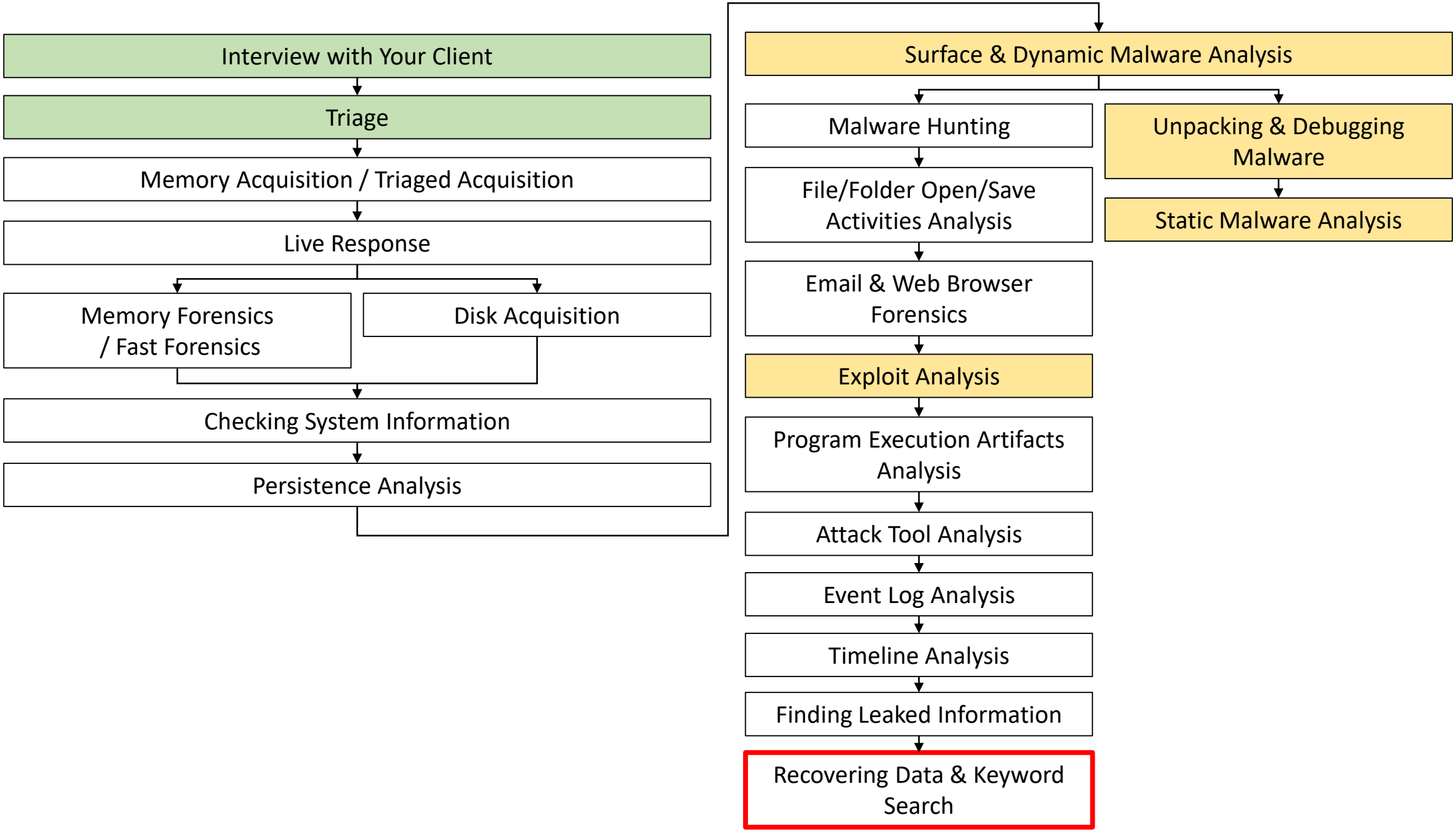
Recovering Deleted Data


Interview with Your Client
Triage
Memory Acquisition / Triaged Acquisition
Live Response
Memory Forensics / Fast Forensics
Disk Acquisition
Checking System Information
Persistence Analysis
Surface & Dynamic Malware Analysis
Malware Hunting
File/Folder Open/Save Activities Analysis
Email & Web Browser Forensics
Exploit Analysis
Program Execution Artifacts Analysis
Attack Tool Analysis
Event Log Analysis
Timeline Analysis
Finding Leaked Information
Recovering Data & Keyword Search
Unpacking & Debugging Malware
Static Malware Analysis

Data Recovering 101

- What is Data Recovering?
  - It is to recover deleted data. Usually, it means extracting deleted files from a disk image.
  - When data that we need to recover is not a form of the complete file, but the data contains a record or some records such as event logs or journal logs, we sometimes try to recover data on per record basis, not on per file basis.
- Why Data Recovering?
  - Attackers often delete files such as attacking tools and collected archives. If we recover and analyze them, we can understand their purpose and what they actually did.
  - We sometimes get important evidences from old log records that were recovered from unallocated spaces. It is very useful when the logs have already been rotated.

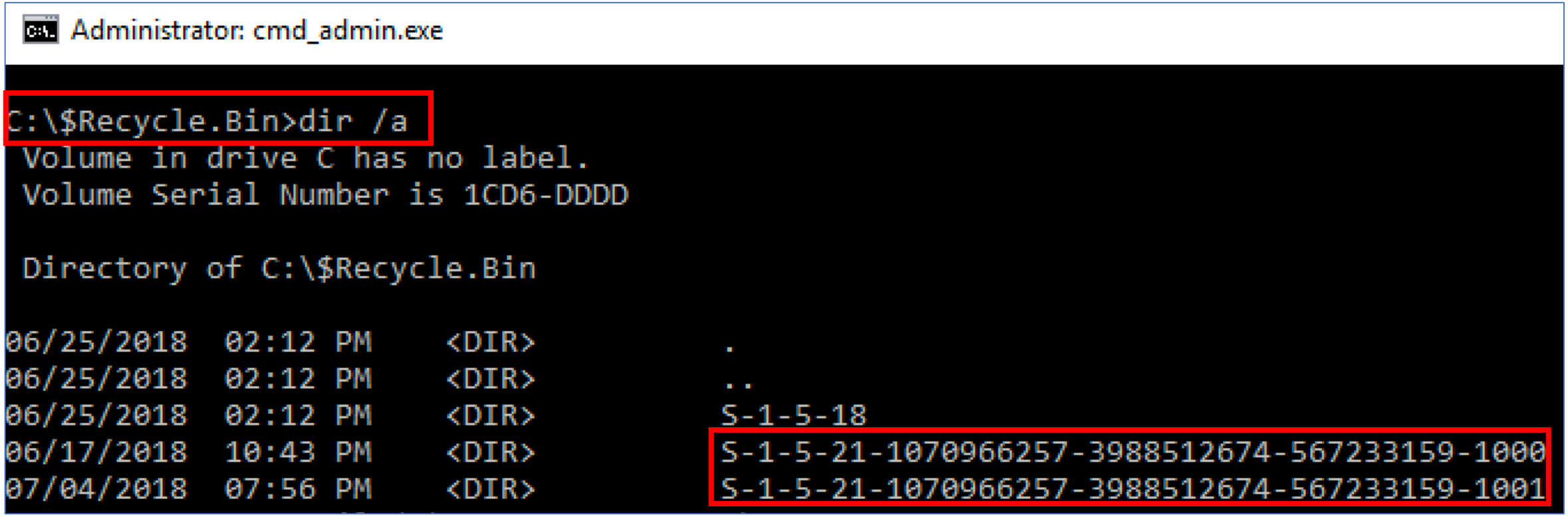
Various Data Recovering Features/Methods

- Recycle Bin
  - We can recover files that were dropped into Recycle Bin. It is easy to extract them from disk images.
- VSS (Volume Shadow Snapshots)
  - Modern Windows systems automatically perform periodic backup with Volume Shadow Copy Service. We sometimes find deleted files from those snapshots.
- Resident data
  - As we mentioned before, Windows does not delete data immediately when files are deleted. It just flags the file entries as "deleted" in Master File Table. Therefore, we can extract deleted files if the entries still exist.
- Carving & keyword search
  - Carving is the process to search large data chunk such as pagefile, unallocated space, file slack, and even the whole disk image, for a specific data. Typically, we use magic or hard coded values in file formats, keywords, regex patterns and so on to identify particular data formats. It takes a long time.

Recovering Files From Recycle Bin

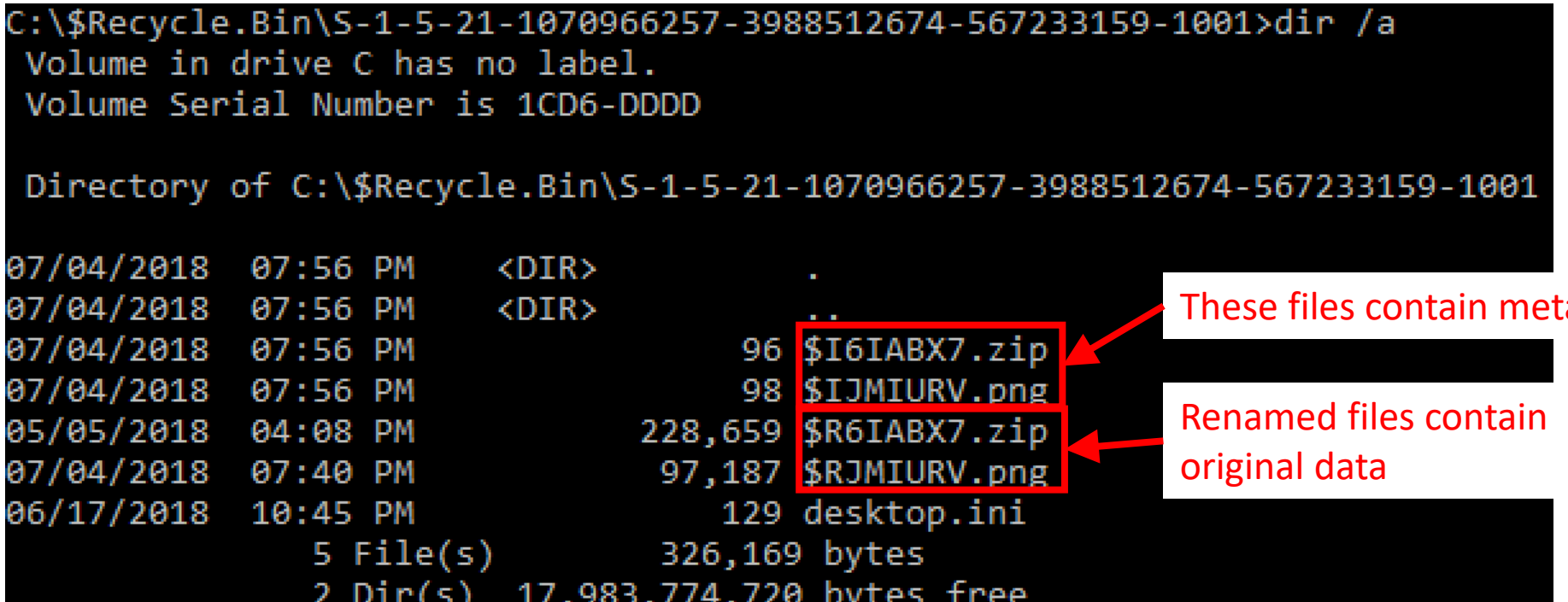
Recovering Files From Recycle Bin (1)

- When you drop some files into the Recycle Bin, those files are moved to the following directory.
  - \$Recycle.Bin\<*USER SID*>\



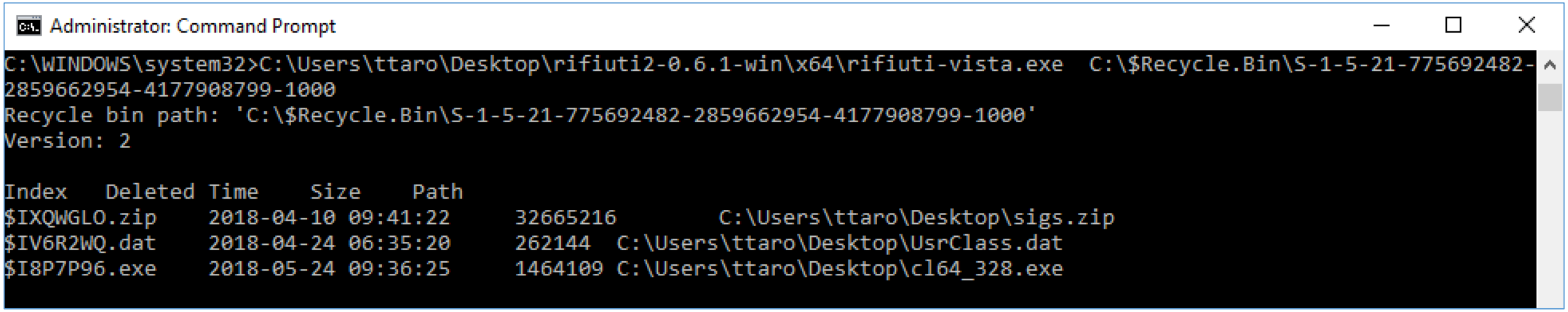
Recovering Files From Recycle Bin (2)

- When a file is dropped into the Recycle Bin, it is renamed to a meaningless strings that starts with “$R”, like "$R6IABX7.zip". In this case, its metadata, including original name, path, and timestamps, is also saved as another file named like "$I6IABX7.zip". Names of metadata files start with "$I". Their file extension is the same as the original one.
- There are some tools to parse these metadata files. We will introduce them later.



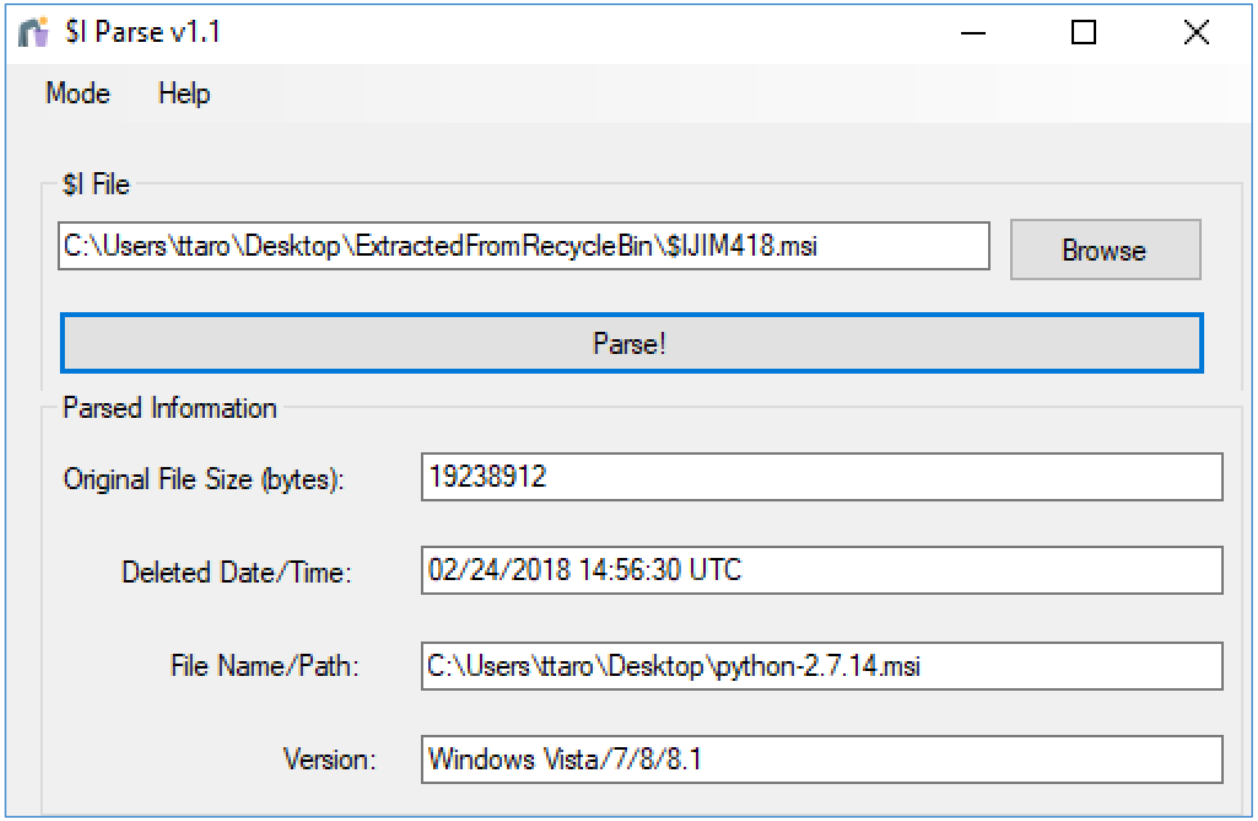
Recycle Bin Analysis Tools (1)

- Rifiuti2
  - It is the command line tool to parse $I files.
  - It can parse files under the given directory.



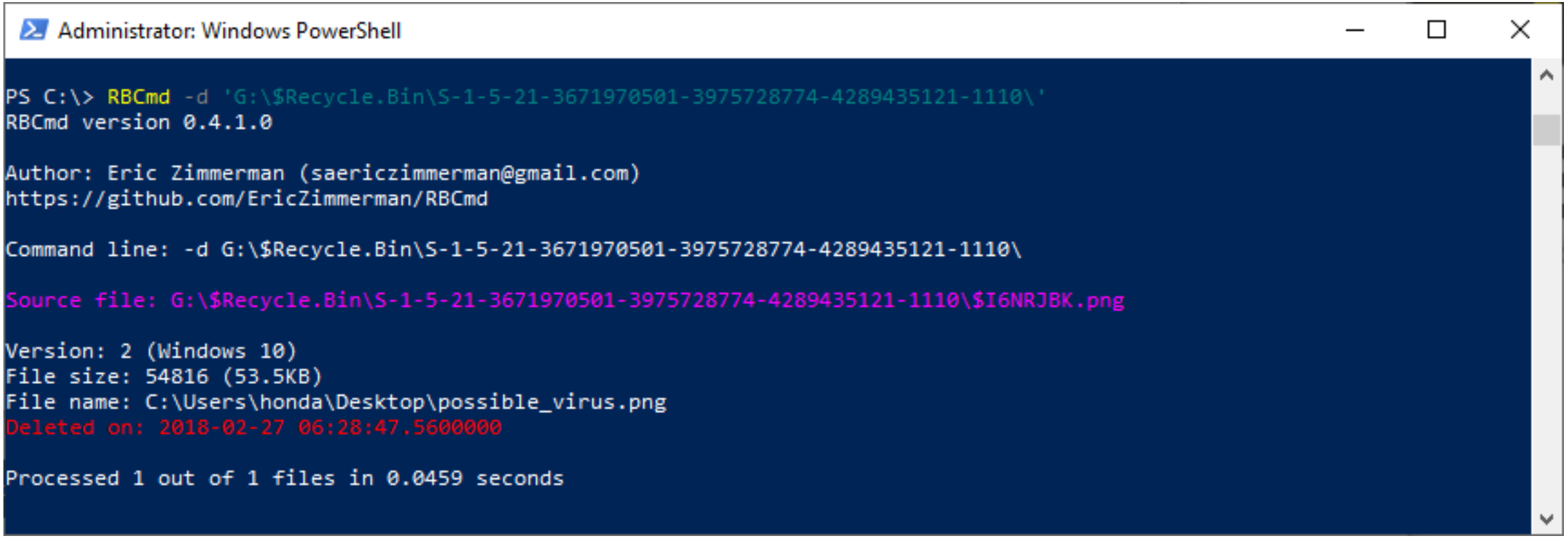
Recycle Bin Analysis Tools (2)

- $I Parse
  - It parses files that start with $I.
  - This tool has two operation modes. File mode is to parse just one file and directory mode is to parse files under the target folder.
  - You have to extract target files from disk images first.



Recycle Bin Analysis Tools (3)

- RBCmd
  - This is yet another command line tool to parse INFO2/$I files.



Practice Exercise 1:

Check the files located in the Recycle Bin with Rifiuti2

Practice Exercise 1:
Check the files located in the Recycle Bin with Rifiuti2 (1)

- Conditions:
  - It is NOT related to the scenario 1. It is just an independent exercise.
  - This is an exercise to deal with Recycle Bin.
  - The target disk image is the following.
    - E:\Artifacts\scenario1_E01\Client-Win10-2_honda.E01
  - The target user honda's SID is the following.
    - S-1-5-21-3671970501-3975728774-4289435121-1110
- Goal:
  - To confirm files under user honda's Recycle Bin folder.

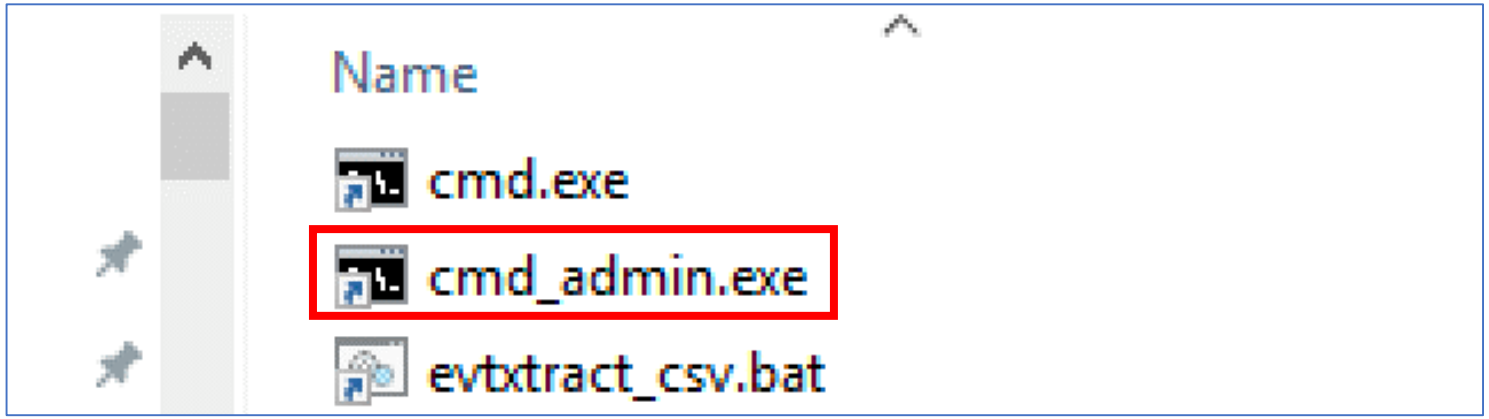
Practice Exercise 1:

Check the files located in the Recycle Bin with Rifiuti2 (2)

- First of all, mount the disk image below with Arsenal Image Mounter.
  - E:\Artifacts\scenario1_E01\Client-Win10-2_honda.E01

- Launch cmd.exe as administrator by double-clicking the following icon.

Shortcuts\09_RecoveringDataKeywordSearch



Practice Exercise 1:

Check the files located in the Recycle Bin with Rifiuti2 (3)

- Check the Recycle.Bin folder for user "Honda" with the following command.
  - Note: Honda's SID is S-1-5-21-3671970501-3975728774-4289435121-1110

```
dir G:\$Recycle.Bin\S-1-5-21-3671970501-3975728774-4289435121-1110
```

Honda's SID

```
Volume in drive G has no label.
 Volume Serial Number is B81C-324B

 Directory of G:\$Recycle.Bin\S-1-5-21-3671970501-3975728774-4289435121-1110

02/27/2018  03:28 PM               112 $I6NRJBK.png
02/27/2018  03:24 PM            54,816 $R6NRJBK.png
               2 File(s)         54,928 bytes
               0 Dir(s)  27,537,383,424 bytes free
```

Metadata file

Actual content file

Practice Exercise 1:

Check the files located in the Recycle Bin with Rifiuti2 (4)

- Run rifiuti command to parse the metadata file under the target location.

```
rifiuti-vista.exe -z G:\$Recycle.Bin\S-1-5-21-3671970501-3975728774-4289435121-1110
```

```
Recycle bin path: 'G:\$Recycle.Bin\S-1-5-21-3671970501-3975728774-4289435121-1110'
Version: 2
OS Guess: Windows 10 or above
Time zone: Tokyo Standard Time [+0900]

Index   Deleted Time     Size     Path
$I6NRJBK.png    2018-02-27 15:28:47    54816    C:\Users\honda\Desktop\possible_virus.png
```

The original file name and path

Size

- If you are interested to check the actual content of the file, you can open the content file that have a name starting with "$R".

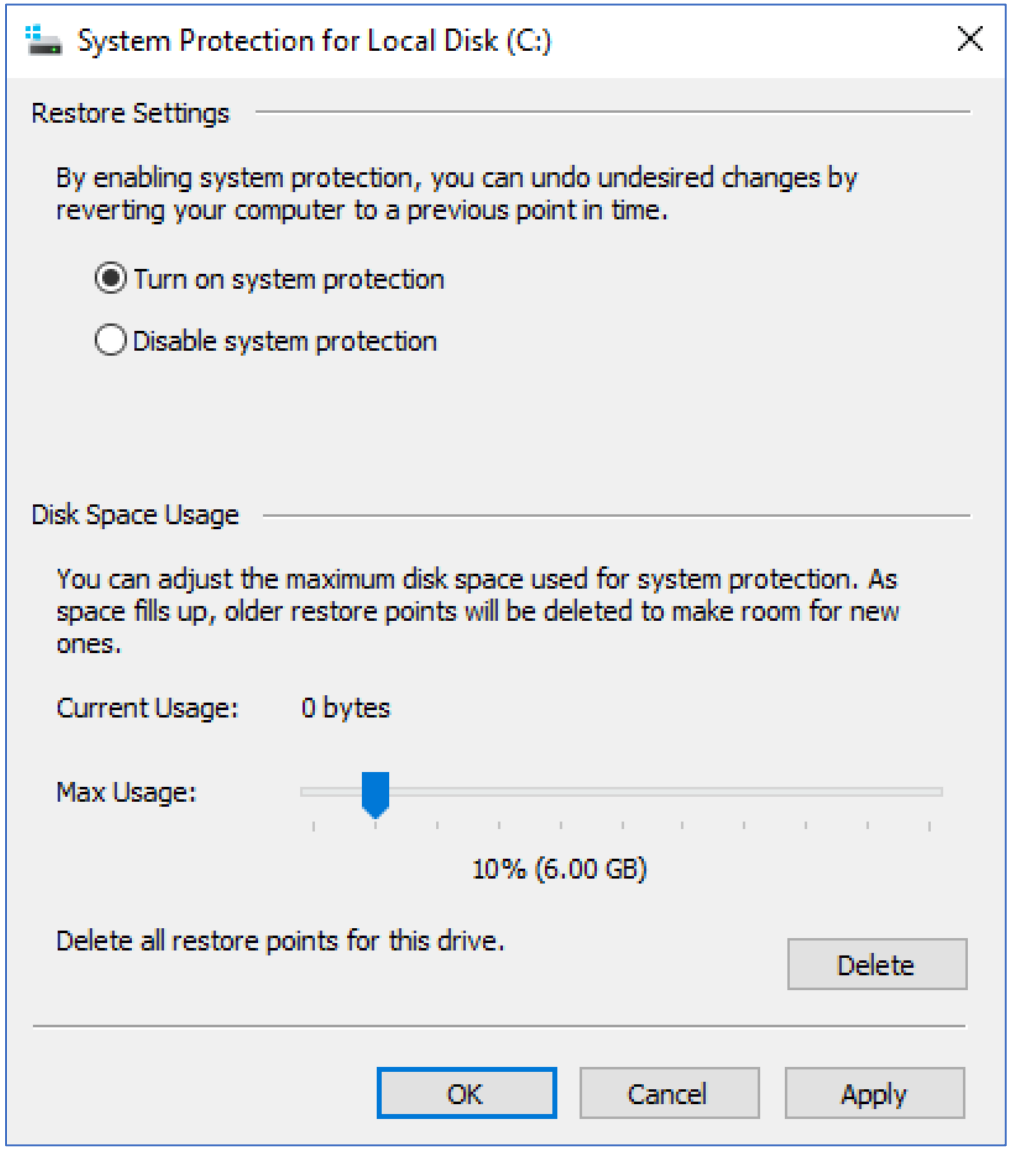
Preparation for the Next Exercise

- Unmount the disk image.
- Quit all applications.

Data Recovering With VSS Snapshots

Data Recovering With VSS Snapshots (1)

- Windows OS takes backup automatically with Volume Shadow Copy Service (VSS). It is for "System Protection for Local Disk" function.
- We can restore a system with VSS snapshots taken by this function.
- We can also extract files from VSS snapshots contained in disk images.



Data Recovering With VSS Snapshots (2)

- The default backup targets and triggers to take snapshots depend on Windows version.

	Files to backup	Backup interval / trigger to take backup
Windows 7	All files except for some files*1.	Once a week.
Windows 8 and above	Typically, system binaries and file system metadata files are taken*2.	Triggered by execution of several specific functions such as Windows Update and each installer.
Windows Servers	All files except for some files*1.	Twice (7am and 12pm) on every weekday.

1. The following registry key contains settings of exclusion files.
   - HKEY_LOCAL_MACHINE\System\CurrentControlSet\Control\BackupRestore\FilesNotToSnapshot
2. Microsoft recommends to use "Previous versions" function for user files to backup. However, we can change this behavior by configuring ScopeSnapshots feature.

For further information:
https://www.iij.ad.jp/en/dev/iir/pdf/iir_vol37_focused1_EN.pdf

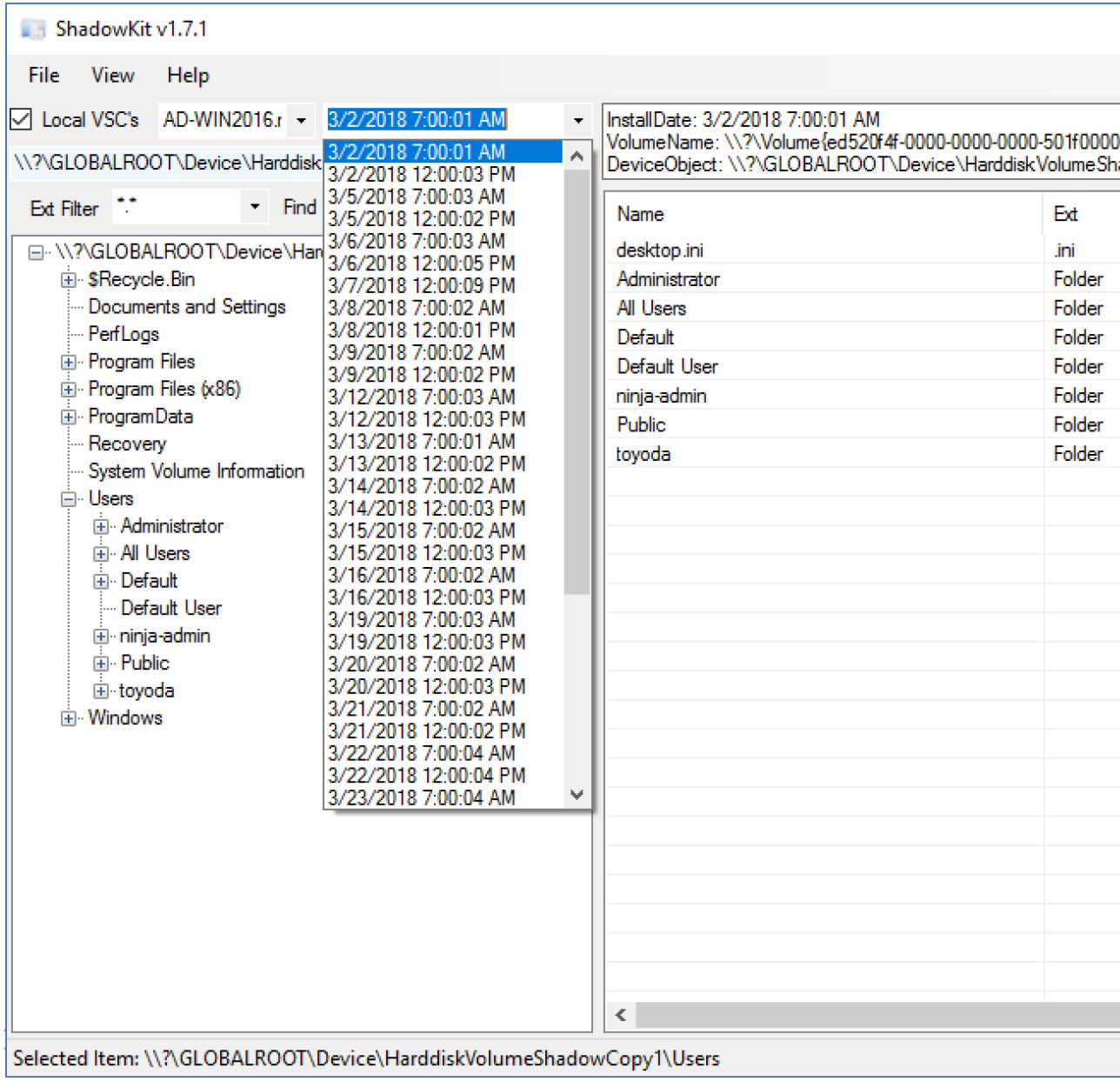
Data Recovering With VSS Snapshots (3)

- How VSS works?
  - When a VSS snapshot is created, "Catalog" and "Store" are created and saved under System Volume Information folder located at the NTFS root.
  - Catalog is used to store metadata such as creation date of the snapshot.
  - Store backs up the actual data. It keeps only the differential data.
  - Therefore, when a certain snapshot is restored, it applies those stored differentials to the current files.
  - If a snapshot is deleted, its Catalog and Store are also deleted. However we can recover deleted snapshots with vss_carver if the Store data is not overwritten.

- For further information, check our briefing session at Black Hat USA 2018:
  - RECONSTRUCT THE WORLD FROM VANISHED SHADOW: RECOVERING DELETED VSS SNAPSHOTS
    - https://i.blackhat.com/us-18/Thu-August-9/us-18-Kobayashi-Reconstruct-The-World-From-Vanished-Shadow-Recovering-Deleted-VSS-Snapshots.pdf

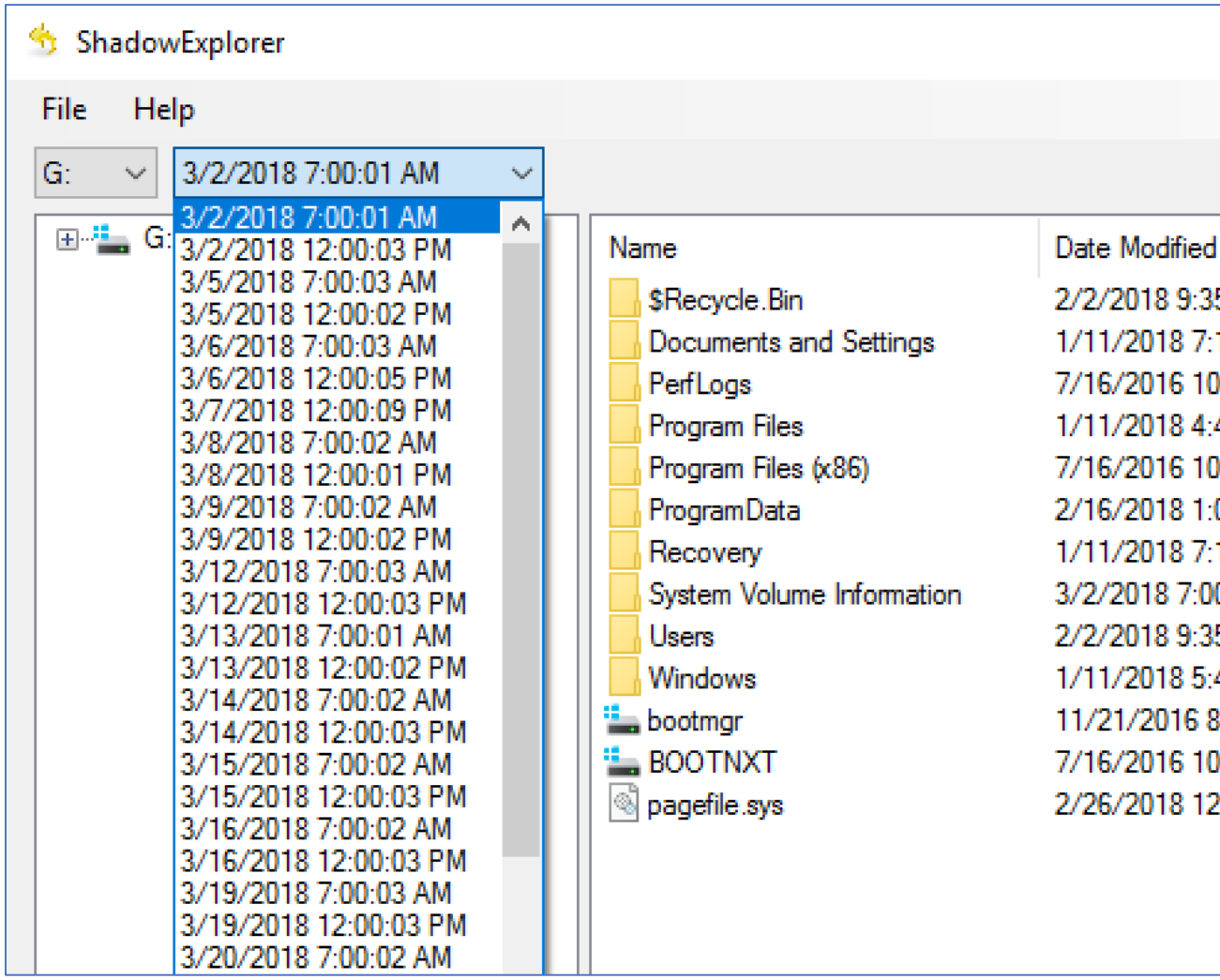
VSS Exploring Tools (1)

- ShadowKit
  - It can be used for exploring VSS snapshots with GUI.
  - We can recover snapshots data, including files in the Recycle Bin folder.
  - However, it cannot treat file system metadata such as $MFT.



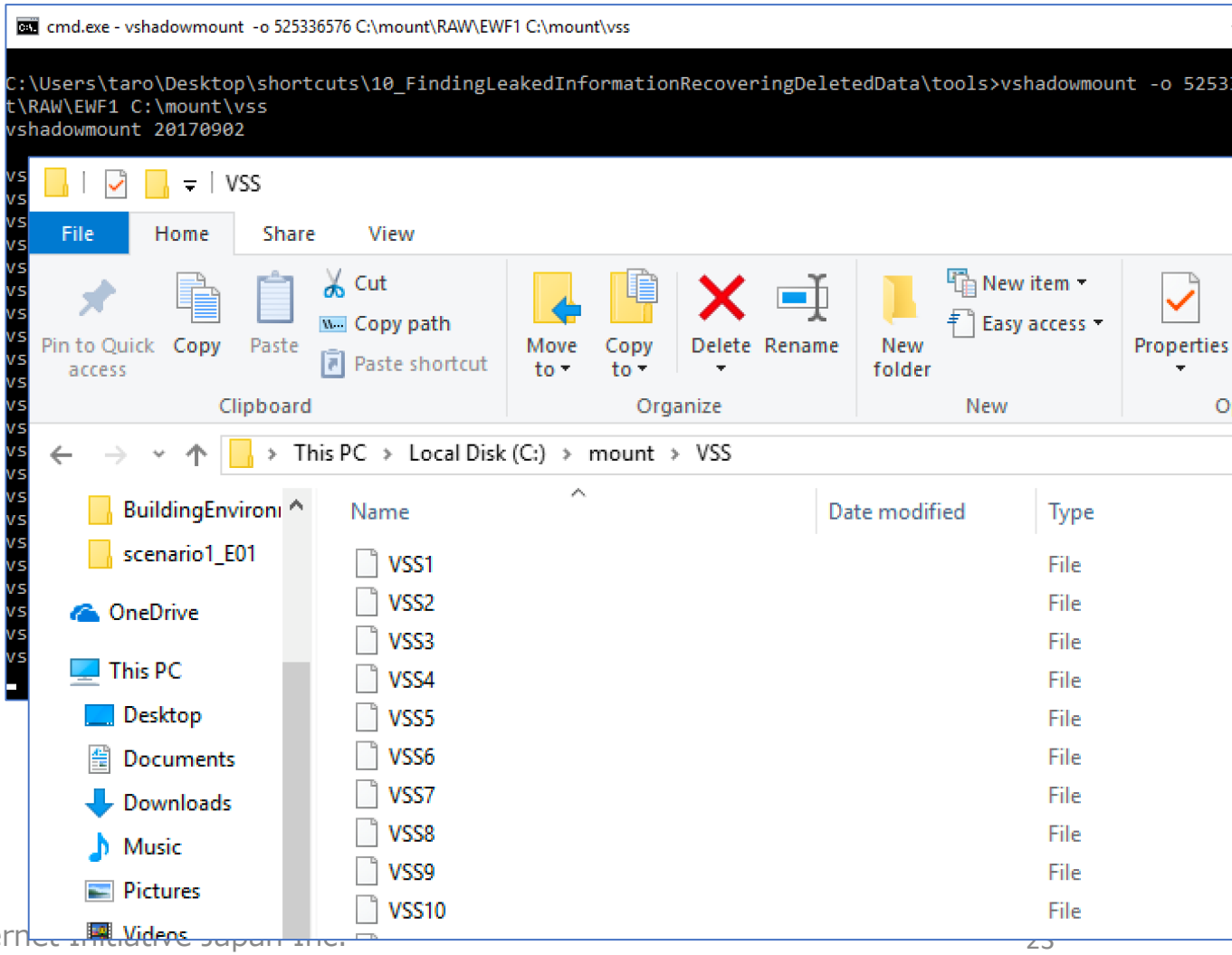
VSS Exploring Tools (2)

- ShadowExplorer
  - It is also a GUI based VSS snapshot explorer and very similar to ShadowKit.
  - It cannot treat file system metadata, either.



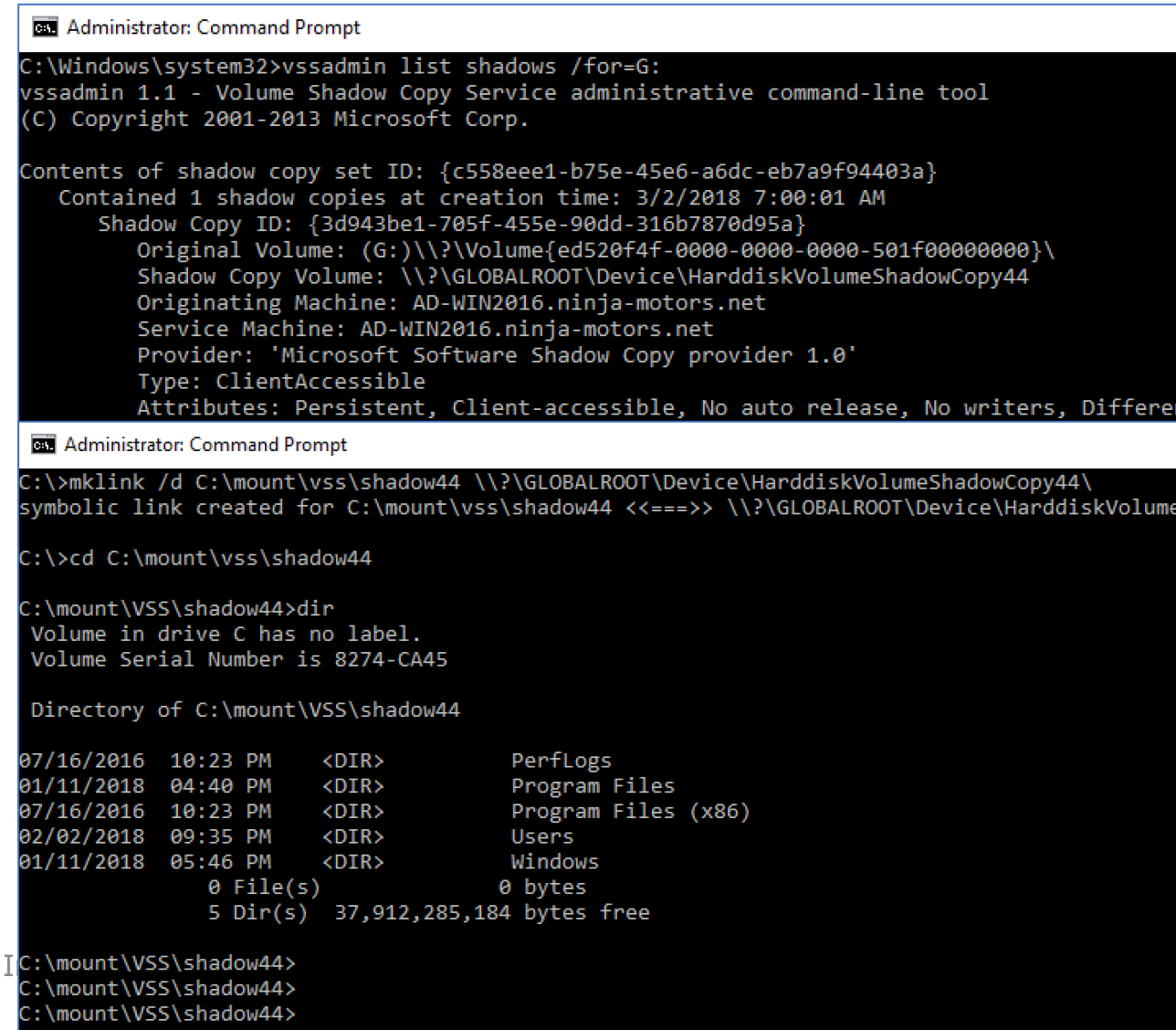
VSS Exploring Tools (3)

- vshadowmount
  - It presents each VSS snapshot as a raw disk image.
  - This tool is a part of libvshadow library, and the library is open source.



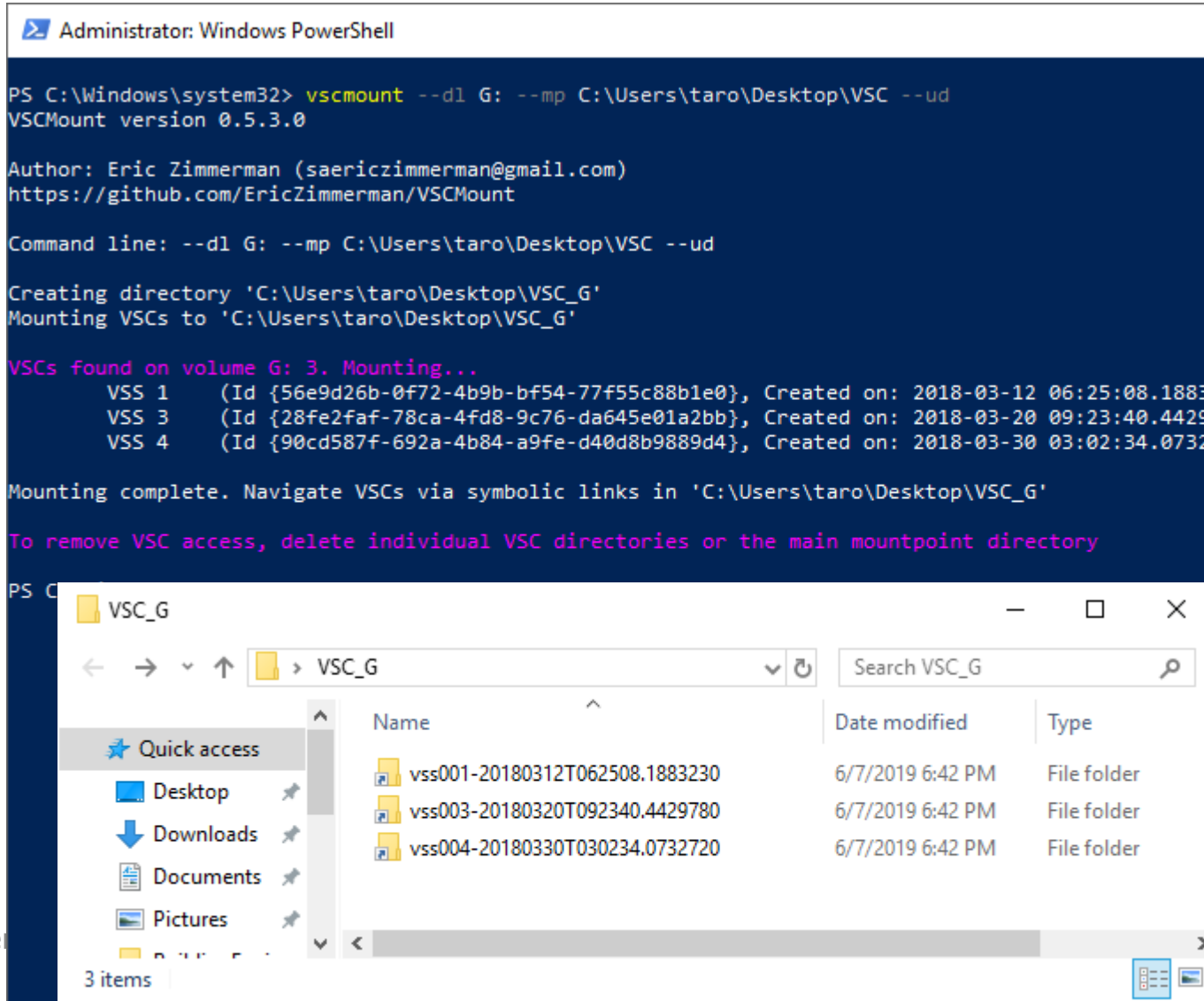
VSS Exploring Tools (4)

- vssadmin & mklink
  - We can also explore VSS snapshots using basic Windows commands.
  - First, check the location of each snapshot with vssadmin command. Then, create a symbolic link with mklink command. In that way, we can view the VSS snapshots.

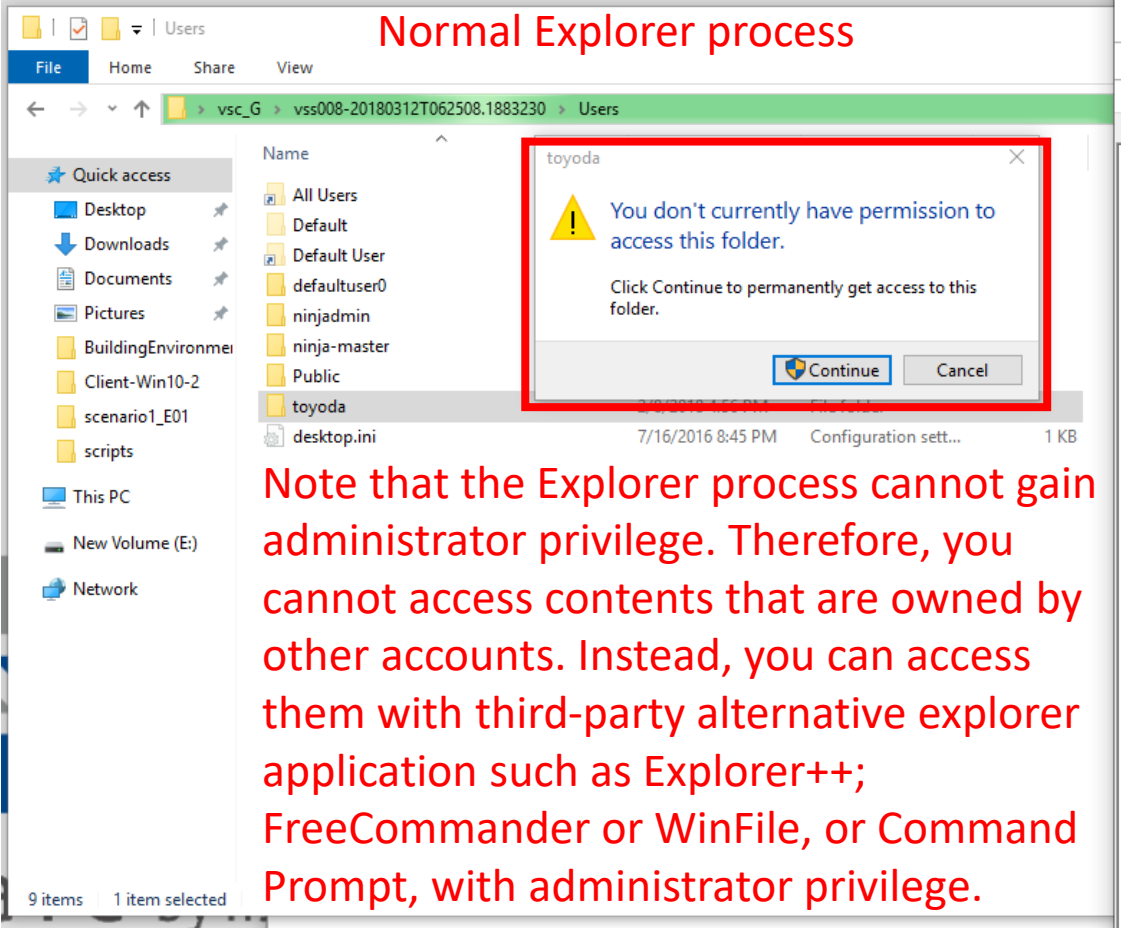


VSS Exploring Tools (5)

- VSCMount
  - You can access VSS via symbolic links and files that are managed by the snapshots with Command Prompt or Explorer.
  - https://binaryforay.blogspot.com/2018/09/introducing-vscmount.html

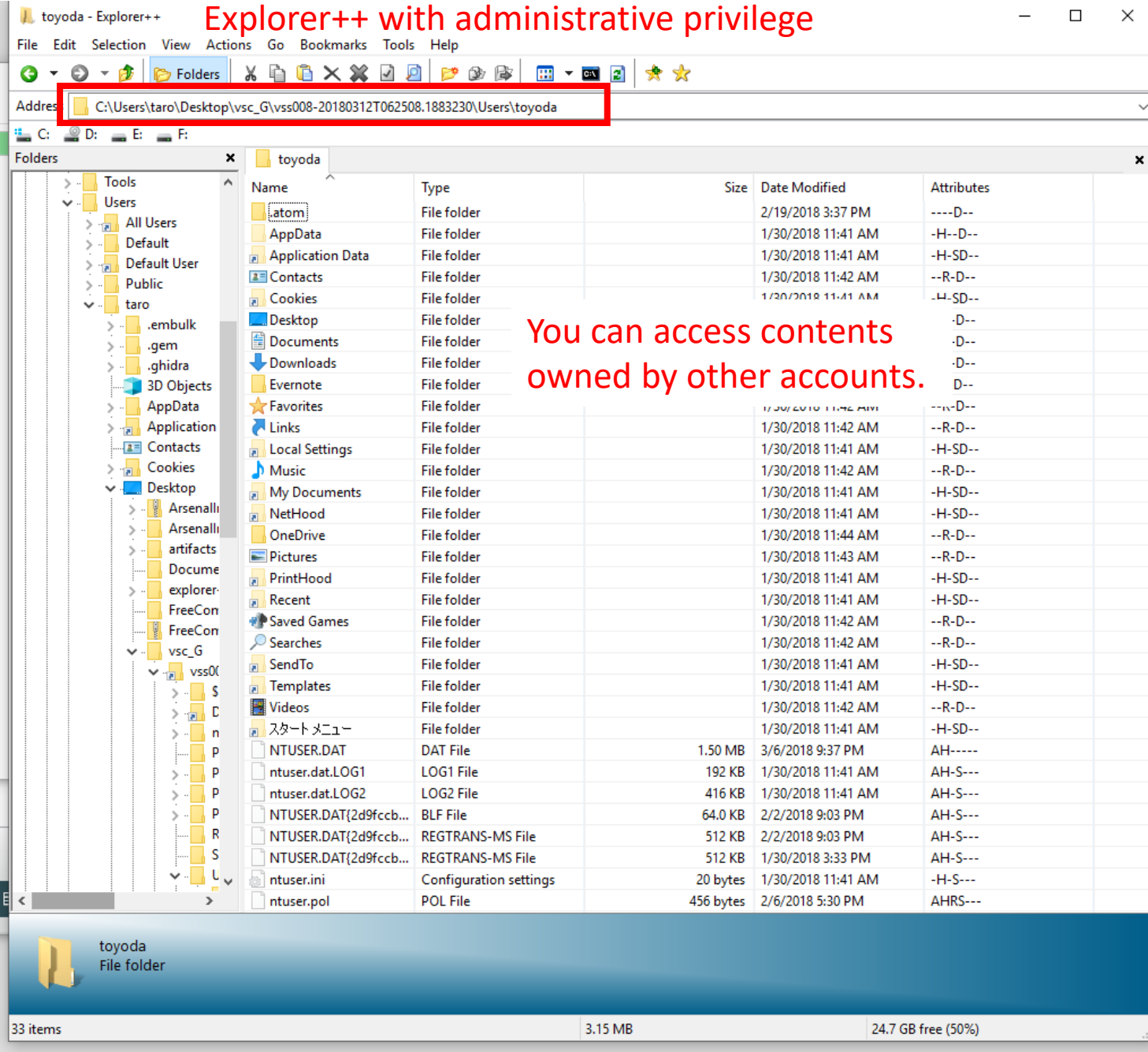


Normal Explorer process



Note that the Explorer process cannot gain administrator privilege. Therefore, you cannot access contents that are owned by other accounts. Instead, you can access them with third-party alternative explorer application such as Explorer++; FreeCommander or WinFile, or Command Prompt, with administrator privilege.

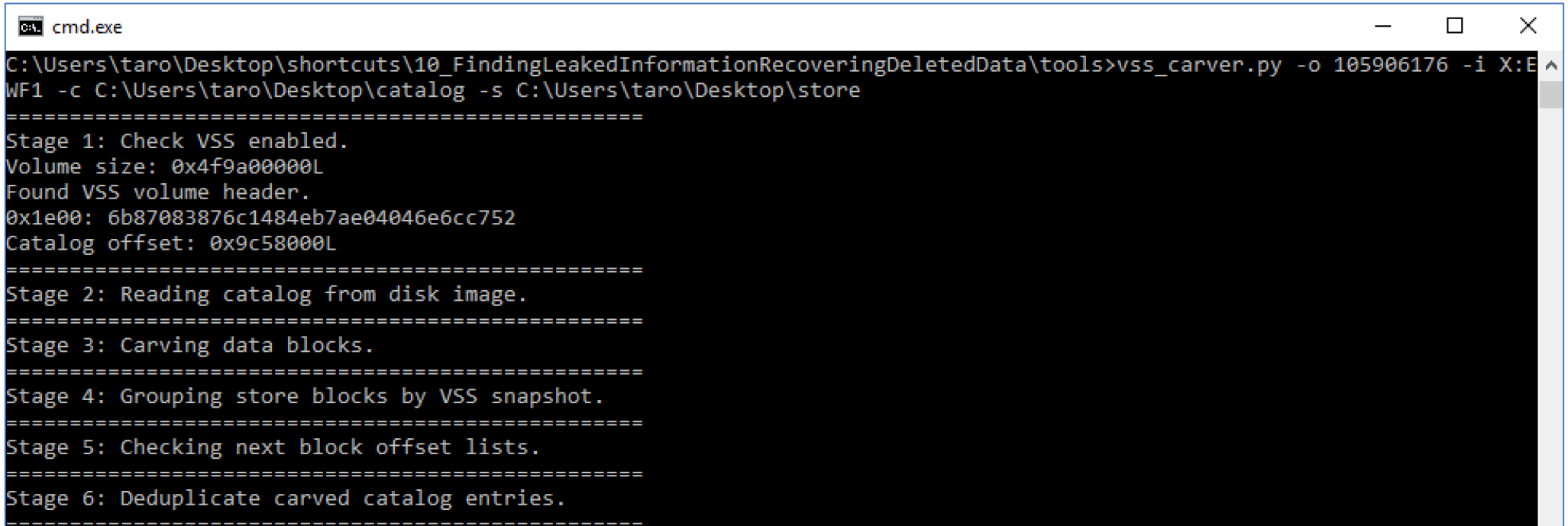
Explorer++ with administrative privilege



You can access contents owned by other accounts.

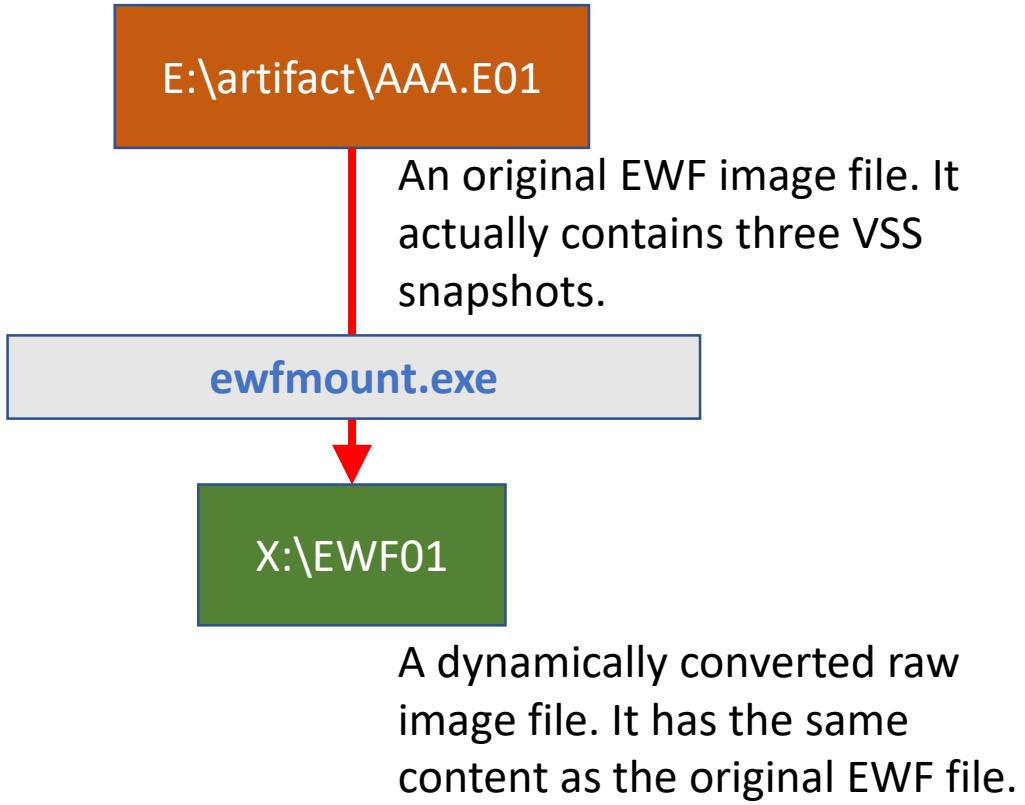
VSS Exploring Tools (6)

- vss_carver
  - It is a tool to carve deleted VSS snapshots.
  - It requires enhanced version of vshadowmount to mount carved snapshots. The enhanced version is released by the same author of this tool.



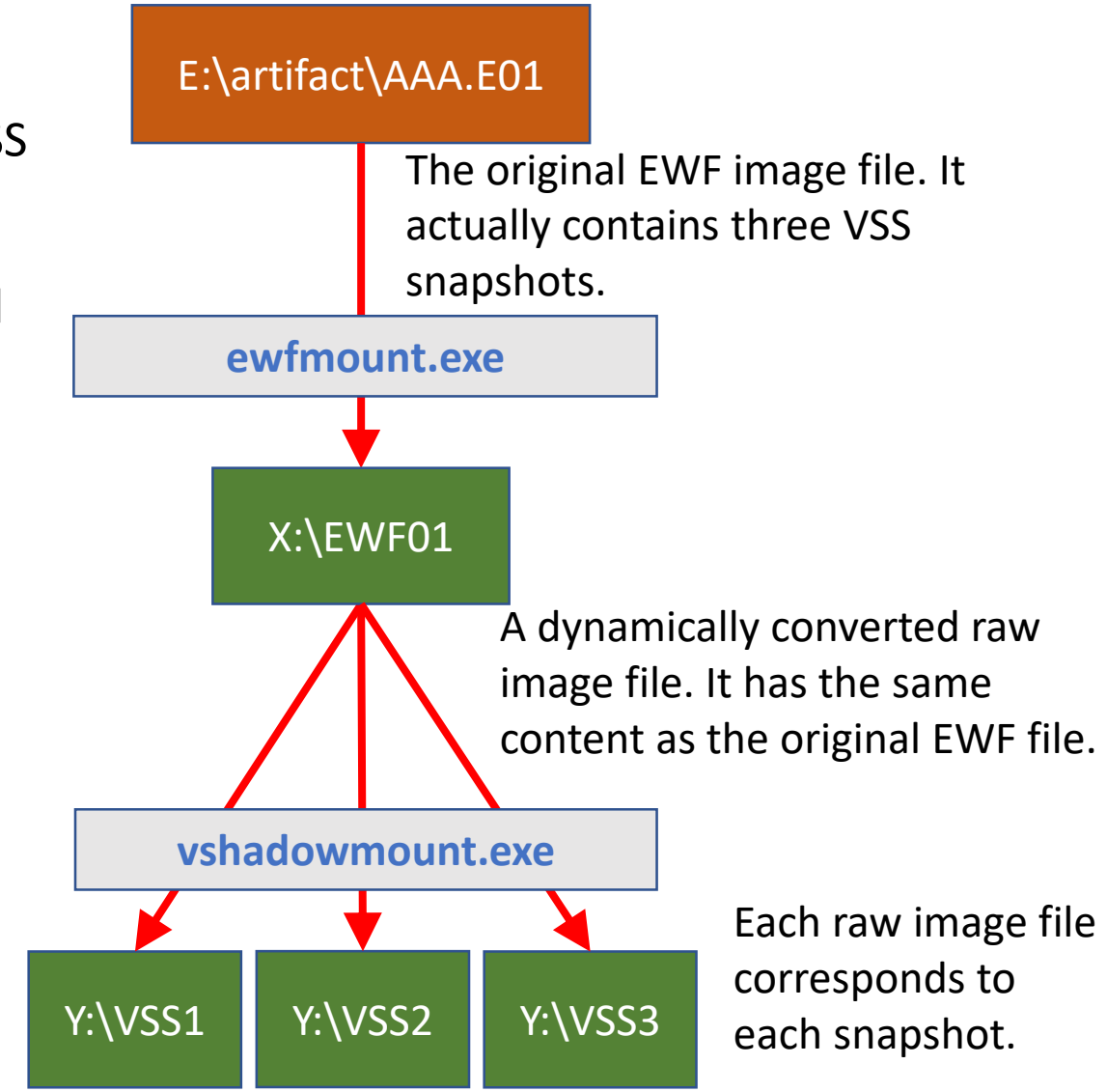
How We Access VSS Snapshots (1)

- We will use ewfmount.exe and vshadowmount.exe to access VSS snapshots contained in a certain EWF (.E01) disk image.
- ewfmount command dynamically converts from an original EWF image into a raw image file named EWF01. In this case, the EWF file AAA.E01 is presented as a raw image file under drive X.
- Then, we can mount and parse the raw image file with image mounting and parsing tools.
- Note that, Arsenal Image Mounter supports E01 format. It can dynamically mount E01 files. However, some image mounting and parsing tools support raw image format only.



How We Access VSS Snapshots (2)

- vshadowmount command dynamically converts VSS snapshots within a certain raw image file into individual raw image files. In this case, there are three VSS snapshots in the original disk image, and those snapshots are presented as individual raw image files under drive Y.
- Then, we can mount and parse the raw image files VSS1, VSS2, and VSS3 with image mounting and parsing tools.

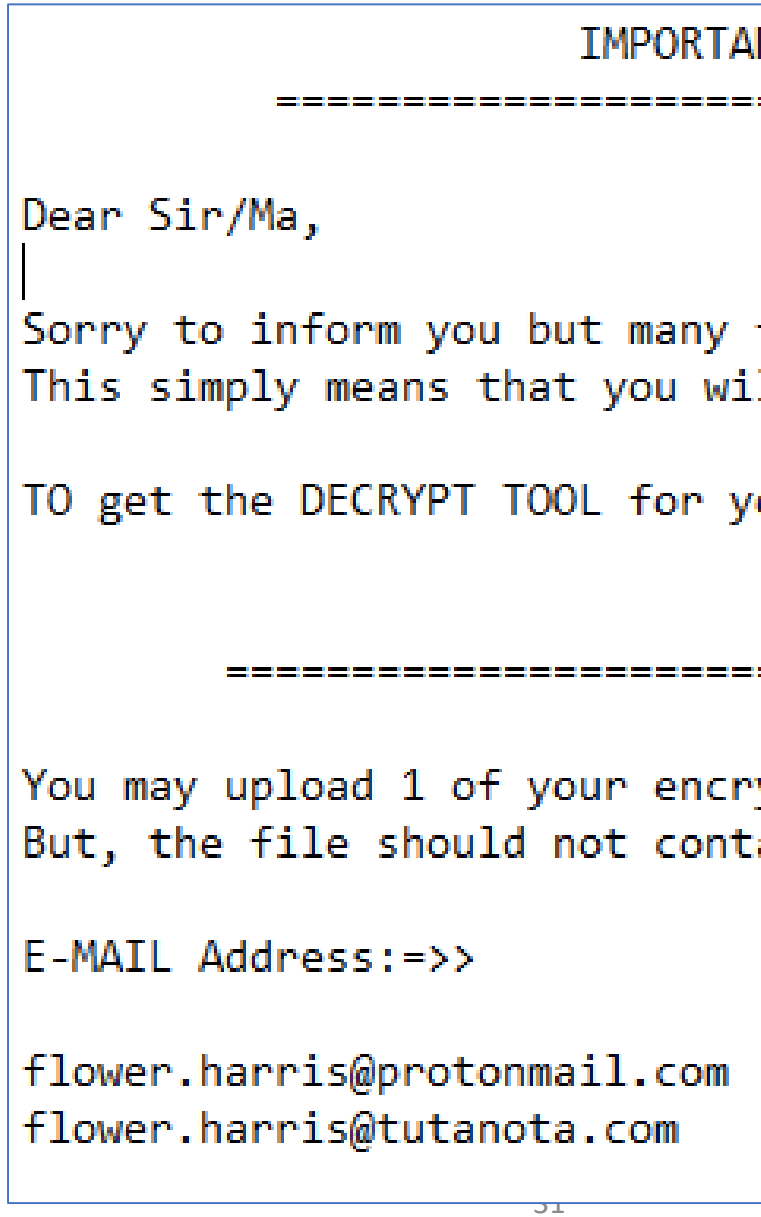


Practice Exercise 2:

Recovering Deleted VSS Snapshots

Practice Exercise 2:
Recovering Deleted VSS Snapshots (1)

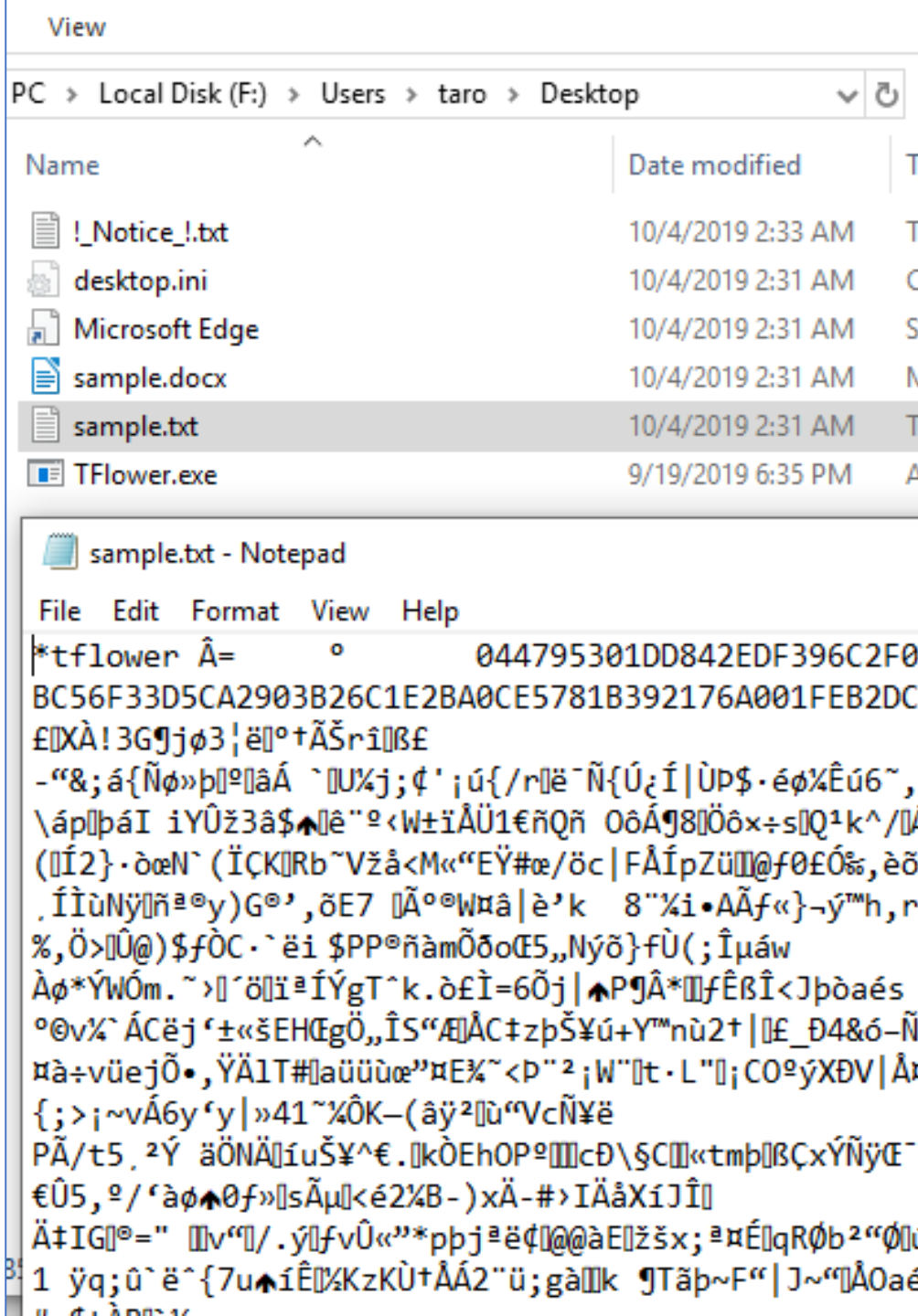
- Condition:
  - The following disk image contains a Windows volume compromised by TFlower ransomware.
    - E:\Artifacts\other_E01\infected_drive_d.E01
  - A huge text file "sample.txt" is placed on the user Taro's Desktop, and it is encrypted by the ransomware.
  - VSS snapshots are also deleted by the ransomware.
- Goal:
  - To recover the encrypted text file.
- Hint:
  - You might carve deleted VSS snapshots with vss_carver.



Practice Exercise 2:

Recovering Deleted VSS Snapshots (2)

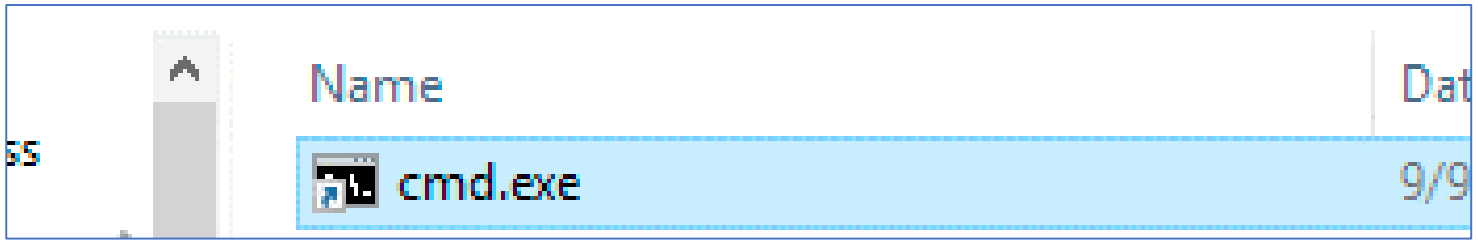
- “sample.txt” and “sample.docx” are placed on the user Taro’s Desktop. And these files are encrypted by the ransomware.



Practice Exercise 2:
Recovering Deleted VSS Snapshots (3)

- In order to examine the compromised volume, we should use ewfmount first.
  - Launch cmd.exe from the path below.

Shortcuts\09_RecoveringDataKeywordSearch

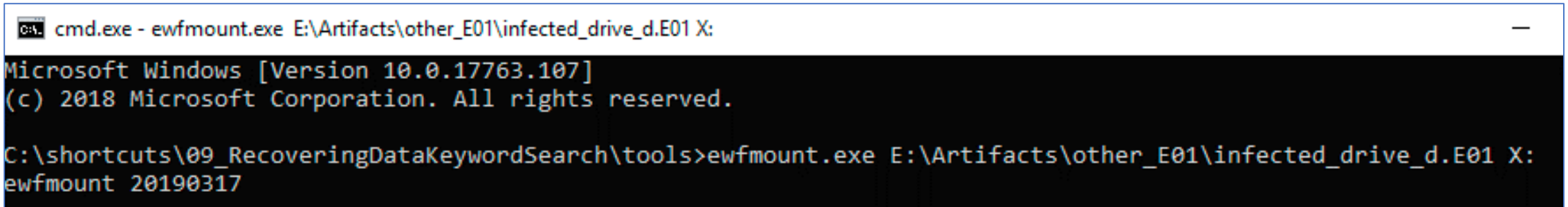


  - Convert from an EWF image file to the raw image dynamically with the following command.

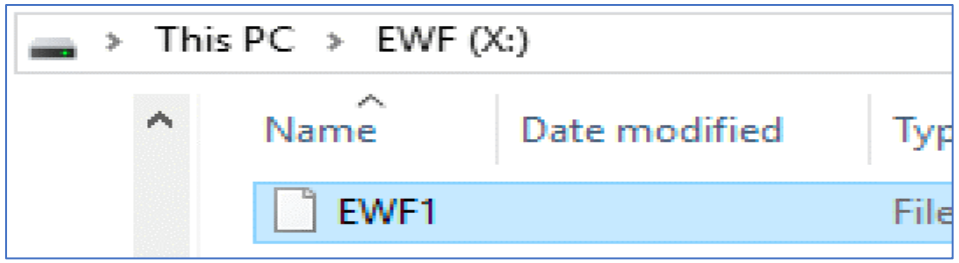
```
ewfmount.exe E:\Artifacts\other_E01\inected_drive_d.E01 X:
```

Path to the target disk image

Where dynamically converted raw image files are represented



Practice Exercise 2:
Recovering Deleted VSS Snapshots (4)



- Check the partition table
  - The E01 image is presented as a raw disk image on drive X.
  - Next, let's confirm volume offsets of the image with the following command.

```
mmls.exe X:\EWF1
```

```
GUID Partition Table (EFI)
Offset Sector: 0
Units are in 512-byte sectors

      Slot      Start        End          Length       Description
000:  Meta      0000000000   0000000000   0000000001   Safety Table
001:  -------   0000000000   0000002047   0000002048   Unallocated
002:  Meta      0000000001   0000000001   0000000001   GPT Header
003:  Meta      0000000002   0000000033   0000000032   Partition Table
004:  000       0000002048   0000411647   0000409600   EFI system partition
005:  001       0000411648   0000673791   0000262144   Microsoft reserved partition
006:  002       0000673792   0062912511   0062238720   Basic data partition
007:  -------   0062912512   0062914559   0000002048   Unallocated
```

The result shows the partition table of the image. The 6th partition is recognized as Basic data partition, which seems to be a regular system volume.

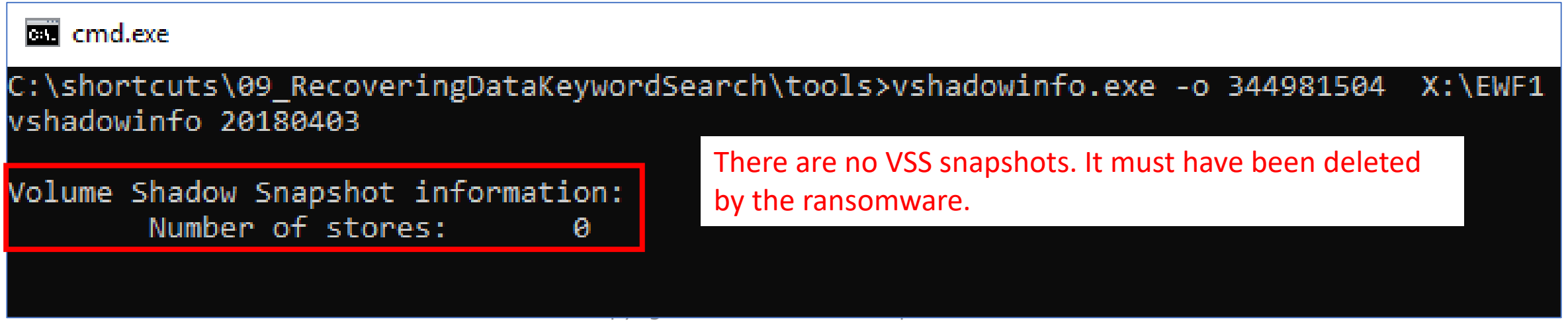
Practice Exercise 2:
Recovering Deleted VSS Snapshots (5)

- Get the target volume's VSS information
  - The following command shows the VSS snapshots stored in the volume.

```
vshadowinfo.exe -o 344981504 X:\EWF1
```

Path to the target disk image. It must be a file in raw image format.

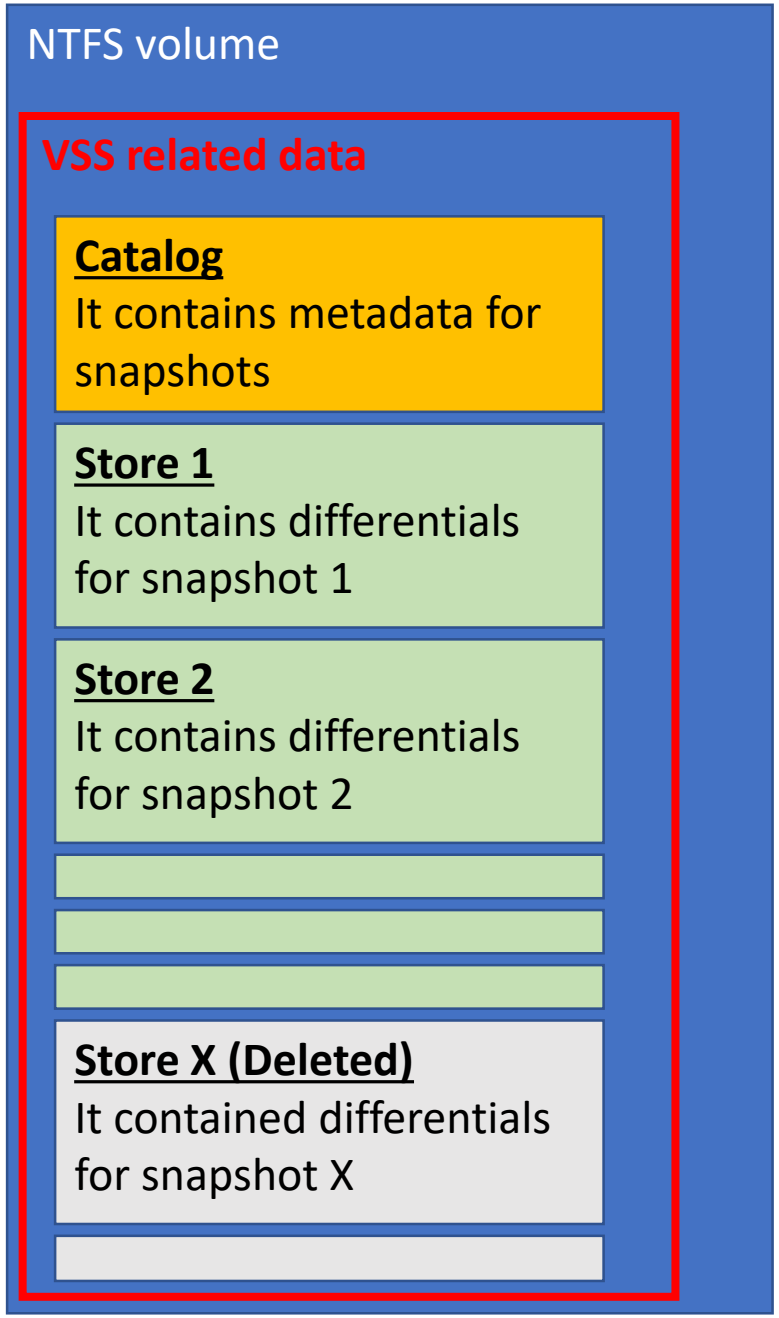
The offset of the volume in bytes.
We can calculate it by multiplying the sector size (512 bytes) by offset of the volume (sector 673,792).



There are no VSS snapshots. It must have been deleted by the ransomware.

How We Carve The Deleted VSS

- We will access deleted VSS snapshots by the following procedures.
  1. We will run vss_carver to recover deleted Store data. In addition, vss_carver also generates a catalog entry for recovered Store data at the same time.
  2. We might use vss_catalog_manipulator to tweak the generated Catalog data if necessary.
  3. We would execute enhanced vshadowmount to present all VSS snapshots including recovered ones as raw disk images.

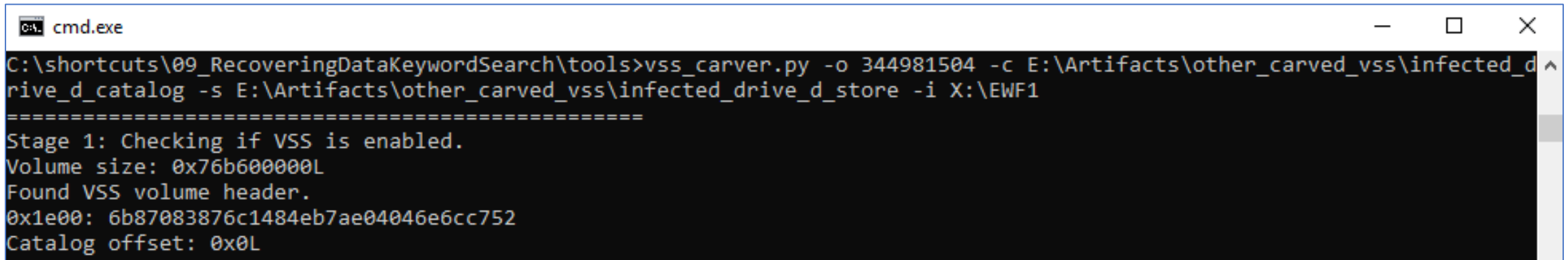


Practice Exercise 2:
Recovering Deleted VSS Snapshots (6)

- Find deleted VSS snapshots in order to restore the encrypted file (1)
  - The following command carves deleted VSS snapshots. We prepared the result in advance because it takes a long time. So you do not need to execute it now.

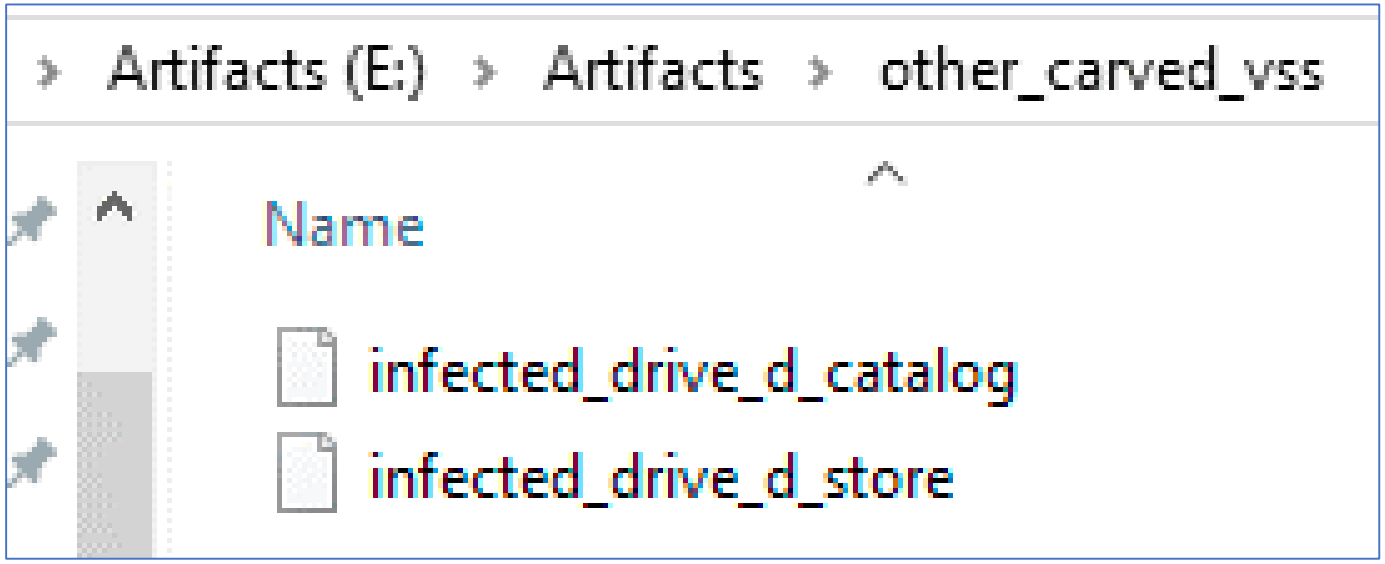
```
vss_carver.py -o 344981504 -c infected_drive_d_catalog -s infected_drive_d_store -i
X:\EWF1
```

  - The options means:
    - -i: Path to the target disk image file.
    - -o: Offset of the target volume to carve VSS snapshots.
    - -s: Path to the carved store data.
    - -c: Path to the generated catalog data.



Practice Exercise 2:
Recovering Deleted VSS Snapshots (7)

- Find deleted VSS snapshots in order to restore the encrypted file (2)
  - We were able to get the carved Store and updated Catalog by executing vss_carver. They are saved in the following folder.



Practice Exercise 2:
Recovering Deleted VSS Snapshots (8)

- Find deleted VSS snapshots in order to restore the encrypted file (3)
  - We are able to confirm carved VSS snapshots with following command.

Prepared “Catalog” that was generated by vss_carver.

```
py -3 vss_catalog_manipulator.py list E:\Artifacts\other_carved_vss\infected_drive_d_catalog
```

```
[0] Enable, Date: 2019-10-04 02:06:23, GUID: 21608282-08e6-e911-8f9c-705681abad74
```

This is the carved VSS snapshot!

  - This command lists both carved snapshots and existing snapshots at the same time.
  - vss_carver can recover only "Store" data of VSS snapshots, and it generates a new "Catalog" for carved "Store" with certain timestamps and GUIDs based on values of the current ones. Generated timestamps are set an hour earlier than the earliest one or the current time, and are set when they are found. Sometimes you need to modify these timestamps in order to correct the order of carved snapshots. vss_catalog_manipulator is also capable of modifying them.
  - We can estimate creation time of carved snapshots from timestamps of files contained in them.

Practice Exercise 2:
Recovering Deleted VSS Snapshots (9)

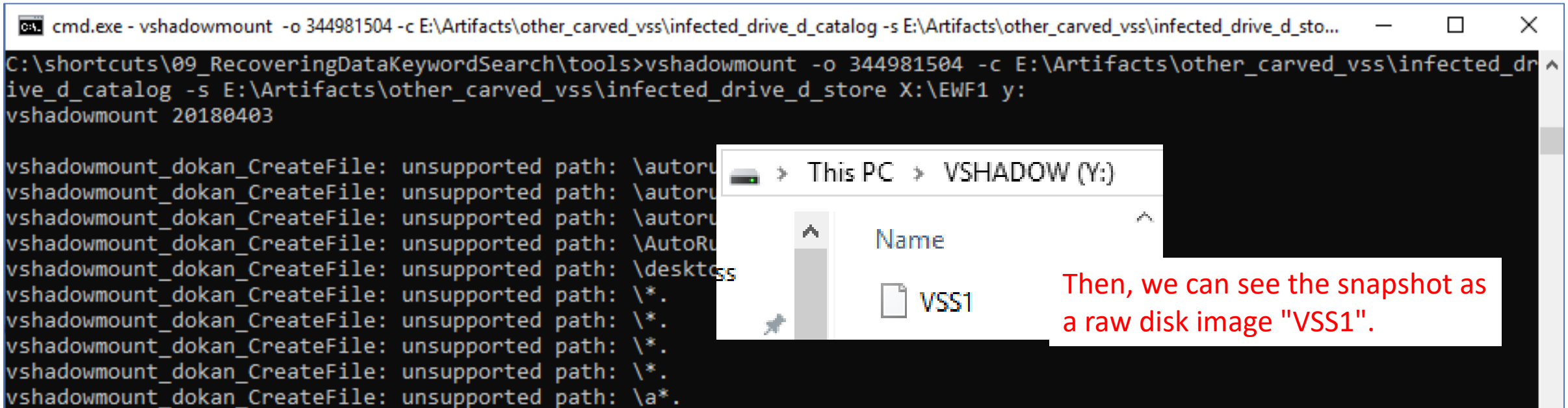
- Mount the carved VSS snapshot (1)
  - Convert the VSS snapshot into a raw disk image dynamically by the following command. Enhanced version of vhadowmount use carved "Store" and generated "Catalog" to do that.

```
vshadowmount -o 344981504 -c E:\Artifacts\other_carved_vss\infected_drive_d_catalog
-s E:\Artifacts\other_carved_vss\infected_drive_d_store X:\EWF1 y:
```

Enter this in a single line.

Prepared "Store" file

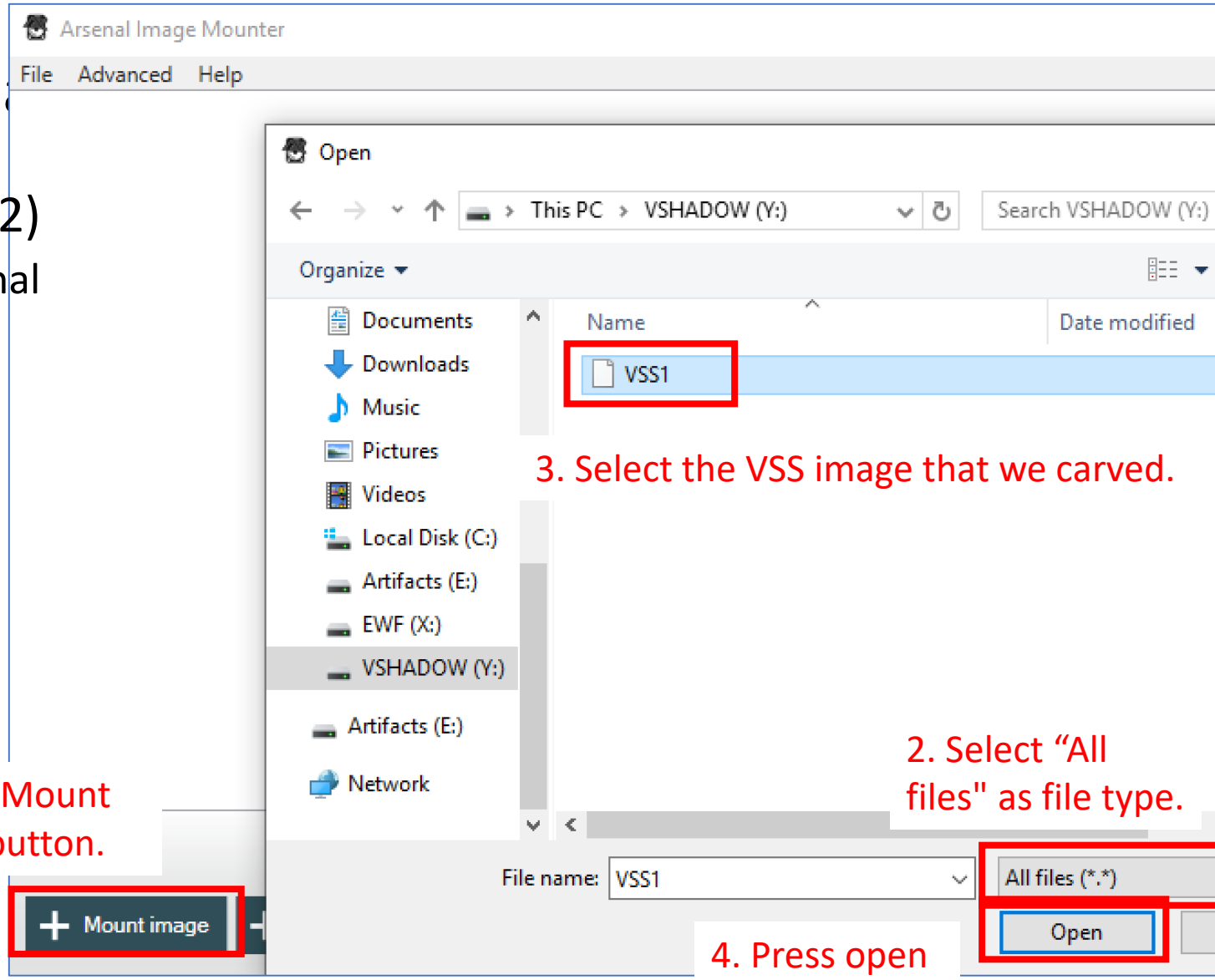
Prepared "Catalog" file



Practice Exercise 2:

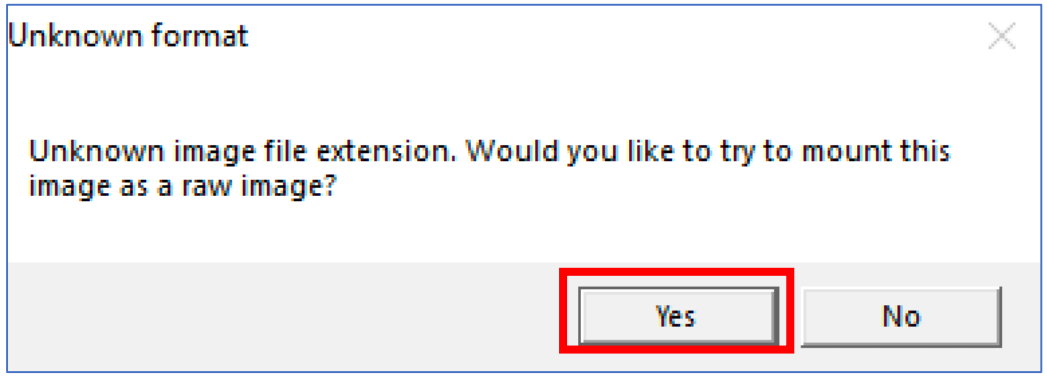
Recovering Deleted VSS Sn

- Mount the carved VSS snapshot (2)
  - Mount the carved image with Arsenal Image Mounter.

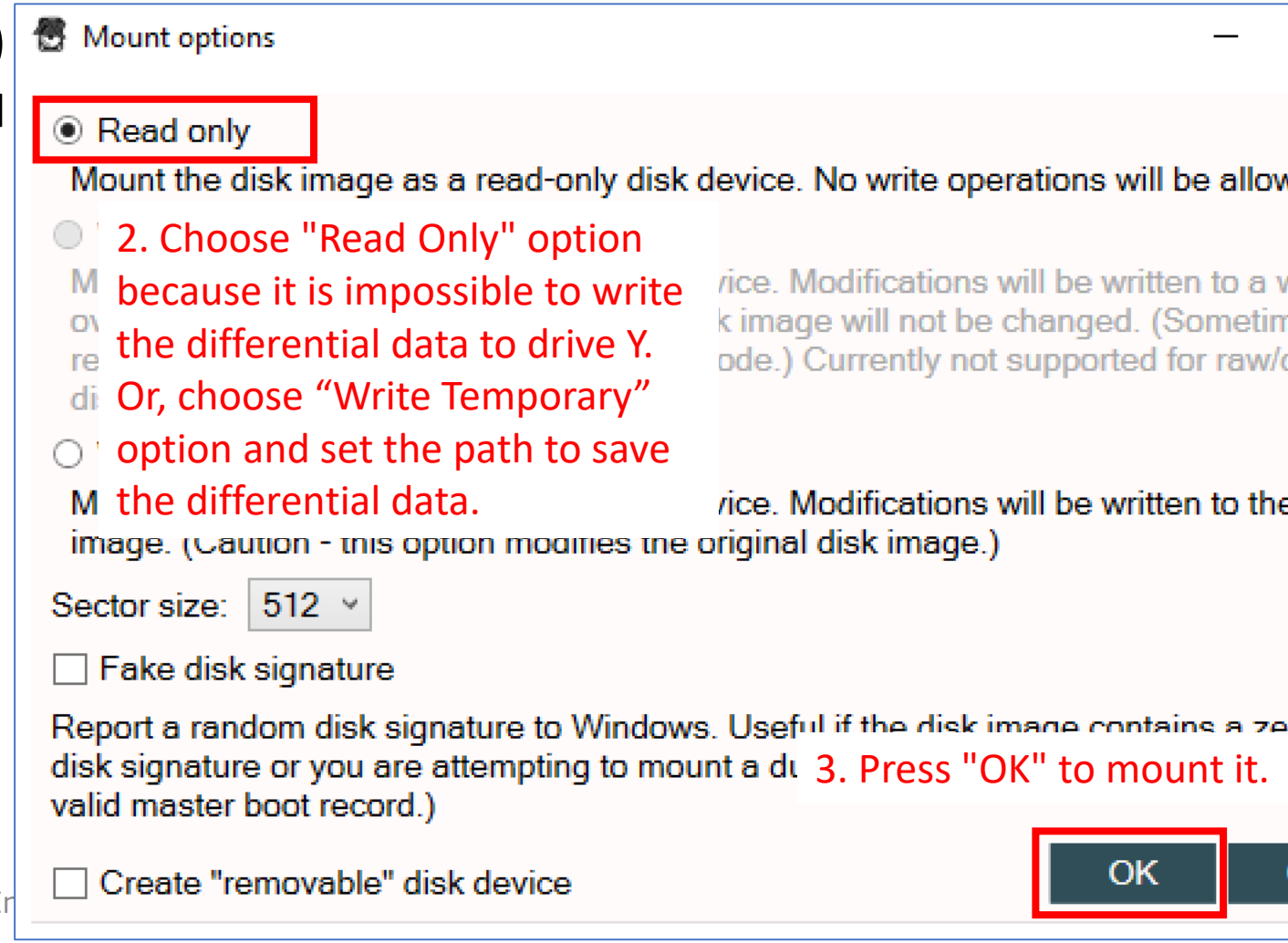


Practice Exercise 2:
Recovering Deleted VSS Snapshots (11)

- Mount the carved VSS snapshot (3)
  - Mount the carved image with Arsenal Image Mounter. (Cont.)

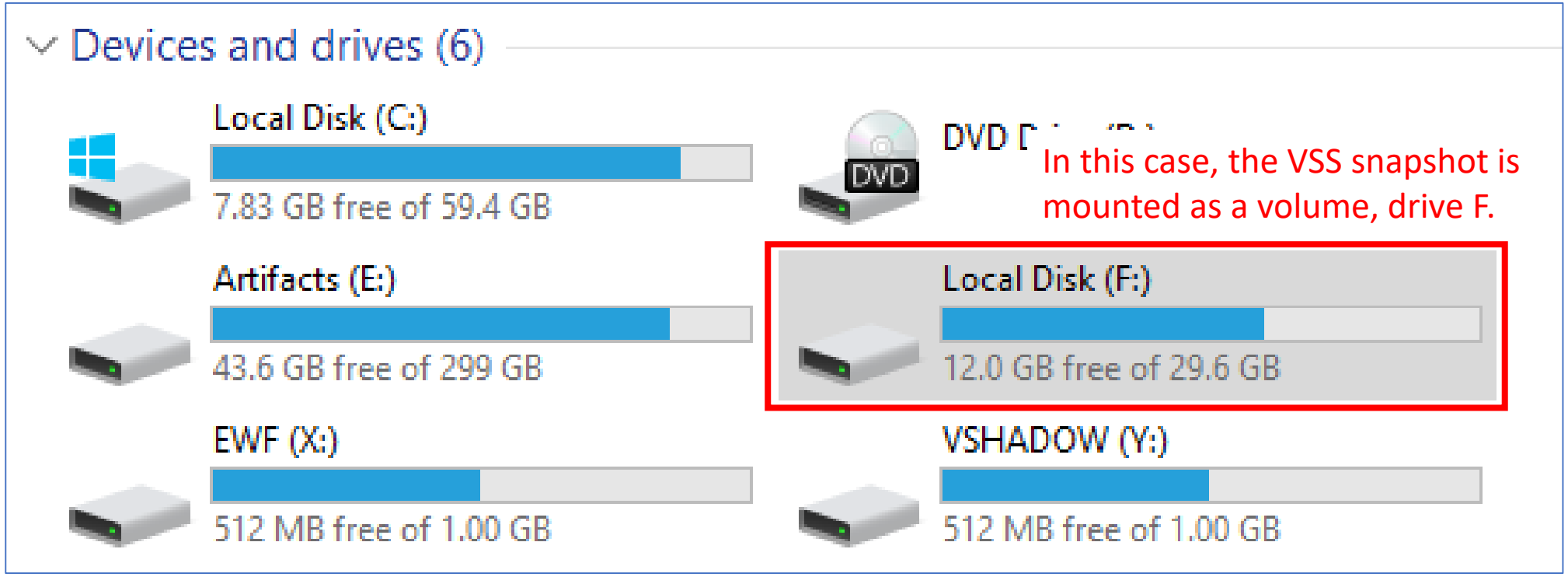


1. Press Yes on this dialog.



Practice Exercise 2:
Recovering Deleted VSS Snapshots (12)

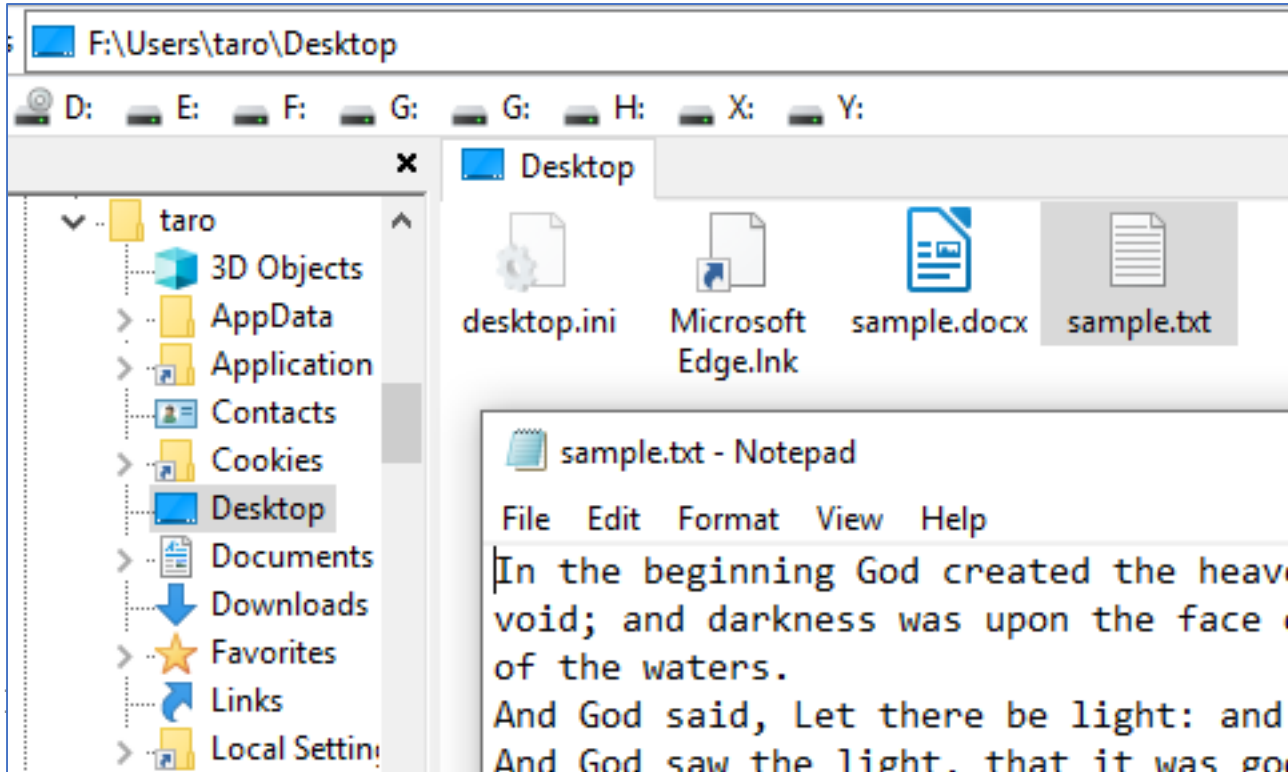
- Mount the carved VSS snapshot (4)
  - Mount the carved image with Arsenal Image Mounter. (Cont.)



Practice Exercise 2:

Recovering Deleted VSS Snapshots (13)

- Finally, you can get the original files in the carved VSS snapshot.
- You can confirm that the txt file is restored. However, the docx file is not restored properly. Carving data is not always successful.
- Note: In this case, you can use Explorer++ to open Taro's %USERPFORILE% folder without modifying the volume. Explorer++ is useful to explorer volumes mounted as "read-only".



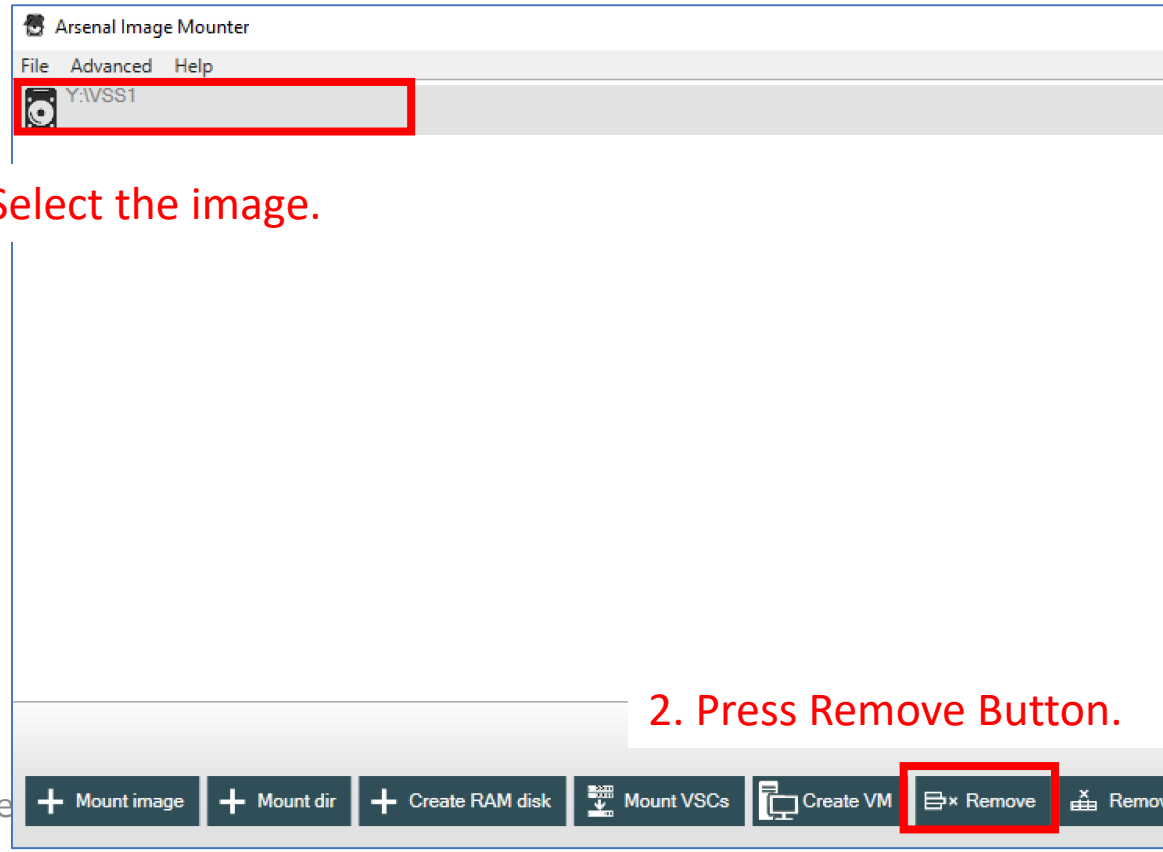
Practice Exercise 2:
Recovering Deleted VSS Snapshots (14)

- Note:
  - The data contained in deleted VSS snapshots might be overwritten with encrypted contents and other general files. Therefore, carving deleted VSS snapshots is not always success.
  - When a file is updated/deleted, VSS saves the differentials of the original file and updated one. Thus, files that have never updated are not stored in VSS snapshots.

Practice Exercise 2:

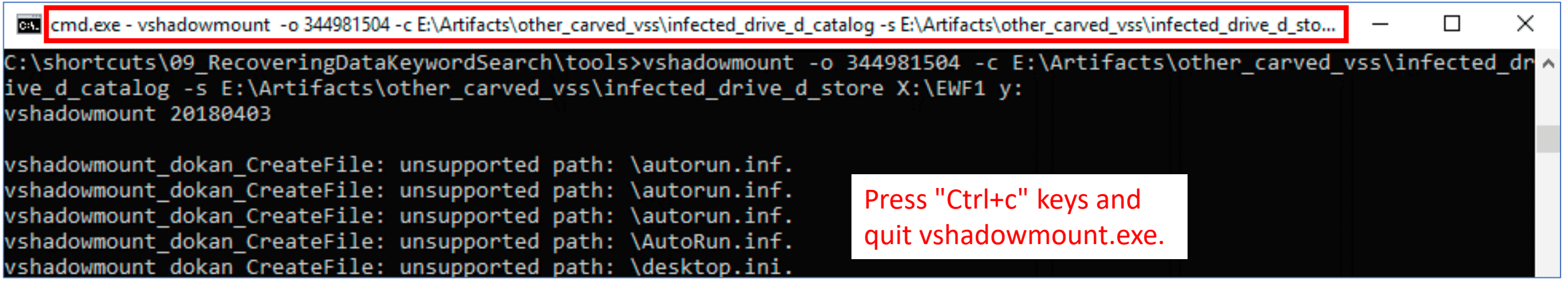
Recovering Deleted VSS Snapshots (15)

- Unmount the carved VSS snapshot
  - Quit Event Log Explorer and close the Explorer window.
  - Then, unmount the drive F on Arsenal Image Mounter

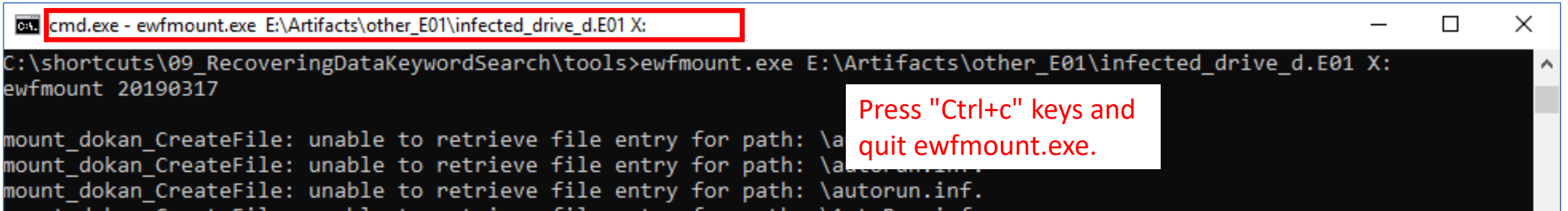


Practice Exercise 2:
Recovering Deleted VSS Snapshots (16)

- Unmount all
  - Press "Ctrl+c“ on the vshadowmount's prompt.



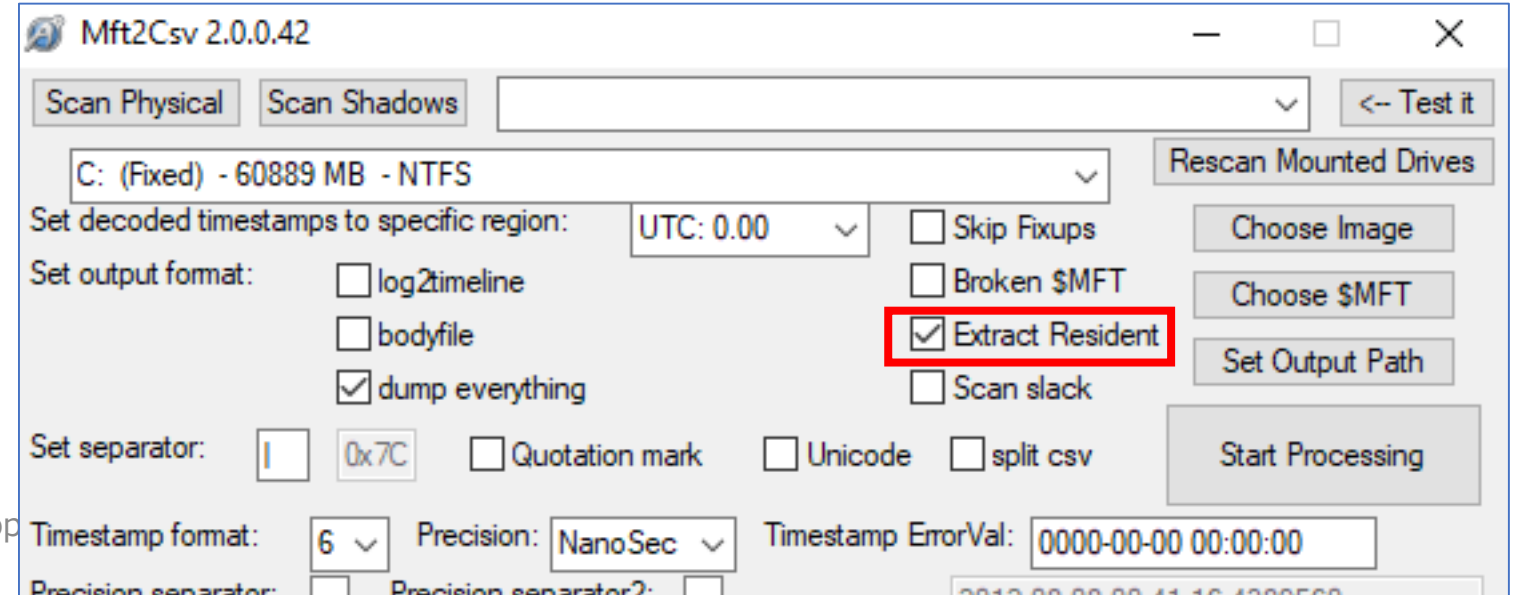
  - Finally, press "Ctrl+c" on the ewfmount's prompt.



Resident Data in MFT Records

Resident Data in MFT Records

- As we already mentioned in Timeline Analysis chapter, Windows does not delete data immediately when files are deleted. Windows just flags the files' entries as "deleted" in Master File Table.
- Therefore, we might be able to extract deleted files if the entries exist.
  - Sometimes this is categorized as one of the data carving techniques.
  - For example, you can extract resident files from $MFT by executing Mft2Csv with “Extract Resident” option.



Data Carving and Keyword Search

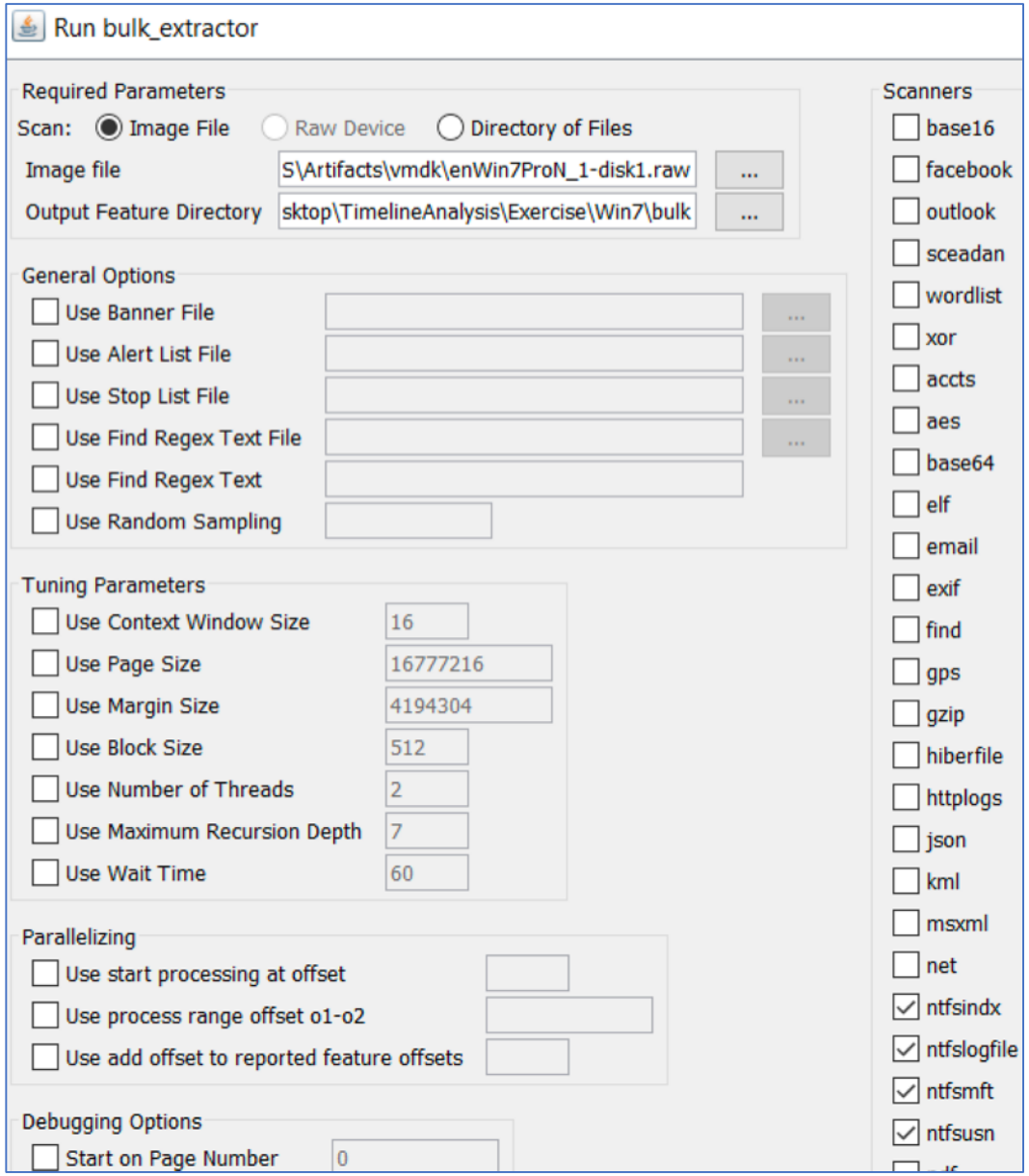
Data Carving

Data Carving

- Carving is to find and extract a specific data structure from large data chunk such as disk images, memory images, swap files, unallocated spaces, file slack, and so on.
- We often use this method to recover deleted files from unallocated space of acquired disk images.
- In order to find a specific data structure, we typically use file magics, signatures, and other characteristics of their format.

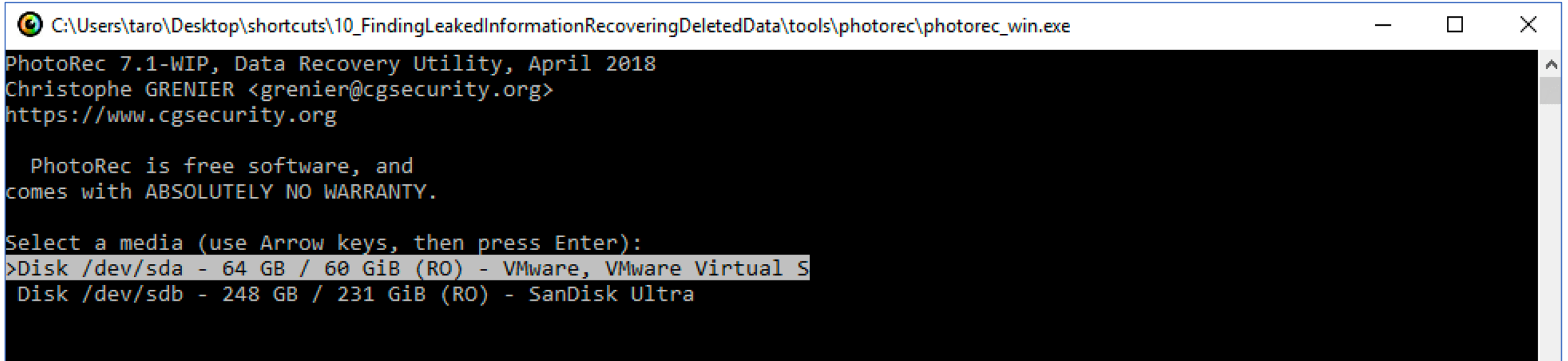
Data Carving Tools (1)

- Bulk Extractor with Record Carving
  - It is an enhanced version from the original Bulk Extractor. It contains scanner plugins for records of $MFT, $LogFile, $UsnJrnl:$J, $INDEX_ALLOCATION, and utmp structure.
  - We can also use it for regex text search.
  - It supports several disk image formats such as E01, vmdk and so on.



Data Carving Tools (2)

- PhotoRec
  - It is a file recovering tool.
  - It supports some popular file systems such as NTFS, ext2/3/4, HFS+, and so on. It can carve files with awareness for file system format.
  - It is capable of making custom signature.
  - It requires the target volume to be mounted.



Data Carving Tools (3)

- Foremost
  - It is an old simple file carving tool.
  - It is capable of using regex custom signatures.
  - It can carve from raw images. It can also carve from memory images and swap files.

cmd.exe

```
C:\shortcuts\12_RecoveringDataKeywordSearch\tools\foremost>foremost.exe -h
foremost version 1.5.7 by Jesse Kornblum, Kris Kendall, and Nick Mikus.
$ foremost [-v|-V|-h|-T|-Q|-q|-a|-w-d] [-t <type>] [-s <blocks>] [-k <size>]
        [-b <size>] [-c <file>] [-o <dir>] [-i <file]

-V  - display copyright information and exit
-t  - specify file type.  (-t jpeg,pdf ...)
-d  - turn on indirect block detection (for UNIX file-systems)
-i  - specify input file (default is stdin)
-a  - Write all headers, perform no error detection (corrupted files)
-w  - Only write the audit file, do not write any detected files to the disk
-o  - set output directory (defaults to output)
-c  - set configuration file to use (defaults to foremost.conf)
-q  - enables quick mode. Search are performed on 512 byte boundaries.
```

Data Carving Tools Comparison Table

- Each tool has both strong and weak points.

	Bulk Extractor with Record Carving	PhotoRec	Foremost
Performance	Y		
File system awareness		Y	
Carving with memory images	Y		Y
Per record carving	Y		
Custom ascii search	Y	Y	Y
Custom ascii search with regex	Y		Y
Custom binary search		Y	Y
Custom binary search with regex			Y
Plugin extendable	Y		

Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost

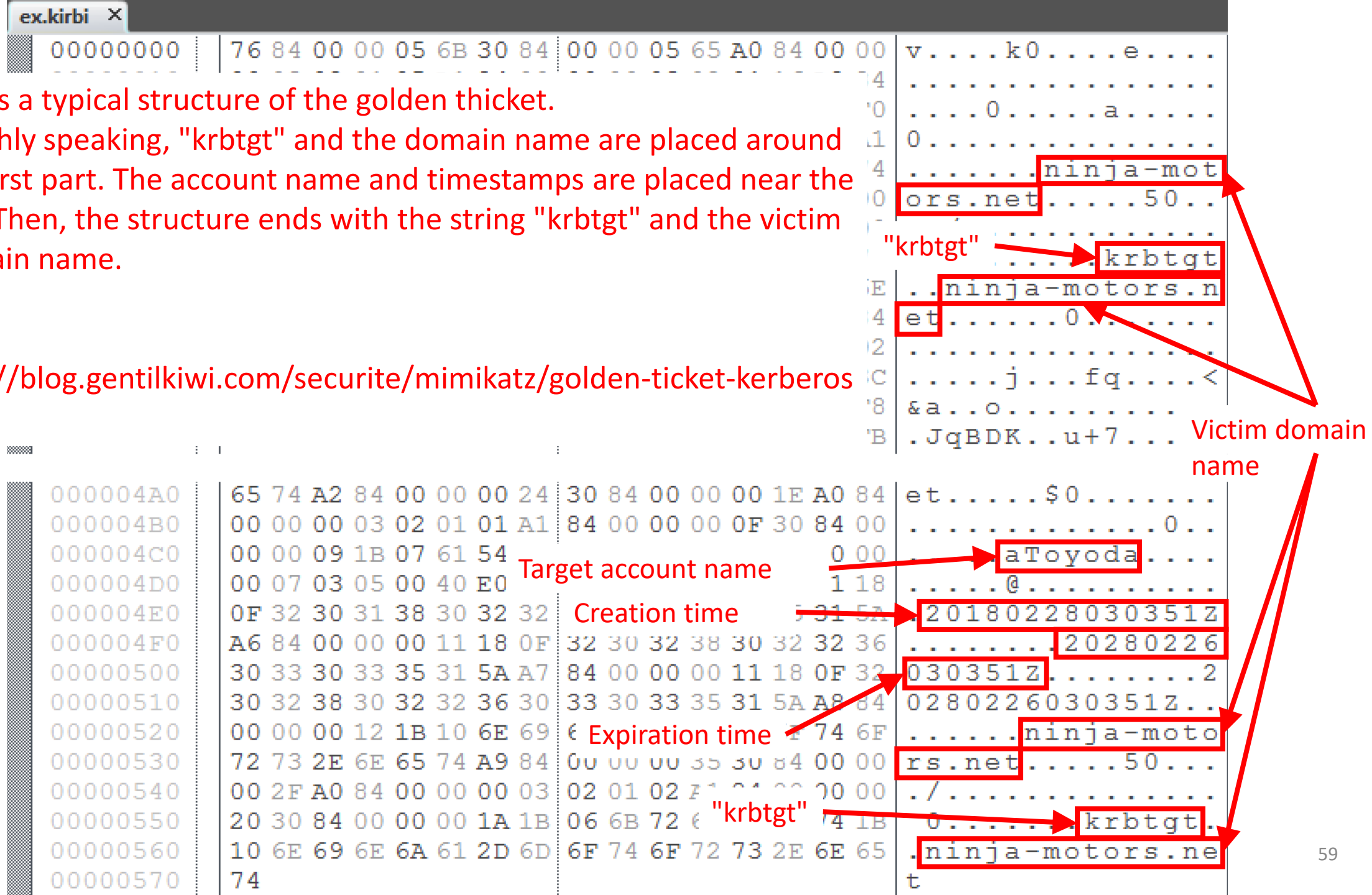
Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (1)

- Condition:
  - We have already known that the attacker could use the golden ticket on client-win10-1.
- Goal:
  - To search the pagefile for the golden ticket structure. The pagefile contains swap-outed data. If we could find it, it could be a clear evidence of golden ticket being used.

This is a typical structure of the golden thicket.
Roughly speaking, "krbtgt" and the domain name are placed around the first part. The account name and timestamps are placed near the last. Then, the structure ends with the string "krbtgt" and the victim domain name.

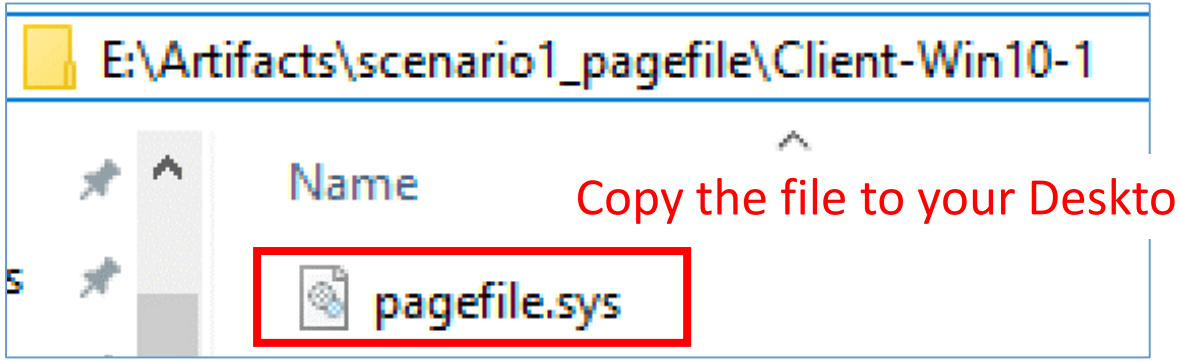
Ref:
http://blog.gentilkiwi.com/securite/mimikatz/golden-ticket-kerberos



Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (3)

- First, copy the following pagefile to your Desktop. It is because foremost fails to process images on an exFAT formatted removable drives.



- Then, launch cmd.exe by double-clicking the shortcut icon.

Shortcuts\09_RecoveringDataKeywordSearch

Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (4)

- Execute the following commands to carve with foremost!

```
cd foremost
mkdir carved
foremost.exe -c foremost-asn1.conf -o carved C:\Users\taro\Desktop\pagefile.sys
```

-c option is to set a configuration file

-o option is to set an output folder

The last argument is the target image

```
1 asn1    y  4096  \x76\x82??\x30\x82??\xa0\x03\x02\x01\x05\xa1\x03\x02\x01\x16
2 asn1_84 y  4096  \x76\x84????\x30\x84????\xa0\x84\x00\x00\x00\x03\x02\x01\x05\xa1\x84\x00\x00\x00\x03\x02\x01\x16
```

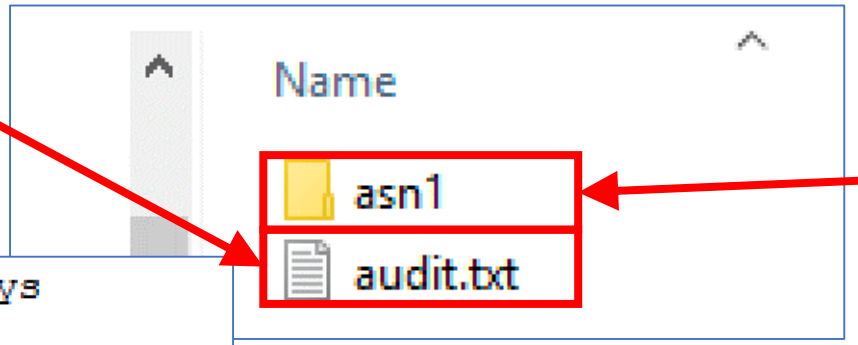
- This is the content of the configuration file. These are the signatures for the golden tickets' ASN.1 structure.
- We referenced the blog below to make these signatures.
  - https://blog.didierstevens.com/2016/08/12/mimikatz-golden-ticket-dcsync/

Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (5)

- You might get the following result.

foremost\carved

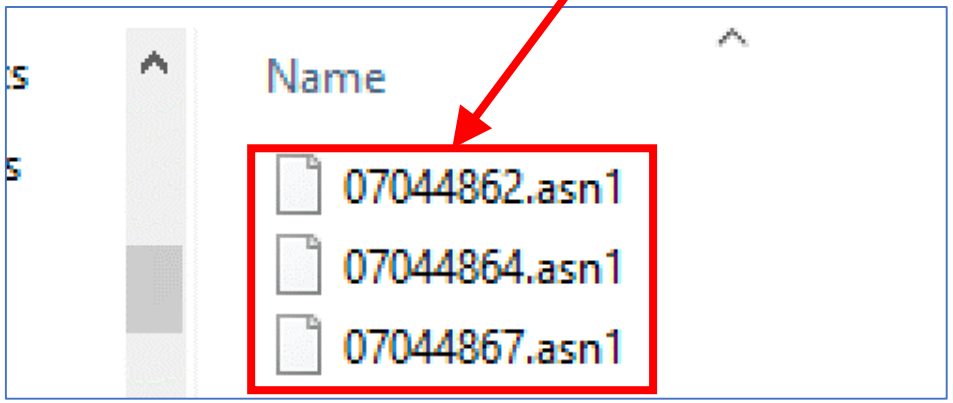


The report

Carved files

```
 9  File: C:\Users\taro\Desktop\pagefile.sys
10  Start: Sun Jul 29 12:08:34 2018
11  Length: Unknown
12
13  Num   Name (bs=512)         Size   File Offset
14
15  0:   07044862.asn1          4 KB       3606969356
16  1:   07044864.asn1          4 KB       3606970828
17  2:   07044867.asn1          4 KB       3606972300
18  Finish: Sun Jul 29 12:08:47 2018
19
20  3 FILES EXTRACTED
21
22  asn1:= 3
```

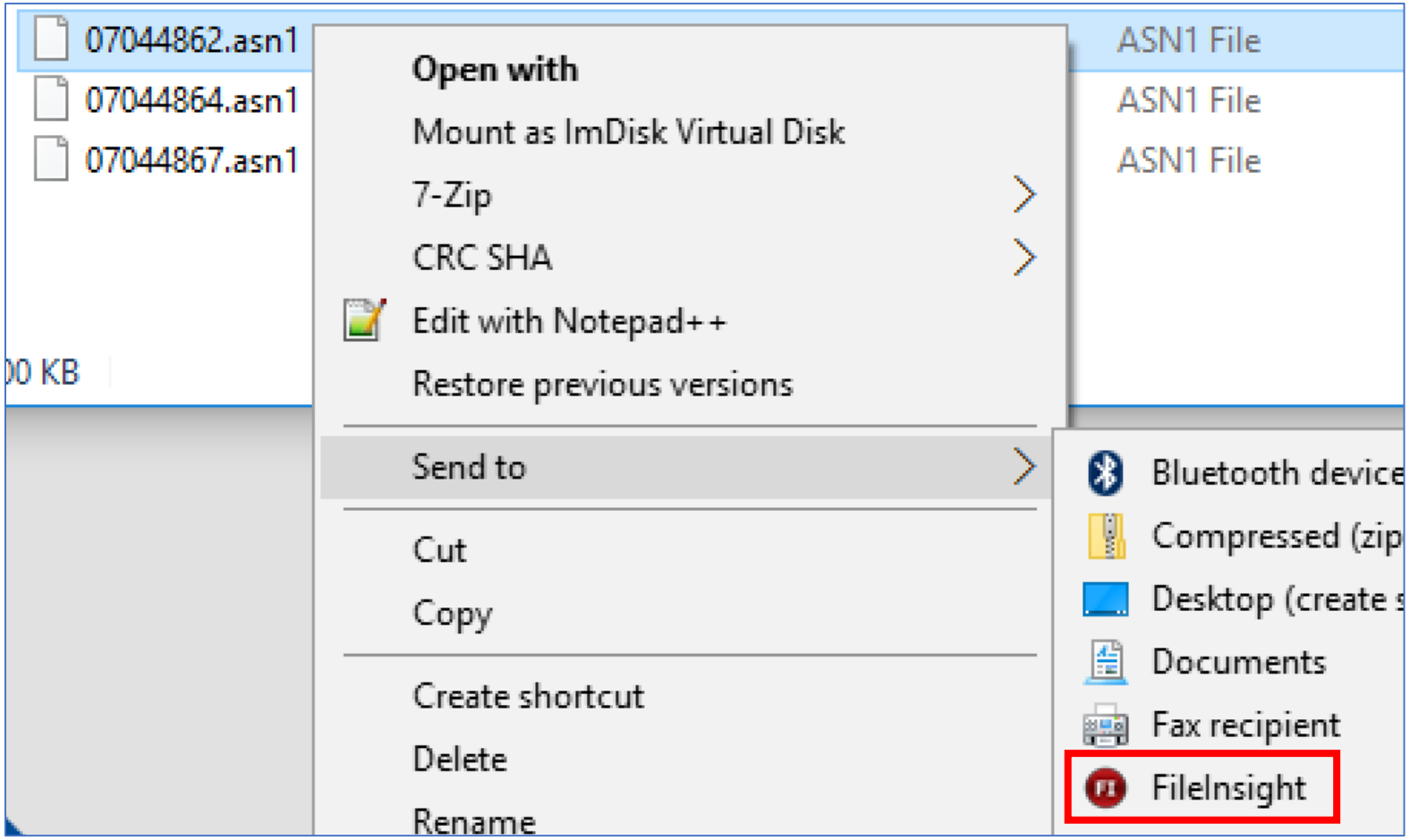
foremost\carved\asn1



Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (6)

- Let's open the carved files with a hex editor such as FileInsight.



Scenario 1 Labs: Lab 1

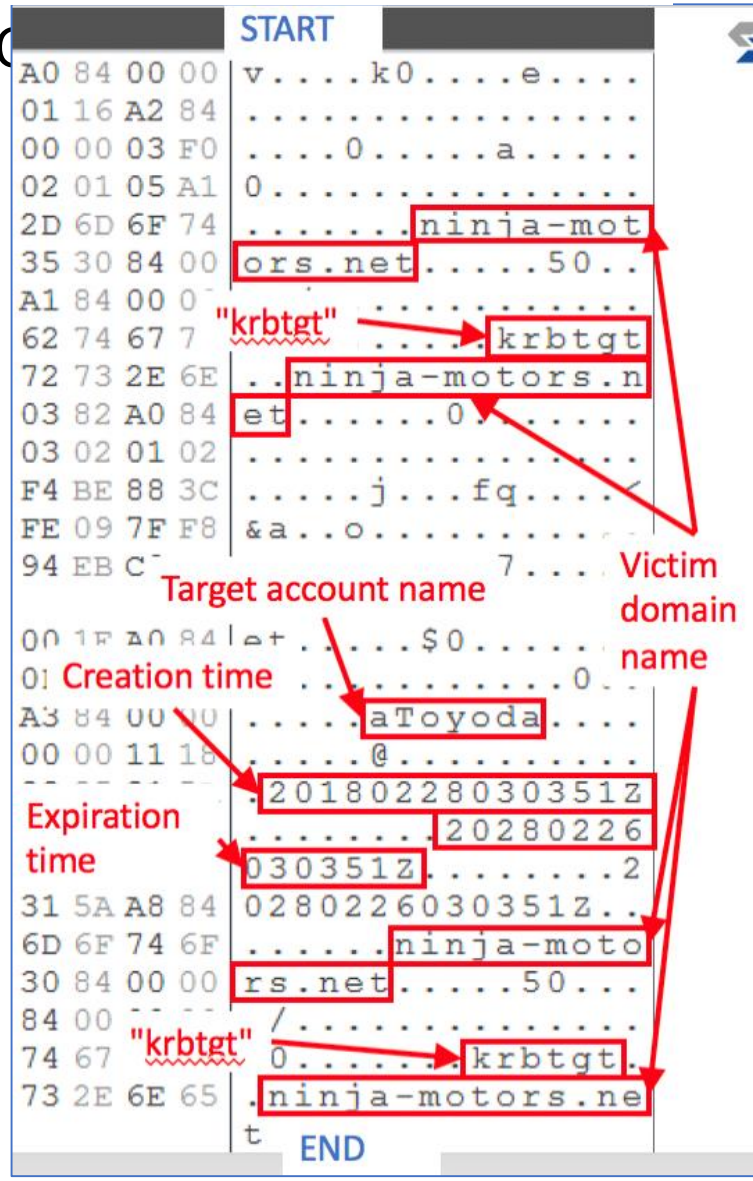
To search pagefiles for the golden tickets with fo

- The first part looks very similar to the typical golden ticket structure we checked before. However, we cannot find the last part that should contain the target user name and timestamps. In addition, we cannot find the end of the structure that should contain strings "krbtgt" and its domain name placed after the target username and timestamps.
- Moreover, the domain name is written in all capital letters. Therefore, we cannot consider these carved files as the golden ticket.
- They might be parts of other credential data structures.

07044862.asn1

```
00000000  76 82 05 A0 30 82 05 9C A0 03 02 01 05 A1 03 02  v...0...........
00000010  01 16 A2 82 04 72 30 82 04 6E 61 82 04 6A 30 82  .....r0..na..j0.
00000020  04 66 A0 03 02 01 05 A1 12 1B 10 4E 49 4E 4A 41  .f.........NINJA
00000030  2D 4D 4F 54 4F 52 53 2E 4E 45 54 A2 25 30 23 A0  -MOTORS.NET.%0#.
00000040  03 02 01 02 A1 1C 30 1A 1B 06 6B 72 62 74 67 74  ......0...krbtgt
00000050  1B 10 4E 49 4E 4A 41 2D 4D 4F 54 4F 52 53 2E 4E  ..NINJA-MOTORS.N
00000060  45 54 A3 82 04 22 30 82 04 1E A0 03 02 01 12 A1  ET..."0.........
00000070  03 02 01 02 A2 82 04 10 04 82 04 0C F8 F8 6E D5  ..............n.
00000080  AB BE 0E D7 C5 A8 75 29 DE 17 8E 82 B2 CE 0F B0  ......u).......
00000090  3F 46 C3 0D E4 EC B6 D2 A3 C2 70 A3 56 62 AA 61  ?F........p.Vb.a
```

Typical golden ticket structure



Scenario 1 Labs: Lab 1

To search pagefiles for the golden tickets with foremost (8)

- Unfortunately, we failed to find the structure of the golden tickets in this exercise.
- This kind of task does not always success. Also it takes a lot of time.
- However, by performing carving methods, we might recover deleted important files such as forged credentials, rotated program execution artifacts, stolen archives, and so on.

Per Record Carving

Per Record Carving

- If it is impossible to restore the whole file body, we can use per record carving method.
- It recovers data per record basis instead of per file basis. We typically use this method to recover the following records.
  - $MFT records
  - $INDX records
  - $USNJrnl:$J records
  - Event logs
  - SQLite records
  - Web browser histories

We have already mentioned them in File System Timeline Analysis chapter.

We have already mentioned them in Web Browser Forensics chapter.

Per Record Carving Tools

- We have already leaned about these per record carving tools in Timeline Analysis Chapter.
  - Bulk Extractor with Record Carving
    - It supports recovering data of INDX, $LOGFILE, $MFT, and $UsnJrnl:$J per record basis.
    - We usually use USN Analytics to parse $J records carved by this tool.
  - MftCarver
    - It supports recovering data of $MFT per record basis.
    - We usually use MFT2Csv to parse $MFT records carved by this tool.
  - IndxCarver
    - It supports recovering data of INDX per record basis.
    - We usually use Indx2Csv to parse INDX records carved by this tool.

Per-Record Carving of Event Logs

Event Log Record Carving 101 (1)

- What is Event Log Record Carving?
  - It is a method to recover event records from unallocated spaces or memory images by carving when you lost event logs for some reasons, such as:
    - Deleted by attackers
    - Time past
    - Misconfiguration
    - …
- Why should we do this?
  - Carbon Black said, "*It's fitting, given the destructive nature of contemporary attacks, that 72% of IR professionals saw counter IR in the form of destruction of logs*", in their report. So, this task is very important for IR.
    - https://www.carbonblack.com/global-incident-response-threat-report/november-2018/
- Tools
  - EvtXtract
    - https://github.com/williballenthin/EVTXtract
  - Evtx Explorer/EvtxECmd + Bulk Extractor with Record Carving
    - https://ericzimmerman.github.io/#!index.md
    - https://www.kazamiya.net/en/bulk_extractor-rec

Event Log Record Carving 101 (2)

- We will use a similar technique we applied in Event Log Analysis section. In that section, we applied the per record carving methods to each file.
- In contrast, we will apply the method to a whole disk image, an unallocated space of a disk, or a pagefile.

Algorithm of EvtXtract

1. Scan for chunk signatures ("ElfChnk")
   - check header for sane values (0x80 <= size <= 0x200)
   - verify checksums (header, data)
2. Extract records from valid chunks found in (1)
3. Extract templates from valid chunks found in (1)
4. Scan for record signatures
   - check header for sane values
   - extract timestamp
   - attempt to parse substitutions
   - attempt to decode substitutions into EID, other fields
5. Reconstruct records by reusing old templates with recovered substitutions

https://github.com/williballenthin/EVTXtract

Using EvtXtract

Using EvtXtract (1)

- Open the folder below on Desktop of the analysis machine, then open command prompt.
  - Shortcuts\10_FindingLeakedInformationRecoveringDeletedData\tools

- Convert a disk image to a raw disk image dynamically with ewfmount.

```
ewfmount E:\artifacts\scenario1_E01\Client-Win10-1_toyoda.E01 Y:
```

- Extract event logs with record carving using EvtXtract from the raw disk image

```
evtxtract Y:\EWF1 > E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract\Client-Win10-1-evtxtract.xml
```

Note that this command takes long time! We have already prepared the command result.
The whole command needs to be written in a single line.

Using EvtXtract (2)

- Next, fix two bugs in the result of EvtXtract XML file

```
py.exe fix_evtxtract_xml.py
E:\Artifacts\scenario1_eventlog\record_carving_with_evtxtract\Client-Win10-1-evtxtract.xml
```

Note that this command takes long time! We have already prepared the command result.
The whole command needs to be written in a single line.

  - Remove “\0”
  - Move Xml header into the top of the file
- Convert XML to CSV (strictly speaking, it is TSV though…) with our script.

```
py.exe xml_evtx_parse.py
E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract\Client-Win10-1-
evtxtract.xml.fixed.xml >
E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract\Client-Win10-1-
evtxtract.xml.fixed.xml.csv
```

Note that this command takes long time! We have already prepared the command result.
The whole command needs to be written in a single line.

Using EvtXtract (3)

- Then add a CSV header and sort lines.

```
add_header_and_sort.bat E:\Artifacts\scenario1_eventlog\record_carving_with_evtxtract\Client-Win10-1-evtxtract.xml.fixed.xml.csv
```

Note that this command takes long time! We have already prepared the command result.
The whole command needs to be written in a single line.

- Now we are ready to check the results.
- Actually, if you execute “evtxtract_csv.bat”, you can perform the same process related to EvtXtract like the following.

```
evtxtract_csv.bat Y:\EWF1 "" E:\Artifacts\scenario1_eventlog\record_carving_with_evtxtract Client-Win10-1-evtxtract
```

Note that this command takes long time! We have already prepared the command result.
The whole command needs to be written in a single line.

Scenario 1 Labs: Lab 2

Checking carved events

Scenario 1 Labs: Lab 2

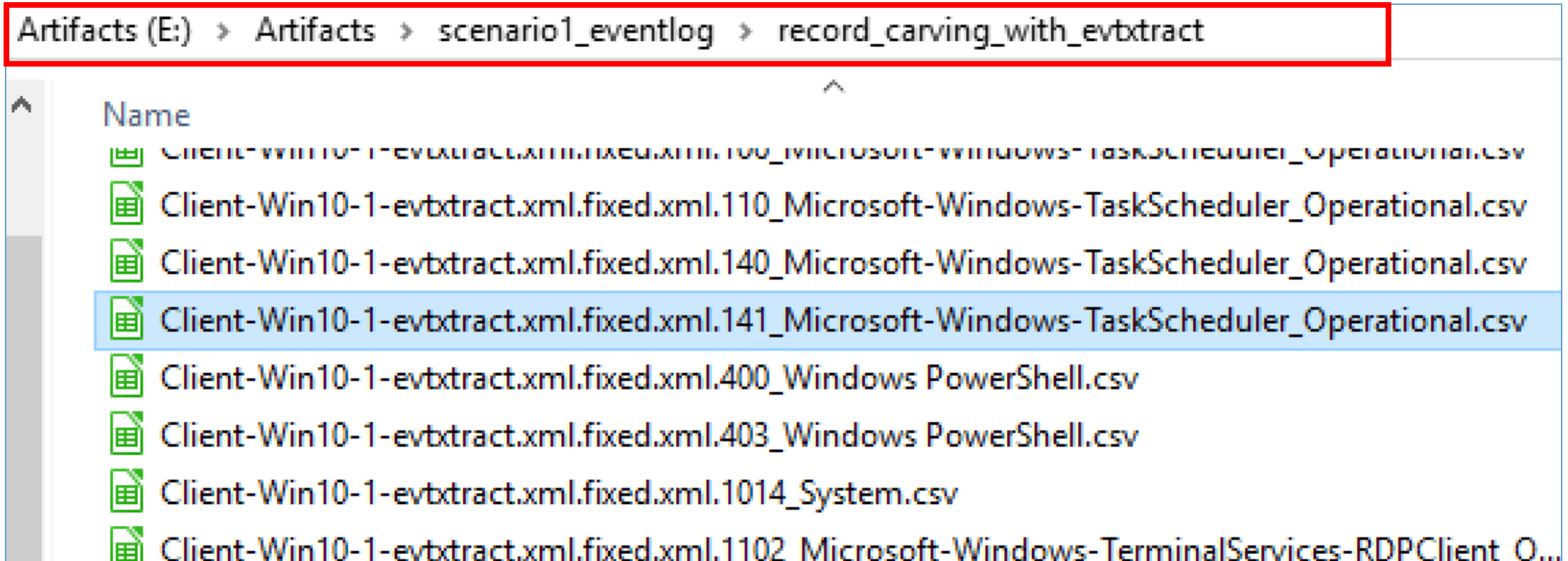
Checking carved events (1)

- Condition:
  - We already know that the task "SyS" was registered by the attackers on Client-win10-1 at Mar 15 6:53PM from Event Log analysis.
  - However, we could not find the task on the current disk image of Client-win10-1.
- Goal:
  - To find out when the task was deleted by checking carved event logs.

Scenario 1 Labs: Lab 2

Checking carved events (2)

- After executing EvtXtract and the bat files on client-win10-1, we got many carved event logs. The bat would output parsed csv files for each Event ID.



Scenario 1 Labs: Lab 2

Checking carved events (3)

- Open the result with LibreOffice.
  - ID 141 is a deletion event of a scheduled task.
  - Let's open “Client-Win10-1-evtxtract.xml.fixed.xml.141_Microsoft-Windows-TaskScheduler_Operational.csv” on “E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract”.

local_time	EID	Category	User	Computer	Data_Name_T
2018-03-13 13:46:35.673298	141	Microsoft-W	S-1-5-18	client-win10-1.ninja-motors.net	\Adobe Acrob
2018-03-23 13:26:30.447702	141	Microsoft-W	S-1-5-18	client-win10-1.ninja-motors.net	\SyS
2018-03-14 23:03:18.748373	141	Microsoft-W	S-1-5-18	client-win10-1.ninja-motors.net	\Microsoft\Wi

You can get the deletion time of the task “\SyS” that had dumped credentials in memory of Client-Win10-1.

Scenario 1 Labs: Lab 2

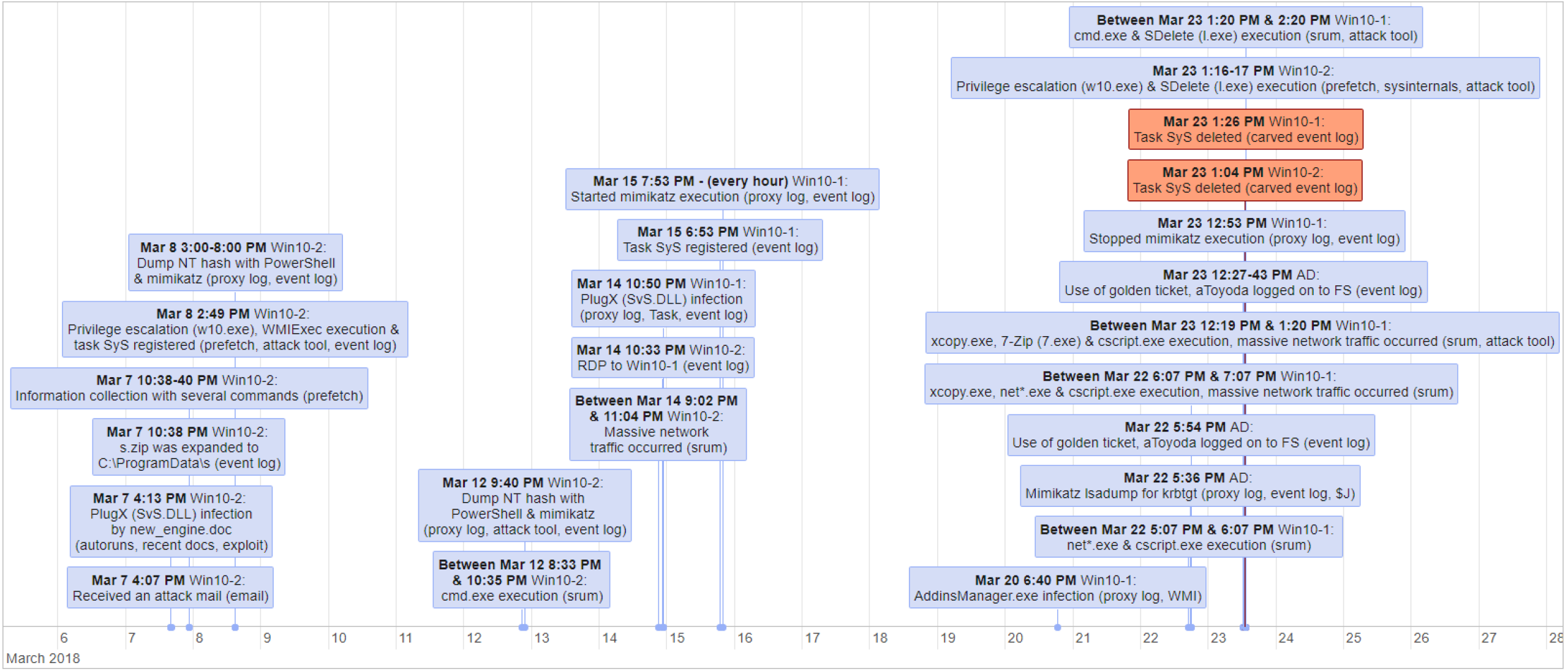
Checking carved events (4)

- How about Client-Win10-2?
  - Let's open “Client-Win10-2-evtxtract.xml.fixed.xml.141_Microsoft-Windows-TaskScheduler_Operational.csv” on “E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract”.
  - You can also find out the similar log.

local_time	EID	Category	User	Computer	Data_Name_TaskName
2018-03-23 13:04:31.450266	141	Microsoft-Win	S-1-5-18	client-win10-2.ninja-motors.net	\SyS
2018-03-19 19:48:50.753693	141	Microsoft-Win	S-1-5-18	client-win10-2.ninja-motors.net	\Microsoft Office 15 Sync M

You can get the deletion time of the task “\SyS” that had dumped credentials in memory of Client-Win10-2.

Scenario 1 Labs: Lab 2



Scenario 1 Labs: Lab 3

Golden ticket detection in carved events

Scenario 1 Labs: Lab 3

Golden ticket detection in carved events (1)

- Open cmd.exe in “shortcuts\09_RecoveringDataKeywordSearch”.
- Type the command below.

```
py.exe golden_tickets.py
E:\artifacts\scenario1_eventlog\record_carving_with_evtxtract\AD-Win2016-
evtxtract.xml.fixed.xml.csv
```

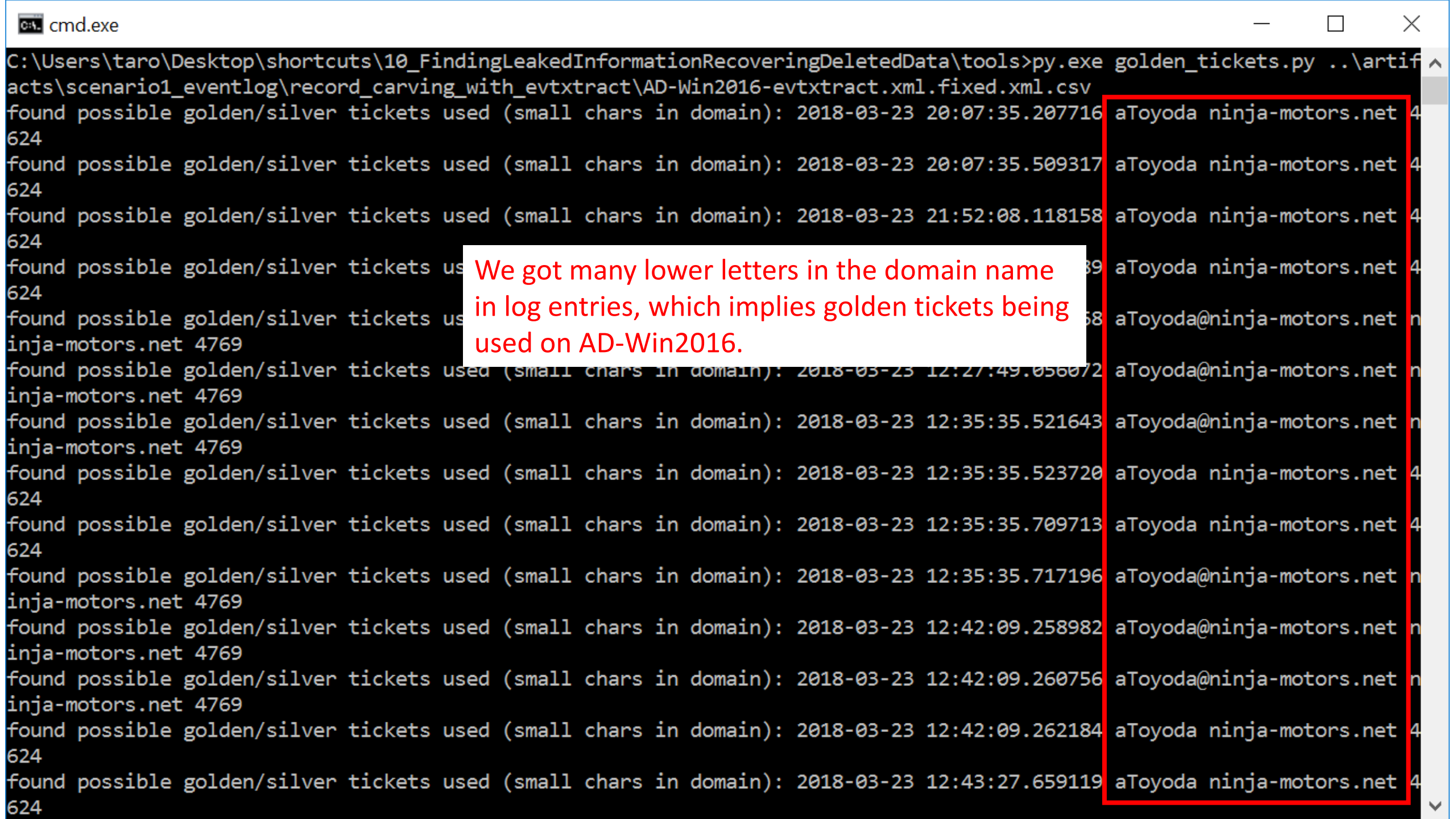
Enter this line in a single line.

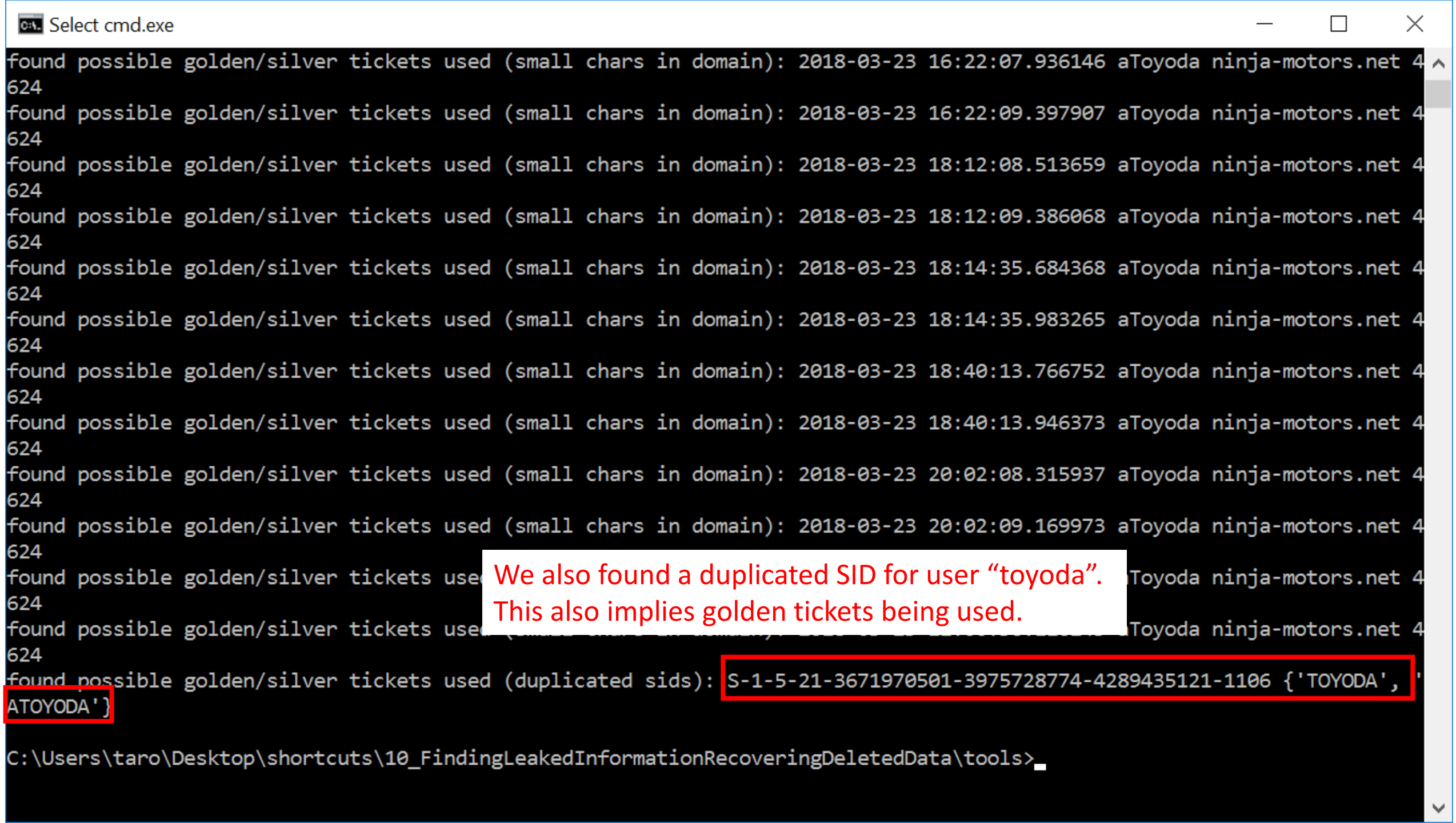
Mimikatz Golden/Silver Tickets Detection Method

- We could detect Golden/Silver Tickets by enumerating user names and SIDs in all security logs and checking duplicate user names corresponding to each SID.

SID	User
S-1-2-21-XXXXX-500	Administrator
S-1-2-21-XXXXX-1000	Alice
S-1-2-21-XXXXX-1001	Bob
S-1-2-21-XXXXX-1002	Carol
S-1-2-21-XXXXX-1003	Dave, Mallory
S-1-2-21-XXXXX-1004	Ellen
S-1-2-21-XXXXX-1005	Frank
…	…

Golden/Silver Ticket


cmd.exe
C:\Users\taro\Desktop\shortcuts\10_FindingLeakedInformationRecoveringDeletedData\tools>py.exe golden_tickets.py ..\artifacts\scenario1_eventlog\record_carving_with_evtxtract\AD-Win2016-evtxtract.xml.fixed.xml.csv
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:07:35.207716 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:07:35.509317 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 21:52:08.118158 aToyoda ninja-motors.net 4624
found possible golden/silver tickets us 9 aToyoda ninja-motors.net 4624
found possible golden/silver tickets us 8 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:27:49.056072 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:35:35.521643 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:35:35.523720 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:35:35.709713 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:35:35.717196 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:42:09.258982 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:42:09.260756 aToyoda@ninja-motors.net ninja-motors.net 4769
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:42:09.262184 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 12:43:27.659119 aToyoda ninja-motors.net 4624
We got many lower letters in the domain name in log entries, which implies golden tickets being used on AD-Win2016.


Select cmd.exe
found possible golden/silver tickets used (small chars in domain): 2018-03-23 16:22:07.936146 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 16:22:09.397907 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:12:08.513659 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:12:09.386068 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:14:35.684368 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:14:35.983265 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:40:13.766752 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 18:40:13.946373 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:02:08.315937 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:02:09.169973 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:02:09.169973 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (small chars in domain): 2018-03-23 20:02:09.169973 aToyoda ninja-motors.net 4624
found possible golden/silver tickets used (duplicated sids): S-1-5-21-3671970501-3975728774-4289435121-1106 {'TOYODA', 'ATOYODA'}
C:\Users\taro\Desktop\shortcuts\10_FindingLeakedInformationRecoveringDeletedData\tools>
We also found a duplicated SID for user “toyoda”.
This also implies golden tickets being used.

Another Record Carving Tool for Event Logs

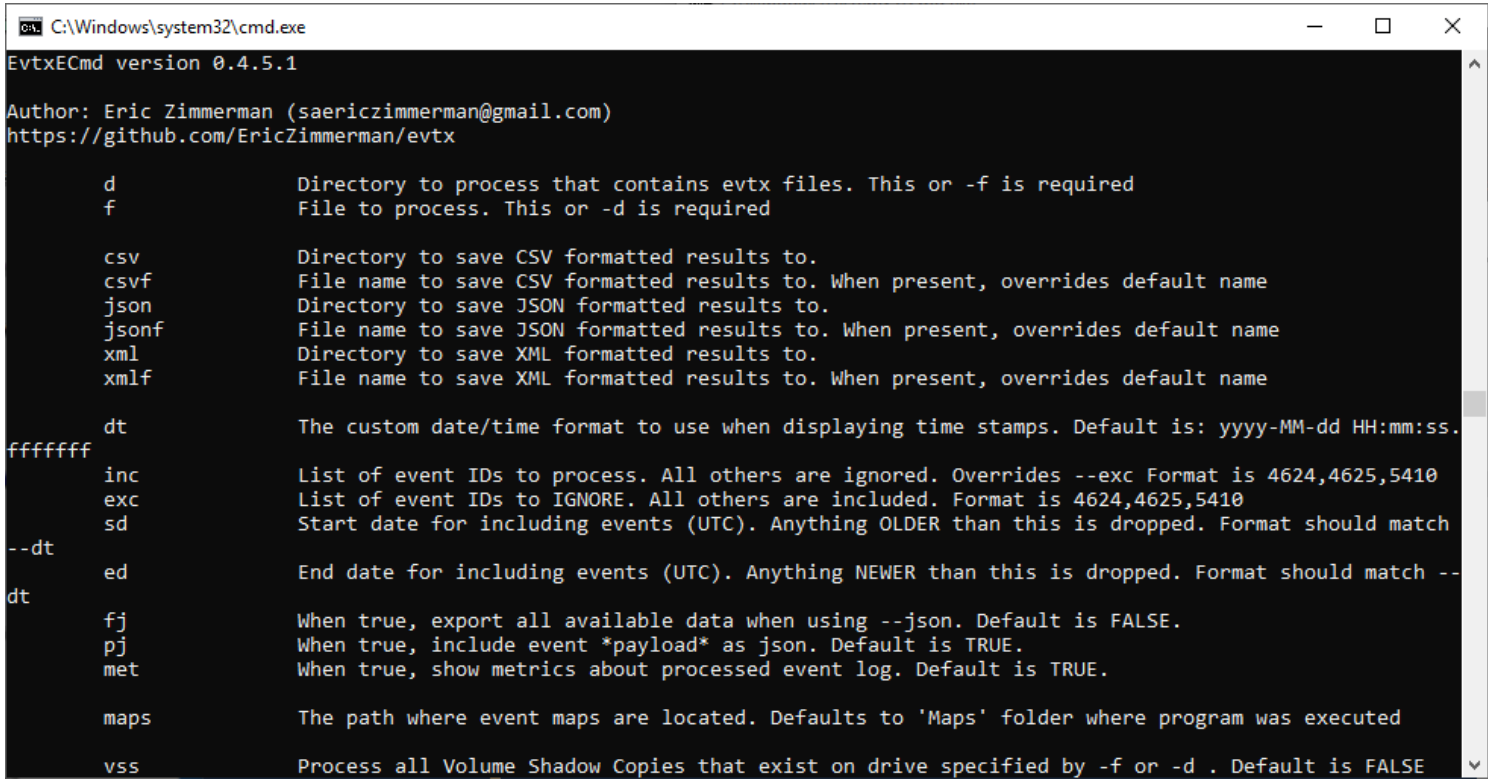
Checking carved events with BulkExtractor with Record Carving + EvtxECmd (1)

- You can carve event log records with “Bulk Extractor with Record Carving”. And you can analyze the carved records with “EvtxECmd”.
- This is another method of event log per-record carving.
- This is neither Lab nor Exercise.

Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (2)

- EvtxECmd
  - This is a command line tool for parsing event logs, by Eric Zimmerman.
  - It can parse Evtx format and save as CSV, JSON or XML format.
  - You need to create a “map” file if you would like to see parsed CSV format, or you should see payload column that is written in the JSON format.



Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (3)

- First, in order to get the offset of the Windows partition, execute mmls command.

```
mmls E:\Artifacts\scenario1_E01\Client-Win10-2_honda.E01
```

```
DOS Partition Table
Offset Sector: 0
Units are in 512-byte sectors

      Slot      Start        End          Length       Description
000:  Meta      0000000000   0000000000   0000000001   Primary Table (#0)
001:  -------   0000000000   0000002047   0000002048   Unallocated
002:  000:000   0000002048   0001026047   0001024000   NTFS / exFAT (0x07)
003:  000:001   0001026048   0104855551   0103829504   NTFS / exFAT (0x07)
004:  -------   0104855552   0104857599   0000002048   Unallocated
```

Choose the big NTFS partition

Offset

Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (4)

- Second, execute blkls command to get unallocated space.

```
blkls -A -o 1026048  E:\Artifacts\scenario1_E01\Client-Win10-2_honda.E01 >
E:\Artifacts\scenario1_eventlog\record_carving_with_BE\Client-Win10-2\unalloc.dat
```

You do not need to execute this command because the command takes long time and we have already prepared the image of unallocated space in the path above. When executing this command, enter the whole line in a single line.

Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (5)

- Third, execute bulk_extractor command with evtx scanner to carve event log records in the extracted unallocated space.

```
bulk_extractor -E evtx -o
E:\Artifacts\scenario1_eventlog\record_carving_with_BE\Client-Win10-2\Carved
E:\Artifacts\scenario1_eventlog\record_carving_with_BE\Client-Win10-2\unalloc.dat
```

You do not need to execute this command because the command takes long time and we have already prepared the image of unallocated space in the path above. When executing this command, enter the whole line in a single line.

Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (6)

- Lastly, in order to analyze the carved records, execute EvtxECmd command.

```
EvtxECmd.exe -d E:\Artifacts\scenario1_eventlog\record_carving_with_BE\Client-Win10-2\Carved --csv E:\Artifacts\scenario1_eventlog\record_carving_with_BE\Client-Win10-2
```

You do not need to execute this command because we have already prepared the result In the directory above.
When executing this command, enter the whole line in a single line.

Another Record Carving Tool for Event Logs

Checking carved events with BulkExtractor with Record Carving + EvtxECmd (7)

- You can see the carved events.

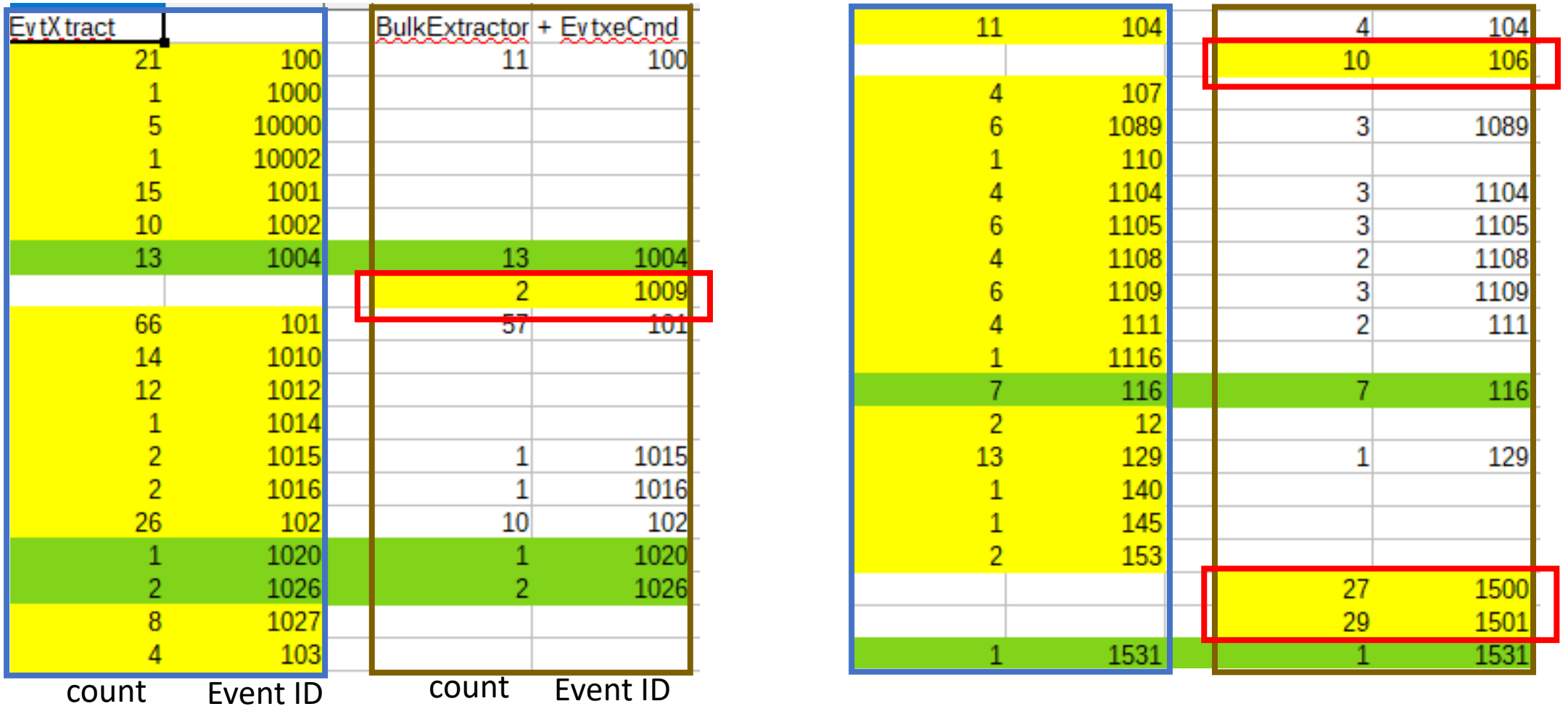
20190607022424_EvtxECmd_Output.csv - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

Liberation Sans 10

A1 RecordNumber

	A	B	C	D	E	F	G	H	I	J	K	
1	Re	Ev	TimeCreated	EventId	Level	Provider	Channel	ProcessId	ThreadId	Computer	UserId	MapDescriptio
2	###	###	2018-02-08 09:06:32.3247376	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
3	###	###	2018-02-08 09:06:32.3247385	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
4	###	###	2018-02-08 09:06:32.3247395	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
5	###	###	2018-02-08 09:06:32.3247450	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
6	###	###	2018-02-08 09:06:32.3247455	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
7	###	###	2018-02-08 09:06:32.3918898	28125	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	672	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
8	###	###	2018-02-08 09:06:33.0167576	9707	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
9	###	###	2018-02-08 09:06:33.8951647	9708	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
10	###	###	2018-02-08 09:06:33.8958480	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
11	###	###	2018-02-08 09:06:33.8958536	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
12	###	###	2018-02-08 09:06:33.8958554	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
13	###	###	2018-02-08 09:06:33.8959541	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
14	###	###	2018-02-08 09:06:33.8959569	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
15	###	###	2018-02-08 09:06:33.8959583	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
16	###	###	2018-02-08 09:06:33.8960286	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
17	###	###	2018-02-08 09:06:33.9101206	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
18	###	###	2018-02-08 09:06:33.9101239	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
19	###	###	2018-02-08 09:06:33.9102053	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
20	###	###	2018-02-08 09:06:33.9102151	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
21	###	###	2018-02-08 09:06:33.9102165	62171	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	1384	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
22	###	###	2018-02-08 09:06:33.9102351	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	672	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
23	###	###	2018-02-08 09:06:33.9103184	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	672	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	
24	###	###	2018-02-08 09:06:33.9103203	62170	4	Microsoft-Windows-Shell-Core	Microsoft-Windows-Shell-Core/Operational	2992	672	client-win10-2.ninja-motors.net	S-1-5-21-3671970501-3975728774-4289435121-1110	



count	Event ID
21	100
1	1000
5	10000
1	10002
15	1001
10	1002
13	1004
66	101
14	1010
12	1012
1	1014
2	1015
2	1016
26	102
1	1020
2	1026
8	1027
4	103

count	Event ID
11	100
13	1004
2	1009
57	101
1	1015
1	1016
10	102
1	1020
2	1026

count	Event ID
11	104
4	107
6	1089
1	110
4	1104
6	1105
4	1108
6	1109
4	111
1	1116
7	116
2	12
13	129
1	140
1	145
2	153
1	1531

count	Event ID
4	104
10	106
3	1089
3	1104
3	1105
2	1108
3	1109
2	111
7	116
1	129
27	1500
29	1501
1	1531

By the way, these are comparative results of record-carving between EvtXtract and BulkExtractor + EvteCmd on unallocated data of Client-Win10-2.E01.
As you can see, in most cases, EvtXtract is superior to BulkExtractor + EvtxECmd.
However, the latter one could sometimes carve several events that EvtXtract was not able to do.
As a result, we recommend you should use both.

Keyword Search

Keyword Search

- We perform it in order to get certain strings such as command names and file names from unallocated spaces, memory images, paging files and so on.
- We usually apply this method with keywords such as names of well-known attacking tools, archiving tools, deletion tools, and extensions of archive files.
- Then, we could get the arguments of the tools, and metadata of those files and folders. Metadata might provide their attributes such as size and timestamps. In other words, we might get the names of tools the attacker used, the names of files they accessed, size of the files, and timestamps of them.

Practice Exercise 3:

Gathering attributes of the archives that attackers created

Practice Exercise 3:
Gathering attributes of the archives that attackers created (1)

- Conditions:
  - It is NOT related to the scenario 1. It's just an independent exercise.
  - We are investigating a certain compromised system.
  - We already know that the attacker used 7-Zip to archive stolen files. In addition, the attacker renamed "7z.exe" to "7.exe".
  - The stolen files are "docs.zip" and "secret.zip".
  - In this case, we will search the following pagefile.sys for traces of 7-Zip execution.
    - E:\Artifacts\scenario2_extracted_pagefile\win10\pagefile.sys
- Goal:
  - To confirm any evidence related to the archive files.

Practice Exercise 3:

Gathering attributes of the archives that attackers created (2)

- Launch the command prompt from the shortcut folder.
- Start text search with the following command.

```
bulk_extractor -E find -f 7\.exe -o
E:\Artifacts\scenario2_carved_command\BE_output_win10_pagefile
E:\Artifacts\scenario2_pagefile\win10\pagefile.sys
```

Enter this in a single line.

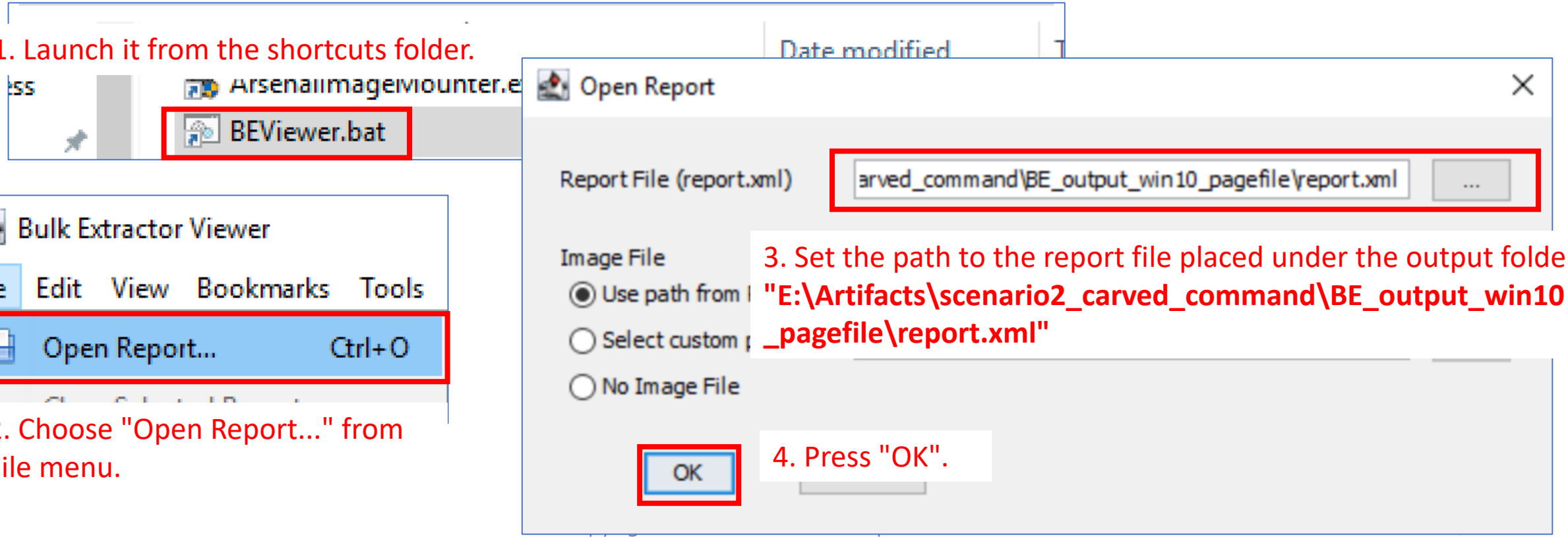
  - -E option is to set the scanner plugin to use.
  - -f option is to set the search string for find plugin.
  - -o option is to set the output folder.
  - The last argument is the target image file.
- In this case, we prepared the result in advance. Please do not execute it now. It takes a while.

Practice Exercise 3:

Gathering attributes of the archives that attackers created (3)

- Then, open the result with BEViewer.

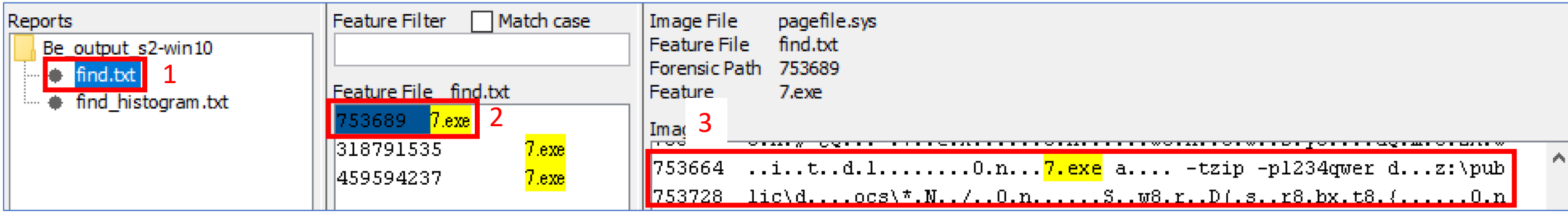
Shortcuts\09_RecoveringDataKeywordSearch



Practice Exercise 3:

Gathering attributes of the archives that attackers created (4)

- You can get the result like following. It contains several important information.
  1. Select "find.txt" in the Reports window
  2. Click a certain line in the Feature window.
  3. You can see the raw data around detected strings on the target disk image.



- The result looks like a command line to create an archive file. We can guess the original command line as below.

```
7.exe a -tzip -pl234qwer  d  z:\public\docs\*
```

It might be the password for the archive.

It might be a part of the archive file name.

It might be the source files of the archive

Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016

Scenario 1 Labs: Lab 4

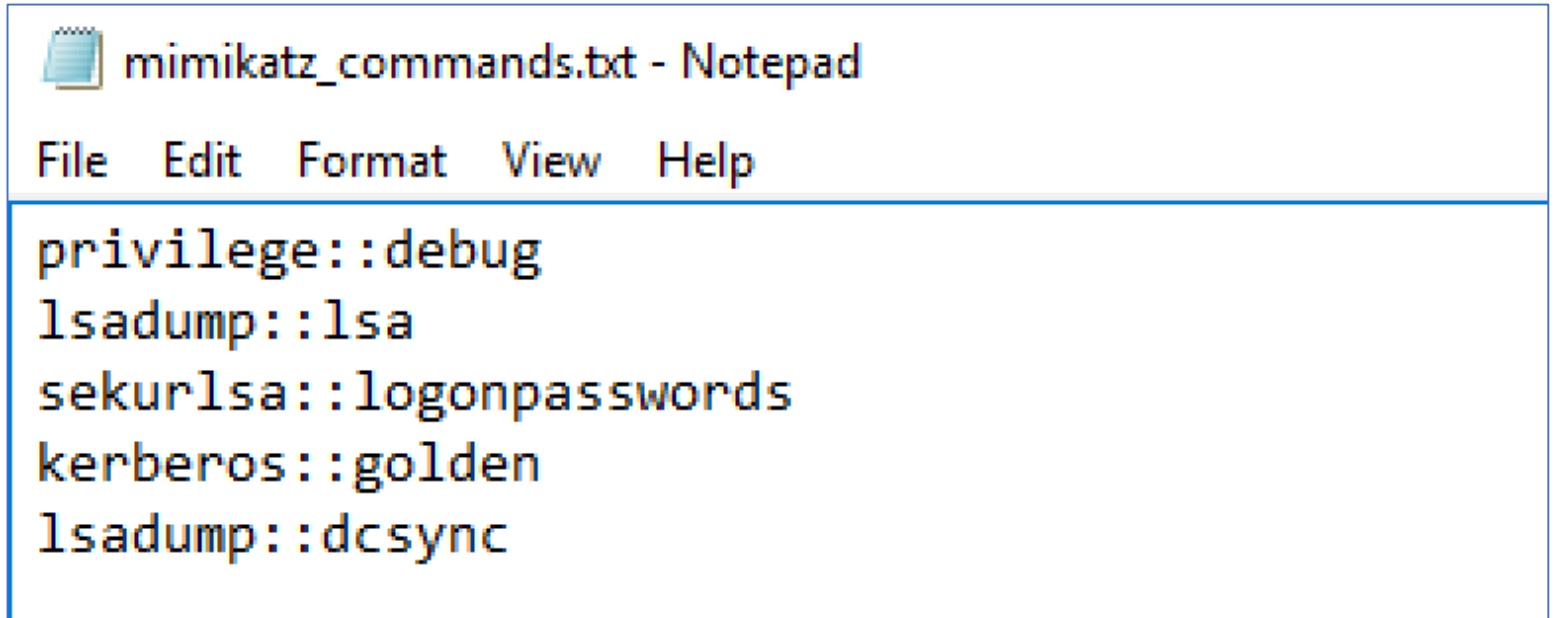
Keyword search with Mimikatz commands on AD-win2016 (1)

- Conditions:
  - This is an investigation for scenario 1.
  - We also know that the credential information was stolen from the AD server and the attacker could have used Mimikatz for it.
- Goal:
  - To find traces of Mimikatz execution on AD-win2016 with Bulk Extractor's text search function.

Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016 (2)

- We already prepared Mimikatz command list as the following txt file. Mimikatz usually output these commands with its result. So if the attacker redirected the result to a file, we might be able to carve the files.
  - C:\Tools\mimikatz_commands.txt



Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016 (3)

- Launch the Command Prompt from the shortcuts folder.
- Start text search with the following command.

```
bulk_extractor -E find -F C:\Tools\mimikatz_commands.txt -o
E:\Artifacts\scenario1_carved_command\BE_output_ad E:\Artifacts\scenario1_E01\AD-
Win2016.E01
```

Enter this in a single line.

  - -E option is to set the scanner plugin to use.
  - -F option is to set the text file containing search strings for find plugin.
  - -o option is to set the output folder.
  - The last argument is the target image file.
- In this case, we prepared the result in advance. Please do not execute it now. It takes several hours.

Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016 (4)

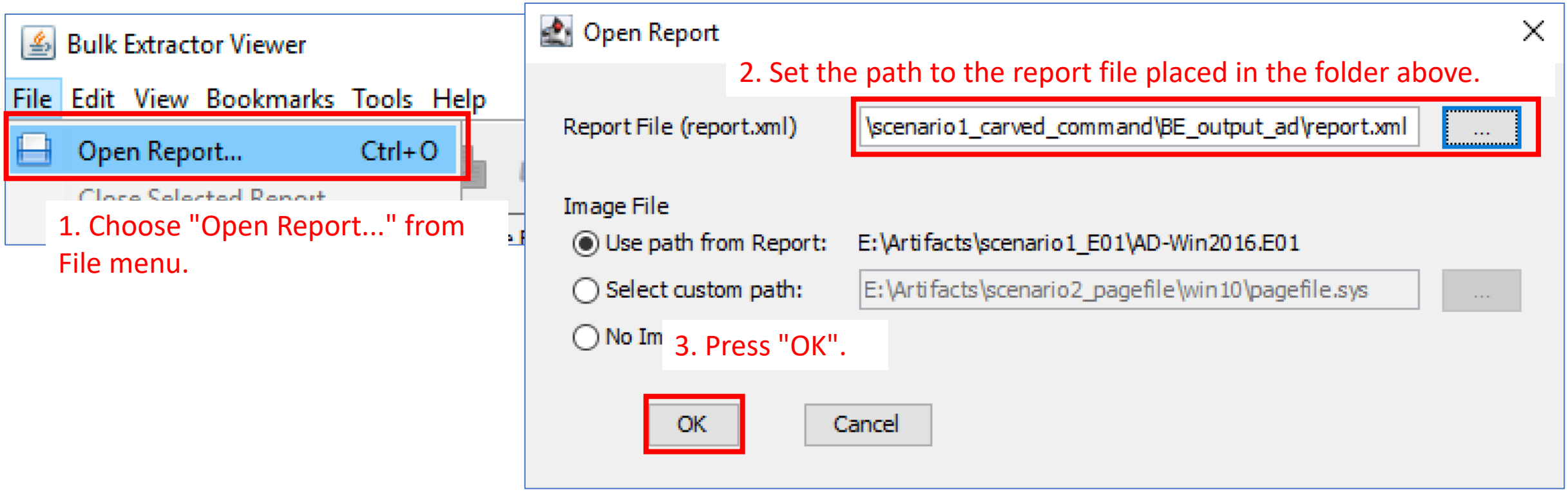
- It will take several hours, so we prepared the result in advance.
- Input Ctrl+c to cancel it and view the report that we prepared.

```
C:\shortcuts\09_RecoveringDataKeywordSearch>bulk_extractor -E find -F C:\Tools\mi
nario1_carved_command\BE_output_ad E:\Artifacts\scenario1_E01\AD-Win2016.E01
bulk_extractor version: 1.6.0-dev-rec03
Input file: E:\Artifacts\scenario1_E01\AD-Win2016.E01
Output directory: E:\Artifacts\scenario1_carved_command\BE_output_ad
Disk Size: 53687091200
Threads: 2
20:04:17 Offset 67MB (0.12%) Done in  0:47:38 at 20:51:55
20:04:18 Offset 150MB (0.28%) Done in  0:35:10 at 20:39:29
20:04:27 Offset 234MB (0.44%) Done in  0:54:34 at 20:59:02
20:04:31 Offset 318MB (0.59%) Done in  0:51:24 at 20:55:56
20:04:34 Offset 402MB (0.75%) Done in  0:45:35 at 20:50:09
^C
C:\shortcuts\09_RecoveringDataKeywordSearch>
```

Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016 (5)

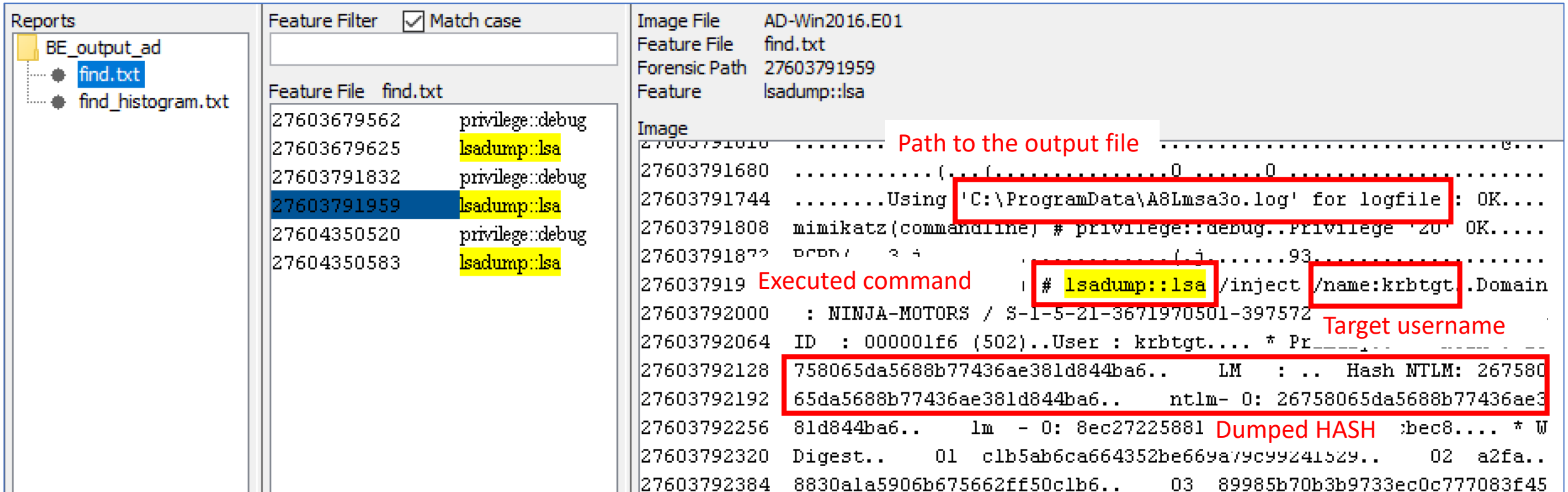
- Let's open the reports located in following folder.
  - E:\Artifacts\scenario1_carved_command\BE_output_ad



Scenario 1 Labs: Lab 4

Keyword search with Mimikatz commands on AD-win2016 (6)

- The report shows traces of Mimikatz lsadump command. It could be an evidence to prove that the attacker stole NTLM hash of the user krbtgt on the AD host.
- Typically, attackers generate Golden Tickets with the krbtgt's hash.



Scenario 1 Labs: Lab 5

Keyword search with Mimikatz commands on client-win10-1

Scenario 1 Labs: Lab 5

Keyword search with Mimikatz commands on client-win10-1 (1)

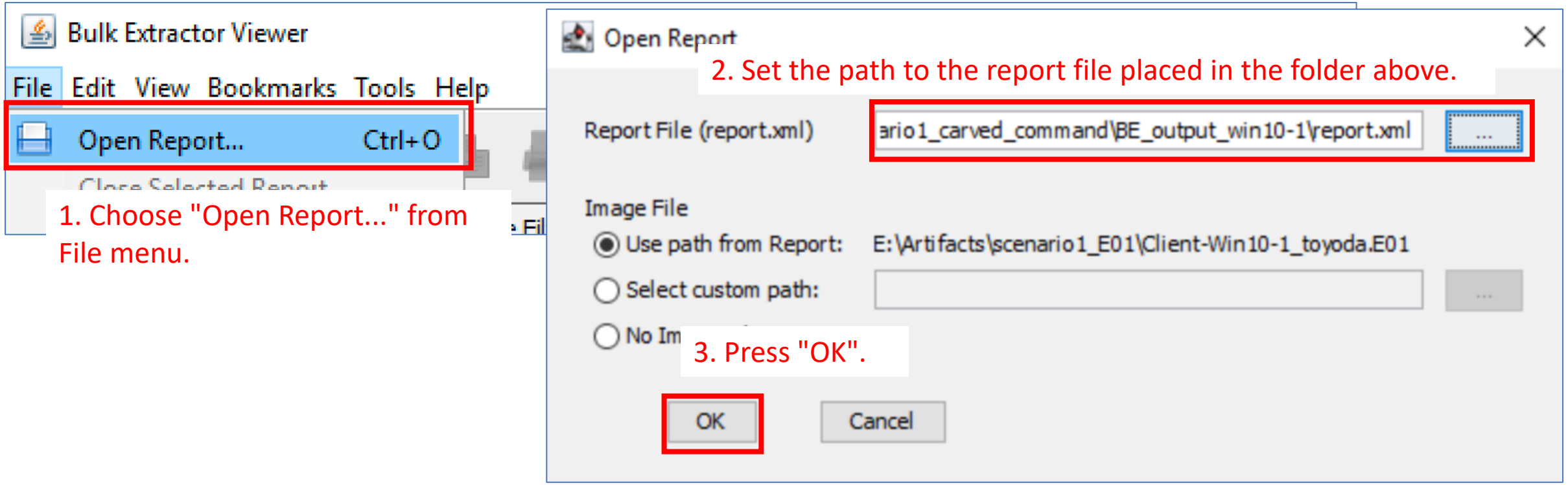
- Conditions:
  - This is an investigation for scenario 1.
  - In the scenario, we have determined that Mimikatz was used to steal and forge credentials.

- Goal:
  - To find traces of Mimikatz execution on client-win10-1 with Bulk Extractor's text search function.

Scenario 1 Labs: Lab 5

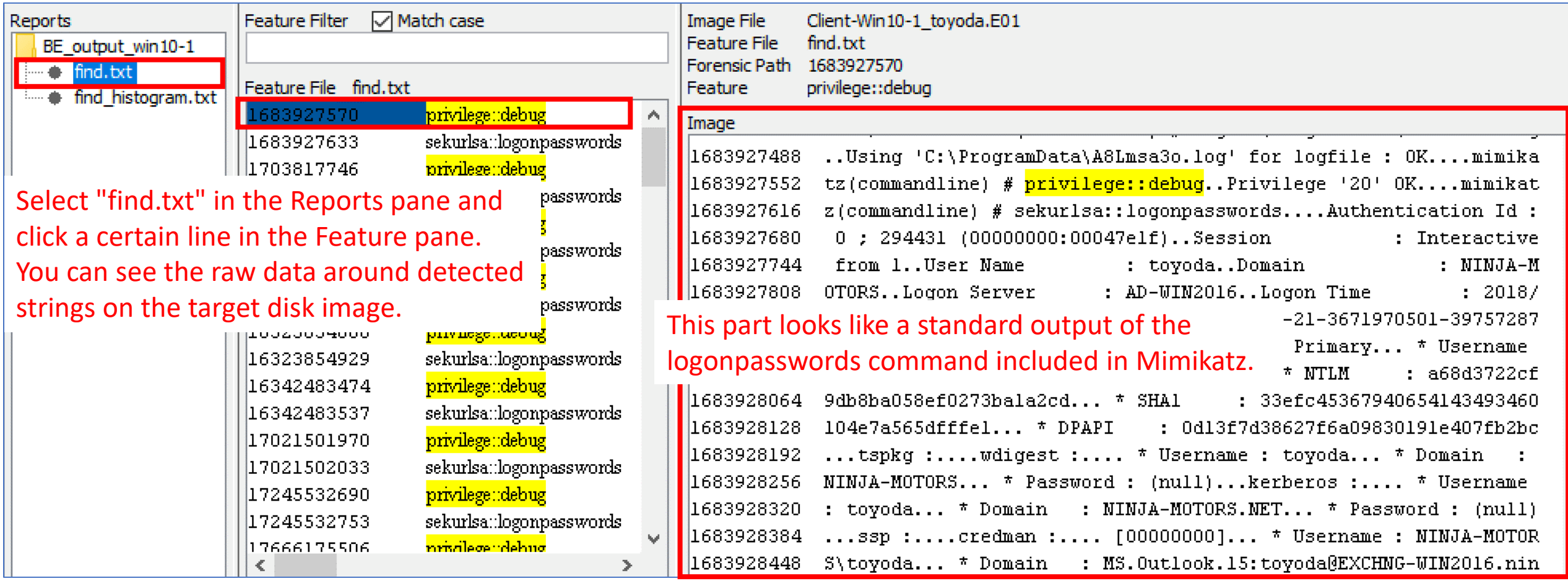
Keyword search with Mimikatz commands on client-win10-1 (2)

- After canceling the execution, let's view the prepared report saved in the following folder.
  - E:\Artifacts\scenario1_carved_command\BE_output_win10-1



Scenario 1 Labs: Lab 5

Keyword search with Mimikatz commands on client-win10-1 (3)



Select "find.txt" in the Reports pane and click a certain line in the Feature pane.
You can see the raw data around detected strings on the target disk image.

This part looks like a standard output of the logonpasswords command included in Mimikatz.

Scenario 1 Labs: Lab 6

Keyword search with Mimikatz commands on client-win10-2

Scenario 1 Labs: Lab 6

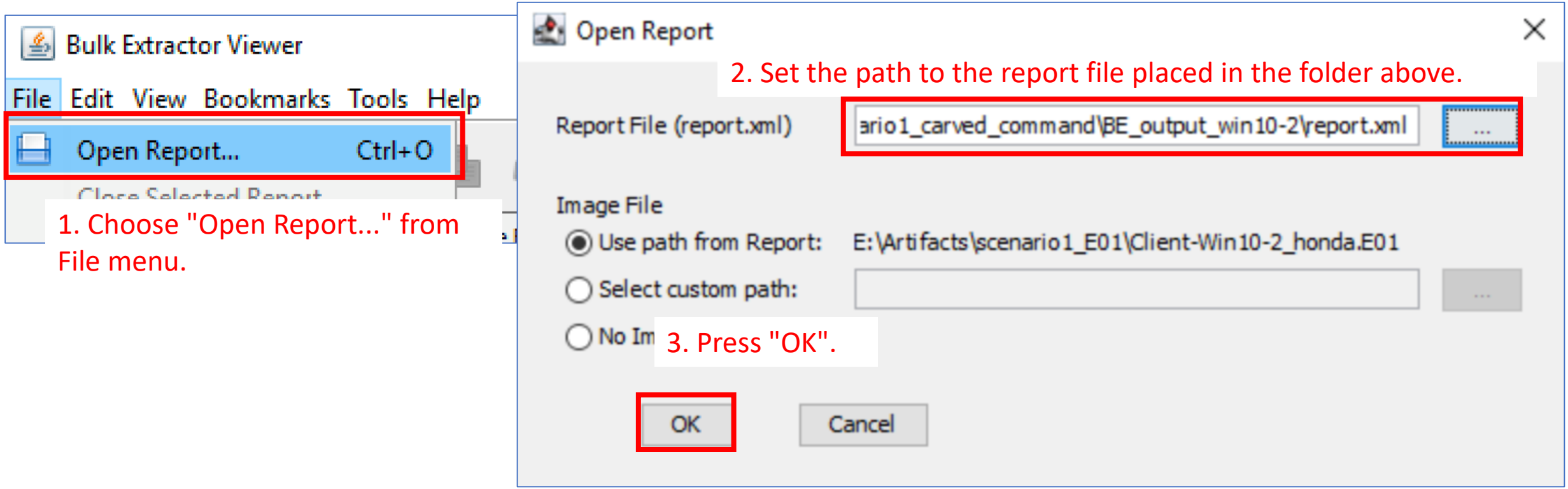
Keyword search with Mimikatz commands on client-win10-2 (1)

- Conditions:
  - This is an investigation for scenario 1.
  - In the scenario, we have already determined that Mimikatz was used to steal and forge credentials.
- Goal:
  - To find traces of Mimikatz execution on client-win10-2 with Bulk Extractor's text search function.

Scenario 1 Labs: Lab 6

Keyword search with Mimikatz commands on client-win10-2 (2)

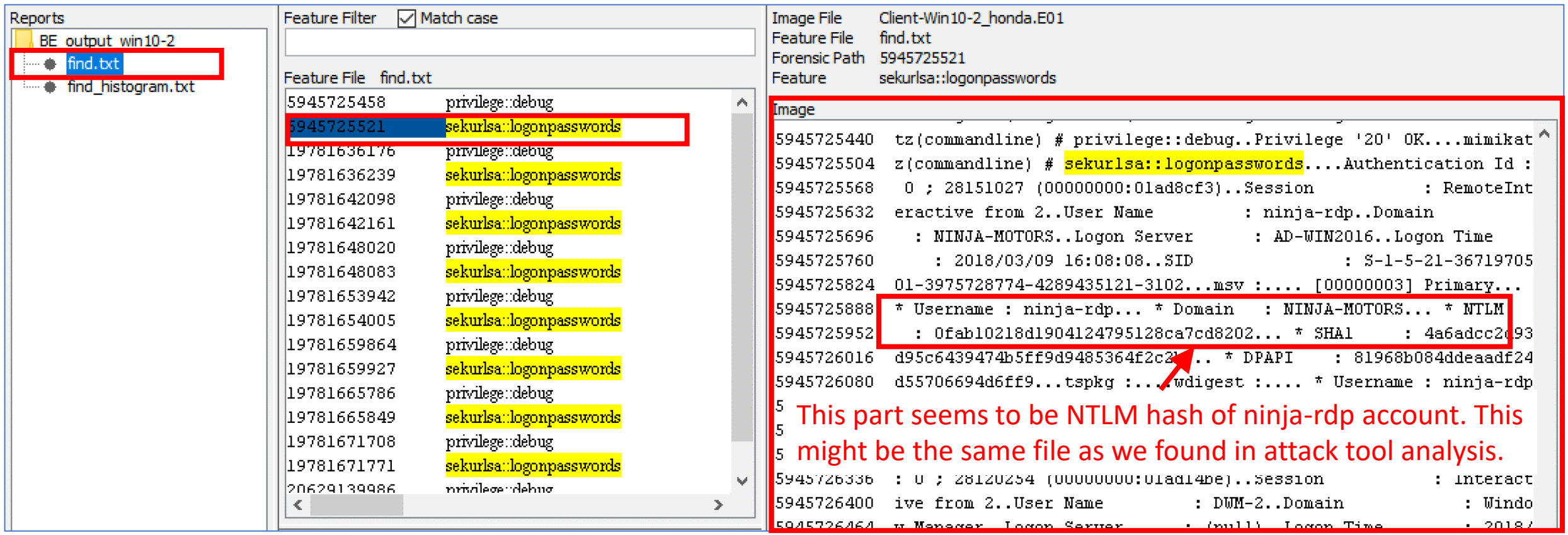
- Let's open the reports located in the following folder.
  - E:\Artifacts\scenario1_carved_command\BE_output_win10-2



Scenario 1 Labs: Lab 6

Keyword search with Mimikatz commands on client-win10-2 (3)

- We can also confirm that Mimikatz's logonpasswords command was executed on this host like the previous one.



Results of the Keyword Search Labs

- So far, we can get the evidences of the following facts:
  - The attacker explicitly used lsadump command of Mimikatz on AD-Win2016 to steal krbtgt's NTLM hash. It also means that the attacker had privilege on the host.
  - The attacker explicitly used logonpasswords command of Mimikatz on client-win10-1 and client-win10-2. They could have stolen the credentials of the users who were logging onto the hosts. It means that the attacker had privilege on each host.
- Although we already know these facts, the new evidences could reinforce the evidence that we found before. Confirming each fact with multiple evidences is very important.

Wrap Up

Conclusion (1)

- We often attempt to restore the following data.
  - Tools that the attacker used
  - Archive files that the attacker made to bring the contents out
  - Traces of commands that the attacker executed in attacks
  - Evidence files such as browser cache, prefetch and so on
  - Event log and other logs that are already rotated
- Carving methods take a long time and sometimes generate noisy output. Therefore, we have to be clear about what data to restore. In addition, we also have to be sure about how to restore them.

Conclusion (2)

- We recommend to use these carving methods and test your custom signatures in advance.
- If you cannot find something by these recovering methods, it does not prove that something did not exist. It just means the method was not efficient in that case. We cannot know whether it was overwritten or it did not actually exist.

Tools

- Rifiuti2 https://abelcheung.github.io/rifiuti2/
- RBCmd https://ericzimmerman.github.io/#!index.md
- $I Parse https://df-stream.com/recycle-bin-i-parser/
- ShadowKit http://www.easymetadata.com/shadowkit/
- ShadowExplorer https://www.shadowexplorer.com/
- Vshadowmount https://github.com/libyal/libvshadow/wiki/Mounting
- vssadmin & mklink https://www.forensicswiki.org/wiki/Mount_shadow_volumes_on_disk_images
- VSCMount https://binaryforay.blogspot.com/2018/09/introducing-vscmount.html
- vss_carver https://github.com/mnrkbys/vss_carver
- Bulk Extractor with Record Carving https://www.kazamiya.net/bulk_extractor-rec
- Photorec https://www.cgsecurity.org/wiki/PhotoRec
- Foremost http://foremost.sourceforge.net/
- MftCarver https://github.com/jschicht/MftCarver
- IndxCarver https://github.com/jschicht/IndxCarver
- EvtXtract https://github.com/williballenthin/EVTXtract
- Evtx Explorer/EvtxECmd https://ericzimmerman.github.io/#!index.md

Signature Samples
for Photorec and Foremost

Signature Samples (1)
Additional Signatures for Photorec

- Following samples are additional signature samples that we often use in actual incidents. You can check and try it if necessary.

```
# Prefetch files
pf 0 0x11, 0x00, 0x00, 0x00, 0x53, 0x43, 0x43, 0x41
pf 0 0x17, 0x00, 0x00, 0x00, 0x53, 0x43, 0x43, 0x41
pf 0 0x1A, 0x00, 0x00, 0x00, 0x53, 0x43, 0x43, 0x41
pf 0 0x1E, 0x00, 0x00, 0x00, 0x53, 0x43, 0x43, 0x41
pfcomp(10) 0 "MAM"
```

These are saved in the file below.
C:\Tools\photorec\photorec-samples.sig

Signature Samples (2)
Additional Signatures for Foremost

```
# Prefetch files.
pf        y         1000000   \x11\x00\x00\x00\x53\x43\x43\x41
pf        y         1000000   \x17\x00\x00\x00\x53\x43\x43\x41
pf        y         1000000   \x1A\x00\x00\x00\x53\x43\x43\x41
pf        y         1000000   \x1E\x00\x00\x00\x53\x43\x43\x41
pfcomp    y         1000000   MAM

# RAR archives
rar       y         10000000  \x52\x45\x7E\x5E
rar       y         10000000  \x52\x61\x72\x21\x1A\x07\x00

# Scheduled tasks
task      y         100000    /\xff\xfe<.\?.x.m.l.+?<.T.a.s.k.+?<.U.R.I.>.\\.+?<.C.o.m.m.a.n.d.>./ /<./.T.a.s.k.>./

# ASN1 structures such as extracted credentials by Mimikatz.
asn1      y         4096      \x76\x82??\x30\x82??\xa0\x03\x02\x01\x05\xa1\x03\x02\x01\x16
asn1_84   y         4096      \x76\x84????\x30\x84????\xa0\x84\x00\x00\x00\x03\x02\x01\x05\xa1\x84\x00\x00\x00\x03\x02\x01\x16

# EDB databases such as Windows Desktop Search's Index, Exchange databases, and AD databases(NTDS.DIT).
edb       y         100000000 ????\xef\xcd\xab\x89\x20\x06\x00\x00\x00\x00\x00\x00
edb       y         100000000 ????\xef\xcd\xab\x89\x20\x06\x00\x00\x01\x00\x00\x00
```

These are saved in the file below.
C:\Tools\foremost\foremost-samples.conf