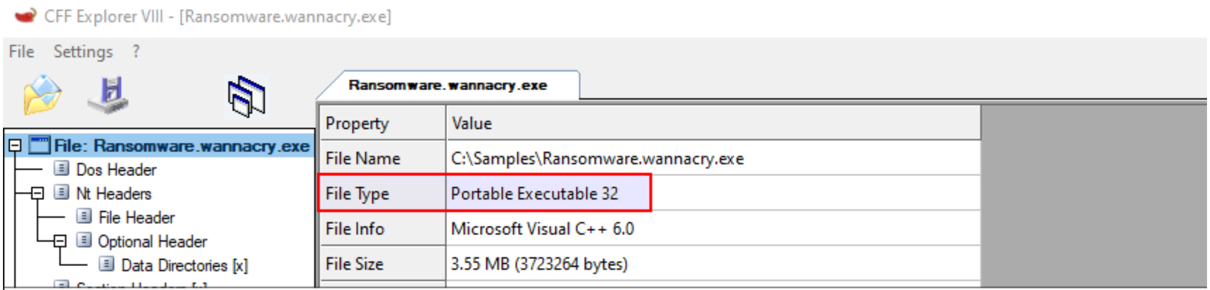
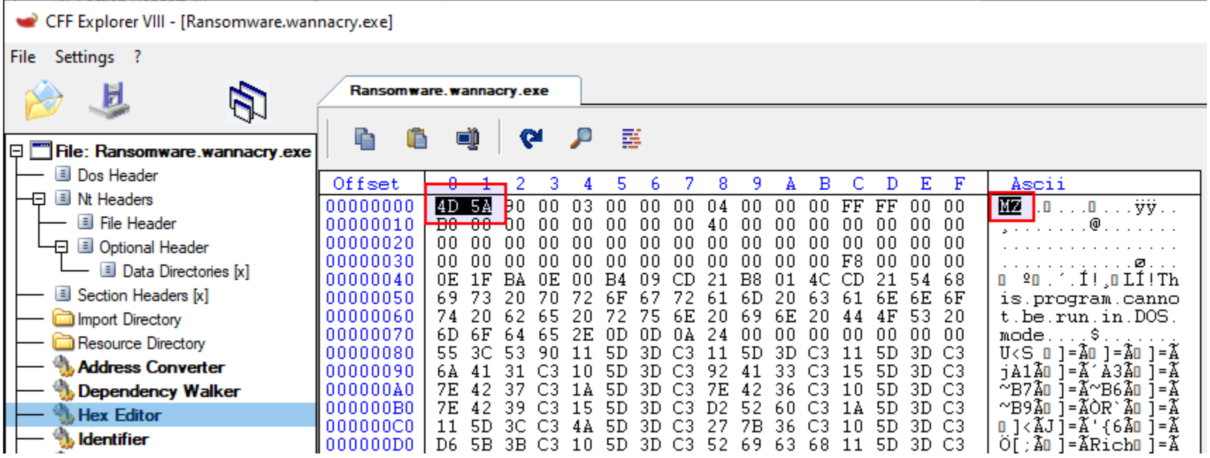
Identifying The File Type

Our first port of call in this stage is to ascertain the rudimentary information about the malware specimen to lay the groundwork for our investigation. Given that file extensions can be manipulated and changed, our task is to devise a method to identify the actual file type we are encountering. Establishing the file type plays an integral role in static analysis, ensuring that the procedures we apply are appropriate and the results obtained are accurate.

Let's use a Windows-based malware named Ransomware.wannacry.exe residing in the C:\Samples\MalwareAnalysis directory of this section's target as an illustration.

We can use a solution like CFF Explorer (available at C:\Tools\Explorer Suite) to check the file type of this malware as follows.





On a Windows system, the presence of the ASCII string MZ (in hexadecimal: 4D 5A) at the start of a file (known as the "magic number") denotes an executable file. MZ stands for Mark Zbikowski, a key architect of MS-DOS.

Malware Fingerprinting

In this stage, our mission is to create a unique identifier for the malware sample. This typically takes the form of a cryptographic hash - MD5, SHA1, or SHA256.

Fingerprinting is employed for numerous purposes, encompassing:

- Identification and tracking of malware samples
- Scanning an entire system for the presence of identical malware
- Confirmation of previous encounters and analyses of the same malware
- Sharing with stakeholders as IoC (Indicators of Compromise) or as part of threat intelligence reports

As an illustration, to check the MD5 file hash of the abovementioned malware we can use the Get-FileHash PowerShell cmdlet as follows.

```
PS C:\Users\htb-student> Get-FileHash -Algorithm MD5
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe


Algorithm      Hash                                    Path

---------      ----                                    ----

MD5          DB349B97C37D22F5EA1D1841E3C89EB4
C:\Samples\MalwareAnalysis\Ra...
```

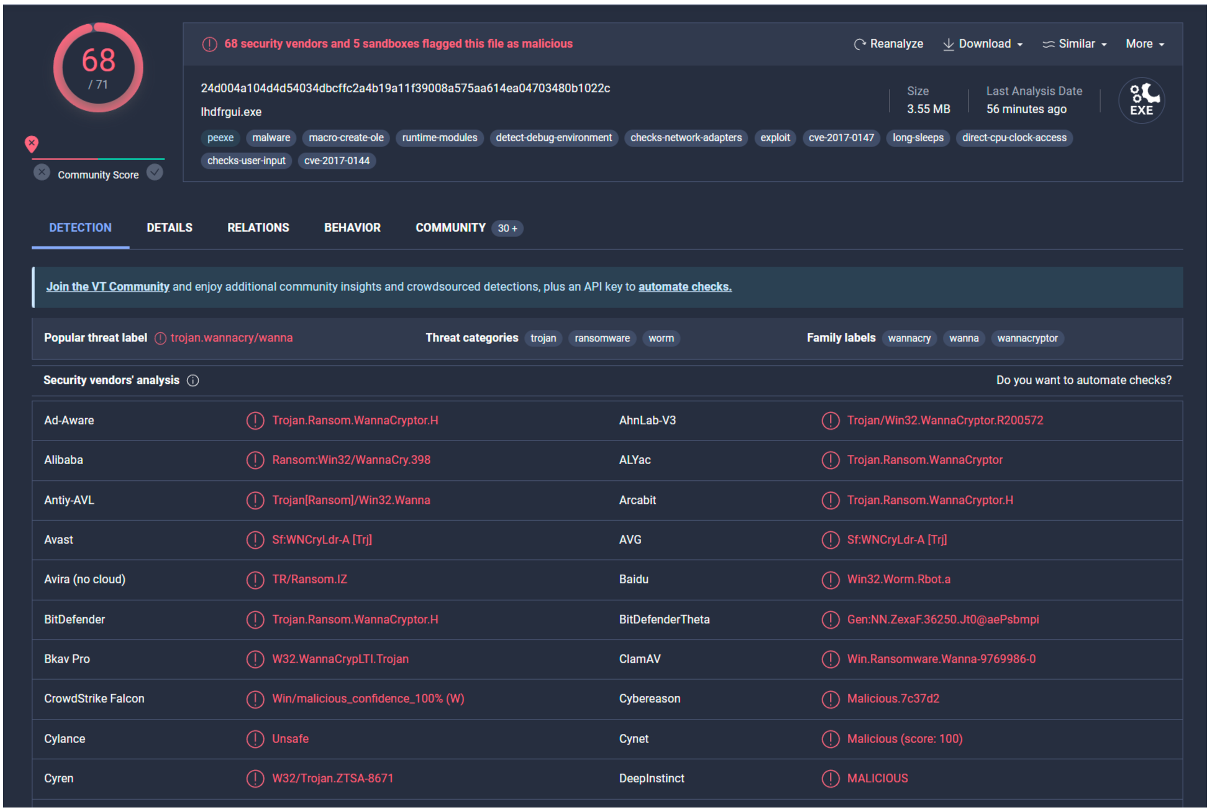
To check the SHA256 file hash of the abovementioned malware the command would be the following.

```
PS C:\Users\htb-student> Get-FileHash -Algorithm SHA256
C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe


Algorithm      Hash                                    Path

---------      ----                                    ----

SHA256
24D004A104D4D54034DBCFFC2A4B19A11F39008A575AA614EA04703480B1022C
C:\Samples\MalwareAnalysis\Ra...
```

File Hash Lookup

The ensuing step involves checking the file hash produced in the prior step against online malware scanners and sandboxes such as Cuckoo sandbox. For instance, VirusTotal, an online malware scanning engine, which collaborates with various antivirus vendors, allows us to search for the file hash. This step aids us in comparing our results with existing knowledge about the malware sample.

The following image displays the results from **VirusTotal** after the SHA256 file hash of the aforementioned malware was submitted.



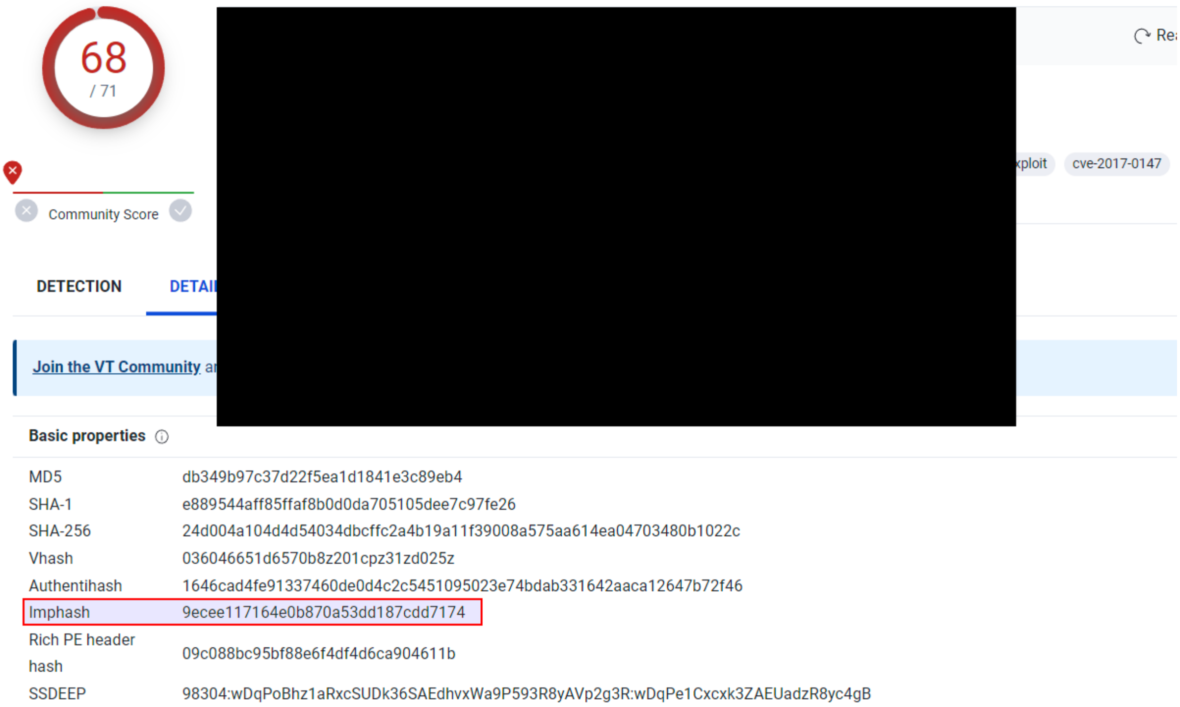
Even though a file hash like MD5, SHA1, or SHA256 is valuable for identifying identical samples with disparate names, it falls short when identifying similar malware samples. This is primarily because a malware author can alter the file hash value by making minor modifications to the code and recompiling it.

Nonetheless, there exist techniques that can aid in identifying similar samples:

Import Hashing (IMPHASH)

IMPHASH, an abbreviation for "Import Hash", is a cryptographic hash calculated from the import functions of a Windows Portable Executable (PE) file. Its algorithm functions by first converting all imported function names to lowercase. Following this, the DLL names and function names are fused together and arranged in alphabetical order. Finally, an MD5 hash is generated from the resulting string. Therefore, two PE files with identical import functions, in the same sequence, will share an IMPHASH value.

We can find the IMPHASH in the Details tab of the VirusTotal results.



Note that we can also use the pefile Python module to compute the IMPHASH of a file as follows.

Code: python

```python
import sys
import pefile
import peutils

pe_file = sys.argv[1]
pe = pefile.PE(pe_file)
imphash = pe.get_imphash()

print(imphash)
```

To check the IMPHASH of the abovementioned WannaCry malware the command would be the following. imphash_calc.py contains the Python code above.

```
C:\Scripts> python imphash_calc.py C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe
9ecee117164e0b870a53dd187cdd7174
```

Fuzzy Hashing (SSDEEP)

Fuzzy Hashing (SSDEEP), also referred to as context-triggered piecewise hashing (CTPH), is a hashing technique designed to compute a hash value indicative of content similarity between two files. This technique dissects a file into smaller, fixed-size blocks and calculates a hash for each block. The resulting hash values are then consolidated to generate the final fuzzy hash.

The SSDEEP algorithm allocates more weight to longer sequences of common blocks, making it highly effective in identifying files that have undergone minor modifications, or are similar but not identical, such as different variations of a malicious sample.

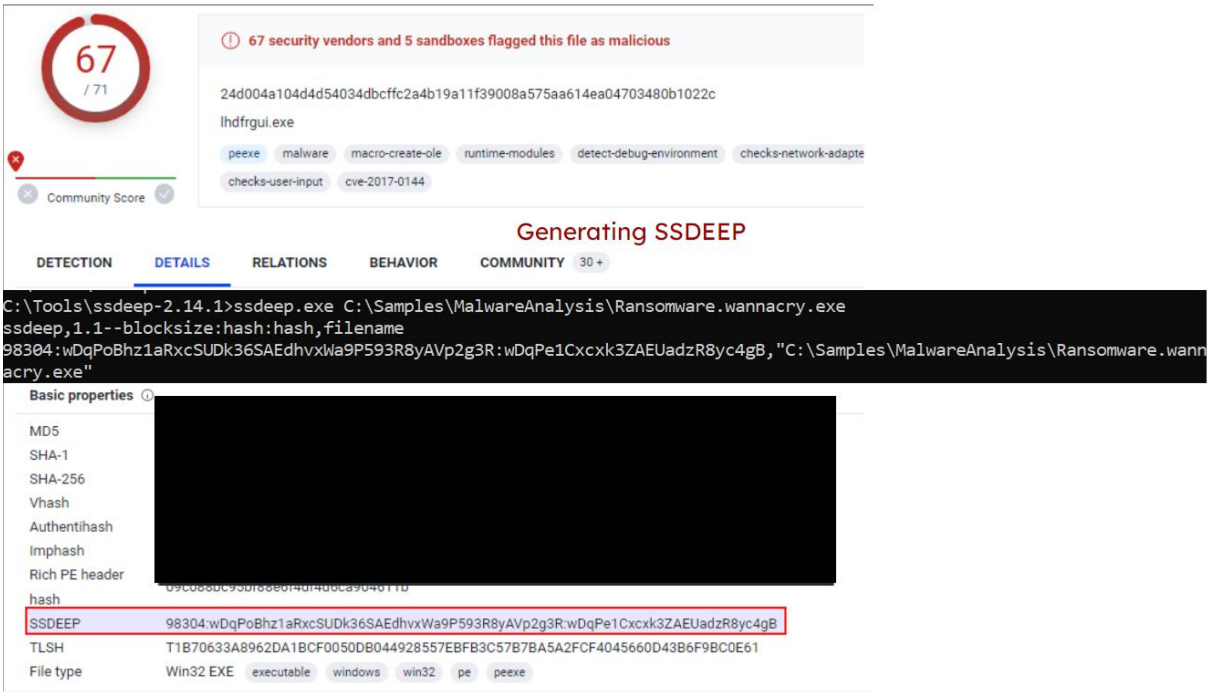
We can find the SSDEEP hash of a malware in the Details tab of the VirusTotal results.

We can also use the ssdeep tool (available at C:\Tools\ssdeep-2.14.1) to calculate the SSDEEP hash of a file. To check the SSDEEP hash of the abovementioned WannaCry malware the command would be the following.

C:\Tools\ssdeep-2.14.1> ssdeep.exe C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe

ssdeep,1.1--blocksize:hash:hash,filename

98304:wDqPoBhz1aRxcSUDk36SAEdhvxWa9P593R8yAVp2g3R:wDqPe1Cxcxk3ZAEUadzR8yc4gB,"C:\Samples\MalwareAnalysis\Ransomware.wannacry.exe"



Section Hashing (Hashing PE Sections)

Section hashing, (hashing PE sections) is a powerful technique that allows analysts to identify sections of a Portable Executable (PE) file that have been modified. This can be particularly useful for identifying minor variations in malware samples, a common tactic employed by attackers to evade detection.

The Section Hashing technique works by calculating the cryptographic hash of each of these sections. When comparing two PE files, if the hash of corresponding sections in the two files matches, it suggests that the particular section has not been modified between the two versions of the file.

By applying section hashing, security analysts can identify parts of a PE file that have been tampered with or altered. This can help identify similar malware samples, even if they have been slightly modified to evade traditional signature-based detection methods.

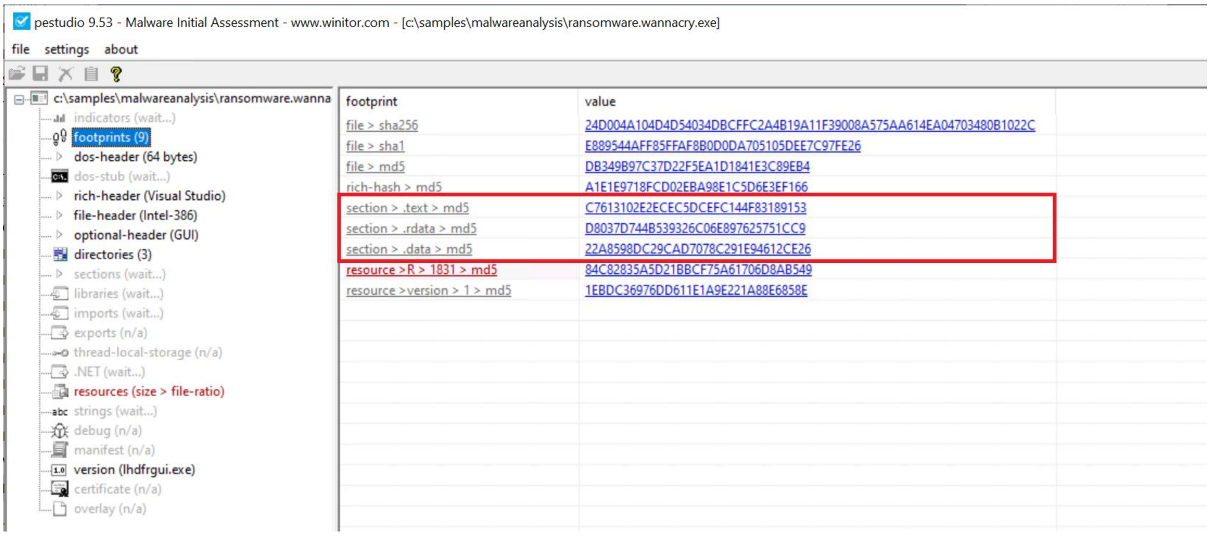
Tools such as pefile in Python can be used to perform section hashing. In Python, for example, you can use the pefile module to access and hash the data in individual sections of a PE file as follows.

Code: python

```python
import sys

import pefile

pe_file = sys.argv[1]

pe = pefile.PE(pe_file)

for section in pe.sections:

   print (section.Name, "MD5 hash:", section.get_hash_md5())

   print (section.Name, "SHA256 hash:", section.get_hash_sha256())
```

Remember that while section hashing is a powerful technique, it is not foolproof. Malware authors might employ tactics like section name obfuscation or dynamically generating section names to try and bypass this kind of analysis.

As an illustration, to check the MD5 file hash of the abovementioned malware we can use pestudio (available at C:\Tools\pestudio\pestudio) as follows.



String Analysis

In this phase, our objective is to extract strings (ASCII & Unicode) from a binary. Strings can furnish clues and valuable insight into the functionality of the malware. Occasionally, we can unearth unique embedded strings in a malware sample, such as:

- Embedded filenames (e.g., dropped files)
- IP addresses or domain names

- Registry paths or keys
- Windows API functions
- Command-line arguments
- Unique information that might hint at a particular threat actor

The Windows strings binary from Sysinternals can be deployed to display the strings contained within a malware. For instance, the command below will reveal strings for a ransomware sample named dharma_sample.exe residing in the C:\Samples\MalwareAnalysis directory of this section's target.

C:\Users\htb-student> strings C:\Samples\MalwareAnalysis\dharma_sample.exe

Strings v2.54 - Search for ANSI and Unicode strings in binary images.

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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.

gaT

Rich

.text

`.rdata

@.data

HQh

9A s

9A$v

---SNIP---

GetProcAddress

LoadLibraryA

WaitForSingleObject

InitializeCriticalSectionAndSpinCount

LeaveCriticalSection

GetLastError

EnterCriticalSection

ReleaseMutex

CloseHandle

KERNEL32.dll

RSDS%~m

#ka

C:\crysis\Release\PDB\payload.pdb

---SNIP---

Occasionally, string analysis can facilitate the linkage of a malware sample to a specific threat group if significant similarities are identified. For **example**, in the link provided, a string containing a PDB path was used to link the malware sample to the Dharma/Crysis family of ransomware.

It should be noted that the FLOSS tool is also available for Windows Operating Systems.

The command below will reveal strings for a malware sample named shell.exe residing in the C:\Samples\MalwareAnalysis directory of this section's target.

```
C:\Samples\MalwareAnalysis> floss shell.exe

INFO: floss: extracting static strings...

finding decoding function features:
100%|████████████████████████████████████████| 85/85
[00:00<00:00, 1361.51 functions/s, skipped 0 library functions]

INFO: floss.stackstrings: extracting stackstrings from 56 functions

INFO: floss.results: AQAPRQVH1

INFO: floss.results: JJM1

INFO: floss.results: RAQH

INFO: floss.results: AXAX^YZAXAYAZH

INFO: floss.results: XAYZH

INFO: floss.results: ws232

extracting stackstrings:
100%|██████████████████████████████████████████████████
██████████████████████████████| 56/56 [00:00<00:00, 81.46 functions/s]

INFO: floss.tightstrings: extracting tightstrings from 4 functions...
```

extracting tightstrings from function 0x402a90:
100%|[redacted]| 4/4 [00:00<00:00, 25.59 functions/s]

INFO: floss.string_decoder: decoding strings

emulating function 0x402a90 (call 1/1):
100%|[redacted]| 22/22 [00:14<00:00, 1.51 functions/s]

INFO: floss: finished execution after 25.20 seconds

FLARE FLOSS RESULTS (version v2.3.0-0-g037fc4b)

```
+------------------------+------------------------------------------------------------------------------------+
| file path              | shell.exe                                                                          |
| extracted strings      |                                                                                    |
|  static strings        | 254                                                                                |
|  stack strings         | 6                                                                                  |
|  tight strings         | 0                                                                                  |
|  decoded strings       | 0                                                                                  |
+------------------------+------------------------------------------------------------------------------------+
```

FLOSS STATIC STRINGS

```
+----------------------------------+
| FLOSS STATIC STRINGS: ASCII (254) |
+----------------------------------+
```

!This program cannot be run in DOS mode.

.text

P`.data

.rdata

`@.pdata

0@.xdata

0@.bss

.idata

.CRT

.tls

8MZu

HcP<H

D$ H

AUATUWVSH

D$ L

---SNIP---

C:\Windows\System32\notepad.exe

Message

Connection sent to C2

[-] Error code is : %lu

AQAPRQVH1

JJM1

RAQH

AXAX^YZAXAYAZH

XAYZH

ws2_32

PPM1

APAPH

WWWM1

VPAPAPAPI

Windows-Update/7.6.7600.256 %s

1Lbcfr7sAHTD9CgdQo3HTMTkV8LK4ZnX71

open

SOFTWARE\Microsoft\Windows\CurrentVersion\Run

WindowsUpdater

---SNIP---

TEMP

svchost.exe

%s\%s

http://ms-windows-update.com/svchost.exe

45.33.32.156

Sandbox detected

iuqerfsodp9ifjaposdfjhgosurijfaewrwergwea.com

SOFTWARE\VMware, Inc.\VMware Tools

InstallPath

C:\Program Files\VMware\VMware Tools\

Failed to open the registry key.

Unknown error

Argument domain error (DOMAIN)

Overflow range error (OVERFLOW)

Partial loss of significance (PLOSS)

Total loss of significance (TLOSS)

The result is too small to be represented (UNDERFLOW)

Argument singularity (SIGN)

_matherr(): %s in %s(%g, %g) (retval=%g)

Mingw-w64 runtime failure:

Address %p has no image-section

  VirtualQuery failed for %d bytes at address %p

  VirtualProtect failed with code 0x%x

  Unknown pseudo relocation protocol version %d.

  Unknown pseudo relocation bit size %d.

.pdata

RegCloseKey

RegOpenKeyExA

RegQueryValueExA

RegSetValueExA

CloseHandle

CreateFileA

CreateProcessA

CreateRemoteThread

DeleteCriticalSection

EnterCriticalSection

GetComputerNameA

GetCurrentProcess

GetCurrentProcessId

GetCurrentThreadId

GetLastError

GetStartupInfoA

GetSystemTimeAsFileTime

GetTickCount

InitializeCriticalSection

LeaveCriticalSection

OpenProcess

QueryPerformanceCounter

RtlAddFunctionTable

RtlCaptureContext

RtlLookupFunctionEntry

RtlVirtualUnwind

SetUnhandledExceptionFilter

Sleep

TerminateProcess

TlsGetValue

UnhandledExceptionFilter

VirtualAllocEx

VirtualProtect

VirtualQuery

WriteFile

WriteProcessMemory

__C_specific_handler

__getmainargs

__initenv

__iob_func

__lconv_init

__set_app_type

__setusermatherr

_acmdln

_amsg_exit

_cexit

_fmode

_initterm

_onexit

_vsnprintf

abort

calloc

exit

fprintf

free

fwrite

getenv

malloc

memcpy

printf

puts

signal

sprintf

strcmp

strlen

strncmp

vfprintf

ShellExecuteA

MessageBoxA

InternetCloseHandle

InternetOpenA

InternetOpenUrlA

InternetReadFile

WSACleanup

WSAStartup

closesocket

connect

freeaddrinfo

getaddrinfo

htons

inet_addr

socket

ADVAPI32.dll

KERNEL32.dll

msvcrt.dll

SHELL32.dll

USER32.dll

WININET.dll

WS2_32.dll

+------------------------------------+

| FLOSS STATIC STRINGS: UTF-16LE (0) |

+------------------------------------+

FLOSS STACK STRINGS

AQAPRQVH1

JJM1

RAQH

AXAX^YZAXAYAZH

XAYZH

ws232

FLOSS TIGHT STRINGS

FLOSS DECODED STRINGS

Unpacking UPX-packed Malware

In our static analysis, we might stumble upon a malware sample that's been compressed or obfuscated using a technique referred to as packing. Packing serves several purposes:

- It obfuscates the code, making it more challenging to discern its structure or functionality.
- It reduces the size of the executable, making it quicker to transfer or less conspicuous.

- It confounds security researchers by hindering traditional reverse engineering attempts.

This can impair string analysis because the references to strings are typically obscured or eliminated. It also replaces or camouflages conventional PE sections with a compact loader stub, which retrieves the original code from a compressed data section. As a result, the malware file becomes both smaller and more difficult to analyze, as the original code isn't directly observable.

A popular packer used in many malware variants is the Ultimate Packer for Executables (UPX).

Let's first see what happens when we run the strings command on a UPX-packed malware sample named credential_stealer.exe residing in
the C:\Samples\MalwareAnalysis\packed directory of this section's target.

C:\Users\htb-student> strings C:\Samples\MalwareAnalysis\packed\credential_stealer.exe

Strings v2.54 - Search for ANSI and Unicode strings in binary images.

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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.

UPX0

UPX1

UPX2

3.96

UPX!

ff.

8MZu

HcP<H

tY)

L~o

tK1

7c0

VDgxt

amE

8#v

$ /uX

OAUATUWVSH

Z6L

<=h

%0rv

o?H9

7sk

3H{

HZu

'.}

c|/

c`fG

Iq%

[^_]A\A]

> -P

fo{Wnl

c9"^$!=

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%&m

')A

v/7>

07ZC

_L$AAl

mug.%(

t%n

#8%,X

e]'^

(hk

Dks

zC:

Vj<

w~5

m<6

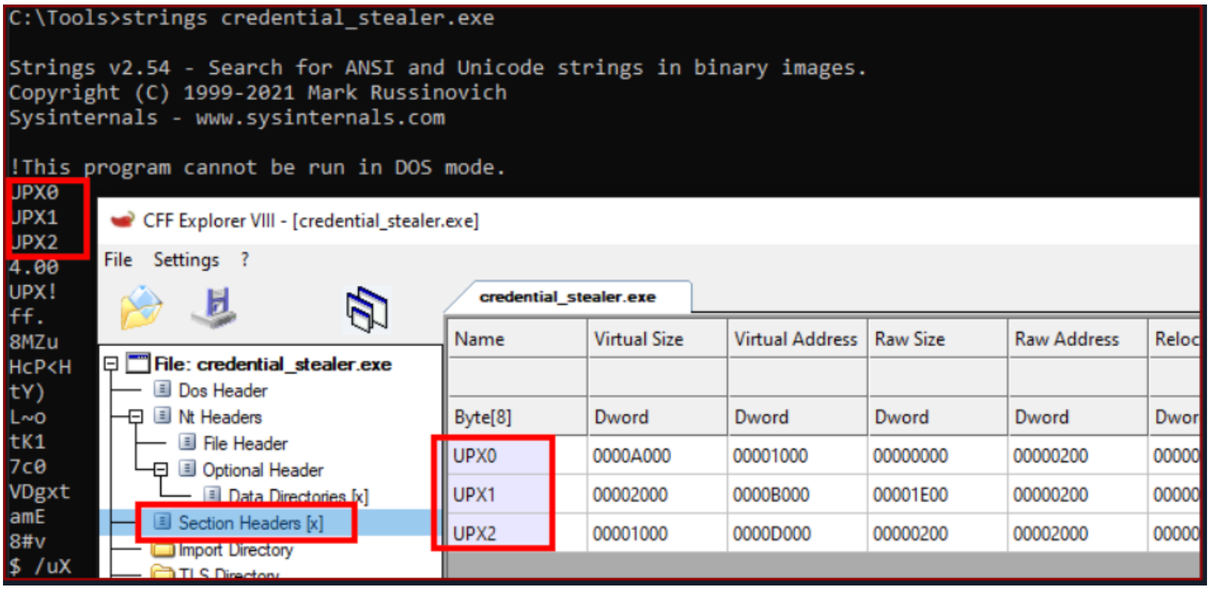
|$PD

c(t

\3_

---SNIP---

Observe the strings that include UPX, and take note that the remainder of the output doesn't yield any valuable information regarding the functionality of the malware.



We can unpack the malware using the UPX tool (available at C:\Tools\upx\upx-4.0.2-win64) with the following command.

C:\Tools\upx\upx-4.0.2-win64> upx -d -o unpacked_credential_stealer.exe C:\Samples\MalwareAnalysis\packed\credential_stealer.exe

Ultimate Packer for eXecutables

Copyright (C) 1996 - 2023

UPX 4.0.2 Markus Oberhumer, Laszlo Molnar & John Reiser Jan 30th 2023

```
        File size         Ratio      Format      Name
   --------------------   ------   -----------   -----------
     16896 <-      8704   51.52%    win64/pe     unpacked_credential_stealer.exe
```

Unpacked 1 file.

Let's now run the strings command on the unpacked sample.

C:\Tools\upx\upx-4.0.2-win64> strings unpacked_credential_stealer.exe

```
Strings v2.54 - Search for ANSI and Unicode strings in binary images.
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Sysinternals - www.sysinternals.com

!This program cannot be run in DOS mode.
.text
P`.data
.rdata
`@.pdata
0@.xdata
0@.bss
.idata
.CRT
.tls
ff.
8MZu
HcP<H
---SNIP---
D$(
D$
D$0
D$(
D$
t'H
%5T
@A\A]A^
SeDebugPrivilege
SE Debug Privilege is adjusted
lsass.exe
Searching lsass PID
```

Lsass PID is: %lu

Error is - %lu

lsassmem.dmp

LSASS Memory is dumped successfully

Err 2: %lu

@u@

` p@

Unknown error

Argument domain error (DOMAIN)

Overflow range error (OVERFLOW)

Partial loss of significance (PLOSS)

Total loss of significance (TLOSS)

The result is too small to be represented (UNDERFLOW)

Argument singularity (SIGN)

_matherr(): %s in %s(%g, %g) (retval=%g)

Mingw-w64 runtime failure:

Address %p has no image-section

  VirtualQuery failed for %d bytes at address %p

  VirtualProtect failed with code 0x%x

  Unknown pseudo relocation protocol version %d.

  Unknown pseudo relocation bit size %d.

.pdata

 0@

00@

` E@

` E@

@v@

hy@

` y@

@p@

0v@

Pp@

AdjustTokenPrivileges

LookupPrivilegeValueA

OpenProcessToken

MiniDumpWriteDump

CloseHandle

CreateFileA

CreateToolhelp32Snapshot

DeleteCriticalSection

EnterCriticalSection

GetCurrentProcess

GetCurrentProcessId

GetCurrentThreadId

GetLastError

GetStartupInfoA

GetSystemTimeAsFileTime

GetTickCount

InitializeCriticalSection

LeaveCriticalSection

OpenProcess

Process32First

Process32Next

QueryPerformanceCounter

RtlAddFunctionTable

RtlCaptureContext

RtlLookupFunctionEntry

RtlVirtualUnwind

SetUnhandledExceptionFilter

Sleep

TerminateProcess

TlsGetValue

UnhandledExceptionFilter

VirtualProtect

VirtualQuery

__C_specific_handler

__getmainargs

__initenv

__iob_func

__lconv_init

__set_app_type

__setusermatherr

_acmdln

_amsg_exit

_cexit

_fmode

_initterm

_onexit

abort

calloc

exit

fprintf

free

fwrite

malloc

memcpy

printf

puts

signal

strcmp

strlen

strncmp

vfprintf

ADVAPI32.dll

dbghelp.dll

KERNEL32.DLL

msvcrt.dll

Now, we observe a more comprehensible output that includes the actual strings present in the sample.