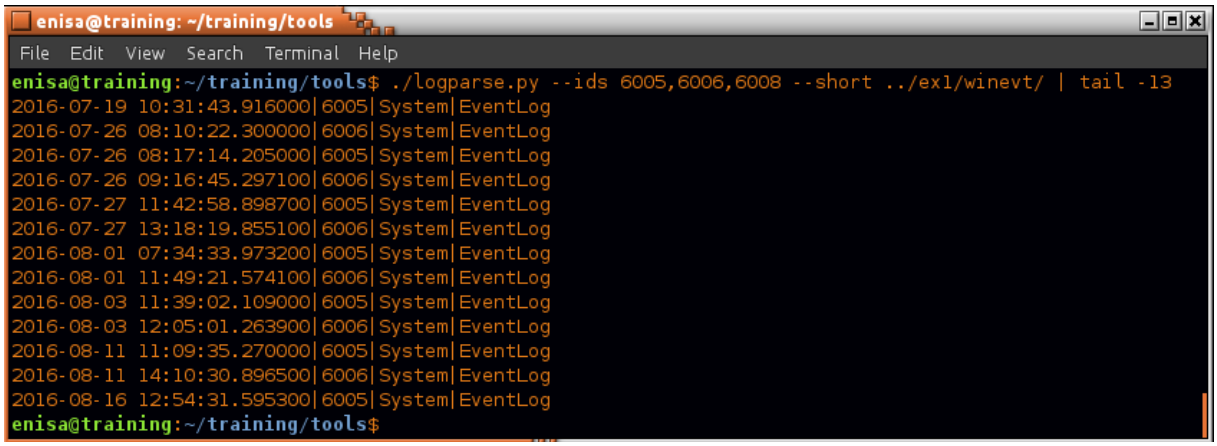



**Figure 104: Logparse.py**

# 8. Registry analysis

## 8.1 Copying and viewing the Registry

In this task students will copy registry files from the mounted disk and use MiTeC Windows Registry Recovery[33] tool to view the content of the Windows registry.

Main registry files used by Windows 10 can be found at %SystemRoot%\System32\config\ directory and are[34]:

- SYSTEM – HKEY_CURRENT_CONFIG
- SAM – HKEY_LOCAL_MACHINE\SAM
- SECURITY – HKEY_LOCAL_MACHINE\Security
- SOFTWARE – HKEY_LOCAL_MACHINE\Software
- DEFAULT – HKEY_USERS\.DEFAULT

Moreover user specific hives can be found in user profile directory C:\Users\{Username}:

- NTUSER.DAT
- AppData\Local\Microsoft\Windows\UsrClass.dat

Locations of registry files in other Windows versions might slightly differ.

Students should start by copying all registry files to separate directory at ~/training/ex1/registry:

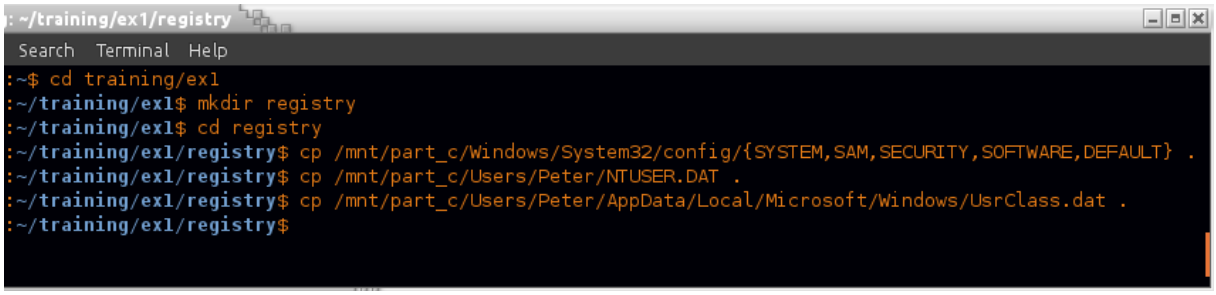



**Figure 105: Copying all registry files to separate directory**

Then to view content of the registry users can use Windows Registry Recovery (WRR) tool which is located at ~/training/tools/WRR/WRR.exe and should be started using Wine.

[33] Windows Registry Recovery http://www.mitec.cz/wrr.html (last accessed 30.09.2016)
[34] Registry Hives https://msdn.microsoft.com/pl-pl/library/windows/desktop/ms724877(v=vs.85).aspx (last accessed 30.09.2016)

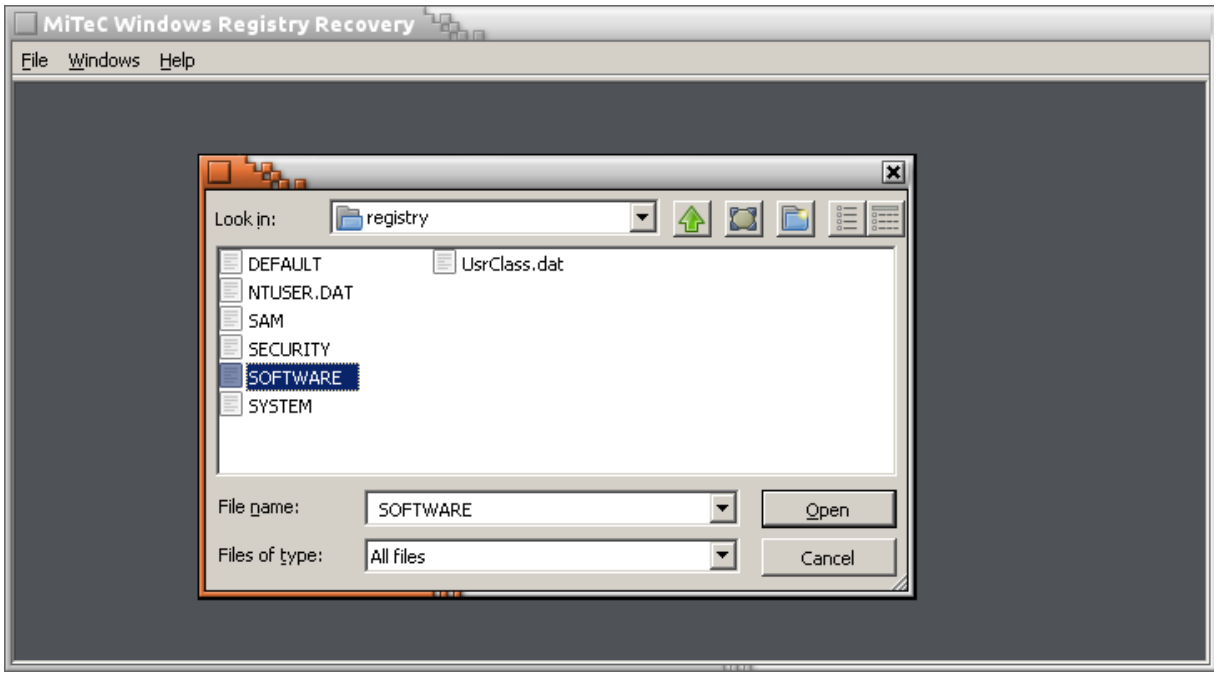



**Figure 106: Windows Registry Recovery (WRR) tool**

For example, using WRR students can open HKLM\Software hive located in SOFTWARE file.

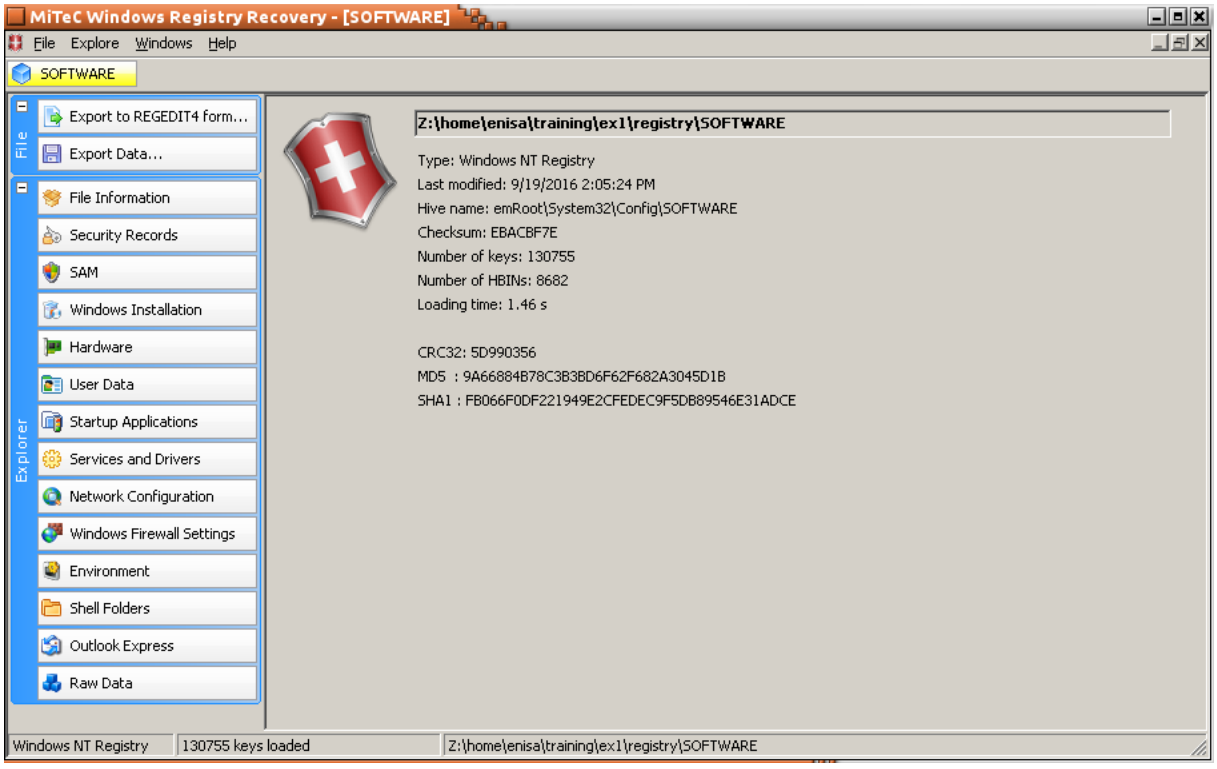



**Figure 107: Windows Registry Recovery (WRR) tool**

Now using options from the left panel, students can extract information from the registry about the operating system. Though they should note that some types of information can be extracted only from a specific registry hive.

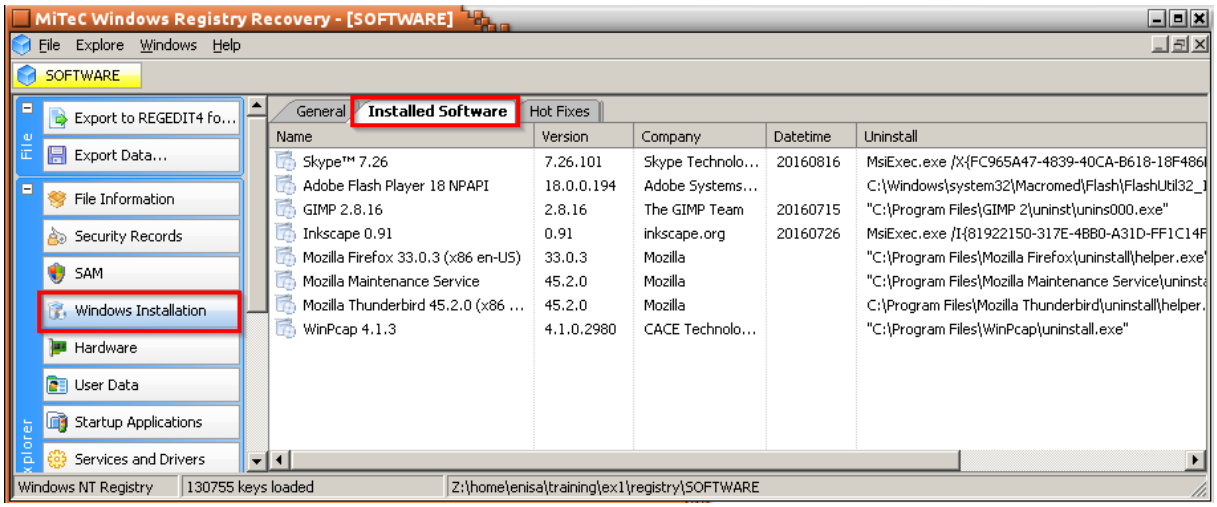



**Figure 108: Windows Registry Recovery (WRR) tool**

Additionally using the *Raw Data* option, students can preview the original registry structure from a given hive.

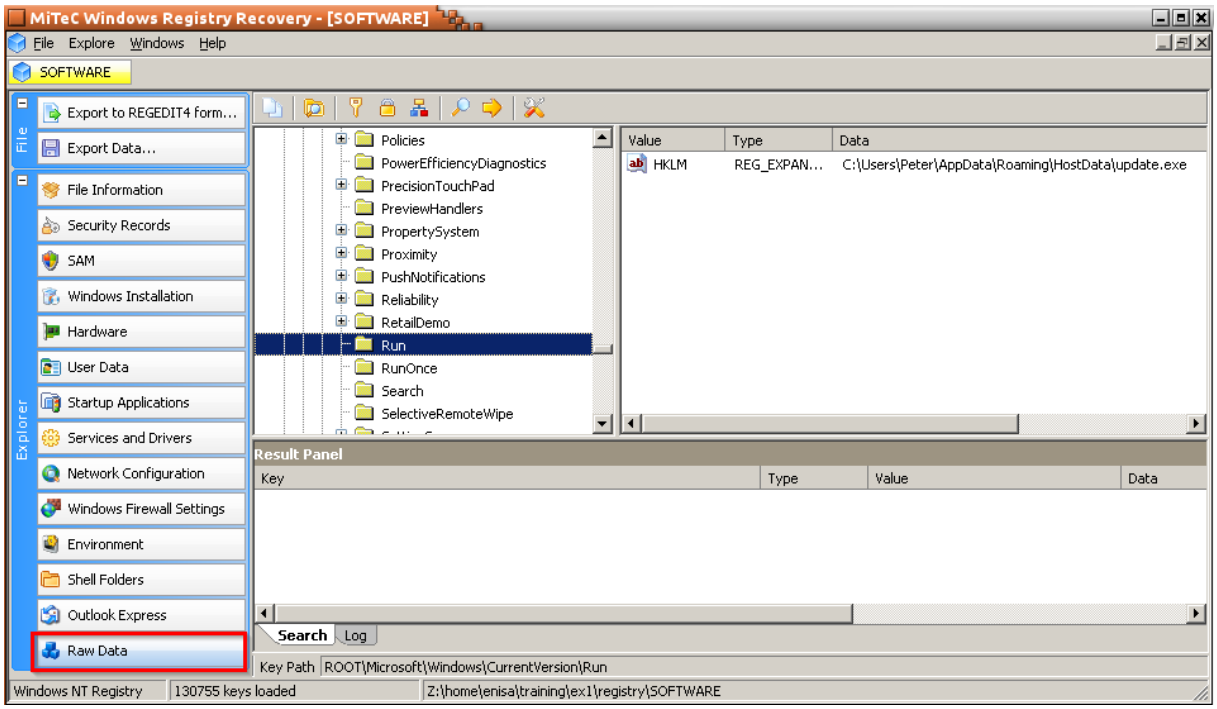



**Figure 109: Windows Registry Recovery (WRR) tool**

## 8.2 Inspecting registry timeline

From the forensic point of view, one very interesting characteristic of the Windows registry is that each registry sub key consists of a last modification timestamp. This can be leveraged to check which registry sub keys were modified around the time of the incident.

To generate a list of all registry sub keys sorted by the date of last modification, students can use the regtime plugin of RegRipper tool.

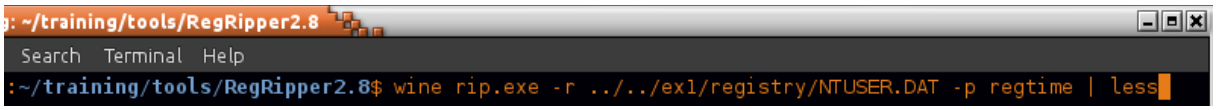



**Figure 110: Regtime tool**

By inspecting the timeline created from the NTUSER.DAT file, students can notice that at 13:02:57 *Run* and *RunOnce* subkeys (used for autostarting applications when user logs in to the system) were modified. Additionally at 13:03:10 some strangely named sub key – GhCtxq8t – was also modified.

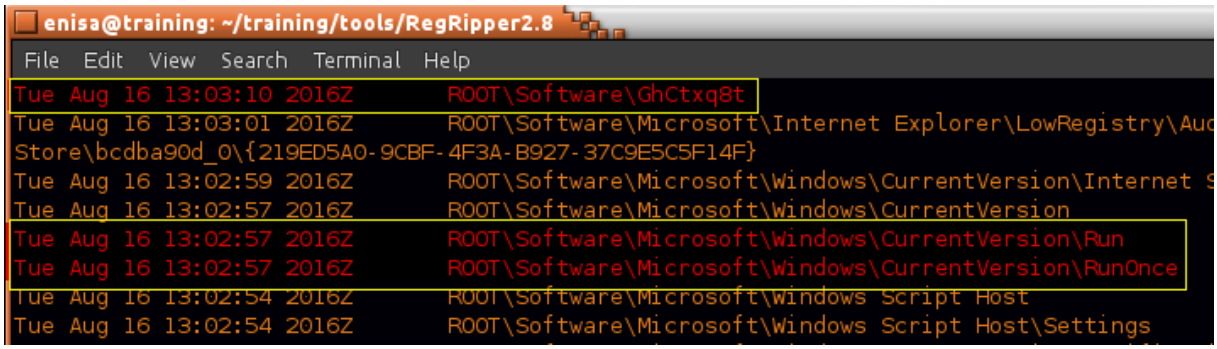



**Figure 111: RegRipper tool**

Further inspection of NTUSER.DAT with the WRR tool reveals that GhCtxq8t looks to be used by the update.exe process. *FirstExecution* value of the GhCtxq8t subkey confirms previous observations that update.exe was installed in the system and executed for the first time at 13:03:10 UTC (15:03:10 local time).

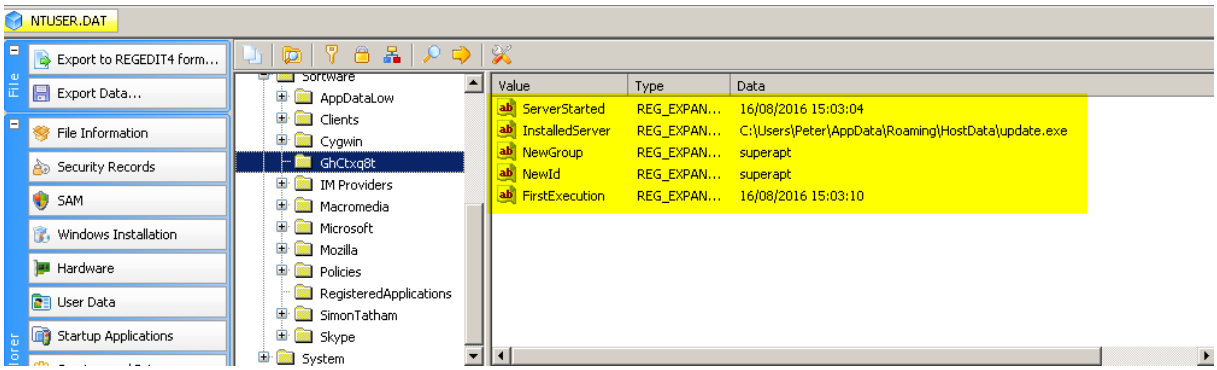



**Figure 112: Windows Registry Recovery (WRR) tool**

Further analysis of the registry timeline created from NTUSER.DAT reveals that PuTTY-related sub keys were modified at 14:11:26 what corresponds to the time of Plink.exe execution (as found during prefetch analysis).

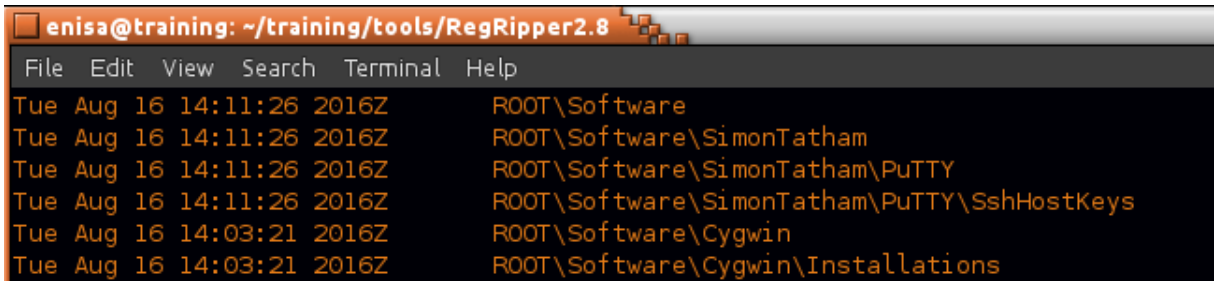



**Figure 113: RegRipper**

Analysis of SSHHostKeys shows it contains single value with RSA key from 192.168.5.10.

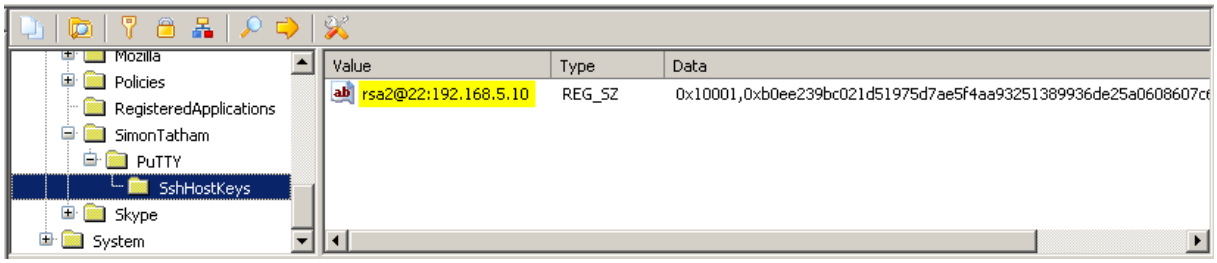



**Figure 114: Registry settings**

This suggests that at 14:11:26 someone was trying to connect over SSH to 192.168.5.10 host.

## 8.3 UserAssist

The Windows operating system stores information about frequently used applications. This information is stored in NTUSER.DAT as a group of ROT13 encoded entries in UserAssist key[35]:

Software\Microsoft\Windows\CurrentVersion\Explorer\UserAssist.

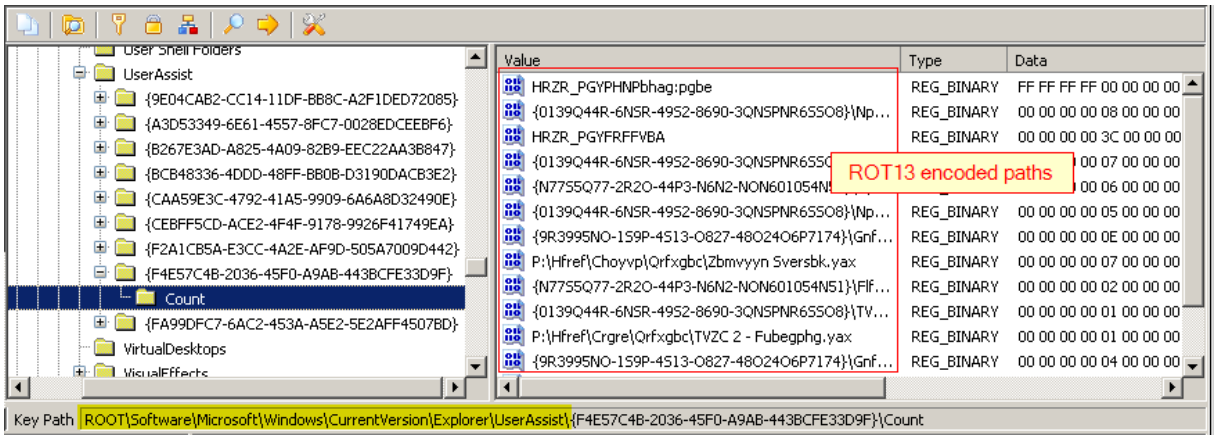



**Figure 115: Registry settings**

To quickly decode and extract information about UserAssist entries students can use Userassist plugin from the RegRipper tool.

[35] UserAssist http://forensicartifacts.com/2010/07/userassist/ (last accessed 30.09.2016)


Figure 116: RegRipper tool

From the plugin output, students can read that at 13:50:29 winpcap-nmap-4.13.exe executable was started. This is shortly before network scans were performed (13:59:29-13:59:36).

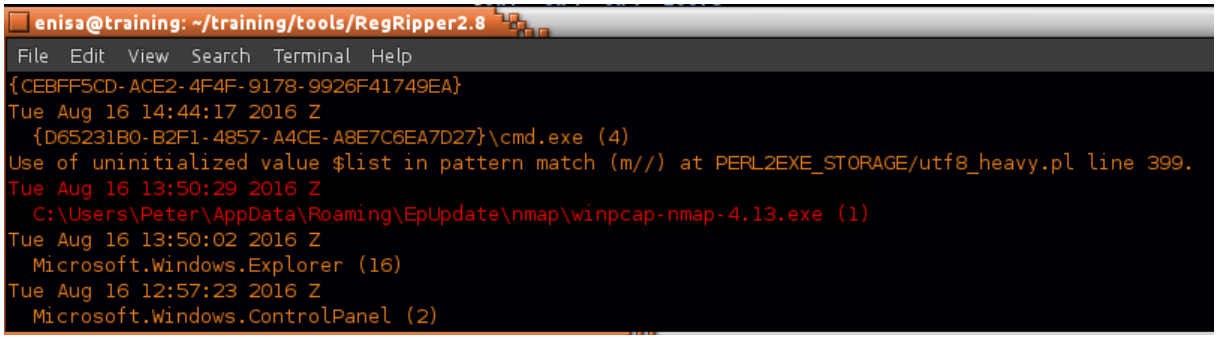



Figure 117: RegRipper tool

Moreover at 12:55:53, a shortcut to the Mozilla Firefox web browser was used which is consistent with previous observations of user being infected around 13:02:50 after visiting a malicious website with the Mozilla Firefox browser.

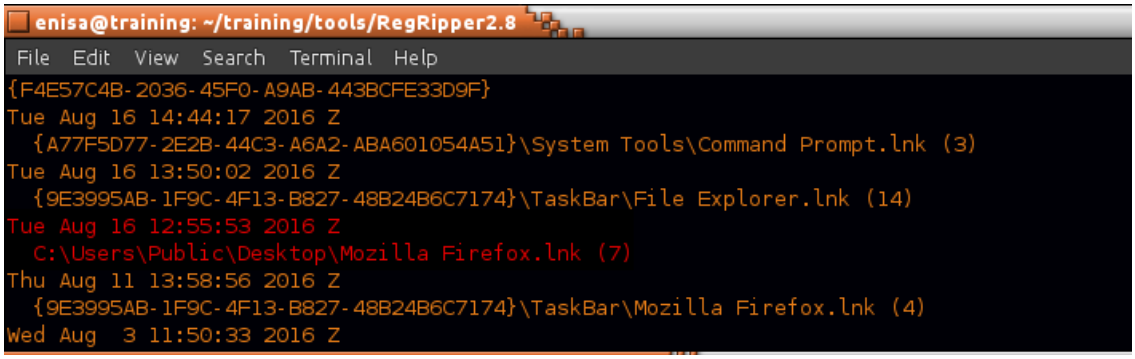



Figure 118: RegRipper tool

## 8.4 List of installed applications

During forensic investigation, it is important to obtain a list of applications installed in the system. Knowing what applications were present in the operating system can give an analyst insight into user activities in the operating system as well as information about potential attack vectors (e.g. presence of file sharing applications, usage of outdated applications or installation of certain application directly preceding an incident). Moreover knowing what applications were present in the system, an analyst can check if some of them were storing additional log data that might give additional information about the incident.

When an application is installed in the system, it usually leaves multiple traces in the system registry. Keys worth inspecting are:

- HKLM\SOFTWARE\Microsoft\Windows\CurrentVersion\Uninstall
- HKLM\SOFTWARE\Classes\Installer\Products

- HKLM\SOFTWARE (subkeys used by applications)
- HKLM\SOFTWARE\Wow6432Node[36]
- HKLM\SOFTWARE\Wow6432Node\Microsoft\Windows\CurrentVersion\Uninstall

Though it is important to keep in mind that not all applications leave traces in the system registry (e.g. some portable applications). In such case it might be necessary to search for such applications by inspecting some common filesystem locations (Desktop, C:\, C:\Program Files, etc.).

This task students should start by opening with the WRR tool SOFTWARE registry file. Note that since the analysed operating system is a 32bit version, there is no Wow6432Node key in Software hive.

Now students should navigate in WRR to Microsoft\Windows\CurrentVersion\Uninstall key.

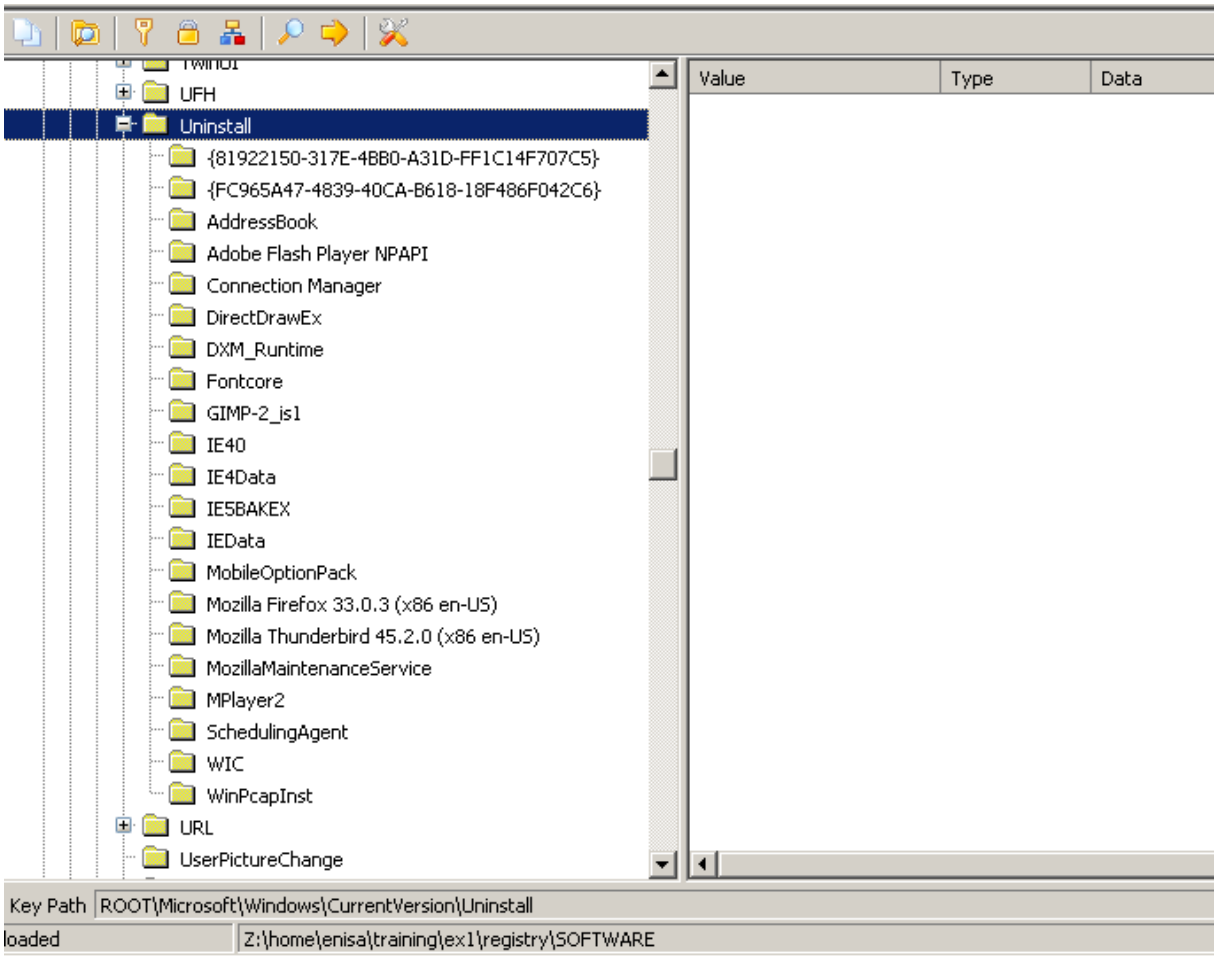



**Figure 119: Registry settings**

Each Uninstall sub key contains some information about application (varying between sub keys) like installation date, path to uninstall binary, app version or install source.

[36] 32-bit and 64-bit Application Data in the Registry https://msdn.microsoft.com/en-us/library/windows/desktop/ms724072(v=vs.85).aspx (last accessed 30.09.2016)

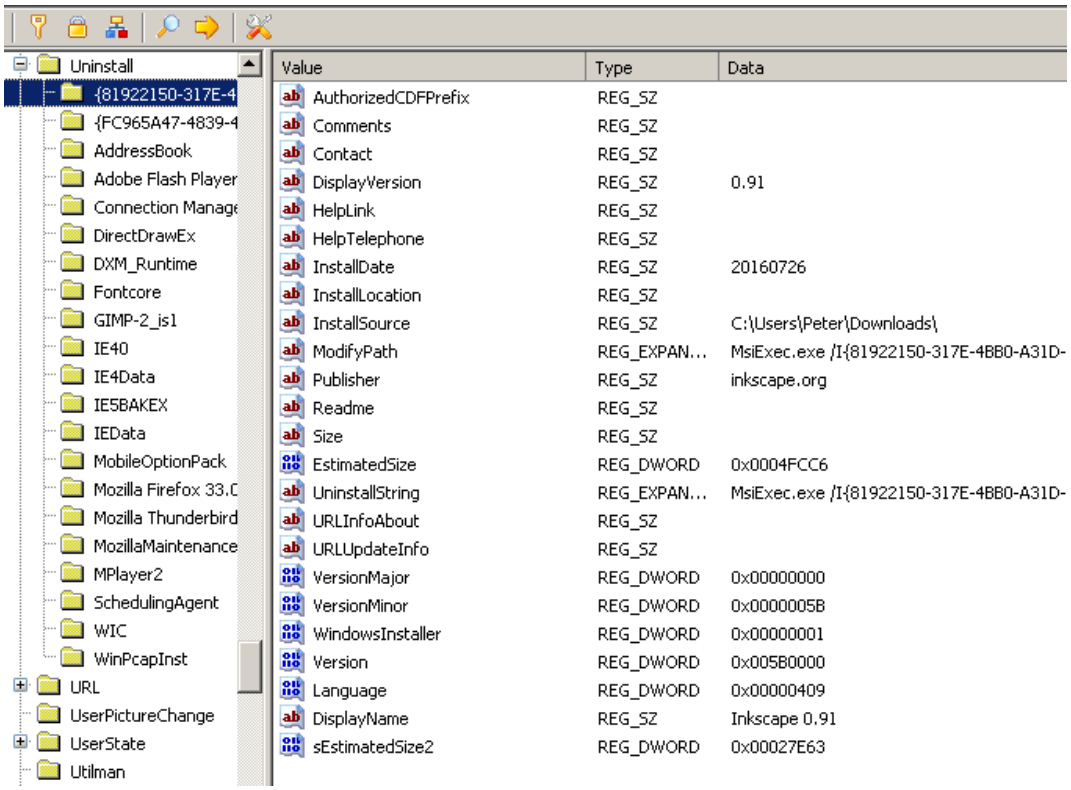



**Figure 120: Registry settings**

Based on information found in Uninstall key, students can determine that during the incident the system had an outdated version of Mozilla Firefox (33.0.3) and the Adobe Flash Plugin (18.0.0.194). This might have played important role in workstation infection after the user visited the malicious website.

| Value | Type | Data |
|---|---|---|
| DisplayName | REG_SZ | Adobe Flash Player 18 NPAPI |
| Publisher | REG_SZ | Adobe Systems Incorporated |
| DisplayVersion | REG_SZ | 18.0.0.194 |
| HelpLink | REG_SZ | http://www.adobe.com/go/flashplayer_support/ |
| NoModify | REG_DWORD | 0x00000001 |
| NoRepair | REG_DWORD | 0x00000001 |
| RequiresIESysFile | REG_SZ | 4.70.0.1155 |
| URLInfoAbout | REG_SZ | http://www.adobe.com |
| URLUpdateInfo | REG_SZ | http://www.adobe.com/go/getflashplayer/ |
| VersionMajor | REG_DWORD | 0x00000012 |
| VersionMinor | REG_DWORD | 0x00000000 |
| UninstallString | REG_SZ | C:\Windows\system32\Macromed\Flash\FlashUtil32_18_0_0_194_Plugin.exe -maintain plugin |
| DisplayIcon | REG_SZ | C:\Windows\system32\Macromed\Flash\FlashUtil32_18_0_0_194_Plugin.exe |
| EstimatedSize | REG_DWORD | 0x0000463B |

**Figure 121: Registry settings**

| Value | Type | Data |
|---|---|---|
| Comments | REG_SZ | Mozilla Firefox 33.0.3 (x86 en-US) |
| DisplayIcon | REG_SZ | C:\Program Files\Mozilla Firefox\firefox.exe,0 |
| DisplayName | REG_SZ | Mozilla Firefox 33.0.3 (x86 en-US) |
| DisplayVersion | REG_SZ | 33.0.3 |
| HelpLink | REG_SZ | https://support.mozilla.org |
| InstallLocation | REG_SZ | C:\Program Files\Mozilla Firefox |
| Publisher | REG_SZ | Mozilla |
| UninstallString | REG_SZ | "C:\Program Files\Mozilla Firefox\uninstall\helper.exe" |
| URLUpdateInfo | REG_SZ | https://www.mozilla.org/firefox/33.0.3/releasenotes |
| URLInfoAbout | REG_SZ | https://www.mozilla.org |
| NoModify | REG_DWORD | 0x00000001 |
| NoRepair | REG_DWORD | 0x00000001 |
| EstimatedSize | REG_DWORD | 0x000135EB |
| sEstimatedSize2 | REG_DWORD | 0x000135D3 |

**Figure 122: Registry settings**

When the exact install date is not given, students can check the last modification date of given Uninstall sub key by right clicking on the sub key and choosing *Properties* from the context menu.

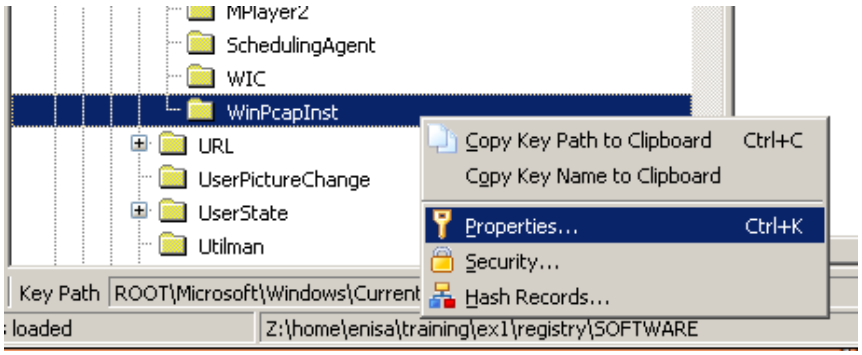



**Figure 123: Registry settings**

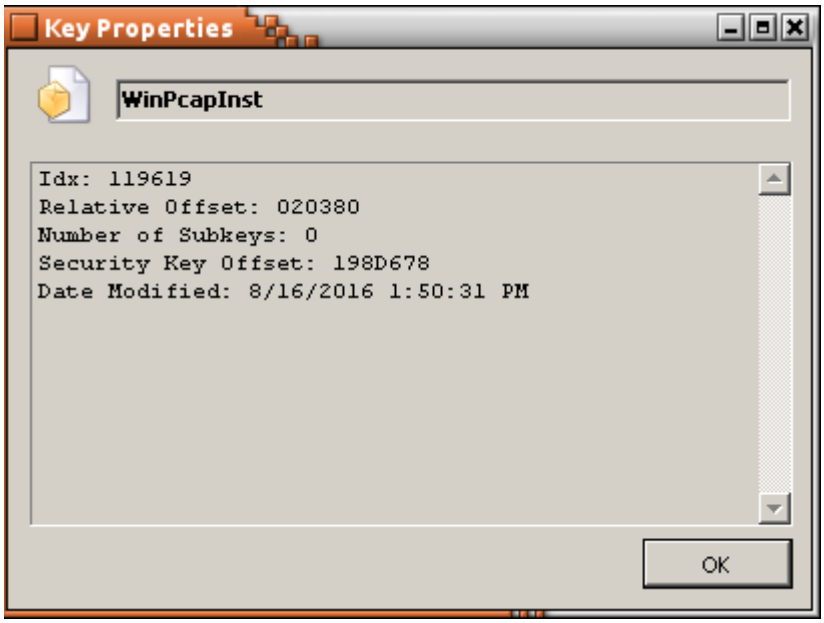



**Figure 124: Key properties**

In this case, it shows that WinPcapInst was likely installed around 13:50:31 which is consistent with previous findings of winpcap-nmap-4.13.exe binary being executed at 13:50:29.

# 9. Building the timeline

To get better picture of the whole incident at the end it is worth to build timeline with all timestamps collected from different sources. List below presents all timestamps obtained from the previous tasks.

Observations that should be correlated with other logs (network logs, logs from other hosts) were additionally bolded.

| TIMESTAMP [UTC] | OBSERVATION | EVIDENCE SOURCE |
|---|---|---|
| 12:54:24 | Start of System process | Memory analysis |
| 12:54:31 | Start of Event log service | System logs |
| 12:55:53 | Start of firefox.exe | Prefetch files<br>UserAssist keys |
| 13:02:46 | **User visits http://blog.mycompany.ex/** | Firefox history |
| 13:02:50 - 13:03:17 | **Browser downloads pages from http://blog.mysportclub.ex/wp-content/uploads/hk/ (EK)** | Firefox history,<br>Filesystem analysis |
| 13:02:53 | Creation of Firefox cache file possibly containing exploit code (CVE-2012-3993) | AV scan<br>Filesystem analysis |
| 13:02:56 | **Creation of 3568226350[1].exe file (referred in one of the cache files)** | AV scan<br>Filesystem analysis |
| 13:02:57 | Creation of svchost.exe binary in %TEMP% directory | Filesystem analysis |
| 13:02:57 | Start of svchost.exe process containing Xtreme RAT code | Memory analysis |
| 13:02:57 | Modification of Run and RunOnce keys | Registry analysis |
| 13:02:58 | Start of second explorer.exe process containing Xtreme RAT code (possible Run PE) | Memory analysis |
| 13:03:04 | Start of update.exe process with Xtreme RAT code | Memory analysis |
| 13:03:10 | Modification of GhCtxq8t registry key (update.exe) | Registry analysis |
| 13:03:16 | Firefox flash plugin crash report | Firefox crash reports |
| 13:07:36 | Start of some cmd.exe process | Memory analysis |
| 13:10:03 | Creation of 54948tp.exe executable in %TEMP% directory | Filesystem analysis |
| 13:10:13 | Execution of 54948tp.exe | Prefetch files |
| 13:10:13-13:14:47 | **Time period when http://blog.mysportclub.ex/wp-content/uploads/hk/files/data_32.bin was downloaded** | Python decompilation |

| | | |
|---|---|---|
| 13:14:47 | Creation of %APPDATA%\EpUpdate folder containing multiple hacking tools | Filesystem analysis |
| 13:14:47 | Creation of %TEMP%\SystemProfile folder containing results of execution various commands | Filesystem analysis |
| 13:14:47 | Execution of mimikatz.exe and creation of mimikatz.log file | Prefetch files<br>Filesystem analysis |
| 13:14:50 | Execution of browserpassworddump.exe and creation of bpd.log | Prefetch files<br>Filesystem analysis |
| 13:34:25 | Creation of sysinfo.txt in %TEMP%\SystemProfile | Filesystem analysis |
| 13:42:12 | Start of some cmd.exe process | Memory analysis |
| 13:50:29 | Start of winpcap-nmap-4.13.exe | UserAssist |
| 13:59:29 | **Port scan of 192.168.5.1** | Filesystem analysis |
| 13:59:34 | **Port scan of 192.168.5.10** | Filesystem analysis |
| 13:59:36 | **Port scan of 192.168.5.15** | Filesystem analysis |
| 14:02:04 | **Execution of hydra.exe process (possible dictionary attack)** | System logs |
| 14:04:44 | **Execution of Hydra.exe (possible dictionary attack)** | Prefetch files<br>System logs |
| 14:08:30 | Start of some cmd.exe process | Memory analysis |
| 14:10:49 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:11:20 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:11:26 | Modification of PuTTY SshHostKeys (RSA key pointing to 192.168.5.10) | Registry analysis |
| 14:17:45 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:18:48 | Start of some cmd.exe process | Memory analysis |
| 14:20:44 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:22:45 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:23:02 | Start of some cmd.exe process | Memory analysis |
| 14:23:31 | **Possible login to some remote host (Plink.exe execution)** | Prefetch files |
| 14:23:46 | Start of some cmd.exe process | Memory analysis |
| 14:47:12 | **Execution of PSCP tool, possibly to download/upload some data from remote host** | Prefetch files |

| | | |
|---|---|---|
| 14:47:54 | **execution of PSCP tool, possibly to download/upload some data from remote host** | Prefetch files |
| 14:50:09 | **execution of PSCP tool, possibly to download/upload some data from remote host** | Prefetch files |

# 10. Summary and next steps

In this exercise, students have learnt how to use various tools to perform forensic analysis of a compromised workstation with the Windows 10 operating system. The exercise started with the analysis of the memory dump using Volatility Framework. Then students proceeded to the analysis of the artefacts found on the disk image. To ease initial analysis, memory was scanned using Yara signatures and disk was scanned with ClamAV antivirus. During disk analysis, students created a filesystem timeline as well as checked Mozilla Firefox logs, prefetch files and system logs. The next step was the analysis of the system registry. In this task, students learnt how to create a timeline of registry changes, check UserAssist keys as well as extract a list of installed applications.

During the analysis, it was determined that the system was most likely compromised on 2016-08-16 at 13:02:46 after user visited infected website http://blog.mycompany.ex/ which was redirecting to another domain (blog.mysportclub.ex) hosting some exploit kit. As a result, the operating system was infected with Xtreme RAT malware. At 13:10:03, 54948tp.exe executable was created on disk and then executed. As a result, an additional tools pack was downloaded from blog.mysportclub.ex and then unpacked in the local filesystem (%APPDATA%\EpUpdate). An additional directory *SystemProfile* was created in %TEMP% location.

Among the tools were tools like Nmap, THC-Hydra, Mimikatz, BrowserPasswordDump, Plink and Pscp. This suggests that the attacker's intention was to gather information about the local system and then possibly compromise other hosts on the network. At 13:59:00, a port scan of three hosts on the local network was performed: 192.168.5.1, 192.168.5.10, 192.168.5.15. Shortly after that, THC-Hydra was executed possibly to perform some dictionary attack. Then plink/pscp was executed a few times. The RSA key found in the registry suggests that attacker might have been trying to login to 192.168.5.10 host.

To continue the investigation and find additional information, forensic evidence found on the Windows workstation should be correlated with evidence obtained from other systems, especially network logs, and, if possible, evidence preserved from blog.mysportclub.ex and blog.mycompany.ex.

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