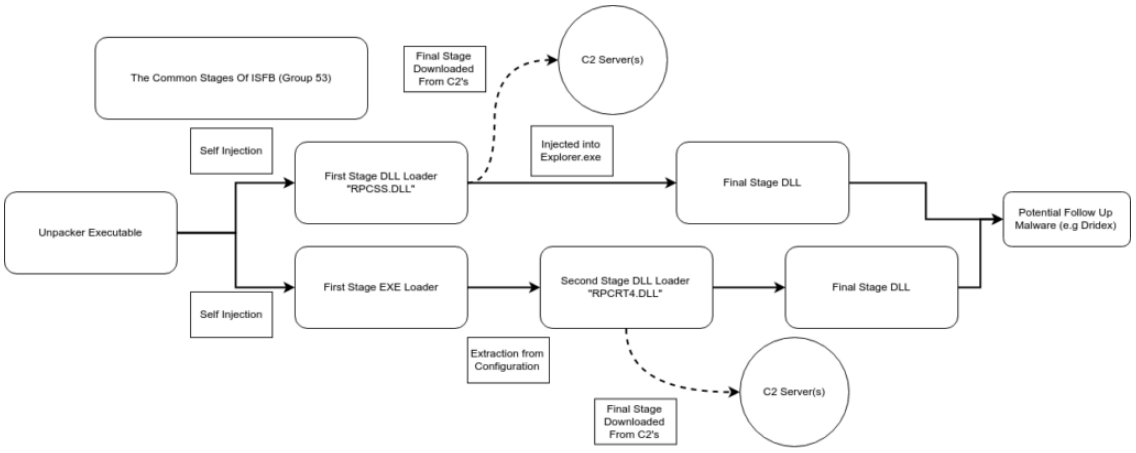
Analysing ISFB – The First Loader | 0ffset Training Solutions

By 0verfl0w_

Published: 2019-03-13 · Archived: 2026-04-05 20:44:08 UTC

I'm finally getting round to writing this post – for the past few months I have been analysing different versions of ISFB/Ursnif/Gozi to gain a deeper understanding in the functionality of this specific malware. In this post, I will be detailing how to unpack and then analyse the first stage loader executable, and then use that information to extract the second stage loader DLL, known as **rpcrt4.dll**, which we will analyse in a later post.

In a nutshell, ISFB is a banking trojan used to steal financial information from unsuspecting victims. It utilizes several methods to do so, from stealing saved passwords to injecting JavaScript into predetermined websites. This specific sample of ISFB is version 2.14.60, and can be attributed to a specific ISFB v2 group based on the infection routine used – specifically the macros that execute a powershell command that is simply Base64 encoded. The group behind this sample also reuse the encryption key for different campaigns (the default key), making their samples easily identifiable compared to other large groups utilizing ISFB. I have been unable to locate specific threat actor names, and as a result, I will be referring to this group as **Group 53**, based off of **this** presentation by FireEye.



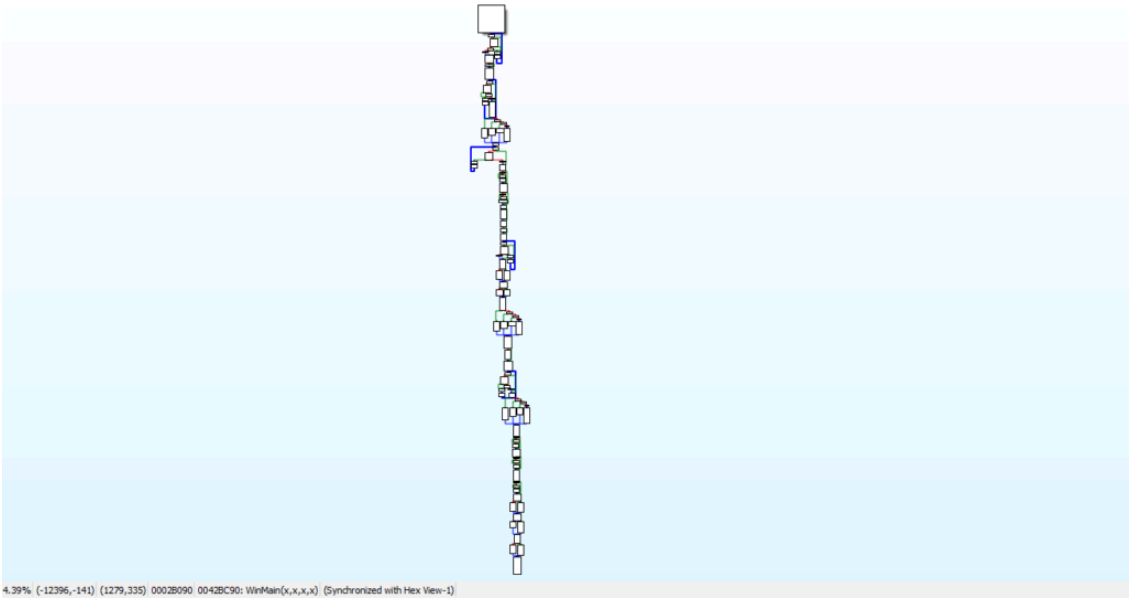
Similarly to other groups utilizing ISFB for financial gain or simply as a stager, **Group 53** gains a foothold on the target's system using a malicious Word document containing embedded macros, which in turn lead to the execution of a Powershell script responsible for downloading the first stage executable. Certain groups "partner" with other groups that are able to distribute malicious spam (malspam) on a large scale, such as the group behind Hancitor. This could potentially result in larger infection numbers, compared to those groups that are relying on their own distribution methods. I would assume "renting" a spot from the group behind Hancitor would be quite expensive as a result of its enormous outreach, which is why a lot of groups, including **Group 53**, have to distribute their own malicious documents. I will be focusing on the unpacker executable and the first stage executable loader in this post, rather than the Word Document itself, as its functionality is quite straightforward. As always, the samples have been uploaded to **VirusBay**. So, let's crack it open!

But, before I do I'd like to thank all of the people who helped me out in analysing the different samples of ISFB, including **@VK_Intel**, **@Nazywam**, and **@Maciekkotowicz** (for his great papers on ISFB). Anyway, let's get on with the reversing!

Part 1: Unpacking the first stage executable

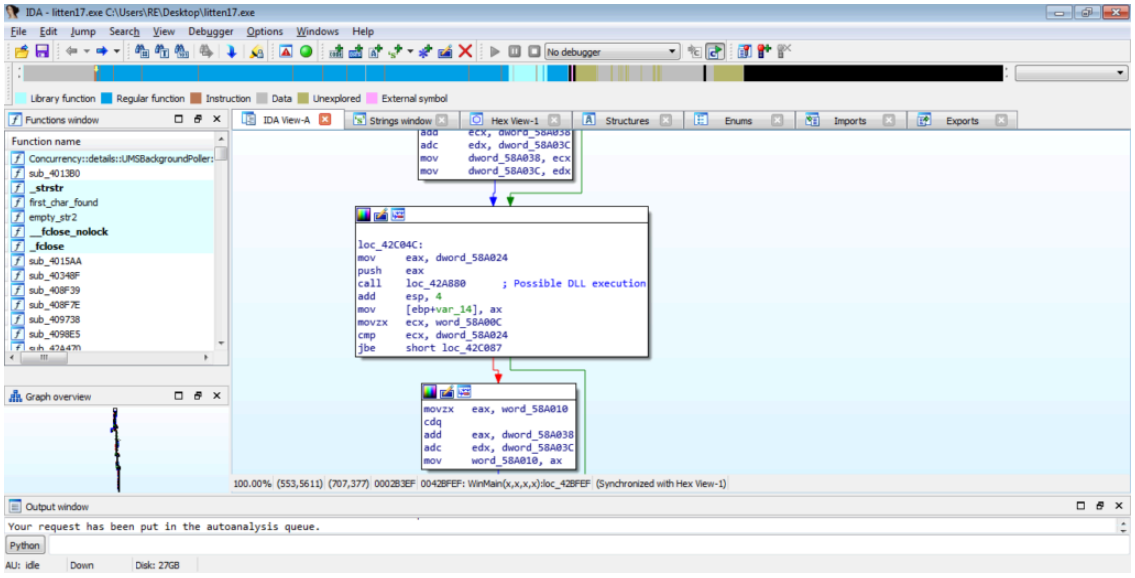
```
MD5 of First Stage Executable: bc72604061732a9280edbe5e2c1db33b
```

Typically I would open it up in PEStudio or perhaps perform some static analysis, however at this point I have already determined that it is highly likely to be a sample of ISFB, based on the Word Macro, although we still want to unpack the first EXE to be 100% sure that it is in fact ISFB. First, let's open it in IDA to try and find a call (or jmp) to a memory region or register – this could possibly be a call to the unpacked stage.

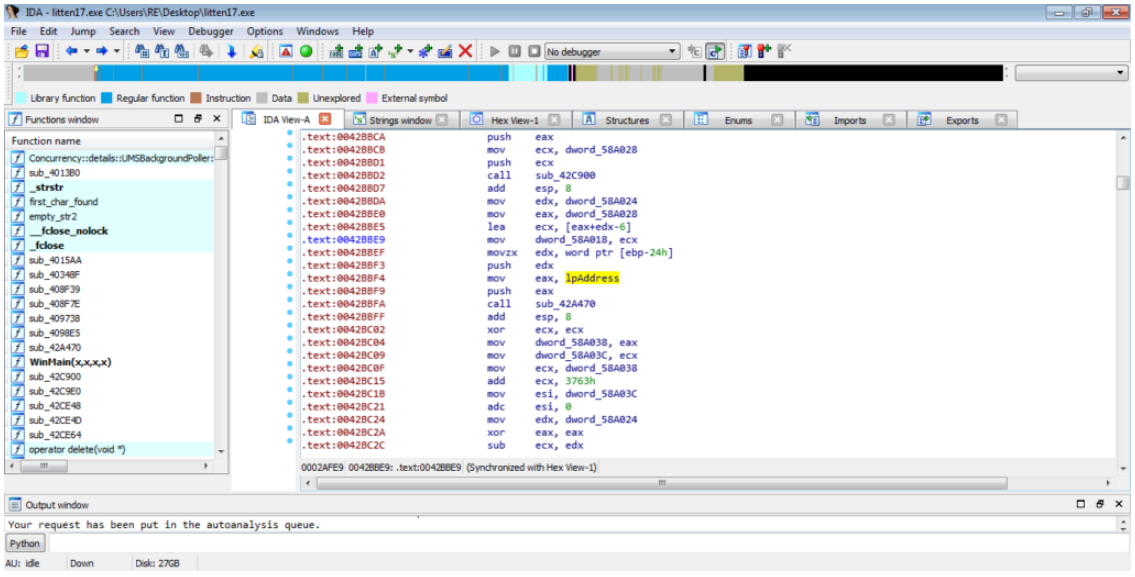


It definitely looks like there is some unpacking going on here (based on the length and intricate flow shown in the image above), and upon looking at the strings in the binary we can see that there aren't many that are legible, or meaningful. Normally when unpacking a sample, I start at the bottom and work my way up – most unpackers exit once the file has been unpacked – although this depends. In this case, the unpacker performs **Self-Injection**, and overwrites itself with the unpacked file. This is not unusual for ISFB, and if you analyse some other samples (even from other groups), you will most likely find this occurring too. This means that the unpacker does not exit until the unpacked file does, although we can assume that the last function called will transfer execution over to the unpacked executable.

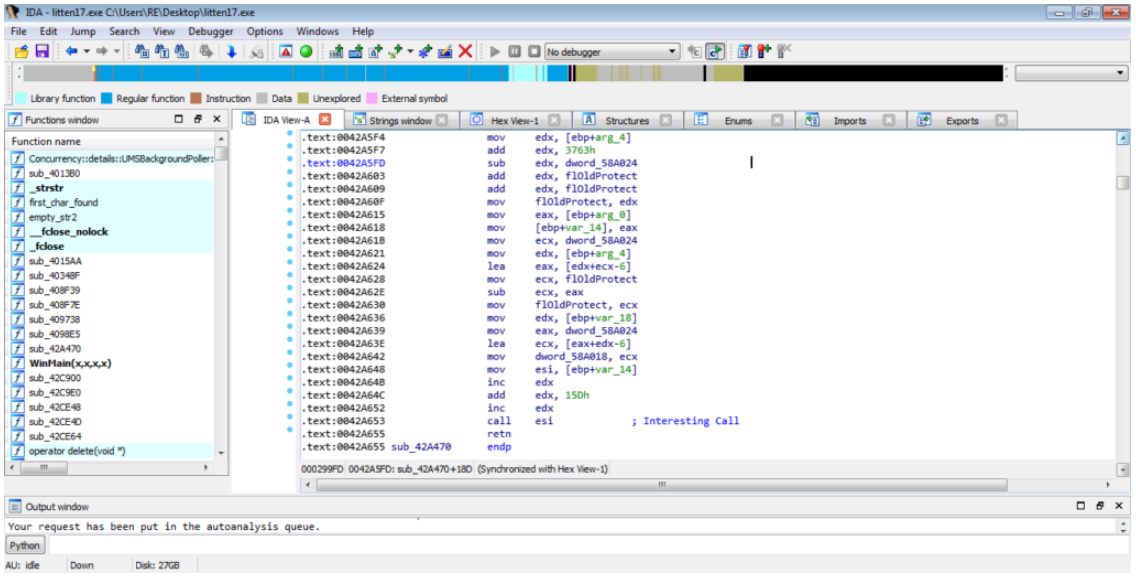
In this specific file, there is no call or jmp to a register or memory region – however, there is a call to **loc_42A880**. It's the last call in WinMain, so as mentioned before, this function is most likely responsible for transferring execution over to the EXE.



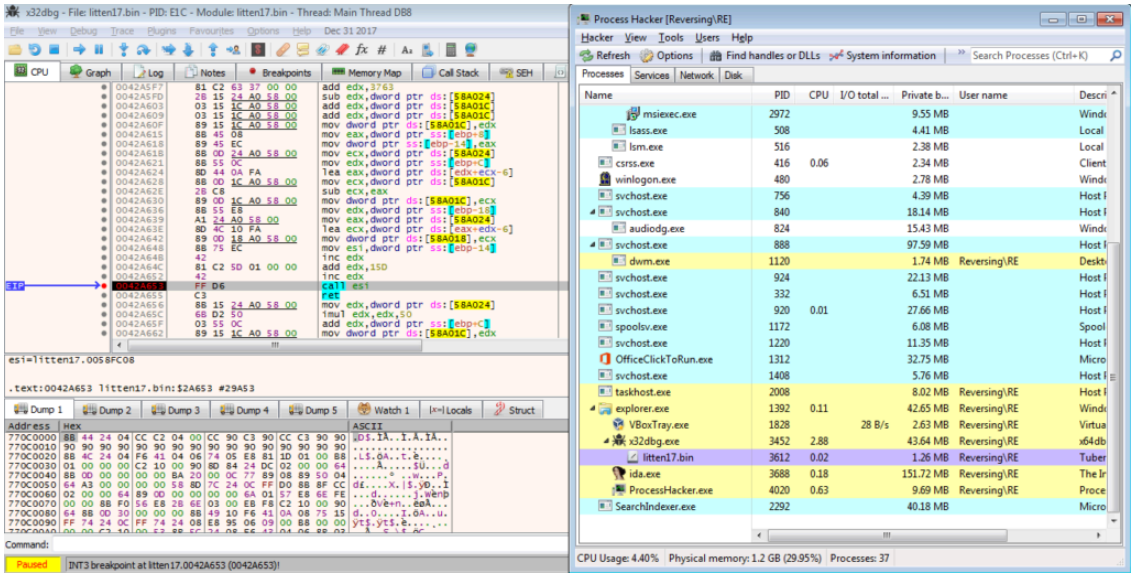
When we jump into this function, it is clear that it hasn't been converted to a function yet, and so we are unable to view it as a graph. Sometimes, you are able to turn it into a function by pressing "P", although it doesn't seem to work in this case. So, we will have to deal with the text mode. It is definitely possible to follow the jumps and conditional jumps to try and find the call or jump to our executable, but we can speed this up a bit. Locate a **call** instruction and click it – this should highlight the instruction and other instances of it. This doesn't work for every sample, but it is worth a try to speed things up. Simply scroll down or up from where you are, looking for other instances of **call**. The last call I located took **lpAddress** as the first argument, so let's take a look at this. **lpAddress** indicates that it contains an address to a region of memory, meaning it could contain the address of our unpacked executable.



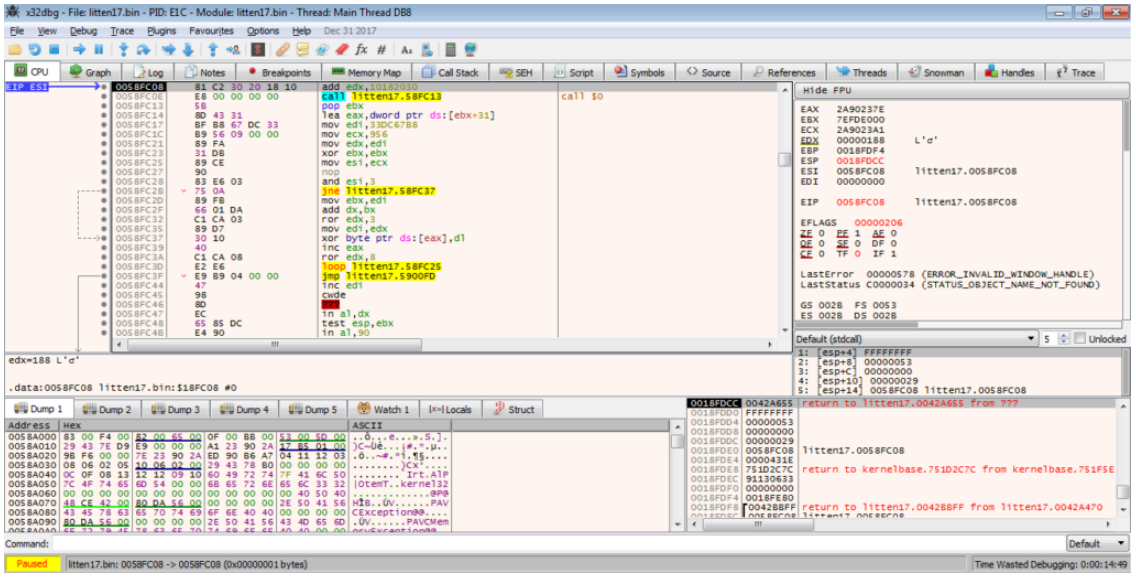
Inside this function, if we jump straight to the end, we can see a call to **ESI**. Hit space to jump from the Graph view back to Text view in order to get the address of this call. This could be the call to our unpacked EXE, and so we need the address of it to view it in x32dbg and put a breakpoint on it.

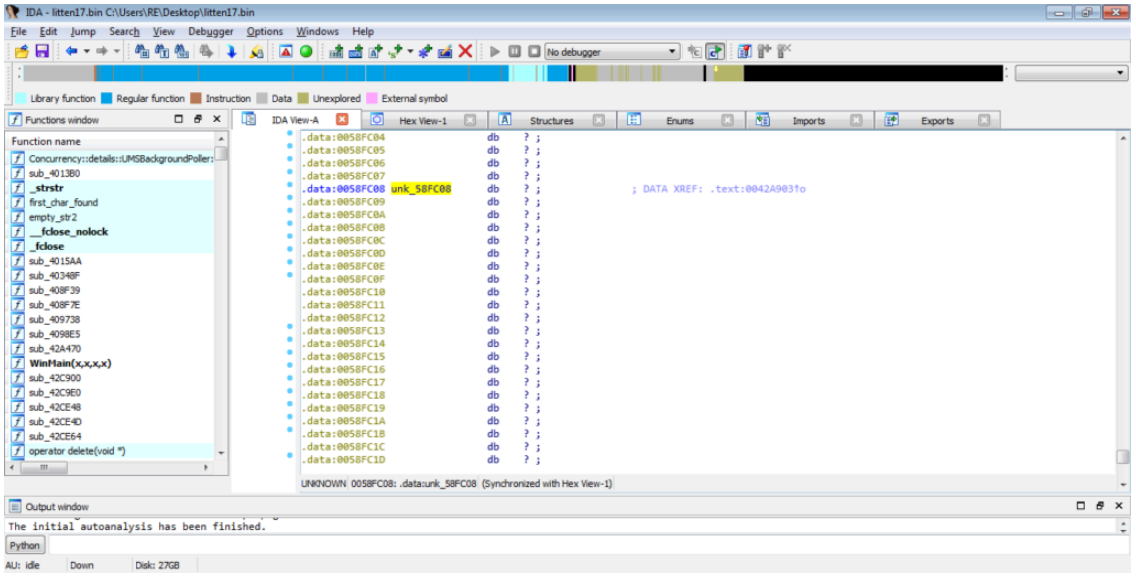


So the memory address to this call is **0x0042A653**, so let's now open this up in x32dbg and jump to this address. Simply push CTRL-G in x32dbg and type in **0042A653**, and then hit enter – this will jump to that address, allowing you to put a breakpoint on it. Whilst attempting to unpack a sample, I prefer to open up Process Hacker alongside it, so that if I put a breakpoint on the wrong address and the unpacked process executes, I can easily detect it, either through the **Network** tab or through the **Processes** tab.



Once the breakpoint has been hit, step into **ESI** and in this sample there is what seems to be a second unpacking "stage" – this code was not here originally, in fact if we try and view it in IDA, you will simply see a lot of question marks and the variable **unk_58FC08**.

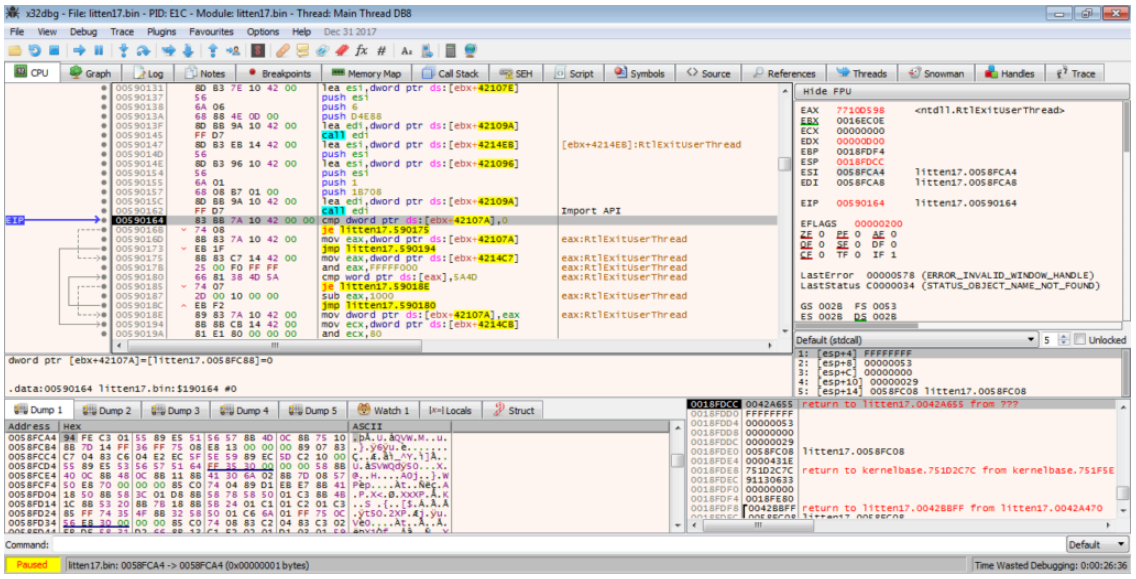




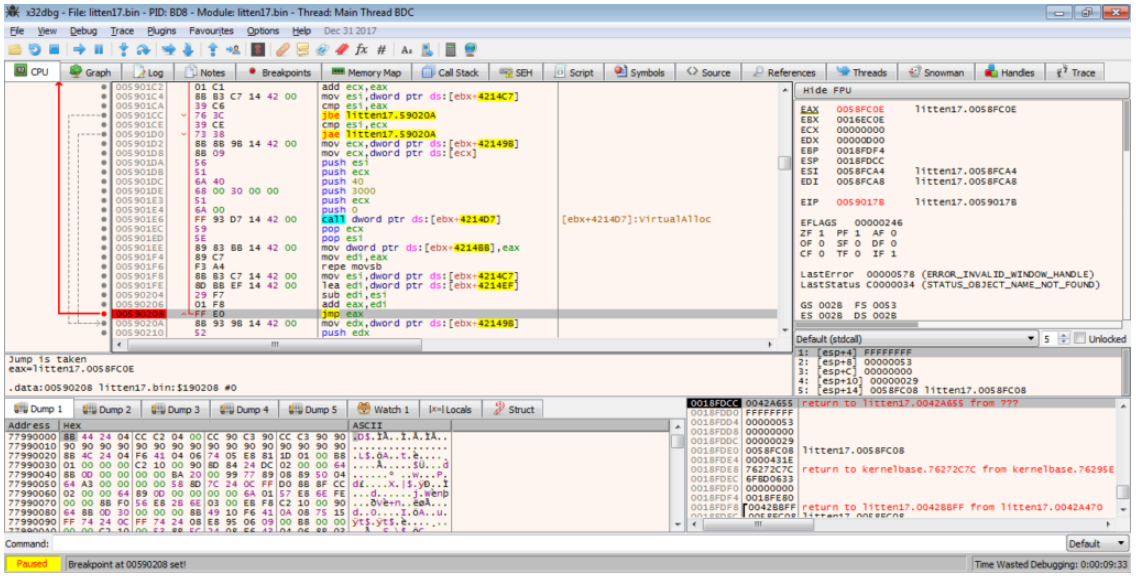
As it is difficult to statically analyse this section without dumping it and opening it up in IDA, I will be jumping over functions, rather than stepping through them manually. This will also help to speed things up, but make sure your network adapter is not attached, as one of these functions may execute the executable.

In the GIF below, you can see there is some form of loop going on, with XOR being used to XOR a byte at the memory address stored in EAX, with the value in DL. You might also notice that the assembly is changing as each loop goes on – this is another example of the second unpacking stage. We can simply put a breakpoint on the jmp and then run the program until it hits it.

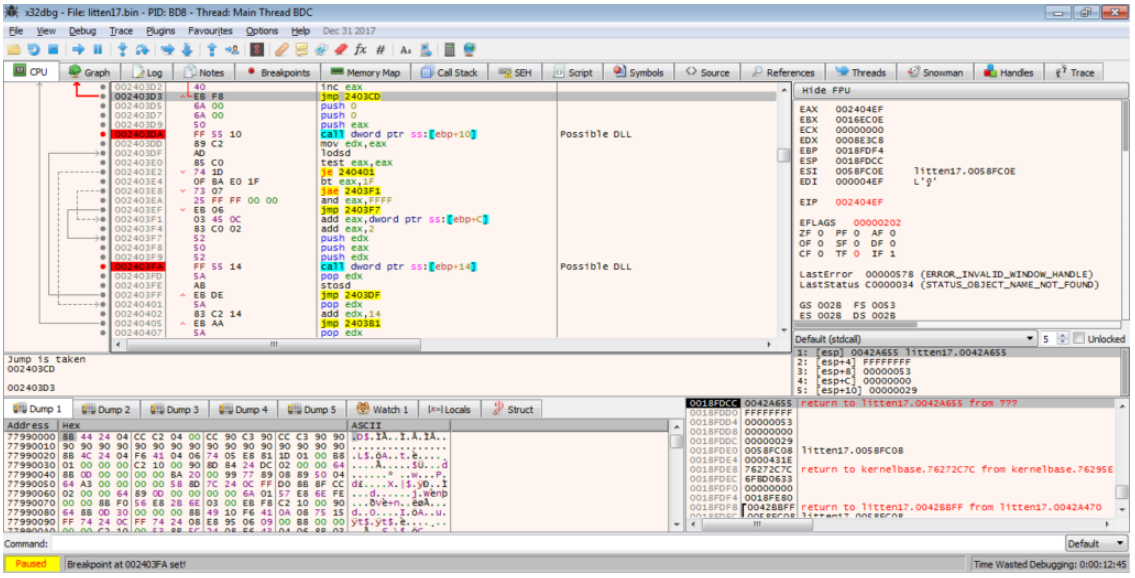
Once we follow the jump, we are met with several calls to **[ebx+xxxxxx]**. Each of these could jump to the unpacked EXE, however as we progress further on, it is clear that these are simply calls to Windows API functions. Notice the call to **EDI**? EDI is pointing to a function that dynamically imports these APIs so that they can be called by the unpacking stub. The result is stored in EAX, and as seen in the image below, this specific call imported the API **RtlExitUserThread**.



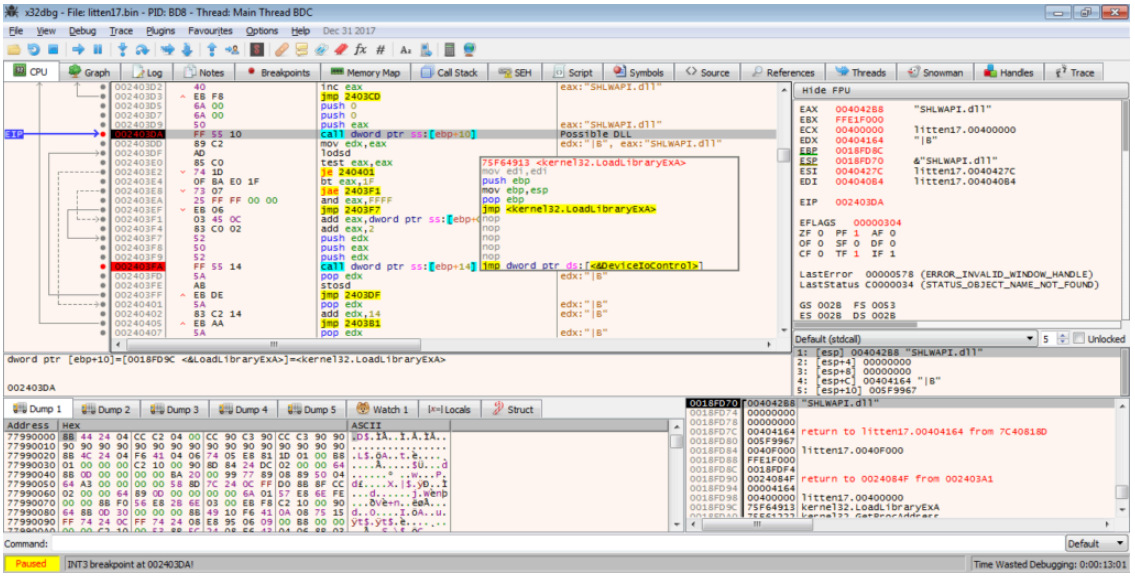
Scrolling down a bit, we can see a **jmp eax**, so let's put a breakpoint on that and run to it, and then follow the jump.

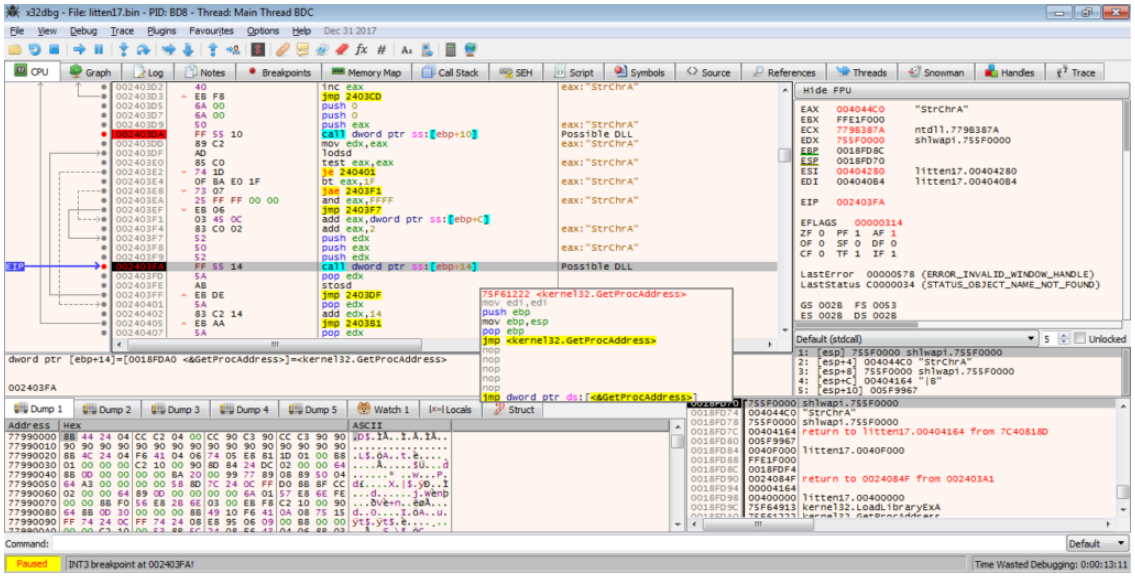


This jump takes us to a newly allocated region of memory, with more code. I didn't want to examine each function, so I scrolled down until the **ret** instruction, and started examining the (**local** – not API calls) functions backwards. The last function did not seem likely to be the executable "executor", as there was no call or jump instruction to a different region of memory, however the second last function had some calls to **[ebp+14]** and **[ebp+C]**, so let's put a few breakpoints on those.

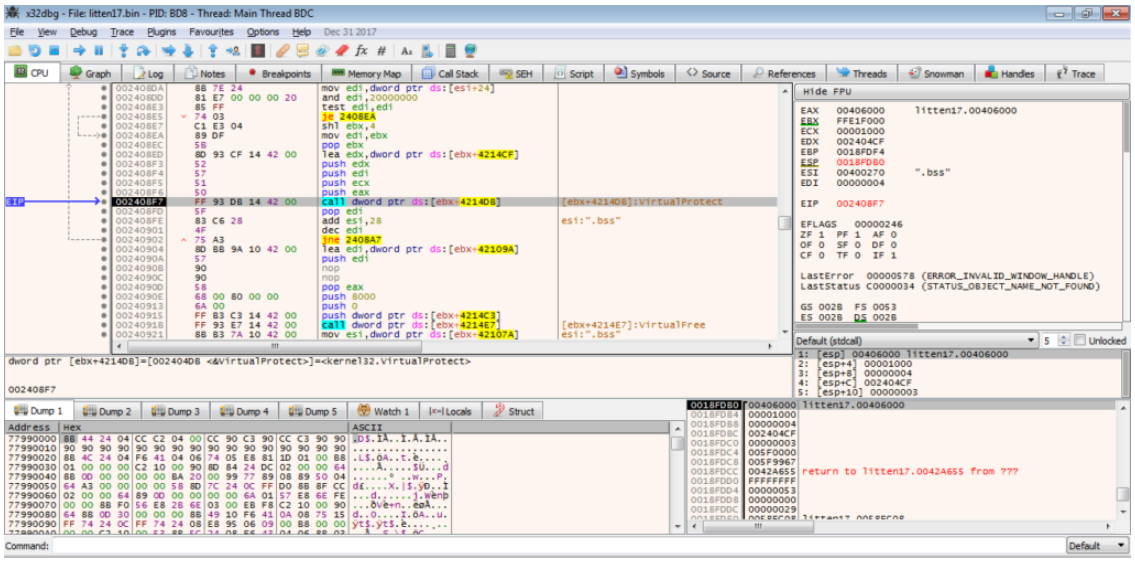


However, upon executing the program and hitting the breakpoint, it is clear that they are simply calling **LoadLibrary** and **GetProcAddress**.

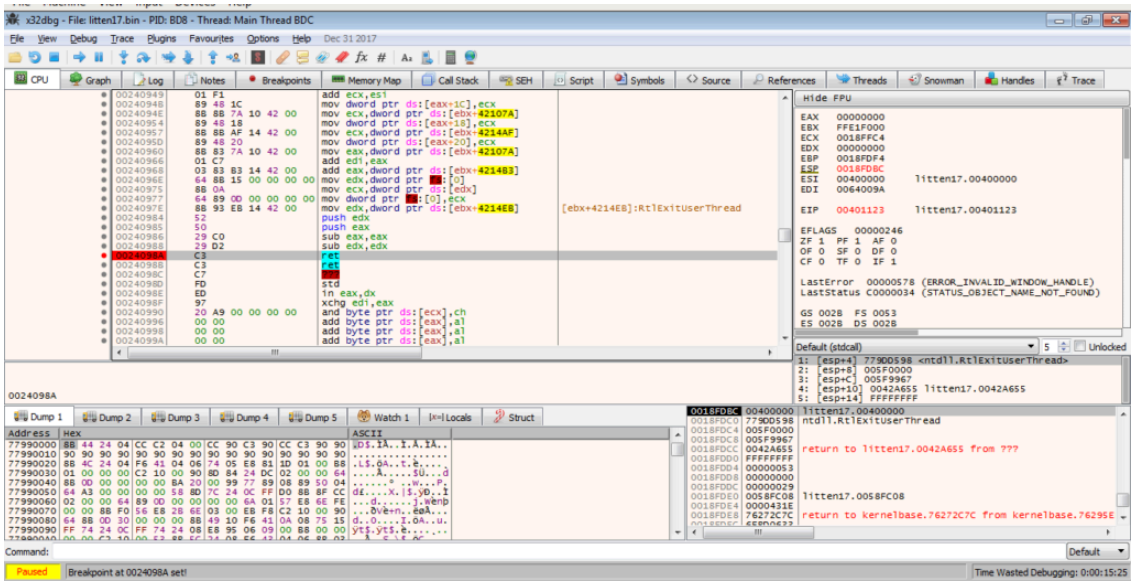




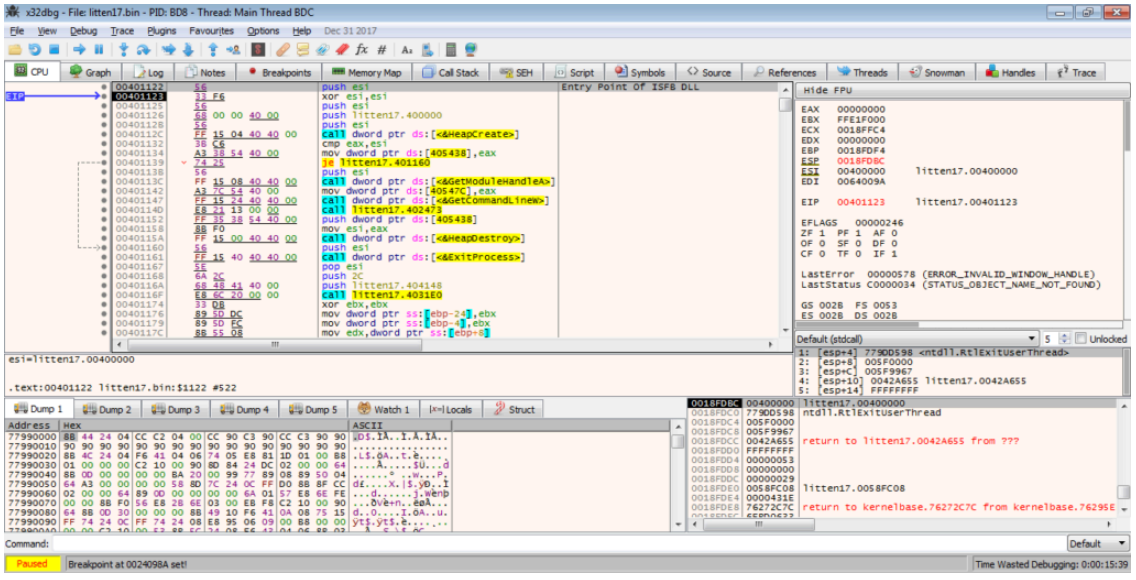
Therefore, we can simply return from this function, as it is just importing API's, which isn't extremely important to us yet. After exiting the function, there are several calls to API's, in particular **VirtualProtect**. **VirtualProtect** is responsible for changing the permissions/protection of different memory regions, so that they are readable, writable, or executable (can be one, two, or all three). In this case, we can see that **VirtualProtect** is being used to change the protection of the memory region at **0x00406000**, which is the **.BSS** section. As I mentioned before, this unpacker overwrites itself with the unpacked executable, so it is safe to say that we are extremely close to the unpacked EXE. We could dump it now, but there could be some extra unpacking going on, so let's wait until we jump to the **0x00400000** memory region.



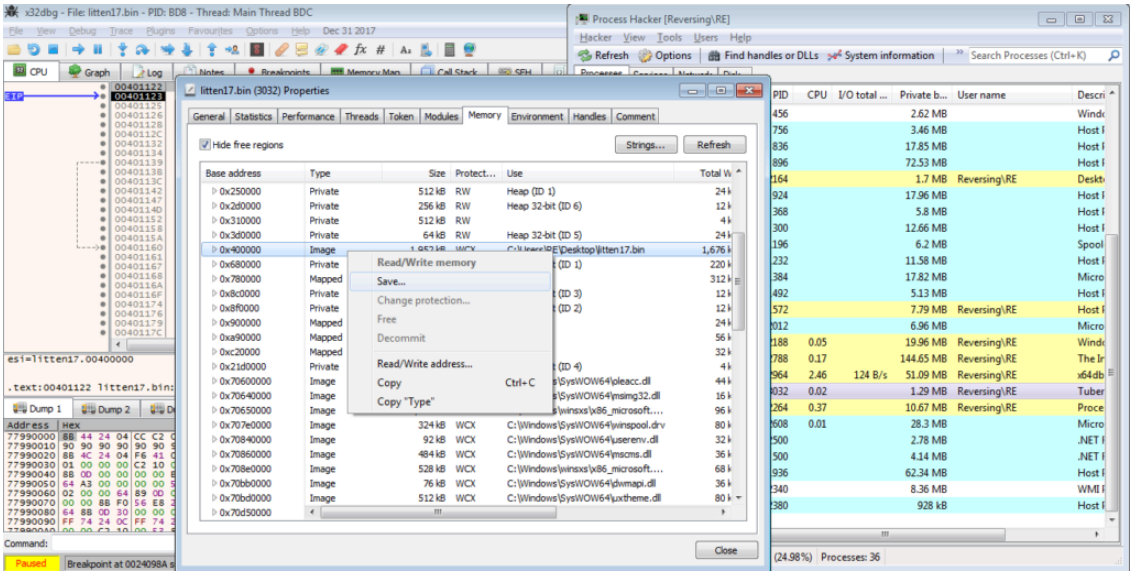
At this point, there isn't much going on in the function, so we can simply put a breakpoint on the **ret** instruction and return from this function.



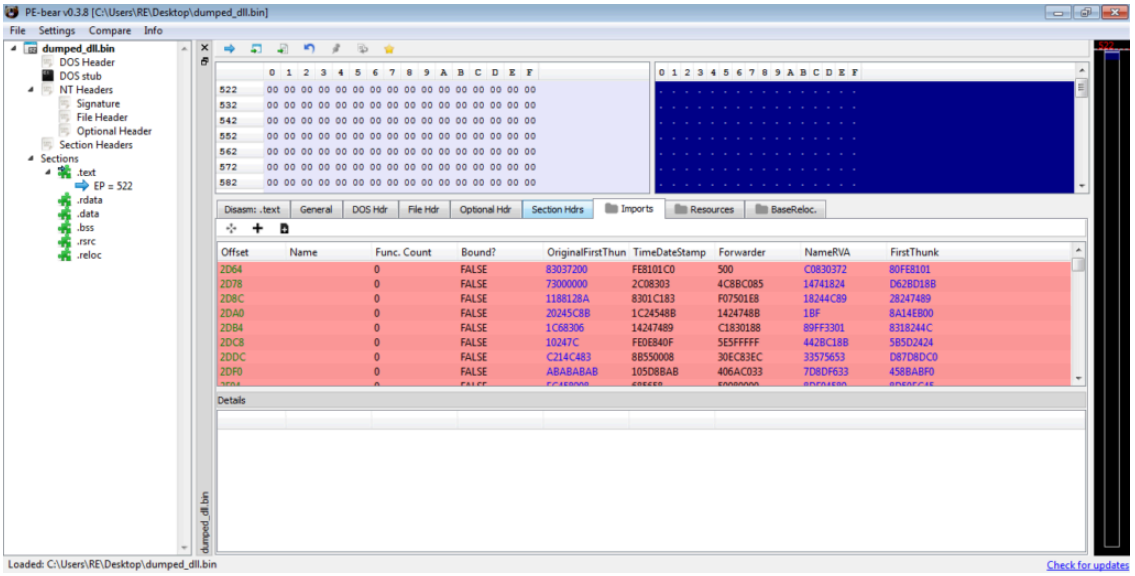
Upon exiting the function, you'll notice the memory address is in the **0x00401000** region. This is the unpacked program! Now we can dump it out, so make sure you have Process Hacker open, although you can dump it from x32dbg.



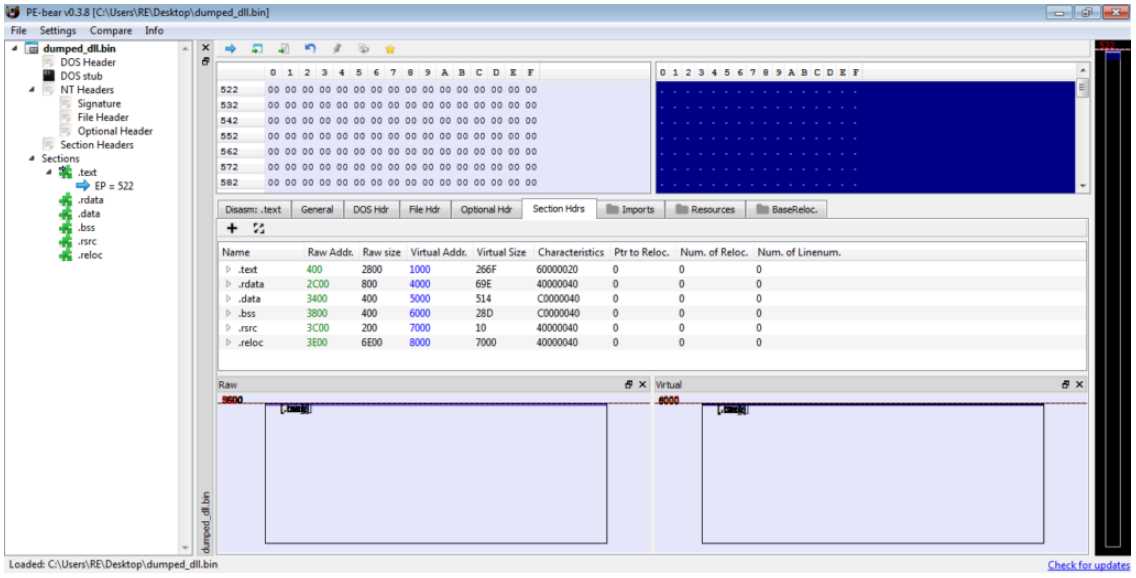
To dump it from memory, simply double click the process in Process Hacker, and right click the **0x400000** region of memory, and select **Save**.



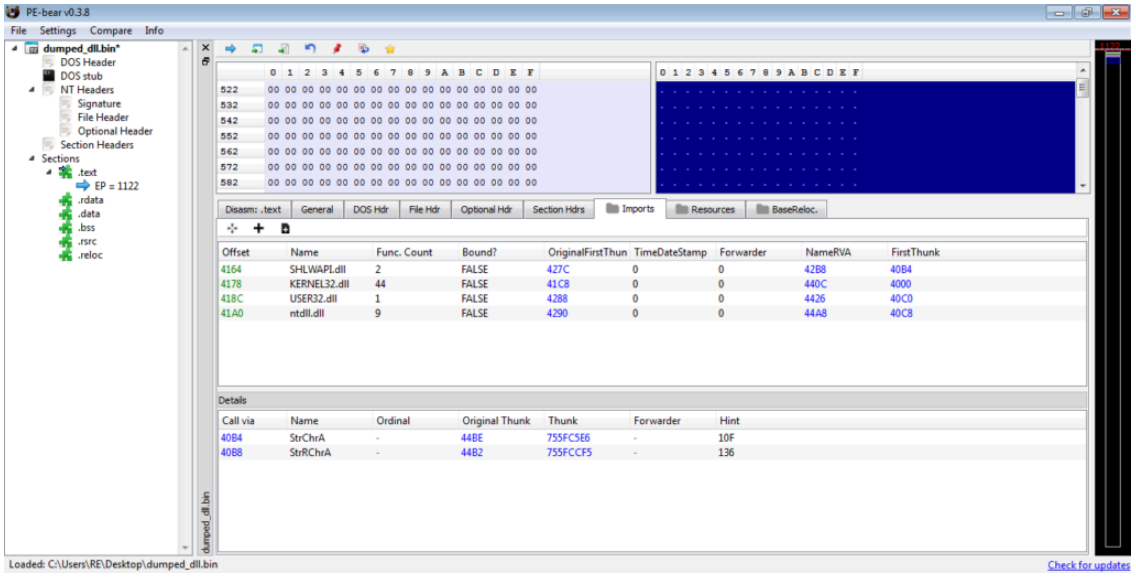
Now we can open it up in PEBear and unmap the dumped file. Upon doing so, you can see that the imports have not been successfully resolved by PEBear. This is why we need to unmap the file. When a program is about to be executed, it needs to be mapped in memory, so that it can be interpreted correctly. Therefore, PEBear is unable to resolve the imports until we unmap it.

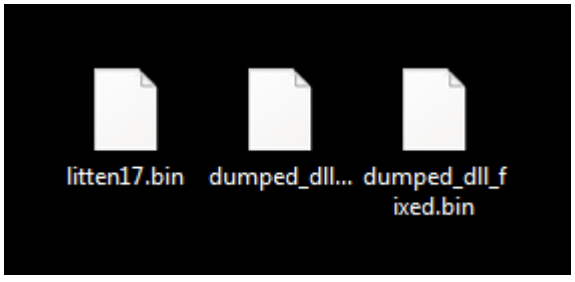


To do so, we simply change the **Raw Addr.** so that it matches the **Virtual Addr.**, and then change the **Raw Size** accordingly. This should result in something looking like the image below.



We can check the imports and sure enough, there are 4 imported DLL's, meaning we have the correctly unmapped file. We can now save this to the desktop and congratulations! You have now successfully unpacked the first stage! Let's open it up in IDA for further analysis!

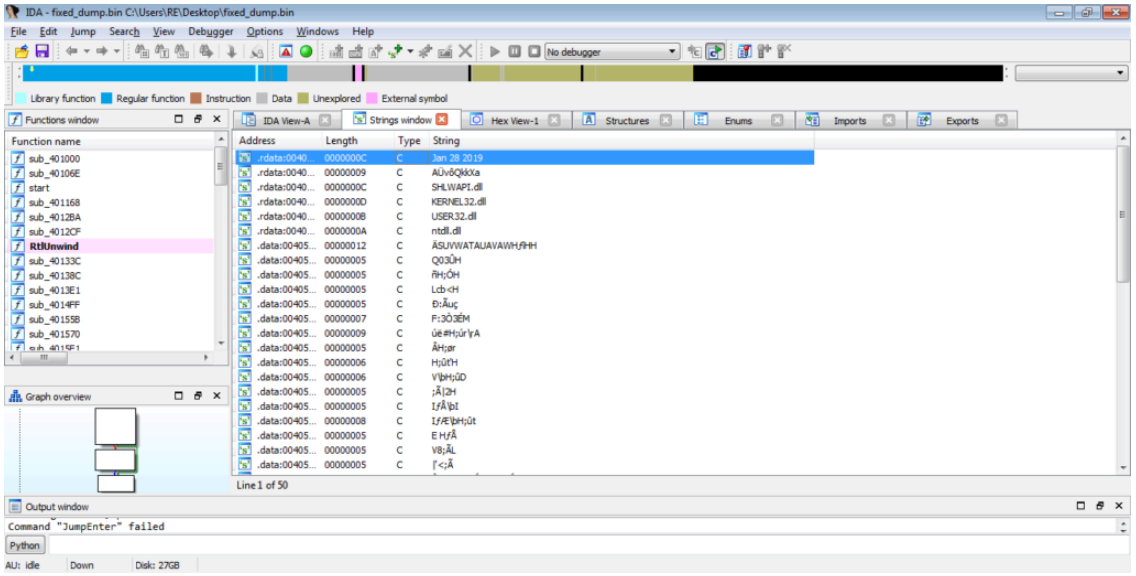




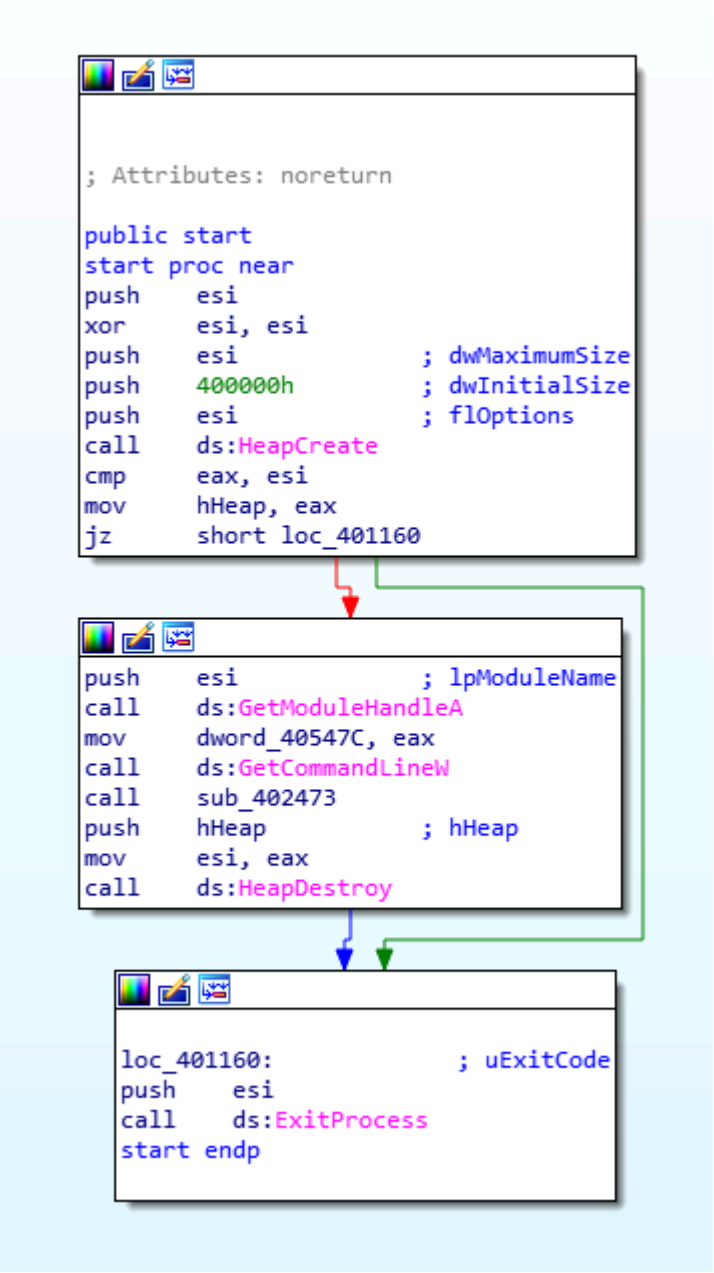
Part 2: Analysing the Dumped Executable

```
MD5 of Dumped Executable: 0063316975e55c765cd12e3d91820478
```

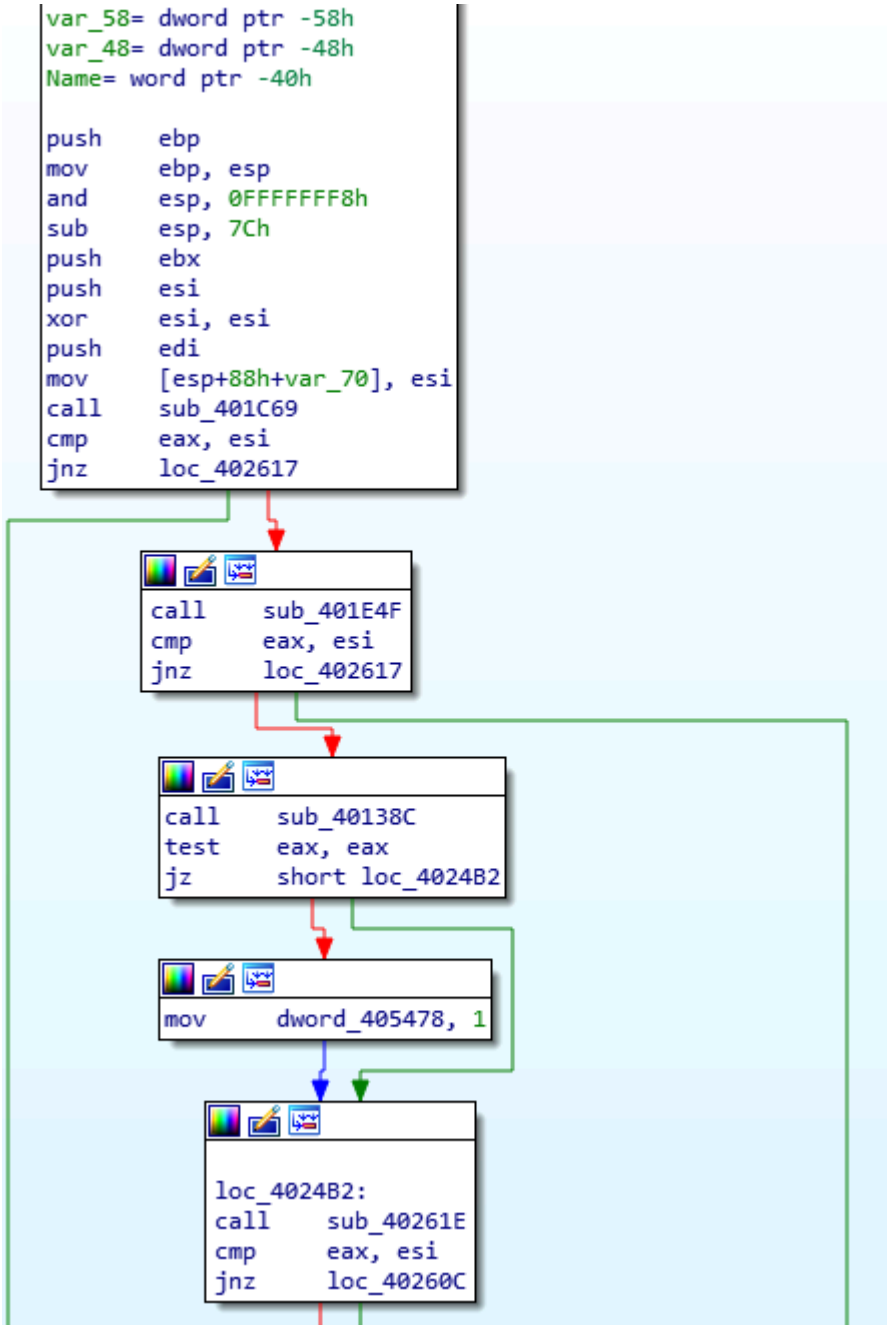
Upon opening the file in IDA, we can see that the main function only calls one local function and then exits, so it's not too difficult to find the malicious code. If you're not sure if a certain sample is ISFB or not, one telltale sign can be found in the strings window. Most, if not all, ISFB payloads (version 2 – haven't taken a look at version 3 yet so not sure) store a compile/campaign start date in plaintext that is used for string decryption. In this sample, the date is **Jan 28 2019**, so a relatively new sample at the time of writing this. I will go over the string decryption method soon, but first let's take a look at what happens first in the function.

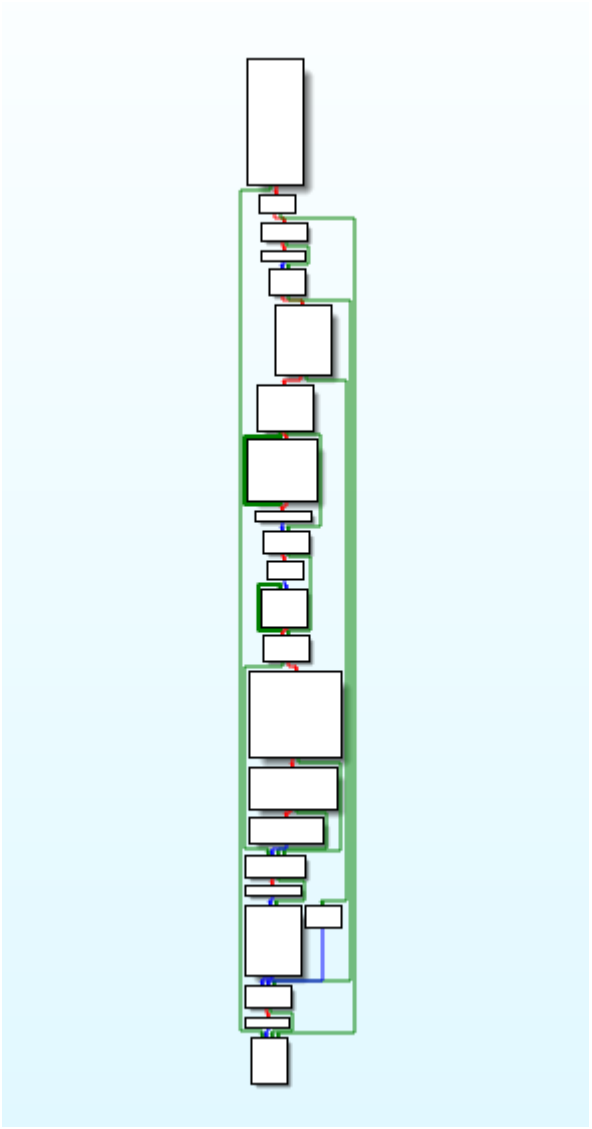


Strings

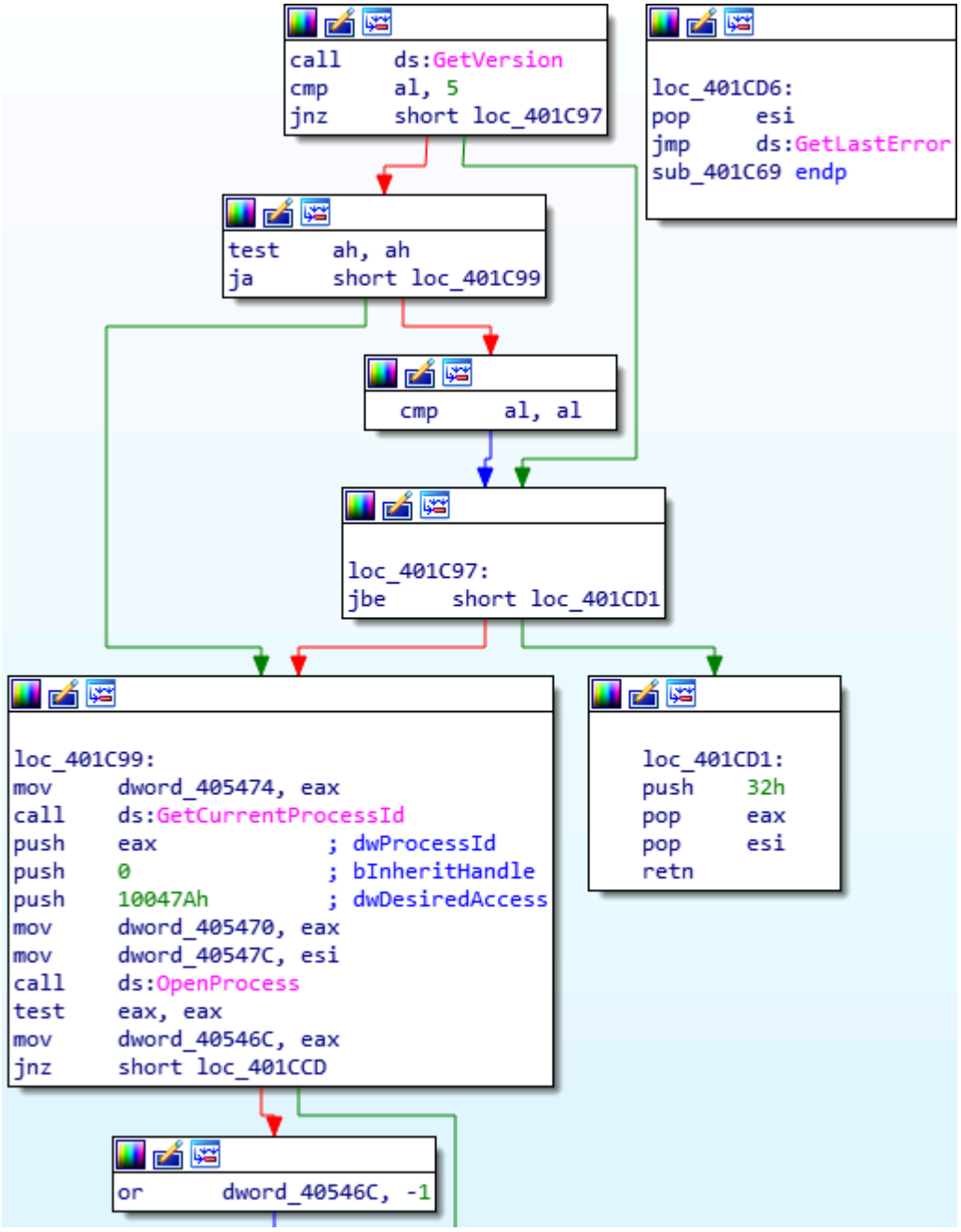


There are several functions called inside this function, so let's take it section by section, so first let's take a look at the first four functions. From the image below, it is clear that the return value of **sub_401C69** (stored in **eax**) needs to match the value in **esi**, otherwise it will jump to the exit. The second called function – **sub_401E4F** – seems to do the same thing. The third function seems to be a check for something, as **1** is moved into a DWORD based on the result of a bit-wise AND (**test** performs a bit-wise AND on the two values, however it just sets flags based on the result, which is not stored) on **eax**. Finally, the fourth function seems to act in the same way as the first and second function, in the sense that the returned value is compared to the value in **esi**, and it will exit if the conditions are not met. Anyway, enough assuming, let's actually take a look at these functions.

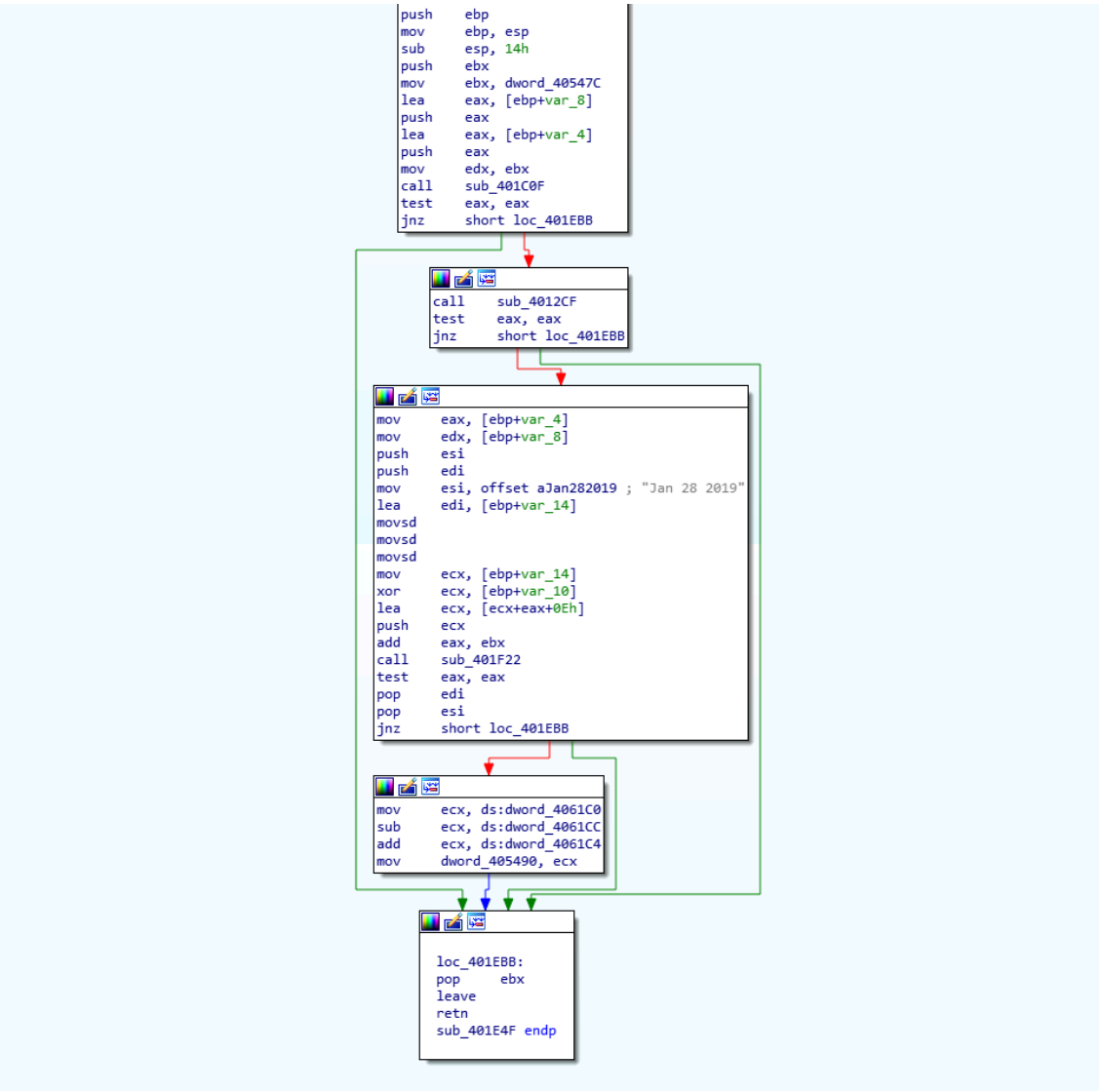

var_58= dword ptr -58h
var_48= dword ptr -48h
Name= word ptr -40h
push ebp
mov ebp, esp
and esp, 0FFFFFFF8h
sub esp, 7Ch
push ebx
push esi
xor esi, esi
push edi
mov [esp+88h+var_70], esi
call sub_401C69
cmp eax, esi
jnz loc_402617
call sub_401E4F
cmp eax, esi
jnz loc_402617
call sub_40138C
test eax, eax
jz short loc_4024B2
mov dword_405478, 1
loc_4024B2:
call sub_40261E
cmp eax, esi
jnz loc_40260C



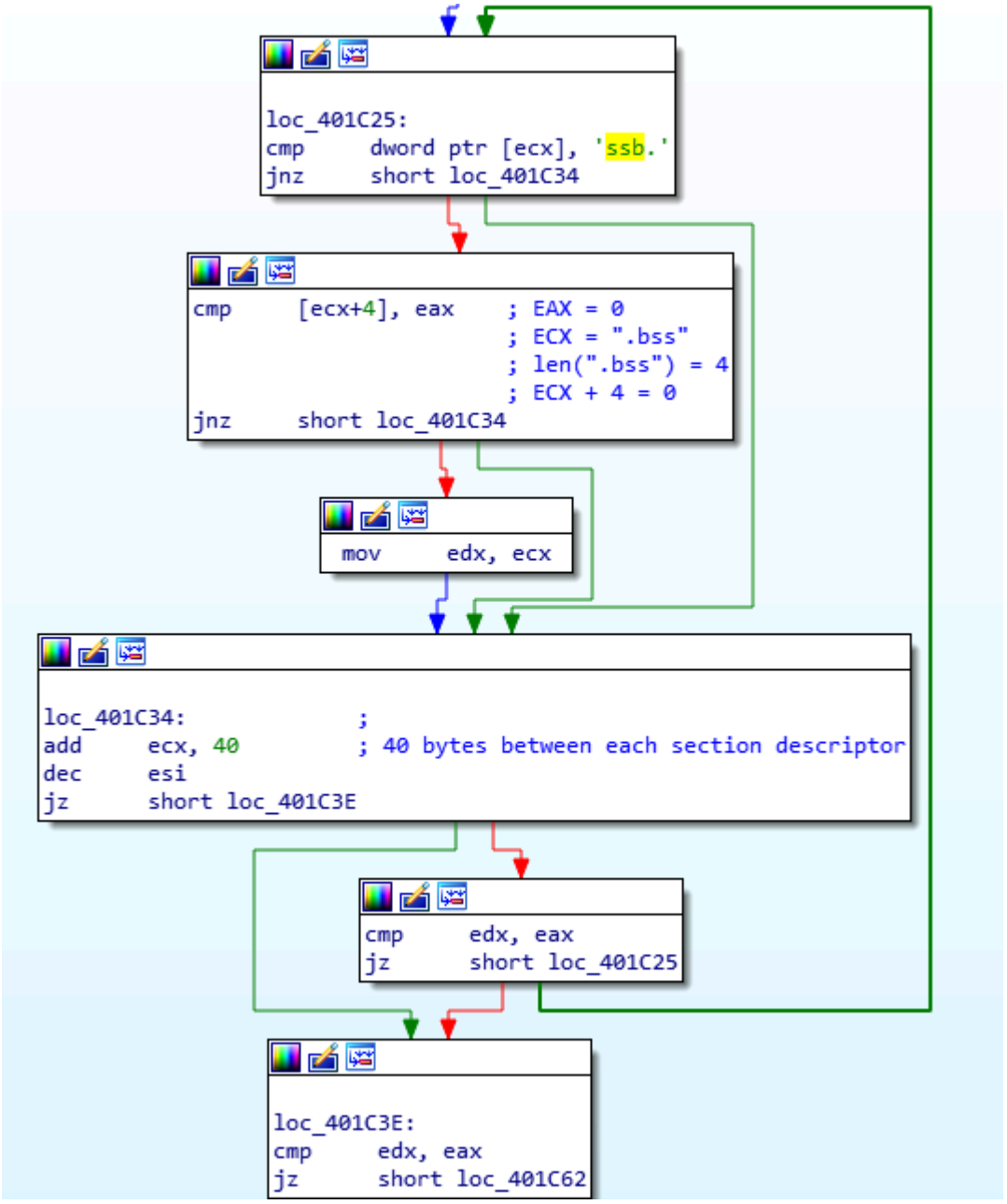
Taking a look at the first function (the main bit), we can see that the malware is opening it's own process and storing the handle in a DWORD, which is set to **-1** if the malware failed to open the process. This then returns back to the main function, where the returned result is compared against the value in **ESI**.

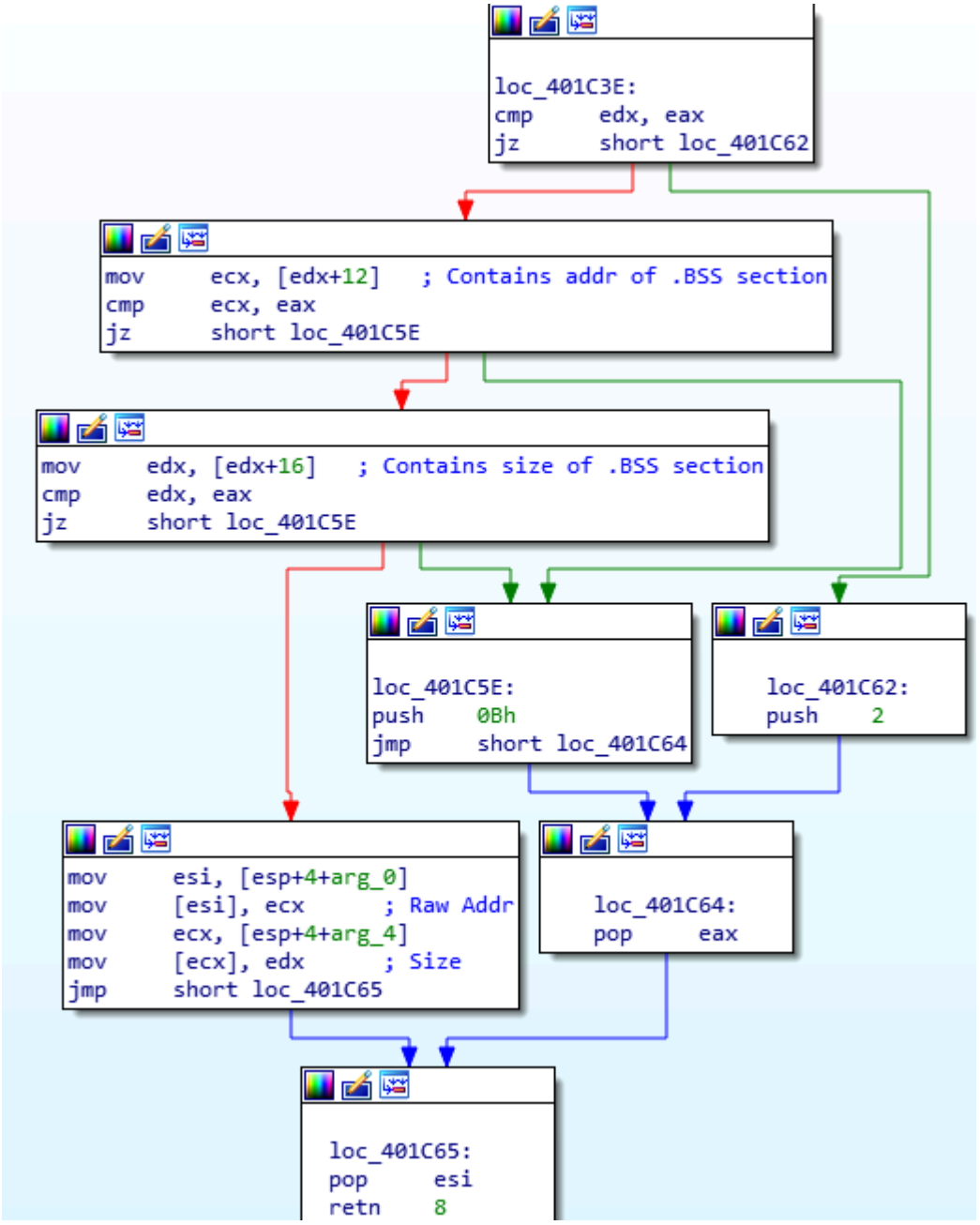


The second function is where things start to get interesting. In the image below, you'll notice the compile date being moved into **ESI**, which, as I mentioned before, is used for string decryption. You might already know this, but for those that don't, ISFB contains a **.BSS** section, which contains multiple strings that are all encrypted using a ROR-XOR algorithm. The XOR key is calculated based on a given date, and in order to decrypt the strings, ISFB needs to perform the calculations again to get the correct key, allowing us to easily reverse it. But first, let's take a look at the two functions called beforehand.

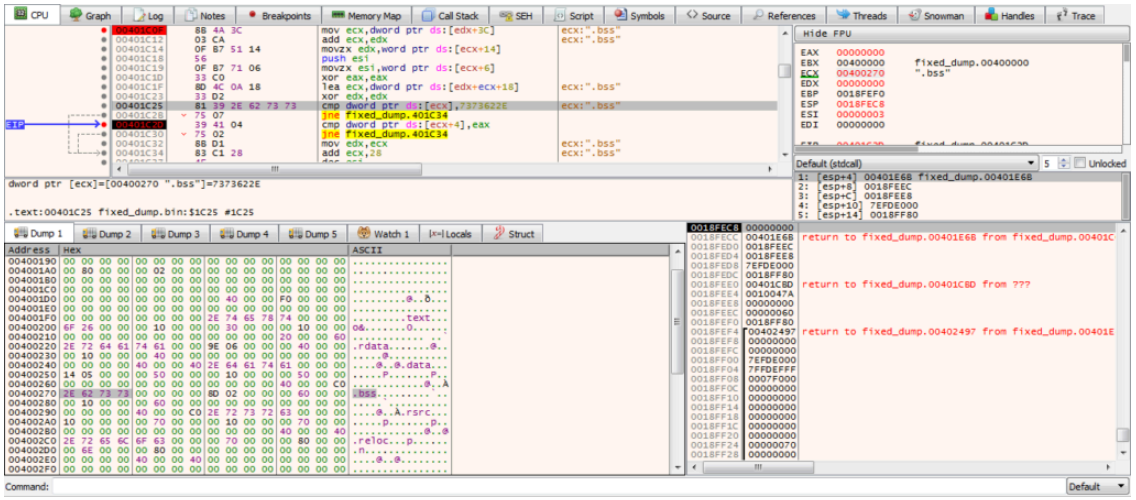


Looking at the first function, you'll notice **ssb.** (endian issues, as it is stored as hex – actually is **.bss**) being compared to the value at **[ECX]**, inside a loop. In order to decrypt the strings in the .BSS section, ISFB must first locate the .BSS section, and in order to do so, it simply reads it's own PE header and gets the size and address of the required section. If the value at **[ECX]** doesn't match **.bss**, **40** is added the the memory address in **ECX**, due to the fact that the spacing between the section descriptors/structures (**.text**, **.data**, etc.) is 40 bytes. The loop will the continue. If there is a match, the length of the string is checked, making sure that it is not longer than 4 bytes. The malware does this by checking the byte after the string, and comparing it to zero. If the string is the correct length, the memory address pointing to "**.bss**" is moved into **EDX**. If everything is successful, ISFB will get the address and size of the .BSS section and store it in memory. In this case, the address is **0x6000** (add this to the image base and you will be able to locate it), and the size is **0x1000**. If this is still difficult to understand, there is an image of what the section table looks like in x32dbg – this should help you to understand how it is able to get the address and size.


loc_401C25:
cmp dword ptr [ecx], 'ssb.'
jnz short loc_401C34
cmp [ecx+4], eax ; EAX = 0
; ECX = ".bss"
; len(".bss") = 4
; ECX + 4 = 0
jnz short loc_401C34
mov edx, ecx
loc_401C34: ;
add ecx, 40 ; 40 bytes between each section descriptor
dec esi
jz short loc_401C3E
cmp edx, eax
jz short loc_401C25
loc_401C3E:
cmp edx, eax
jz short loc_401C62



Function: sub_401C0F #2



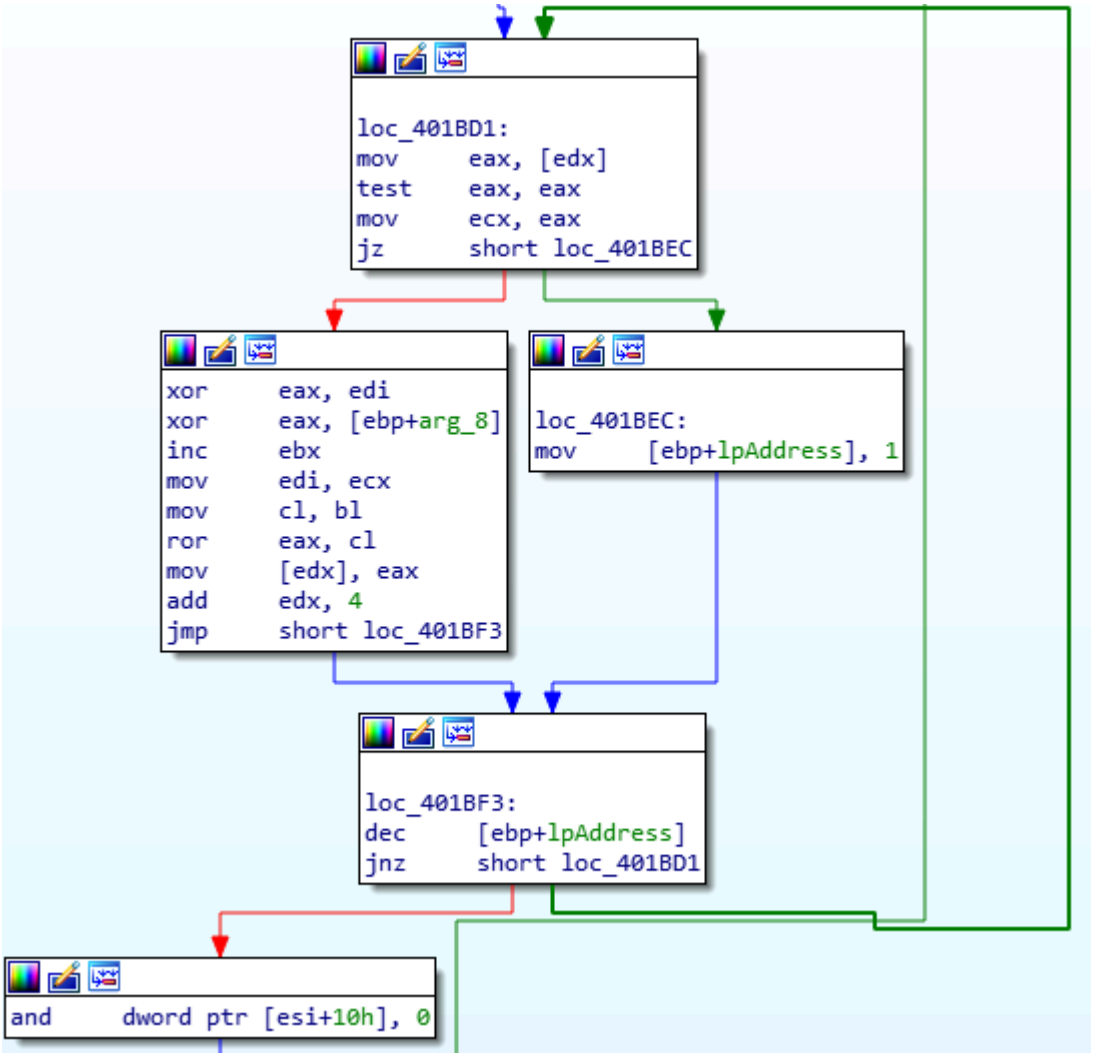
With that function analysed, let's move onto the next one. The main purpose of this function is to add a vectored exception handler using **AddVectoredExceptionHandler**. The second argument is a pointer to the handler function that will be executed when the program runs into an exception, so lets take a look at the function **Exception_Handle_Function**.q

```
signed int sub_4012CF()
{
  struct _RTL_CRITICAL_SECTION *v0; // eax
  struct _RTL_CRITICAL_SECTION *Critical_Section; // esi
  DWORD v2; // eax
  int v3; // eax
  DWORD v4; // edi

  v0 = (struct _RTL_CRITICAL_SECTION *)Allocate_Heap(0x28u);
  Critical_Section = v0;
  if ( !v0 )
    return 8;
  v0[1].LockCount = (LONG)&v0[1];
  v0[1].DebugInfo = (PRTL_CRITICAL_SECTION_DEBUG)&v0[1];
  InitializeCriticalSection(v0);
  v2 = TlsAlloc();
  Critical_Section[1].OwningThread = (HANDLE)v2;
  if ( v2 != -1
    && (v3 = AddVectoredExceptionHandler(1, Exception_Handle_Function), (Critical_Section[1].RecursionCount = v3) != 0) )
  {
    lpCriticalSection = Critical_Section;
    v4 = 0;
  }
  else
  {
    v4 = GetLastError();
    if ( v4 )
      Remove_Exception_And_VirtualProtect(Critical_Section);
  }
  return v4;
}
```

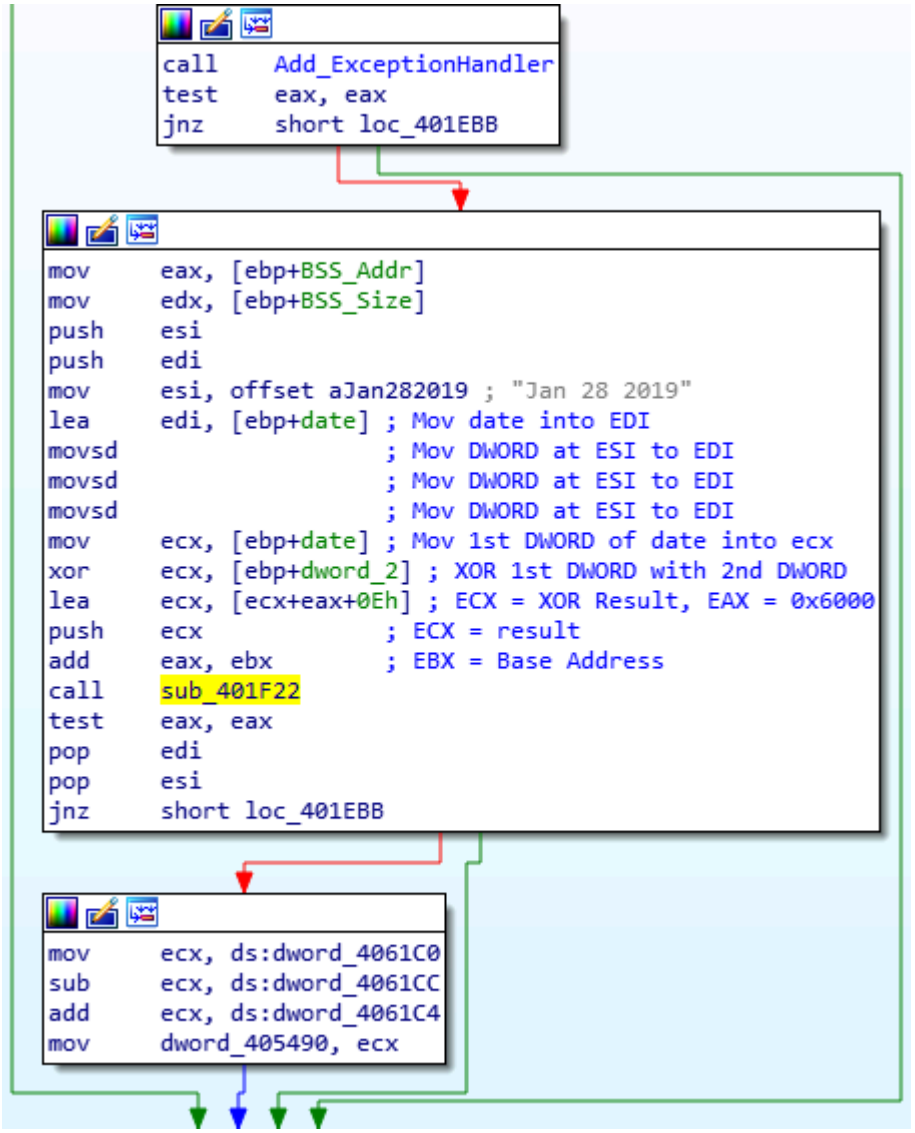
This function checks the value of the exception – whether it is an **EXCEPTION_ACCESS_VIOLATION** or **EXCEPTION_SINGLE_STEP**, however they both end up executing the same function, so lets move into that function.

```
signed int __stdcall Exception_Handle_Function(int **a1)
{
  int v1; // ebp
  LPCRITICAL_SECTION v2; // ebx
  int *v3; // ecx
  int v4; // edx
  void *v5; // edi
  DWORD *v6; // esi
  void *v7; // eax

  v1 = 0;
  v2 = lpCriticalSection;
  if ( lpCriticalSection )
  {
    v3 = *a1;
    v4 = **a1;
    if ( v4 == 0xC0000005 )
    {
      v5 = (void *)v3[6];
      if ( !sub_401B36(lpCriticalSection, (LPVOID)v3[6], 1) )
      {
        TlsSetValue((DWORD)v2[1].OwningThread, v5);
        a1[1][48] |= 0x100u;
        return -1;
      }
    }
    else if ( v4 == 0x80000004 )
    {
      v6 = (DWORD *)&lpCriticalSection[1].OwningThread;
      v7 = TlsGetValue((DWORD)lpCriticalSection[1].OwningThread);
      if ( v7 )
      {
        if ( !sub_401B36(v2, v7, 0) )
        {
          TlsSetValue(*v6, 0);
          return -1;
        }
      }
    }
  }
  return v1;
}
```

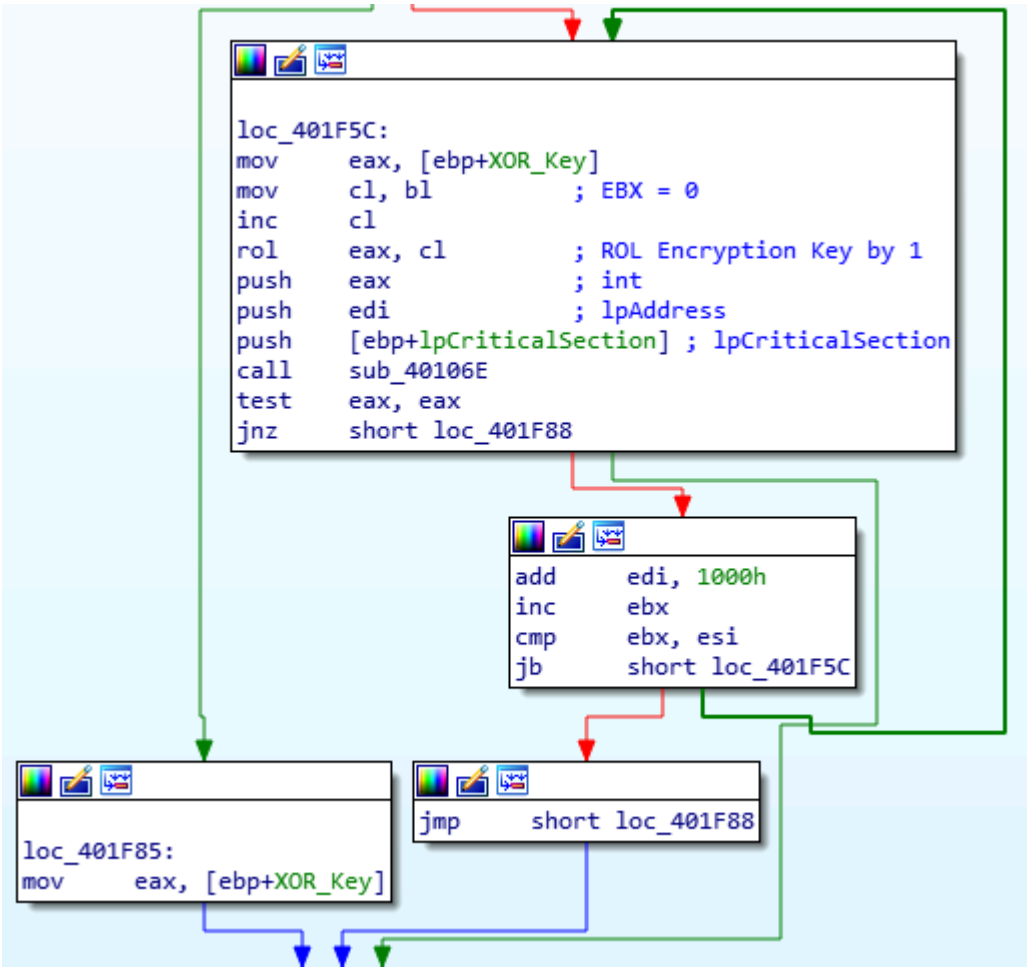
The important part of this function happens soon after it is executed. In the image below, you'll be able to make out a loop, as well as two XOR instructions and a ROR instruction. This is the BSS section decryption – the XOR key that is created later on is actually **arg_8**, so take note of that. So, now we know that there will be an exception that is caused at some point, which will in turn execute the BSS string decryption function. Now we have this information, we can move onto reversing how the XOR key is created from the compilation/campaign date.



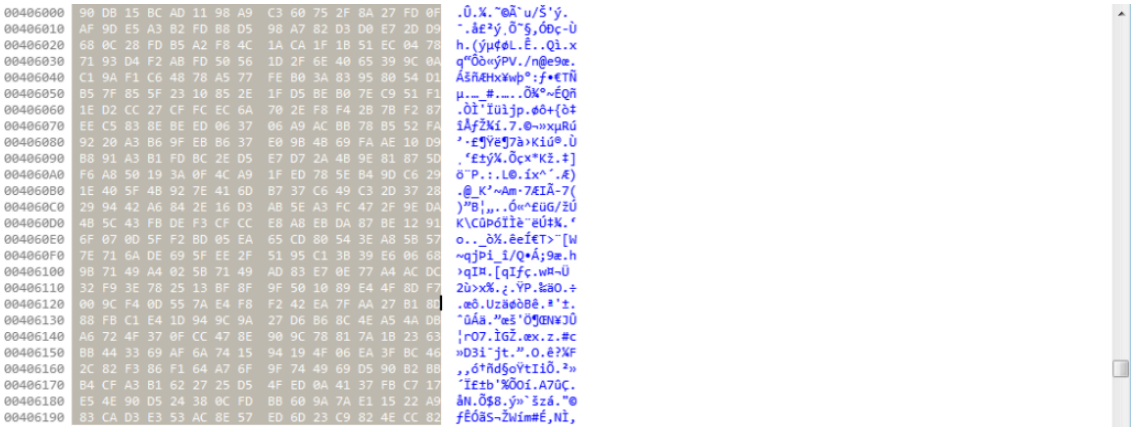
As the XOR key is based off of the date, thats where we need to look. First, the address of the BSS section (**0x6000**) is moved into EAX, and the size of it (**0x1000**) is moved into EDX. Then, the memory address of the compile date is moved into ESI, and a memory address (pointing to an empty section of memory) is moved into EDI. The compile date is then moved into that empty region of memory, using **MOVSD**, which moves a DWORD from the memory address in ESI to the memory address in EDI. Next, the first DWORD of the compile date is moved into ECX, and this is XOR'ed against the second DWORD of the compile date. Then, the result of this is added to the address of the BSS section (**0x6000** here) and the value **0xE**. This is then pushed as the first argument for the next function that will be called.

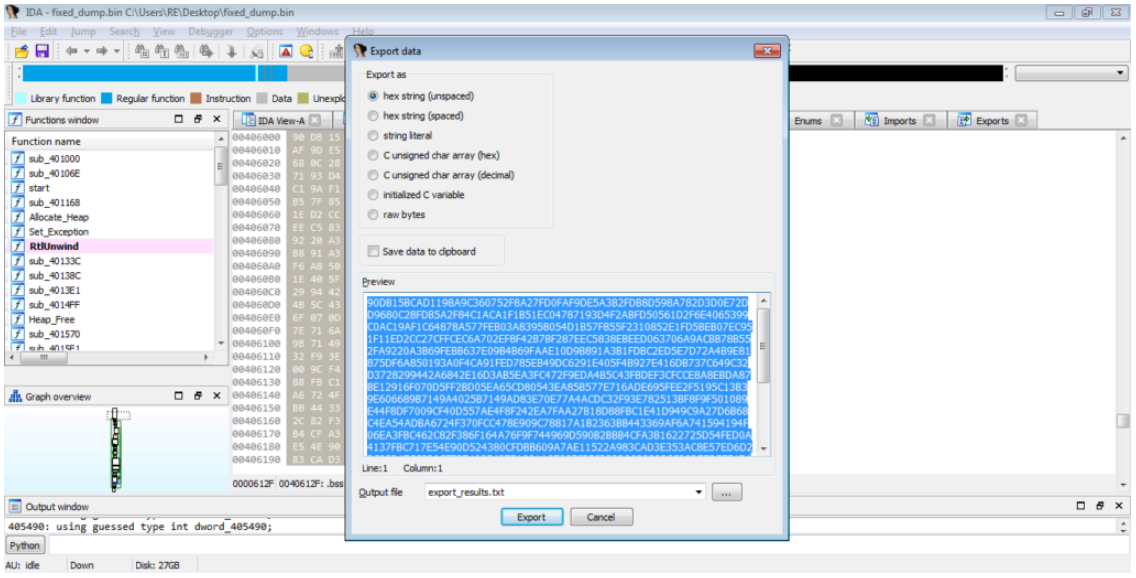


Taking a look at the function, **arg_0** (the XOR key) is used in a Rotate Left instruction. Here, we see BL being moved into CL, which is incremented by 1 and used to rotate the XOR key left by 1. This results in the final XOR key that is used to decrypt the BSS strings.



Once we have performed these calculations, we get this as the key: **0x249d730c**. Whilst it is possible to get the strings from a debugger and copy it over to an IDA instance, I prefer to replicate custom routines using Python. I'm currently polishing up the decryption script I have been using, and when it is complete, you can get it **here** (my GitHub). Simply put, the algorithm decrypts the data in DWORDs, using a mixture of XOR's and rotate right (ROR) instructions. First, we're going to want to copy out the data in the BSS section. View it in the hex editor mode, select the entire section (where there is data), and then go **Edit->Export Data**, and you can copy the unspaced data. Next, we need to parse this blob of data so that we can decrypt it.

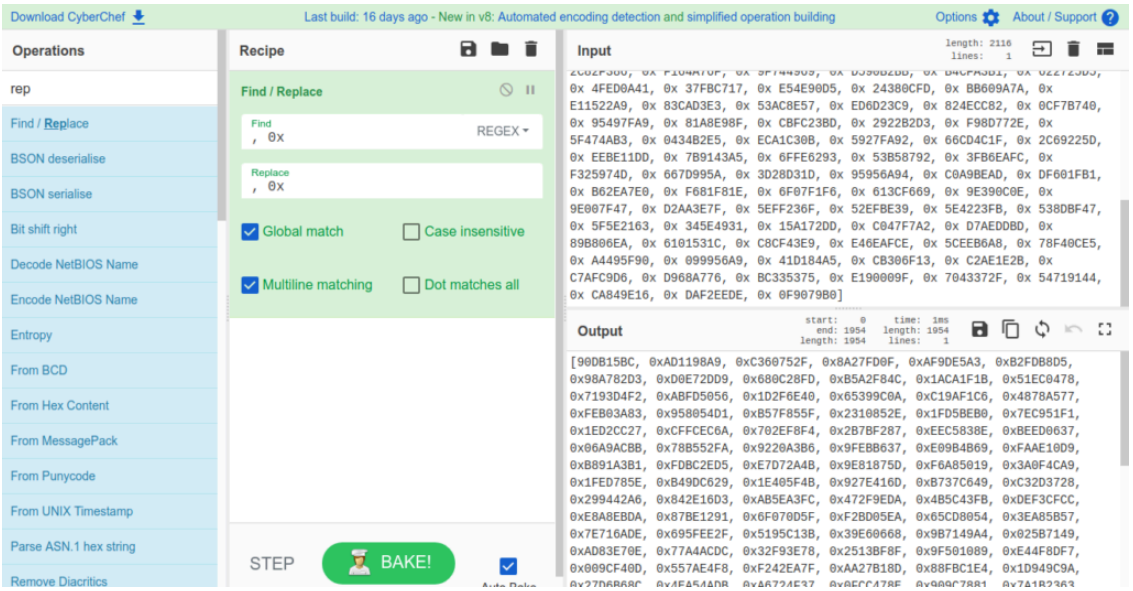




To parse it, I will be using python. All we need to do is split the hex bytes by 4, and store that in a list. This means each value will be a DWORD. If you follow the commands below, you should be able to get the output seen in the image.

```
r00t@ubuntu:~/Documents/Reverse Engineering/Tools/Malware/Hancitor+Ursnif/Ursnif/Ursnif_1$ python
Python 2.7.14+ (default, Dec  5 2017, 15:17:02)
[GCC 7.2.0] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> data = """90DB15BCAD1198A9C360752F8A27FD0FAF9DE5A3B2FDB8D598A782D3D0E72DD9680C28FDB5A2F84C1ACA1F1B51EC04787193D4F2ABFD50561D2F6E4065399C0AC1
9AF1C64878A577FEB03A83958054D1B57F855F2310852E1FD5BEB07EC951F11ED2CC27CFFCEC6A702EF8F42B7BF287EEC5838EBEED063706A9ACBB78B552FA9220A3B69FEBB637E0
9B4B69FAAE10D9B891A3B1FDBC2ED5E7D72A4B9E81875DF6A850193A0F4CA91FED785EB49DC6291E405F4B927E416DB737C649C32D3728299442A6842E16D3AB5EA3FC472F9EDA4B
5C43FBDEF3CFCCE8A8EBDA87BE12916F070D5FF2BD05EA65CD80543EA8SB577E716ADE695FEE2F5195C13B39E606689B7149A4025B7149AD83E70E77A4ACDC32F93E782513BF8F9F
501089E44F8DF7009CF40DS57AE4F8F242EA7FAA27B18D88FBC1E41D949C9A27D6B68C4EA54ADBA6724F370FCC478E909C78817A1B2363BB443369AF6A741594194F06EA3FBC462C
82F386F164A76F9F744969D590B2BBB4CFA3B1622725D54FED0A4137FBC717E54E90D524380CFDBB609A7AE11522A983CAD3E353AC8E57ED6D23C9824ECC820CF7B74095497FA981
A8E98FCBFC23BD2922B2D3F98D772E5F474AB30434B2E5ECA1C30B5927FA9266CD4C1F2C69225DEEBE11DD7B9143A56FFE629353B587923FB6EAFCF325974D667D995A3D28D31D95
956A94C0A9BEADDF601FB1B62EA7E0F681F81E6F07F1F6613CF6699E390C0E9E007F47D2AA3E7F5EFF236F52EFBE395E4223FB538DBF475F5E2163345E493115A172DDC047F7A2D7
AEDDBD89B806EA6101531CC8CF43E9E46EAFCE5CEEB6A878F40CE5A4495F90099956A941D184A5CB306F13C2AE1E2BC7AFC9D6D968A776BC335375E190009F7043372F54719144CA
849E16DAF2EEDE0F9079B0"""
>>> len(data)
1304
>>> n = 8
>>> [data[i:i+n] for i in range(0, len(data), n)]
['90DB15BC', 'AD1198A9', 'C360752F', '8A27FD0F', 'AF9DE5A3', 'B2FDB8D5', '98A782D3', 'D0E72DD9', '680C28FD', 'B5A2F84C', '1ACA1F1B', '51EC0478',
 '7193D4F2', 'ABFD5056', '1D2F6E40', '65399C0A', 'C19AF1C6', '4878A577', 'FEB03A83', '958054D1', 'B57F855F', '2310852E', '1FD5BEB0', '7EC951F1',
 '1ED2CC27', 'CFFCEC6A', '702EF8F4', '2B7BF287', 'EEC5838E', 'BEED0637', '06A9ACBB', '78B552FA', '9220A3B6', '9FEBB637', 'E09B4B69', 'FAAE10D9',
 'B891A3B1', 'FDBC2ED5', 'E7D72A4B', '9E81875D', 'F6A85019', '3A0F4CA9', '1FED785E', 'B49DC629', '1E405F4B', '927E416D', 'B737C649', 'C32D3728',
 '299442A6', '842E16D3', 'AB5EA3FC', '472F9EDA', '4B5C43FB', 'DEF3CFCC', 'E8A8EBDA', '87BE1291', '6F070D5F', 'F2BD05EA', '65CD8054', '3EA85B57',
 '7E716ADE', '695FEE2F', '5195C13B', '39E60668', '9B7149A4', '025B7149', 'AD83E70E', '77A4ACDC', '32F93E78', '2513BF8F', '9F501089', 'E44F8DF7',
 '009CF40D', '557AE4F8', 'F242EA7F', 'AA27B18D', '8BFBC1E4', '1D949C9A', '27D6B68C', '4EA54ADB', 'A6724F37', '0FCC478E', '909C7881', '7A1B2363',
 'BB443369', 'AF6A7415', '94194F06', 'EA3FBC46', '2C82F386', 'F164A76F', '9F744969', 'D590B2BB', 'B4CFA3B1', '622725D5', '4FED0A41', '37FBC717',
 'E54E90D5', '24380CFD', 'BB609A7A', 'E11522A9', '83CAD3E3', '53AC8E57', 'ED6D23C9', '824ECC82', '0CF7B740', '95497FA9', '81A8E98F', 'CBFC23BD',
 '2922B2D3', 'F98D772E', '5F474AB3', '0434B2E5', 'ECA1C30B', '5927FA92', '66CD4C1F', '2C69225D', 'EEBE11DD', '7B9143A5', '6FFE6293', '53B58792',
 '3FB6EAFC', 'F325974D', '667D995A', '3D28D31D', '95956A94', 'C0A9BEAD', 'DF601FB1', 'B62EA7E0', 'F681F81E', '6F07F1F6', '613CF669', '9E390C0E',
 '9E007F47', 'D2AA3E7F', '5EFF236F', '52EFBE39', '5E4223FB', '538DBF47', '5F5E2163', '345E4931', '15A172DD', 'C047F7A2', 'D7AEDDBD', '89B806EA',
 '6101531C', 'C8CF43E9', 'E46EAFCE', '5CEEB6A8', '78F40CE5', 'A4495F90', '099956A9', '41D184A5', 'CB306F13', 'C2AE1E2B', 'C7AFC9D6', 'D968A776',
 'BC335375', 'E190009F', '7043372F', '54719144', 'CA849E16', 'DAF2EEDE', '0F9079B0']
>>>
```

Next, we're going to use CyberChef to do a bit more fixing, although we will be replacing different characters, so that there is an **0x** before every DWORD, and so Python won't treat the list as a list of strings.

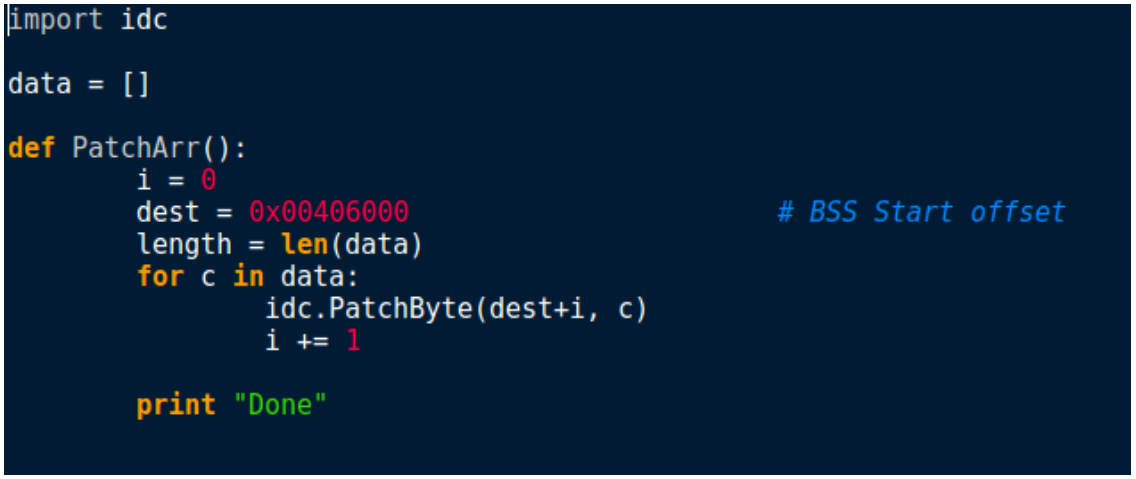


So now you should have a suitable list of hex DWORDs which we can then decrypt. In order to decrypt it, you simply have to copy it into the script and make sure the key is correct, and then it will decrypt and spit out the raw data, as well as a list of integers, and you will see why just now. In the image below, you can see the decryption part of my script, which isn't too complicated, so if it hasn't gone up on my GitHub yet, it shouldn't be too difficult to replicate.

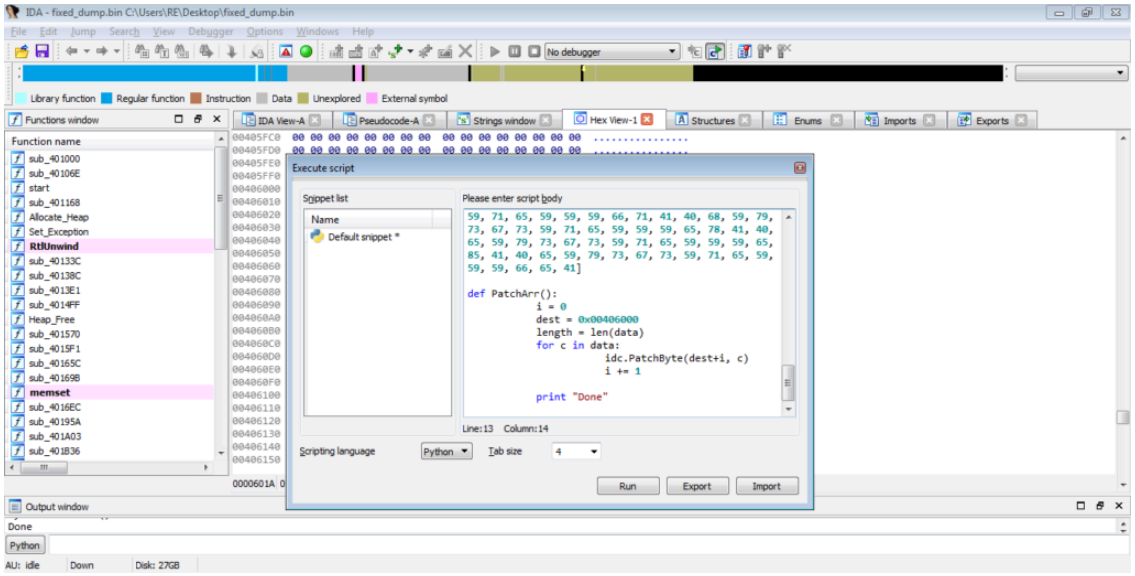
```
for i in range(len(encrypt)):
        '''
        mov eax, encrypt
        mov ecx, eax
            |
        xor eax, ebx                    - 4 bytes of encrypt are used as xor?
        xor eax, arg_4
        add encrypt, 4
        inc ror_counter
        mov ebx, ecx
        mov cl, byte ror_counter
        ror eax, cl
        mov decrypt, eax
        add decrypt, 4
        ------------------
        xor encrypt[i], encrypt[i]
        xor encrypt[i], arg_4
        inc ror_counter
        mov cl, byte ror_counter
        ror encrypt[i], cl
        mov decrypt, encrypt[i]
        '''
        try:
                encrypt[i] = swap32(encrypt[i])
        except Exception as E:
                print encrypt[i]
                print "Error!. Stopping Decryption."
                print E
                break
        test = encrypt[i] ^ ebx
        ebx = encrypt[i]
        test2 = test ^ arg_4
        ror_counter = ror_counter + 1
        test2 = ror(test2, ror_counter, 32)
        final_data = pack("<I", test2)
```

Once the script has decrypted the data, the output looks like this:

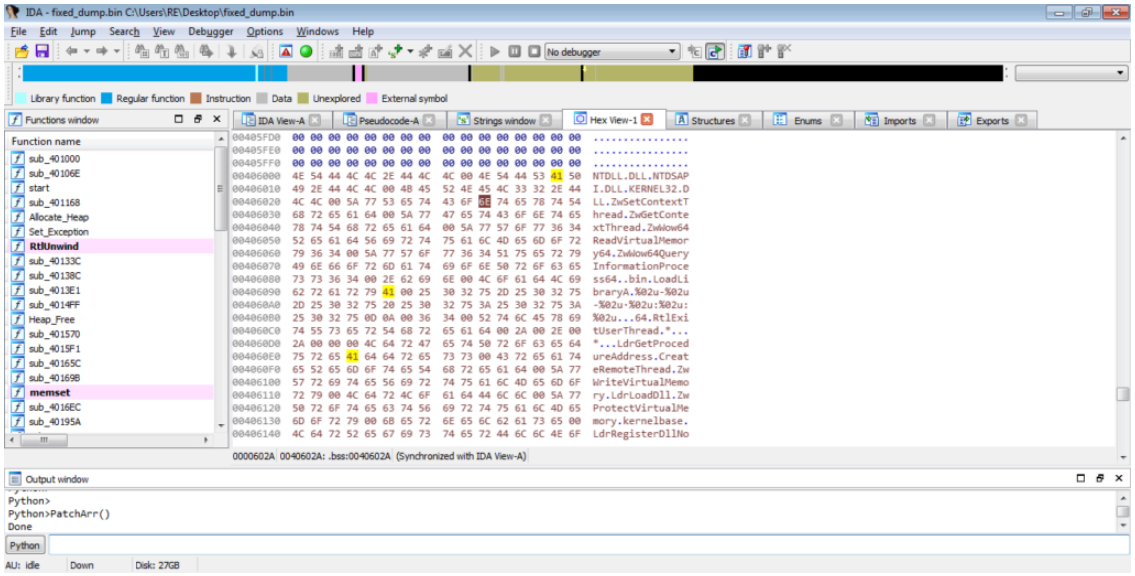
So now we can copy the decrypted strings over to IDA. There is an extremely basic IDA Python script in the image below, which overwrites bytes at **dest** with bytes of data in **data**. The list **data** will contain the integer values that our script printed to the terminal, so you can simply copy it from there and paste it into the document.



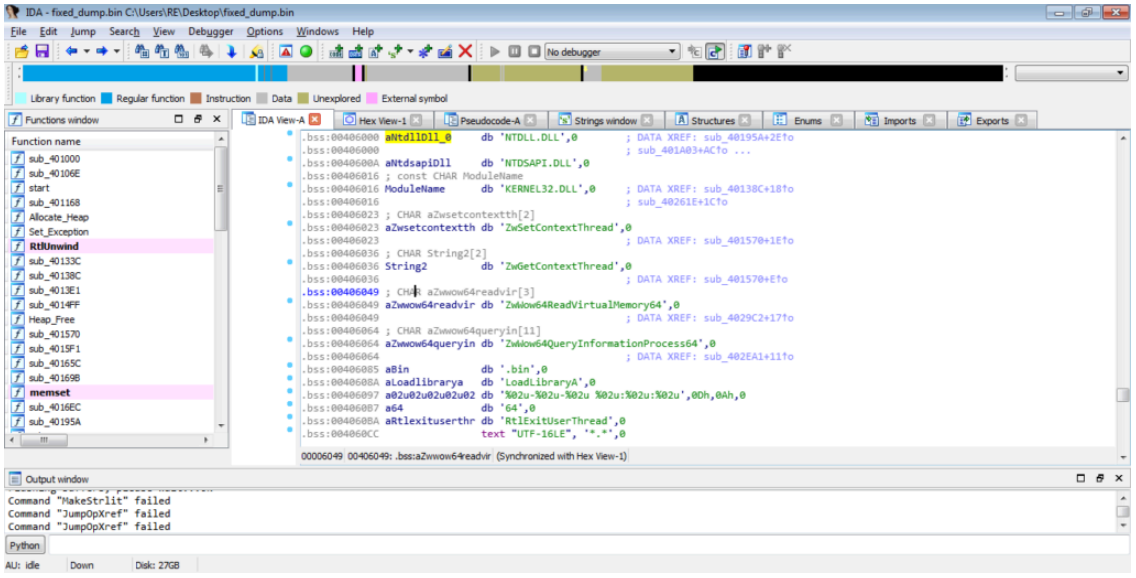
From there, we need to import it as a script/module in IDA, so you can do that either by importing the file, or by copying the text and pasting it into the box as shown below. All you need to do then is click **Run**, and it should be imported – although we physically have to call the script, **Run** won't execute it – at least not in this case.



Upon typing **PatchArr()** into the console and hitting enter, the script should overwrite all bytes in the BSS section with our decrypted strings, so you should see something similar to the image below.

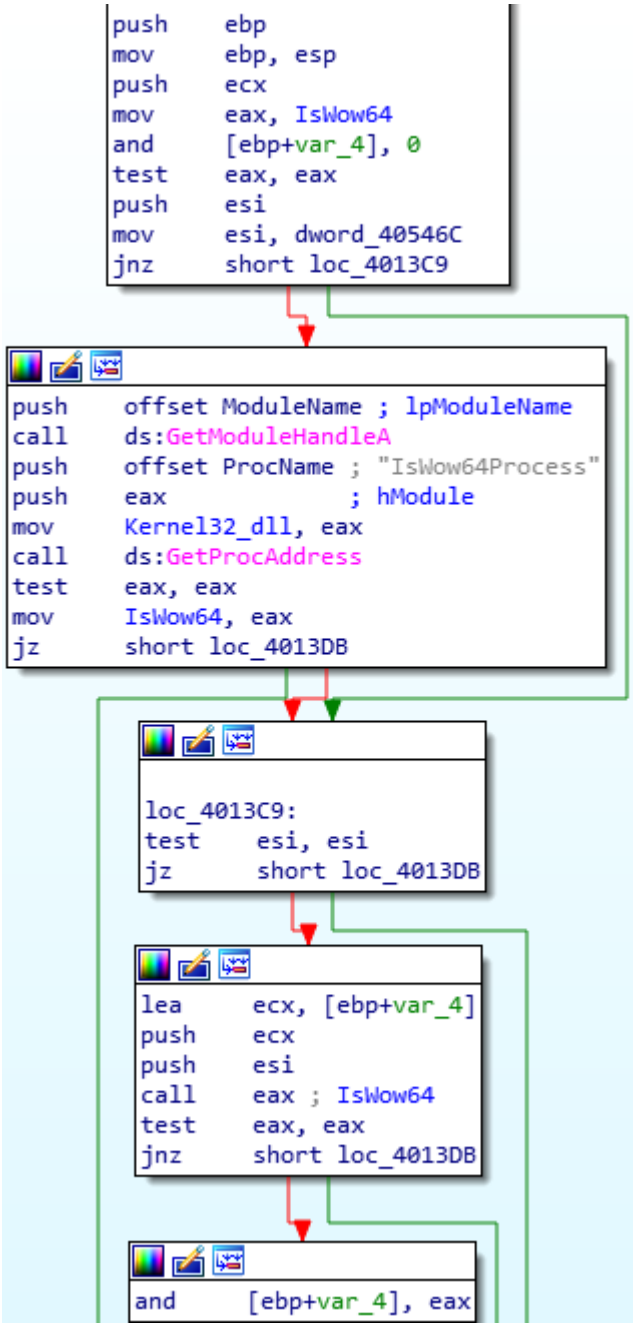


We can then reanalyse the payload, by going **Options->General->Analysis->Reanalyze Program**, and it should recognize most of the strings, although there will be the occasional error.

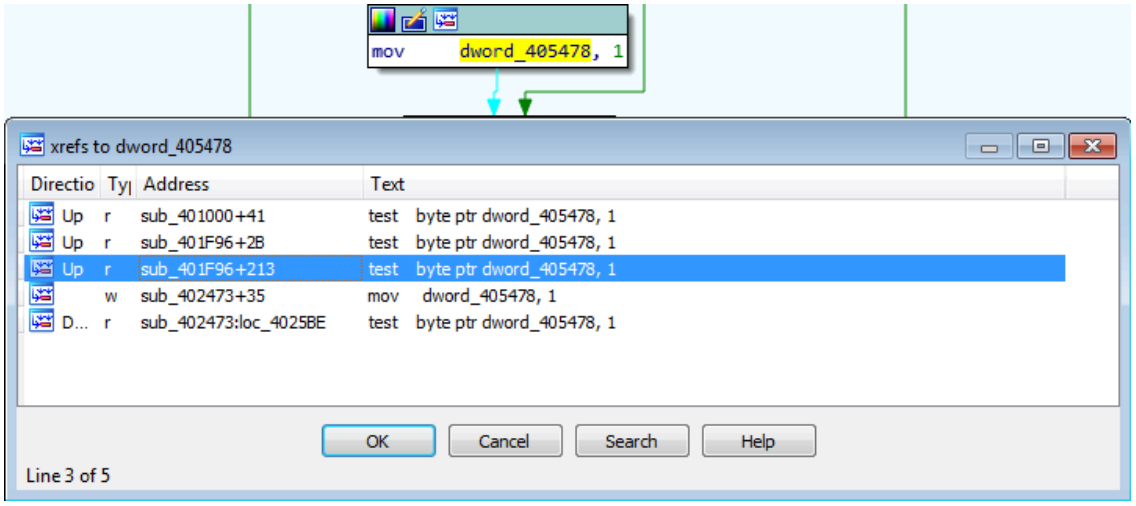


With the newly decrypted BSS section, we should be able to analyse the rest of the payload without issues.

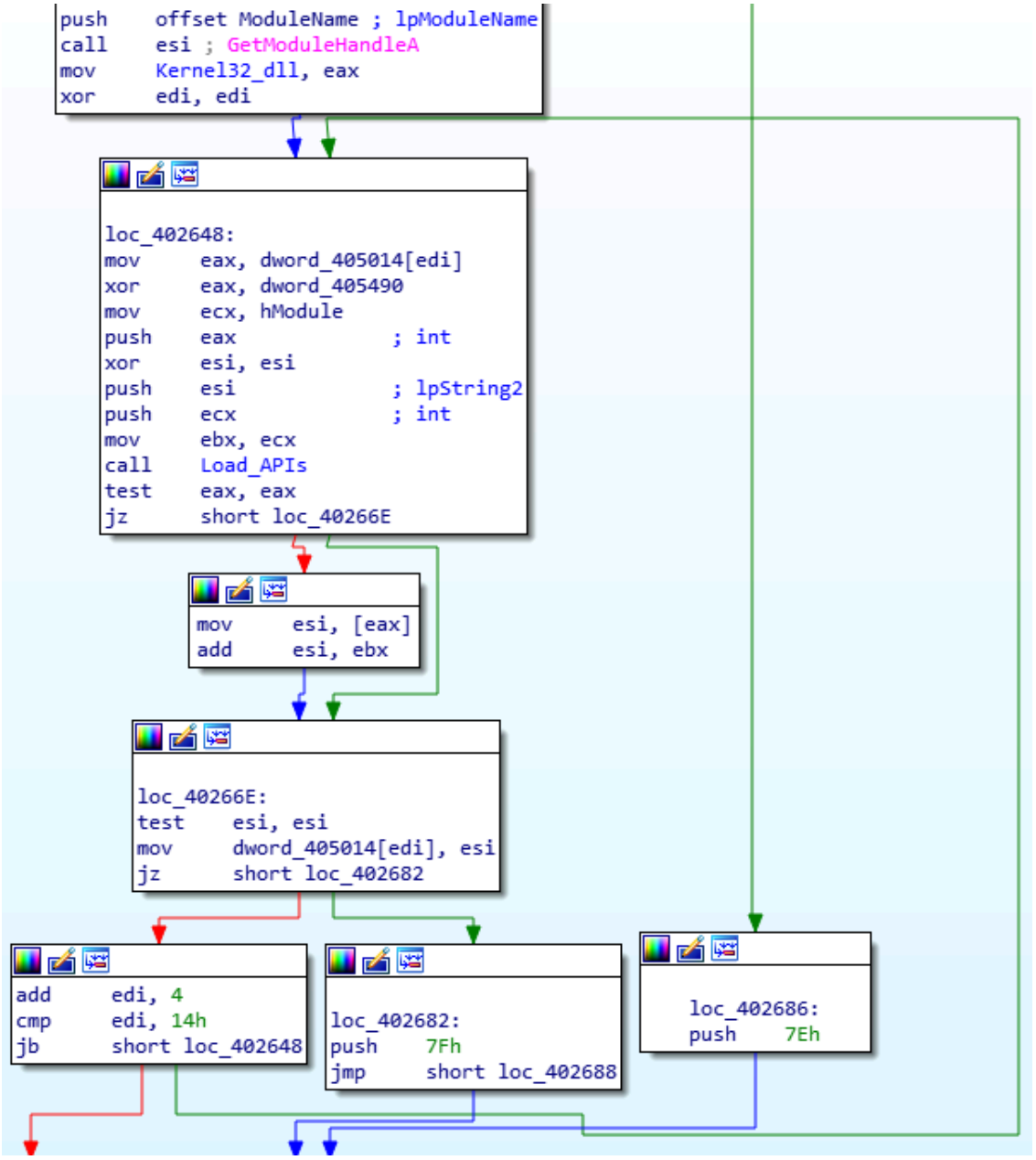
Once the strings have been decrypted, ISFB then calls a function that utilizes one of the decrypted strings – **IsWow64Process**. As you probably have guessed, this checks to see if the architecture of the system is 64 bit or not. The result (stored in EAX – **1** if x64, **0** if not) is then tested. If the system is not 64 bit, the variable **var_4** in the graph below is used in an AND operation with EAX, which would be equal to **0**, meaning the value in **var_4** would be **0**. If the system is 64 bit, this is skipped. Then, regardless of the system architecture, the value in **var_4** is moved into EAX, which is the return value.



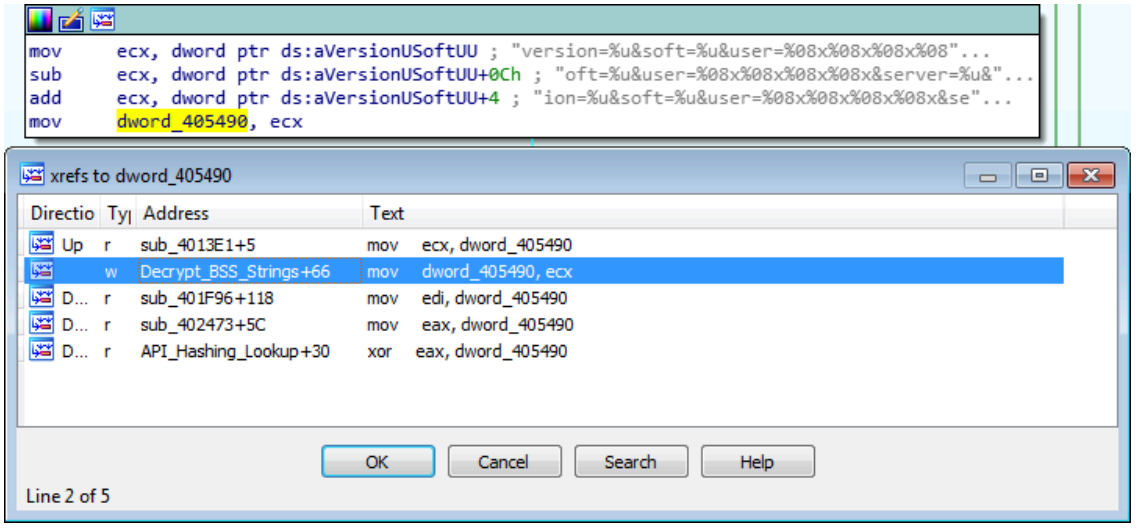
If we back out of the function, we can see EAX is tested again, and if the result is not zero, the value **1** will be moved into the DWORD **dword_405478**. As the system I am running on is 64 bit, **dword_405478** will contain the value **1**. If we search for cross references to this DWORD, we can find test instructions that use it. Therefore we can determine this is an indicator of the architecture.



The next function that is called is quite complex. In a nutshell, this function is responsible for getting the address to a select few API calls. To do this, it uses a list of predefined values, a “key”, and a hashing routine. First, let’s take a look at the key and find out what it is. Looking at the image below, just before the value in **hModule** is moved into ECX, EAX is XOR’d with a DWORD inside the binary, however upon viewing this DWORD, it is empty – this means it is resolved dynamically.



To find out what this DWORD will contain, we need to find cross references to it – specifically, we are looking for a reference to it being used as the destination in a MOV instruction. Luckily enough for us, it only appears once as the destination, inside the BSS Decrypt function. From the image below, we can see that a DWORD from a string is moved into ECX, which is then used in a subtraction and addition instruction. In this case, it may be much easier to understand what is going on by looking at it in a decompiler.

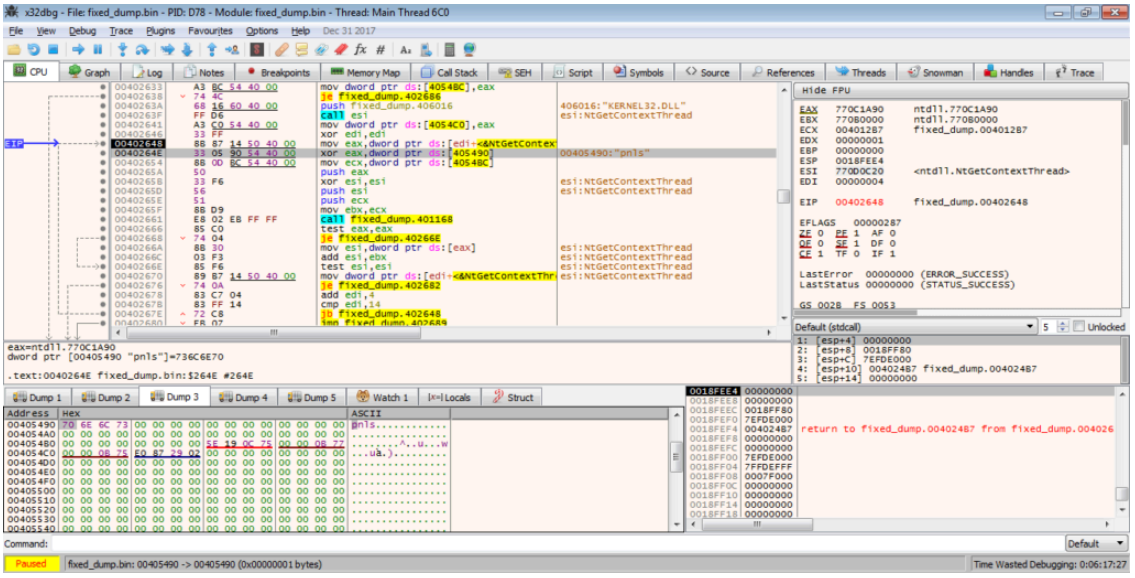



```
int __thiscall Decrypt_BSS_Strings(void *this)
{
  HMODULE v1; // ebx
  int result; // eax
  int dword_1; // [esp+4h] [ebp-14h]
  int dword_2; // [esp+8h] [ebp-10h]
  int BSS_Size; // [esp+10h] [ebp-8h]
  int BSS_Addr; // [esp+14h] [ebp-4h]

  v1 = dword_40547C;
  result = Get_Address_And_Size_Of_BSS((int)this, (int)dword_40547C, &BSS_Addr, &BSS_Size);
  if ( !result )
  {
    result = Set_Exception();
    if ( !result )
    {
      strcpy((char *)&dword_1, "Jan 28 2019");
      result = sub_401F22((int)v1 + BSS_Addr, BSS_Size, (dword_2 ^ dword_1) + BSS_Addr + 14);
      if ( !result )
        dword_405490 = *(_DWORD *)&aVersionUSoftUU[4] + *(_DWORD *)aVersionUSoftUU - *(_DWORD *)&aVersionUSoftUU[12];
    }
  }
  return result;
}
```

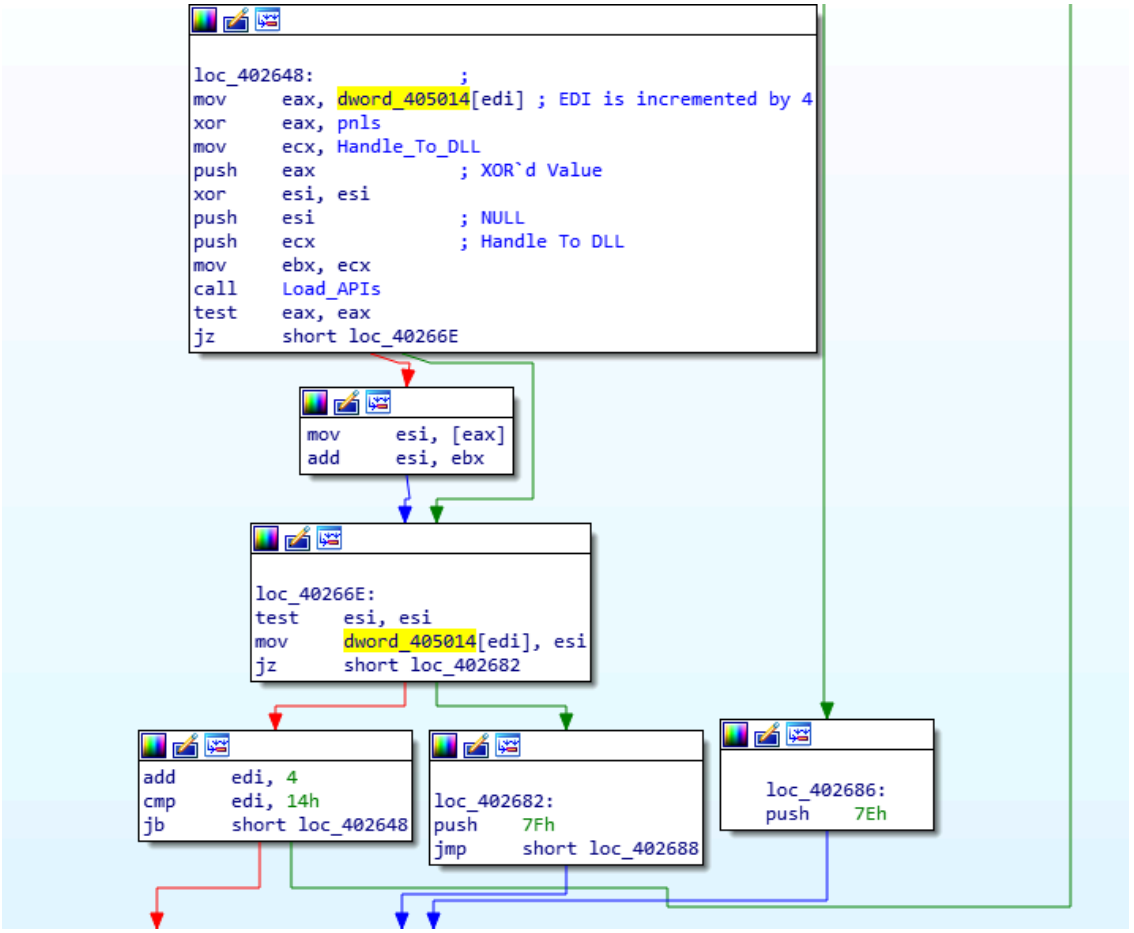
So, from the looks of it, we can get the key used by performing a simple operation, as seen below:

```
 key = (dword string[4] + dword string[0]) - dword string[12]
key = ("ion=" + "vers") - "oft="
We need to convert these values to hex to perform addition and subtraction:
key = (0x696f6e3d + 0x76657273) - 0x6f66743d
key = 0x706E6C73
Convert the key from hex and we get this: "pnls"
```

We can double check this by looking at the binary in a debugger, as shown in the image below.

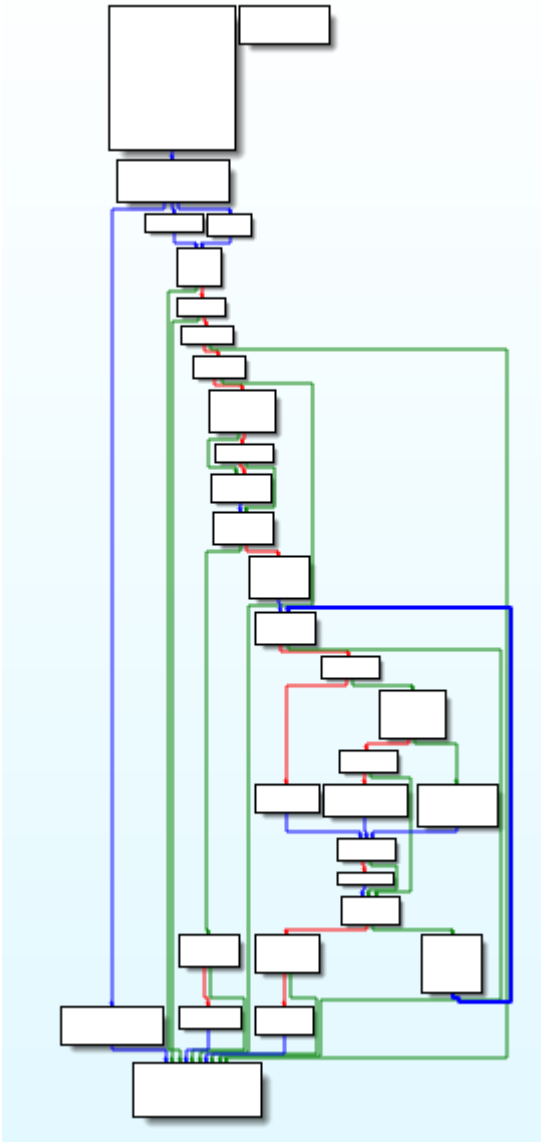


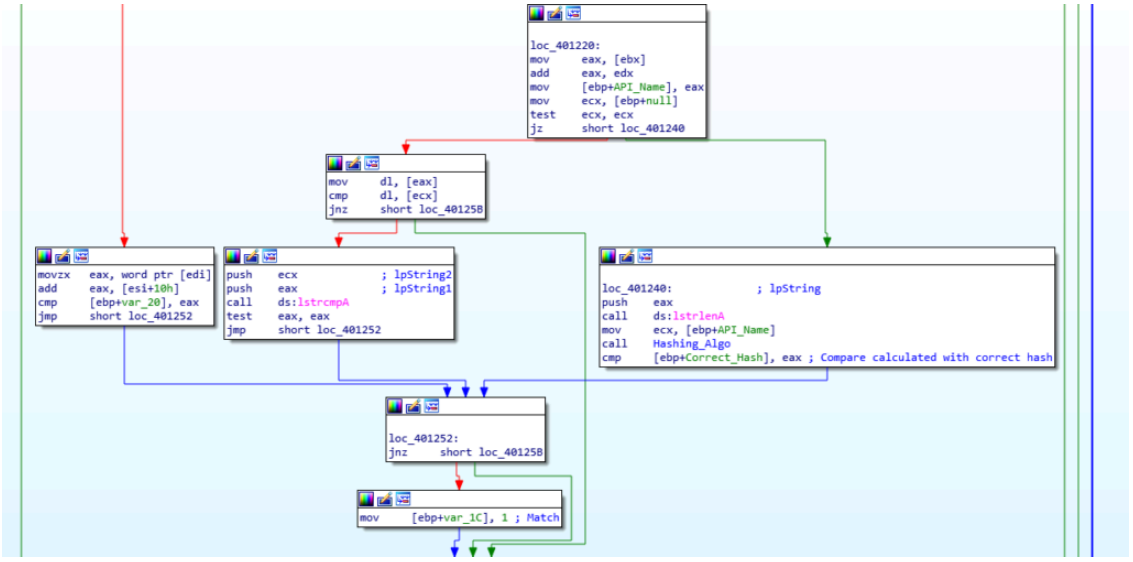
Now we have the key, let's take a look at the values used for determining which API to import. This is quite simple to find, as it is already inside the executable. We can also see that EDI is being used as a counter, as each loop it is incremented by 4, until the value reaches 20, where it returns. This means there are 5 API's in total that are looked up using this method. The values in the embedded list are all XOR'd by the key, which results in the hash lookup value used for comparison. So, from this, we can start examining the hashing algorithm to see how it functions and to locate what API's are lookup up and stored.



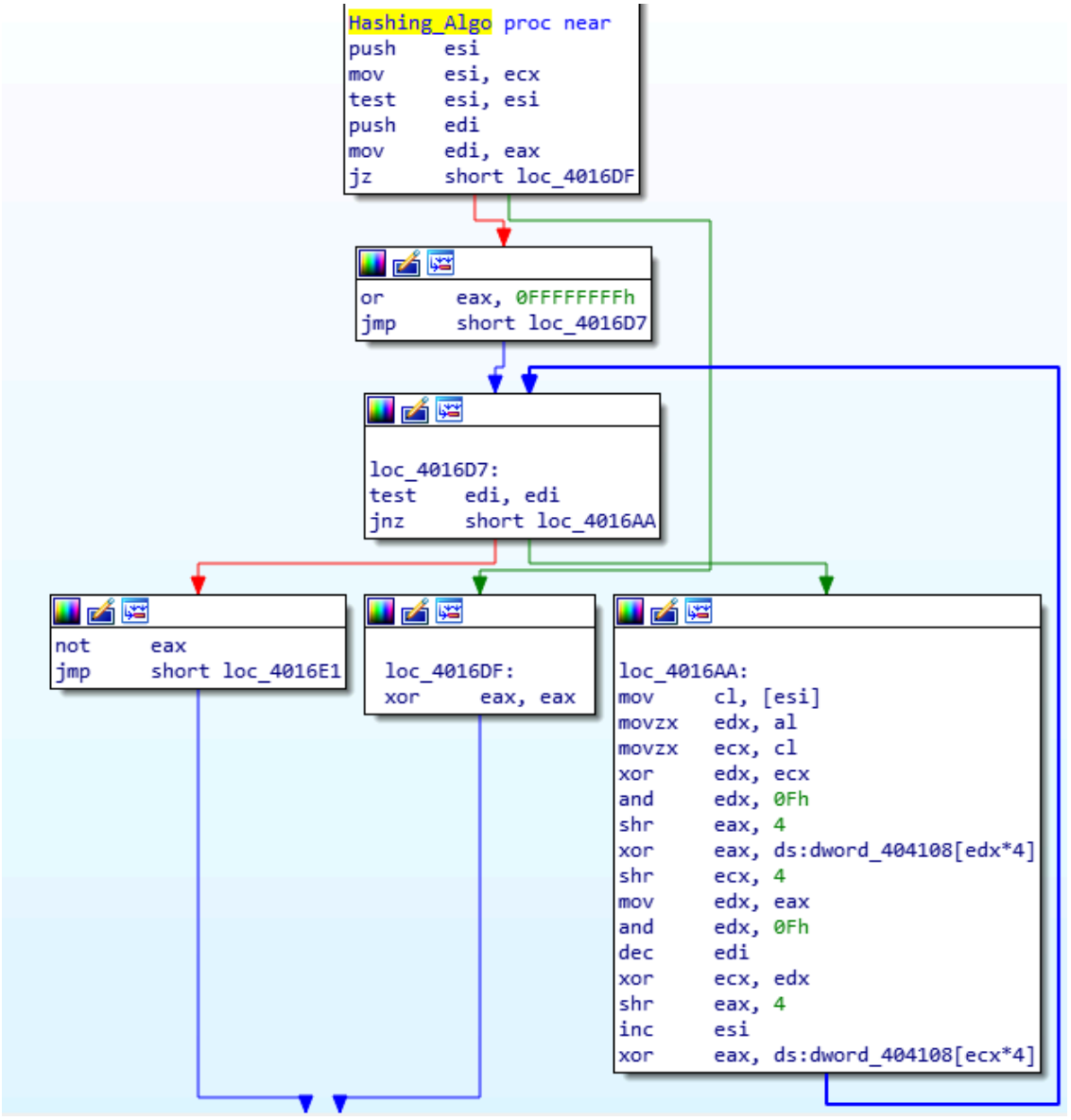
```
.data:00405011                 db    0
.data:00405012                 db    0
.data:00405013                 db    0
.data:00405014 ; int dword_405014[]
.data:00405014 dword_405014    dd 29510894h          ; DATA XREF: sub_401CDD↑r
.data:00405014                                       ; API_Hashing_Lookup:loc_402648↑r ...
.data:00405018 dword_405018    dd 1B477A8Dh          ; DATA XREF: sub_40234A+D7↑r
.data:0040501C                 dd 1D1D4817h
.data:00405020 dword_405020    dd 6569CE63h          ; DATA XREF: sub_401EDF↑r
.data:00405024 dword_405024    dd 54B334FBh          ; DATA XREF: sub_40133C+5↑r
.data:00405028                 db  80h ; €
.data:00405029                 db    0
```

As the function is quite large, I will focus on the section that calls the hashing function. The three arguments passed to this function are; the address of the DLL, the value **0**, and the correct hash for comparison. The function uses the base address to perform some calculations in order to get to the export table inside the DLL. From there, it loops through each of the exports and hashes the name of the export, which is then compared to the predefined hash. If the hashes match, the function retrieves the address to the exported API, and overwrites the predefined hash with the address for later use. If they do not match, the function simply continues onto the next export, until a match is finally discovered.

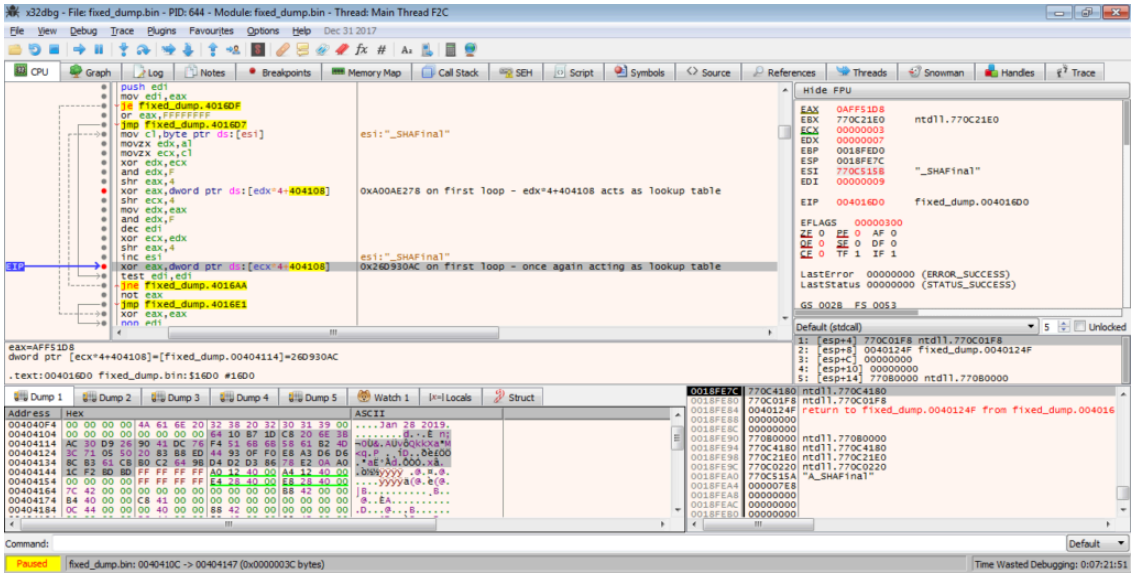




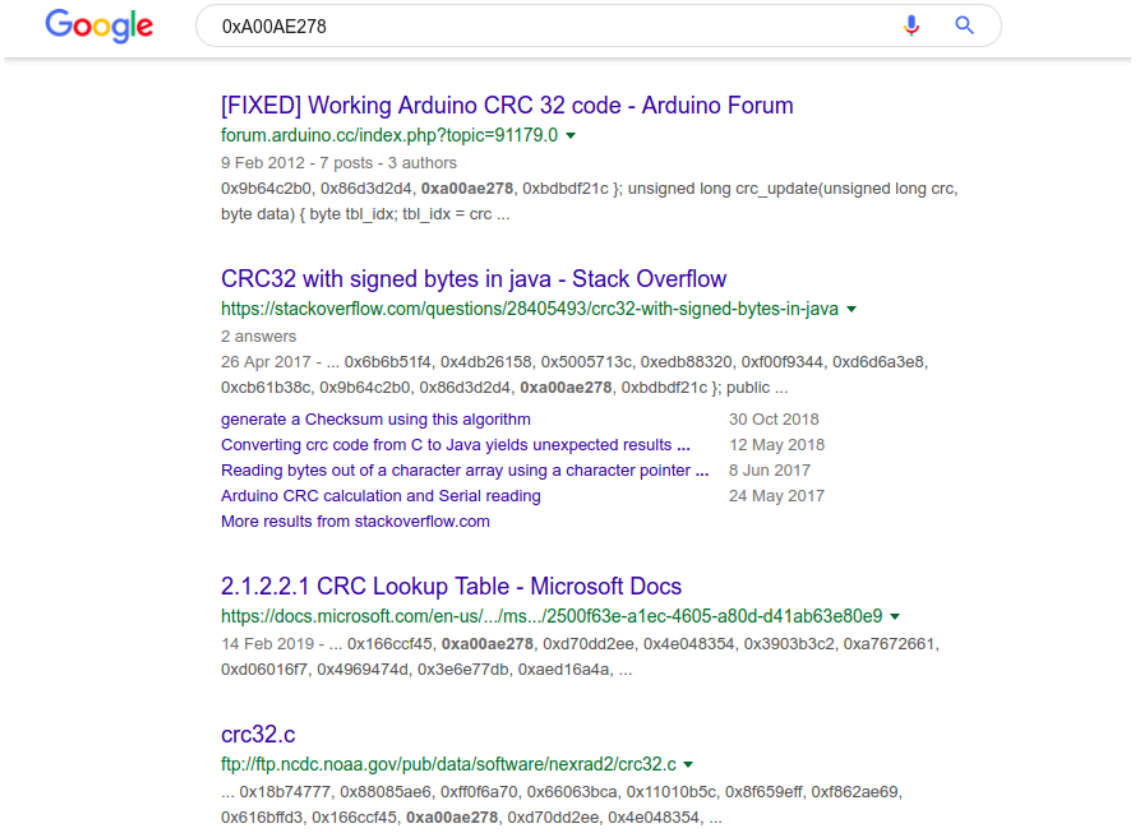
Taking a look at the actual hashing function, it is quite difficult to come to the conclusion (especially for a beginner) that the function is responsible for hashing, until it is run in a debugger. There is definitely something happening in this function from a static analysis perspective, as there are multiple logic instructions, but we can’t know for sure until we analyse it further.



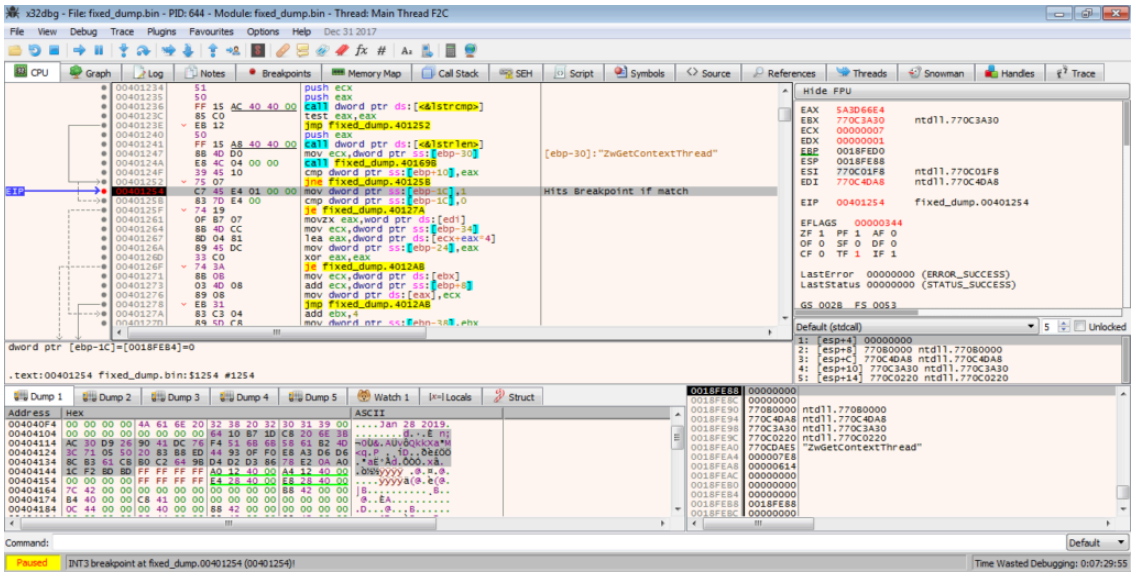
Taking a look in a debugger, it is clear that [edx*4+404108] and [ecx*4+404108] are values from a lookup table, as the XOR values used constantly change, however the values are repeated, and therefore we can determine that they are not randomized. Base64 encoding/decoding use lookup tables as well, so if you have looked at that before (or at least the psuedocode), you might be able to recognize the lookup table aspect here. When we take a look at the memory region where the lookup table is located, it is easy to see where it begins and ends. So, now we know that there is a lookup table, how do we find out the hashing mechanism in use?



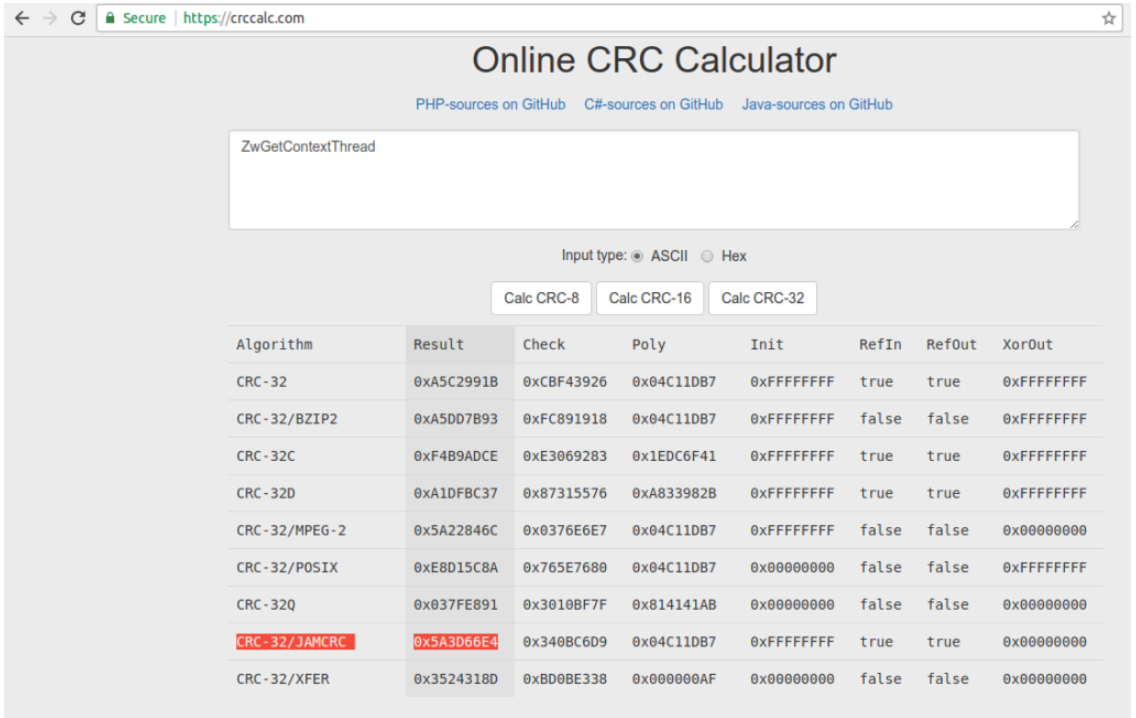
Typically, custom encryption and hashing implementations are quite difficult to determine, unless you know what you are looking for. As long as the algorithm is publicly available (such as AES or Serpent), and not a custom developed one by the author, there will almost always be specific values or instructions that stick out to those who have looked at crypto before – these are known as Constants. We will revisit these later (in the next post) when looking at the other encryption methods used in this sample, however to sum it up, it basically refers to values that must be used in the algorithm to achieve the correct results. In this case, let's take one value from the lookup table: 0xA00AE278. We can run a quick search for this value online, and as you can see from the image below, this is definitely linked to CRC-32, although it is more of a variant – we just need to find out which variant.



In this specific sample, the program loops through the NTDLL.DLL export functions and hashes them all until it finds a matching hash. What makes hashing worse is that hashes are irreversable, meaning the only way you can find the matching hash is by brute forcing – to do this you could hash each API exported by NTDLL until you found the matching hashes, but this is too time consuming, and it is quite simple to find the matching API anyway – all you have to do is put a breakpoint on the instruction that is hit if a match is found, and execute the program. Once the breakpoint is hit, you'll be able to locate the correct API. From the image below, you can see the first API call that matches is ZwGetContextThread. We can now use this to get the variant of CRC-32 used.

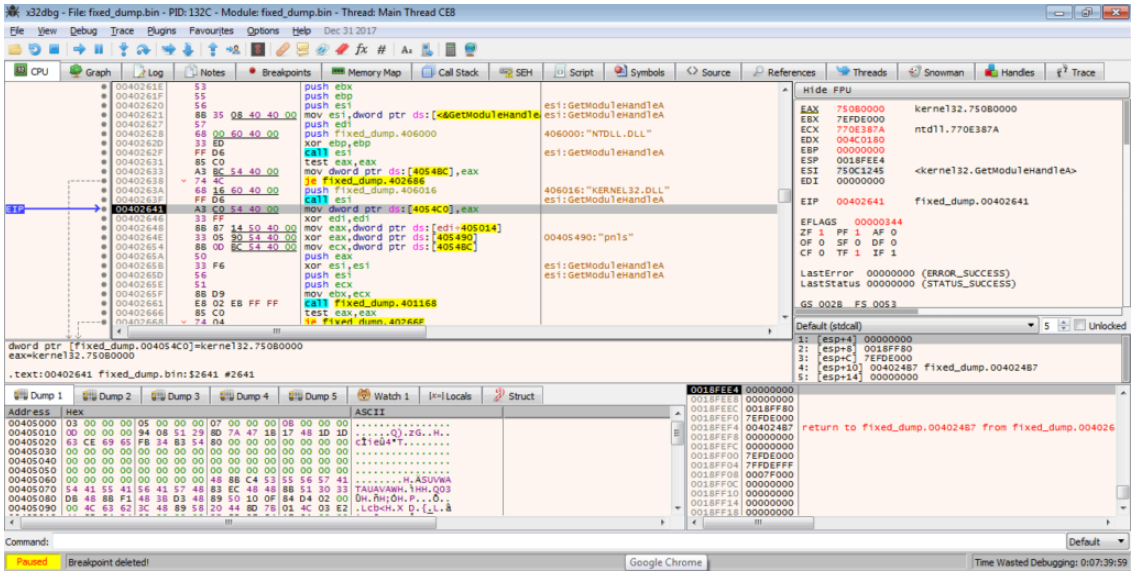


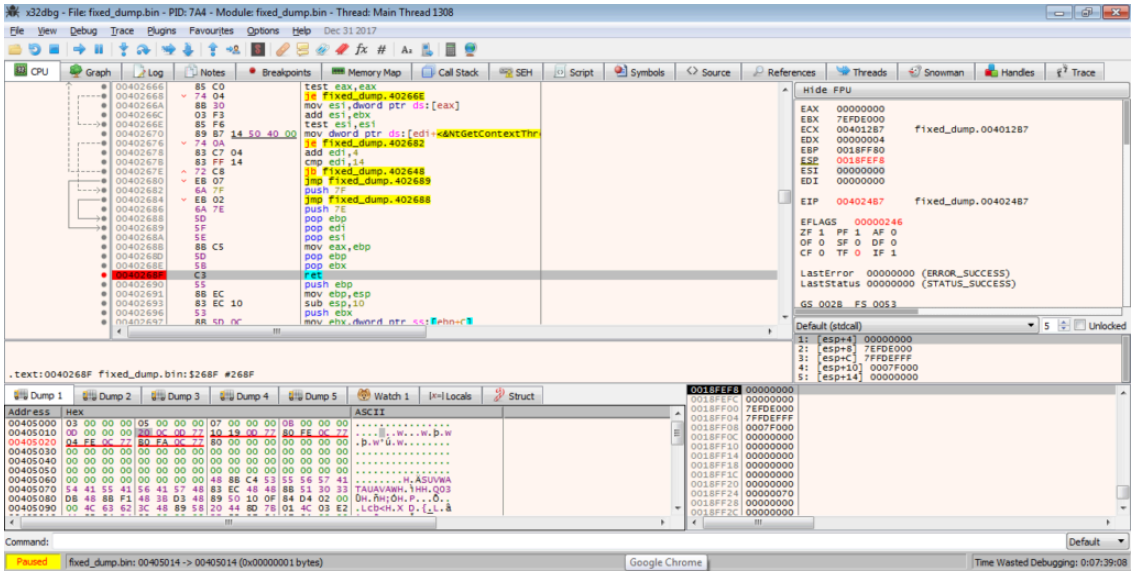
In order to do so, we can use this **site**, which is extremely useful. It hashes the input using several different variants of CRC-8, CRC-16, and CRC-32, allowing us to compare the value from the debugger to the output of the different variants. With the API name, ZwGetContextThread, and the required output, 0x5A3D66E4, we can find the variant used: CRC-32/JAMCRC.



Algorithm	Result	Check	Poly	Init	RefIn	RefOut	XorOut
CRC-32	0xA5C2991B	0xCBF43926	0x04C11DB7	0xFFFFFFFF	true	true	0xFFFFFFFF
CRC-32/BZIP2	0xA5DD7B93	0xFC891918	0x04C11DB7	0xFFFFFFFF	false	false	0xFFFFFFFF
CRC-32C	0xF4B9ADCE	0xE3069283	0x1EDC6F41	0xFFFFFFFF	true	true	0xFFFFFFFF
CRC-32D	0xA1DFBC37	0x87315576	0xA833982B	0xFFFFFFFF	true	true	0xFFFFFFFF
CRC-32/MPEG-2	0x5A22846C	0x0376E6E7	0x04C11DB7	0xFFFFFFFF	false	false	0x00000000
CRC-32/POSIX	0xE8D15C8A	0x765E7680	0x04C11DB7	0x00000000	false	false	0xFFFFFFFF
CRC-32Q	0x037FE891	0x3010BF7F	0x814141AB	0x00000000	false	false	0x00000000
CRC-32/JAMCRC	0x5A3D66E4	0x340BC6D9	0x04C11DB7	0xFFFFFFFF	true	true	0x00000000
CRC-32/XFER	0x3524318D	0xBD0BE338	0x000000AF	0x00000000	false	false	0x00000000

As we can find out the matching APIs, there is no need to write a brute force script, although for families **such as GootKit**, this is sometimes necessary. So, the 5 APIs imported are: ZwGetContextThread, ZwSetContextThread, ZwReadVirtualMemory, ZwWriteVirtualMemory, and ZwAllocateVirtualMemory. With that, we can move out of this function, and onto the next.

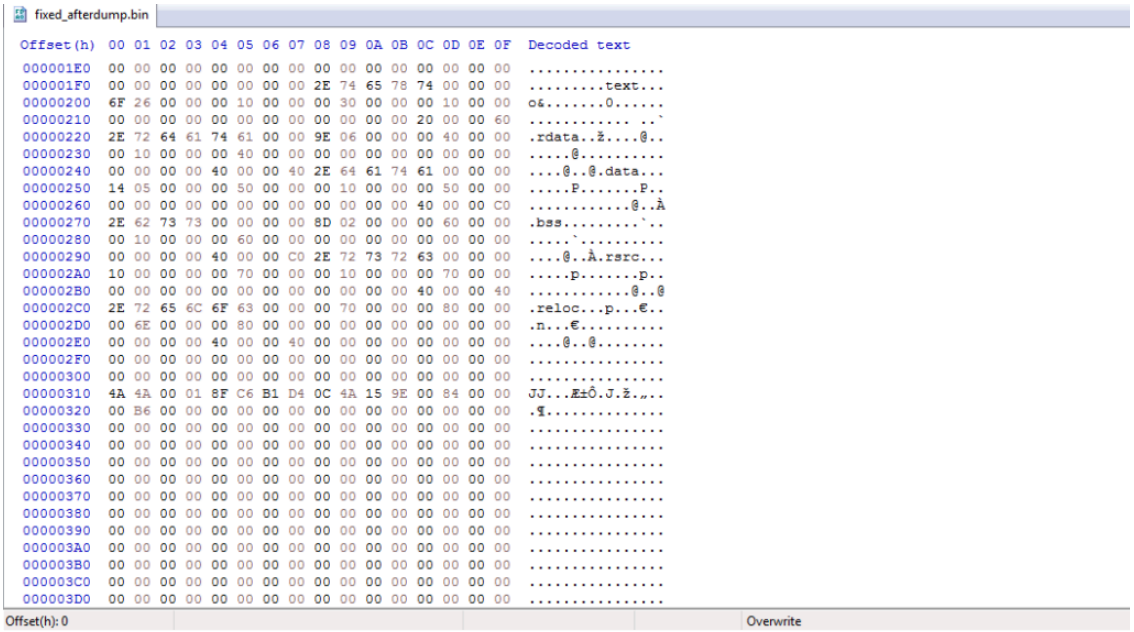




The next function simply retrieves the file name to store in memory, potentially for use later on in the sample. The next function gets much more interesting, so lets move onto that.

```
int Get_FileName()
{
  WCHAR *v0; // ebx
  DWORD v1; // esi
  WCHAR *v2; // eax
  int v4; // [esp+Ch] [ebp-8h]
  LPCWSTR lpszShortPath; // [esp+10h] [ebp-4h]

  v4 = GetModule_FileName(base_addr, (int)&lpszShortPath, 1);
  if ( v4 )
  {
    lpString2 = 0;
  }
  else
  {
    v0 = (WCHAR *)lpszShortPath;
    v1 = GetLongPathNameW(lpszShortPath, 0, 0);
    if ( v1 && (v2 = (WCHAR *)Allocate_Heap(2 * v1 + 2), (lpString2 = v2) != 0) )
    {
      GetLongPathNameW(v0, v2, v1);
      Heap_Free(v0);
    }
    else
    {
      lpString2 = v0;
    }
  }
  return v4;
}
```

If you've looked at ISFB or read anything about it before, you might be aware of an embedded FJ, F1, or JJ structure that is located just after the section table. This structure contains pointers to appended (also known as joined) data, such as configuration information, an RSA public key, or even another executable. There are differences between FJ, F1, and JJ, although they are quite small changes. In this case, the sample is using an embedded JJ structure, identifiable from the magic value 0x4A4A ("JJ").



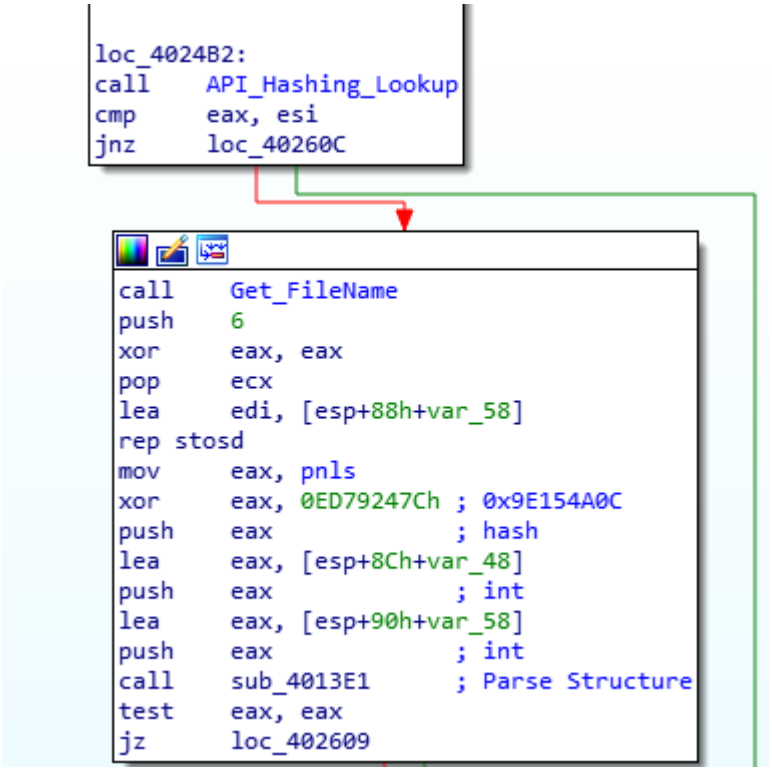
The format of this structure is shown below:

```
 Joined Resource Structure {
        WORD    Magic Value
        WORD    Flags
        DWORD   XOR Key
        DWORD   CRC-32 Hash
        DWORD   Address
        DWORD   Size
}
```

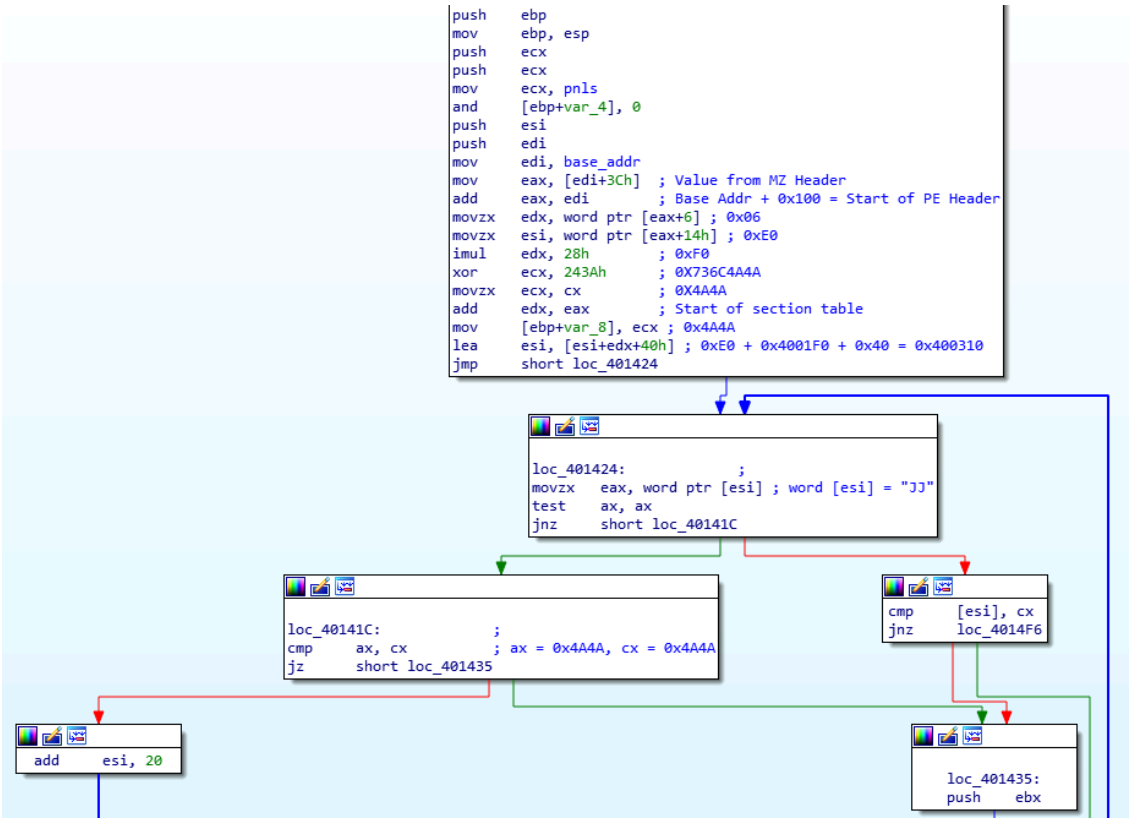
The parsed structure in this binary can be seen below:

```
 Joined Resource Structure {
        WORD    0x4A4A
        WORD    0x0001
        DWORD   0xD4B1C68F
        DWORD   0x9E154A0C
        DWORD   0x00008400
        DWORD   0x0000B600
}
```

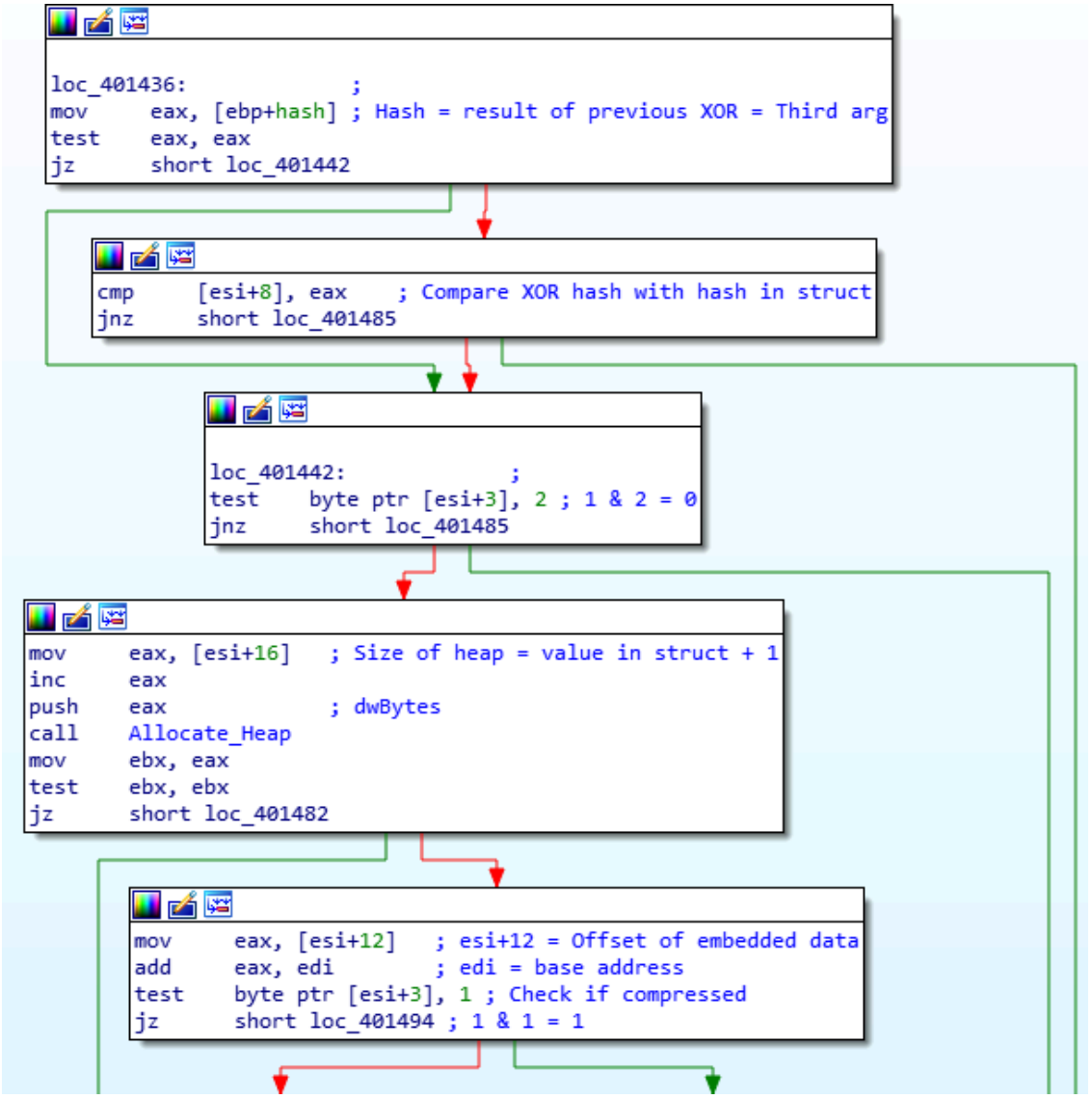
The function we are looking at is responsible for parsing this structure and locating the needed data. The main argument for this function is the third one, which is the result of an XOR between the “pnls” string and an embedded hex value. The first and second arguments are simply the start and end of an empty region of memory, so they are not that important right now.



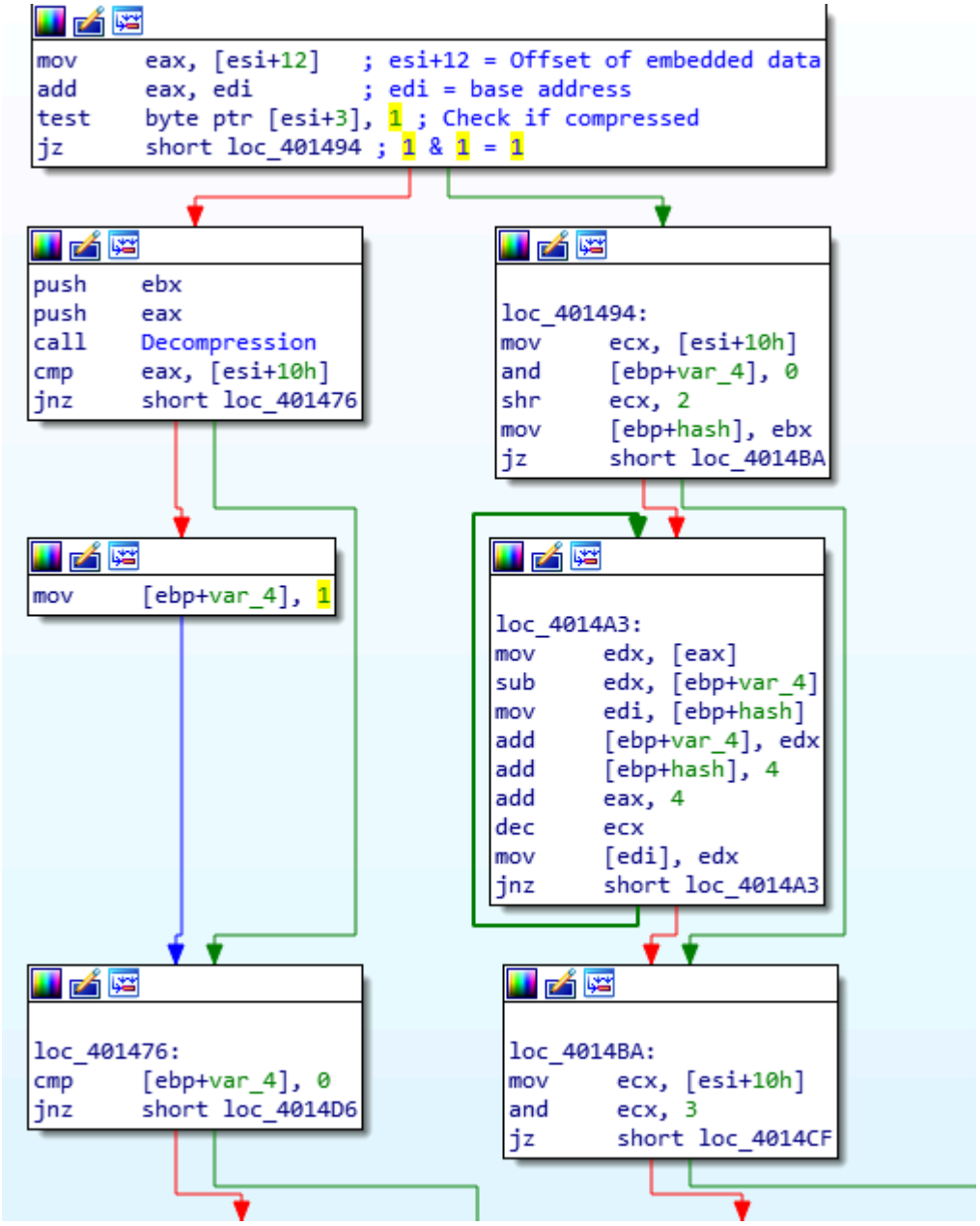
The first half of the parsing function traverses through the MZ and PE header until it has reached the resource structure located just after the section table. It then checks that the magic value is in fact “JJ” (0x4A4A), otherwise it will add 0x14 to the current address and try again.



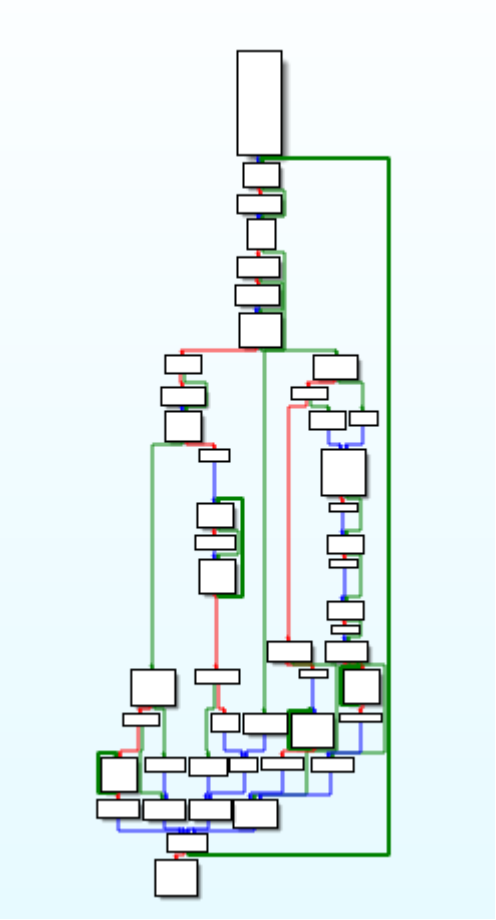
Once the structure has been located successfully, the function compares the third argument (0x9E154A0C) with the embedded CRC-32 hash, which is also 0x9E154A0C. If these do not match, the function will return or loop around again. If they do match, the function performs a bitwise AND on the structure flag and 0x2, which must return 0, otherwise the function will loop or return. If 0 is returned, a heap is allocated based on the size value stored in the structure. From there, it will get the full memory address of the joined data by adding the address in the structure to the base address of the executable, and then a bitwise AND is performed on the structure flag and 0x1. If the result is 0 the joined data is not compressed and is encoded, and if the result is not 0 (which in this case it is 1), the joined data is compressed. As the joined data is compressed in this binary, we will focus on the compression method.



The two arguments pushed to the function are the location of the compressed data, and the address of the newly allocated heap.



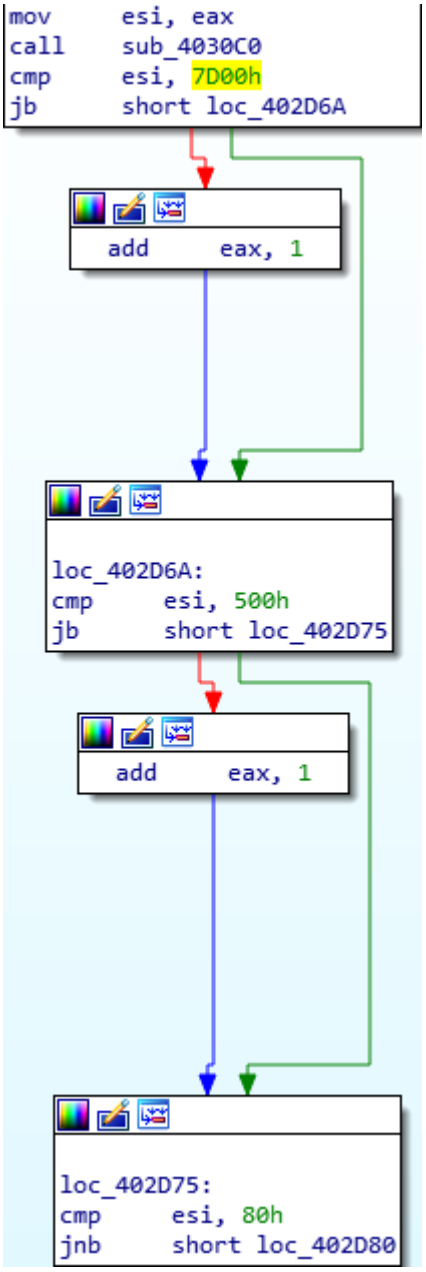
Looking at an overview of the function, you can see it is quite intricate and difficult to follow. Remember what I was saying about crypto constants earlier? They are also present in some, if not all, (de)compression routines, although it is much more difficult to identify the algorithm compared to encryption algorithms.



Searching through the graph, there are calls to the same functions several times over, but we are looking for a hardcoded value that is not stored in memory. Sure enough, after searching through the right branch, we can see a CMP instruction being used, comparing the value in esi to the value 0x7D00. Using this, we can search “0x7d00 compression” on Google and after scrolling down a bit, come across this **site**. Comparing this python code:

```
def lengthdelta(offset):
   if offset < 0x80 or 0x7D00 <= offset:
       return 2
   elif 0x500 <= offset:
       return 1
   return 0
```

To a section of the assembly:

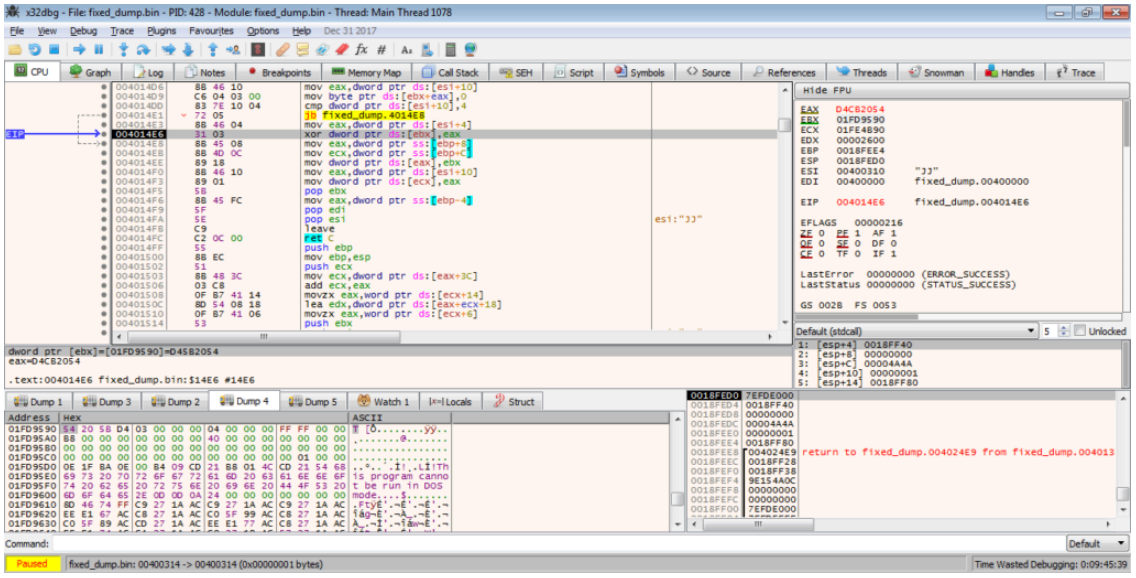


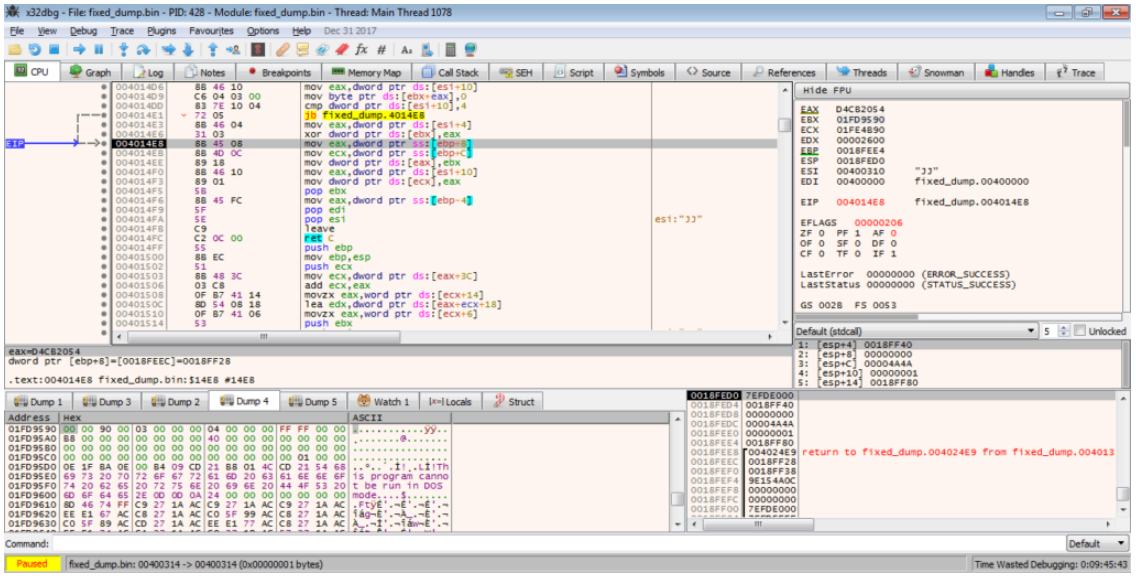
We can see some clear similarities. From this, we can deduce that the decompression algorithm used here is APLib, and with this knowledge we can write a simple extraction script to extract any joined data from the binary and decompress it using the great Python library **Mlib**, created by Mak. You might be wondering how I was able to determine if something was decompressed before even looking at the function. I have read up on ISFB and have also analysed it quite frequently, however it is quite easy to figure out that the joined data is compressed by simply looking at it. Opening up the binary in a hex editor and going to the location of the joined data, you might be able to recognize the string “This Program Cannot Be Run In DOS Mode”, although part of it is obfuscated. Recognizing compression also depends on the level of compression, however for the ISFB malware strain, APLib is the defacto compression method for now, so it is relatively simple.

fixed_afterdump.bin

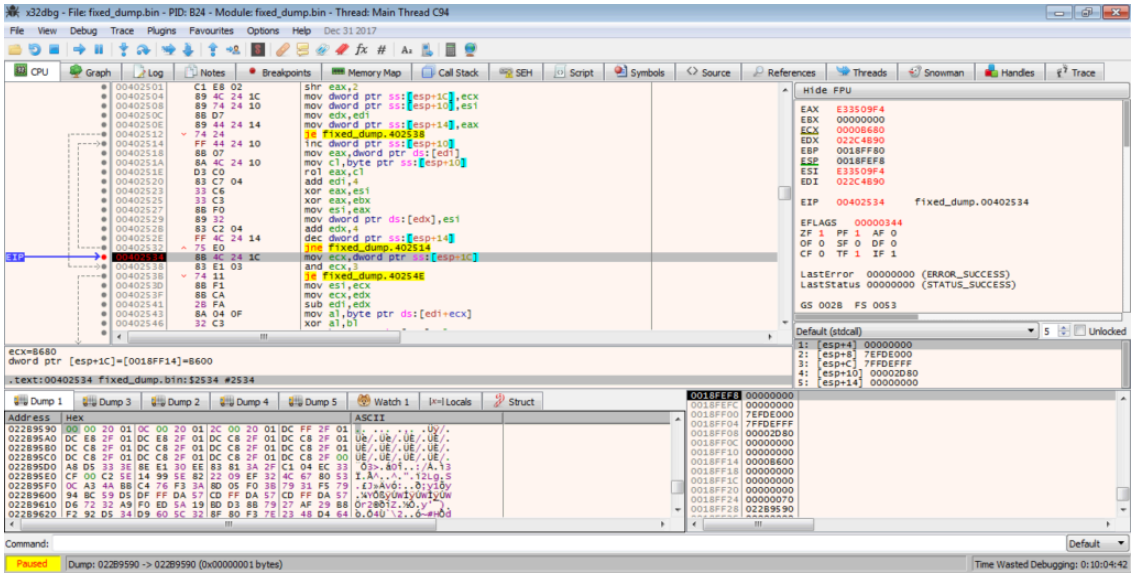
Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	Decoded text
000083F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	.....
00008400	8F	0E	C6	21	D4	03	19	02	04	9C	09	FF	60	70	B8	A4	..Æ!Ô....œ.ÿ`p¸¤
00008410	01	70	40	85	79	01	87	06	0E	1F	BA	3E	00	B4	09	CD	.p@…y.‡...º>.´.Í
00008420	21	B8	FA	4C	C0	0A	54	68	69	73	20	0E	70	72	6F	67	!¸úLÀ.This .prog
00008430	67	61	6D	87	63	47	6E	1F	4F	74	E7	62	65	AF	CF	75	gam‡cGn.Otçbe¯Ïu
00008440	5F	98	69	06	44	4F	7E	53	03	6D	6F	64	65	2E	0D	89	_˜i.DO~S.mode..‰
00008450	0A	24	4C	43	8D	01	46	74	FF	C9	27	1A	AC	58	04	EE	.$LC..FtÿÉ'.¬X.î
00008460	3E	E1	67	30	C8	11	C0	5F	99	8E	7C	89	54	CD	18	77	>ág0È.À_™Ž|‰TÍ.w
00008470	86	CF	10	74	8A	CA	2C	9F	1B	18	57	11	0A	28	7C	47	†Ï.tŠÊ,Ÿ..W..(|G
00008480	43	CA	3E	45	21	C8	95	15	10	67	50	6B	C5	EC	4A	08	CÊ>E!È•..gPkÅìJ.
00008490	60	38	65	62	41	08	52	69	63	68	44	68	68	C7	4C	38	`8ebA.RichDhhÇL8
000084A0	01	05	05	10	1B	4F	5C	63	10	E0	80	02	21	0B	33	01	.....O\c.à€.!.3.
000084B0	08	12	8A	29	1B	26	14	0C	A5	5A	0B	10	CA	09	A0	0F	..Š).&..¥Z..Ê. .
000084C0	BD	54	0C	02	92	38	86	34	F1	4A	3D	47	0D	29	02	2B	½T..'8†4ñJ=G.).+
000084D0	B4	58	39	08	0D	47	12	82	33	11	A6	02	50	4F	64	44	´X9..G.‚3.¦.POdD
000084E0	D0	0D	C4	BA	1A	01	A4	49	A8	40	23	A0	B4	A2	29	08	Ð.Äº..¤I¨@# ´¢).
000084F0	C0	1F	58	2E	74	39	65	78	E2	11	0F	88	BA	91	12	EC	À.X.t9exâ..ˆº'.ì
00008500	36	68	40	20	60	07	2E	72	64	61	74	28	0A	D3	0C	FC	6h@ `..rdat(.Ó.ü
00008510	E6	0E	09	56	8E	28	8C	40	07	2E	A4	27	C8	D8	02	95	æ..VŽ(Œ@..¤'ÈØ.•
00008520	B0	FD	CA	9C	28	F8	C0	2E	38	62	73	D0	0C	DD	70	0A	°ýÊœ(øÀ.8bsÐ.Ýp.
00008530	AC	99	81	58	9E	4A	28	C0	72	65	6C	6F	63	AE	9C	53	¬™.XžJ(Àreloc®œS
00008540	D0	28	21	AA	5B	9C	8E	0F	A3	4A	8F	00	11	D9	CF	B1	Ð(!ª[œŽ.£J...ÙÏ±
00008550	07	D4	64	5E	28	E1	04	D8	0A	84	14	41	41	9C	C8	01	.Ôd^(á.Ø.„.AAœÈ.
00008560	E1	DD	D1	8F	C1	DA	01	B0	01	C2	BD	01	FE	01	56	57	áÝÑ.ÁÚ.°.Â½.þ.VW
00008570	6A	28	E8	55	4B	80	12	8B	F0	85	F6	74	4F	B0	8F	1D	j(èUK€.‹ð…ötO°..
00008580	18	56	89	1C	1C	EE	0C	0E	15	A0	3C	19	10	0C	88	11	.V‰..î... <...ˆ.
00008590	83	F8	FB	03	28	24	74	1E	68	5A	AE	1A	32	6A	01	2A	ƒøû.($t.hZ®.2j.*
000085A0	8C	23	85	C0	0E	28	20	74	0A	A3	35	54	B2	06	1A	33	Œ#…À.(t.£5T²..3
000085B0	FF	EB	17	2E	44	3C	8B	3E	F8	85	01	74	0B	56	E8	9F	ÿë..D<‹>ø….t.VèŸ
000085C0	59	80	A6	EB	03	6A	08	5F	8B	73	C7	1D	5E	C3	55	8E	Y€¦ë.j._‹sÇ.^ÃUŽ
000085D0	EC	83	46	14	53	DB	7D	27	7D	8D	61	F0	5E	E8	ED	4C	ìƒF.SÛ}'}.að^èíL
000085E0	BB	F9	18	DC	4A	F3	D8	85	3F	DB	74	00	FF	75	0C	8D	»ù.ÜJóØ…?Ût.ÿu..

Backing out from the decompression function, the program makes sure that the size of the decompressed executable is the same size as the value stored in the JJ structure. If the sizes do not match, the decompressed executable is cleared from memory, using HeapFree(). Then, the malware XORs the first DWORD of the decompressed data with the XOR key stored in the structure. Taking a look at the decompressed data, we can see that the first DWORD of the executable is not valid – it should look like 00009000, but instead looks like 54205BD4. After the XOR, the valid value can be seen. The function cleans up after itself, and then returns back to the calling function. If you were to dump the executable at this stage and add “MZ” to the start, you would be unable to open it in PE Bear – this is due to the fact that not only is “MZ” missing, “PE” is also missing from the header, so make sure you add that as well.

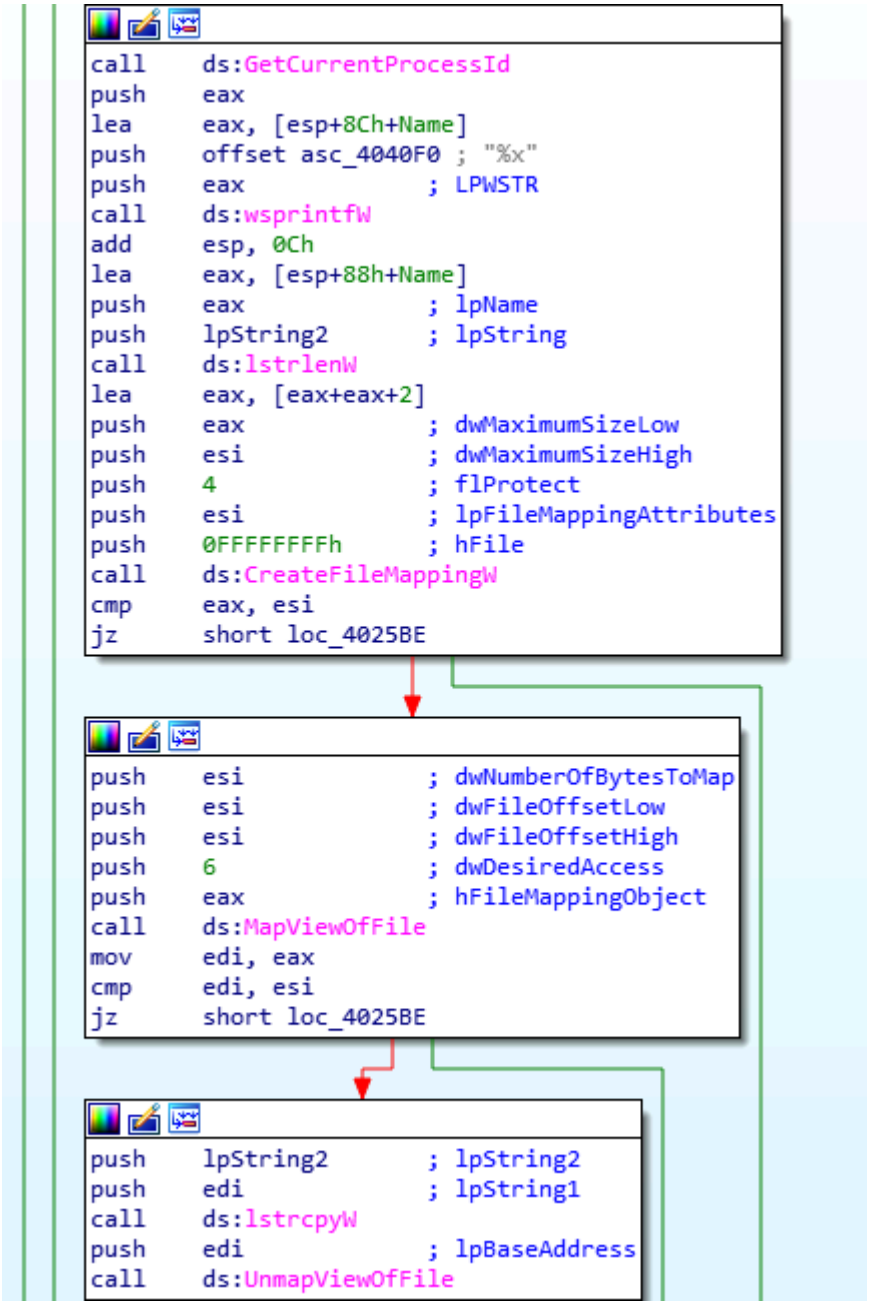




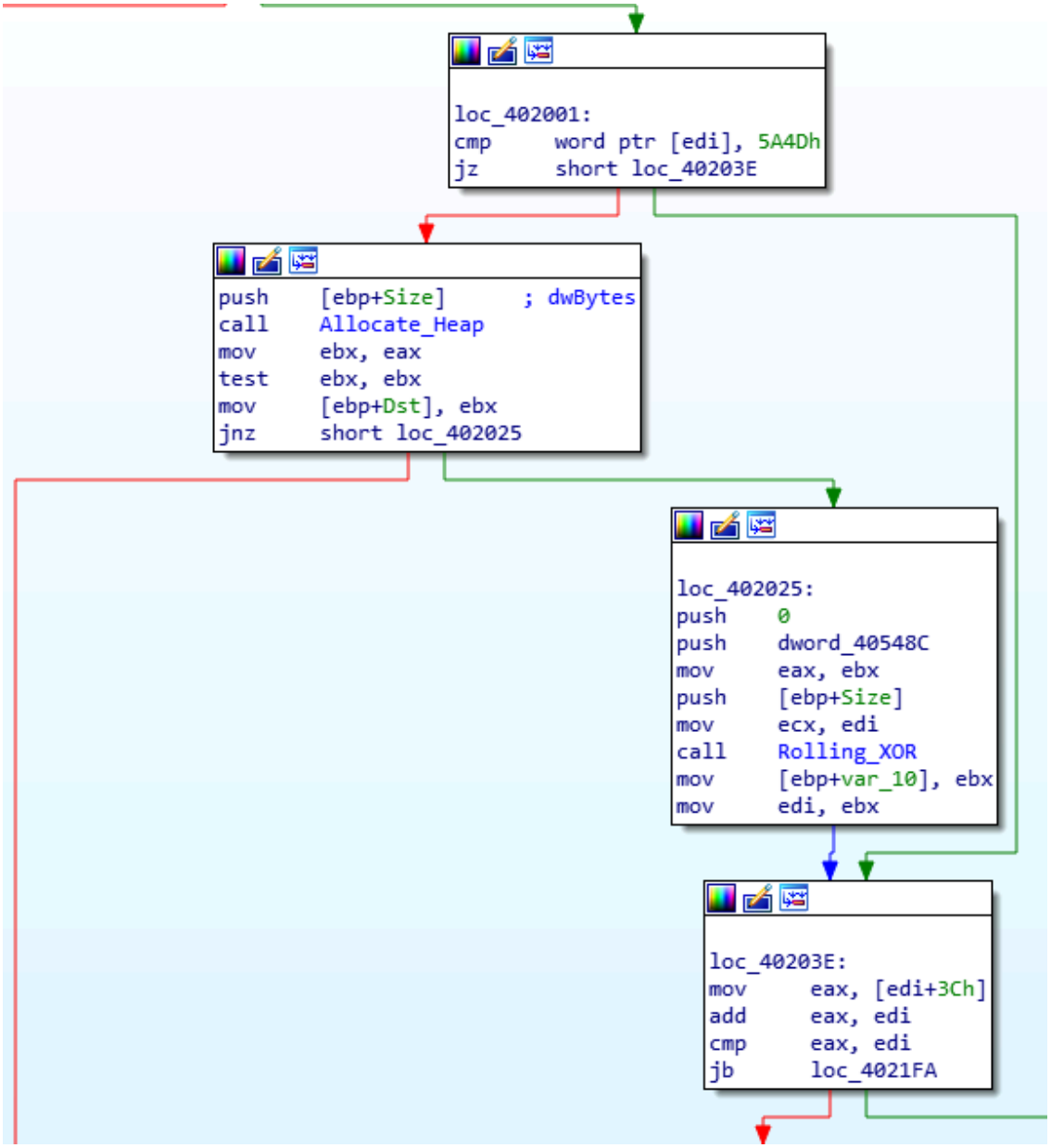
Back in the calling function, the malware then overwrites the decompressed executable using a rolling XOR algorithm. I'm not exactly sure why it does this, as the executable is later decrypted, so if someone could let me know that would be great! Anyway, once the executable has been encrypted, the function carries on.

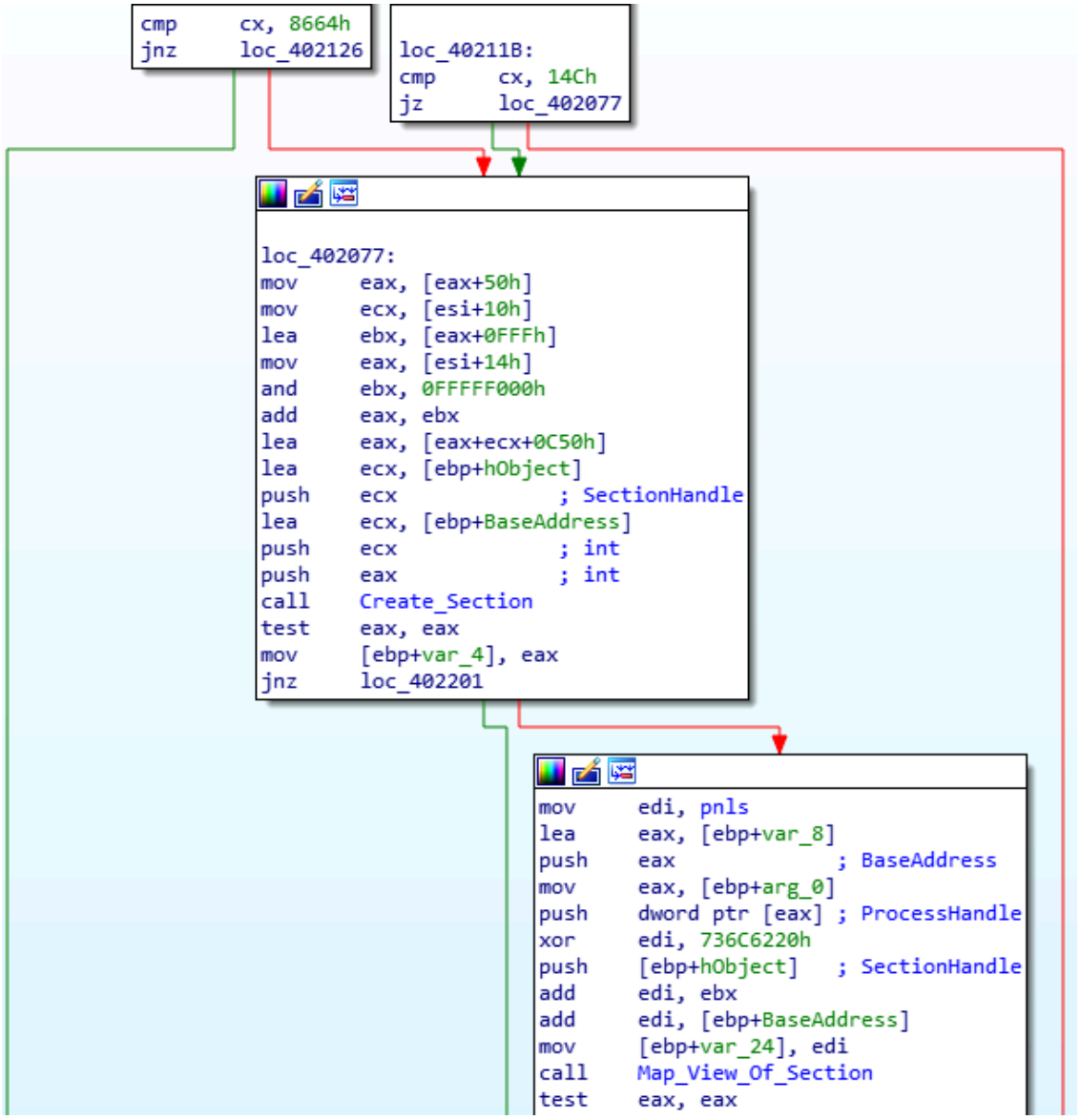


First, it creates a new file mapping, and calls MapViewOfFile, and then copies it's filename to the newly mapped region, before calling UnmapViewOfFile. Again, I'm not too sure why this is being called, as it doesn't seem to do anything, but if someone could drop an answer to this that would be great, and I can incorporate it into the post.



Moving on, the final function in this sample is called. This is quite a large function, so I will attempt to summarize the main points. Firstly, the function begins by moving different pointers around, and then compares the first 2 bytes of the encrypted executable to the value 0x5A4D (MZ) to check if the data is encrypted or not. As it is encrypted, the result will not be 0, and so it will allocate a heap based on the size seen in the embedded JJ structure. Next, it will call another function responsible for performing another rolling XOR algorithm, that will decrypt the data. This is a bit different to the last one, but should return the same executable that was decompressed earlier. Then, it will locate the value in the PE header that indicates the architecture of the executable, which in this case is 0x14C, meaning it is x86 based.

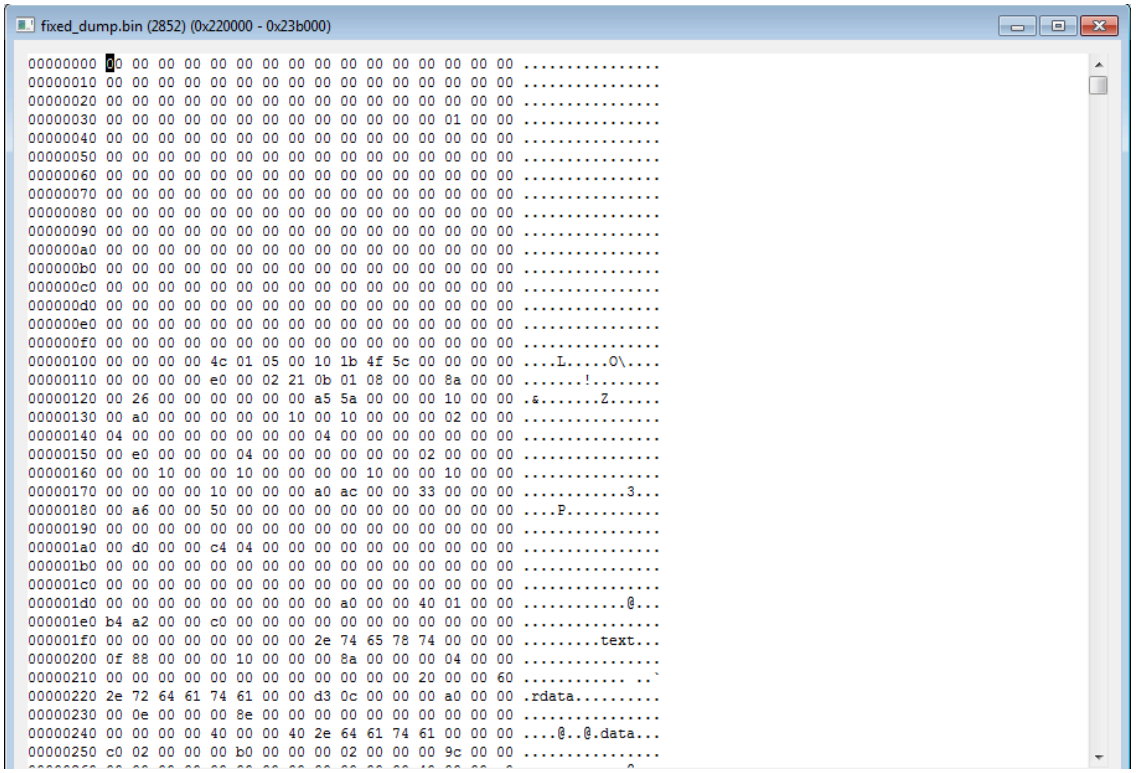

loc_402001:
cmp word ptr [edi], 5A4Dh
jz short loc_40203E
push [ebp+Size] ; dwBytes
call Allocate_Heap
mov ebx, eax
test ebx, ebx
mov [ebp+Dst], ebx
jnz short loc_402025
loc_402025:
push 0
push dword_40548C
mov eax, ebx
push [ebp+Size]
mov ecx, edi
call Rolling_XOR
mov [ebp+var_10], ebx
mov edi, ebx
loc_40203E:
mov eax, [edi+3Ch]
add eax, edi
cmp eax, edi
jb loc_4021FA



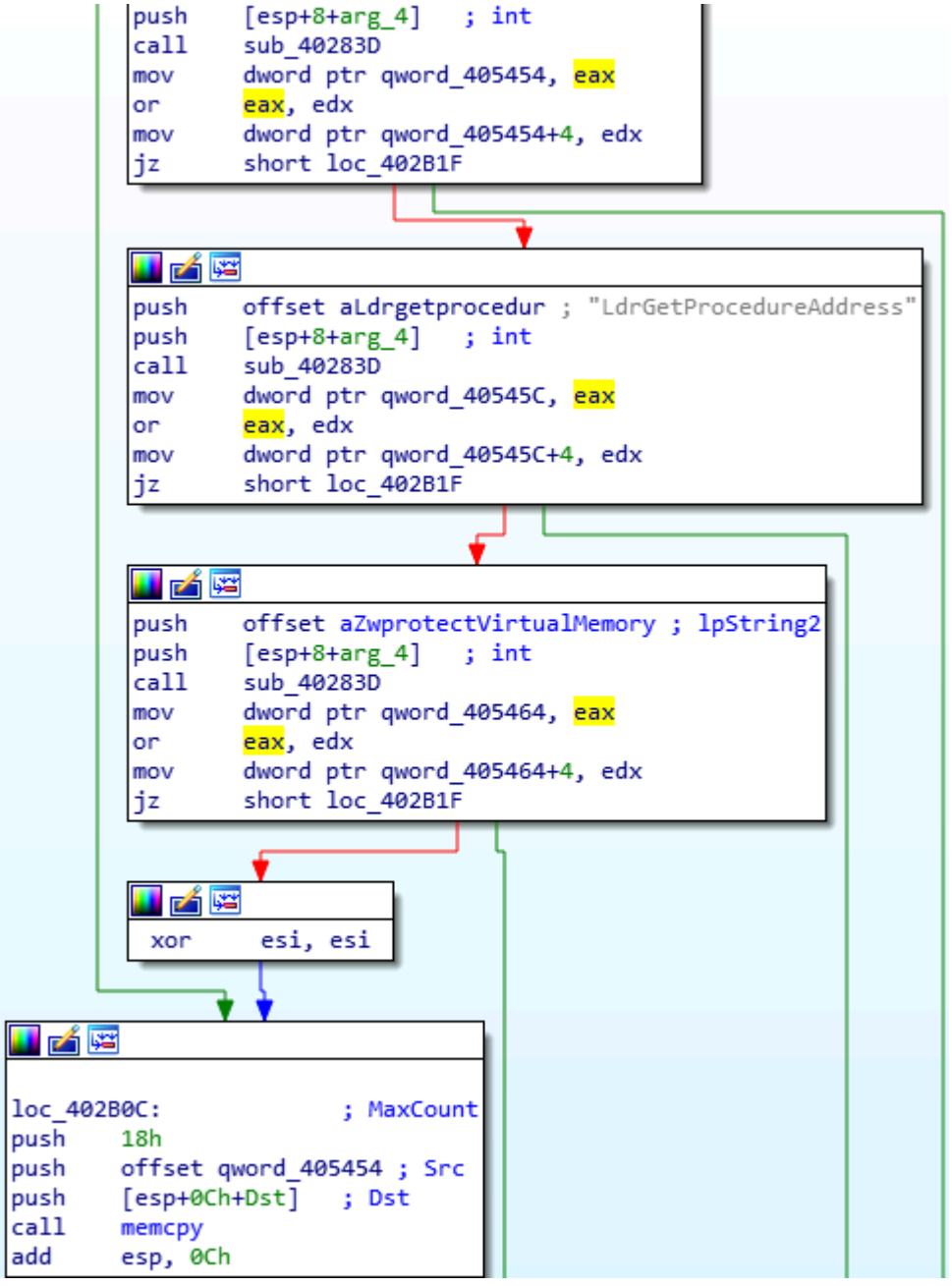
Next, the malware will allocate a brand new section of memory using NtCreateSection(), which will be set to Read-Write-eXecute. Eventually, this will contain the decompressed executable.

```
ULONG __stdcall Create_Section(int a1, int a2, void *SectionHandle)
{
  _DWORD *v3; // ebx
  NTSTATUS v4; // eax
  ULONG v5; // edi
  struct _OBJECT_ATTRIBUTES ObjectAttributes; // [esp+10h] [ebp-2Ch]
  union _LARGE_INTEGER MaximumSize; // [esp+28h] [ebp-14h]
  void *Dst; // [esp+34h] [ebp-8h]

  v3 = SectionHandle;
  MaximumSize.QuadPart = (unsigned int)a1;
  ObjectAttributes.Attributes = 64;
  SectionHandle = 0;
  Dst = 0;
  ObjectAttributes.Length = 24;
  ObjectAttributes.RootDirectory = 0;
  ObjectAttributes.ObjectName = 0;
  ObjectAttributes.SecurityDescriptor = 0;
  ObjectAttributes.SecurityQualityOfService = 0;
  v4 = NtCreateSection(&SectionHandle, 0xF001Fu, &ObjectAttributes, &MaximumSize, 0x40u, 0x8000000u, 0);
  if ( v4 < 0 )
  {
    v5 = RtlNtStatusToDosError(v4);
  }
  else
  {
    v5 = Map_View_Of_Section(SectionHandle, (HANDLE)0xFFFFFFFF, &Dst);
    if ( !v5 )
    {
      memset(Dst, 0, MaximumSize.LowPart);
      *(_DWORD *)a2 = Dst;
      if ( v3 )
        *v3 = SectionHandle;
    }
  }
  if ( SectionHandle && !v3 )
    ZwClose(SectionHandle);
  return v5;
}
```

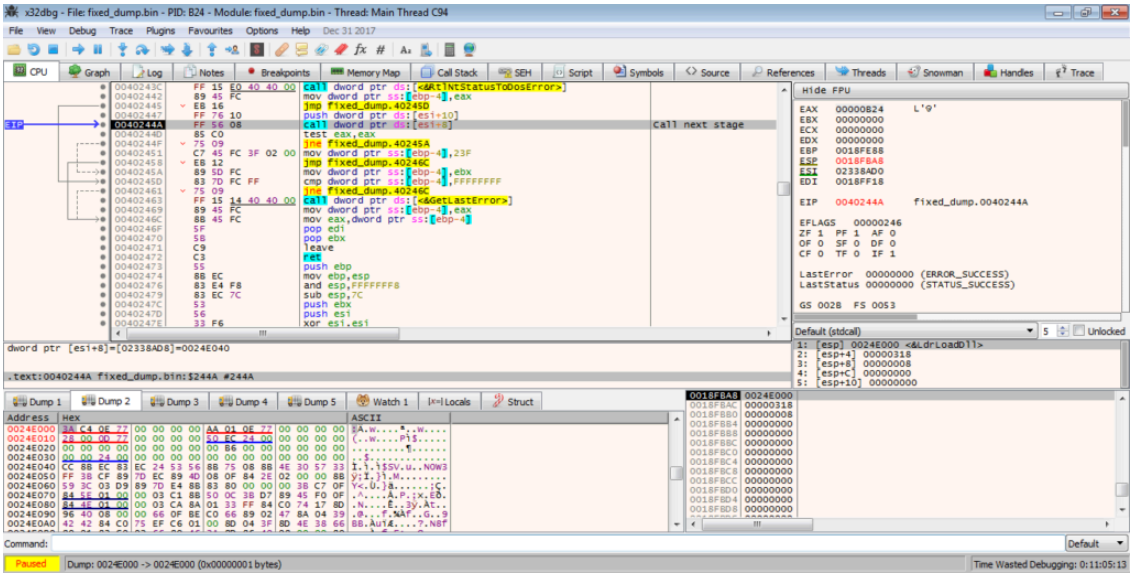
From there, an address located inside the newly created section of memory will be formed, pointing to 0x0022EC50, which will be used later. The created section of memory is replicated, to the address 0x00240000. Next, the program begins to copy over the executable to the new addresses, however it skips the entire MZ header and simply copies everything from the PE header.



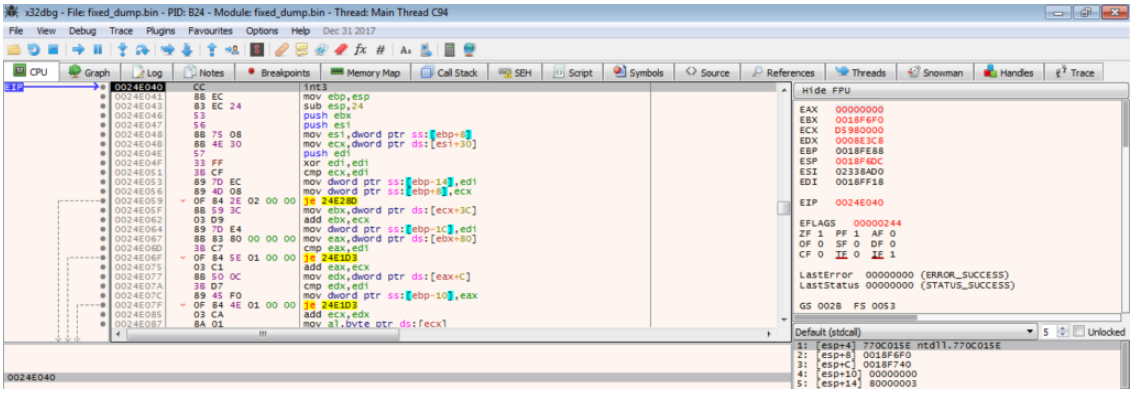
Then, a function is called that imports some more API calls from NTDLL, however this time it is not done using CRC hashes, and the name is simply passed as an argument. The imported API calls are; LdrLoadDll, LdrGetProcedureAddress, and ZwProtectVirtualMemory. The pointers to the addresses are stored in the same region of memory, split by 4 null bytes each. These addresses are then copied over to the executable at 0x00220000 for usage during it's execution. Next, a region of code is copied over to the executable in memory, just 40 bytes after the loaded APIs. This is what will be called before the next stage is completely executed.



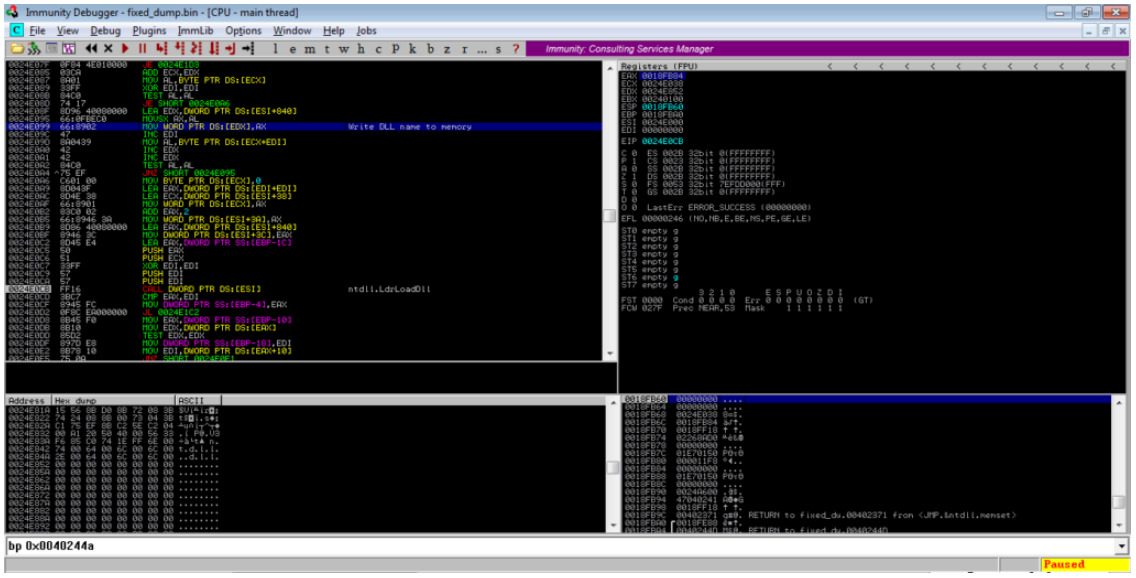
Continuing on, the next function is responsible for passing execution over to the executable. There are 2 functions that pass over execution to the executable, however they depend on the architecture. In this case, I will be looking at the x64 version. It is quite simple, as all it does is call the function at the address 0x0022E040, which will prepare the next stage. Therefore, you can think of this stage as another "unpacker", as all it does is unpacks the executable, however there are many functions that carry over to the next stage, making it much easier to analyse.

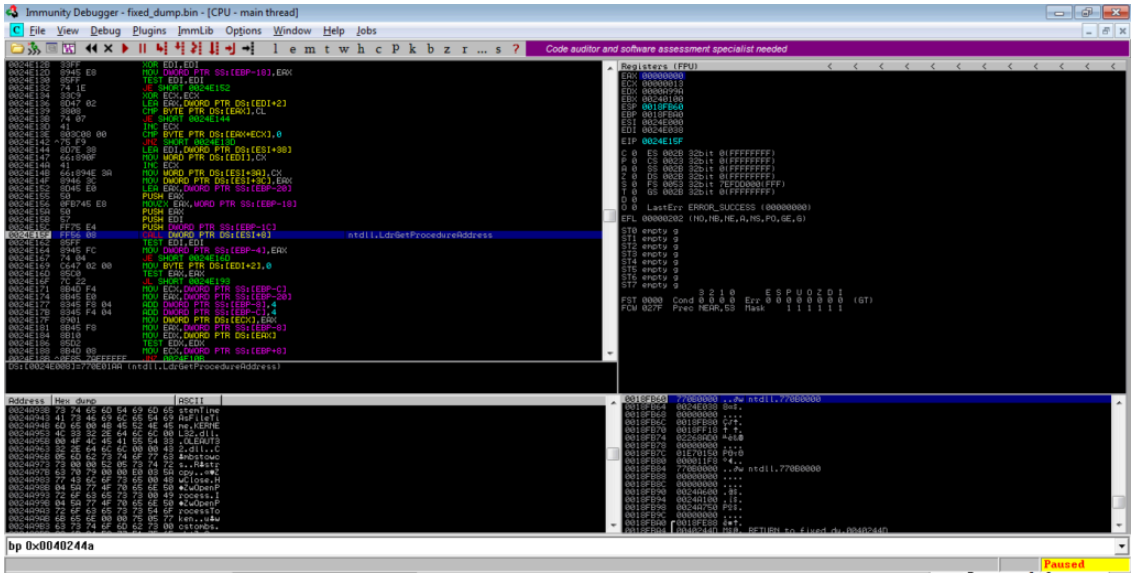


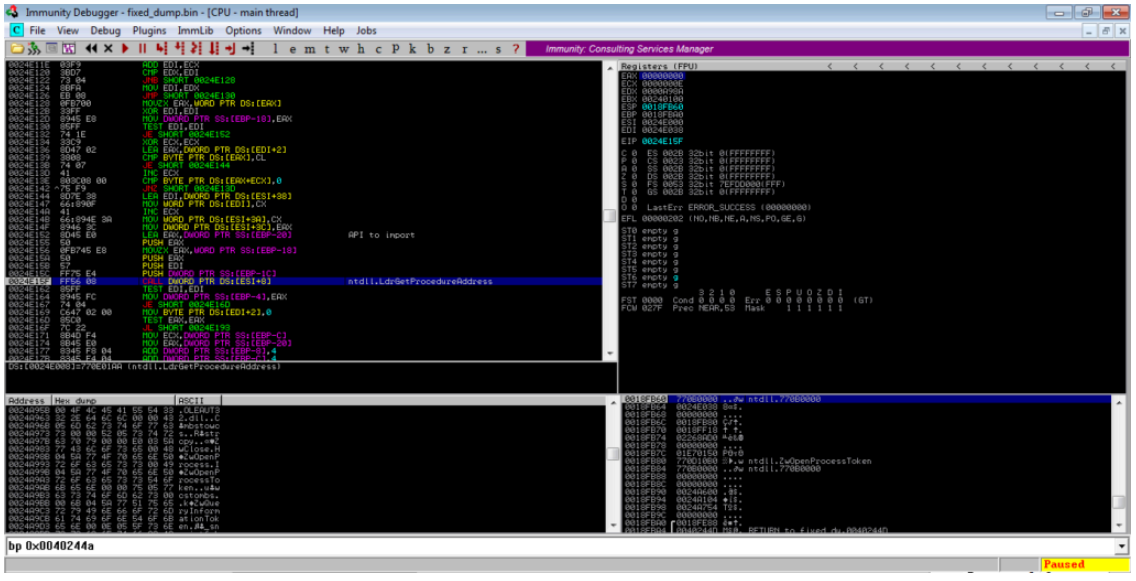
When we step into the function, there is an int3 waiting for us, which acts as a breakpoint that raises an exception, stopping us from stepping over it. To fix this, we can put a breakpoint on the previous call, restart the debugger and then run it until the breakpoint is hit. This should hopefully remove the int3.



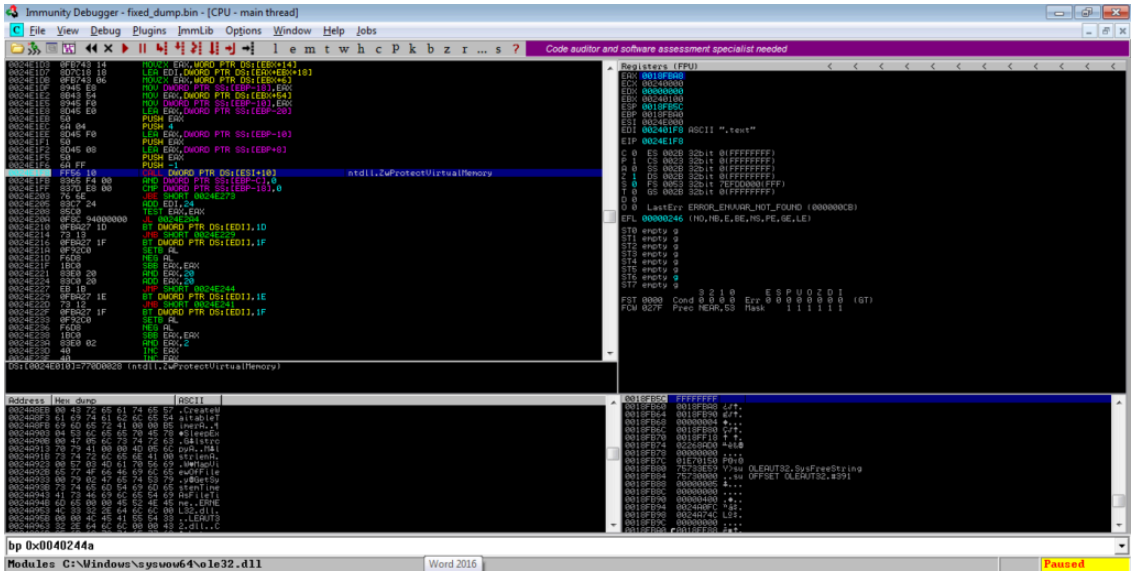
As it didn't remove it in my case, I will use Immunity Debugger to carry on this section. The code is responsible for importing DLLs using the previously imported API's – First, there is a loop which stores a DLL name in memory that will be loaded using LdrLoadDll. Then, a list of hardcoded APIs are looped over, with each being passed to LdrGetProcedureAddress. The DLLs that are loaded are; NTDLL.DLL, KERNEL32.DLL, AND OLEAUT32.DLL.


Immunity Debugger - fixed_dump.bin - [CPU - main thread]
File View Debug Plugins ImmLib Options Window Help Jobs
Immunity: Consulting Services Manager
Registers (FPU)
Write DLL name to memory
ntdll.LdrLoadDll
RETURN to fixed_du.00402371 from <JMP.&ntdll.wenset>
bp 0x0040244a
Paused

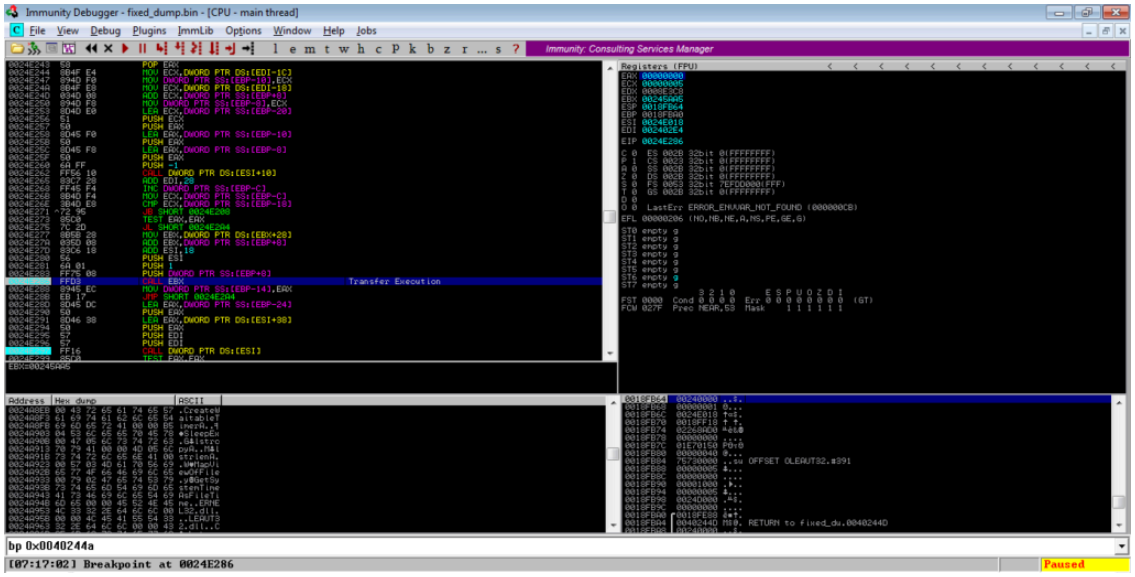

Immunity Debugger - fixed_dump.bin - [CPU - main thread]
File View Debug Plugins ImmLib Options Window Help Jobs
Code auditor and software assessment specialist needed
Registers (FPU)
ntdll.LdrGetProcedureAddress
bp 0x0040244a
Paused

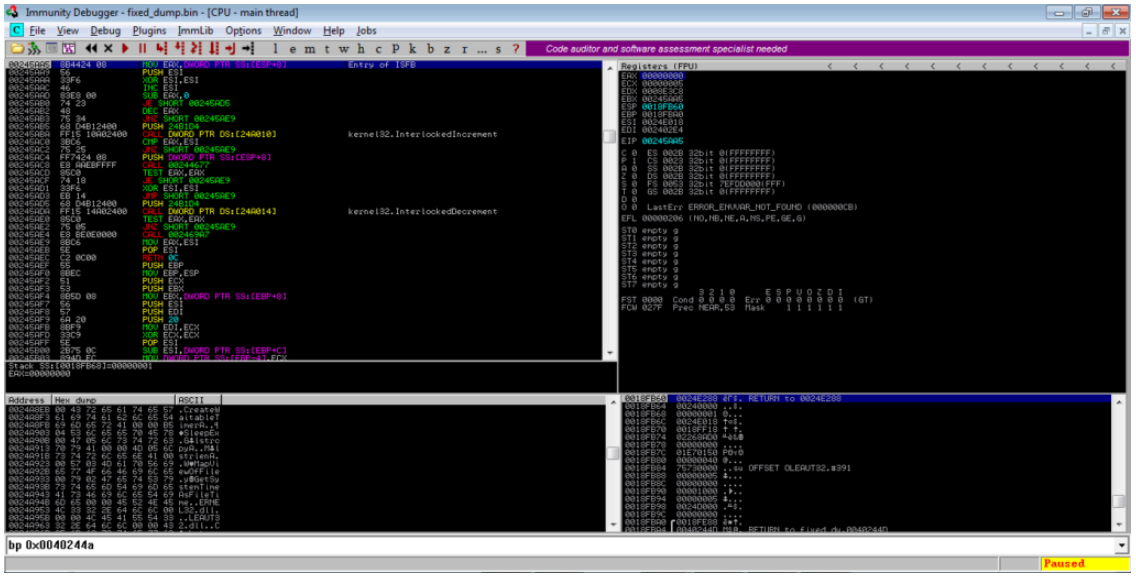

Immunity Debugger - fixed_dump.bin - [CPU - main thread]
File View Debug Plugins ImmLib Options Window Help Jobs
Immunity: Consulting Services Manager
Registers (FPU)
API to import
ntdll.LdrGetProcedureAddress
bp 0x0040244a
Paused

Once the APIs have been imported, ZwProtectVirtualMemory is called several times in a loop to alter the protections on several regions of memory.



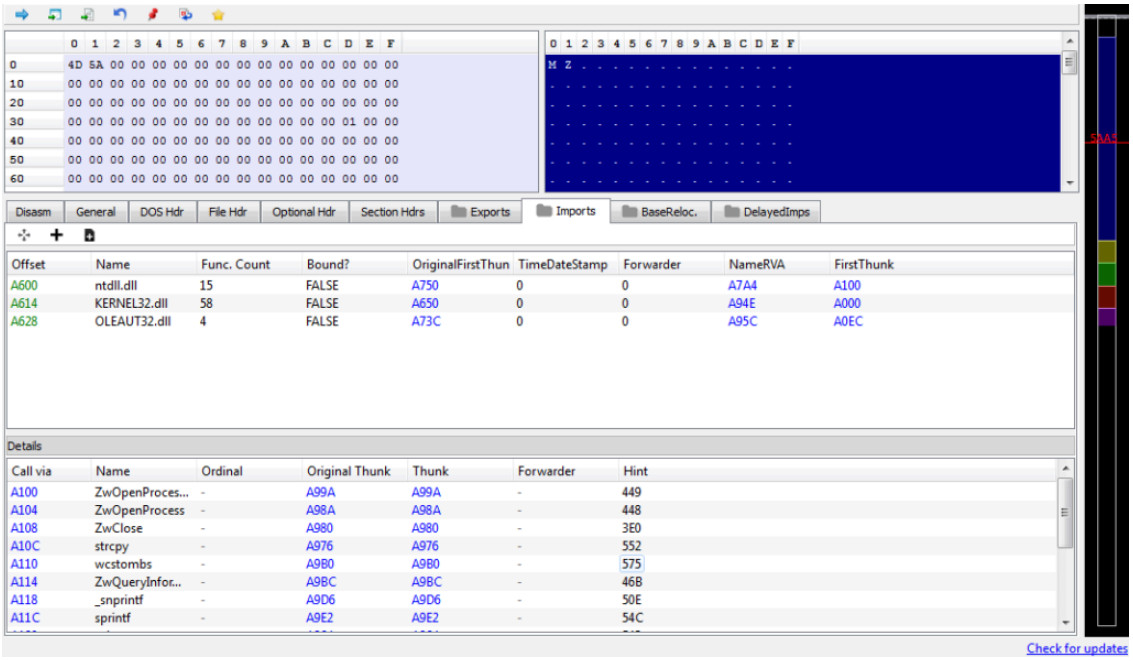
In order to jump to where the execution of the payload happens, we want to put a breakpoint on a call to a register, which in this instance is EBX. Run to that, and then step into it, and you should find yourself in the next stage of ISFB!

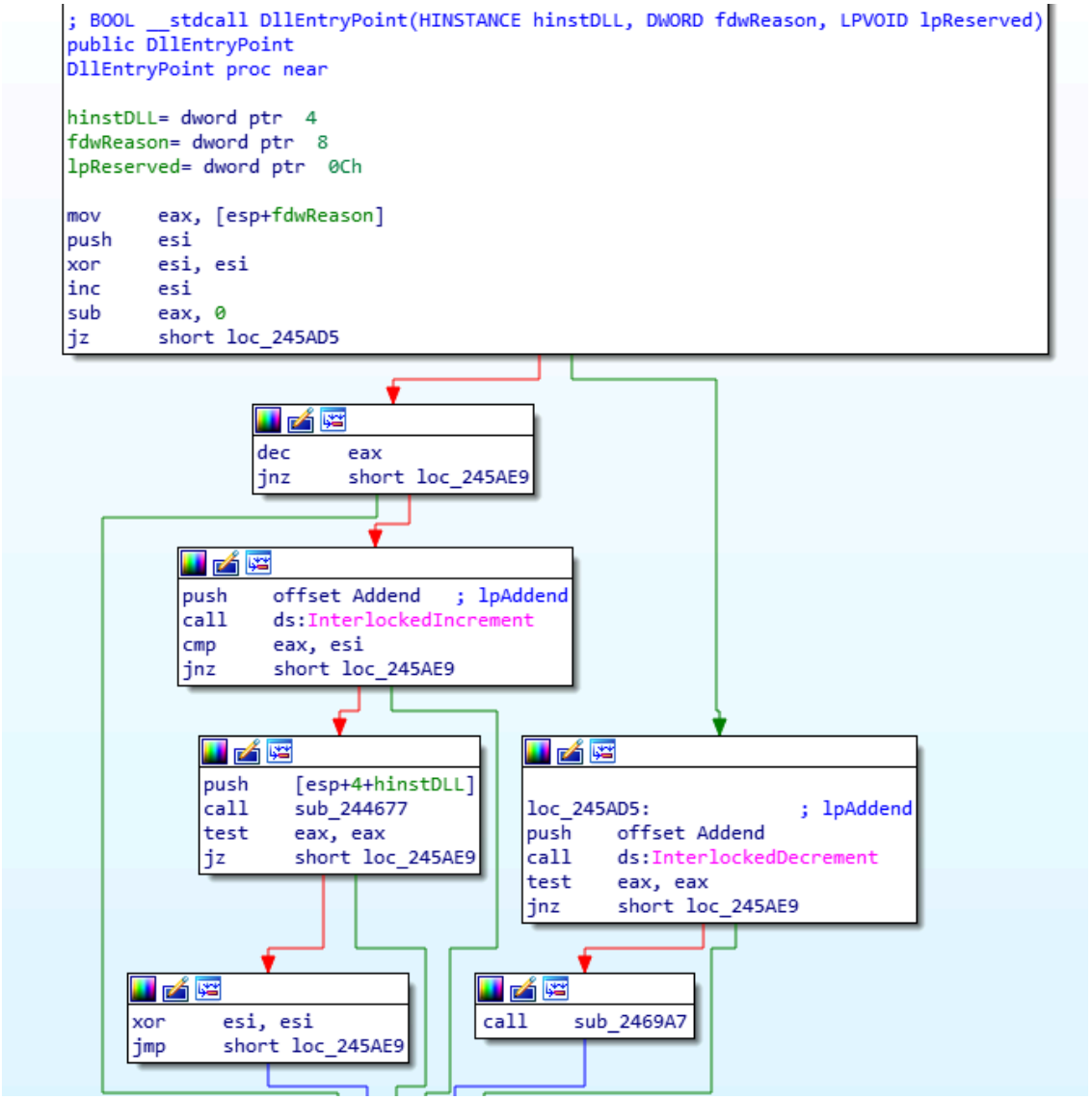




All we need to do now is to dump it out, add “MZ” and “PE” to the header, unmap and rebase it using PE Bear, and then we can start analysing the next stage!

Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	Decoded text
00000000	4D	5A	00	00	00	00	00	00	00	00	00	00	00	00	00	00	MZ..............
00000010	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000020	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000030	00	00	00	00	00	00	00	00	00	00	00	00	00	01	00	00	....
00000040	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000050	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000060	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000070	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000080	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000090	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000C0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000D0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000E0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000000F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
00000100	50	45	00	00	4C	01	05	00	10	1B	4F	5C	00	00	00	00	PE..L.....O\....
00000110	00	00	00	00	E0	00	02	21	0B	01	08	00	00	8A	00	00	....à..!.....Š..
00000120	00	26	00	00	00	00	00	00	A5	5A	00	00	00	10	00	00	.&......¥Z......
00000130	00	A0	00	00	00	00	00	10	00	10	00	00	00	02	00	00	. ...
00000140	04	00	00	00	00	00	00	00	04	00	00	00	00	00	00	00	....
00000150	00	E0	00	00	00	04	00	00	00	00	00	00	02	00	00	00	.à..............
00000160	00	00	10	00	00	10	00	00	00	00	10	00	00	10	00	00	....
00000170	00	00	00	00	10	00	00	00	A0	AC	00	00	33	00	00	00	.... ¬..3...
00000180	00	A6	00	00	50	00	00	00	00	00	00	00	00	00	00	00	.¦..P...........
00000190	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000001A0	00	D0	00	00	C4	04	00	00	00	00	00	00	00	00	00	00	.Ð..Ä...........
000001B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000001C0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
000001D0	00	00	00	00	00	00	00	00	00	A0	00	00	40	01	00	00	....@...
000001E0	B4	A2	00	00	C0	00	00	00	00	00	00	00	00	00	00	00	´¢..À...........
000001F0	00	00	00	00	00	00	00	00	2E	74	65	78	74	00	00	00	.........text...


Disasm
General
DOS Hdr
File Hdr
Optional Hdr
Section Hdrs
Exports
Imports
BaseReloc.
DelayedImps
Offset
Name
Func. Count
Bound?
OriginalFirstThun
TimeDateStamp
Forwarder
NameRVA
FirstThunk
A600 ntdll.dll 15 FALSE A750 0 0 A7A4 A100
A614 KERNEL32.dll 58 FALSE A650 0 0 A94E A000
A628 OLEAUT32.dll 4 FALSE A73C 0 0 A95C A0EC
Details
Call via
Name
Ordinal
Original Thunk
Thunk
Forwarder
Hint
A100 ZwOpenProces... - A99A A99A - 449
A104 ZwOpenProcess - A98A A98A - 448
A108 ZwClose - A980 A980 - 3E0
A10C strcpy - A976 A976 - 552
A110 wcstombs - A9B0 A9B0 - 575
A114 ZwQueryInfor... - A9BC A9BC - 46B
A118 _snprintf - A9D6 A9D6 - 50E
A11C sprintf - A9E2 A9E2 - 54C
Check for updates


; BOOL __stdcall DllEntryPoint(HINSTANCE hinstDLL, DWORD fdwReason, LPVOID lpReserved)
public DllEntryPoint
DllEntryPoint proc near
hinstDLL= dword ptr 4
fdwReason= dword ptr 8
lpReserved= dword ptr 0Ch
mov eax, [esp+fdwReason]
push esi
xor esi, esi
inc esi
sub eax, 0
jz short loc_245AD5
dec eax
jnz short loc_245AE9
push offset Addend ; lpAddend
call ds:InterlockedIncrement
cmp eax, esi
jnz short loc_245AE9
push [esp+4+hinstDLL]
call sub_244677
test eax, eax
jz short loc_245AE9
loc_245AD5: ; lpAddend
push offset Addend
call ds:InterlockedDecrement
test eax, eax
jnz short loc_245AE9
xor esi, esi
jmp short loc_245AE9
call sub_2469A7

```
MD5 of Dumped DLL: 52b4480de6f4d4f32fba2b535941c284
```

Congratulations! You have managed to analyse the loader and “unpack” the next stage, which I will be analysing in the next post (because this one has now amassed over 6,000 words which is much longer than I planned). So, feel free to ask any questions you have down below, or over Twitter (**@0verfl0w_**) and I will be glad to answer them! I apologize again for the lack of posts recently, I’ve been working on my course as well, so I’ve had a lot of stuff to do! Hopefully the next post on ISFB shouldn’t take too long to do, so make sure to sign up to my mailing list to stay updated whenever I post! Thanks again 🙂
