Redline Stealer - Static Analysis and C2 Extraction

embee-research.ghost.io/redline-stealer-basic-static-analysis-and-c2-extraction/

Matthew

April 10, 2023

Ghidra Featured

Deep dive analysis of a redline stealer sample. I will use manual analysis to extract C2 information using a combination of Ghidra and x32dbg

Deep-dive analysis of a packed Redline Stealer sample. Utilising manual analysis and semi-automated string decryption to extract C2 information and ultimately identify the malware.

In this write-up, I intentionally try to touch on as many concepts as possible in order to demonstrate practical applications and hopefully provide a better learning experience for the reader.

Quick Caveat

> *I realized after the initial post that this sample is actually Amadey Bot. The analysis and RE techniques remain equally relevant, but the sample is not actually Redline as the title suggests :)*
> (There is a second file in the .cab which contains Redline Stealer, which may explain why the initial file was semi-incorrectly marked as Redline)
>
> I was able to determine this by researching the decrypted strings that are detailed at the end of the post.
>
> If you're interested in how to use decrypted strings to identify or confirm a malware family. Jump to the bonus section "*Utilising Decrypted Strings To Identify the Malware Family*" of this blog.

Link Sample

The initial file can be downloaded from Malware Bazaar with SHA256: .
`449d9e29d49dea9697c9a84bb7cc68b50343014d9e14667875a83cade9adbc60`

Analysis Summary

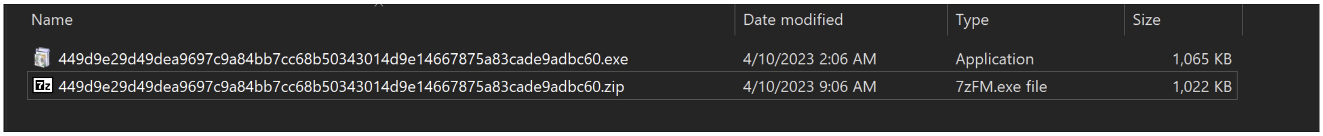
Feel free to jump to certain sections if you are already comfortable with some of these concepts.

- Saving the file and extracting the initial .exe
- Using Entropy to identify that the initial .exe is packed
- Using a debugger to manually unpack the first payload
- Initial analysis of the unpacked payload
- Identifying interesting strings and imports
- Static Analysis to establish context of interesting strings and imports
- Utilising a debugger to analyse the String Decryption function
- Automating the String Decryption using X32dbg
- Utilising Decrypted strings to identify the malware family.

Actual Analysis

The analysis can kick off by downloading the above file and transferring it into a safe analysis machine. (I strongly recommend and personally use FLARE-VM for analysis)

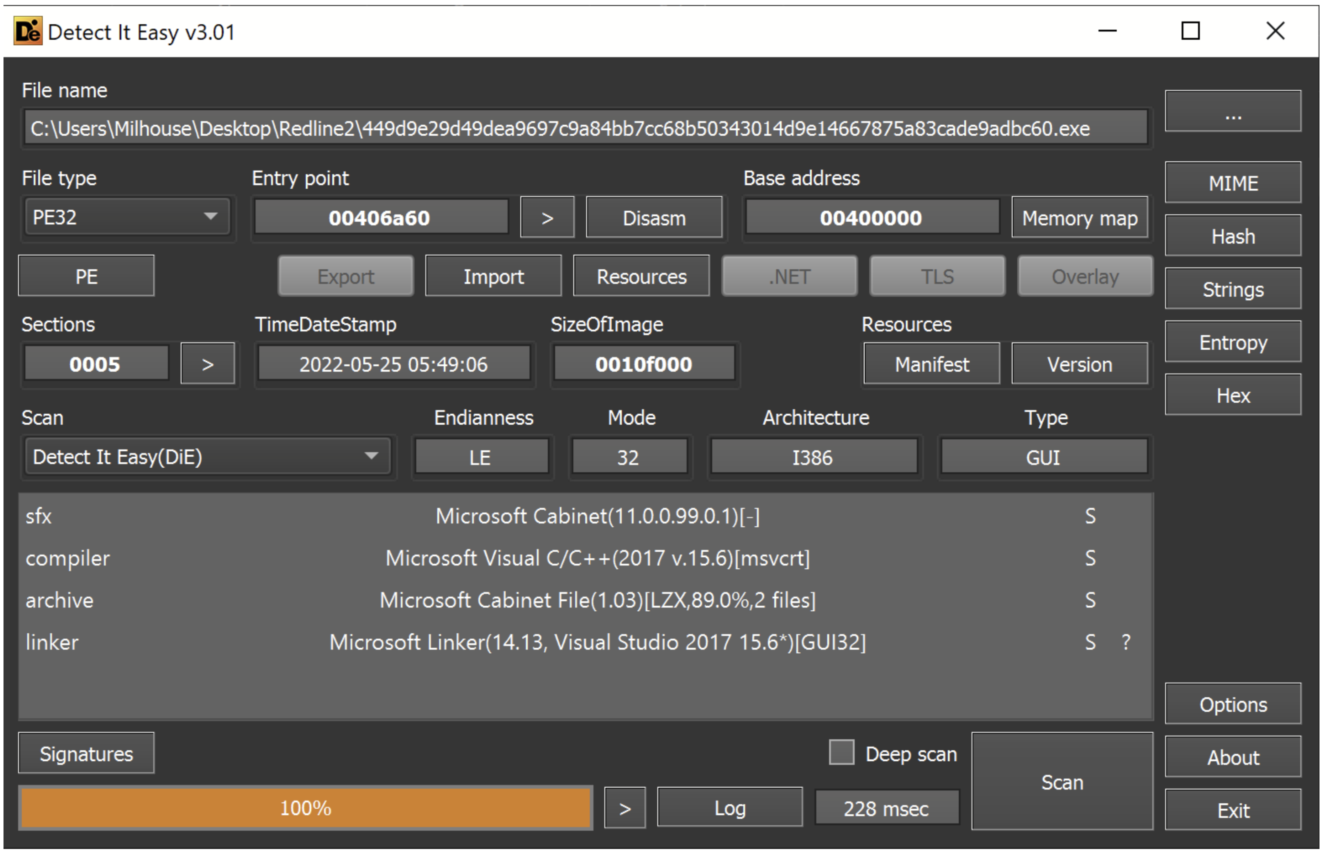
The file can be extracted with the password `infected`.



Unzipping the file with the password "infected"

After successful extraction - detect-it-easy can be used to perform an initial analysis of the file.

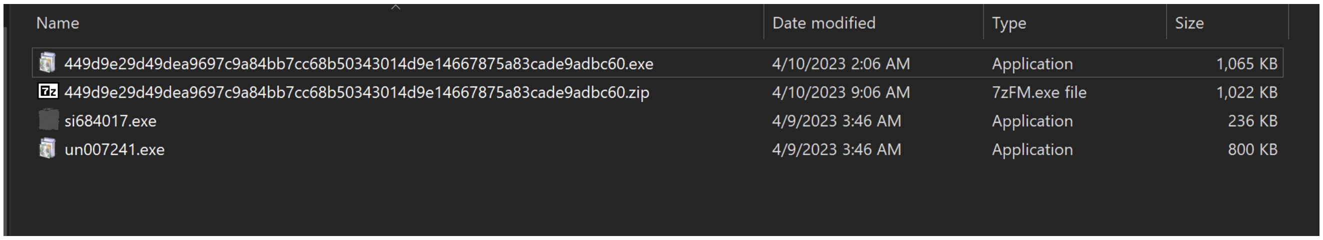
This reveals that the file is a 32 bit executable. Which in this case is actually a Microsoft Cabinet file. This is essentially a `.zip` that can be executed as a `.exe` file.



Initial Malware Analysis using Detect-it-easy

The file is similar enough to a `.zip` that `7-zip` is able to extract the contents of the file just like a regular zip file.

I was able to use 7zip to extract the contents, creating two new exe's in the process. These are `si684017.exe` and `un007241.exe` in the screenshot below.



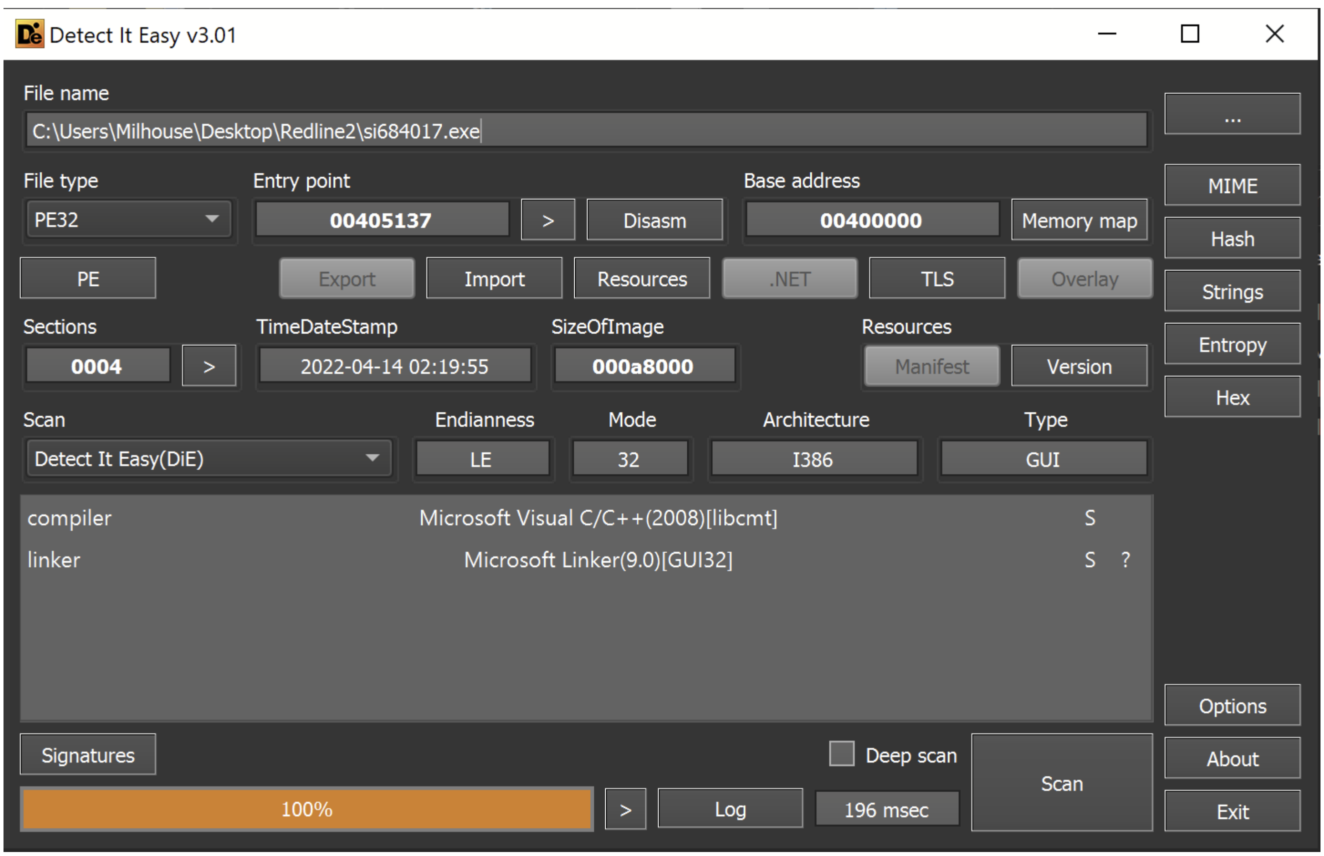
Additional files after extracting initial .cab.
For now, I'll focus on the `si684017.exe` file.

Initial Executable File

The initial is file recognized as a 32-bit exe file by `detect-it-easy`.

Interestingly - it was not a .NET as most Infostealers generally are. This means that the usual DnSpy won't be applicable here.

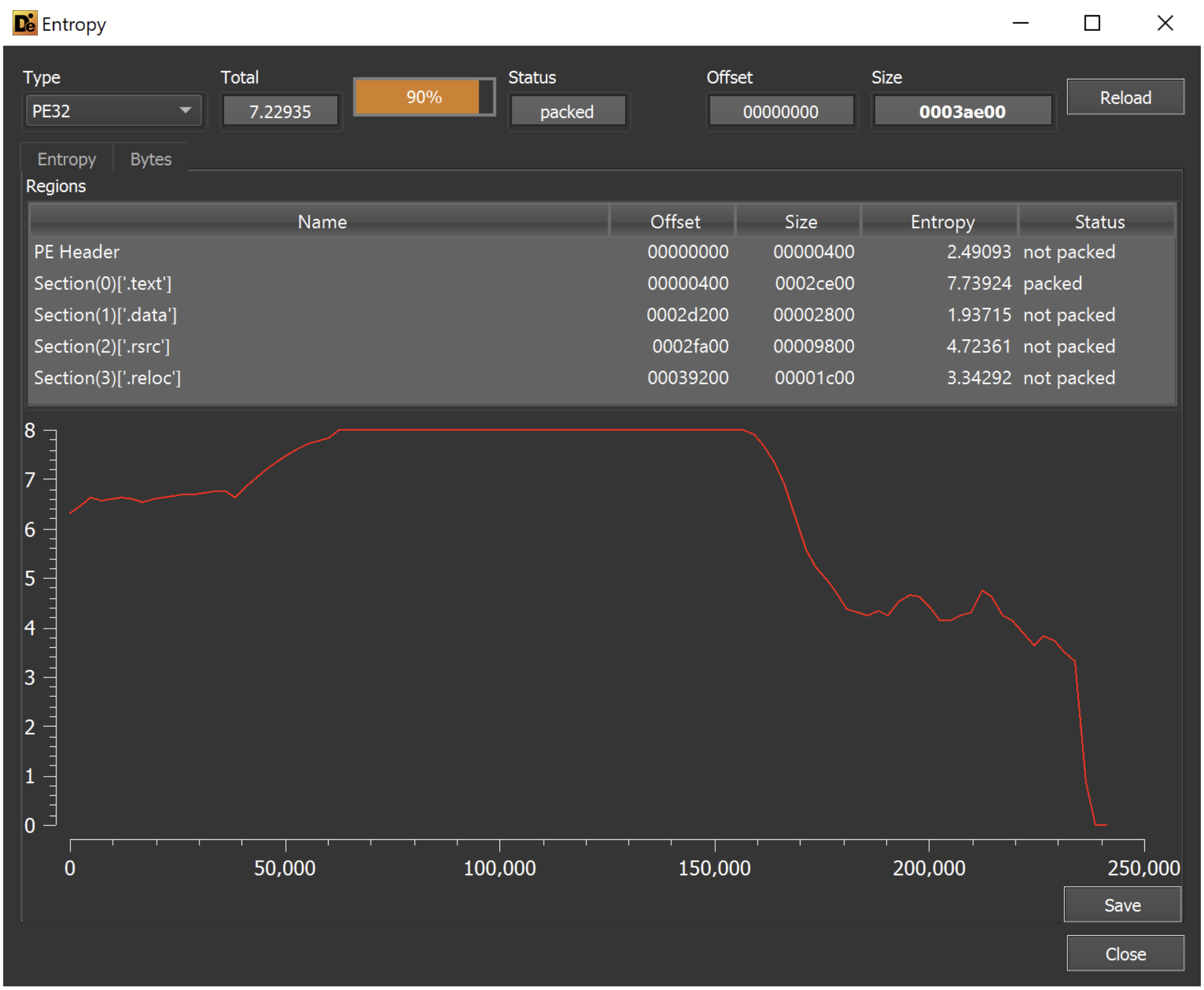
(Check out my analysis of dcrat for tips on using Dnspy)



Initial file analysis using Detect-it-easy
During initial analysis, I always want to determine if the file is potentially a packed loader rather than a final payload. If I have reason to suspect a packed payload, I typically focus on unpacking rather than strings or other static analysis.

A packed sample will typically contain areas of significantly high entropy.

To determine areas of entropy - I utilized the `Entropy Graph` feature within Detect-it-easy.



Malware Entropy Analysis Using Detect-it-easy

This revealed a *very* area of high entropy within the file. This is a strong indicator that the file is a packed loader and not the final payload.

In situations like this - I proceed to focus on unpacking the file.

Since this is a "regular" exe file and not a .NET-based file - I proceeded to unpack the file using X32dbg.

Unpacking Using X32dbg

When a standard-exe-based loader unpacks a file, it typically uses a combination of `VirtualAlloc` , `VirtualProtect` and `CreateThread`. These functions allow the malware to allocate new sections of memory that can be used to store and execute the unpacked payload.

> Advanced malware will heavily obfuscate these functions and/or avoid using them completely. But in 90% of cases - the previously mentioned functions are relevant. (Check out my blog on API hashing for how this obfuscation can be done)

In most malware - We can set breakpoints on the `VirtualAlloc` and `VirtualProtect` function calls and monitor the results using Hardware Breakpoints . This will alert when the newly allocated buffer is accessed, from there it is generally simple to obtain the decoded payload.

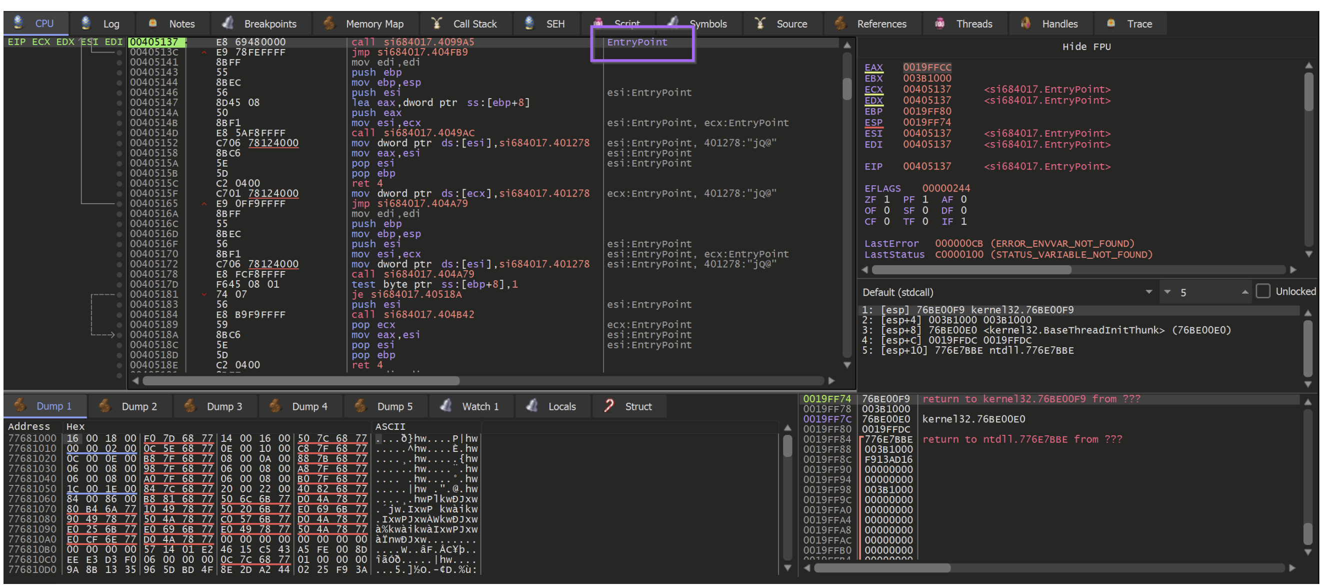
To summarise this:

- Identify a Function of Interest (In this case `VirtualAlloc`)
- Create a breakpoint to monitor `VirtualAlloc`
- Obtain the Memory Buffer created by `VirtualAlloc`
- Use a `Hardware Breakpoint` - to alert when the new memory buffer is accessed
- Allow the malware to execute until the buffer is filled
- Save the buffer to a file

I've previously written a thread on how to use Hardware Breakpoints to unpack Cobalt Strike Loaders. You can check it out here.

Loading the File into X32dbg

To initiate this process - I dragged the file into a debugger (x32dbg) and allowed the file to execute until the Entry Point. This can be done by loading the file and *once* clicking the `F9` button.



Viewing the Entrypoint using a Debugger (x32dbg)

Creating The Breakpoints

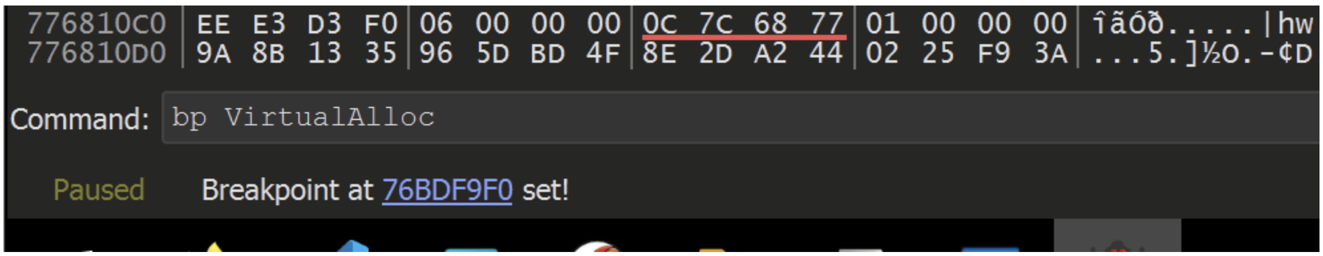
Breakpoints were then required in order to inspect the appropriate `VirtualAlloc` function.

> Note that in this case - the primary interest is in the output (or return value) of `VirtualAlloc`. The relevance of this is that we care about the data at the "end" of the breakpoint, and not at the moment where the breakpoint is hit.

If that's confusing then let's just see it in action (it's always confusing the first dozen times)

Set two breakpoints using the following commands

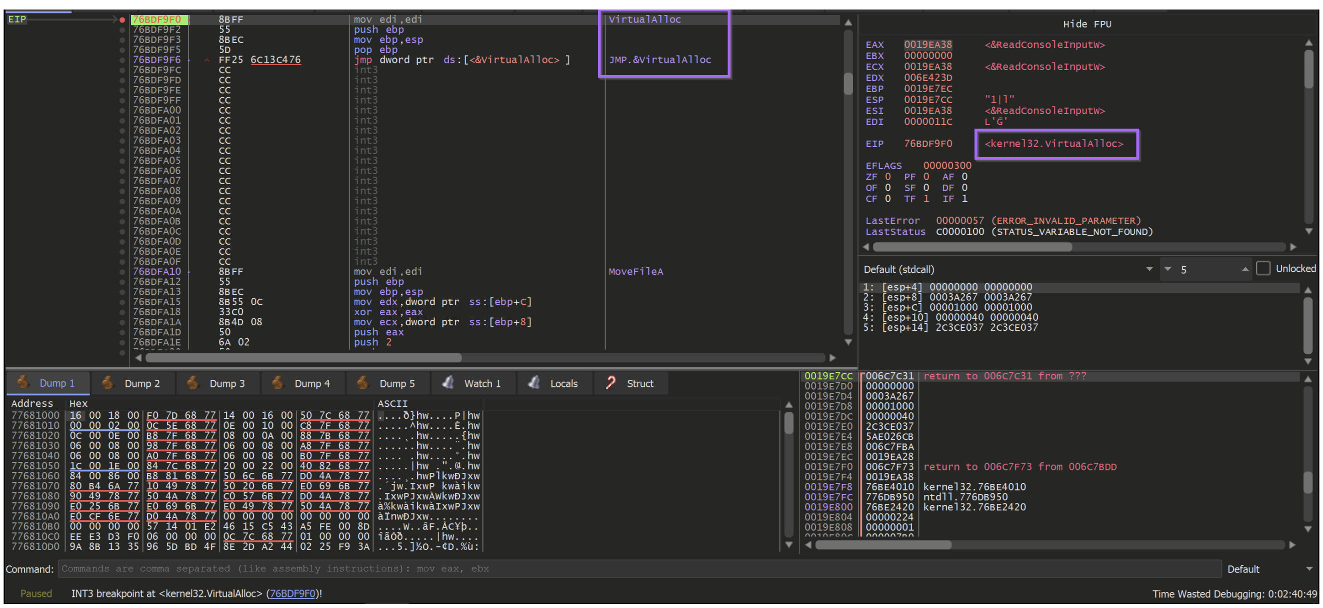
`bp VirtualAlloc` , `bp VirtualProtect`



Setting a breakpoint on VirtualAlloc using x32dbg

Hit `F9` (Continue) again, allowing the malware to execute until a breakpoint is hit.

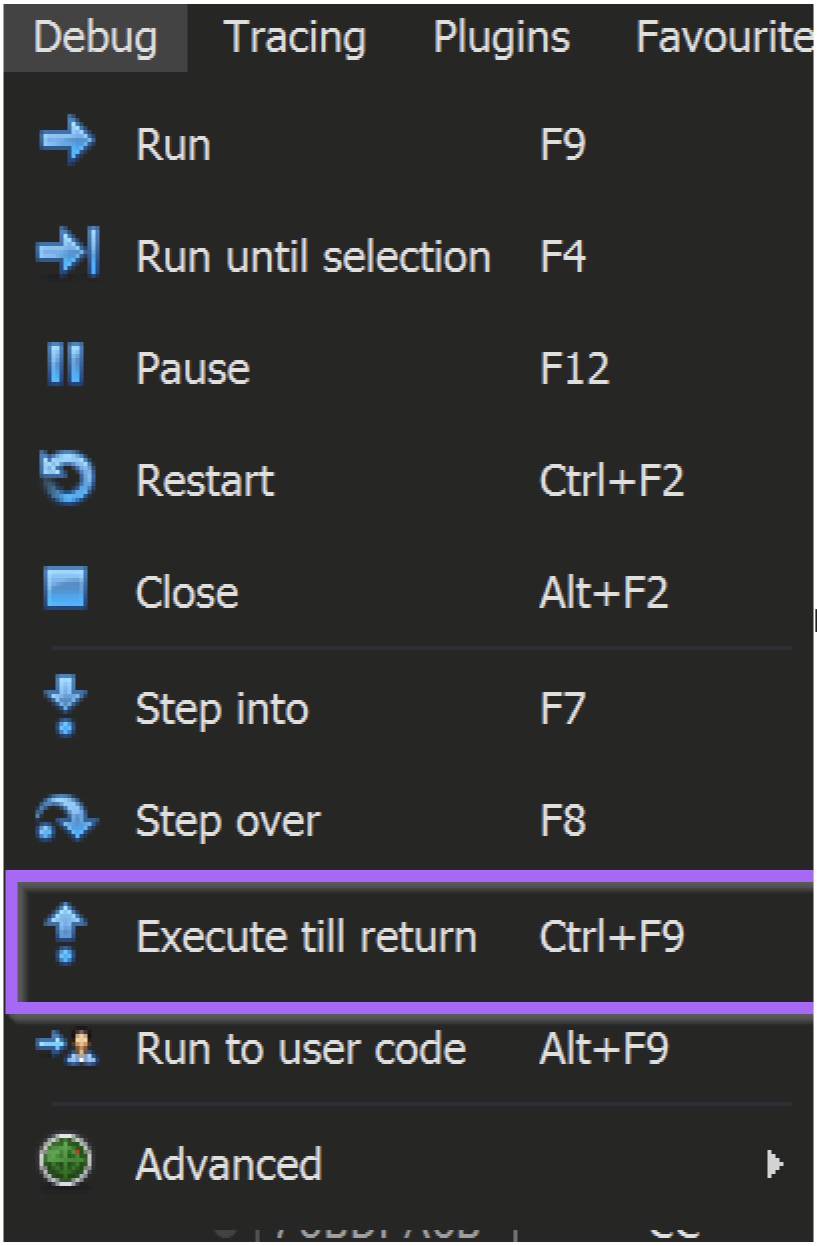
A breakpoint is immediately hit on the `VirtualAlloc` function



Triggering a breakpoint on VirtualAlloc

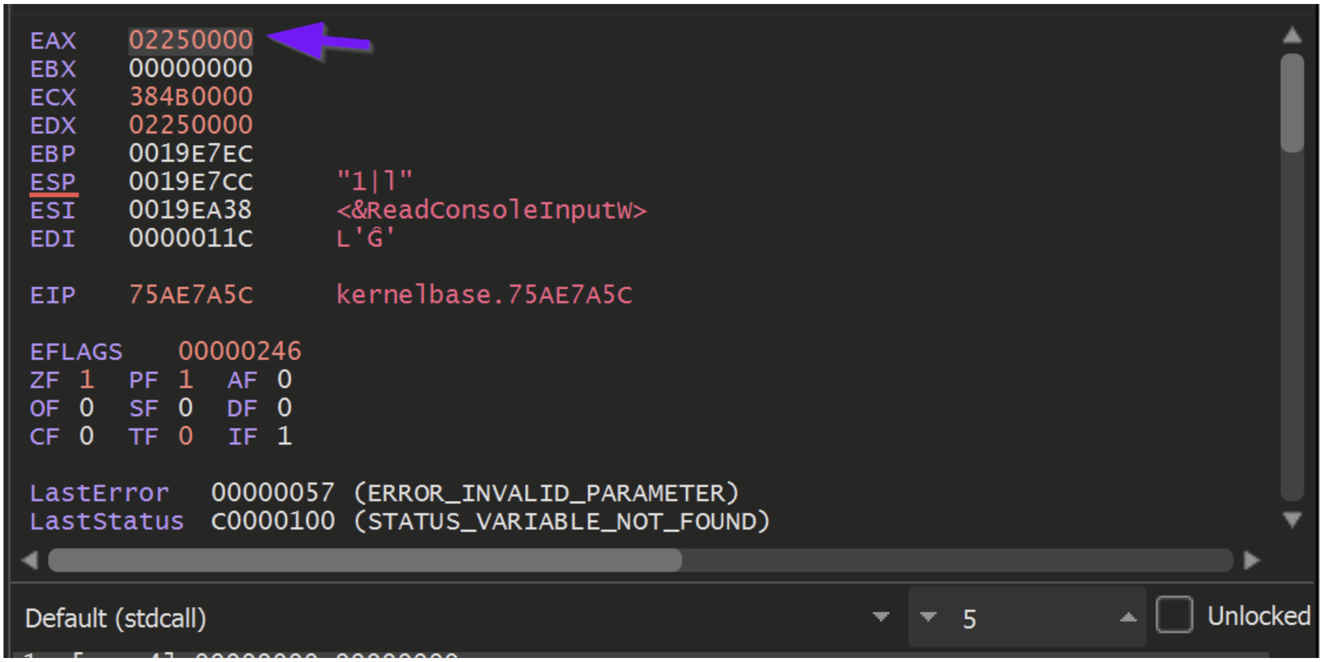
The primary purpose of `VirtualAlloc` is to allocate memory and return an address to the newly allocated buffer. This newly allocated memory is contained in the `EAX` register when the function is *completed*.

TLDR: Since I'm only interested in that buffer - I utilized the `Execute Until Return` or `CTRL+F9` to jump straight to the end of the function and obtain the result.



How to "Execute Until Return" using x32dbg

Allowing the malware to Execute Until Return - provides an EAX register containing the address of the memory buffer to be used by the malware.



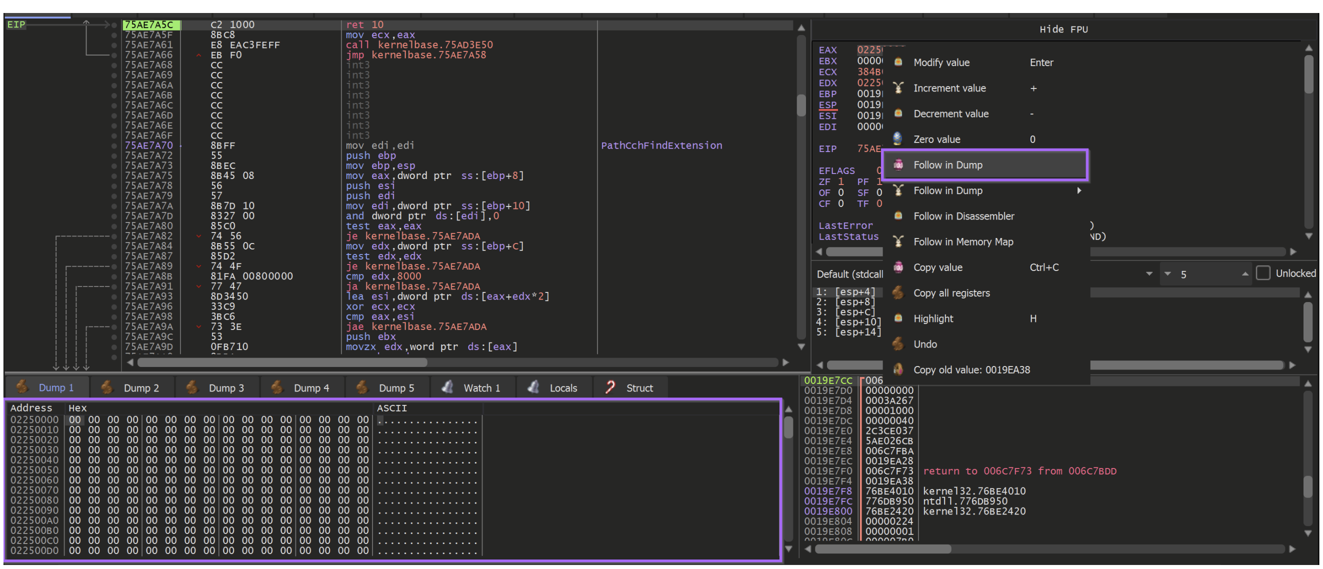
Viewing the memory buffer returned by VirtualAlloc

> There is nothing particularly special about EAX, it is just the standard register used for returning the results of a function.
> To learn more about `EAX` and calling conventions - there's a great video on that from OALABS.

To monitor the buffer returned by `VirtualAlloc`, Right-Click on the returned address `02250000` address and select `Follow in Dump`.

This will cause the bottom-left window to display the newly-allocated memory.

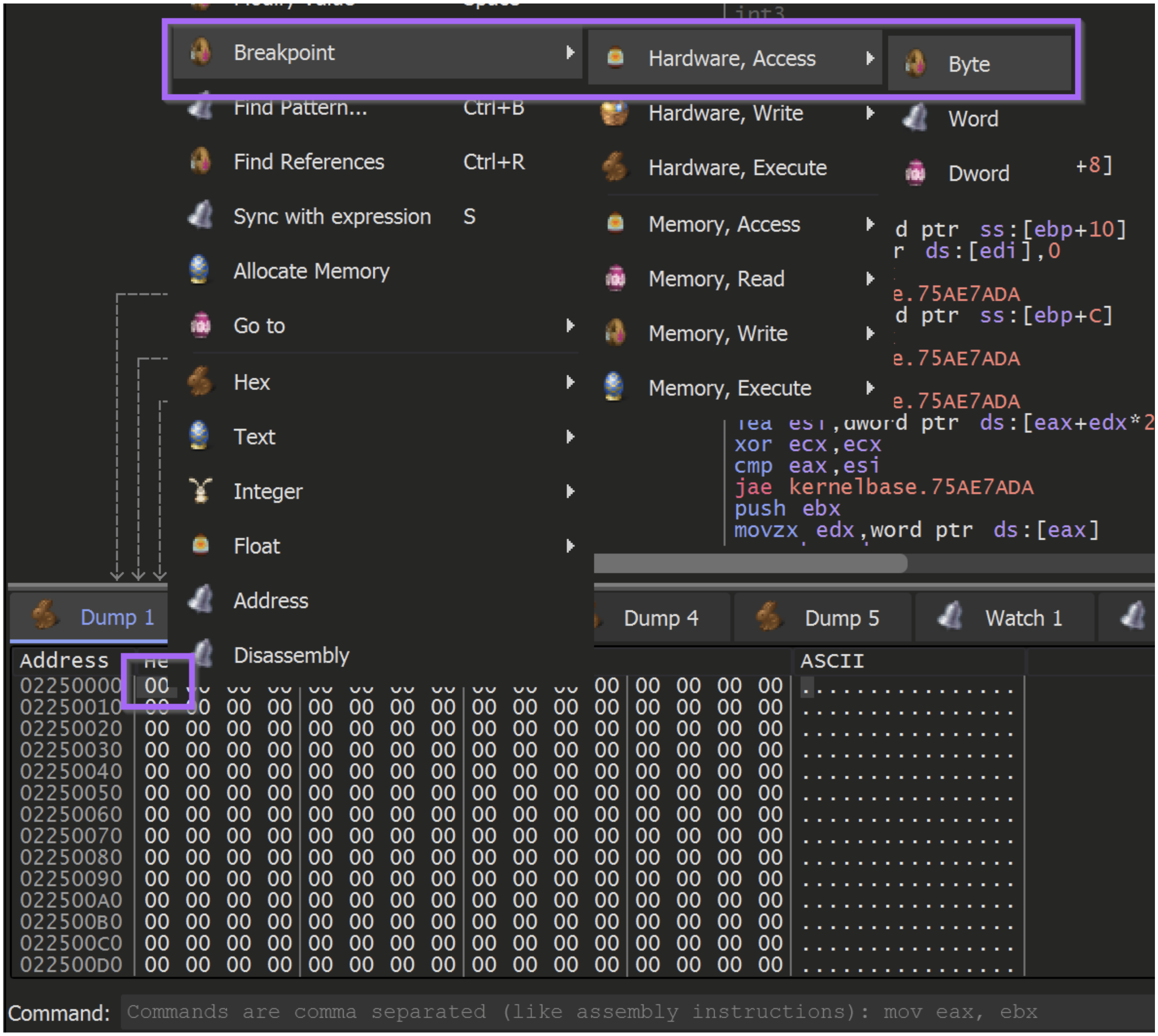
The buffer of memory currently contains all `00`'s, as nothing has used or written to the buffer yet.



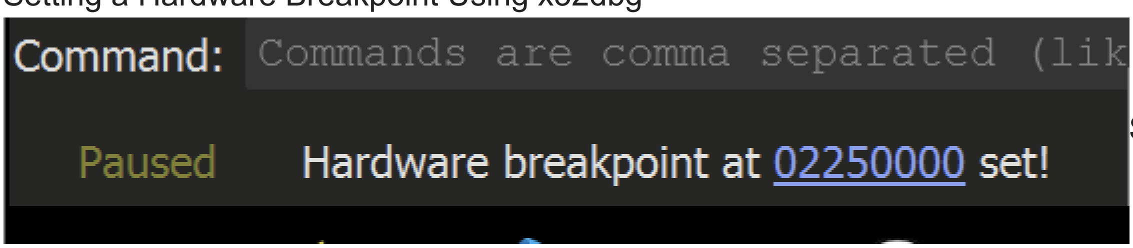
Using x32dbg (Follow In Dump) to view the contents of a memory buffer

It is important to be notified when that buffer of `00`'s is no longer a buffer of `00`'s.

To achieve this - A hardware breakpoint can be applied on the first byte of the newly allocated buffer.



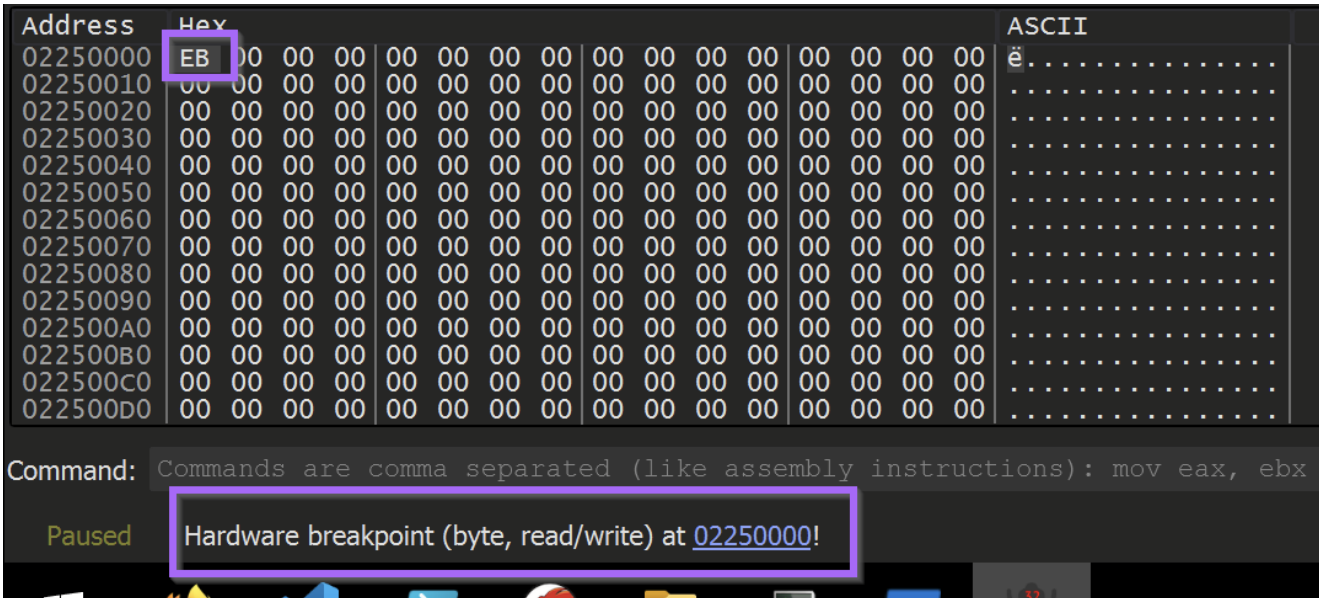
Setting a Hardware Breakpoint Using x32dbg



Successful creation of a Hardware Breakpoint

Once the hardware breakpoint is set - the malware can continue to execute using the `F9` button.

The Hardware Breakpoint will immediately be triggered.

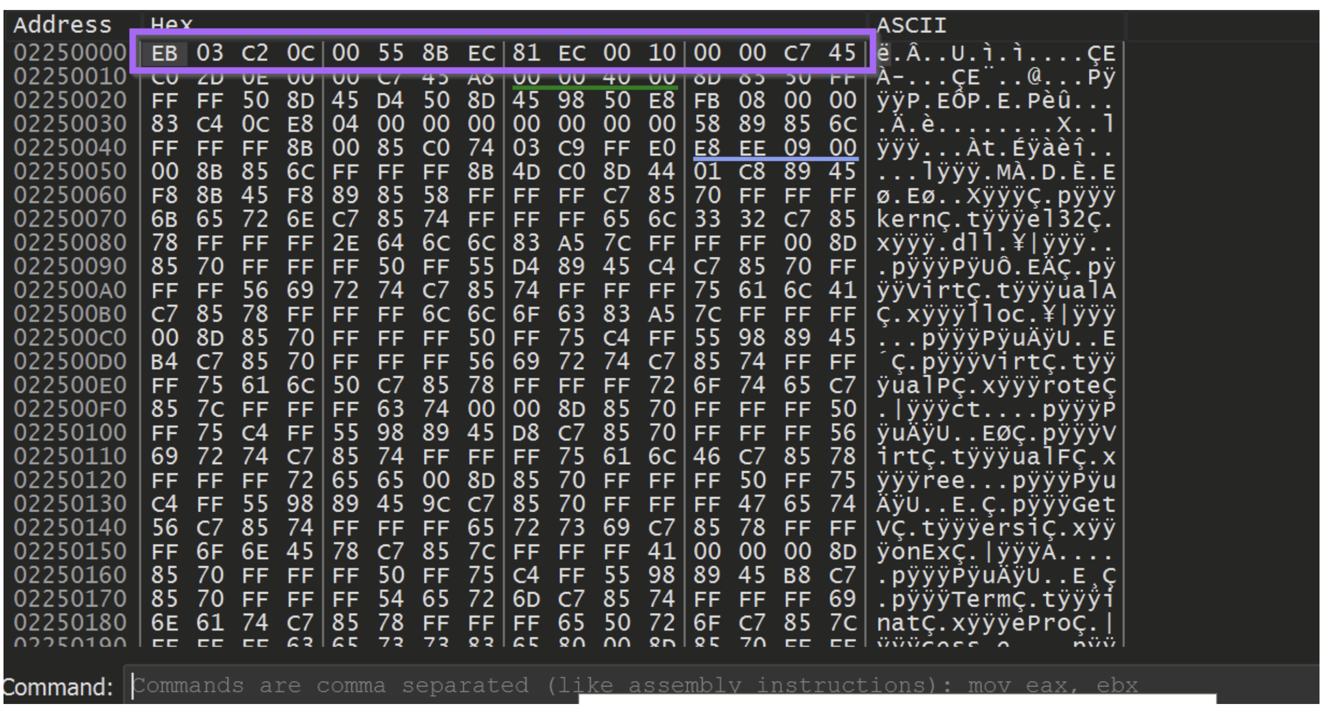


Triggering a Hardware Breakpoint using X32dbg

Once this happens, use `CTRL+F9` (Execute Until Return, aka "just finish what you're doing now, but don't do anything else") to allow the malware to continue writing to the buffer without actually executing it.

(Utilising `CTRL+F9` will cause the malware to stop at the end of the current function - preventing the execution of the rest of the malware)

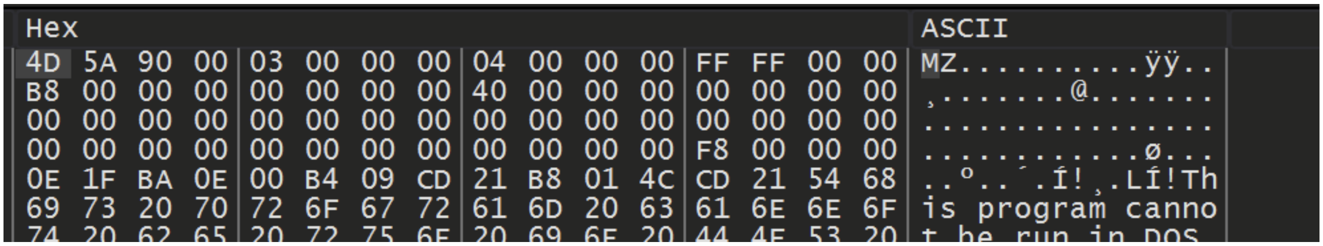
Once the current function is finished - the buffer will look something like this.



Identifying a Memory Buffer containing Shellcode

Unfortunately - the first buffer does not contain an unpacked PE file. It does contain a large buffer of shellcode which is used to unpack the next section using another `VirtualAlloc`.

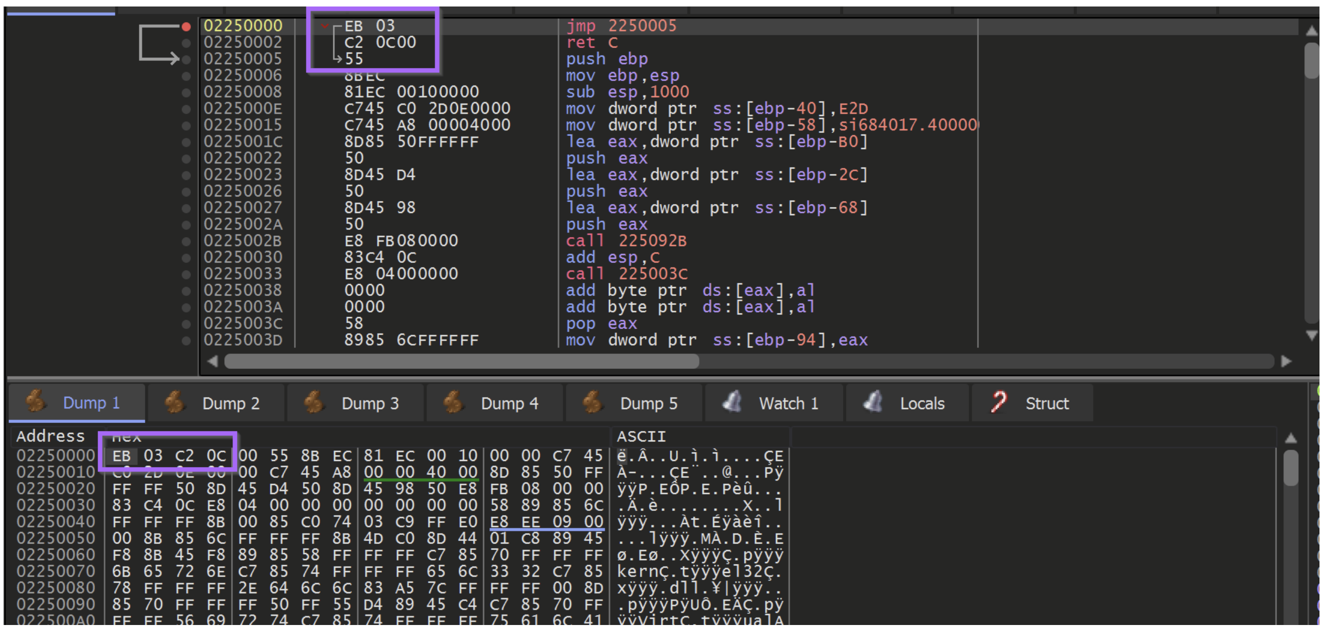
If the file was sucessfully unpacked - it would typically look something more akin to this



Identifying an unpacked PE file in a memory buffer

In this case there is only shellcode in the buffer. You can typically determine that the buffer is shellcode by the presence of the `EB` (jmp) byte. You can also confirm suspected shellcode by inspecting the instruction using `Right-Click -> Follow in Disassembler`.

If the code disassembles without errors (No glaring red sections) - it is highly likely to be shellcode.

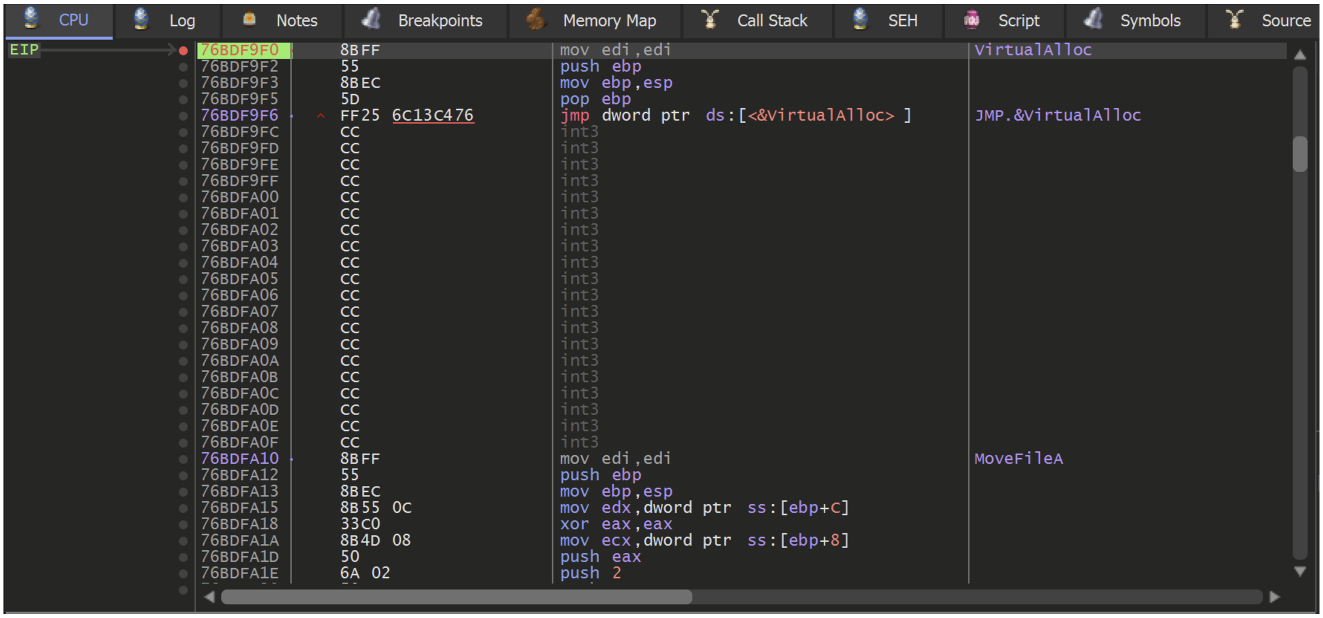


Using x32dbg to validate shellcode contained in a memory buffer
At this stage - the shellcode *could* be dumped into a file for further analysis.

However, It is often better to allow the shellcode to execute. Malicious actions taken by the shellcode will often trigger the same breakpoints intended for the "original" malware.

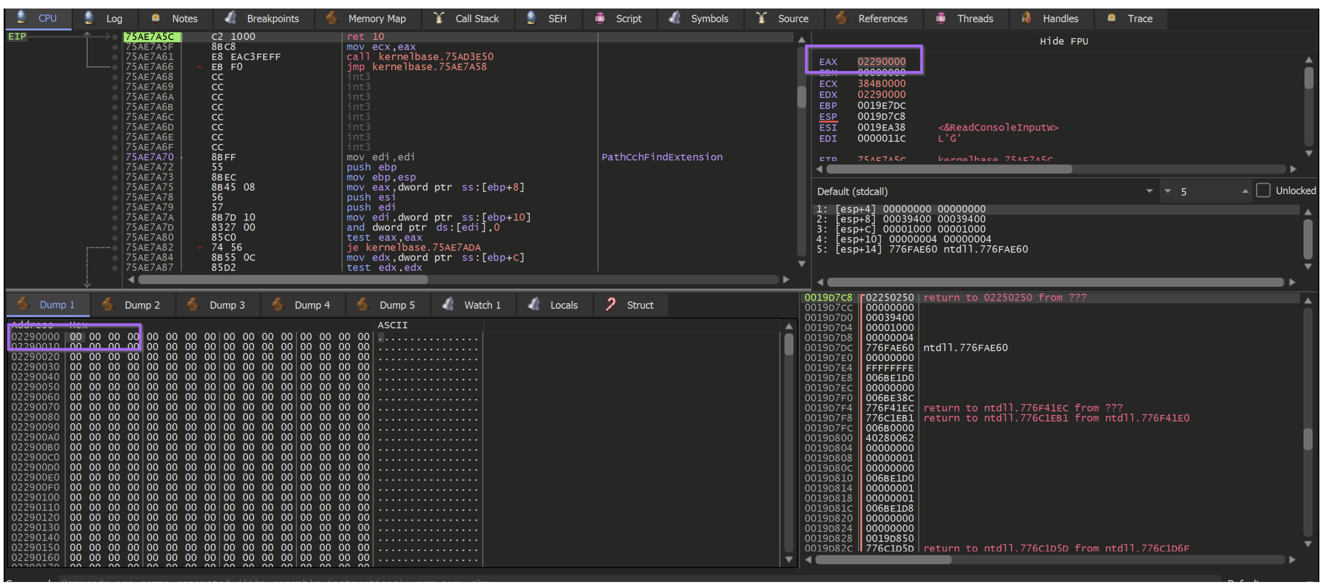
Obtaining The Unpacked Payload

Hitting `F9` (Continue) to allow the malware to execute - another breakpoint is hit on `VirtualAlloc`



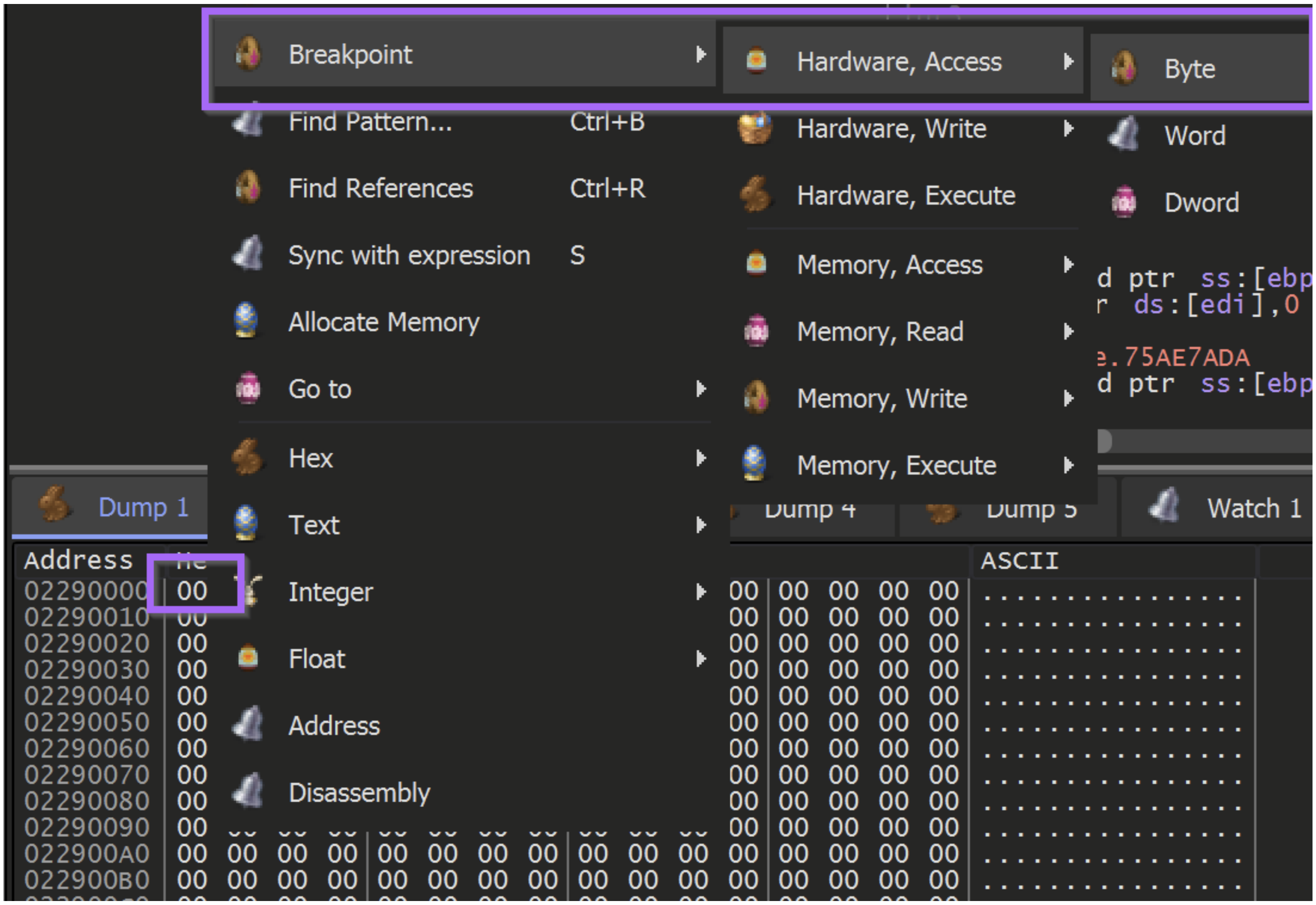
Viewing VirtualAlloc function in a debugger (x32dbg)

Using the same trick of `Execute Until Return` , `Select EAX` and `Right-Click -> Follow in Dump`, the second allocated buffer can be obtained.



Using x32dbg to locate another memory buffer returned by VirtualAlloc

Another `Hardware Breakpoint` will need to be set at the start of the buffer.



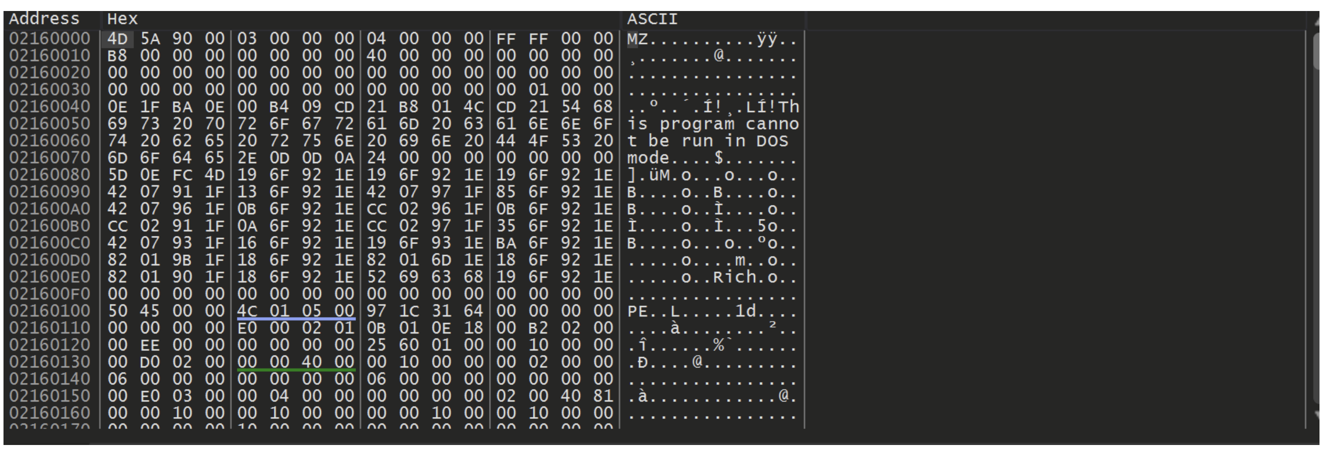
Creating another Hardware Breakpoint on the memory address

Allowing the malware to continue to execute - the hardware breakpoint is hit. This time containing a promising `M`. (First half on an MZ header)

(Side note that my debugger suddenly crashed here and had to be restarted - hence the slight change of address in future screenshots)

Memory buffer - potentially containing an unpacked pe-file payload

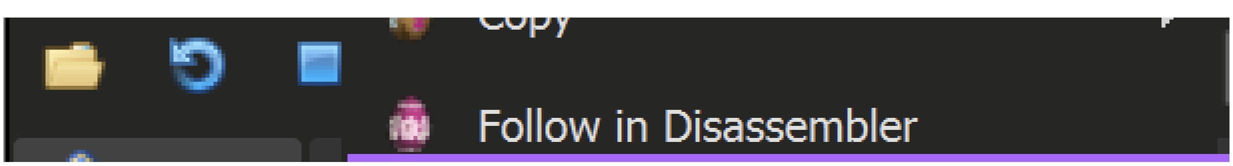
Allowing the malware to continue to execute - A complete MZ/PE file can be found. At this point, the unpacked file has been successfully loaded into memory.

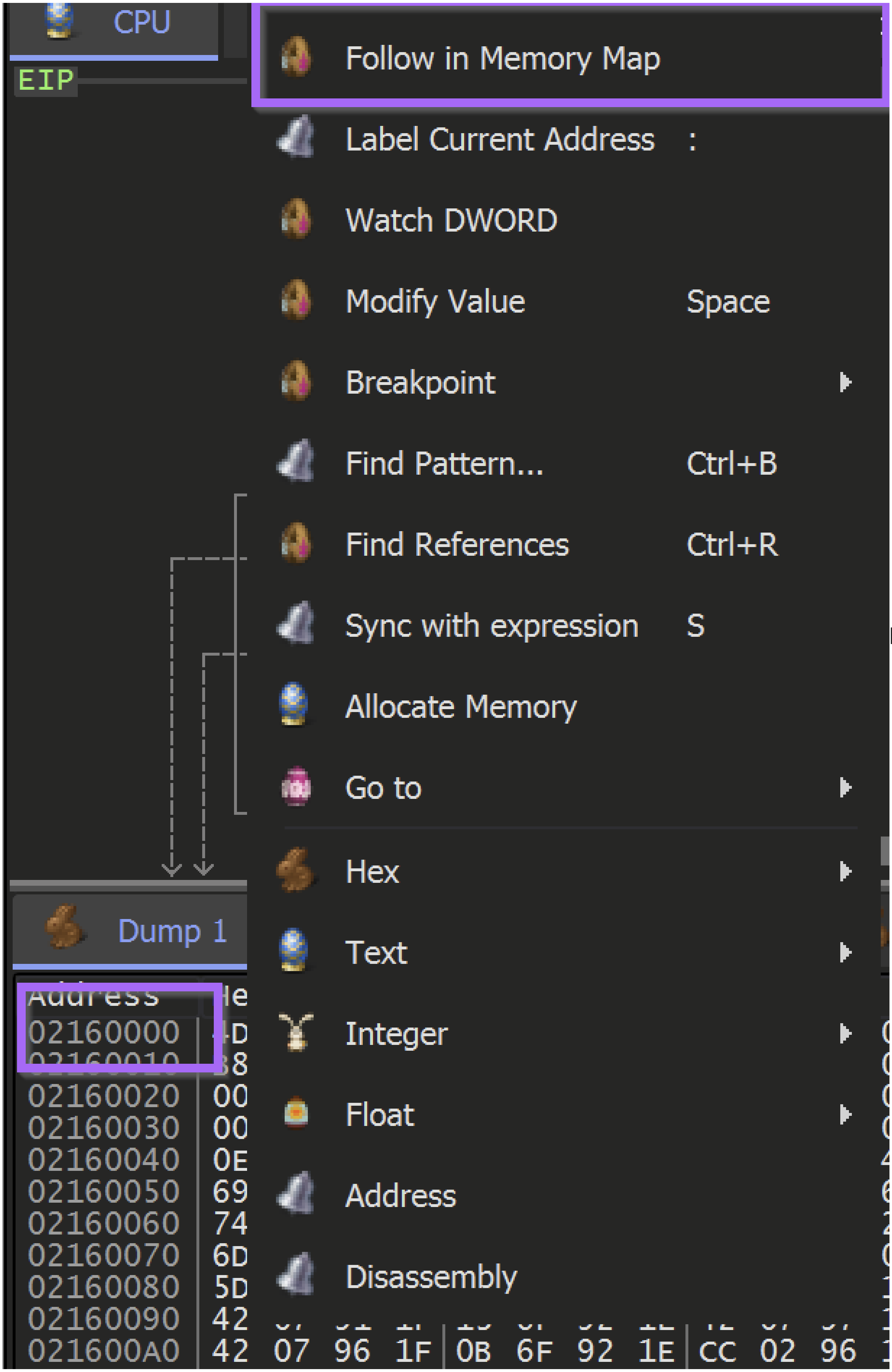


A complete Pe-file written to the memory buffer

Saving the Unpacked File

To save the unpacked file - `Right-Click` on the start address and select `Follow in Memory Map`

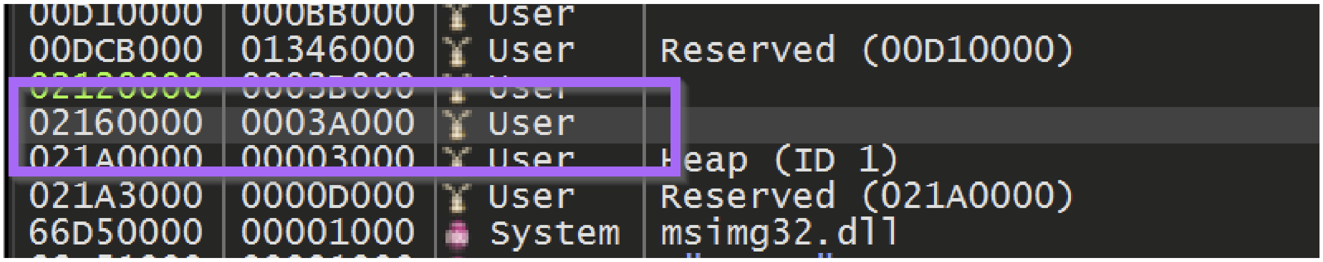



CPU
EIP
Follow in Memory Map
Label Current Address :
Watch DWORD
Modify Value Space
Breakpoint
Find Pattern... Ctrl+B
Find References Ctrl+R
Sync with expression S
Allocate Memory
Go to
Hex
Text
Integer
Float
Address
Disassembly
Dump 1
02160000
02160020 00
02160030 00
02160040 0E
02160050 69
02160060 74
02160070 6D
02160080 5D
02160090 42
021600A0 42 07 96 1F 0B 6F 92 1E CC 02 96

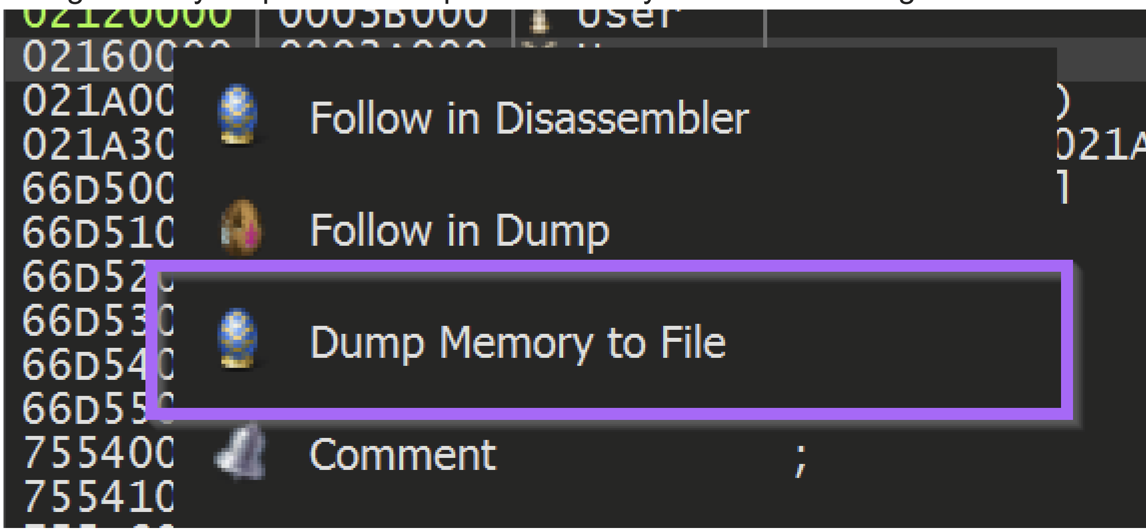
How

to save a memory buffer using x32dbg

This will reveal the location where the buffer was allocated. The entire memory buffer can then be saved by using `Right-Click` and `Dump Memory to File`

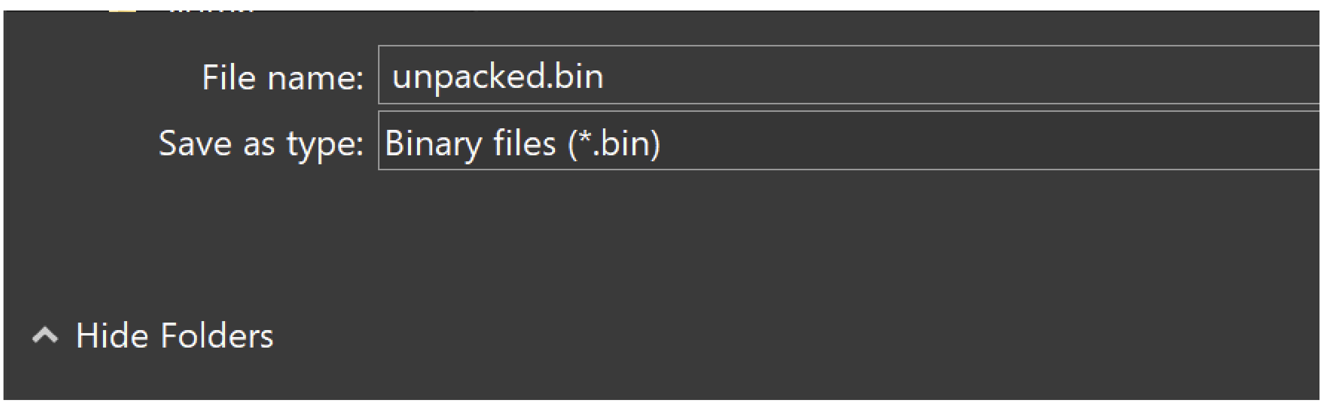


Using Memory Map to save a specific memory section in x32dbg



The final button used to dump the memory to a file using x32dbg

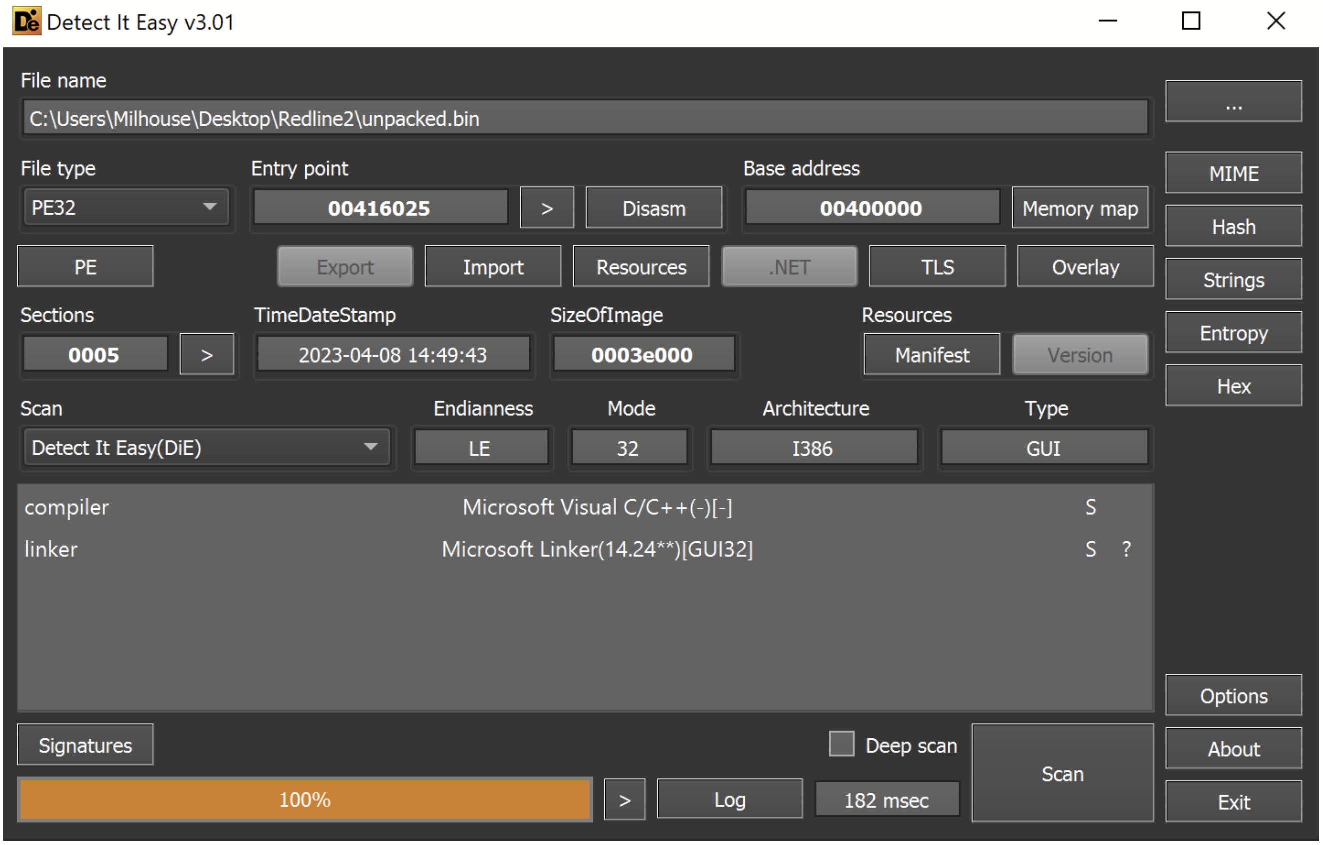
The file can now be saved as `unpacked.bin` (or any other file name of choosing)



Specifying a name for the unpacked file

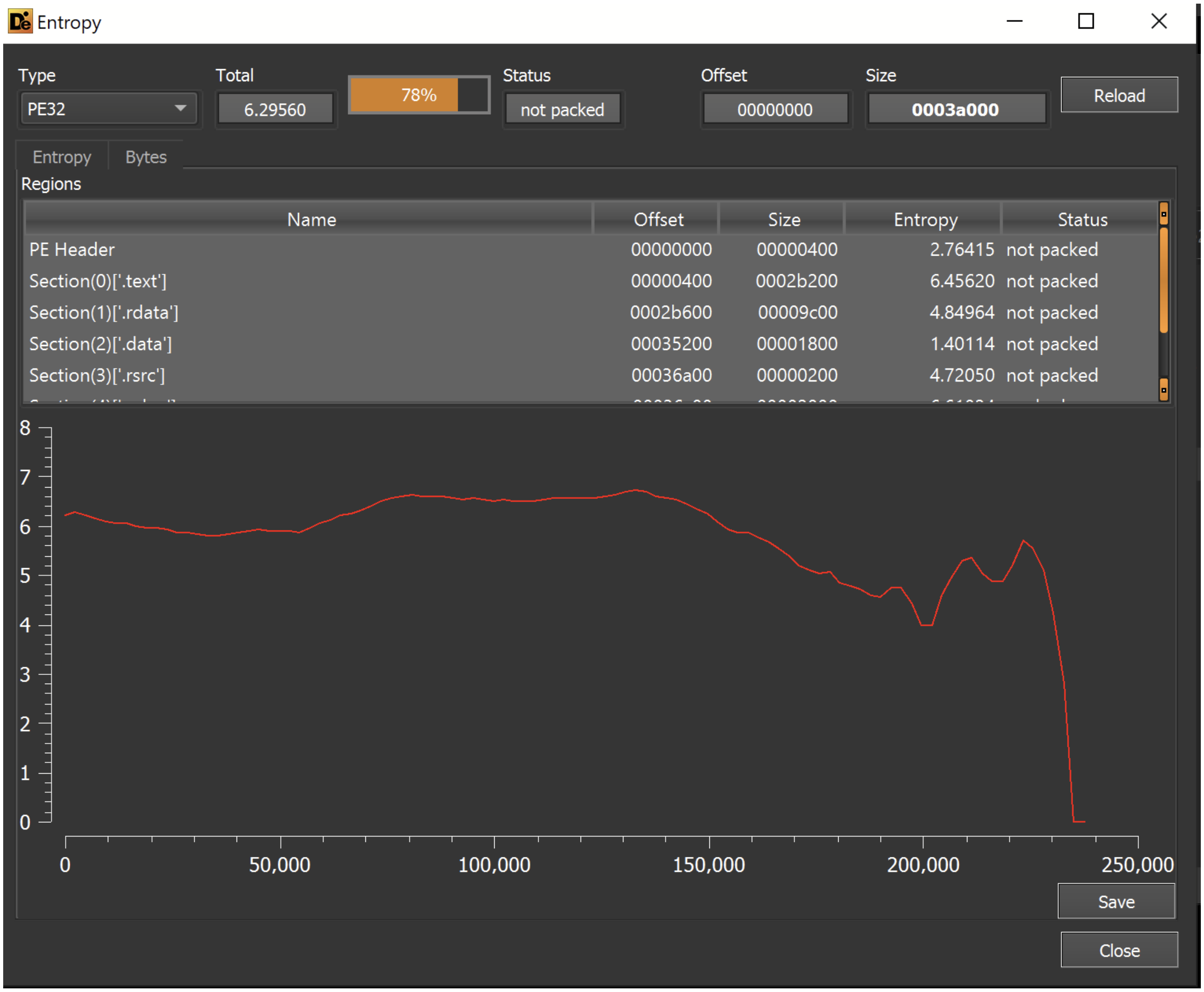
Initial Analysis - Unpacked Payload

The file is a 32-bit executable with no (recognized) packers or obfuscation.



Initial analysis of suspected unpacked payload using detect-it-easy

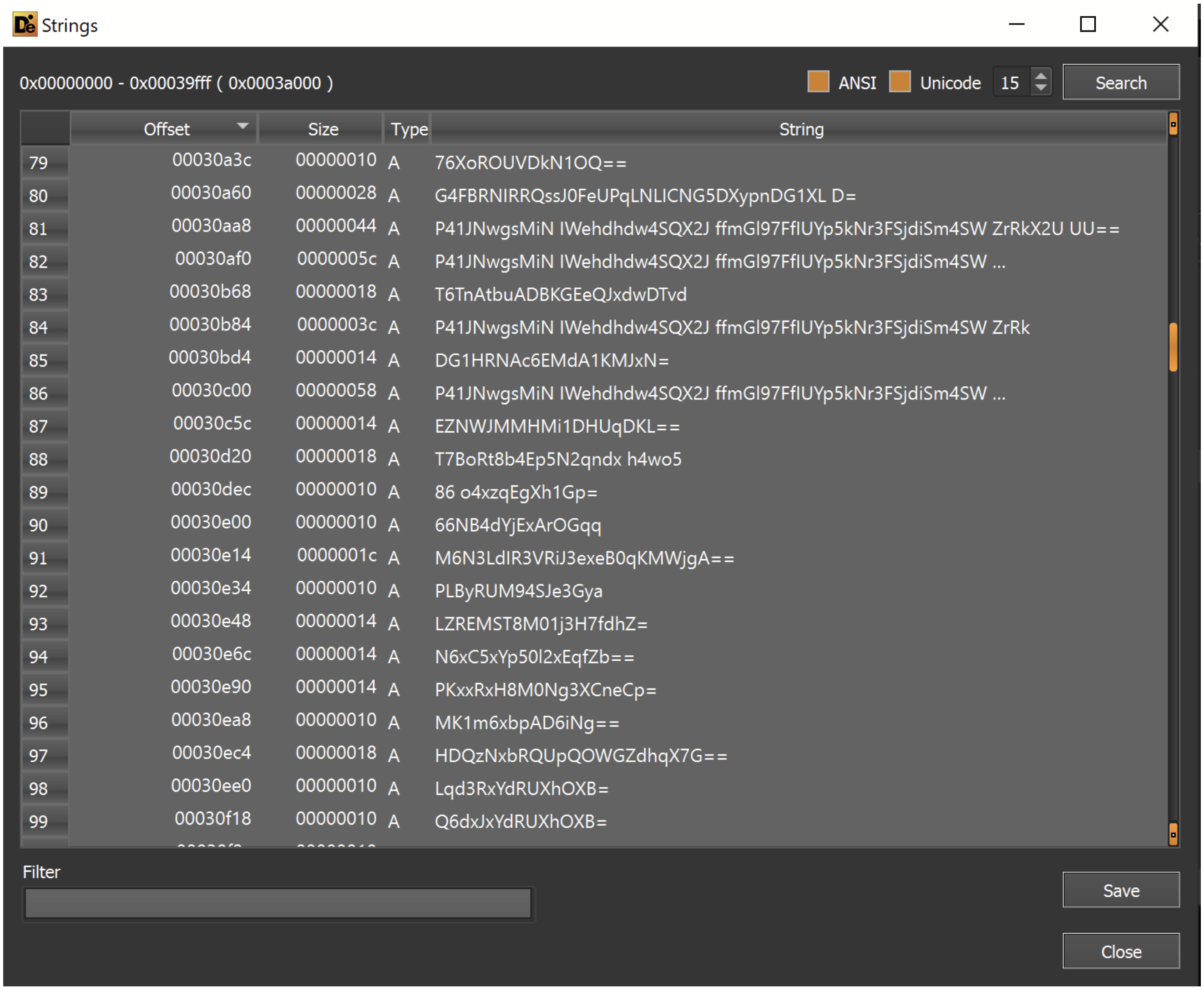
The entropy graph does not contain any areas of significantly high or flat entropy - suggesting that the file is not packed and does not contain any additional payloads.



Additional Entropy Analysis - Suggesting no hidden payloads - No significant areas of entropy
Since this was potentially a final payload - I checked the strings for any unobfuscated information.

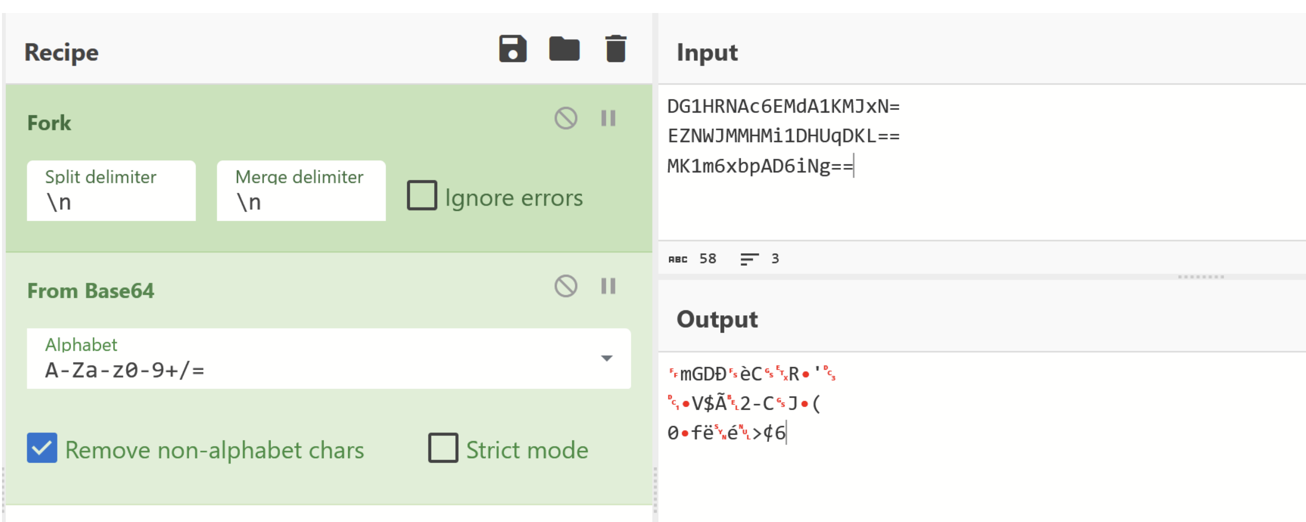
This revealed some base64 encoded data - but I wasn't able to successfully decode it.

The base64 encoding has likely been combined with additional obfuscation.



Base64 Encoded Strings contained within the malware file

Failing to decode the "base64"



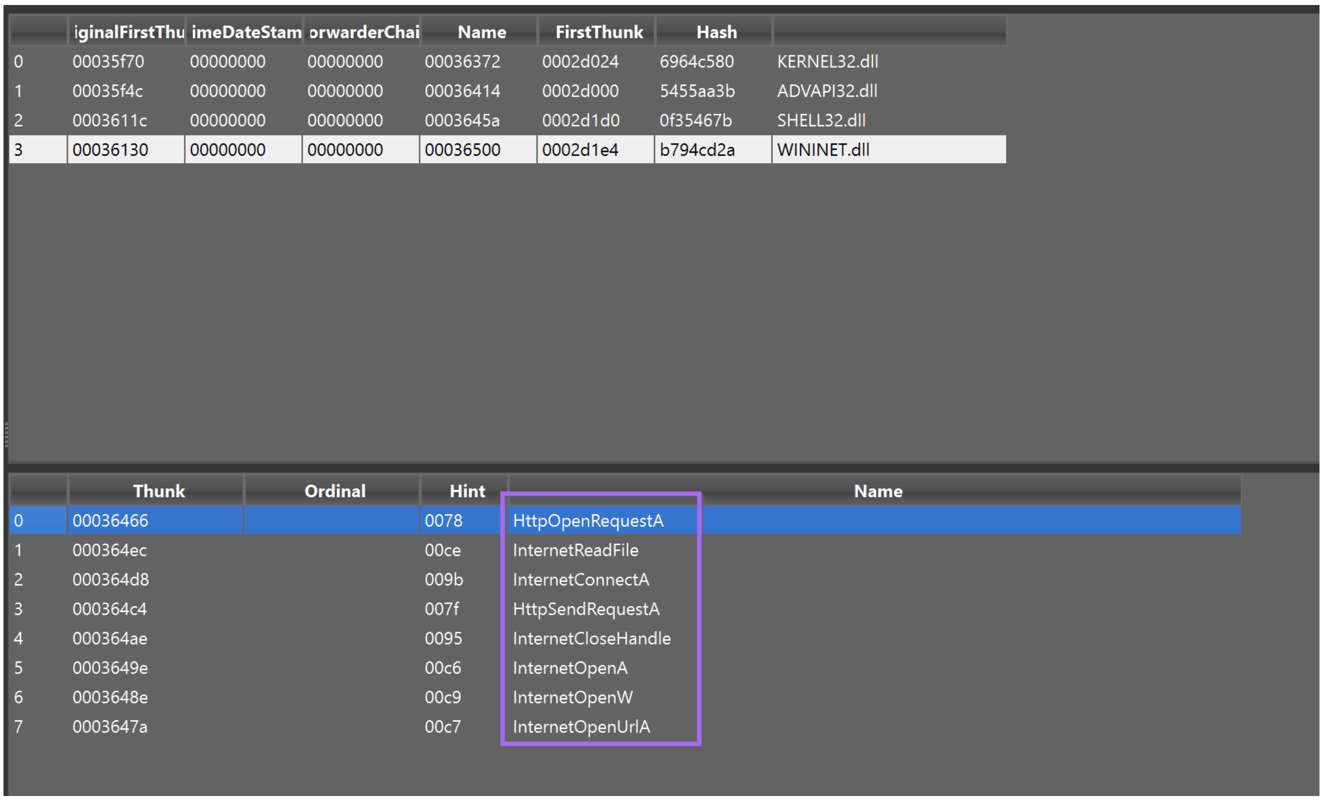
Cyberchef - Failure to decode the base64 strings - signs of additional obfuscation

Import Analysis

Imported functions are an additional valuable source of information. Especially for suspected unpacked files.

The imported functions referenced capability that suggested the file can download data and make internet connections.

Since these functions need C2 information in order to work, this is a good sign that the C2 config may be contained within this file.



	iginalFirstThu	imeDateStam	orwarderChai	Name	FirstThunk	Hash	
0	00035f70	00000000	00000000	00036372	0002d024	6964c580	KERNEL32.dll
1	00035f4c	00000000	00000000	00036414	0002d000	5455aa3b	ADVAPI32.dll
2	0003611c	00000000	00000000	0003645a	0002d1d0	0f35467b	SHELL32.dll
3	00036130	00000000	00000000	00036500	0002d1e4	b794cd2a	WININET.dll

	Thunk	Ordinal	Hint	Name
0	00036466		0078	HttpOpenRequestA
1	000364ec		00ce	InternetReadFile
2	000364d8		009b	InternetConnectA
3	000364c4		007f	HttpSendRequestA
4	000364ae		0095	InternetCloseHandle
5	0003649e		00c6	InternetOpenA
6	0003648e		00c9	InternetOpenW
7	0003647a		00c7	InternetOpenUrlA

Malware Import Analysis Using Detect-it-easy

Ghidra Analysis

At this point I decided to analyze the file further using `Ghidra`. My plan was to utilise `Ghidra` to gather more information on the suspicious imports related to c2 connections `InternetReadFile`, `InternetConnectA`, `HttpSendRequestA` etc.

In addition to this - I wanted to investigate the suspicious "base64" strings identified with detect-it-easy.

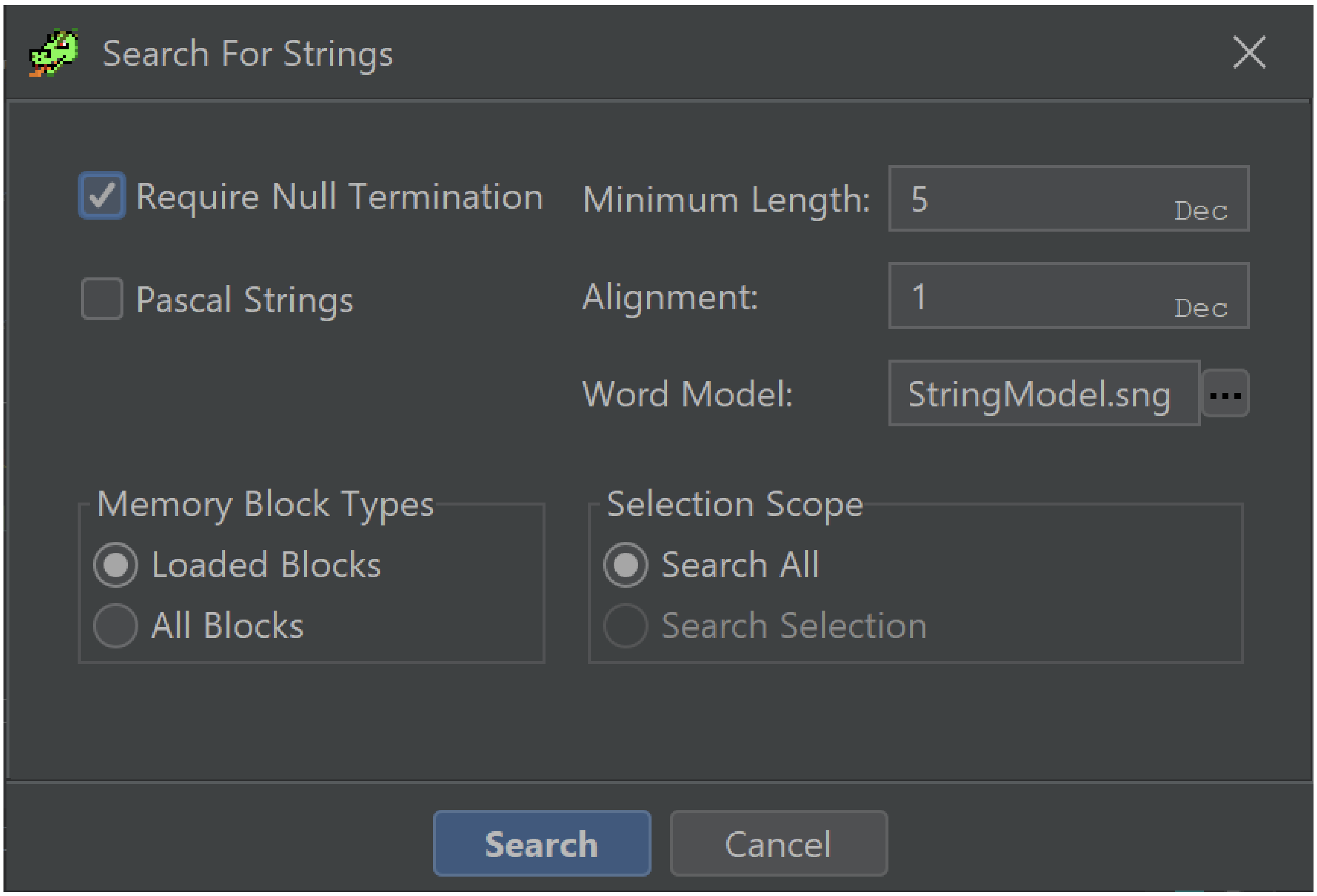
To investigate both - I intended to utilise cross references or `X-refs` to observe where the strings and imports were used throughout the code. From here I hoped to find arguments passed to the internet functions (hopefully containing a C2), or to find the logic behind the function that accesses the base64 encoded strings.

To Summarise - My plan was to Utilise Ghidra to...

- Investigate the suspicious strings - which function are they passed to? what does that function do with them? Can I trace the input and output of that function?
- Investigate Suspicious Imports - Check where the imports were used, and what arguments were being passed. Can I set a breakpoint and view the decrypted C2's?

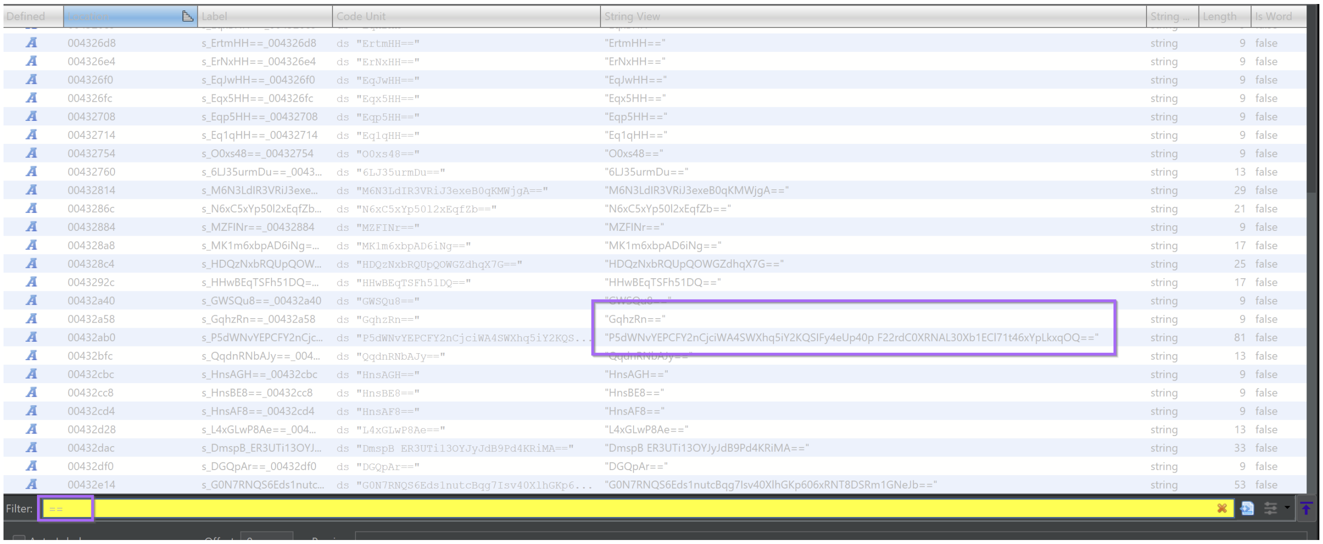
String Searching with Ghidra

I took the first approach first, using Ghidra to search for strings within the file.



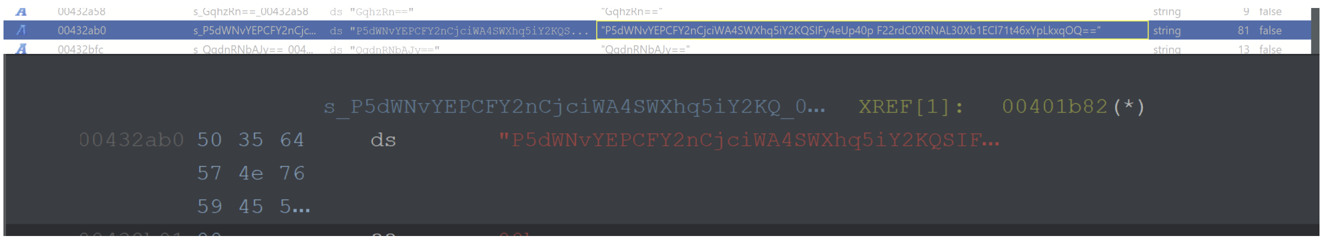
Searching for Strings Using Ghidra

By filtering on `==`, I was quickly able to narrow the results down to the previously identified base64 strings. This was not all relevant strings but was a solid starting point.



Locating base64 strings using Ghidra

I double clicked on one of the larger strings, taking me to it's reference within the file.



From here I could hit `CTRL+SHIFT+F` to find references to this string. Alternatively you could `Right Click -> References -> Show References to Address`

Using Ghidra to locate Cross-references from strings

Clicking on the one available reference - reveals an undefined function acting upon the string.

Encountering an Undefined Function in Ghidra

By clicking on the first address of the function and hitting `F`, we can define a function at the current address.

Defining a Function in Ghidra

After defining a function - the decompiler output now looks much cleaner.

Viewing a new function in Ghidra - an obfuscated string can be seen

From here we can enter the function at `FUN_00414550` and investigate.

The function contains a bunch of c++ looking junk which was difficult to analyse - so I decided to take a slightly different approach.

```

int ** __thiscall FUN_00414550(void *this,void *param_1,int *param_2)

{
  int *piVar1;
  code *pcVar2;
  void *pvVar3;
  void *pvVar4;
  void *pvVar5;
  int **ppiVar6;
  uint uVar7;
  uint uVar8;

  piVar1 = *(int **)((int)this + 0x14);
  if (param_2 <= piVar1) {
    pvVar4 = this;
    if ((int *)0xf < piVar1) {
                    /* WARNING: Load size is inaccurate */
      pvVar4 = *this;
    }
    *(int **)((int)this + 0x10) = param_2;
    FID_conflict:_memcpy(pvVar4,param_1,(size_t)param_2);
    *(undefined *)((int)param_2 + (int)pvVar4) = 0;
    return (int **)this;
  }
  if (param_2 < (int *)0x80000000) {
```
Viewing a suspicious function using Ghidra

I checked the number of cross references on the `FUN_00414550` function. A high number of cross references would indicate that the function is responsible for decoding more than just this encoded string.

If the same function is used for all string related decryption, then perhaps a debugger and a breakpoint is the better approach.

At minimum - a debugger will at least confirm the theory that this function is related to string decryption.

String Decryption Via X32dbg

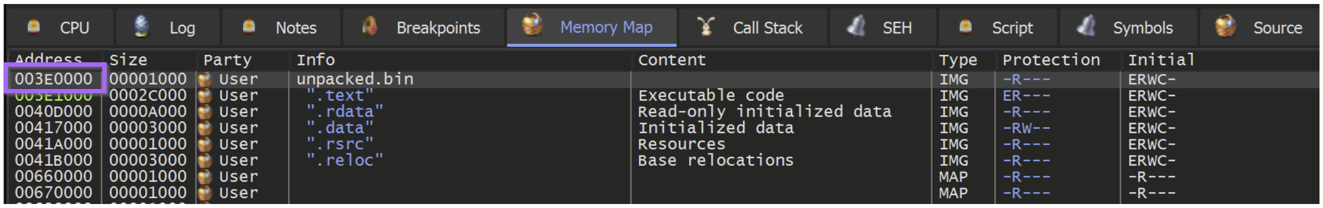
I decided to investigate the string decryption using X32dbg.

To do this - I would need to set a breakpoint on the function that I suspected was responsible for string decryption.

Attempting to copy-and-paste the address directly from Ghidra will likely result in an error as the addresses may not align.

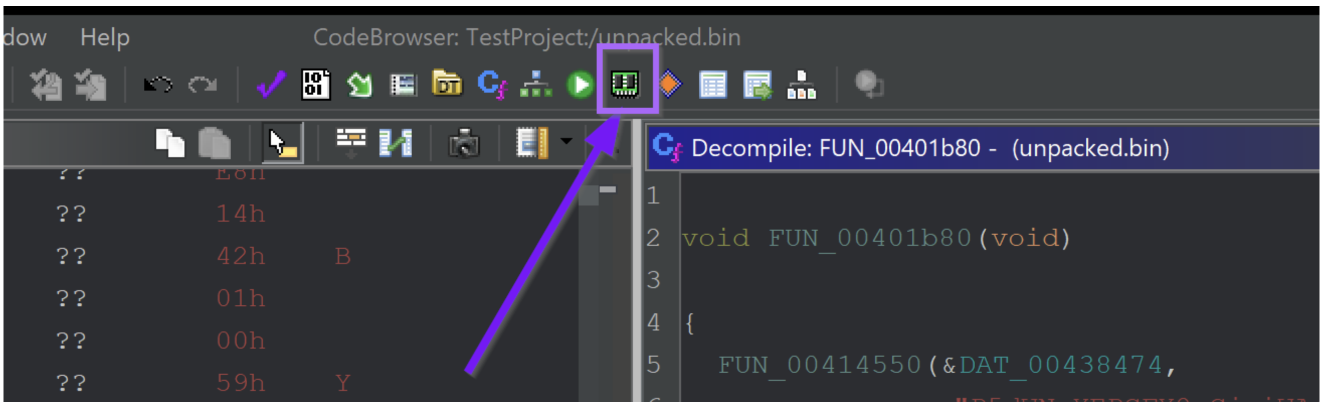
Syncing Addresses with Ghidra and X32dbg

To Sync the Addresses between Ghidra and X32dbg. We need to find the base of our current file. This can be found in the memory map and in this case is `003e0000`. Although it may be different for you.



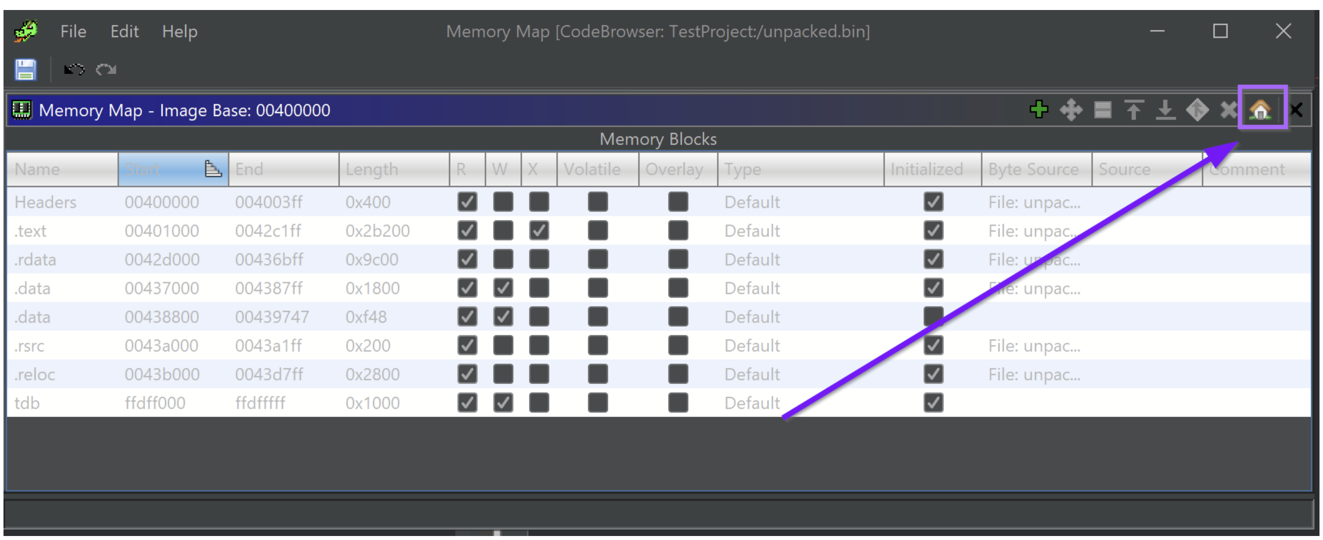
How to identify a base address in a debugger (x32dbg)

From here we can select the memory map within Ghidra.



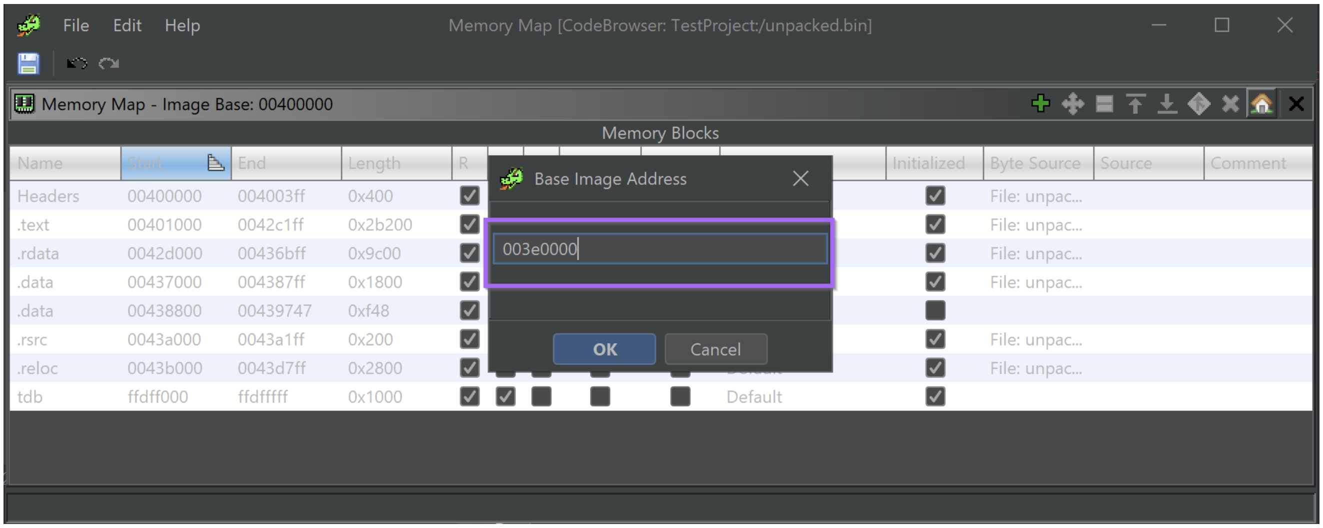
How to use Ghidra to Sync a Memory Address

Then select the `Home` button



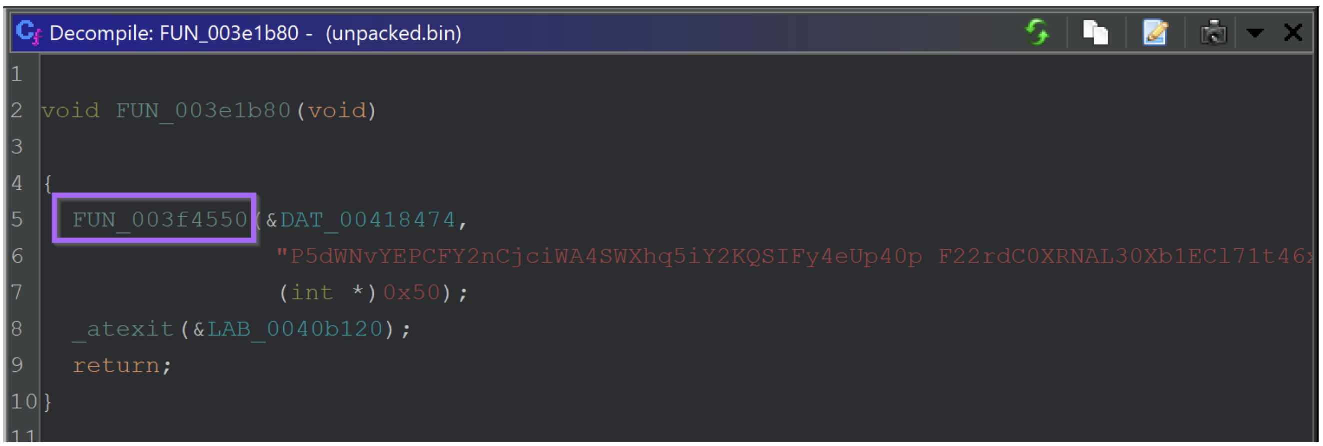
Using Ghidra to Sync memory address with x32dbg

and set the base address according to what was obtained with x32dbg.



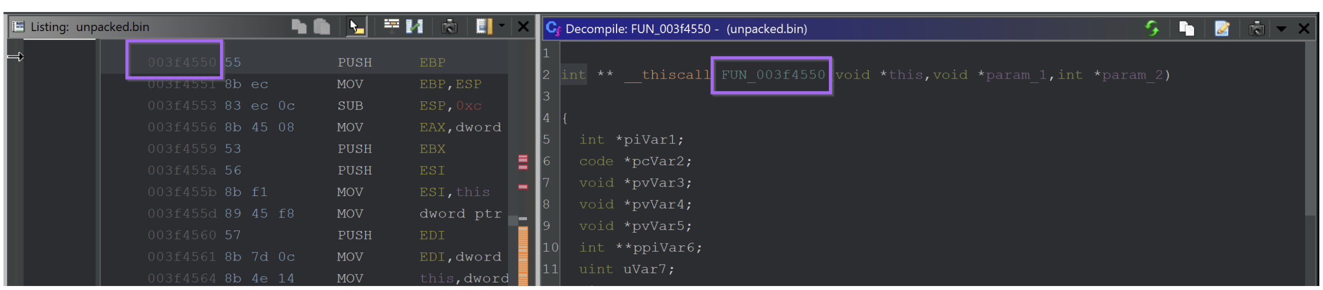
Using Ghidra to sync a memory address with x32dbg

From here, the address of the suspected-string-decryption function will be updated accordingly and be in-sync with x32dbg.

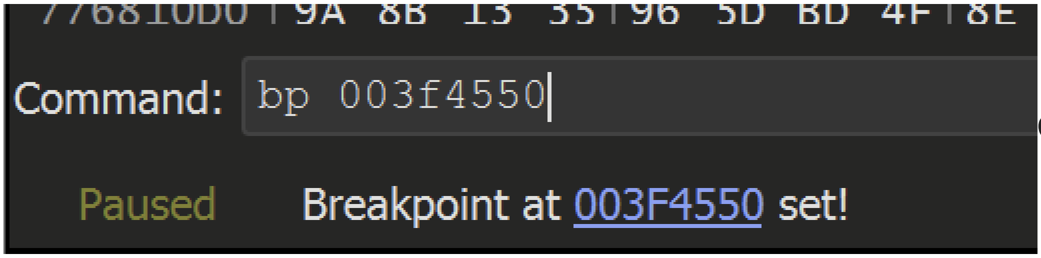


String Decryption Function in Ghidra with Updated Memory Address

The new function address is `003f4550` . This value can be used to create a breakpoint inside of x32dbg.

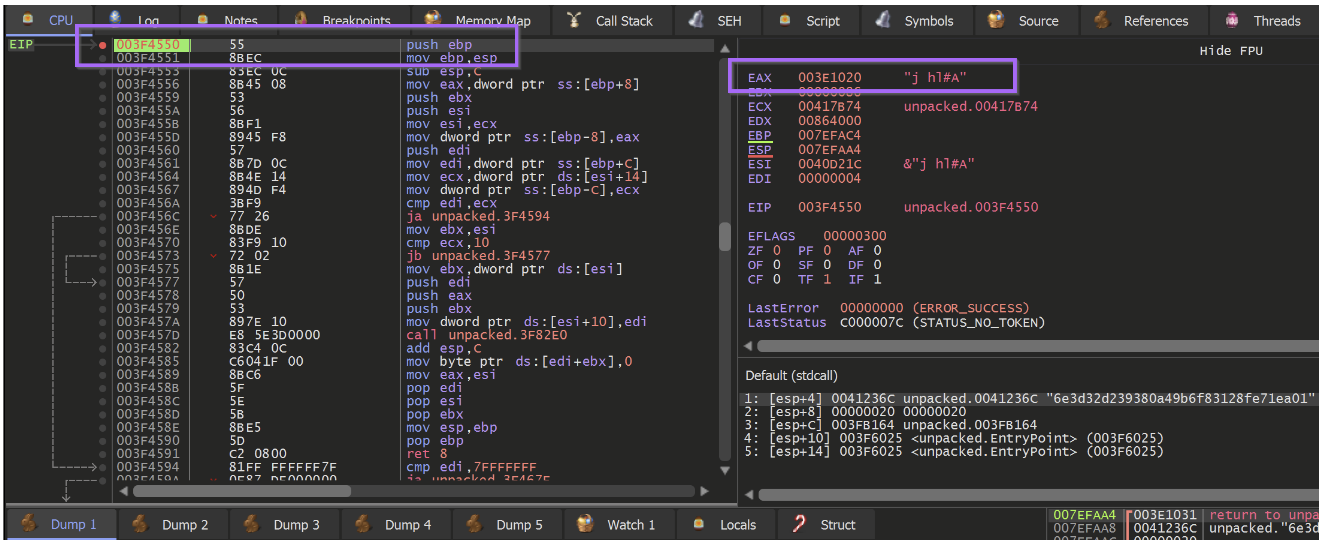


Updated Memory Address in Ghidra



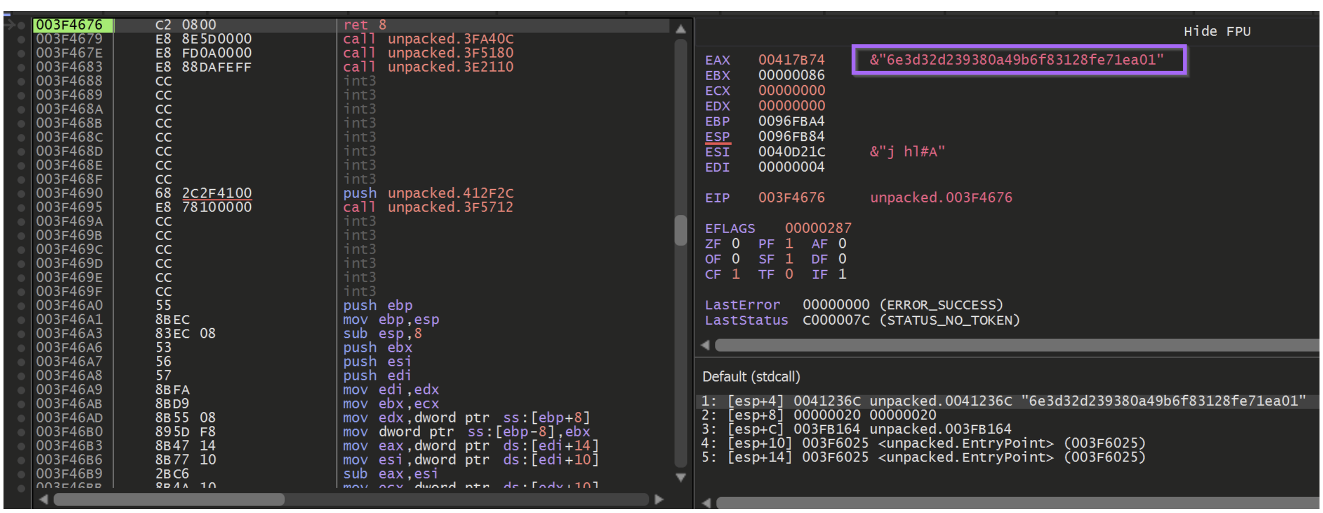
Command for creating a breakpoint on a known suspicious function

The breakpoint is then hit with an argument of `j hl#A`



Beginning of a suspicious function in x32dbg

Allowing the malware to `Execute Until Return` will retrieve the result of the function. In this case it was a large hex string that was pretty uninteresting.



End of a suspicious function - viewing the returned value - possible decoded string

However, Clicking `F9` or `Continue` will cause the Decryption code to be hit again.

Sadly, this again revealed some largely uninteresting strings

I eventually realised that this function was not used to decode the final strings. But was rather to obtain copies of the same base64 obfuscated strings that were previously found.

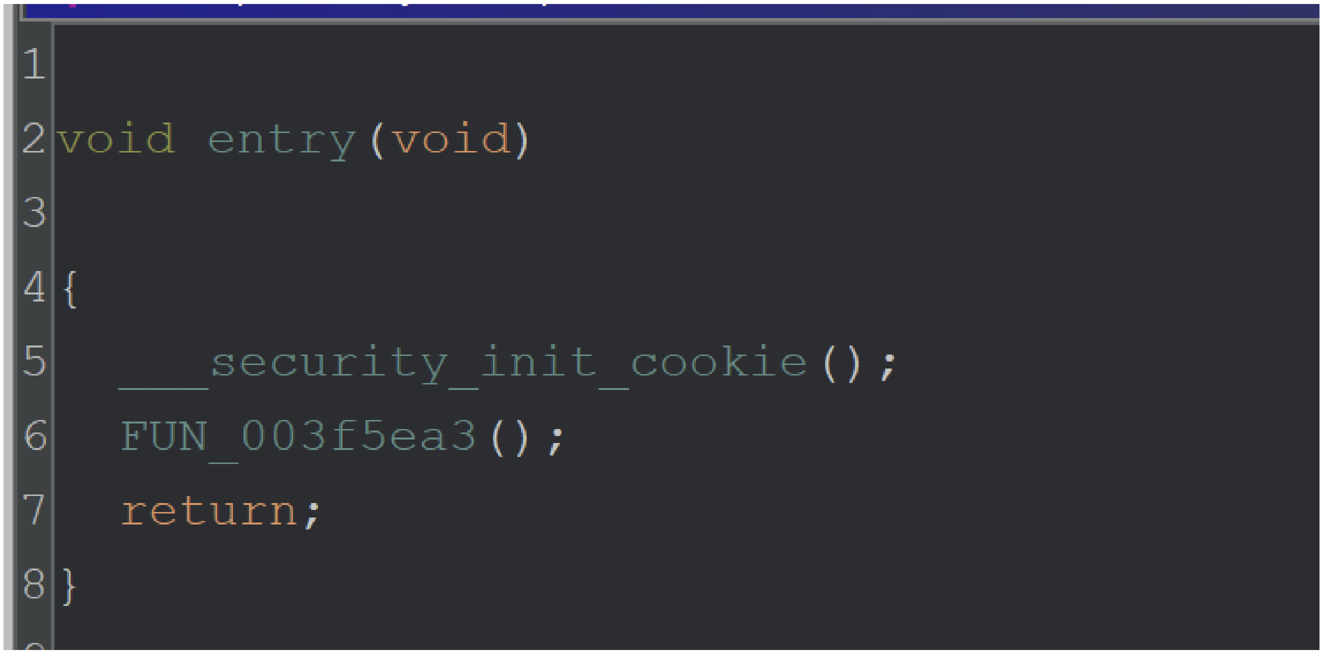
At this point I experimented with the Suspicious imports, but could not reliably trace them back to a function that would obtain the decrypted c2's .

However - I did get lucky and was able to locate an interesting function towards the main malware function of the code.

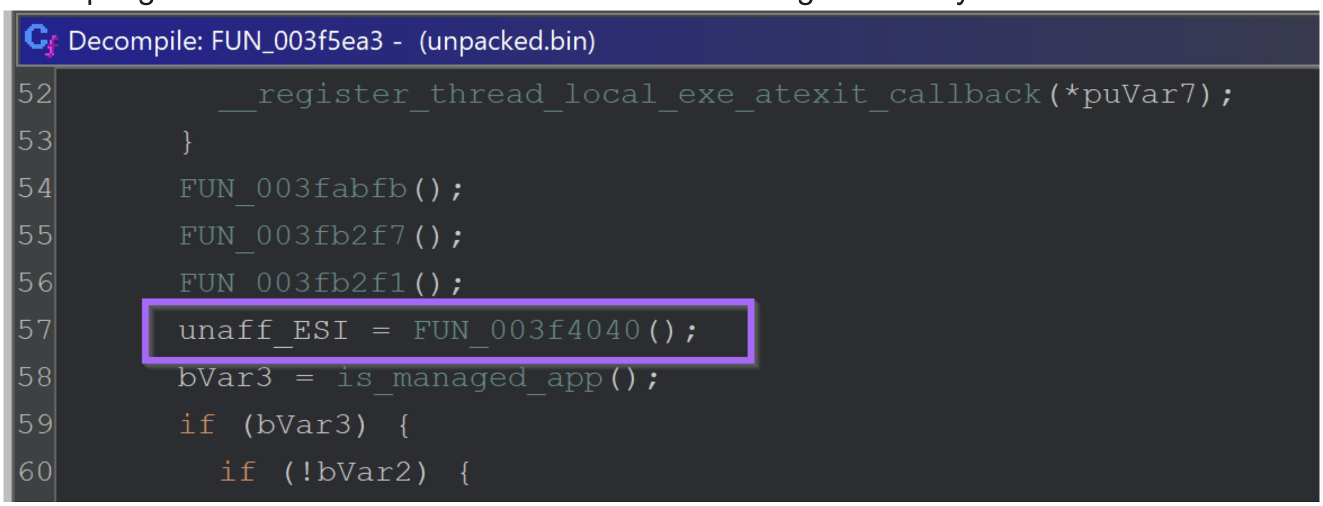
This function was located at `003d29b0`.

Locating Main

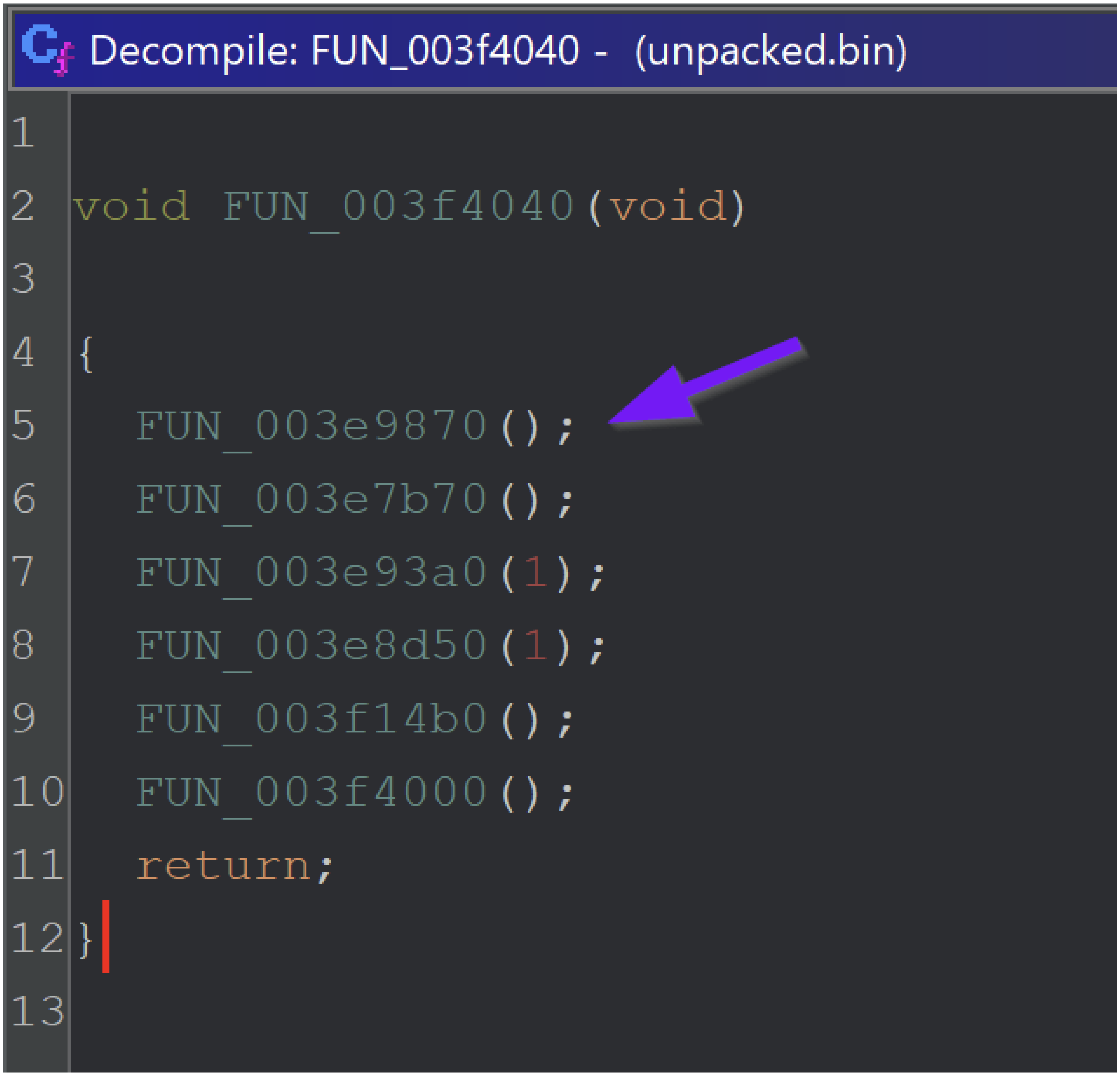
I was able to locate main by browsing to the EntryPoint.



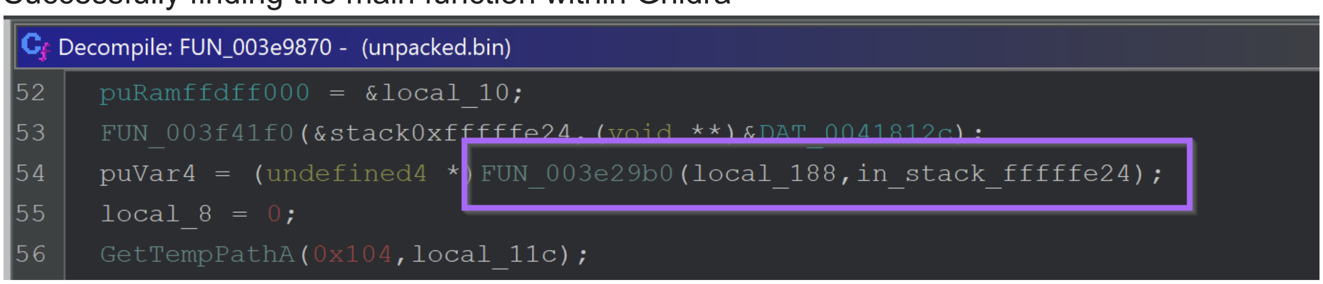
Attempting to locate the main function in Ghidra - Starting from Entry Point



Attempting to locate the main function using Ghidra

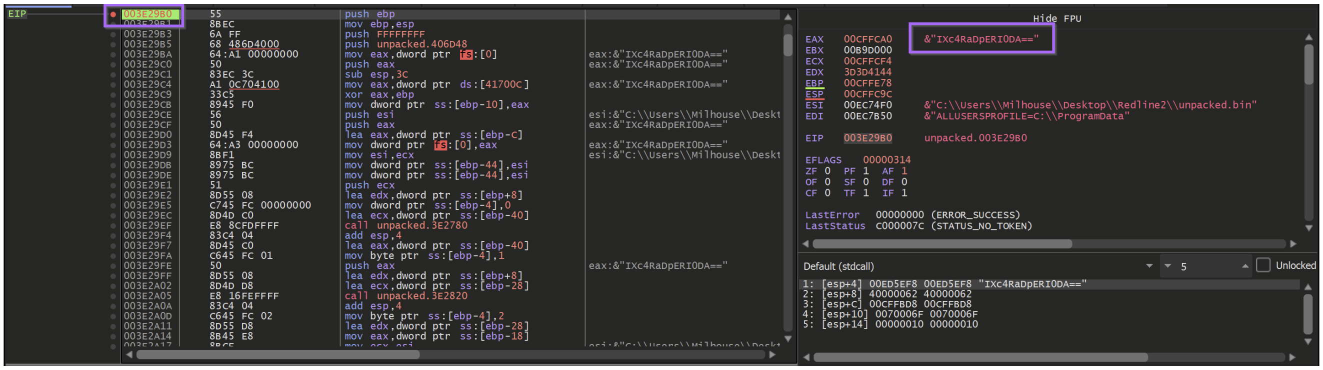


Successfully finding the main function within Ghidra



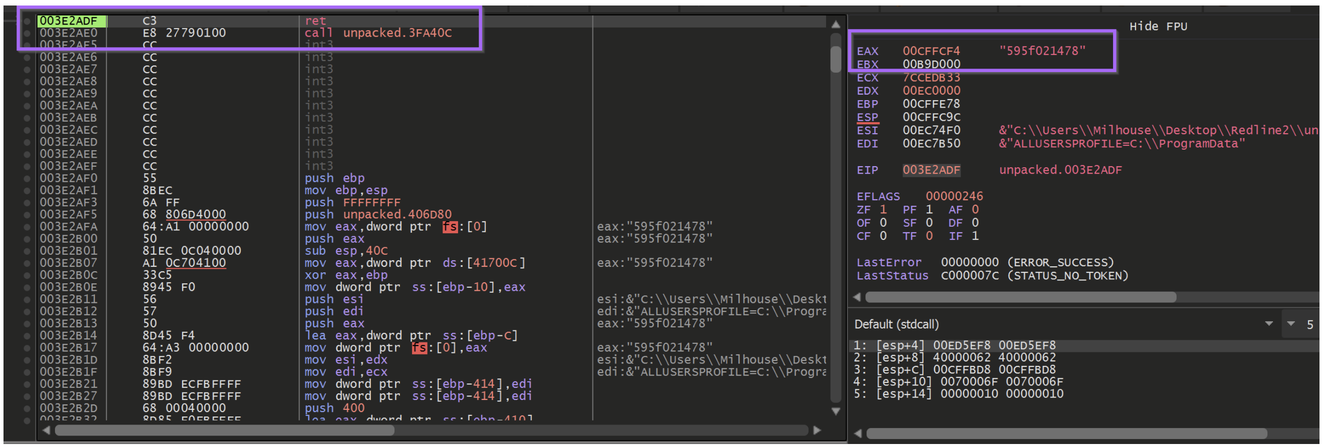
Identifying a possible string decryption function in Ghidra

When this function is executed - a base64 encoded value is passed as an argument.



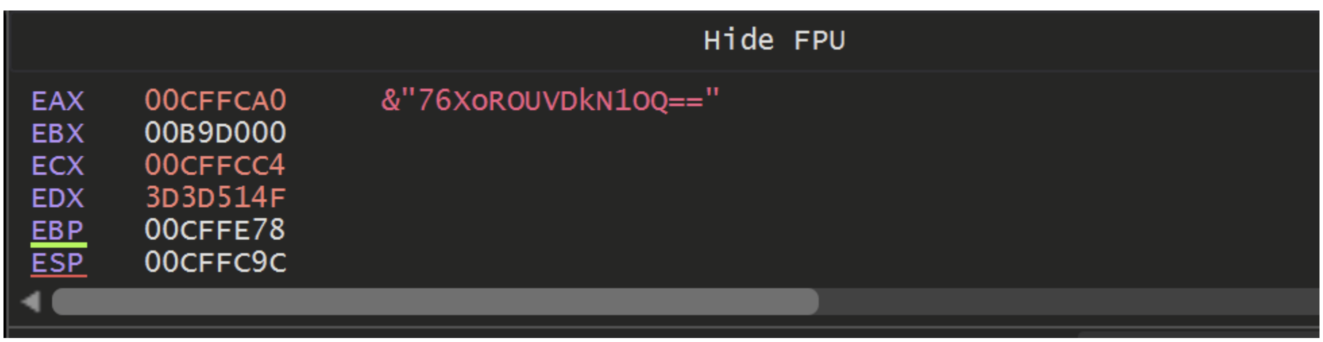
Base64 Function Arguments viewed in a debugger.

Executing until the end of the function - A value is obtained which the malware used to create a folder in the users temp directory.

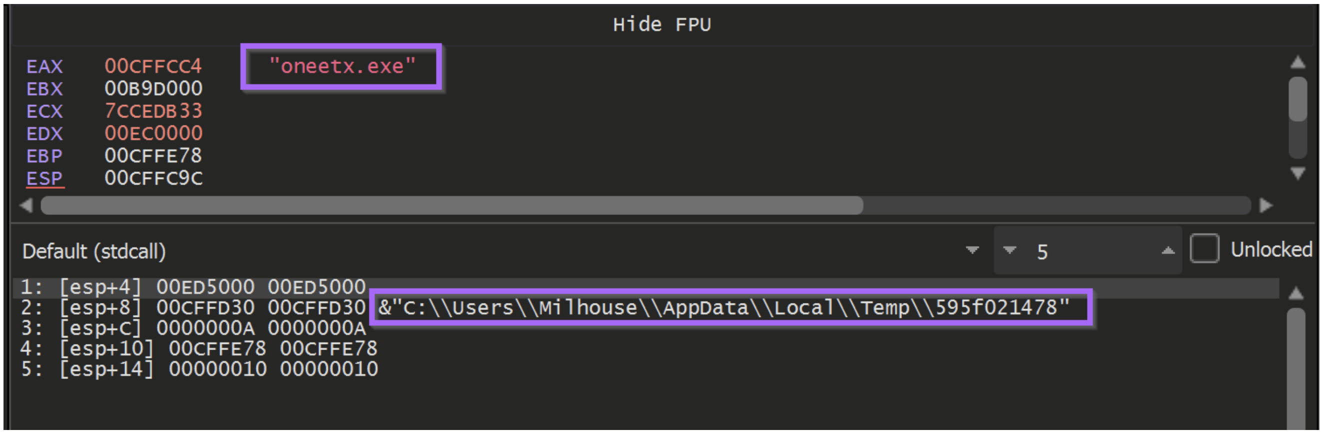


Obtaining a decoded value using x32dbg

The next call to this function - took a base64 encoded argument and returned a file name that the malware was copied into.

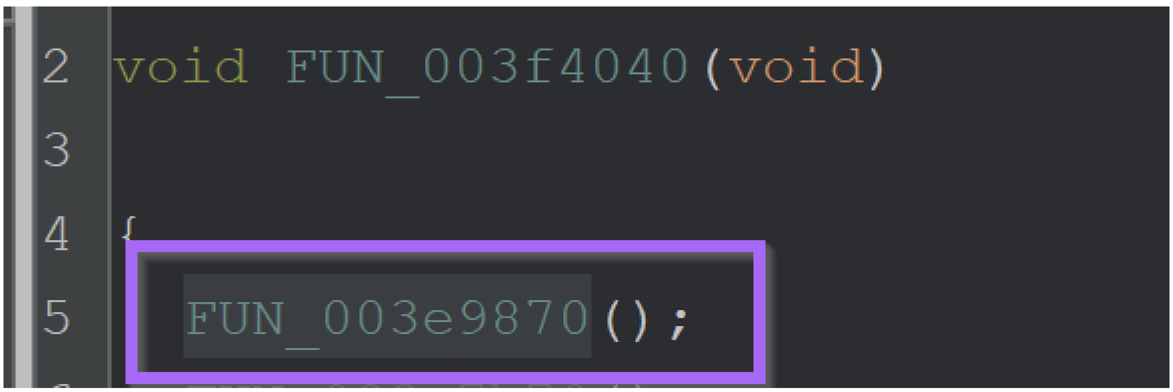


A second encoded value in eax- viewed in x32dbg



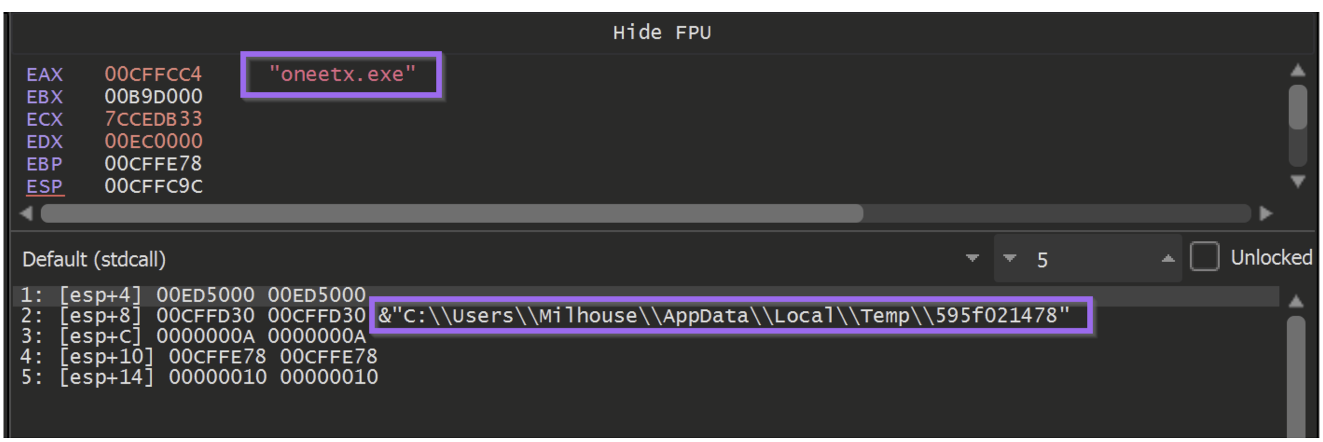
A decoded filename - located using return addresses in x32dbg

At a location of `003e9870` - was a function responsible for checking the location of the current running file.

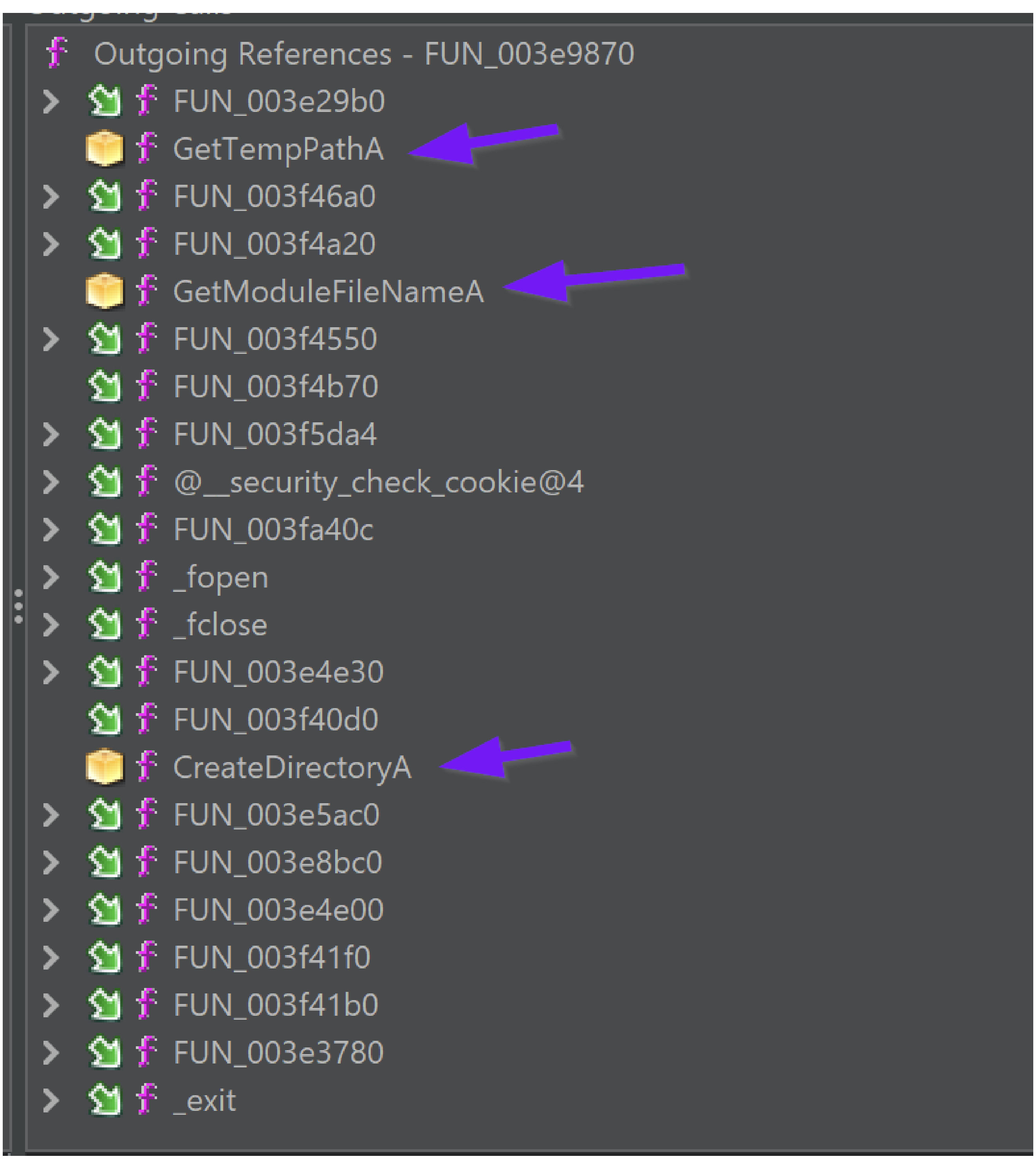


If the location did not match `C:\\users\\<user>\\appdata\\local\\temp\\595f021478\\oneetx.exe` - then the malware would terminate.

Here we can see the return value from the function.



As well as the outgoing function calls in the Ghidra Function Tree.



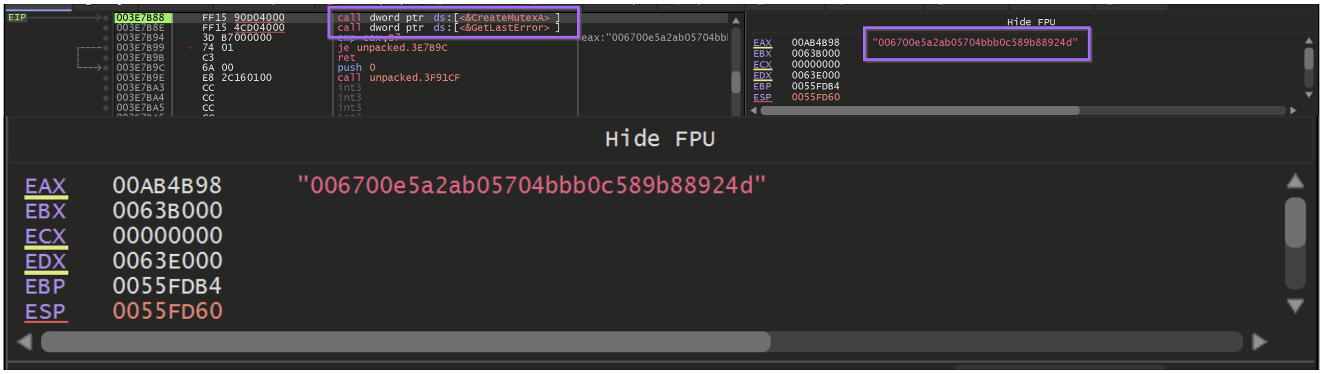
Viewing the Function Tree Using Ghidra

After the directory check is performed - the malware enters `FUN_003e7b70` attempts to creates a mutex with a value of `006700e5a2ab05704bbb0c589b88924d`

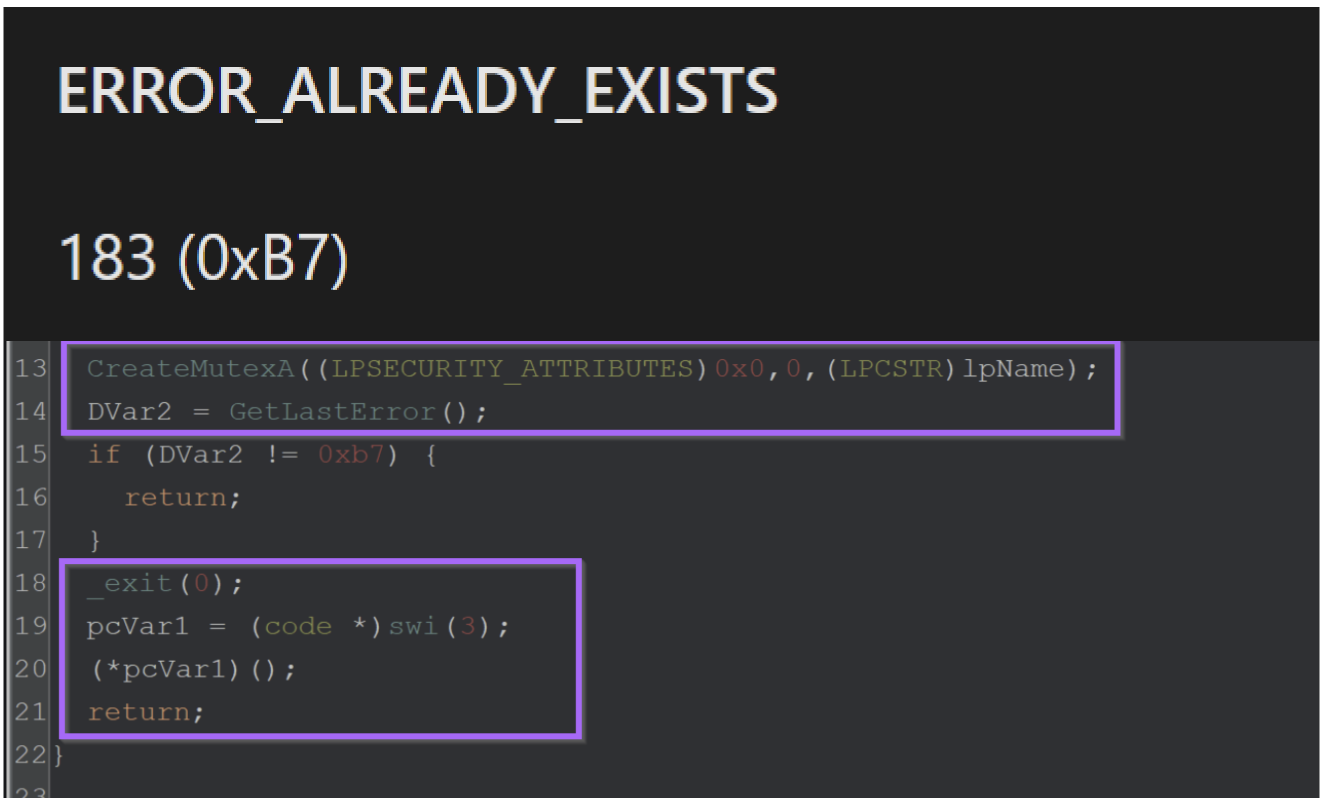
```
void FUN_003f4040(void)

{
  FUN_003e9870();
  FUN_003e7b70();
  FUN_003e93a0(1);
  FUN_003e8d50(1);
  FUN_003f14b0();
  FUN_003f4000();
  return;
}
```

```
void FUN_003e7b70(void)

{
  code *pcVar1;
  undefined4 *lpName;
  DWORD DVar2;

  lpName = &DAT_00418144;
  if (0xf < DAT_00418158) {
    lpName = DAT_00418144;
  }
  CreateMutexA((LPSECURITY_ATTRIBUTES)0x0,0,(LPCSTR)lpName);
  DVar2 = GetLastError();
  if (DVar2 != 0xb7) {
    return;
  }
  _exit(0);
  pcVar1 = (code *)swi(3);
  (*pcVar1)();
  return;
}
```

By breaking on CreateMutexA - The value of `006700e5a2ab05704bbb0c589b88924d` can be seen as an argument.



If the mutex creation returned a value of `0xb7` (Already Exists) - then the malware would terminate itself.

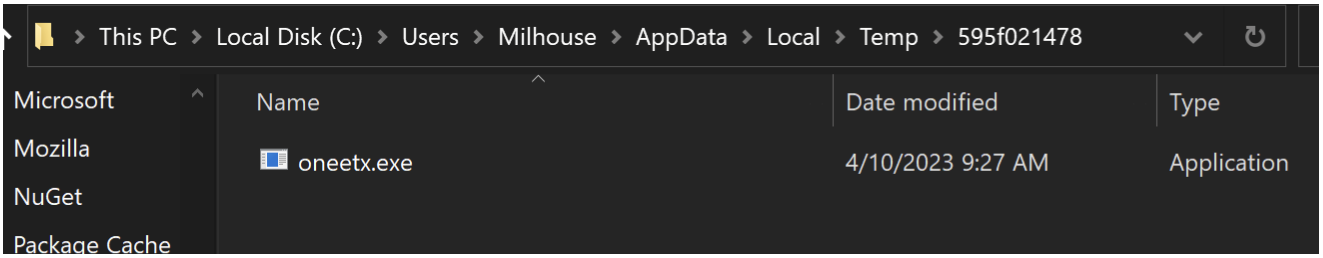


Bypassing Anti-Something Checks

These two checks on the file path and Mutex can function as pseudo anti-debug checks. In order to continue analysis, they needed to either be patched or bypassed.

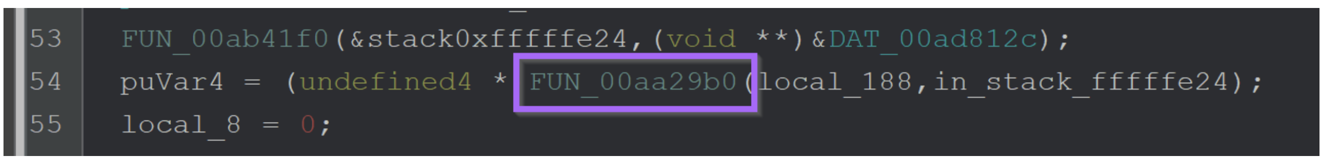
In order to bypass the file path check - I allowed the malware to execute inside the analysis VM and copy itself to the correct folder. I then opened the new file inside the debugger.

Alternatively - You could have patched or nop'd the function. but I found that just moving it to the expected folder worked fine.



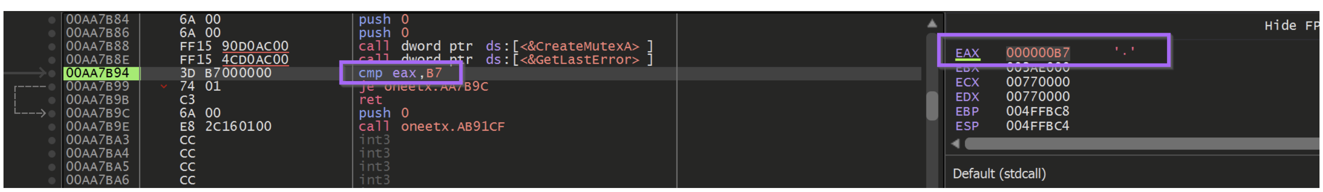
Once the new file was loaded - I updated the base address in Ghidra to match the new address in x32dbg.

Once I updated the base address - I set a breakpoint on `CreateMutexA` and the suspected decryption function `FUN_XXXX29b0`

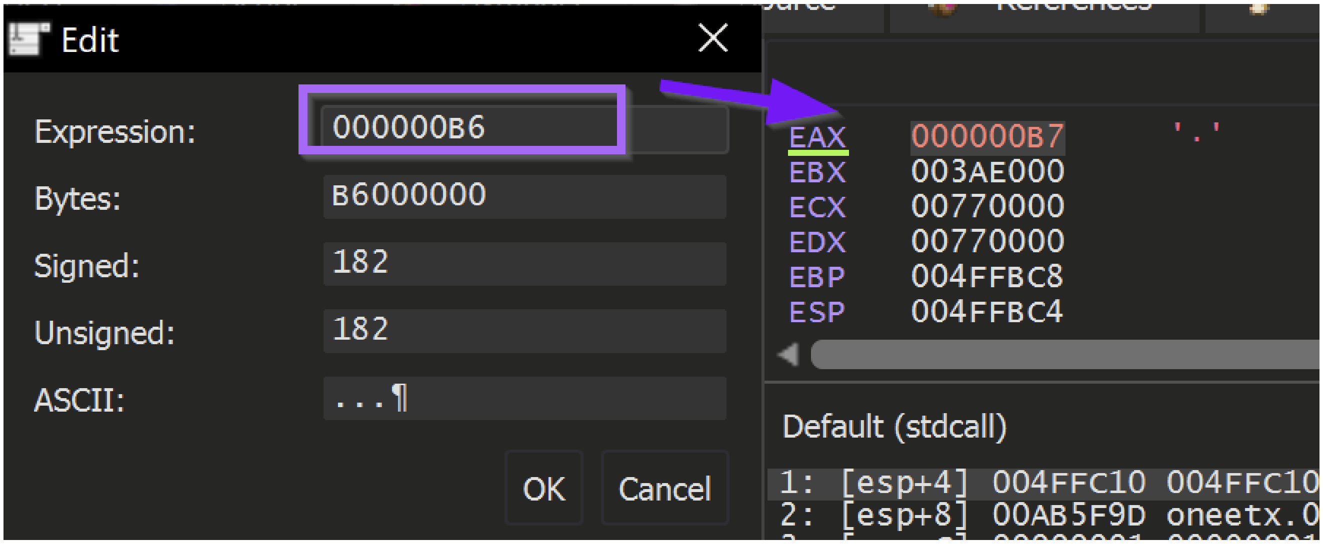


Once I hit the breakpoint on `CreateMutexA` - I stepped out of the function using `Execute Until Return` and then `Step Over` twice.

This allowed me to see the return value of `b7` from the `GetLastError` function. When I allowed the malware to continue to run - it quickly terminated itself without hitting the decryption breakpoint.



To fix this - I used `Edit` to patch the return value to be `B6` instead.

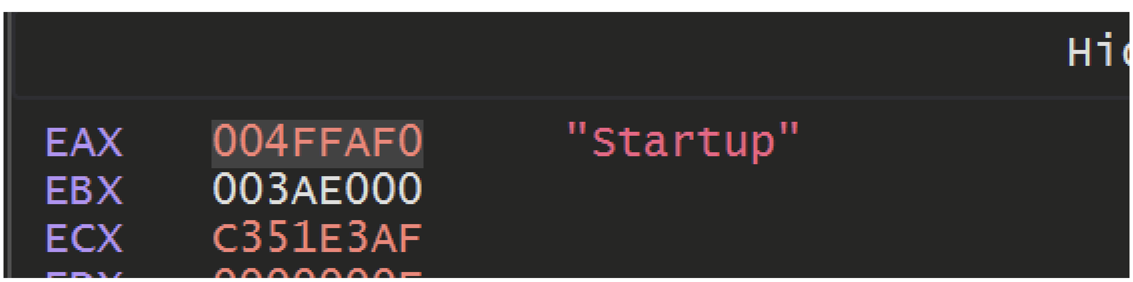


Patching a return value using X32dbg

Upon running the malware - The decryption function was hit again.

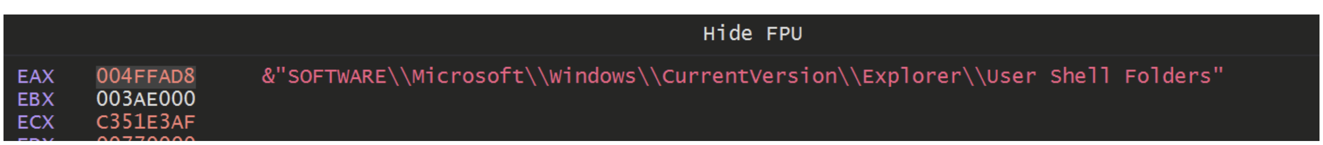
Following the return of the decryption function using `Exeute Until Return` revealed a pretty boring `\\` character.

But allowing it to hit a few more times - it eventually returned a value of `Startup` which was pretty interesting.

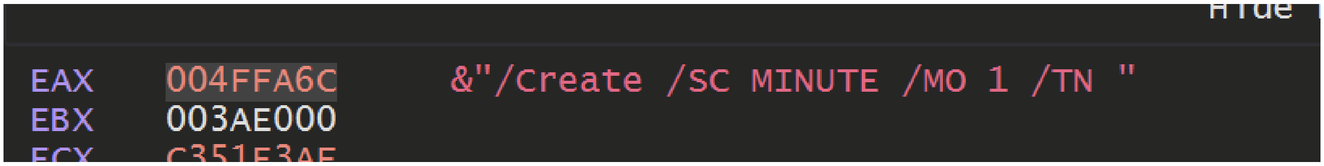


Hitting again revealed a registry path of

`SOFTWARE\\Microsoft\\Windows\\CurrentVersion\\Explorer\\User Shell Folders`

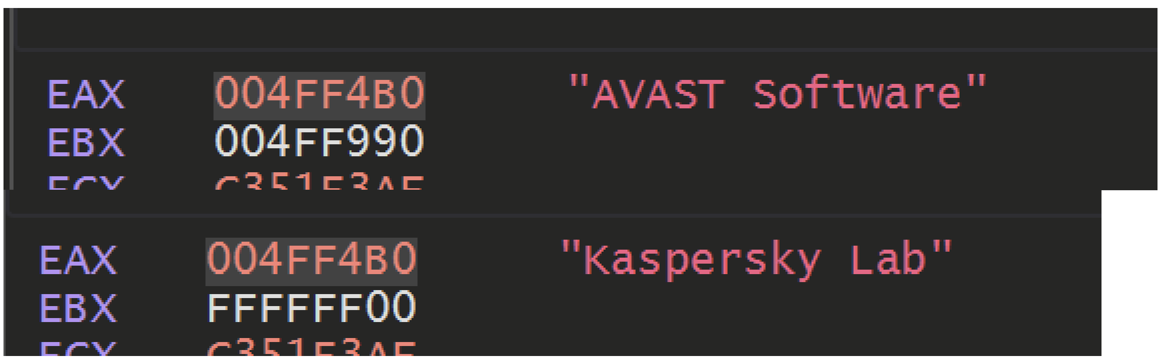


Eventually some more interesting values were returned. Including a partial command likely used to create persistence.



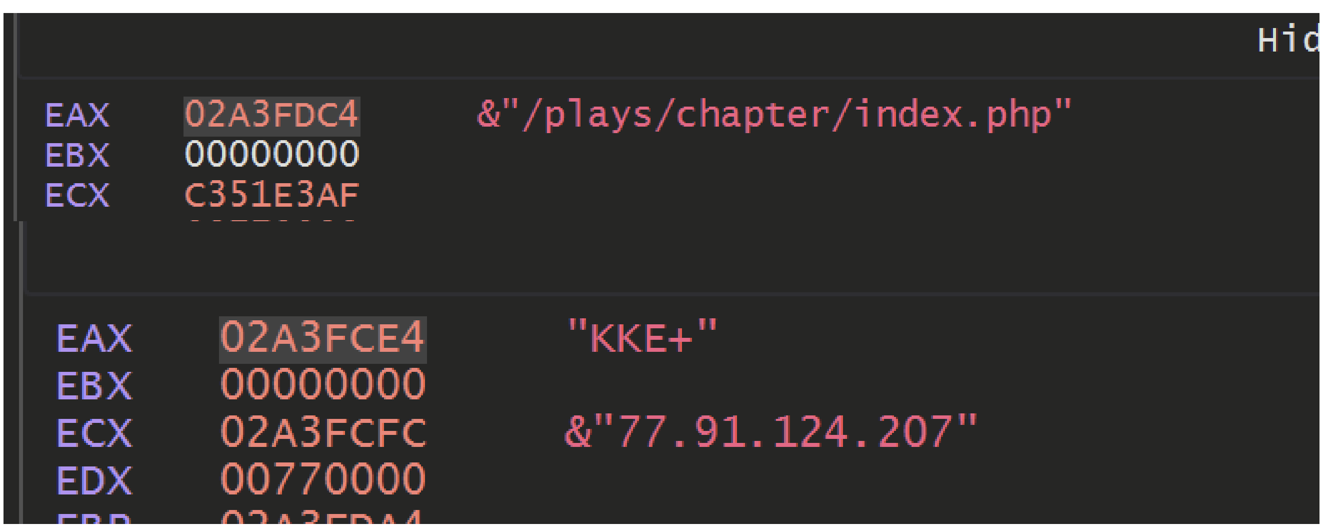
As well as some possible signs of enumeration

Eventually - The names of some security products was also observed. Likely the malware was scanning for the presence of these tools.



C2 Information

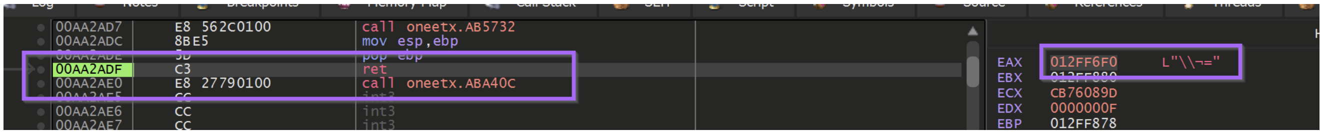
Allowing the decryption function to continue to execute and hit our breakpoint. We can eventually observe C2 information.



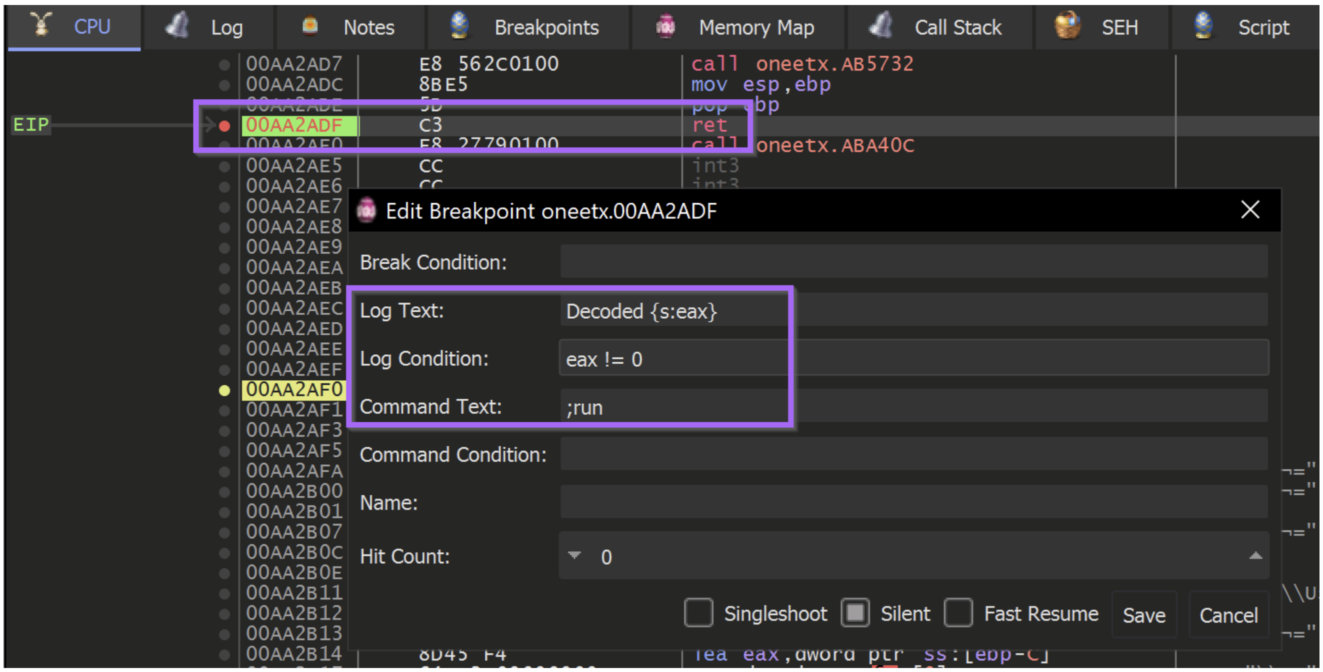
Automating the Decryption - Kinda

Eventually the constant breakpoint + execute until return combination got tiring. So I decided to try and automate it using a Conditional Breakpoint and Log.

To do this - I allowed the malware to execute until the end of a decryption function.

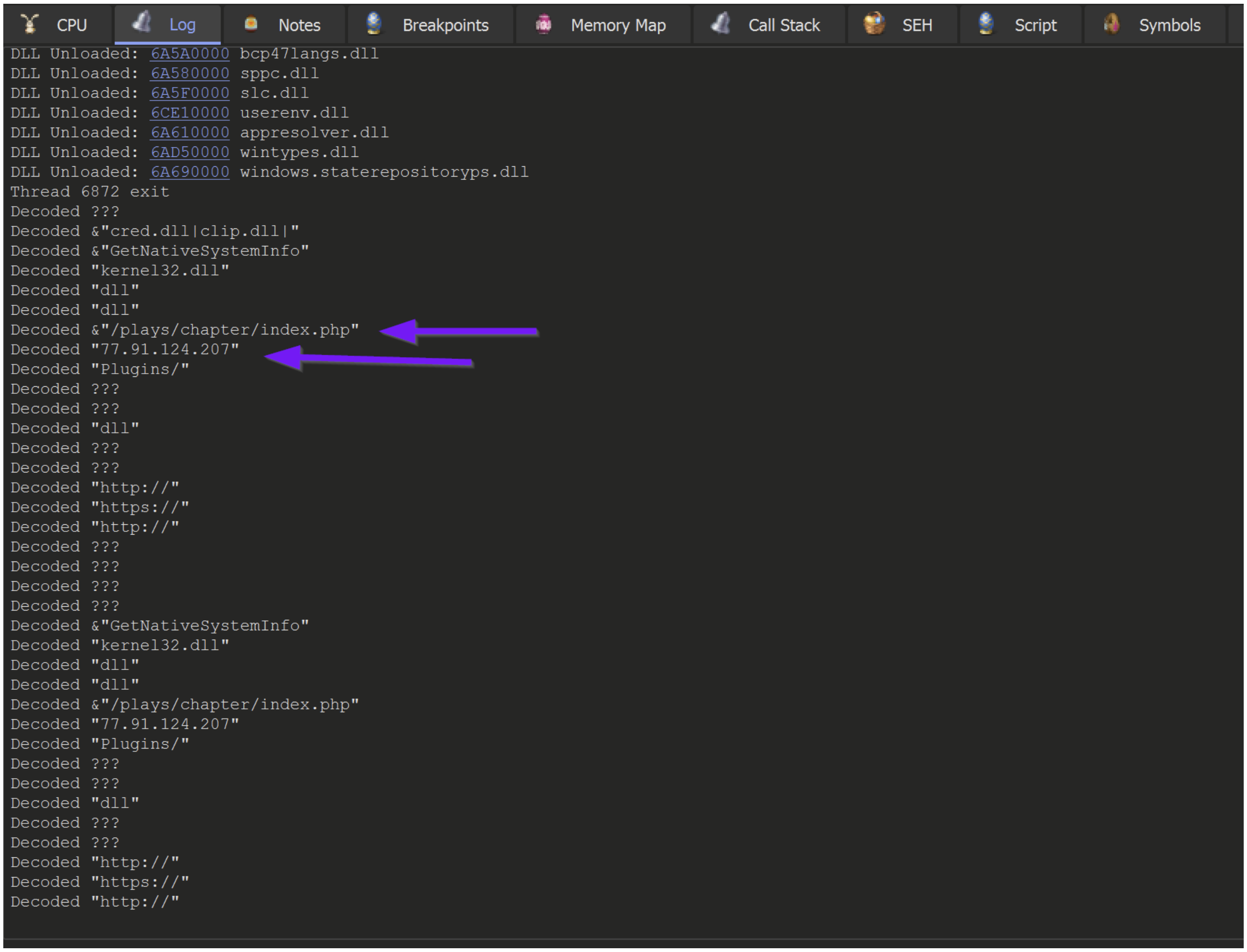


And then created a Conditional Breakpoint that would log any string contained at eax, then continue execution.



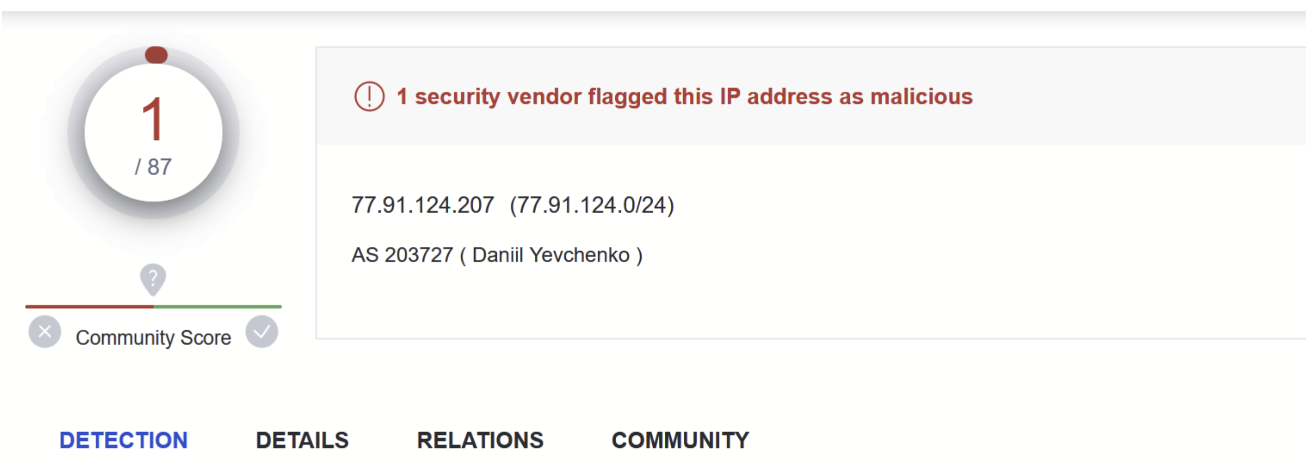
Settiing a Conditional Breakpoint (and logging a value) using X32dbg

Allowing the malware to continue to execute. I could observe the decoded values printed to the log menu of x32dbg.



Successfully using conditional breakpoints to decode a malware sample.

This revealed some c2 information - referencing an IP with 1/87 detections as of `2023/04/10`



The full list of decoded strings can be found here.

```
&"SOFTWARE\\Microsoft\\Windows\\CurrentVersion\\Explorer\\User Shell Folders"
&"SYSTEM\\CurrentControlSet\\Control\\ComputerName\\ComputerName"
&"SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion"
&"abcdefghijklmnopqrstuvwxyz0123456789-_"
&"/Create /SC MINUTE /MO 1 /TN "
&"/plays/chapter/index.php"
&"GetNativeSystemInfo"
&"cred.dll|clip.dll|"
"77[.]91[.]124[.]207"
"Panda Security"
"AVAST Software"
"Kaspersky Lab"
"ProgramData\\"
"ComputerName"
"CurrentBuild"
"kernel32.dll"
"Bitdefender"
"Doctor Web"
"https://"
"Plugins/"
"SCHTASKS"
"http://"
" /TR \""
"Startup"
"Comodo"
"Sophos"
"Norton"
"Avira"
"\" /F"
L"\\¬="
"POST"
"&vs="
"3.70"
"&sd="
"&os="
"&bi="
"&ar="
"&pc="
"&un="
"&dm="
"&av="
"&lv="
"&og="
"ESET"
"dll"
"<c>"
"id="
"AVG"
???
```

Bonus: Utilising Decrypted Strings To Identify the Malware Family

> This section was not in the original blog, but was later added when I was informed by another researcher that the malware might not be Redline.
>
> I then revisited my analysis and determined that the sample was Amadey Bot.
>
> I was able to determine this mostly by researching (googling) the decrypted strings.
>
> I thought it would be useful for others to see what this process looked like :)

Decrypted strings are not just useful for C2 information. They are equally as useful for identifying the malware that you are analyzing.

Unless you are analyzing the latest and greatest APT malware, your sample has likely been analyzed and publically documented before. You'd be surprised how much you can determine using Google and the "intext" operator. (Essentially it forces all search results to contain your query string, significantly reducing unrelated content)

From decrypted strings, try to pick something specific.

For example, the following decrypted string `&"cred.dll|clip.dll|"` can be used to craft a Google query of `intext:clip.dll intext:cred.dll malware`.

This returns 7 results that reference a combination of Redline Stealer and Amadey Bot.

The first link contains IOC's from an Amadey Bot sample, which align closely with the sample analysed in this blog.

Amadey

(PID) Process	(2908) mnolyk.exe
C2 (1)	62.204.41.5/Bu58Ngs/index.php
Version	3.66
Options	
Drop directory	5eb6b96734
Drop name	mnolyk.exe
Strings (116)	SCHTASKS
	/Create /SC MINUTE /MO 1 /TN
	/TR "
	" /F
	SOFTWARE\Microsoft\Windows\CurrentVersion\RunOnce
	SOFTWARE\Microsoft\Windows\CurrentVersion\Explorer\User Shell Folders
	Startup
	Rem
	cmd /C RMDIR /s/q
	SOFTWARE\Microsoft\Windows\CurrentVersion\Run

In the second link - An additional Amadey sample is analysed with the exact same filename as this one. Albeit with a different C2 server.

Malware configuration

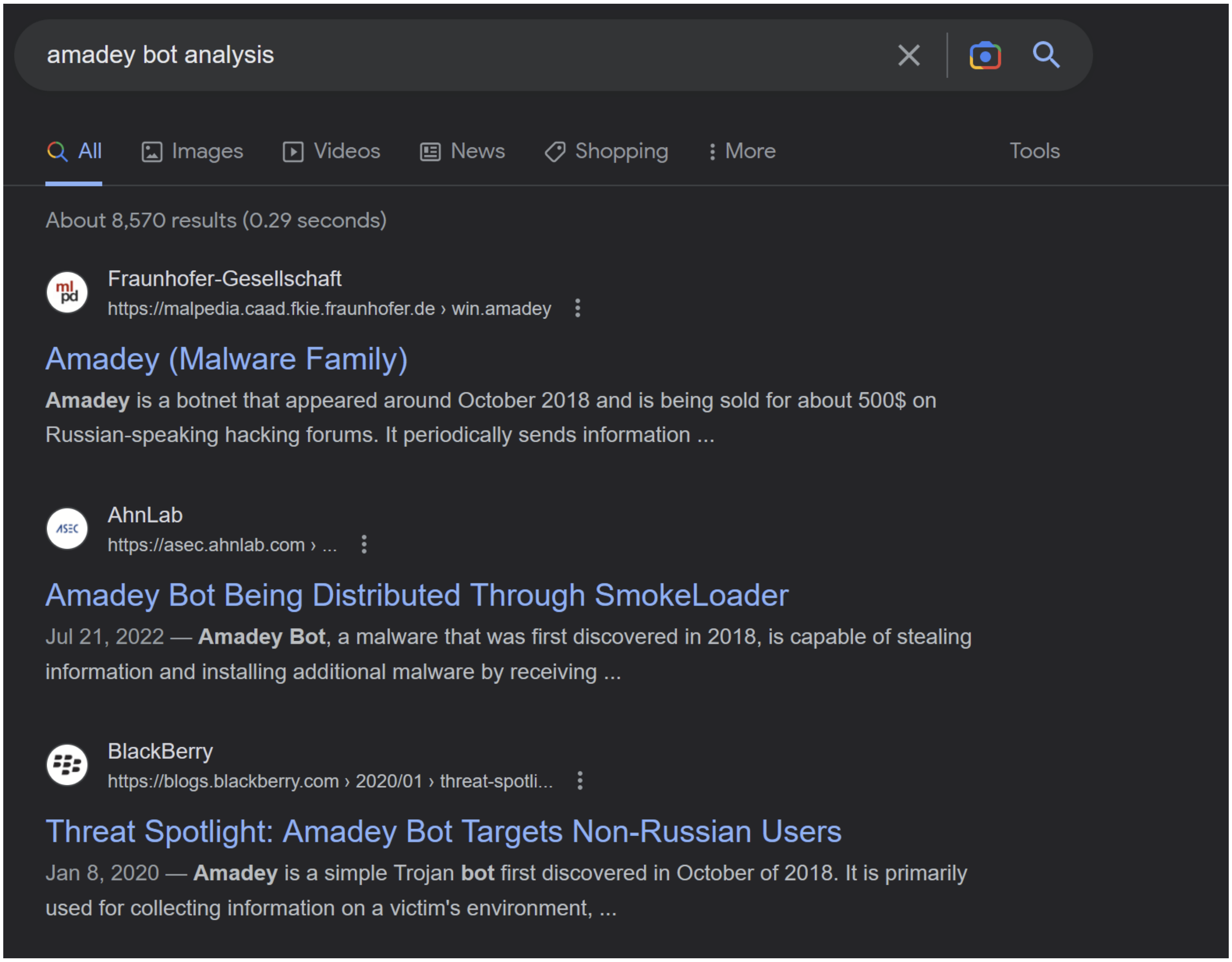
Amadey

(PID) Process	(1692) oneetx.exe
C2 (1)	http://193.233.20.36
Version	3.69
Options	
Drop directory	c5d2db5804
Drop name	oneetx.exe
Strings (116)	SCHTASKS
	/Create /SC MINUTE /MO 1 /TN

At this point - I would have moderate confidence that the sample is Amadey Bot.

For additional confirmation, I would typically google this family and see if any TTP's are the same or at least similar.

I googled `Amadey Bot Analysis` and discovered this blog from AhnLab.com.



The Ahnsec blog details an extremely similar installation path and strings.

> **Amadey Installation Path**
> > %TEMP%\9487d68b99\bguuwe.exe
>
> **Command registered to Task Scheduler**
> > cmd.exe /C REG ADD “HKCU\Software\Microsoft\Windows\CurrentVersion\Explorer\User Shell Folders” /f /v Startup /t REG_SZ /d %TEMP%\9487d68b99\
> > schtasks.exe /Create /SC MINUTE /MO 1 /TN bguuwe.exe /TR “%TEMP%\9487d68b99\bguuwe.exe” /F

The Ahnsec Blog also references a list of AV products that are enumerated by Amadey Bot.

Anti-malware Name	Number
X	0
Avast Software	1
Avira	2
Kaspersky Lab	3
ESET	4
Panda Security	5
Dr. Web	6
AVG	7
360 Total Security	8
Bitdefender	9
Norton	10
Sophos	11
Comodo	12
Windows Defender (assumed)	13

Coincidentally, almost all of those strings were contained in our sample

```
"Panda Security"
"AVAST Software"
"Kaspersky Lab"
"ProgramData\\"
"ComputerName"
"CurrentBuild"
"kernel32.dll"
"Bitdefender"
"Doctor Web"
"https://"
"Plugins/"
"SCHTASKS"
"http://"
" /TR \""
"Startup"
"Comodo"
"Sophos"
"Norton"
"Avira"
```

The Ahnsec blog also references specific parameters that are sent in POST requests made by Amadey Bot.

Item	Data Example	Meaning
id	129858768759	Infected system's ID
vs	3.21	Amadey version
sd	37bbd7	Amadey ID
os	9	Windows version ex) Windows 7 – 9 Windows 10 – 1 Windows Server 2012 – 4 Windows Server 2019 – 16
bi	0	Architecture (x86 – 0, x64 – 1)
ar	0	Admin privilege status (1 if admin privilege is available)
pc	PCNAME	Computer name
un	USERNAME	User name
dm	DOMAINNAME	Domain name
av	0	List of installed anti-malware
lv	0	Set as 0
og	1	Set as 1

Table 1. Data sent to the C&C server

Coincidentally, almost all of those same fields (first column) are referenced in our decrypted strings.

Since POST request parameters are pretty specific - Was confident my sample was actually Amadey bot.

```
L"\\¬="
"POST"
"&vs="
"3.70"
"&sd="
"&os="
"&bi="
"&ar="
"&pc="
"&un="
"&dm="
"&av="
"&lv="
"&og="
"ESET"
"dll"
"<c>"
"id="
"AVG"
???
```

At this point, I also reviewed a second blog from Blackberry. Which confirmed much of the same analysis as AhnSec.

At this point, I was comfortable re-classifying the malware as Amadey bot.

(I also learned not to blindly follow tags from Malware Reps)

Conclusion and Recommendations

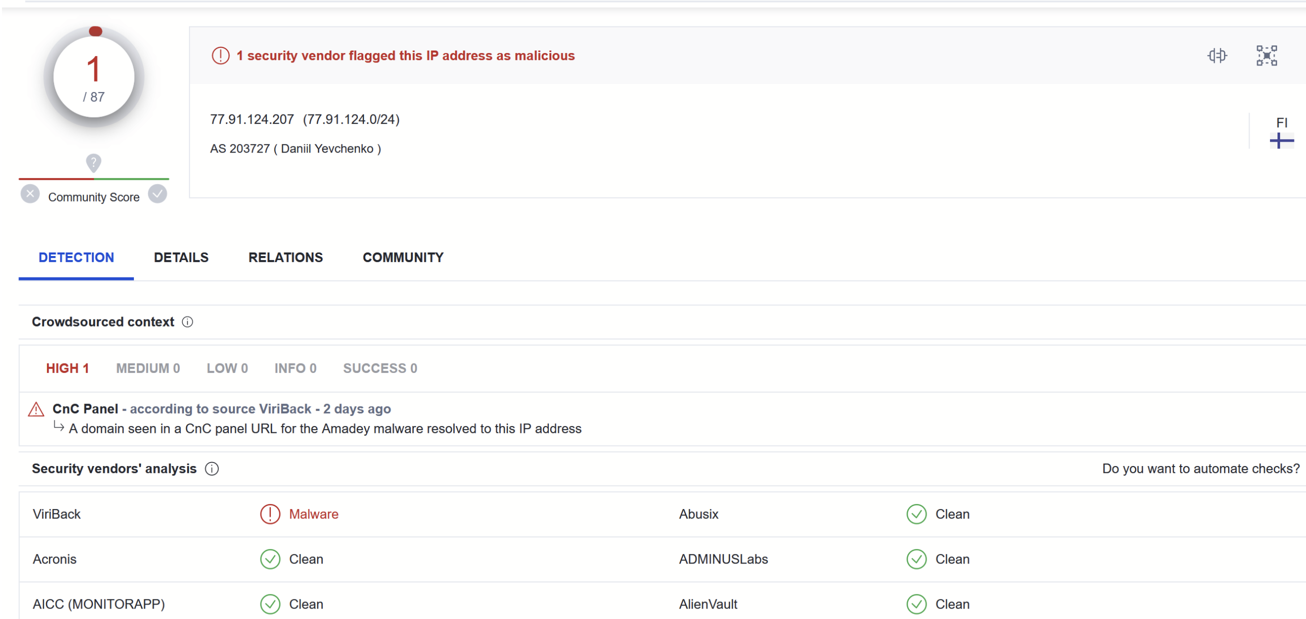
At this point I'm going to conclude the analysis as we have successfully located the C2 information and identified the malware family. In a real life situation, this analysis could serve multiple purposes.

- Decrypted strings can be googled to aid in malware identification.
- Decrypted strings contain commands and process names that can be used for process-based hunting
- Decrypted Strings contain URL structure which can used to hunt or develop detection rules for proxy logs.
- Decrypted Strings contain an IP that could be used to identify infected machines.
- Decrypted Strings can be used to enhance a Ghidra or IDA database - enhancing the decompiler output and leading to better RE analysis.

- Better automation could be used to make a config extractor - useful for a threat intel/analysis pipeline. (Replacing x32dbg with Dumpulator would be a great way to do this)
- + lots of fun :D

Virustotal

At the time of this analysis (2023/04/10) - There is only `1/87` detections for the C2 on Virustotal



Decoded Strings

A full list of strings obtained using the log function of x32dbg.
(Noting that these are in order of length and not location of occurrence.)

```
&"SOFTWARE\\Microsoft\\Windows\\CurrentVersion\\Explorer\\User Shell Folders"
&"SYSTEM\\CurrentControlSet\\Control\\ComputerName\\ComputerName"
&"SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion"
&"abcdefghijklmnopqrstuvwxyz0123456789-_"
&"/Create /SC MINUTE /MO 1 /TN "
&"/plays/chapter/index.php"
&"GetNativeSystemInfo"
&"cred.dll|clip.dll|"
"77[.]91[.]124[.]207"
"Panda Security"
"AVAST Software"
"Kaspersky Lab"
"ProgramData\\"
"ComputerName"
"CurrentBuild"
"kernel32.dll"
"Bitdefender"
"Doctor Web"
"https://"
"Plugins/"
"SCHTASKS"
"http://"
" /TR \""
"Startup"
"Comodo"
"Sophos"
"Norton"
"Avira"
"\" /F"
L"\\¬="
"POST"
"&vs="
"3.70"
"&sd="
"&os="
"&bi="
"&ar="
"&pc="
"&un="
"&dm="
"&av="
"&lv="
"&og="
"ESET"
"dll"
"<c>"
"id="
"AVG"
???
```

Useful Links

- AhnSec Labs - Blog on Amadey Stealer
- Blackberry Blog - Amadey Bot Analysis
- Mandiant - Repo for Flare VM Install
- X32dbg Documentation - Conditional Breakpoints in X32dbg