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COMP 6350 Project 2 - NTFS

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Executive Summary

The objective of this forensic analysis was to investigate an NTFS partition found on the disk image “ShadowLaptop.dd” to recover files related to a digital heist involving a hacker known as “Shadow”. The analysis identified and recovered three files, one of which contained an embedded gile using steganography. The recovered files provided valuable evidence related to the hacker’s identity, communication, and plans. Below is a summary of key findings:

Question	Answer
Q1) Specify the number and type of partitions on the disk image.	There is 1 NTFS partition on the disk image, named “ShadowLaptop.dd1”
Q2) Specify the number of files, file names, and file size of each file on the partition.	3 Files (1 had an additional embedded file): • Name: for_ghost • Ext: txt • Size (Real): 151 bytes • Name: passphrase • Ext: txt • Size (Real): 10 bytes • Name: innocent_cat • Ext: jpg • Size (Real): 58493 bytes • Embedded File Name: secret • Embedded File Ext: txt • Embedded File Size: 135 bytes
Q3) Specify the starting and ending byte offset location of each file on the partition.	Innocent_cat.jpg: • Starting: 133120 * 512 = 68,157,440 • Ending: 133240 * 512 = 68,218,880 For_ghost.txt: • Starting: 133240 * 512 = 68,218,880 • Ending: 133248 * 512 = 68,222,976 Passphrase.txt: • Starting: 133248 * 512 = 68,222,976 • Ending: 133256 * 512 = 68,227,072

Q4) Provide a thorough analysis of the recovered files: Determine the contents of these files to understand the objective, the plan, and any other critical information about the hack.	innocent_cat.jpg: This file contained an image of a cat, as well as an embedded file named "secret.txt" secret.txt: This file contained a message to ghost from Shadow1, who's real name is Sean, as well as his address: 7th Brown Ave, Apt #4. It is saying that Ghost and Sean will meet at his place to discuss the plan. for_ghost.txt: This is a message to Ghost from Shadow1 saying that his steganography skills might come in handy and talking about files he left on his laptop. This is referring to the embedded "secret.txt" in innocent_cat.jpg passphrase.txt: This is the passphrase to access the embedded files in innocent_cat.jpg, it is encoded in base64 and decodes to "1234".

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1 Introduction

The goal of this project was to successfully analyze a New Technology File System (NTFS) partition on a disk image and retrieve critical files that could provide insights into the operations of a hacker known as "Shadow." The disk image, titled *ShadowLaptop.dd*, was acquired from a laptop belonging to the hacker, and the objective was to recover encoded messages, passphrases, and other relevant information. Through this analysis, key evidence related to the hacker's plans was identified, providing valuable clues for law enforcement.

This report is structured as follows:

- **Background**: Provides context for the investigation and how the laptop image was acquired.
- **Methodology**: Describes the forensic techniques and tools used to analyze the NTFS partition and recover the hidden data.
- **Results and Discussion**: Presents the partition details, byte offsets, and a thorough analysis of the file contents.
- **Conclusions and Recommendations**: Summarizes the findings and suggests next steps for further analysis.
- **Acknowledgements**: Recognizes the resources and guidance that contributed to the project.

2 Background

This project is part of an ongoing investigation into a digital heist orchestrated by a hacker known as “Shadow”. Law Enforcement managed to capture Shadow’s partner, “Ghost”, who provided critical information pertaining to the planning and execution of the heist. During interrogation, it was revealed that Ghost had an old laptop belonging to Shadow.

This laptop was seized by Law Enforcement and a forensic image of it's hard drive, *ShadowLaptop.dd*, was created for analysis. The objective was to recover encoded messages and other relevant information from the disk image, which could provide more evidence related to Shadow's whereabouts or other plans.

The disk image contained a single NTFS partition. This partition was suspected to contain files with hidden data, which had been camouflaged with techniques such as base64 encoding and steganography. To uncover this information, I utilized Active Disk Editor, "fdisk", "dd", "hexdump", and Steghide. Using these tools, I was able to locate the files, determine their byte offsets, and extract hidden messages embedded within the file system.

3 Methodology

This section outlines the forensic steps taken to analyze the *ShadowLaptop.dd* disk image, focusing on partition identification, file system analysis, and file recovery. Each phase of the investigation is accompanied by a figure(s) illustrating the steps taken.

3.1 Partition Identification with "fdisk"

The first step involved identifying the number and type of partitions on the disk image using the "fdisk" command. The output revealed a single NTFS partition.

```
user18@siftworkstation: ~/Documents/Project2
$ fdisk -l ShadowLaptop.dd
Disk ShadowLaptop.dd: 143.05 MiB, 149999616 bytes, 292968 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0xf1039d95

Device           Boot Start    End Sectors  Size Id Type
ShadowLaptop.dd1       2048 255999  253952  124M  7 HPFS/NTFS/exFAT
```

Figure 1: Output of fdisk showing the NTFS partition

3.2 Boot Sector Analysis with “hexdump” and Active Disk Editor

To verify the integrity of the NTFS partition, I examined the boot sector using both the “hexdump” command and Active Disk Editor. The hexadecimal data from “hexdump” was cross-referenced with the values obtained through Active Disk Editor to ensure accuracy.

```
user18@siftworkstation: ~/Documents/Project2
$ hexdump -C -s $((2048*512)) -n $((1*512)) ShadowLaptop.dd
00100000  eb 52 90 4e 54 46 53 20  20 20 20 00 02 08 00 00  |.R.NTFS    .....|
00100010  00 00 00 00 00 f8 00 00  00 00 00 00 00 00 00 00  |................|
00100020  00 00 00 00 80 00 80 00  ff df 03 00 00 00 00 00  |................|
00100030  04 00 00 00 00 00 00 00  ff 3d 00 00 00 00 00 00  |.........=......|
00100040  f6 00 00 00 01 00 00 00  67 66 62 12 19 64 7e 30  |........gfb..d~0|
00100050  00 00 00 00 0e 1f be 71  7c ac 22 c0 74 0b 56 b4  |.......q|.".t.V.|
00100060  0e bb 07 00 cd 10 5e eb  f0 32 e4 cd 16 cd 19 eb  |......^..2......|
00100070  fe 54 68 69 73 20 69 73  20 6e 6f 74 20 61 20 62  |.This is not a b|
00100080  6f 6f 74 61 62 6c 65 20  64 69 73 6b 2e 20 50 6c  |ootable disk. Pl|
00100090  65 61 73 65 20 69 6e 73  65 72 74 20 61 20 62 6f  |ease insert a bo|
001000a0  6f 74 61 62 6c 65 20 66  6c 6f 70 70 79 20 61 6e  |otable floppy an|
001000b0  64 0d 0a 70 72 65 73 73  20 61 6e 79 20 6b 65 79  |d..press any key|
001000c0  20 74 6f 20 74 72 79 20  61 67 61 69 6e 20 2e 2e  | to try again ..|
001000d0  2e 20 0d 0a 00 00 00 00  00 00 00 00 00 00 00 00  |. ..............|
001000e0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
*
001001f0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 55 aa  |..............U.|
00100200
```

Figure 2: Boot sector analysis with “hexdump”.

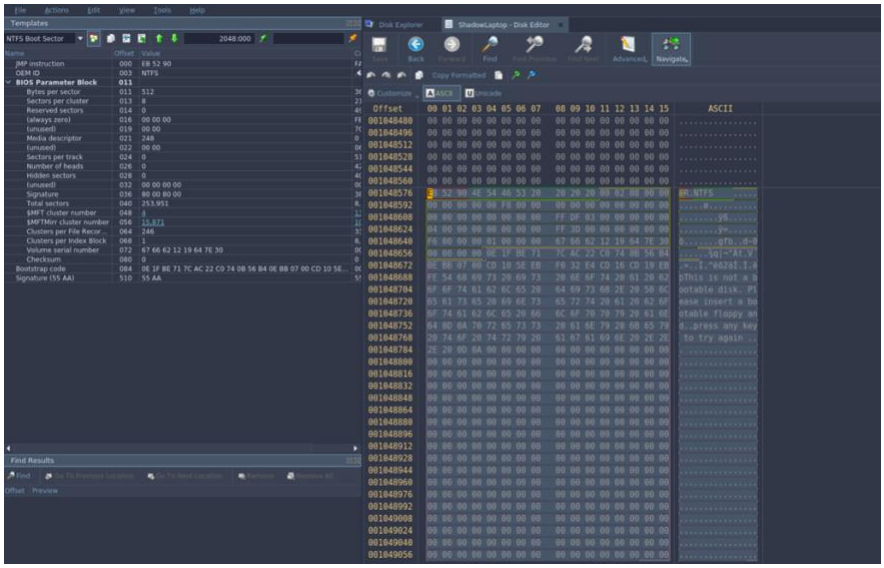


Figure 3: Boot sector analysis with Active Disk Editor.

3.3 Master File Table (MFT) System Record Analysis

After examining the boot sector, I analyzed the Master File Table (MFT) system record, which helps determine the layout of the partition and where the file records are located. Active Disk Editor was used to retrieve and verify the attributes of the MFT system record.

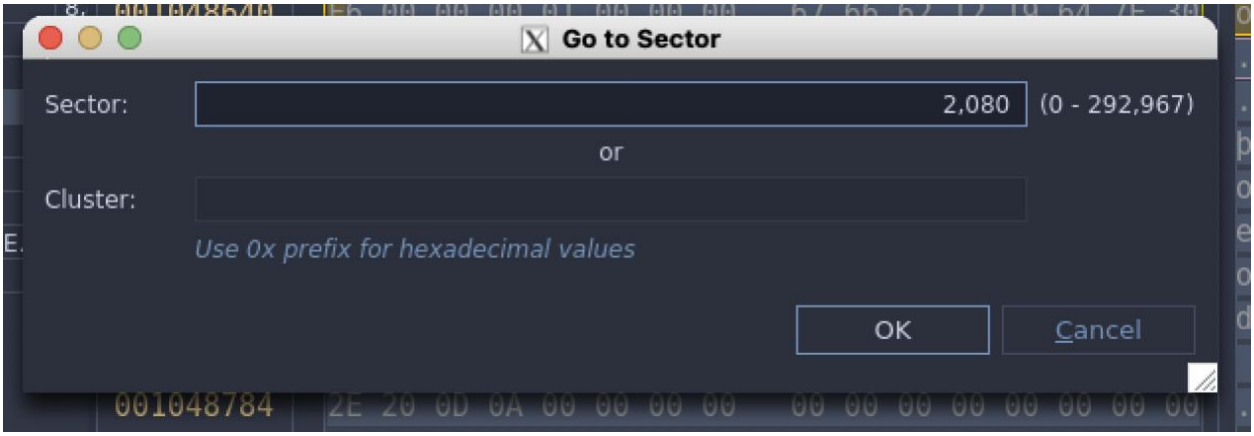


Figure 4: Skip command for MFT System Record in Active Disk Editor.

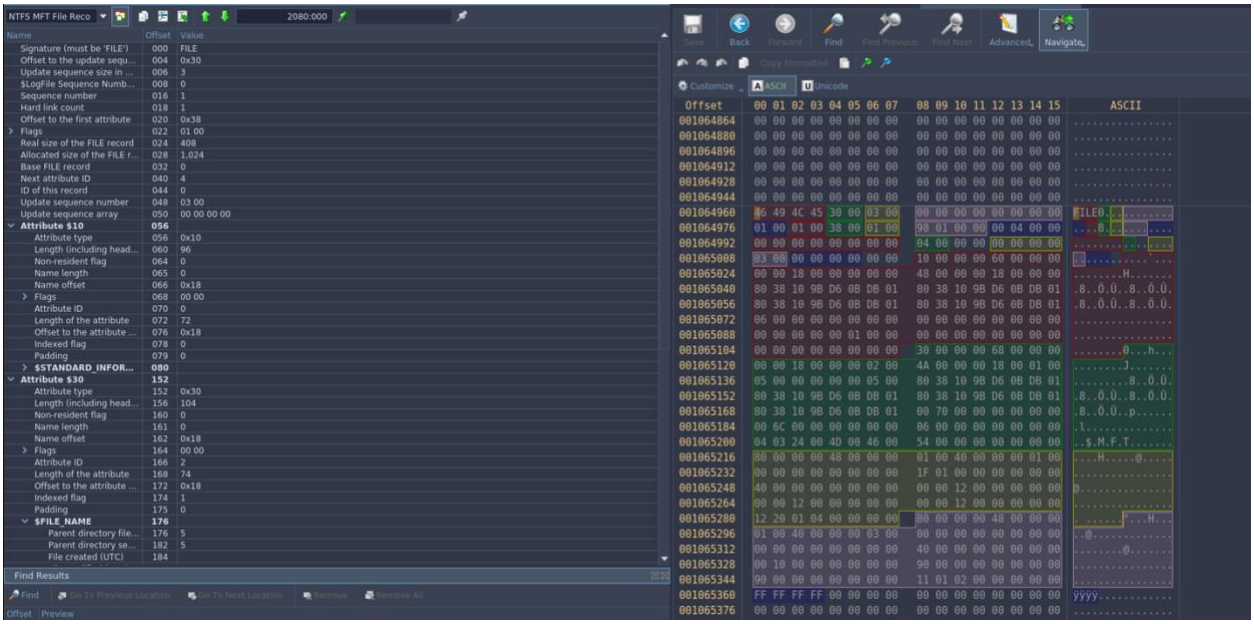


Figure 5: MFT System Record Analysis in Active Disk Editor.

3.4 First File MFT Record Analysis

The first file MFT record was examined to extract metadata such as the file name, file size, and other relevant attributes. To find the first file MFT record, the allocated sectors of the MFT System Records (54 sectors) was added to the start of the MFT System Records (2080), which means the first file MFT Record begins at sector 2134. Each MFT file record occupies 1024 bytes, or 2 sectors. The necessary information was extracted by utilizing Active Disk Editor and applying the MFT File Record template on the first byte of sector 2134. The following figures depict the process of retrieving the necessary information, regarding the first file, from the Active Disk Editor utility.

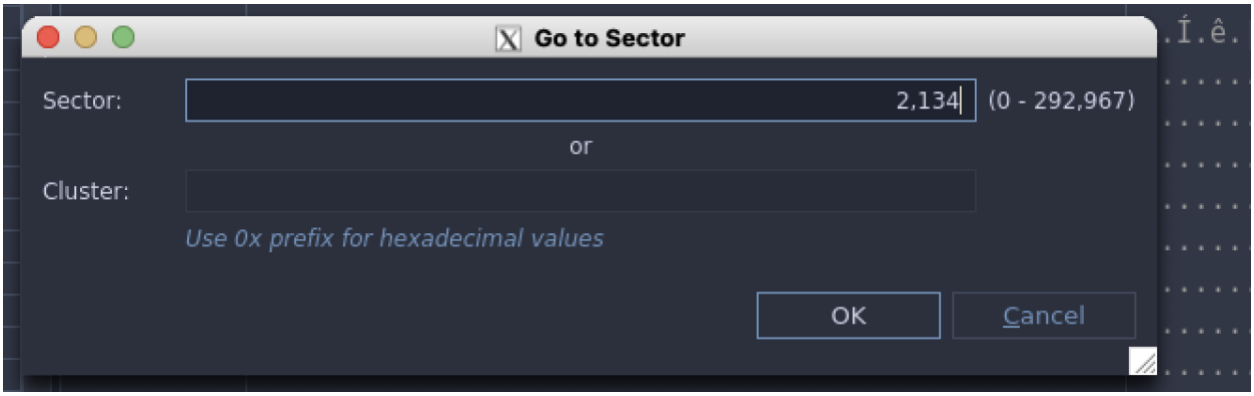


Figure 6: Skip command for first file MFT record in Active Disk Editor.

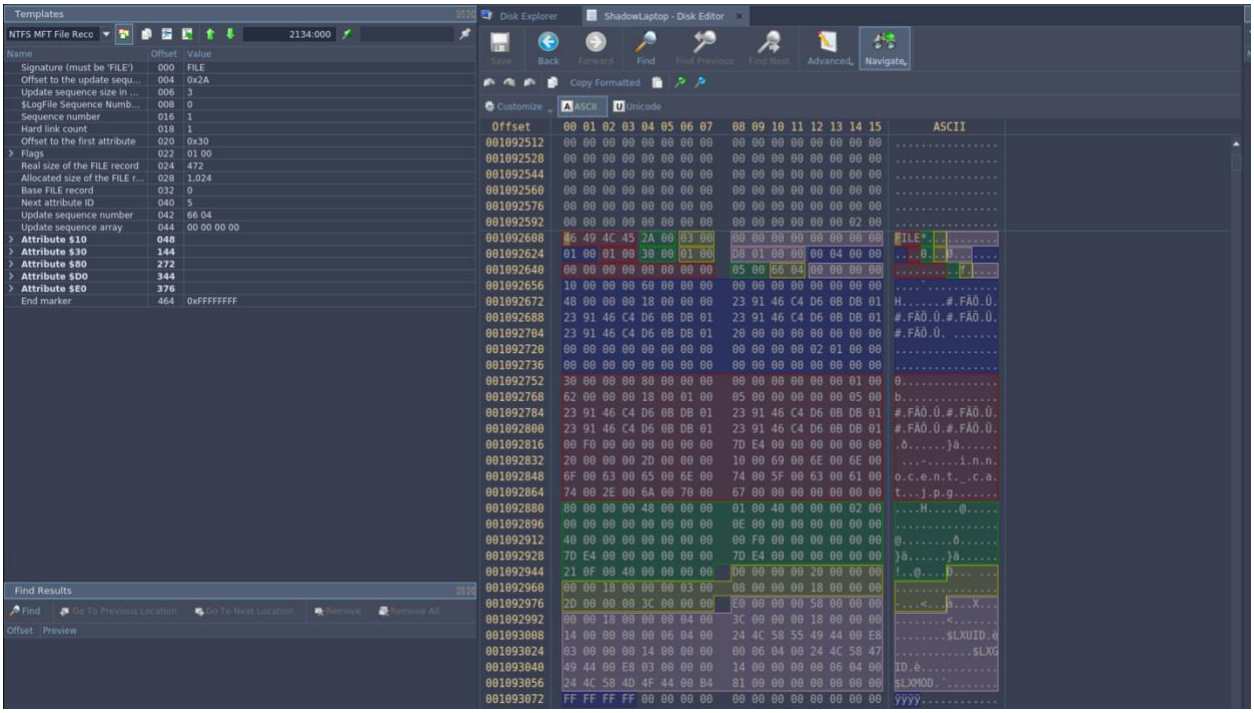


Figure 7: First file MFT Analysis with Active Disk Editor.

Flags	022	01 00
In use	:0	1
Directory	:1	0

Figure 8: First file MFT Analysis shows that it is in use.

Attribute $80	**272**	
Attribute type	272	0x80
Length (including head...	276	72
Non-resident flag	280	1
Name length	281	0
Name offset	282	0x40
Flags	284	00 00
Attribute ID	286	2
First VCN	288	0
Last VCN	296	14
Data runs offset	304	0x40
Compression unit size	306	0
Padding	308	00 00 00 00
Allocated size	312	61,440
Real size	320	58,493
Initialized size	328	58,493
$DATA	**336**	
Data run	**336**	

Figure 9: First file MFT analysis shows first and last VCN, allocated vs. real size, and non-resident flags.

$DATA	336	
Data run	336	
Size	336	0x21
Cluster count	337	15
First cluster	338	16,384

Figure 10: First file MFT analysis shows cluster count and first cluster of file data.

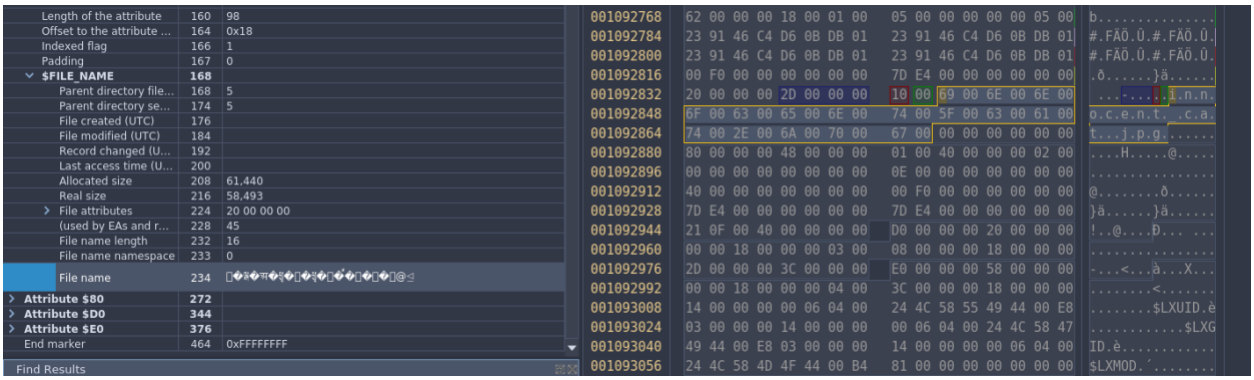


Figure 11: First file MFT analysis shows file name in hexadecimal notation.

3.5 Second File MFT Record Analysis

The second file MFT record was similarly analyzed, confirming details about the second file's location and various information regarding it. The following figures depict the process of retrieving the necessary information, regarding the second file, from the Active Disk Editor utility.

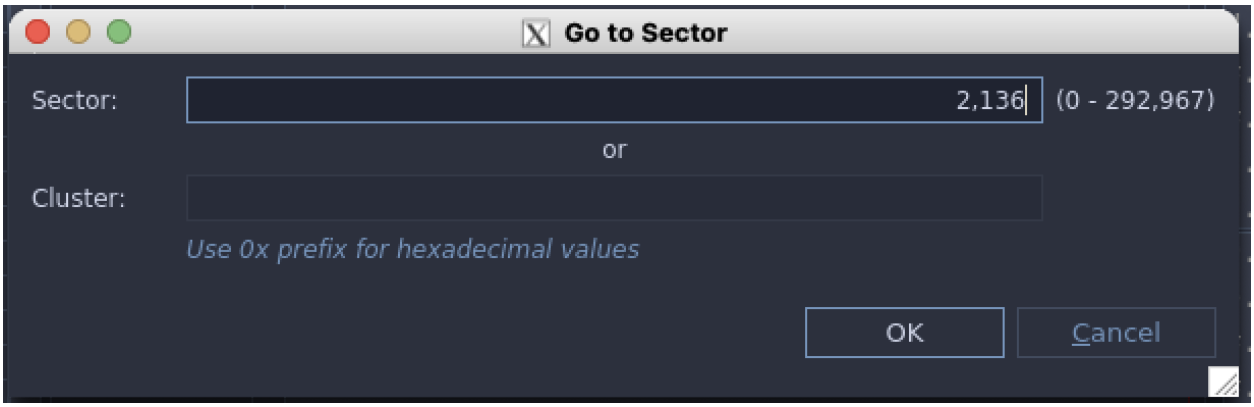


Figure 12: Skip command for second file MFT record in Active Disk Editor.

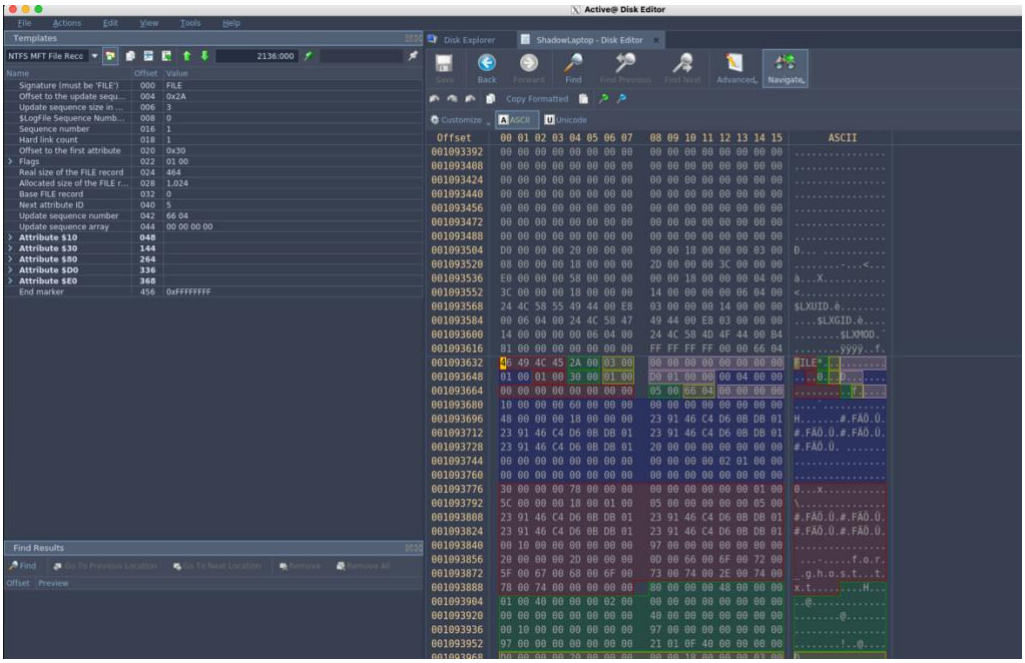


Figure 13: Second file MFT Analysis with Active Disk Editor.

Flags	022	01 00
In use	:0	1
Directory	:1	0

Figure 14: Second file MFT Analysis shows that it is in use.

Attribute $80	**264**	
Attribute type	264	0x80
Length (including head...	268	72
Non-resident flag	272	1
Name length	273	0
Name offset	274	0x40
Flags	276	00 00
Attribute ID	278	2
First VCN	280	0
Last VCN	288	0
Data runs offset	296	0x40
Compression unit size	298	0
Padding	300	00 00 00 00
Allocated size	304	4,096
Real size	312	151
Initialized size	320	151
$DATA	**328**	

Figure 15: Second file MFT analysis shows first and last VCN, allocated vs. real size, and non-resident flags.

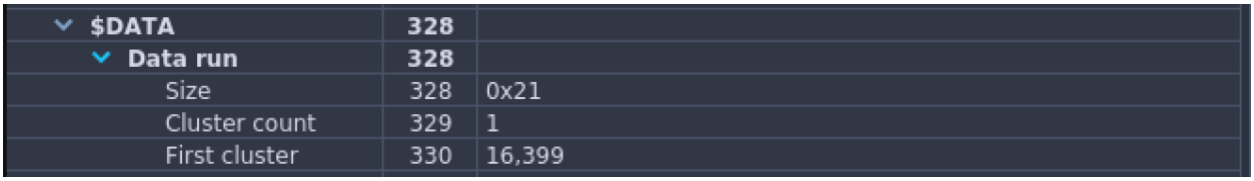


Figure 16: Second file MFT analysis shows cluster count and first cluster of file data.

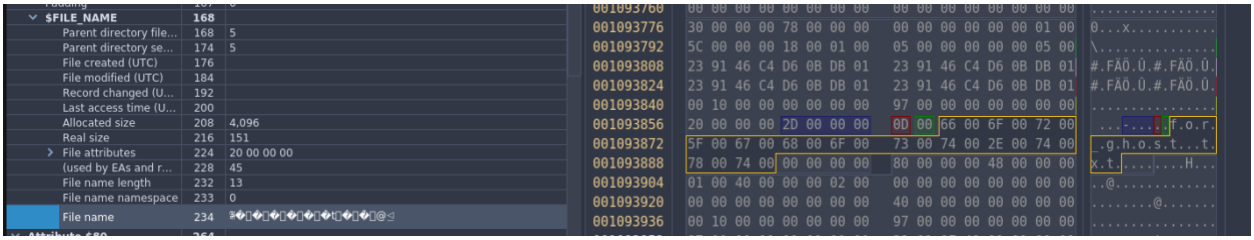


Figure 17: Second file MFT analysis shows file name in hexadecimal notation.

3.6 Third File MFT Record Analysis

The third file MFT record was also similarly analyzed, confirming details about the third file's location and various information regarding it. The following figures depict the process of retrieving the necessary information, regarding the third file, from the Active Disk Editor utility.

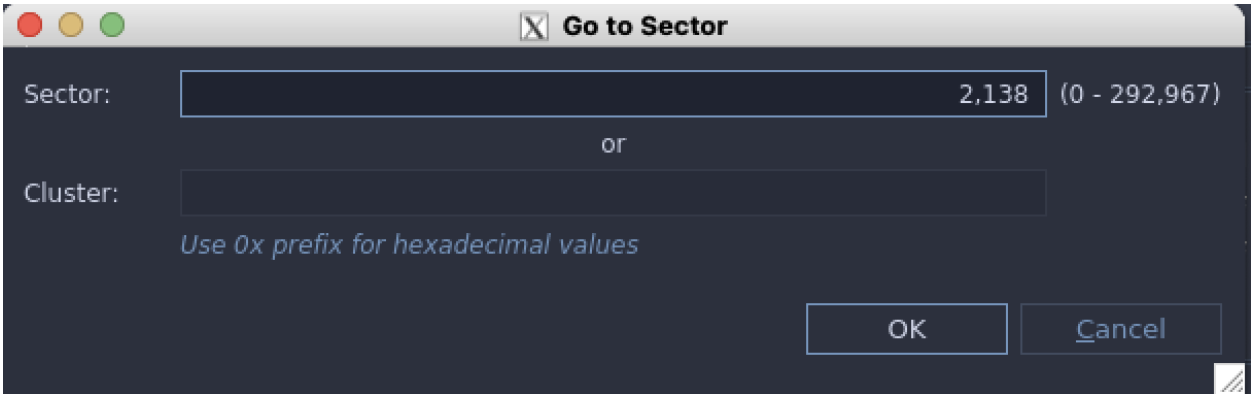
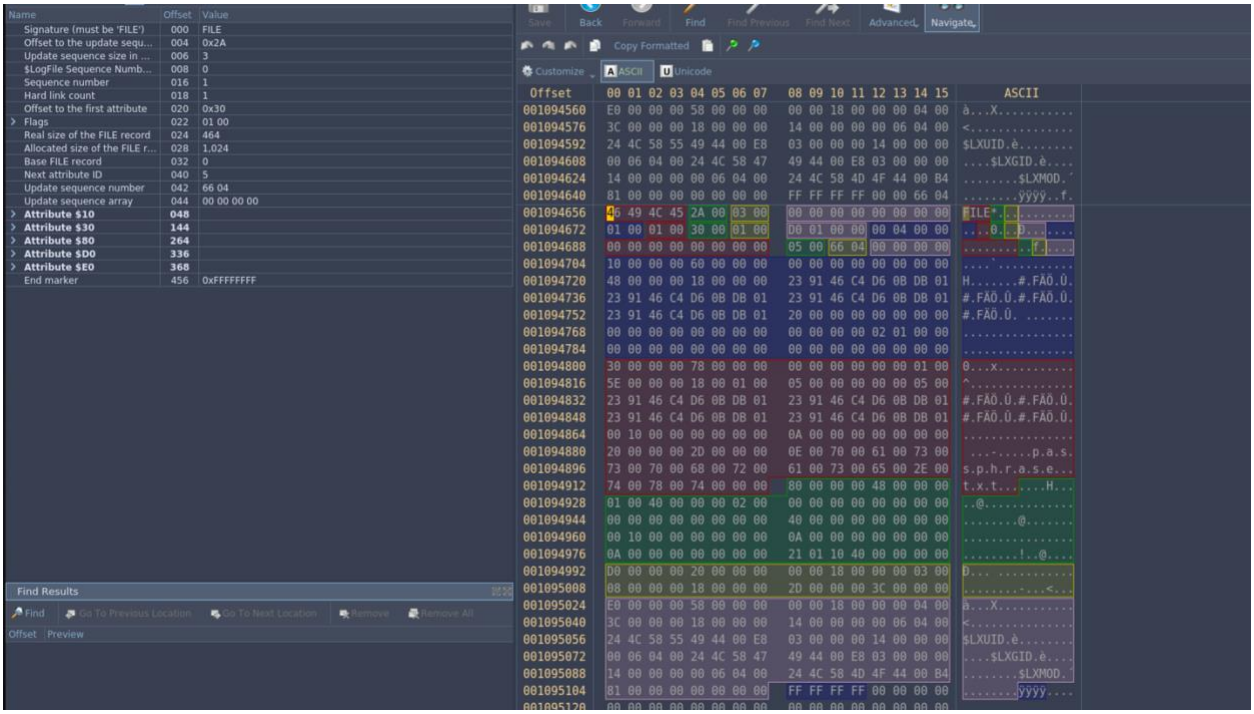


Figure 18: Skip command for third file MFT record in Active Disk Editor.



Name	Offset	Value
Signature (must be 'FILE')	000	FILE
Offset to the update sequ...	004	0x2A
Update sequence size in ...	006	3
$LogFile Sequence Numb...	008	0
Sequence number	016	1
Hard link count	018	1
Offset to the first attribute	020	0x30
Flags	022	01 00
Real size of the FILE record	024	464
Allocated size of the FILE r...	028	1,024
Base FILE record	032	0
Next attribute ID	040	5
Update sequence number	042	66 04
Update sequence array	044	00 00 00 00
Attribute $10	**048**	
Attribute $30	**144**	
Attribute $80	**264**	
Attribute $D0	**336**	
Attribute $E0	**368**	
End marker	456	0xFFFFFFFF

Figure 19: Third file MFT Analysis with Active Disk Editor.

Flags	022	01 00
In use	:0	1
Directory	:1	0

Figure 20: Third file MFT Analysis shows that it is in use

Attribute $80	**264**	
Attribute type	264	0x80
Length (including head...	268	72
Non-resident flag	272	1
Name length	273	0
Name offset	274	0x40
Flags	276	00 00
Attribute ID	278	2
First VCN	280	0
Last VCN	288	0
Data runs offset	296	0x40
Compression unit size	298	0
Padding	300	00 00 00 00
Allocated size	304	4,096
Real size	312	10
Initialized size	320	10
$DATA	**328**	

Figure 21: Third file MFT analysis shows first and last VCN, allocated vs. real size, and non-resident flags.

$DATA	328	
Data run	328	
Size	328	0x21
Cluster count	329	1
First cluster	330	16,400

Figure 22: Third file MFT analysis shows cluster count and first cluster of file data.

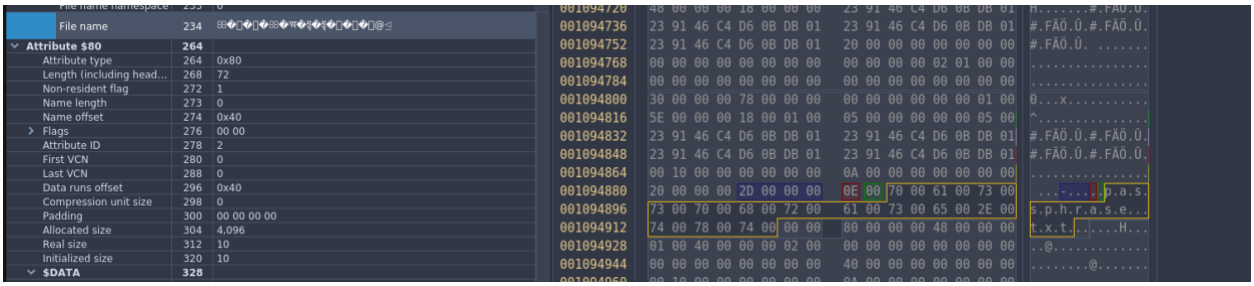


Figure 23: Third file MFT analysis shows file name in hexadecimal notation.

3.7 File Extraction with “dd” command

With all of the information gathered, we can create a general mapping of the NTFS partition to help extract and find the files.

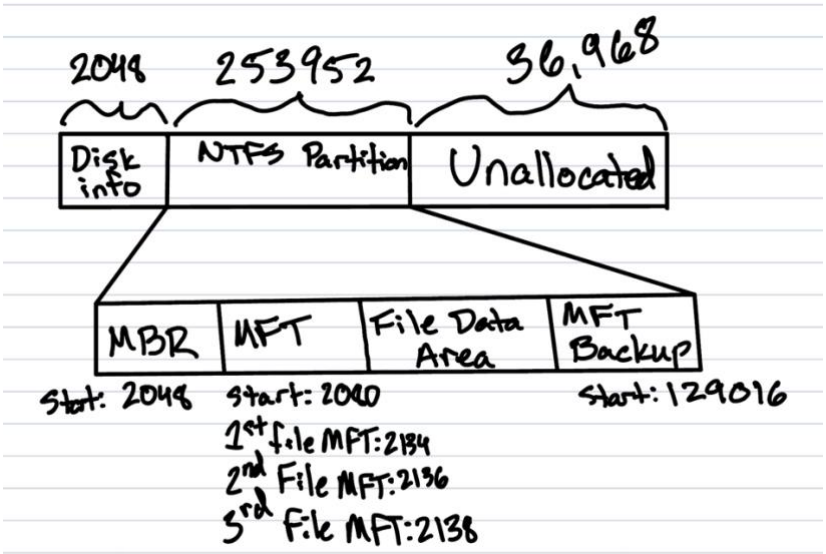


Figure 24: Mapping of NTFS partition.

Using the byte offsets obtained from the MFT record analysis, the dd command was employed to extract files from the disk image. The extracted files were:

- innocent_cat.jpg

```
user18@siftworkstation: ~/Documents/Project2
$ dd if=ShadowLaptop.dd of=innocent_cat.jpg bs=512 skip=133120 count=120
120+0 records in
120+0 records out
61440 bytes (61 kB, 60 KiB) copied, 0.0508547 s, 1.2 MB/s
```

Figure 25: "dd" command to extract innocent_cat.jpg.

Figure 26: Recovered contents of innocent_cat.jpg.

- for_ghost.txt

```
user18@siftworkstation: ~/Documents/Project2
$ dd if=ShadowLaptop.dd of=for_ghost.txt bs=512 skip=133240 count=8
8+0 records in
8+0 records out
4096 bytes (4.1 kB, 4.0 KiB) copied, 0.000341738 s, 12.0 MB/s
```

Figure 27: "dd" command to extract for_ghost.txt.

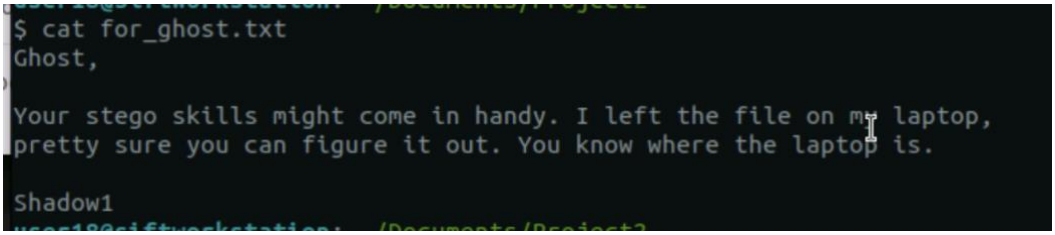


Figure 28: Recovered contents of for_ghost.txt.

- passphrase.txt

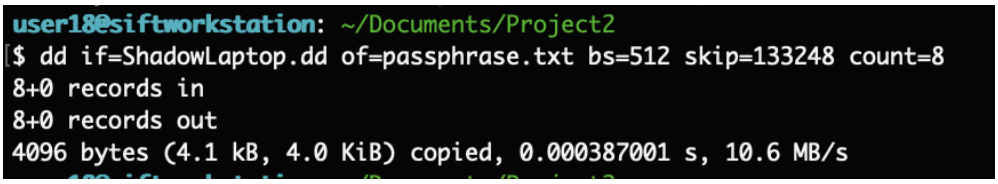


Figure 29: "dd" command to extract passphrase.txt.

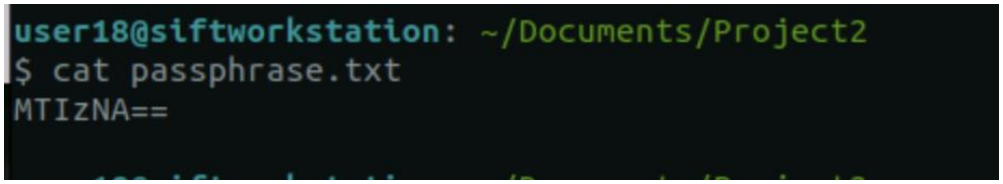


Figure 30: Recovered contents of passphrase.txt.

Upon extraction of the files, further analysis of the "innocent_cat.jpg" file was needed to confirm whether or not any files were embedded in the image using steganography. The passphrase recovered from "passphrase.txt" was encoded in Base64, which decoded to "1234". This was then used, along with Steghide, to analyze and extract the embedded file, named "secret.txt".

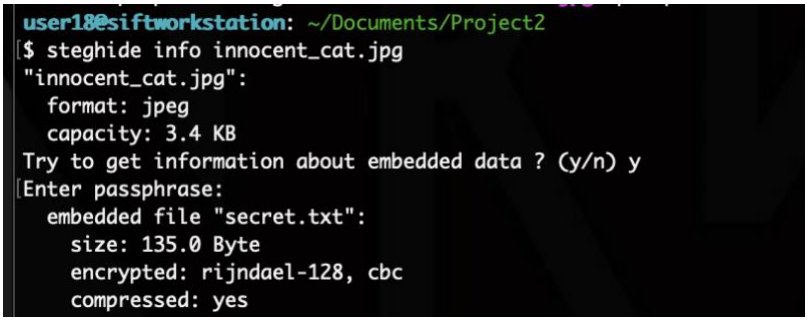


Figure 31: Steghide info command using decoded password on innocent_cat.jpg.

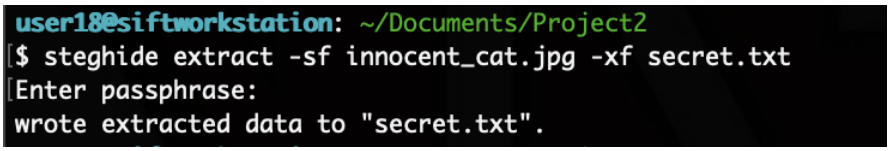


Figure 32: : Steghide extract command using decoded password on innocent_cat.jpg.

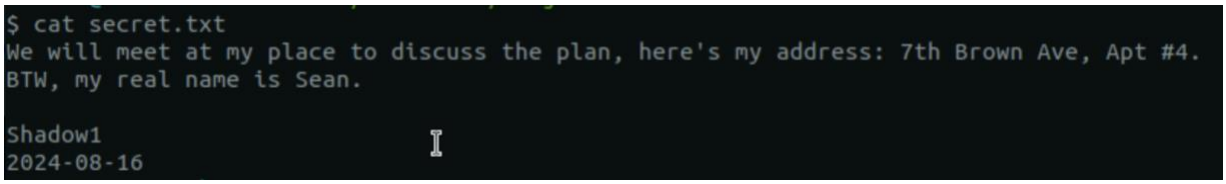


Figure 33: Recovered contents of secret.txt.

4 Results and Discussion

As seen from the steps taken above, there were 3 files extracted from the disk image, one of which had an additional embedded file within it. When analyzing the NTFS Boot Sector with the Active Disk Editor in **Figure 3**, the following information about the partition was determined:

- Bytes/Sector = 512
- Sectors/Cluster = 8
- Sectors Before Partition = 2048
- MFT Cluster Start = 4
- MFT Record Size = 1024

The extracted files, as well as their attributes and offsets, are listed below:

- innocent_cat.jpg

- File Name: innocent_cat
- File Extension: jpg
- Attributes: $10, $30, $80, $D0, $E0
- In Use (yes/no): Yes (1 – Active)
- Non-Resident (yes/no): Yes
- Allocated Size: 61440 bytes
- Real Size: 58493 bytes
- Starting Cluster: 16384
- Starting Byte Offset: 133120 (starting sector offset) * 512 = 68,157,440
- Ending Byte Offset: (133120 + 120 (allocated file size in sectors)) * 512 = 68,218,880
- Embedded File Name: secret
- Embedded File Extension: txt
- Embedded File Size: 135 bytes

- for_ghost.txt
  - File Name: for_ghost
  - File Extension: txt
  - Attributes: $10, $30, $80, $D0, $E0
  - In Use (yes/no): Yes (1 – Active)
  - Non-Resident (yes/no): Yes
  - Allocated Size: 4096 bytes
  - Real Size: 151 bytes
  - Starting Cluster: 16399
  - Starting Byte Offset: 133240 (starting sector offset) * 512 = 68,218,880
  - Ending Byte Offset: (133240 + 8 (allocated file size in sectors)) * 512 = 68,222,976

- passphrase.txt
    - File Name: passphrase
    - File Extension: txt
    - Attributes: $10, $30, $80, $D0, $E0
    - In Use (yes/no): Yes (1 – Active)
    - Non-Resident (yes/no): Yes
    - Allocated Size: 4096 bytes
    - Real Size: 10 bytes
    - Starting Cluster: 16400
    - Starting Byte Offset: 133248 (starting sector offset) * 512 = 68,222,976
    - Ending Byte Offset: (133248 + 8 (allocated file size in sectors)) * 512 = 68,227,072

The information found above was all extracted or derived from the Active Disk Editor and Steghide analysis for each file record in **Section 3**. In **Figure 25**, we see that the contents of "innocent_cat.jpg" is simply and image of a cat. In **Figure 27**, the contents of "for_ghost.txt" we see that Shadow1 left a message for Ghost alluding to the use of steganography in the "innocent_cat.jpg file". **Figure 28**, the contents of "passphrase.txt", includes a passphrase "MTIzNA==" which was found to be encoded in base64, and decodes to "1234". This passphrase was then used to extract the embedded file, "secret.txt", from "innocent_cat.jpg". Within "secret.txt", we find critical information regarding to the hacking plot, where Shadow1 reveals his real name to be Sean, and his home address, "7th Brown Ave, Apt #4".

5 Conclusions and recommendations

The forensic analysis of the NTFS partition on the "ShadowLaptop.dd" disk image successfully recovered critical files that provided insights into the communications and plans of a hacker known as "Shadow". The key findings revealed hidden messages embedded in an

image file, as well as a passphrase that unlocked these hidden contents. Notably, the investigation identified shadow's real name (Sean) and address, which could be pivotal in locating and apprehending the hacker. It is recommended that law enforcement continues to investigate Shadow's associates and potential save houses, particularly focusing on the address found in "secret.txt". The recovered files should be securely stored and preserved for potential legal proceesings, ensuring that the chain of custody is maintained.

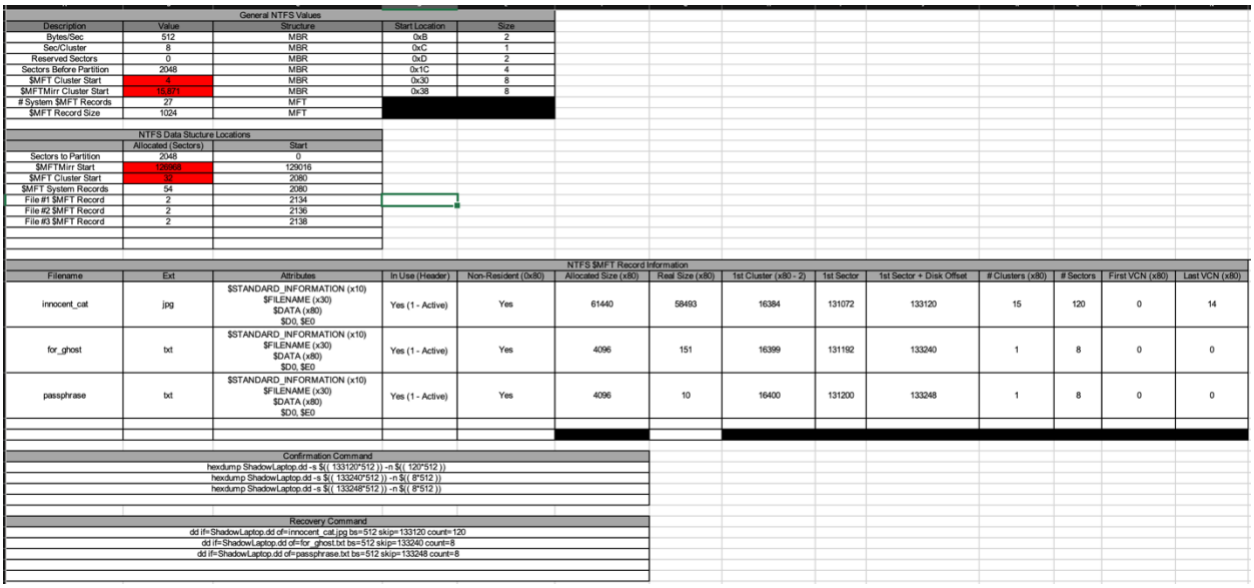
6 Acknowledgements

I would like to express my sincere gratitude to Dr. Farah Kandah, whose insightful lectures and guidance were instrumental in helping me navigate the process of file recovery and digital forensics.

Appendix A: File Recovery and Offset Information

The table below summarizes the information gathered during the forensic analysis of the NTFS partition, including file names, extensions, real and allocated sizes, starting and ending sectors, as well as the offsets for each file. This data was crucial in the recovery of files from the disk image.

Table 1: Excel spreadsheet containing detailed information regarding the disk image analysis.



General NTFS Values

Description	Value	Structure	Start Location	Size
Bytes/Sec	512	MBR	0xB	2
Sec/Cluster	8	MBR	0xC	1
Reserved Sectors	0	MBR	0xD	2
Sectors Before Partition	2048	MBR	0x1C	4
$MFT Cluster Start	4	MBR	0x30	8
$MFTMirr Cluster Start	15,871	MBR	0x38	8
# System $MFT Records	27	MFT		
$MFT Record Size	1024	MFT		

NTFS Data Stucture Locations

	Allocated (Sectors)	Start
Sectors to Partition	2048	0
$MFTMirr Start	126968	129016
$MFT Cluster Start	32	2080
$MFT System Records	54	2080
File #1 $MFT Record	2	2134
File #2 $MFT Record	2	2136
File #3 $MFT Record	2	2138

NTFS $MFT Record Information

Filename	Ext	Attributes	In Use (Header)	Non-Resident (0x80)	Allocated Size (x80)	Real Size (x80)	1st Cluster (x80 - 2)	1st Sector	1st Sector + Disk Offset	# Clusters (x80)	# Sectors	First VCN (x80)	Last VCN (x80)
innocent_cat	jpg	$STANDARD_INFORMATION (x10) $FILENAME (x30) $DATA (x80) $D0, $E0	Yes (1 - Active)	Yes	61440	58493	16384	131072	133120	15	120	0	14
for_ghost	txt	$STANDARD_INFORMATION (x10) $FILENAME (x30) $DATA (x80) $D0, $E0	Yes (1 - Active)	Yes	4096	151	16399	131192	133240	1	8	0	0
passphrase	txt	$STANDARD_INFORMATION (x10) $FILENAME (x30) $DATA (x80) $D0, $E0	Yes (1 - Active)	Yes	4096	10	16400	131200	133248	1	8	0	0

Confirmation Command

```
hexdump ShadowLaptop.dd -s $(( 133120*512 )) -n $(( 120*512 ))
hexdump ShadowLaptop.dd -s $(( 133240*512 )) -n $(( 8*512 ))
hexdump ShadowLaptop.dd -s $(( 133248*512 )) -n $(( 8*512 ))
```

Recovery Command

```
dd if=ShadowLaptop.dd of=innocent_cat.jpg bs=512 skip=133120 count=120
dd if=ShadowLaptop.dd of=for_ghost.txt bs=512 skip=133240 count=8
dd if=ShadowLaptop.dd of=passphrase.txt bs=512 skip=133248 count=8
```