INSTITUTO SUPERIOR TÉCNICO
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Digital Forensics Report

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1 Objectives of the investigation

For several years now, John Mole has been working for DroneX, a major manufacturer of drone technology. In the past few months, motivated by suspicious changes in John's behavior, DroneX started taking measures to investigate him. Since he had privileged access to the design plans of their new revolutionary drones, the fear was that he might be illicitly stealing those plans in order to sell them to competitors. To dissipate such fears, after obtaining legal counseling and authorization, DroneX assembled an auditing team to look for potential evidence of industrial espionage.

2 Artifacts for analysis

The following image is a table with the files and respective md5 found on John Mole's pen-drive before the investigation started:

File	Value
munich.txt	c6596b360ac97889c4f2d68ba6787f92
compress.py	72eab63334dcd0f73418e32999b71f05
cathedral.png	55fd5b1d42072955e15769b55a390400
oktoberfest.png	deb345aea6cdb82ca4636c0811c292df
street.png	f1ea1beaa6a838d16b4d457c6fe68fd0
wursten.png	13c85b20b6b1e481a32700f26818333e
snow.bmp	a6e56c4d34d9a541b622b74c954c3fc9
online_banking.zip	b3baa737b818db4f52a681f0cf8d440c

- munich.txt – UTF-8 Unicode text file corresponding to a Wikipedia page about the history of the city of Munich;
- compress.py – appears to be a compiled python bytecode file;
- cathedral.png – PNG image file of the Cathedral of *Frauenkirche* in Munich;
- oktoberfest.png – PNG image file of a group of young people supposedly at the festival *Oktoberfest*, a beer festival in Munich;
- street.png – PNG image file of a street where you can see the *Hofbrauhaus*, a known brewery in Munich;
- wursten.png – PNG image file of a table with sausages and beer;
- snow.bmp – BMP image file of a snowy landscape;
- online_banking.zip – ZIP file containing two other files encrypted with a password.

3 Evidence to look for

Our first approach was to try and find out if any of the image files had hidden information when converted to hexadecimal format.

Following that, we decided to compare the txt file (munich.txt) with the original Wikipedia page that offers information about Munich and tried to find any differences.

The next step was to investigate the zip file (online_banking.zip) which contained a password encrypting its contents. Inside we could see two files, a .docx file and a .bmp image file with the name drone-A. We figure this drone-A.bmp might be an image containing drone plans of the company DroneX.

Lastly, we examined the python file, finding out through an appropriate tool that it was a steganography program. We hypothesize that it is likely that some information was hidden within the images we found in John Mole's pen-drive using this steganography program. We hope to find hidden messages and incriminating evidence like bank transactions and stolen information that might link the suspect, John Mole, to any rivaling companies in the .docx file as its name is online_banking.

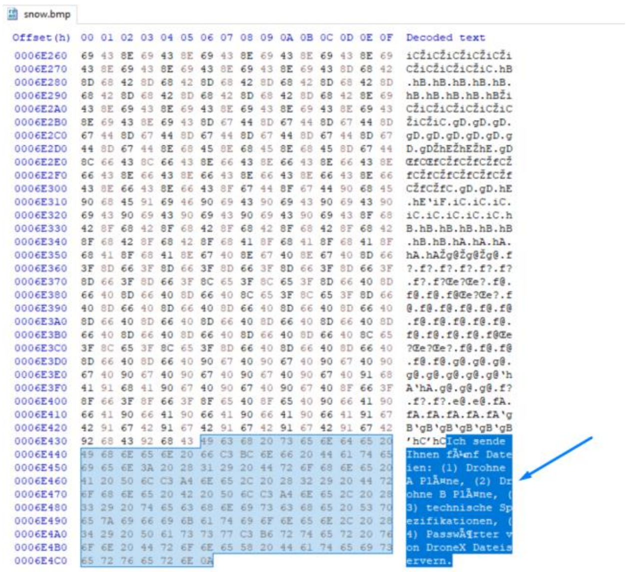
For that matter we will need to discover the password to the zip file mentioned above to access its information and also reverse engineer the program compress.py to find out what might be hidden in the image files we obtained.

4 Examination details

4.1 Hexadecimal Analysis of the Image Files

At 4PM on the 20th of October we started by getting proper clearance and authorization needed to make our investigation legal.

Following that, we started analysis of the image files. We used a software called HxD to analyze all the image files, looking for any content that might have been introduced into the photos. After converting the image file to hexadecimal format, we searched for any piece of text that might look relevant to our investigation. When we analyzed the file snow.bmp, at the end of the file, we found the following message *"Ich sende Ihnen fÃ¼nf Dateien: (1) Drohne A PlÃ¤ne, (2) Drohne B PlÃ¤ne, (3) technische Spezifikationen, (4) PasswÃ¶rter von DroneX Dateiservern"* which translates to in English "I'm sending you five files: (1) drone A plans, (2) drone B plans, (3) technical specifications, (4) passwords from DroneX file servers"



With this hidden message we discovered exactly what we should be looking for inside the pen-drive.

4.2 Analysis of the file munich.txt

After this discovery, at 4:30PM we analyzed the file munich.txt. Our first idea was to find any difference between this file and the text in the original Wikipedia page about Munich. After copying the mentioned Wikipedia text to a txt file, we ran the diff command to find any discrepancies between the two files. Nothing was found proving the texts were identical.

```
root@kali:~/Desktop/csf-lab1-artifacts/diff# diff original.txt copia.txt
root@kali:~/Desktop/csf-lab1-artifacts/diff#
```

4.3 Analysis of the file online_banking.zip

At 5PM we analyzed the zip file, online_banking.zip, and, through the tool fcrackzip, we tried a brute force method to find the password encrypting the files in the zip. We used the file munich.txt as a dictionary for the brute force method, creating a new file munich_new.txt we used the cat command to sort alphabetically and separate each word of the file in a new line.

```
root@kali:~/Downloads/csf-lab1-artifacts# cat munich.txt | tr ' ' '\n' | sort -u > munich_new.txt
root@kali:~/Downloads/csf-lab1-artifacts#
```

Executing the fcrackzip tool we found the password: "*Stadelheim*", the name of a prison in Munich.

```
root@kali:~/Downloads/csf-lab1-artifacts# fcrackzip -b -D -u -v -p munich_new.txt online_banking.zip
found file 'online_banking.docx', (size cp/uc  12936/ 22313, flags 9, chk 59ae)
found file 'drone-A.bmp', (size cp/uc  87952/ 92401, flags 9, chk 71a4)


PASSWORD FOUND!!!!: pw == Stadelheim
root@kali:~/Downloads/csf-lab1-artifacts#
```

4.4 Analysis of the files contained in the zip file

After discovering the password, we used it to gain access to the files inside online_banking.zip at 5:30PM and we found the files online_banking.docx and drone-A.bmp. This last file had his signature corrupted. Once again, we used the software HxD to analyze the file and we noticed the first bytes didn't correspond to a .bmp file. Looking carefully at the hexadecimal format of the image we found the fields IHDR and IDAT which we can typically find in a .png file.

```
drone-A.bmp

Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  Decoded text
00000000   5C 78 30 47 0D 0A 1A 0A 00 00 00 0D 49 48 44 52  \x0G........IHDR
00000010   00 00 02 58 00 00 01 46 08 02 00 00 00 39 30 76  ...X...F.....90v
00000020   FD 00 00 0B 4F 69 43 43 50 69 63 63 00 00 78 DA  ý...OiCCPicc..xÚ
00000030   ED 5A 69 54 13 57 1B 7E 66 02 01 64 5F 64 11 90  íZiT.W.~f..d_d..
```

We then changed the signature of the file to a .png file signature (89 50 4e 47 0D 0a 1a 0a) and verified, as we opened the now uncorrupted file, that it was a drone plan. We called the uncorrupted file drone-A.png.

```
drone-A.bmp

Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  Decoded text
00000000   89 50 4E 47 0D 0A 1A 0A 00 00 00 0D 49 48 44 52  ‰PNG........IHDR
00000010   00 00 02 58 00 00 01 46 08 02 00 00 00 39 30 76  ...X...F.....90v
00000020   FD 00 00 0B 4F 69 43 43 50 69 63 63 00 00 78 DA  ý...OiCCPicc..xÚ
00000030   ED 5A 69 54 13 57 1B 7E 66 02 01 64 5F 64 11 90  íZiT.W.~f..d_d..
```

drone-A.png MD5: d99f500968d444b5e0a1c9fd1dd69274

The file online_banking.docx contained only a password which we hope to be able to use later. Nothing else was found on this file that might feel relevant to the investigation.

4.5 Analysis of the file compress.py

Finally, at 6PM on the 22nd of October, through the tool uncompyle2 the program compress.py was decrypted producing the file uncomp_compress.py. After analyzing its contents, we reached the conclusion that it was a steganography tool to hide information inside images using the technique LSB.

```
C:\Users\user\Desktop>uncompyle6 compress.pyc
# uncompyle6 version 3.2.3
# Python bytecode 2.7 (62211)
# Decompiled from: Python 3.5.2 (v3.5.2:4def2a2901a5, Jun 25 2016, 22:01:18) [MSC v.1900 32 bit (Intel)]
# Embedded file name: csfsteg/csfsteghide.py
# Compiled at: 2018-10-13 11:57:39
import sys, struct, numpy, PIL as pillow
from PIL import Image

def decompose(data):
    v = []
    fSize = len(data)
    bytes = [ ord(b) for b in struct.pack('i', fSize) ]
    bytes += [ ord(b) for b in data ]
    for b in bytes:
        for i in range(7, -1, -1):
            v.append(b >> i & 1)

    return v


def set_bit(n, i, x):
    mask = 1 << i
    n &= ~mask
    if x:
        n |= mask
    return n


def embed(imgFile, payload, password):
    img = Image.open(imgFile)
    width, height = img.size
    conv = img.convert('RGBA').getdata()
    print '[*] Input image size: %dx%d pixels.' % (width, height)
    max_size = width * height * 3.0 / 8 / 1024
    print '[*] Usable payload size: %.2f KB.' % max_size
    f = open(payload, 'rb')
    data = f.read()
    f.close()
    print '[+] Payload size: %.3f KB ' % (len(data) / 1024.0)
    v = decompose(data)
    while len(v) % 6:
        v.append(0)
```

uncomp_compress.py MD5: df79d4920b843912aacd99e515eb49d0

4.6 Reverse Engineering the python code

After analyzing the code, we understood the information was being converted into an array of bits which contained the size of the information and the information itself through the method *decompose* and then being masked into the last two bits of the color codes (RGB) of the pixels after passing a certain number of pixels determined by a password (we hypothesize that the password in the online_banking.docx might be the password that John Mole might have used in his steganography program) that could be part of the input of the program (*displacement*) through the method *set_bit*.

```
def decompose(data):
    v = []
    fSize = len(data)
    bytes = [ ord(b) for b in struct.pack('i', fSize) ]
    bytes += [ ord(b) for b in data ]
    for b in bytes:
        for i in range(7, -1, -1):
            v.append(b >> i & 1)

    return v


def set_bit(n, i, x):
    mask = 1 << i
    n &= ~mask
    if x:
        n |= mask
    return n
```

```
def embed(imgFile, payload, password):
    img = Image.open(imgFile)
    width, height = img.size
    conv = img.convert('RGBA').getdata()
    print('[*] Input image size: %dx%d pixels.', width, height)
    max_size = width * height * 3.0 / 8 / 1024
    print('[*] Usable payload size: %.2f KB.', max_size)
    f = open(payload, 'rb')
    data = f.read()
    f.close()
    print('[+] Payload size: %.3f KB ', (len(data) / 1024.0))
    v = decompose(data)
    while len(v) % 6:
        v.append(0)

    payload_size = len(v) / 8 / 1024.0
    print('[+] Embedded payload size: %.3f KB ', payload_size)
    if payload_size > max_size - 4:
        print('[-] Cannot embed. File too large')
        sys.exit()
    steg_img = Image.new('RGBA', (width, height))
    data_img = steg_img.getdata()
    idx = 0
    displacement = 0
    for h in range(height):
        for w in range(width):
            if displacement < password:
                displacement = displacement + 1
                continue
            r, g, b, a = conv.getpixel((w, h))
            if idx < len(v):
                r = set_bit(r, 0, v[idx])
                r = set_bit(r, 1, v[idx + 1])
                g = set_bit(g, 0, v[idx + 2])
                g = set_bit(g, 1, v[idx + 3])
                b = set_bit(b, 0, v[idx + 4])
                b = set_bit(b, 1, v[idx + 5])
            idx = idx + 6
            data_img.putpixel((w, h), (r, g, b, a))

    steg_img.save(imgFile + '-stego.png', 'PNG')
    print('[+] %s embedded successfully!', payload)
```

Understanding this, we decided to draw a truth table with the variables that would define how the bits were masked into the image.

n	mask	n & ~mask
00	01	00
00	10	00
01	01	01
01	10	00
10	01	00
10	10	10
11	01	01
11	10	10

n	x	o
00	00	00
00	01	10
00	10	01
00	11	11
01	00	00
01	01	10
01	10	01
01	11	11
10	00	00
10	01	10
10	10	01
10	11	11
11	00	00
11	01	10
11	10	01
11	11	11

n	mask	n | mask
00	01	01
00	10	10
01	01	01
01	10	11
10	01	11
10	10	10
11	01	11
11	10	11

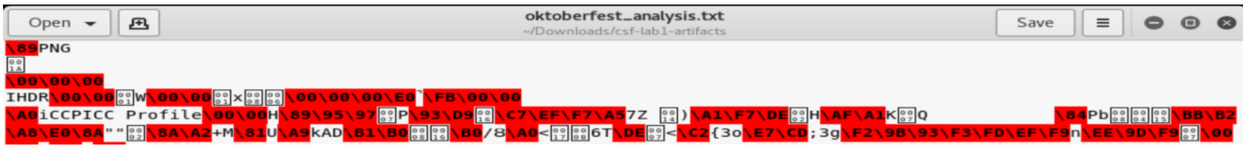
Being n, x and o representative of the original bits of the image, the bits we are trying to mask in the image (information) and the output, we noticed a pattern between x and o. The bits were swapped between them, which meant all we had to do to reverse this process was to swap the bits back to their original places, putting them back together, compose the information and we'd have what was hidden in the image. We then developed a python program named decompress.py which did exactly that and we could go through with the analysis of the image files that gave us no results in the previous one.

decompress.py MD5: 4843c0d7206c92fc0d61f6fffB86b09e

4.7 Second Analysis of the image files

Using the developed tool to decompress information masked into image files we begin to test it using the password we found in online_banking.docx (51782) generating txt output files and analyzing them to see if anything matches what we are looking for. Nothing relevant was found in this part of the analysis as all the output files were either blank or didn't contain any information that we could make sense of. As such we hypothesized that the password might just be an attempt to throw an investigation off done by John Mole and proceeded to try to decompress information masked into files without any password, i.e., without any pixels displacement (right at the beginning of the image file).

When running our tool on the oktoberfest.png, the output file we got, oktoberfest_analysis.txt, contained a .png file header which gave us an indication that it might be an image file, and upon changing the file extension to its correct format we found the second drone plan we were looking for.



We got a similar result when we ran our tool on the street.png, it gave us another .png file, street_anal_res.png, but this time it was just a picture of a castle, as such we thought of doing an analysis on this file as well as it might contain information hidden as the other image file had. The output file, street_anal_res_analysis.txt, we got from that was indeed relevant for our investigation as it was the technical specifications mentioned in the message we discovered right at the beginning of our investigation.

Finally, we ran our tool on wursten.png and in the output file, wursten_analysis.txt, we found the final piece of evidence we were looking for, the passwords for the DroneX file servers.

FILE	MD5
drone-A.png	d99f500968d444b5e0a1c9fd1dd69274
uncomp_compress.py	df79d4920b843912aacd99e515eb49d0
decompress.py	4843c0d7206c92fc0d61f6fffB86b09e
online_banking.docx	b70702822417bd39a7997a0f8c73941f
oktoberfest_analysis.png	cbe4c039f3fa2b312bb95a0964ffba4d
street_anal_res.png	d770b66b4f5833b0be194362f440e494
street_anal_res_analysis.txt	3ba4ca7f05bbf65083360e455fa8ea8a
wursten_analysis.txt	3cb3f3162e4cf990168d904d3bb300b9

5 Analysis results

After the analysis done to the pen-drive, we reached the conclusion John Mole was indeed stealing drone plans and privileged information from inside DroneX and that he would probably sell it to other rivaling companies. This conclusion comes from the fact that we found incriminating evidence that John Mole planned to send this information to another person in his pen-drive.

We didn't find any relation between the server codes in the file wursten_analysis.txt we the rest of the information, neither did we find a purpose for the password found in the file online_banking.docx. In further investigations related to this matter this information might prove relevant.

6 Conclusions

At the end of our investigation, we hypothesize the pen-drive would eventually be delivered to someone who had the password to access the online_banking.zip file or had someway of finding that password by himself and also knew that there was hidden information inside the image files and how to decompress it, perhaps with a tool previously transmitted by John Mole. By doing this the person that might have received the pen-drive would've gotten access to DroneX's drone plans, technical specifications and file server passwords hidden in apparently inoffensive images. The fact that server passwords were included in the transmitted information might mean the idea was to continue extracting confidential information from the company DroneX.

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