IcedID – Technical Malware Analysis [Second Stage]

0x0d4y.blog/icedid-technical-analysis/

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In this report I will technical analyze the new **IcedID** malware, go deep through reverse engineering, debugging and detection engineering.

Introduction

The **IcedID** is a banking malware design to steal financial information from your victims. The **IcedID** malware is also know by *MITRE ATT&CK* as ***S0483***, and has been around since **2017**. The **IcedID** has been used by ***GOLD CABIN*** (also knows as ***TA551*** by *MITRE ATT&CK*), in a lot of campaign since 2017, but recently in a *Covid-19* pandemic, they execute a campaign of *Phishing* emails with malicious attachments (*1st stage* that download the loader) to download and execute the **IcedID**.

Some *public threat reports* points to a modular capability of *IcedID* trojan, this makes this malware family a greater evolution compare to ***Zeus*** malware. This modular capability of IcedID is due to the fact that the malware downloads, through network communication with command and control servers, new modules if necessary during the campaign.

In 2017, when *IcedID* emerge in the cyber scenario, has been observed the *IcedID* malware was delivery through ***Emotet*** infections. Emotet has been a distribution of the elite malware baking trojans, like ***Qbot*** and ***Dridex***, and since 2017 the *IcedID* was added in their list of malware distribution.

Capabilities

In the samples that I will use as an objects of research for this article, I identified the following *MITRE ATT&CK Tactics* and *Techniques*.

ATT&CK Tatic	ATT&CK Technique
DEFENSE EVASION	Obfuscated Files or Information [T1027]
DEFENSE EVASION	Process Injection [T1055]
DEFENSE EVASION	Virtualization/Sandbox Evasion: System Checks [T1497.001]
DEFENSE EVASION	Virtualization/Sandbox Evasion: Time Based Evasion [T1497.003]
DISCOVERY	Account Discovery [T1087]
DISCOVERY	File and Directory Discovery [T1083]
DISCOVERY	System Owner/User Discovery [T1033]
COMMAND AND CONTROL	Application Layer Protocol: Web Protocols [T1071.001]

Furthermore, it was identified that this samples, and members of its family, contain the following capabilities according to **Malware Behavior Catalog**.

ANTI-BEHAVIORAL ANALYSIS	Debugger Detection::Anti-debugging Instructions [B0001.034]
COMMUNICATION	HTTP Communication::Create Request [C0002.012] HTTP Communication::Get Response [C0002.017] HTTP Communication::Read Header [C0002.014] HTTP Communication::WinHTTP [C0002.008]
CRYPTOGRAPHY	Encrypt Data::RC4 [C0027.009] Encryption Key::RC4 KSA [C0028.002] Generate Pseudo-random Sequence::RC4 PRGA [C0021.004]
DATA	Encode Data::XOR [C0026.002]
DEFENSE EVASION	Obfuscated Files or Information::Encoding-Standard Algorithm [E1027.m02]
DISCOVERY	Analysis Tool Discovery::Process detection [B0013.001] File and Directory Discovery [E1083]
FILE SYSTEM	Create Directory [C0046] Read File [C0051] Writes File [C0052]

Purpose of this Technical Article

This is a technical article, which aims to analyze the IcedID second loader. This article will not focus on network traffic analysis, mainly due to the fact that there are already excellent articles written by **techevo**. You can access these articles by clicking **here**.

This analysis will understood as the study of **WHAT** and **HOW** *IcedID* executes its *Tactics*, *Techniques* and *Procedures*. This type of analysis is performed through static analysis through Reverse Engineering, and through dynamic analysis performed through a *Debugger*.

After performing such an analysis, this report will focus on two topics:

- What are the similarities between samples from different years?
- Development of **Yara** detection rules, with the aim of detecting *IcedID* infections.

Technical Analysis

In this article I will focus the analysis on an *IcedID* sample that was seen in *2020*. However, at the end of the technical analysis, we will analyze in more depth the similarities between two more samples, from different years. Below you can see the **SHA-256** hash from it, and the link for download the sample.

```
76cd290b236b11bd18d81e75e41682208e4c0a5701ce7834a9e289ea9e06eb7e new_iced.exe
```

Link to download this sample, here.

This same sample has been executed into *AnyRun Sandbox*, but, the *AnyRun* don't identify this *IcedID* sample as a threat. The same sample has been executed into *Triage Sandbox*, and it's not identify at malicious too. This indicates the sample has a *sandbox evasion technique*, to not be detected by sandbox or other detection methods.

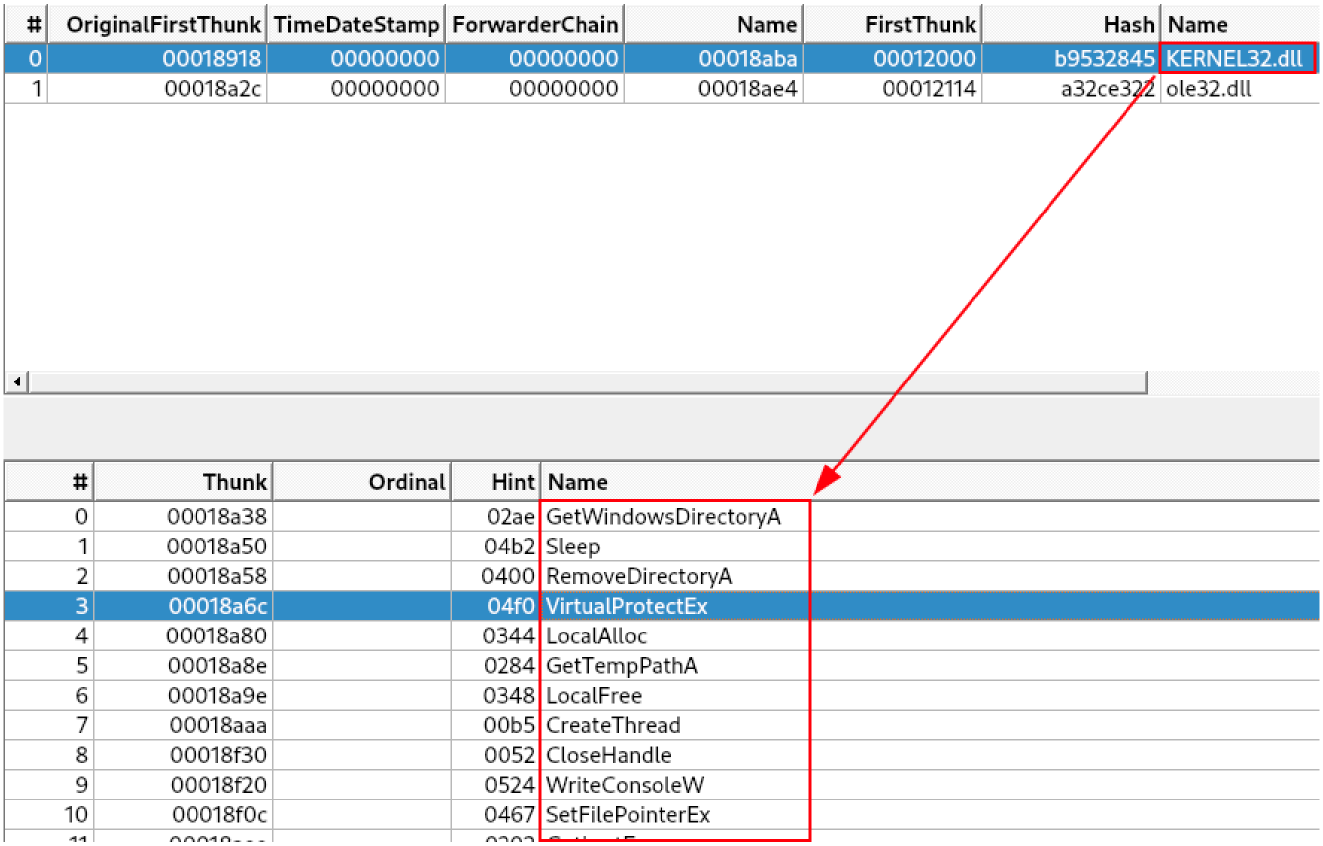
Static Analysis

Now let's start our analysis of this sample, and first, let's identify some screening information to understand the sample we have in hand.

Statically analyzing *DLL imports*, we can observe the import of two *DLLs*:

- **ole32.dll**
- **kernel32.dll**

What catches our eye is the amount of **kernel32.dll** imports, but **67 functions** is explicit imported. This can confuses the analyst, when we are looking for binary packed pattern. But, into the *67 imported* functions, we can identify the **VirtualProtectEx** import.



#	OriginalFirstThunk	TimeDateStamp	ForwarderChain	Name	FirstThunk	Hash	Name
0	00018918	00000000	00000000	00018aba	00012000	b9532845	KERNEL32.dll
1	00018a2c	00000000	00000000	00018ae4	00012114	a32ce322	ole32.dll

#	Thunk	Ordinal	Hint	Name
0	00018a38		02ae	GetWindowsDirectoryA
1	00018a50		04b2	Sleep
2	00018a58		0400	RemoveDirectoryA
3	00018a6c		04f0	VirtualProtectEx
4	00018a80		0344	LocalAlloc
5	00018a8e		0284	GetTempPathA
6	00018a9e		0348	LocalFree
7	00018aaa		00b5	CreateThread
8	00018f30		0052	CloseHandle
9	00018f20		0524	WriteConsoleW
10	00018f0c		0467	SetFilePointerEx
11	[illegible]		[illegible]	[illegible]

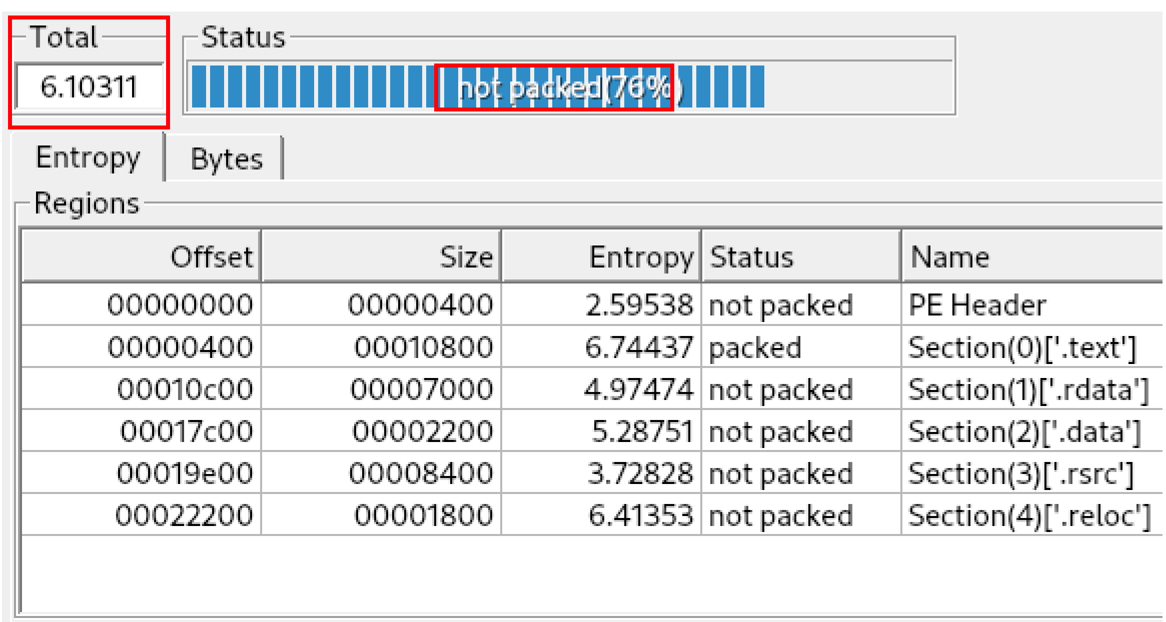
The ***VirtualProtectEx*** API is often used by malware to modify memory protection in a process (often to allow write or execution).

With the standard output, *Capa* cannot identify that sample is packed.

```
researcher@malwarelab:~$ capa new_iced.exe

┌──────────────────────────┬──────────────────────────
│ md5                      │ 17091a1e444f306b928d69f2b905bc8b
│
│ sha1                     │ 1078744833050626e9681c7c233c3a0963a0b559
│
│ sha256                   │
76cd290b236b11bd18d81e75e41682208e4c0a5701ce7834a9e289ea9e06eb7e
│
│ os                       │ windows
│
│ format                   │ pe
│
│ arch                     │ i386
│
│ path                     │ /home/researcher/malware/new_iced.exe │
└──────────────────────────┴──────────────────────────

┌──────────────────────────┬──────────────────────────
│ ATT&CK Tactic            │ ATT&CK Technique
│
├──────────────────────────┼──────────────────────────
│ DISCOVERY                │ File and Directory Discovery T1083
│
├────────────────┼────────────────────────────────────
│ EXECUTION                │ Shared Modules T1129
│
└──────────────────────────┴──────────────────────────

┌───────────────────────────────┬─────────────────────
│ MBC Objective                 │ MBC Behavior
│
├───────────────────────────────┼─────────────────────
│ DISCOVERY                     │ File and Directory Discovery [E1083]
│
```

```
└──────────────────────────────────────────────────┴─────────────────────────────────

┌────────────────────────────────────────────────────────────────────────────────────

                │ Capability                                            │ Namespace
│

├────────────────────────────────────────────────────────────────────────────────────

                │ contains PDB path                                     │
executable/pe/pdb                                   │
                │ get common file path                                  │ host-
interaction/file-system                        │
                │ print debug messages                                  │ host-
interaction/log/debug/write-event              │
                │ get thread local storage value                        │ host-
interaction/process                            │
                │ link many functions at runtime                        │
linking/runtime-linking                             │

└────────────────────────────────────────────────────────────────────────────────────
```

This is probably due to the low entropy of the sample (despite the **.text** section being tagged as packed, by ***DiE***). *High entropy* is generally an easy indicator of using encryption in samples. In this case, as we can see in the image below, the entropy is below **7.0**.



Offset	Size	Entropy	Status	Name
00000000	00000400	2.59538	not packed	PE Header
00000400	00010800	6.74437	packed	Section(0)['.text']
00010c00	00007000	4.97474	not packed	Section(1)['.rdata']
00017c00	00002200	5.28751	not packed	Section(2)['.data']
00019e00	00008400	3.72828	not packed	Section(3)['.rsrc']
00022200	00001800	6.41353	not packed	Section(4)['.reloc']

From here, we need to make sure this is not a sample that is *not packed*. To do this, we will dynamically analyze the sample, with the aim of discovering the existence of its unpacking routine.

Unpacking with x32dbg – new_iced.exe

We saw in previous sections of this article, that any sandbox or tool, can be capable to identify that this sample is *packed*, or even malicious. But, in our static analysis, we find the **VirtualProtect** API call, and this API is widely used for unpacking process.

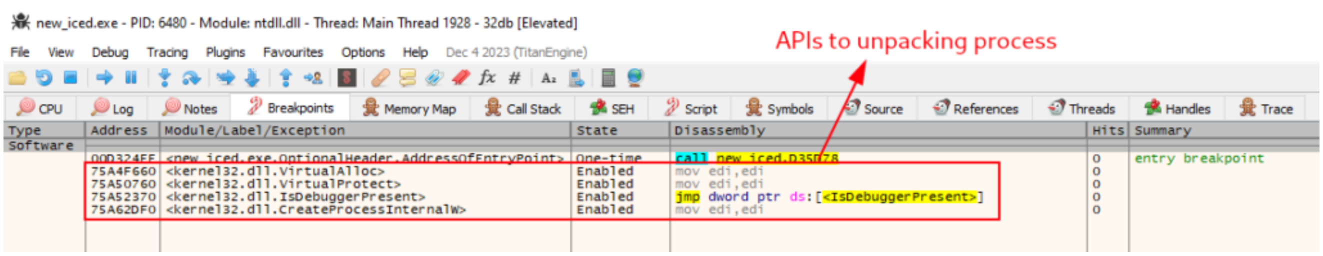
So, let's diving in, and figure out that this sample is really packed or not, with the **x32dbg**.

On the *x32dbg*, we need to set some breakpoints on APIs, that is commonly used to run the unpacking process. Are they:

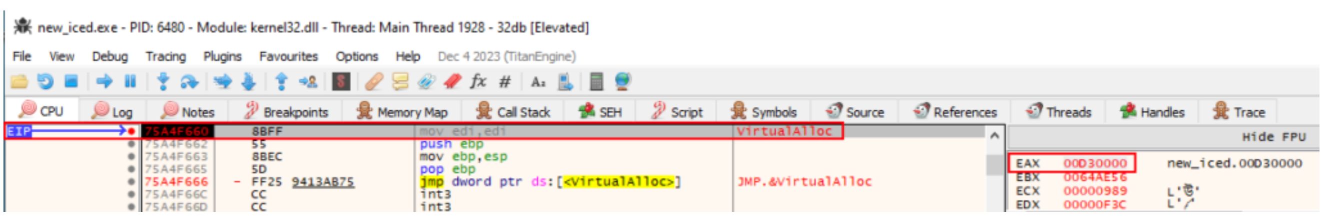
A lot of others APIs can be used, but, this three is commonly used by packers.

As a precaution, we will set a breakpoint at **IsDebuggerPresent** in case the example implements some *Anti-Debugging* techniques.

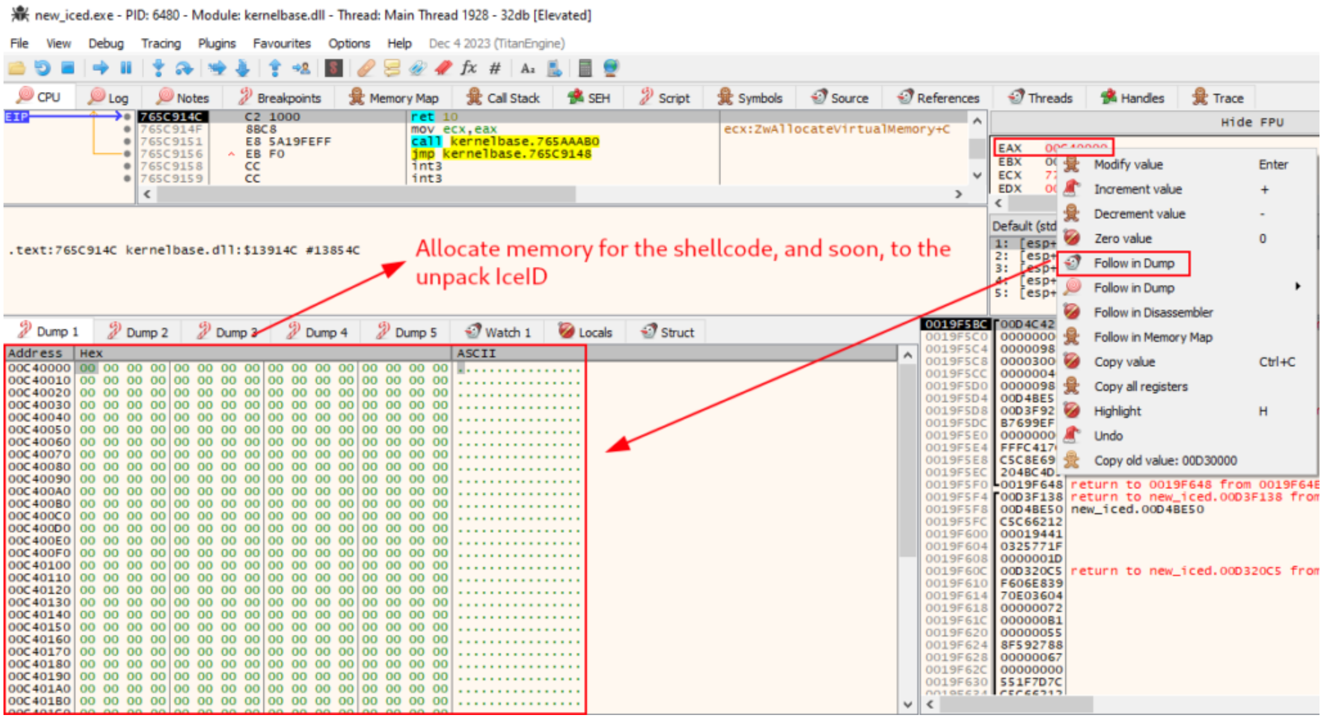
Below, we can see the breakpoints setup.



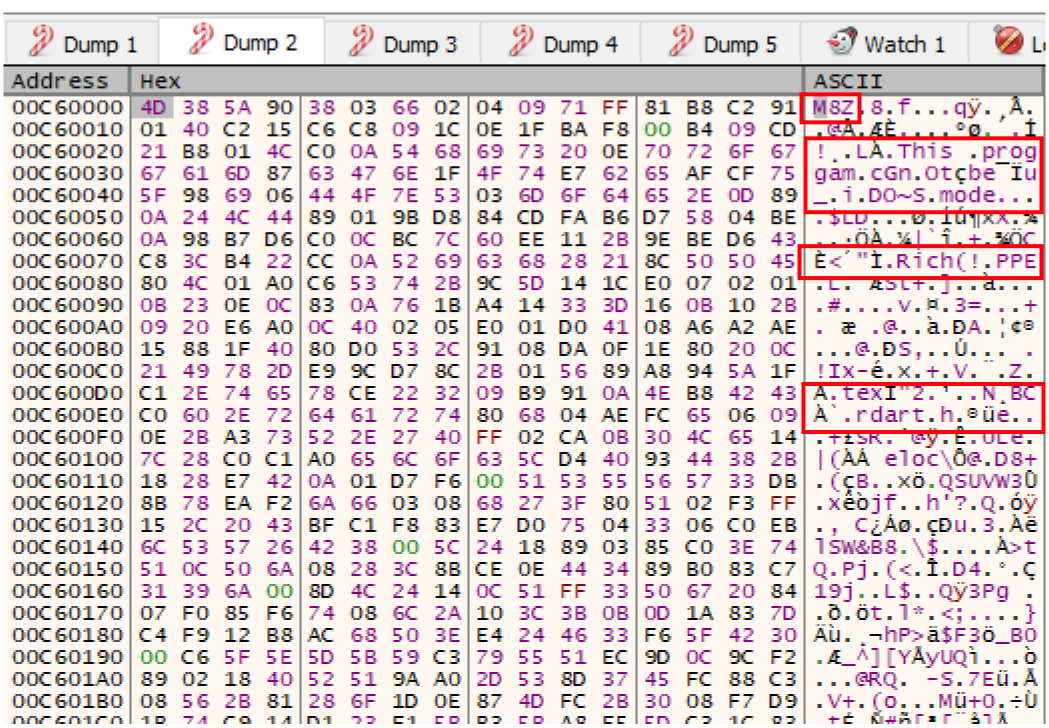
The first breakpoint match in the **VirtualAlloc** API has been triggered, so we need to press execute till returns, and run again the sample, so we can observe memory allocation and filling. This allocation and completion will be stored in the ***EAX register***.



We need to follow in dump on **EAX** memory space, to visualize the allocation and filling with data (possible *shellcode* on first round, and soon will be the unpack *IcedID*).



This process, need to be done three times in this sample (maybe is less or more in other samples), until we can get the unpacked *IcedID*. After repeat this process three times, we get our strange *MZ header*.



The **M8Z header** is what we see on **EAX** register's memory space, after unpacking process is done. This header is a reference to **APlib**, that is widely used to compress malware. Generally, when we find a *PE* artifact, with the *APlib* magic number, we can be sure that the binary is already unpacked in some memory space close to the artifact packed with *APlib*. So let's find the decompress *IcedID*.

Finding the Decompressed Unpacked IcedID

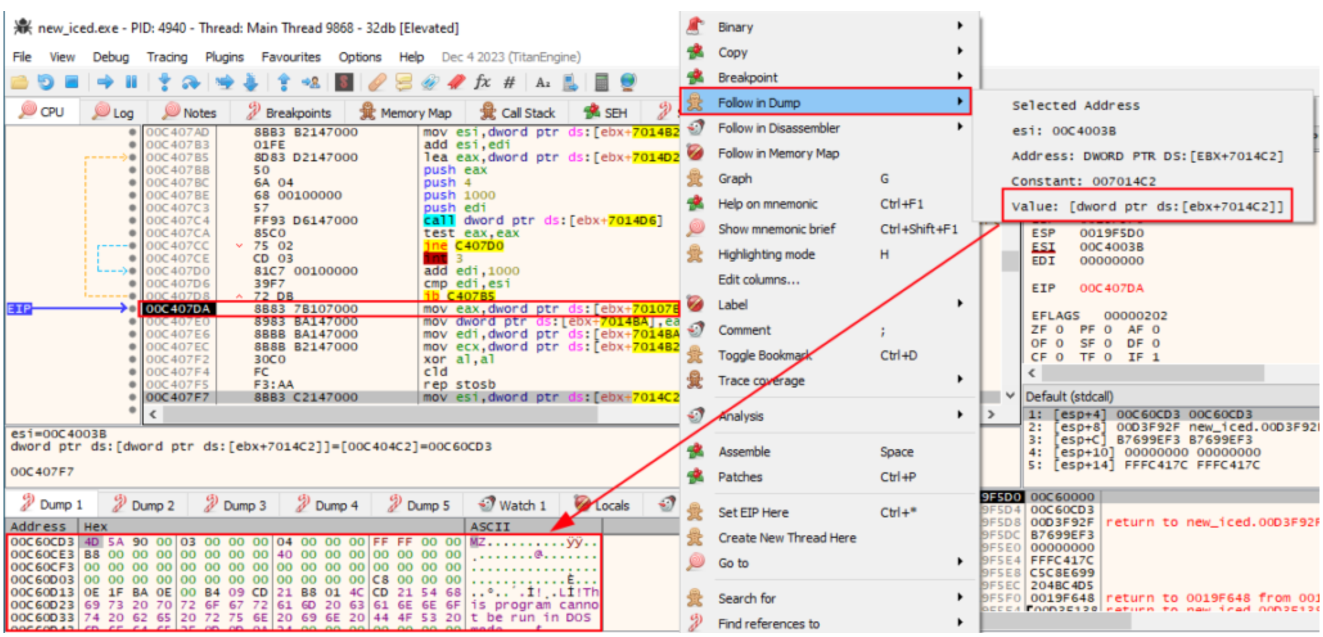
When the last **VirtualAlloc** breakpoint is reached, the next breakpoint is the **VirtualProtect** (*is the API that set protections configuration on that memory region*). We can press *execute till return*, to reached the end of the function, and then, exit the code related to the **VirtualProtect** API and return to the sample code.

After that, we will be redirected to the some instructions that manipulate some address to registers. To try to find the decompressed unpacked *IcedID*, we need to look the dump of each address of the next instructions on the **x32dbg**.

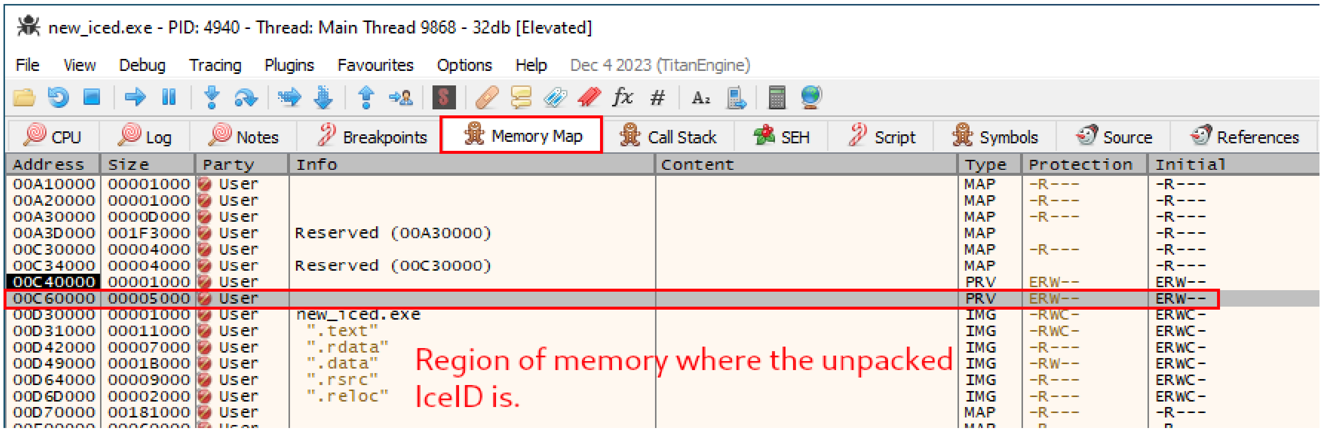
After some try and failure, we encounter the decompressed unpacked *IcedID*, on the follow instruction in **00C407F7** offset.

```
mov esi,dword ptr ds:[ebx+7014C2]
```

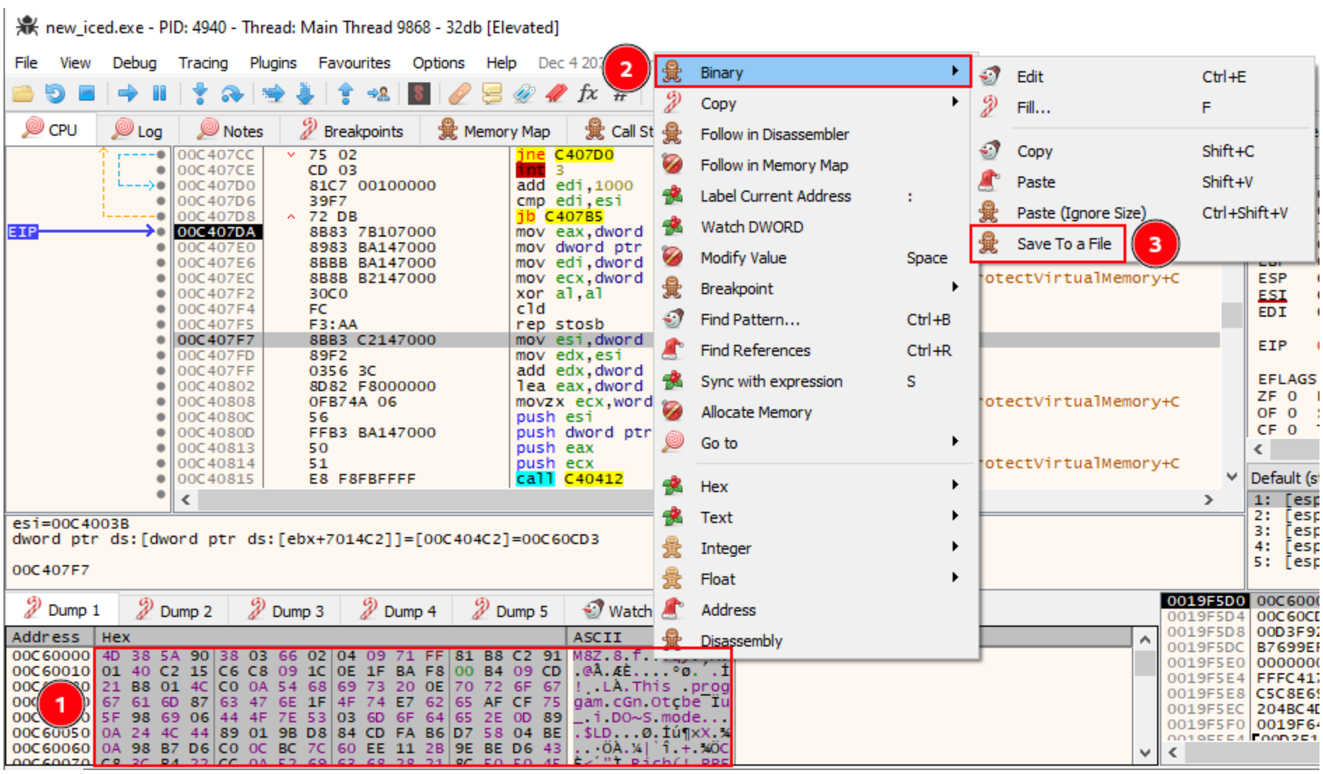
Below we can identify the truly unpacked *IcedID* on the **00C60CD3** address.



To validate this information, we can go to the *Memory Map* tab on the **32xdbg**, and look at `00C60CD3` address protections. As we can see below, this region of memory has **Execute** (***E***), **Read** (***R***) and **Write** (***W***) protections. This indicates that unmapped region, has the same rights of one executable.



Now that we found our unpacked IcedID, we need to save him into a file. To do this, we need to select all data on the dump tab that we identify the unpacked malware, and save to a file.



Now, we have our real IcedID, so let's reverse engineering it.

Reverse Engineering – unpacked_iced.exe

Before we diving in on reverse engineering, let's take a look at some triage information of the unpacked sample.

Below we can see the import of four DLLs (unlike the packed version). Being them:

- **kernel32.dll**

- **winhttp.dll**
- **user32.dll**
- **advapi32.dll**
- **shell32.dll**

However, we will only highlight the most important ones.

The first API that catches our eye, due to its capabilities, is **WINHTTP.dll**. This DLL gives the sample the capabilities of network connection. And, in the import functions, we can identify network connections related functions as we can see below.

00402068	WinHttpCloseHandle	WINHTTP
0040206C	WinHttpSetOption	WINHTTP
00402070	WinHttpOpenRequest	WINHTTP
00402074	WinHttpSendRequest	WINHTTP
00402078	WinHttpQueryHeaders	WINHTTP
0040207C	WinHttpOpen	WINHTTP
00402080	WinHttpReceiveResponse	WINHTTP
00402084	WinHttpQueryDataAvailable	WINHTTP
00402088	WinHttpConnect	WINHTTP
0040208C	WinHttpReadData	WINHTTP

The second DLL of note is **KERNEL32.dll**. As we can see in the image below, this DLL gives the sample the ability to perform file and directory manipulations, in addition to enabling memory space manipulation, allowing the execution of techniques such as code injection into memory.

00402008	lstrcpyA	KERNEL32
0040200C	ExitProcess	KERNEL32
00402010	CreateDirectoryA	KERNEL32
00402014	lstrcatA	KERNEL32
00402018	Sleep	KERNEL32
0040201C	lstrlenA	KERNEL32
00402020	ReadFile	KERNEL32
00402024	HeapFree	KERNEL32
00402028	WriteFile	KERNEL32
0040202C	CreateFileA	KERNEL32
00402030	CloseHandle	KERNEL32
00402034	HeapAlloc	KERNEL32
00402038	GetFileSize	KERNEL32
0040203C	GetProcessHeap	KERNEL32
00402040	GetModuleFileNameA	KERNEL32
00402044	VirtualProtect	KERNEL32
00402048	VirtualAlloc	KERNEL32
0040204C	HeapReAlloc	KERNEL32

This indicates, that the unpacked *IcedID* have the capability of do some, write file to execute the next stage, code injection to evade detection, and network communications to connect to the command and control server. As we can see on public threat intell, the *IcedID* is a modular banking trojan. Network-related API imports are a hint of these modular features of *IcedID*, as seen in the public threat reports described in the introduction sections.

Now, that we understand possible functionalities, let's dive in on reverse engineering.

> **NOTE**: The name of internal functions, variables and data chunks are renamed by me, and it's not the default way that disassembler/decompiler produce.

The first function is start. This section contains only the *IcedID* main function, and then the call to the **ExitProcess** API.

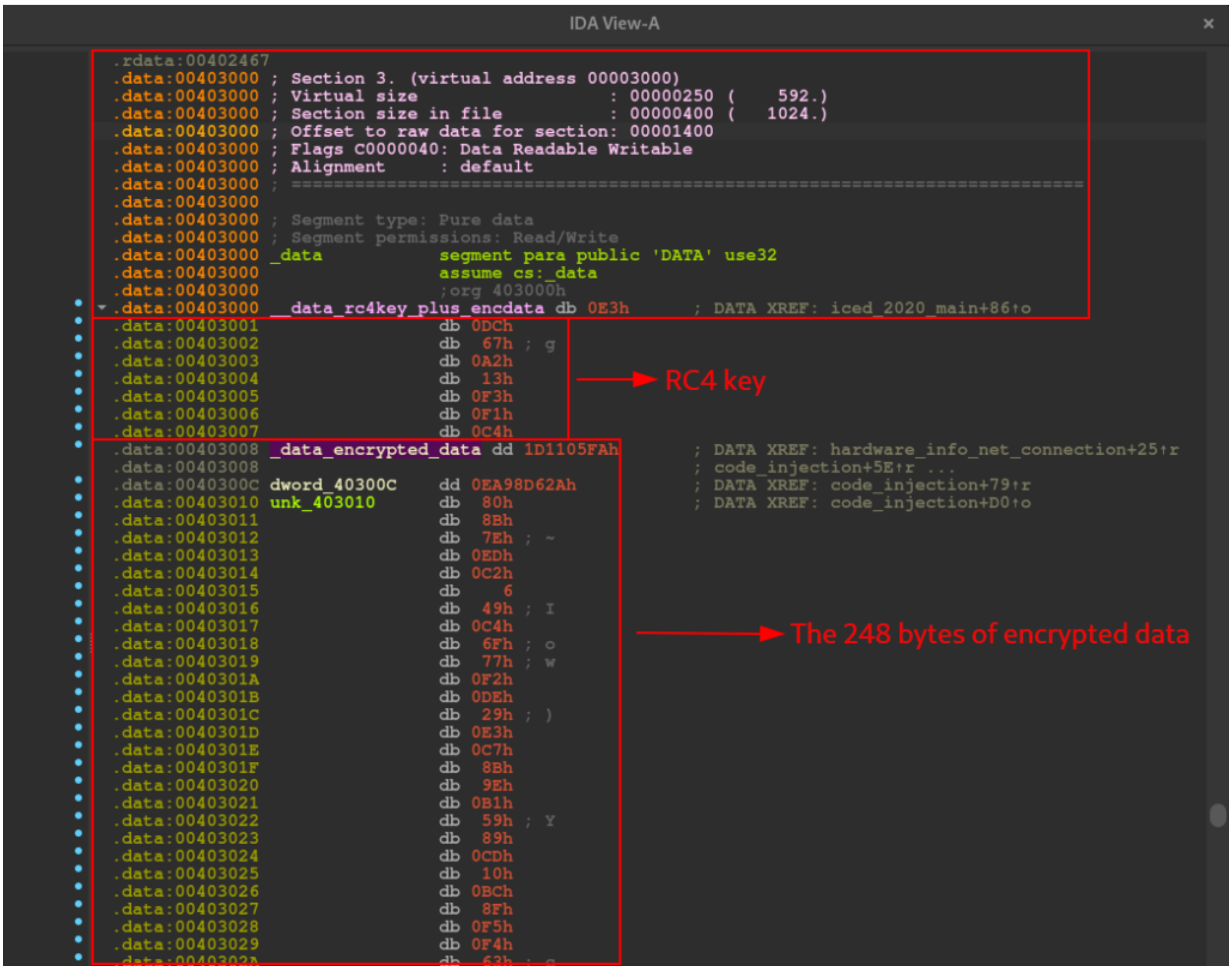
```
; Attributes: noreturn

public start
start proc near
call    iced_2020_main
push    0               ; uExitCode
call    ds:ExitProcess
start endp
```

Now let’s analyze the **iced_2020_main** function. Below, we can see the logical structure of the code.

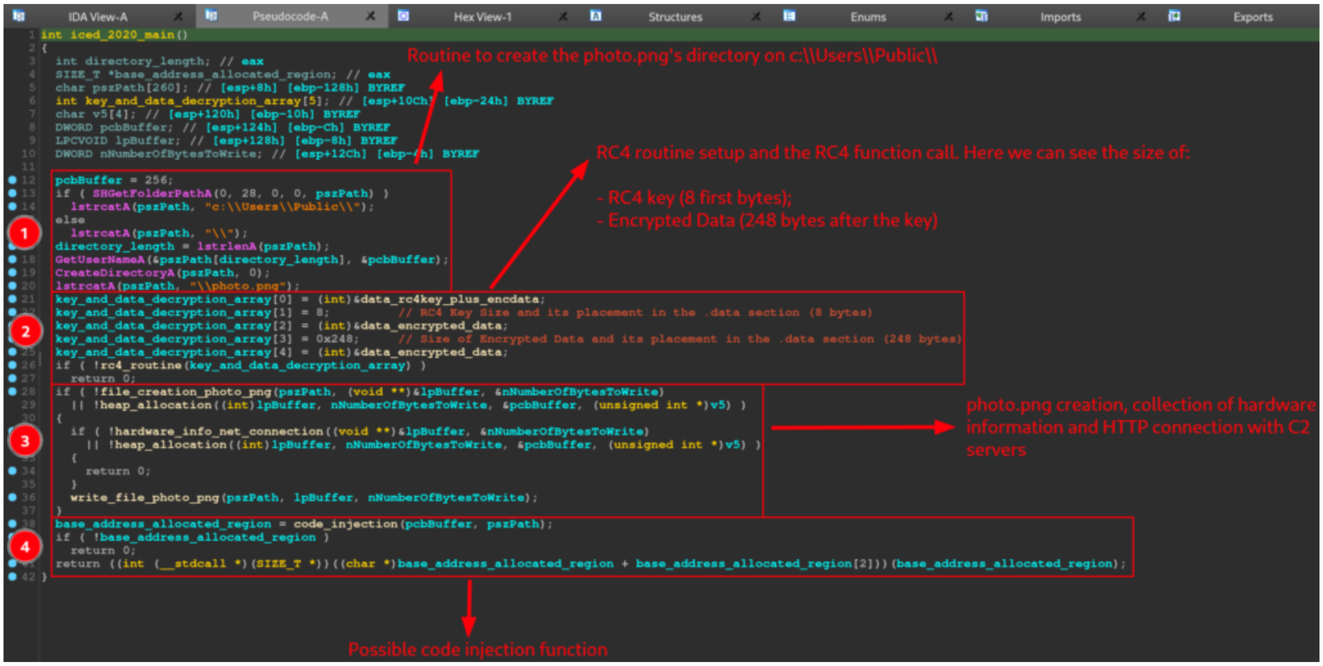
Below, we can see the main function, which can be done through IDA pseudo-code. The image below allows us to identify the main features of this *IcedID* sample:

- Creation of the **c:\\Users\\Public** directory, where the photo.png file will probably be stored.

- Execution of a decryption routine, using the **RC4** algorithm (function **rc4_routine**). It is interesting to note that the IDA Decompiler interpreted a series of setup instructions for calling the routine, as an array (**key_and_data_decryption_array**). And in this array, we are presented with information such as the size and position of the decryption key, the data to be decrypted and the address of all this data (in the **.data** section, as we can see the data reference below).

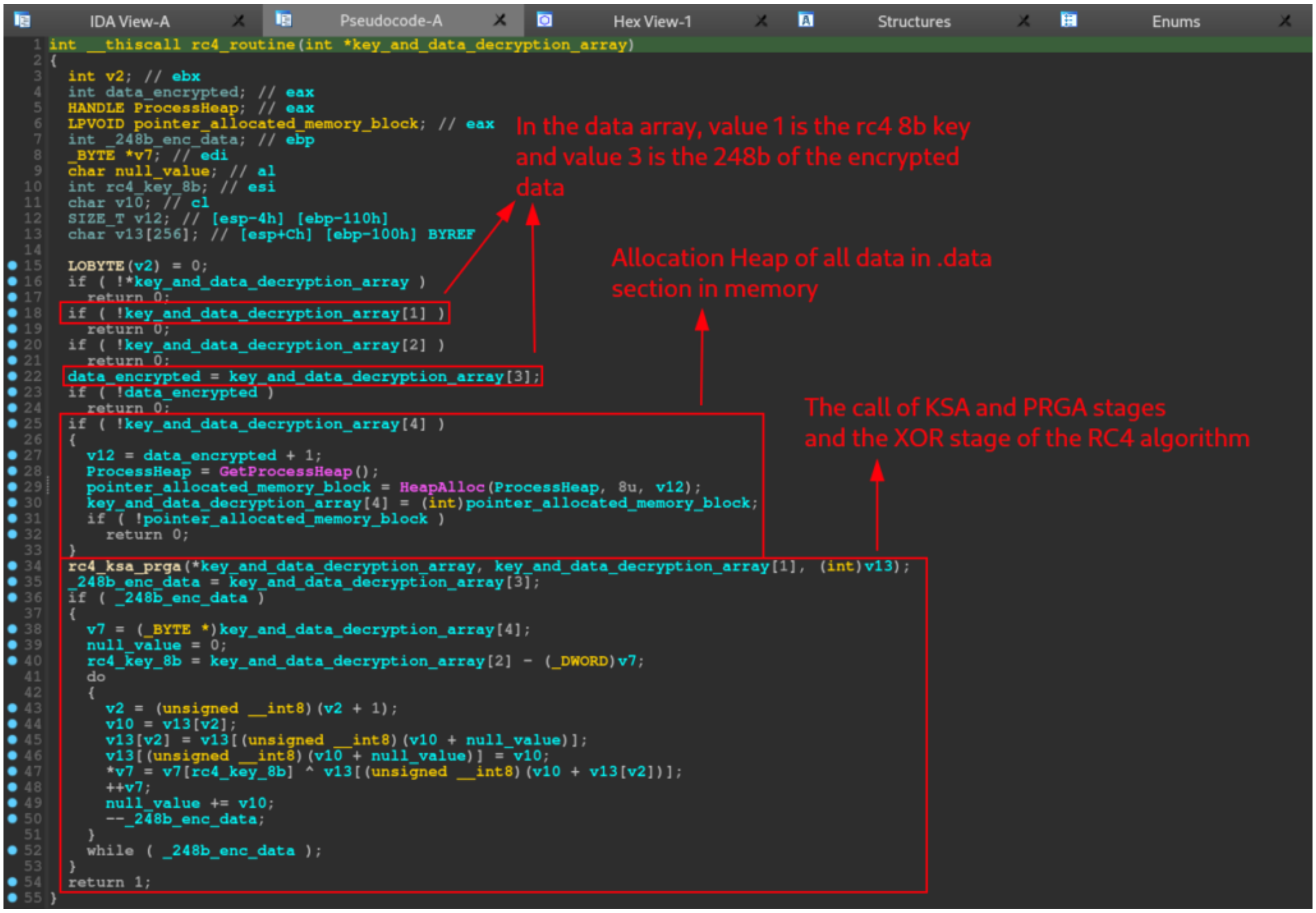


- A series of conditionals to execute the creation of the photo (**file_creation_photo_png** function).png file, collection of hardware information and network communication with the c2 servers (**hardware_info_net_connection** function).
- And the last function to be executed is a function that carries out a series of instructions, which resemble the memory code injection technique (**code_injection** function), using the data encrypted in **.data**.



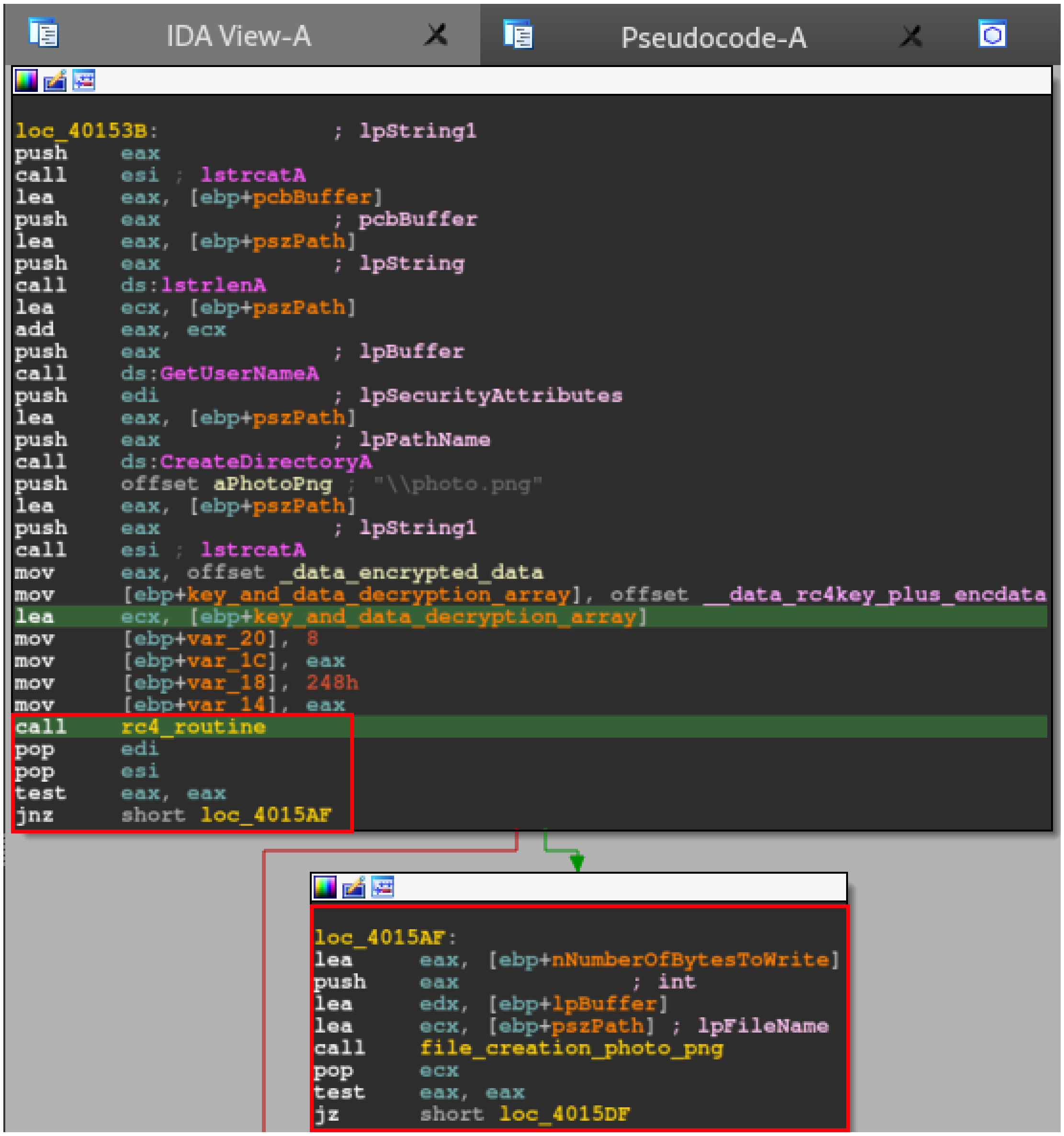
The first block of instructions in the sample, which involve the use of the **CreateDirectoryA** and **GetUserNameA** API, with the purpose of building the path to create a directory (if not existing), with the purpose of dropping the photo.png into it, is very straight to the point. Therefore, we will focus on the function that performs the data decryption process (***rc4_routine***), using the **RC4** algorithm.

Below, we can observe the *pseudo-code* of the ***rc4_routine*** function, which shows us the Heap allocation in memory with the data present in the **.data** section (apparently the key + data), the call of the ***rc4_ksa_prga*** function, which we will see the core of its operation below , and the execution of the **XOR stage** of the RC4 encryption algorithm. It is at this stage that the **248 bytes** after the key are decrypted.



Inside of the ***rc4_routine*** function, we can analyze the core of another function called ***rc4_ksa_prga***. As we can see below, this function have a rc4 *KSA*/*PRGA* routine pattern. This pattern is the two first stages of the **rc4 algorithm**.

As we can see in the image below, after executing the decryption routines, the CPU will do a test between the **EAX** register, and jump to the ***file_creation_photo_png*** function if the result is not zero.

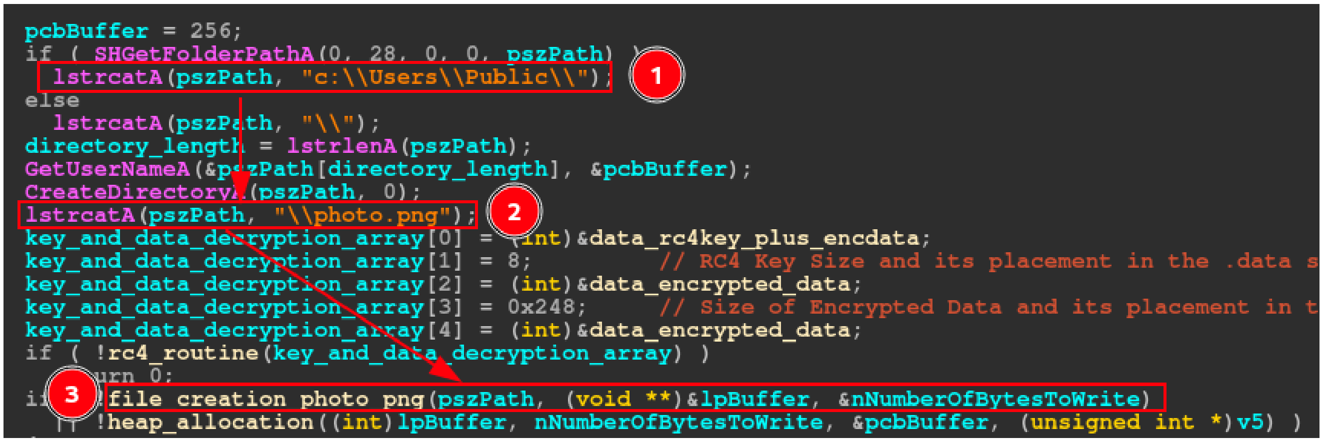


Let’s dive in the instructions of **file_creation_photo_png**.

Before we continue the analysis, we need to remember the pseudo-code of the IcedID main function. As we can see below, the **file_creation_photo_png** function takes three arguments.

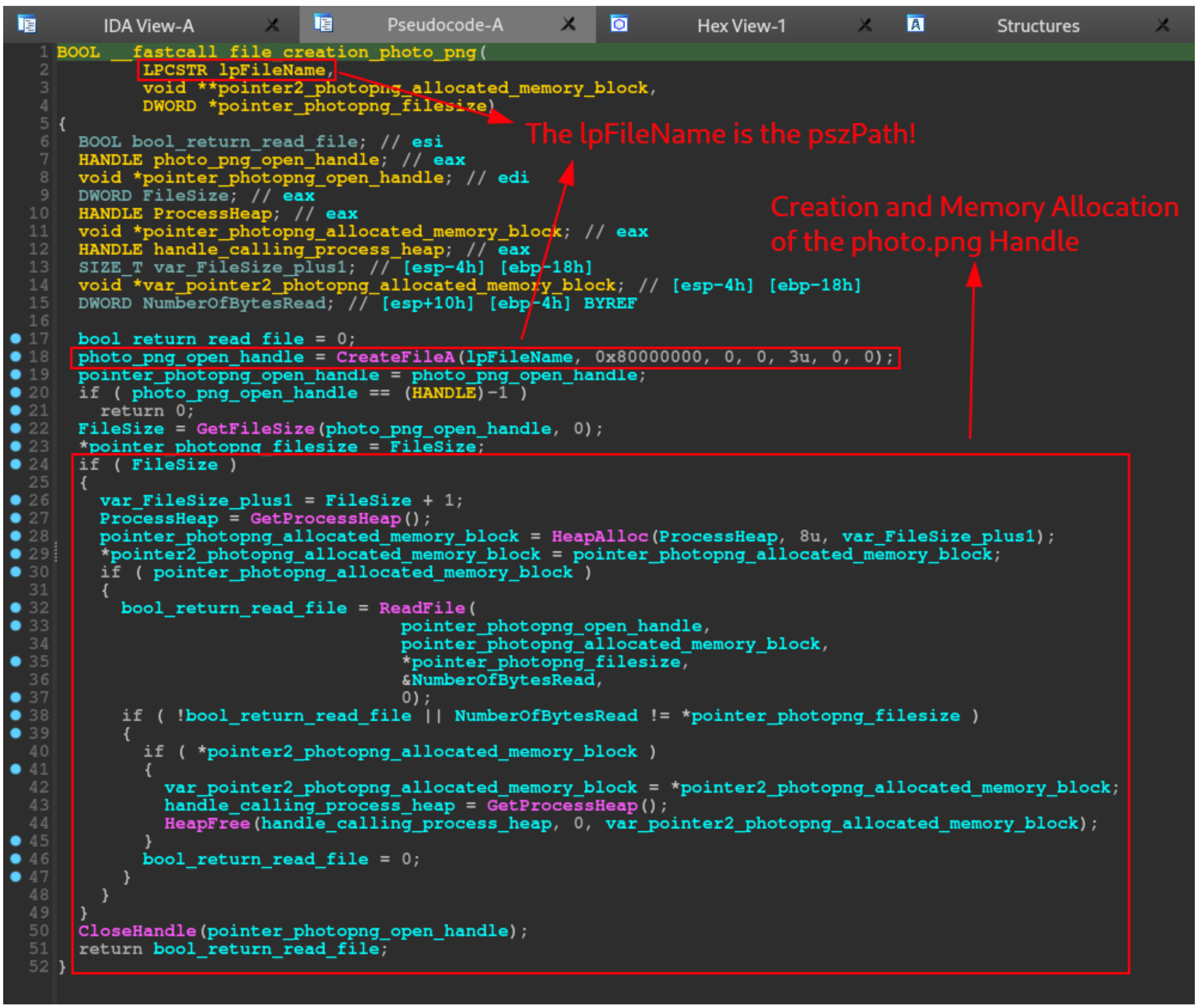
- **pszPath**
- **lpBuffer**
- **NumberOfBytesToWrite**

pszPath in particular underwent a series of transformations throughout the execution of the Main function. And when it is used as an argument in the **file_creation_photo_png** function, it is the absolute path of the **photo.png** file.



```
pcbBuffer = 256;
if ( SHGetFolderPathA(0, 28, 0, 0, pszPath) )
  lstrcatA(pszPath, "c:\\Users\\Public\\");
else
  lstrcatA(pszPath, "\\");
directory_length = lstrlenA(pszPath);
GetUserNameA(&pszPath[directory_length], &pcbBuffer);
CreateDirectoryA(pszPath, 0);
lstrcatA(pszPath, "\\photo.png");
key_and_data_decryption_array[0] = (int)&data_rc4key_plus_encdata;
key_and_data_decryption_array[1] = 8;          // RC4 Key Size and its placement in the .data s
key_and_data_decryption_array[2] = (int)&data_encrypted_data;
key_and_data_decryption_array[3] = 0x248;      // Size of Encrypted Data and its placement in t
key_and_data_decryption_array[4] = (int)&data_encrypted_data;
if ( !rc4_routine(key_and_data_decryption_array) )
  return 0;
if ( !file_creation_photo_png(pszPath, (void **)&lpBuffer, &nNumberOfBytesToWrite)
  || !heap_allocation((int)lpBuffer, nNumberOfBytesToWrite, &pcbBuffer, (unsigned int *)v5) )
```

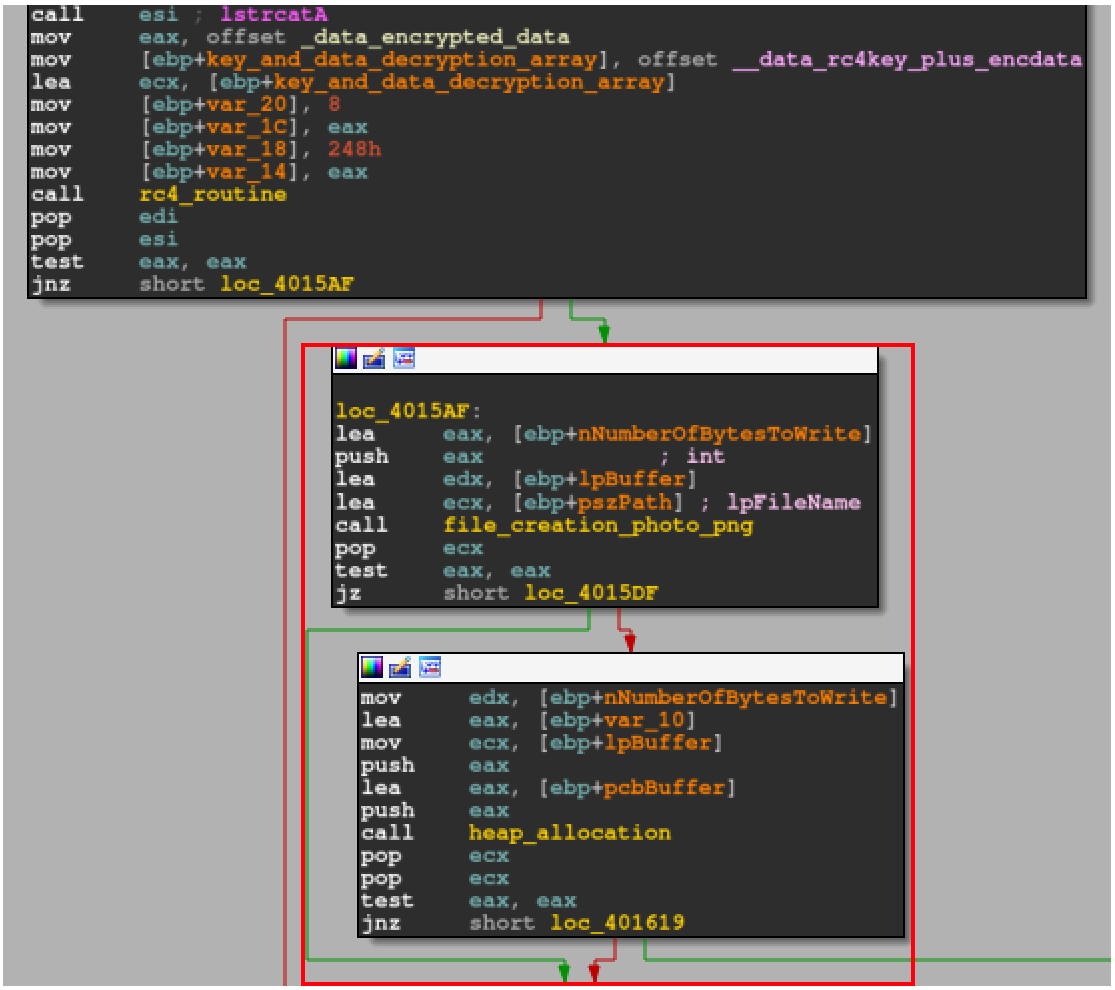

With this in mind, let's look at the pseudo-code of the **file_creation_photo_png** function, and next, we'll analyze its functionality.



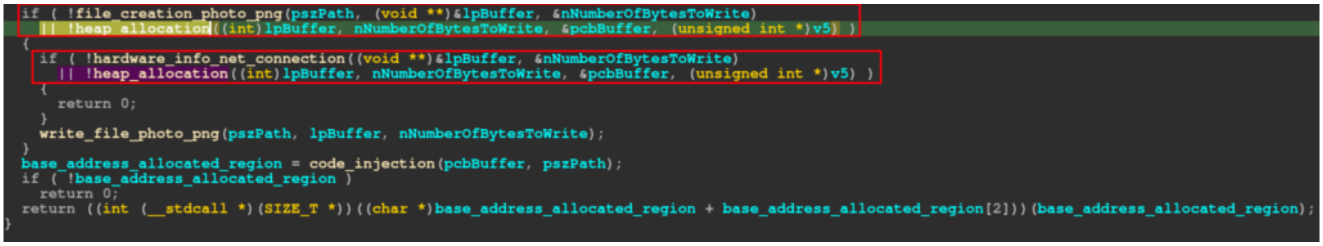

```
BOOL __fastcall file_creation_photo_png(
        LPCSTR lpFileName,
        void **pointer2_photopng_allocated_memory_block,
        DWORD *pointer_photopng_filesize)
{
  BOOL bool_return_read_file; // esi
  HANDLE photo_png_open_handle; // eax
  void *pointer_photopng_open_handle; // edi
  DWORD FileSize; // eax
  HANDLE ProcessHeap; // eax
  void *pointer_photopng_allocated_memory_block; // eax
  HANDLE handle_calling_process_heap; // eax
  SIZE_T var_FileSize_plus1; // [esp-4h] [ebp-18h]
  void *var_pointer2_photopng_allocated_memory_block; // [esp-4h] [ebp-18h]
  DWORD NumberOfBytesRead; // [esp+10h] [ebp-4h] BYREF

  bool_return_read_file = 0;
  photo_png_open_handle = CreateFileA(lpFileName, 0x80000000, 0, 0, 3u, 0, 0);
  pointer_photopng_open_handle = photo_png_open_handle;
  if ( photo_png_open_handle == (HANDLE)-1 )
    return 0;
  FileSize = GetFileSize(photo_png_open_handle, 0);
  *pointer_photopng_filesize = FileSize;
  if ( FileSize )
  {
    var_FileSize_plus1 = FileSize + 1;
    ProcessHeap = GetProcessHeap();
    pointer_photopng_allocated_memory_block = HeapAlloc(ProcessHeap, 8u, var_FileSize_plus1);
    *pointer2_photopng_allocated_memory_block = pointer_photopng_allocated_memory_block;
    if ( pointer_photopng_allocated_memory_block )
    {
      bool_return_read_file = ReadFile(
                                pointer_photopng_open_handle,
                                pointer_photopng_allocated_memory_block,
                                *pointer_photopng_filesize,
                                &NumberOfBytesRead,
                                0);
      if ( !bool_return_read_file || NumberOfBytesRead != *pointer_photopng_filesize )
      {
        if ( *pointer2_photopng_allocated_memory_block )
        {
          var_pointer2_photopng_allocated_memory_block = *pointer2_photopng_allocated_memory_block;
          handle_calling_process_heap = GetProcessHeap();
          HeapFree(handle_calling_process_heap, 0, var_pointer2_photopng_allocated_memory_block);
        }
        bool_return_read_file = 0;
      }
    }
  }
  CloseHandle(pointer_photopng_open_handle);
  return bool_return_read_file;
}
```

As we can see in the pseudo-code above, the function is very straight to the point, where the process of creating a handle for the photo.png file is basically executed, and the allocation of this handle in memory. During the end of the execution of the **file_creation_photo_png** function, it is possible to observe the cleaning being carried out.

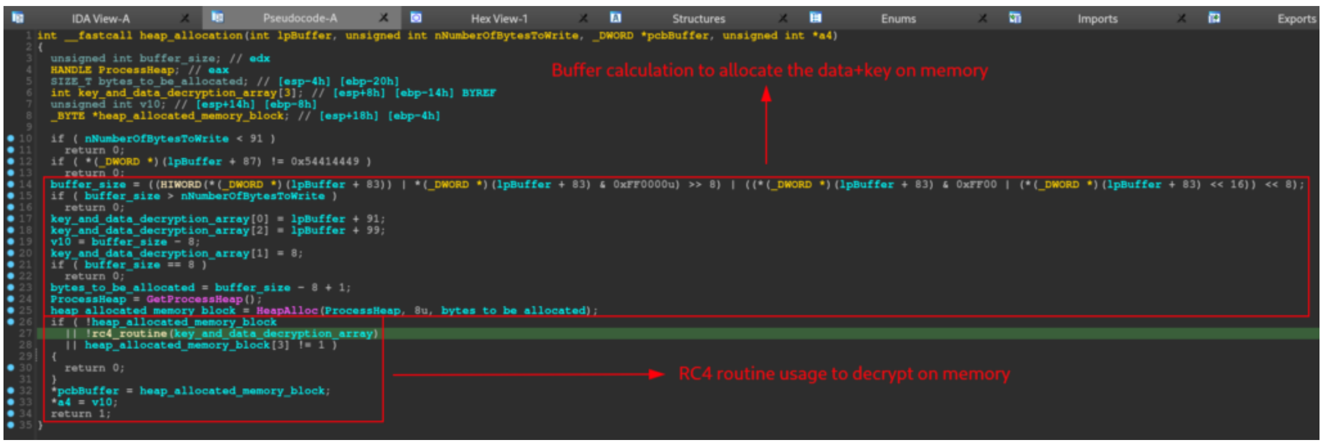
After executing the photo.png file handle creation function, the CPU will perform a test in the **EAX** register and skip the control flow to the ***hardware_info_net_connection*** function, if the condition is met. If the condition is not met, the flow will jump to executing the ***heap_allocation*** function.



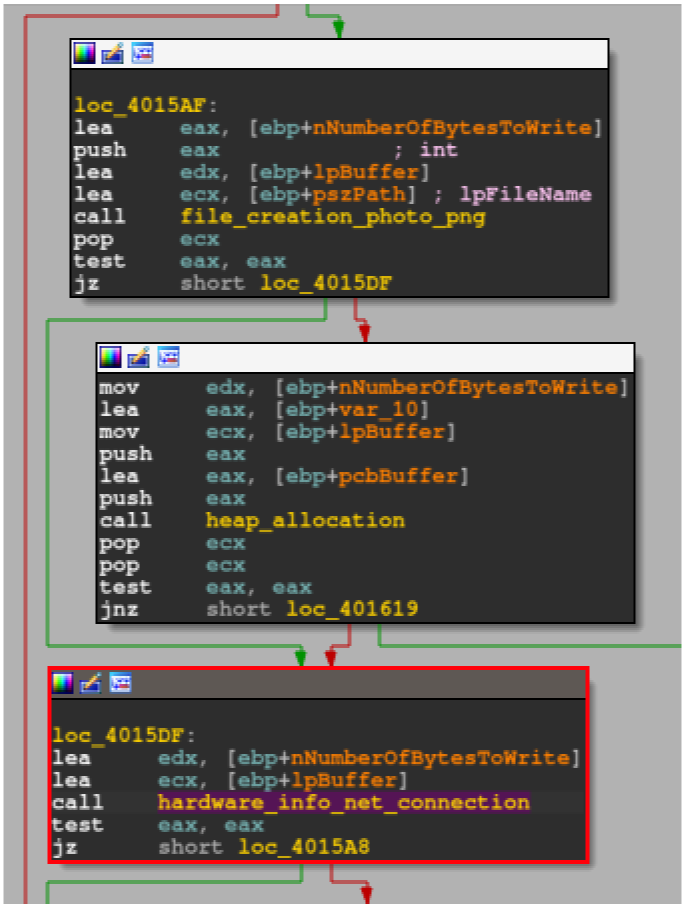
It is important to note (as we can see in the image below) that this function is called twice in the main function. One if the conditions are not met after creating the ***photo.png*** file handle, and another if the conditions are not met after executing the hardware information collection function and **HTTP** network communication routine.



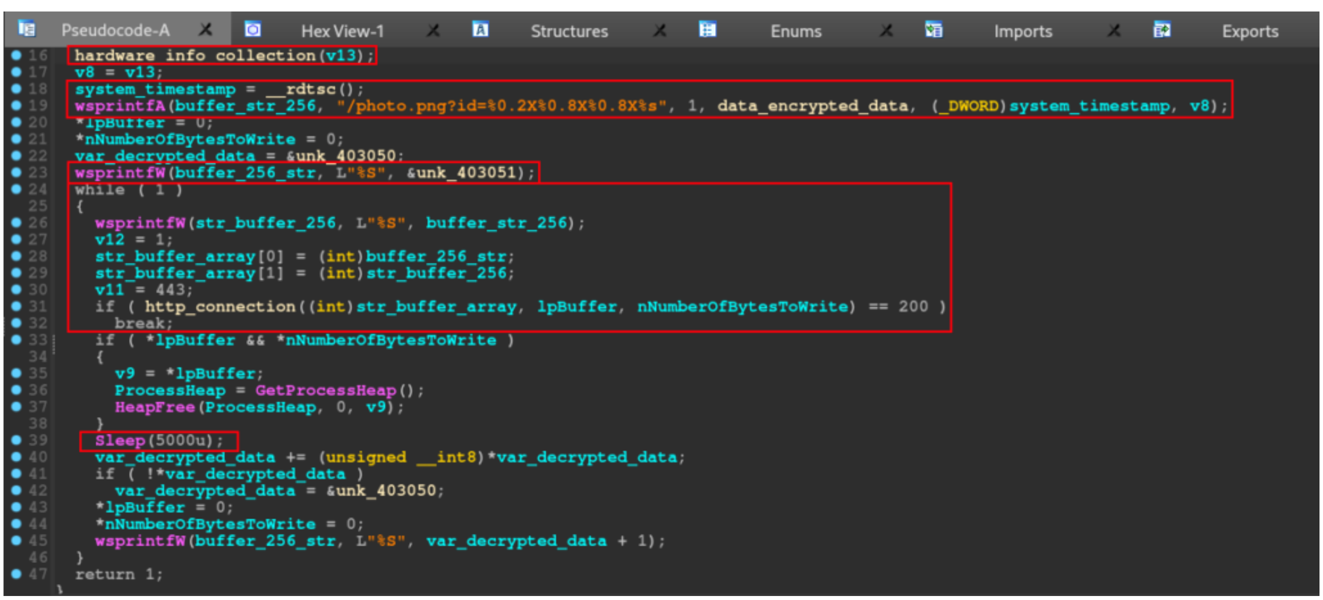
By analyzing what the ***heap_allocation*** function does, we can understand why it is executed if a certain function is not completed as expected. In the pseudo-code below, you can see that this function performs a series of calculations to determine the size of the buffer to be allocated on the heap, with the purpose of allocating the data present in .data (rc4 key and encrypted data). After this allocation, the ***rc4_routine*** function is executed to decrypt the data in memory.



Returning to the normal sample flow, when executing the handle creation function for the photo.png file, if conditionals are met, the flow will jump to the ***hardware_info_net_connection*** function.



As we can see on pseudo-code below, inside of the ***hardware_info_net_connection*** function, has two main functions, the **hardware_info_collection** and the **http_connection**.



The hardware information, was implemented in the code is based on timestamp of the device, and the *CPU model*. Analyzing the call of **_cpuid**, with just a little research on Google, we can find that matches with *VMware* hypervisor **CPUID**. That value, is the same that we can see on IcedID.

```
      goto LABEL_12;
    }
    if ( (unsigned int)sub_system_timestamp < 750 )
    {
      ++v22_zero;
      goto LABEL_12;
    }
    if ( (unsigned int)sub_system_timestamp >= 1000 )
LABEL_11:
      ++v20_zero;
    else
      ++v21_zero;
LABEL_12:
    --v1_255;
  }
  while ( v1_255 );
  _EAX = 6;
  __asm { cpuid }
  v25 = _EAX & 1;
  _EAX = 0x40000000;
  __asm { cpuid }
  return wsprintfA(
           this,
           "%0.2X%0.2X%0.2X%0.2X%0.2X%0.2X%0.8X",
           v25,
           v24_zero,
           v23_zero,
           v22_zero,
           v21_zero,
           v20_zero,
           _EAX);
}
```

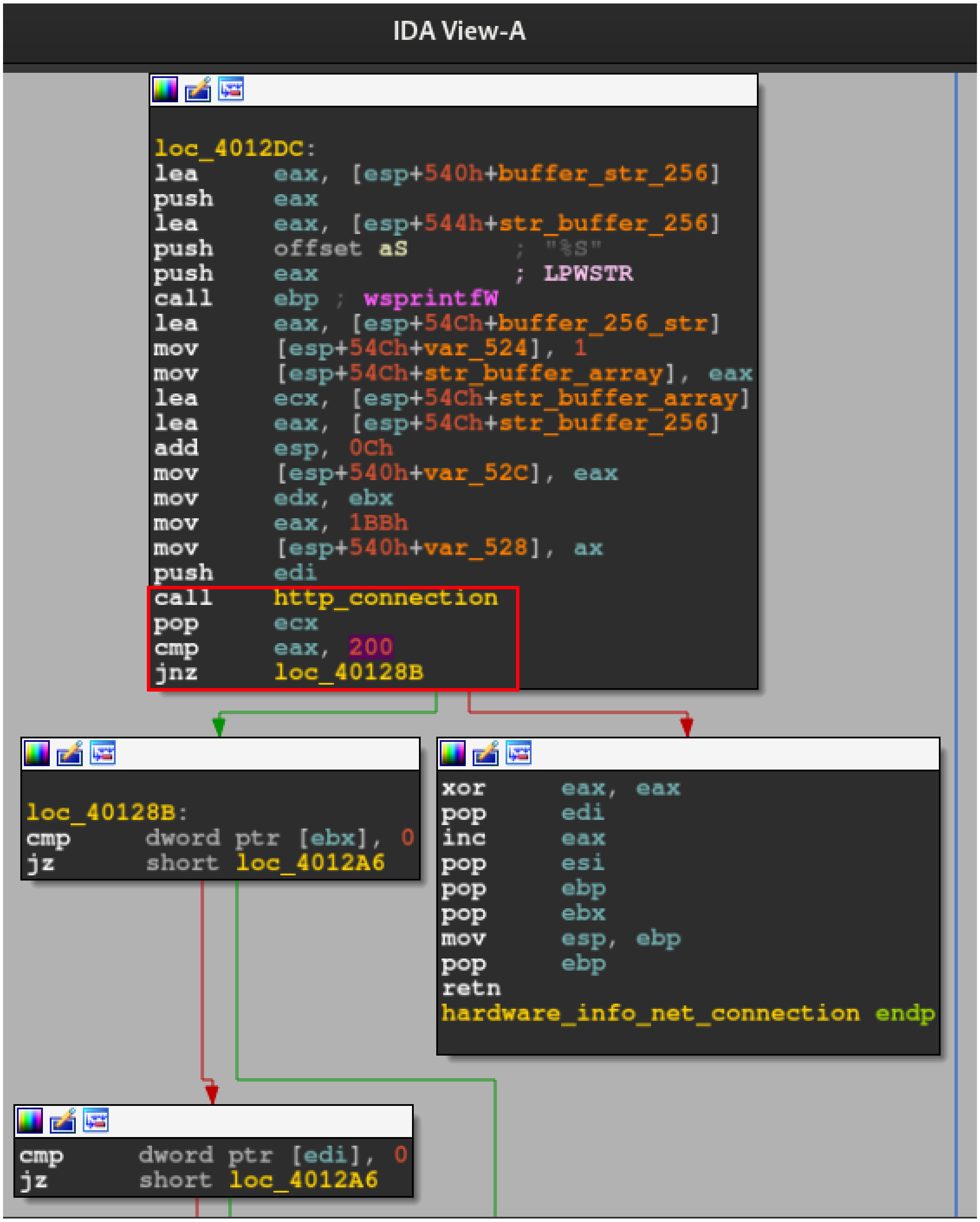
VMware
https://kb.vmware.com › article · Traduzir esta página

Mechanisms to determine if software is running in a ...

5 de jan. de 2015 — VMware defines the **0x40000000** leaf as the hypervisor **CPUID** information leaf. Code running on a VMware hypervisor can test the **CPUID** information ...

However, during the dynamic analysis, we will discover that the hardware information collected by IcedID will be used to build the HTTP request to be sent to C2.

If everything was of expected, the code will continue and execute a network related function, and after that, will check if the result of the communication results in a ***200 HTTP status code***.



Below, we can see the decompiler version of the code above.

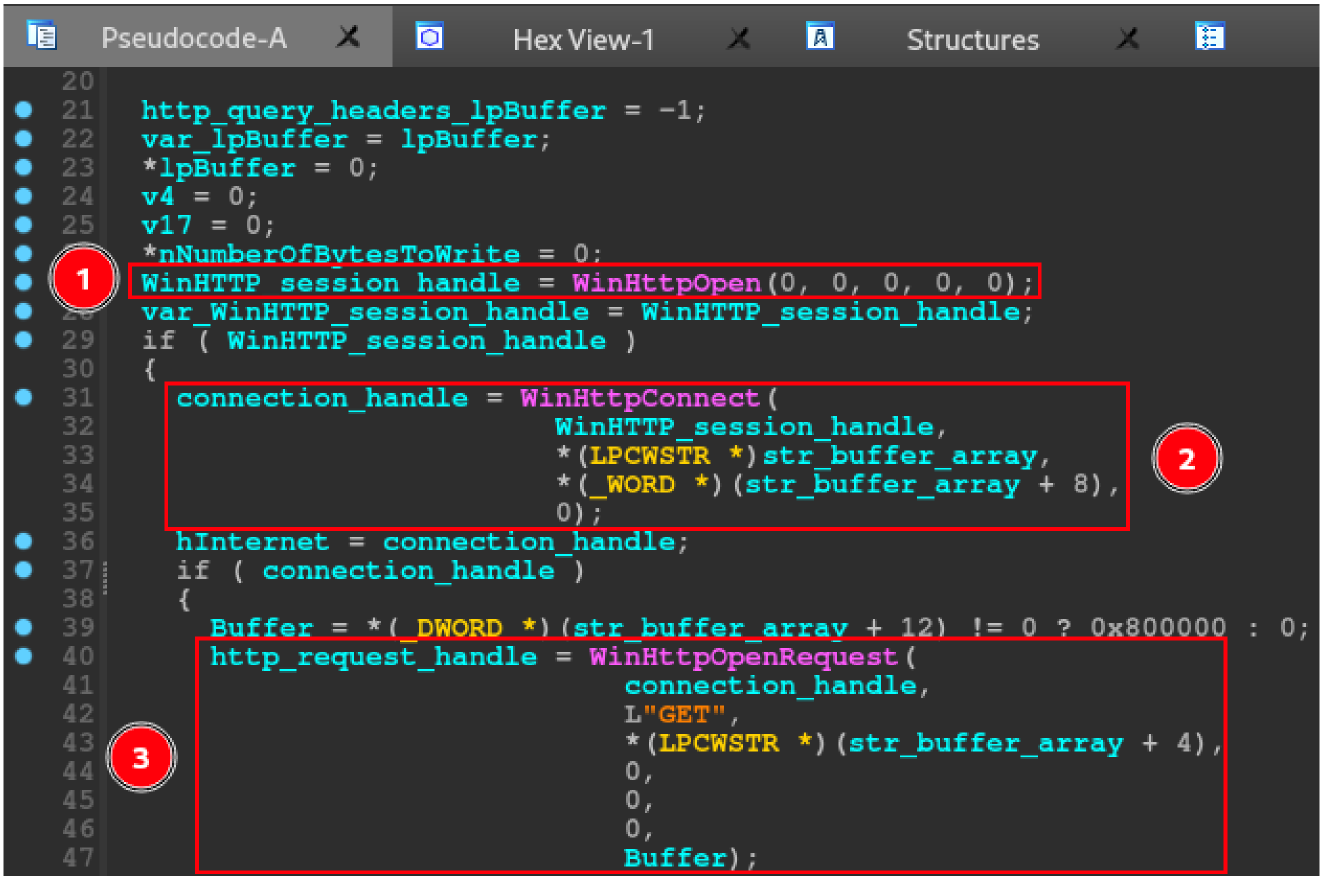
```
while ( 1 )
{
  wsprintfW(str_buffer_256, L"%S", buffer_str_256);
  v12 = 1;
  str_buffer_array[0] = (int)buffer_256_str;
  str_buffer_array[1] = (int)str_buffer_256;
  v11 = 443;
  if ( http_connection((int)str_buffer_array, lpBuffer, nNumberOfBytesToWrite) == 200 )
    break;
```

Let’s dive in the function ***http_connection_func***.

Analysis of http_connection Function

All plaintext config is encrypted, but we can prepare ourselfs to *debugging* process after reverse engineering the sample.

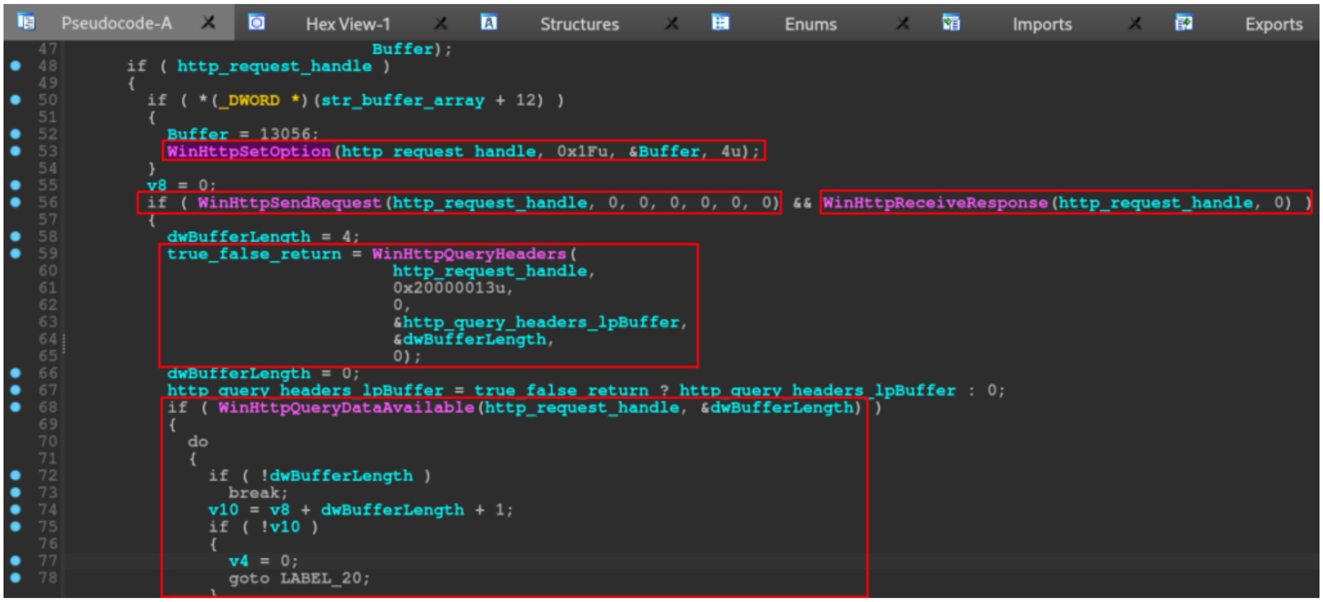
Below we can see the first part of the network communication setup.

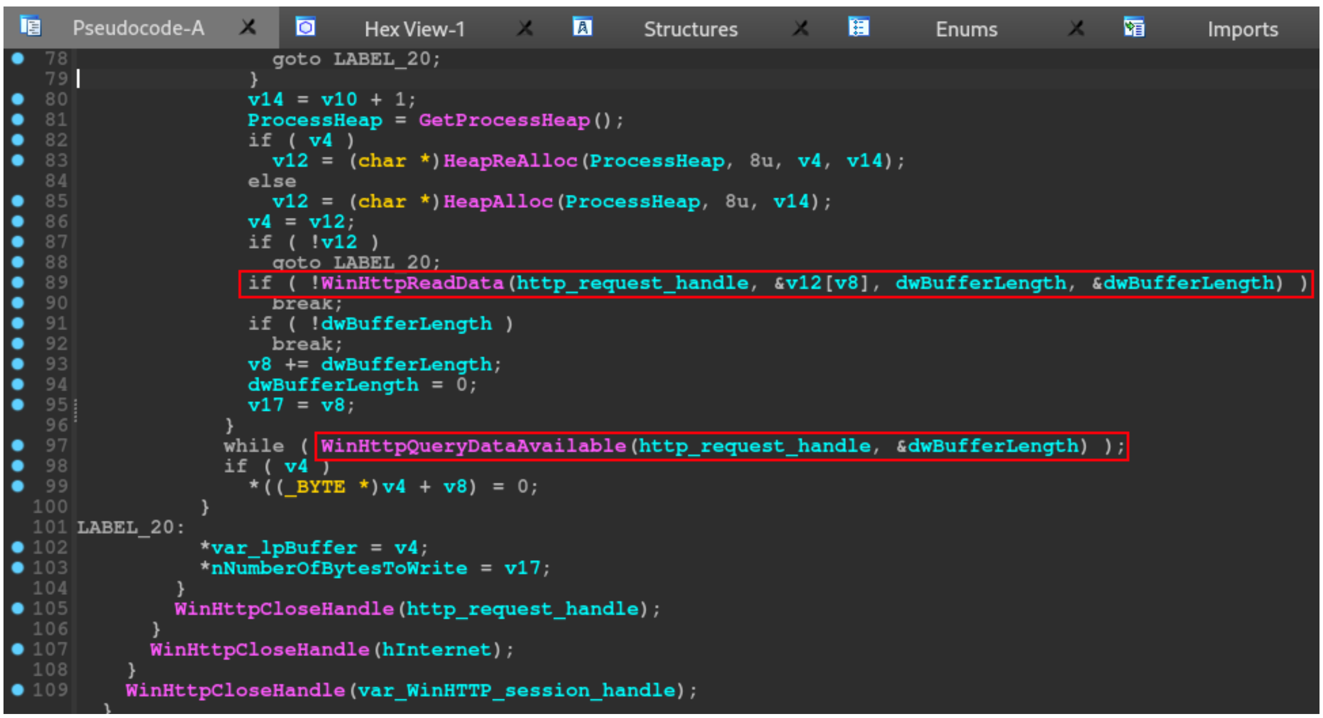


The IcedID use all capability of wininet's APIs. In this first part we can see the usage of the follow APIs:

- WinHttpOpen -> this API initializes, for an application, the use of WinHTTP functions and returns a WinHTTP-session handle;
- WinHttpConnect -> this API specifies the initial target server of an HTTP request and returns an HINTERNET connection handle to an HTTP session for that initial target;
- WinHttpOpenRequest -> this API creates an HTTP request handle;

In this first part of this network communication setup, the IcedID initialize the HTTP connection with the APIs listed above. Below, is the rest of the ***http_connection***.





The rest of the http_connection function, uses the follow APIs:

- WinHttpSetOption -> this API sets an Internet option;
- WinHttpSendRequest -> this API sends the specified request to the HTTP server;
- WinHttpQueryHeaders -> this API retrieves header information associated with an HTTP request;
- WinHttpQueryDataAvailable -> this api returns the amount of data, in bytes, available to be read with WinHttpReadData;
- WinHttpReadData -> this api reads data from a handle opened by the WinHttpOpenRequest function;

- [WinHttpQueryDataAvailable](#) -> returns the amount of data, in bytes, available to be read with WinHttpReadData.

In this part, the function handle with the data downloaded from the command and control servers. Beyond of network communication capabilities, we can observe the usage of heap manipulation APIs, like *HeapAlloc* and *HeapReAlloc*, as a conditional statement for the code proceed.

After that, this functions realize the clean up in the stack, closing the handles.

A curious fact that we can see above, is that data_encrypted pointer is present on this function, and, can be usage if some statements are reached, after a sleep of **5000** seconds (**1 hour and 38 minutes**). By the way, this sleep technique is a sandbox evasion technique.

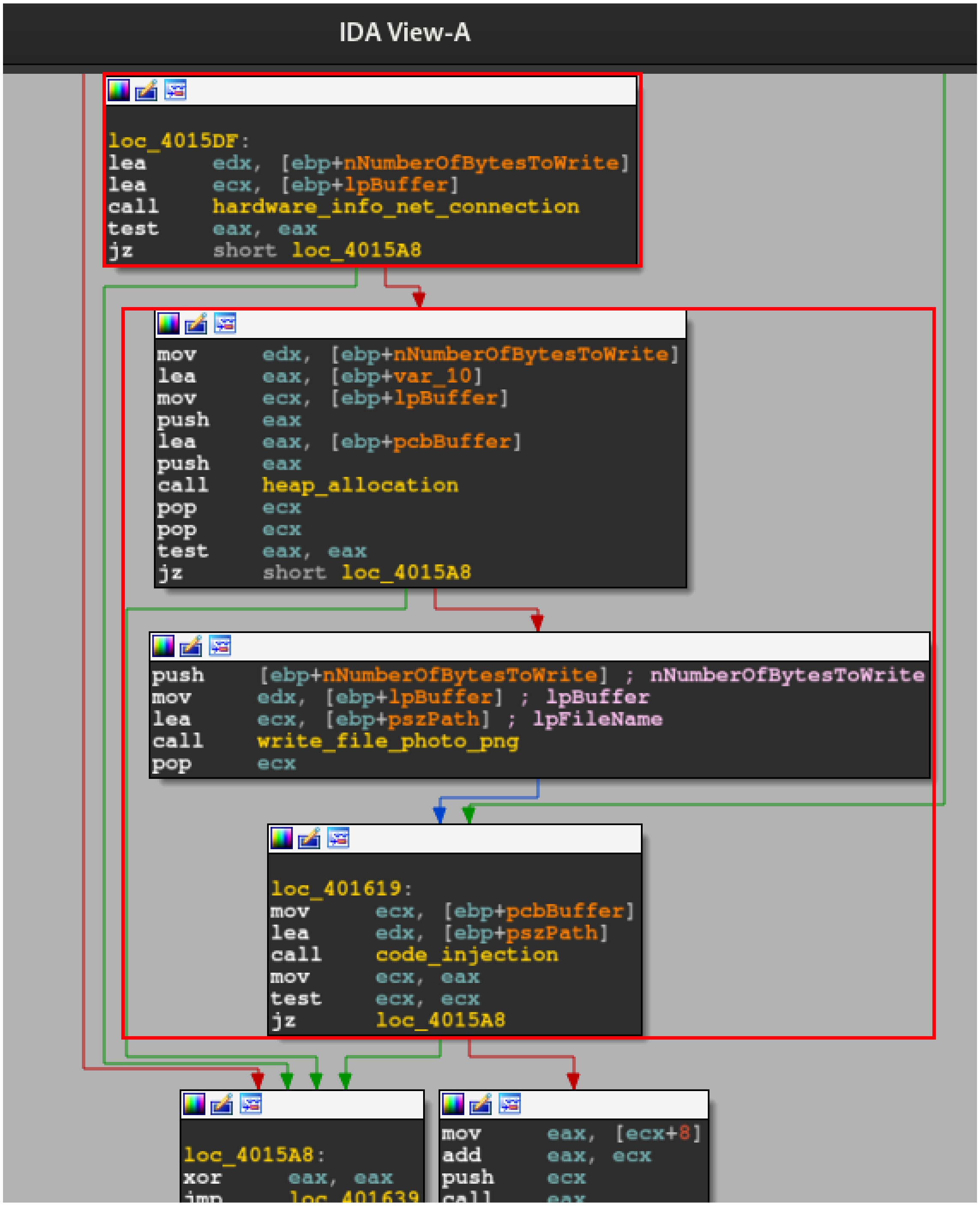
```
while ( 1 )
{
  wsprintfW(str_buffer_256, L"%S", buffer_str_256);
  v12 = 1;
  str_buffer_array[0] = (int)buffer_256_str;
  str_buffer_array[1] = (int)str_buffer_256;
  v11 = 443;
  if ( http_connection((int)str_buffer_array, lpBuffer, nNumberOfBytesToWrite) == 200 )
    break;
  if ( *lpBuffer && *nNumberOfBytesToWrite )
  {
    v9 = *lpBuffer;
    ProcessHeap = GetProcessHeap();
    HeapFree(ProcessHeap, 0, v9);
  }
  Sleep(5000u);
  var_decrypted_data += (unsigned __int8)*var_decrypted_data;
  if ( !*var_decrypted_data )
    var_decrypted_data = &unk_403050;
  *lpBuffer = 0;
  *nNumberOfBytesToWrite = 0;
  wsprintfW(buffer_256_str, L"%S", var_decrypted_data + 1);
}
return 1;
}
```

Write the photo.png and Code Injection

After the network communication routine, do a test on **EAX** register with him self, and if the results not was the operand expected it will jump to the same heap allocation and rc4 routine that we saw before. The processor will do the same test with **EAX**, and with the results are the same as earlier, it will take a jump to the **write_photo.png**.

We will not delve deeper into this function, because the name is self explanatory. The only information that we need, is what API will use to carry out this activity, the answer is simple, the code will just use the **[WriteFile](#)** (writes data to the specified file) API.

After that, the code will call the last function of this sample, the function that execute a code Injection.



Analyzing this function, in the image below, we can see that it is very straight to the point. The function uses **[VirtualAlloc](#)** to allocate memory.

After some calculations, using the variables that contained the return value of the ***VirtualAlloc*** function and the pointer to the previously set buffer size, the function uses **[GetModuleFileNameA](#)** to collect the complete path of a file, performing a series of calculations with the variables.

Pseudocode-A | Hex View-1 | Structures | Enums | Imports

```
v2 = (_BYTE *)a1;
v3 = (SIZE_T *)(a1 + 4);
base_address_allocated_region = (SIZE_T *)VirtualAlloc(0, *(_DWORD *)(a1 + 4) + 1880, 0x3000u, 4u);
v5 = base_address_allocated_region;
if ( base_address_allocated_region )
{
  v6 = *v3;
  if ( *v3 )
  {
    v7 = (char *)((char *)base_address_allocated_region - v2);
    do
    {
      v2[(_DWORD)v7] = *v2;
      ++v2;
      --v6;
    }
    while ( v6 );
    v6 = *v3;
  }
  v8 = *((_BYTE *)base_address_allocated_region + v6 + 2) & 0xF2;
  *(_WORD *)((char *)v5 + v6) = 1;
  *((_BYTE *)v5 + v6 + 2) = v8 | 0x12;
  *(SIZE_T *)((char *)v5 + v6 + 4) = data_encrypted_data;
  *(SIZE_T *)((char *)v5 + v6 + 8) = 0;
  *((_BYTE *)v5 + v6 + 536) = 0;
  *((_BYTE *)v5 + v6 + 792) = 0;
  *(SIZE_T *)((char *)v5 + v6 + 12) = dword_40300C;
  GetModuleFileNameA(0, (LPSTR)v5 + v6 + 16, 0x104u);
  lstrcpyA((LPSTR)v5 + v6 + 276, a2);
  v9 = 512;
  v10 = &unk_403050;
  v11 = (char *)v5 + v6 + 856;
```

In the last part of the code injection function, the code implements some for loops, probably with the aim of iterating each byte of the encrypted data, within a single memory space, which will be used later. Finally, the code will use **VirtualProtect**.

```
    }
    v17 = *v3;
    v5[1] += 1880;
    v5[6] = v17;
    VirtualProtect(v5, v5[1], 0x20u, &flOldProtect);
    return v5;
  }
  return base_address_allocated_region;
}
```

In general, this function gives the ability to inject code into memory (possibly a PE artifact), which must be contained within the previously dropped *photo.png* artifact.

With that, we now can understand what APIs are used to construct a network communication, decrypt data, injection and dropped routines, now we know what APIs we need to set breakpoints when we will doing dynamically analysis of unpacked *IcedID*.

Now that we understand the main functionality of the *IcedID*, let's dive into the debugging stage of our analysis, with *x32dbg*.

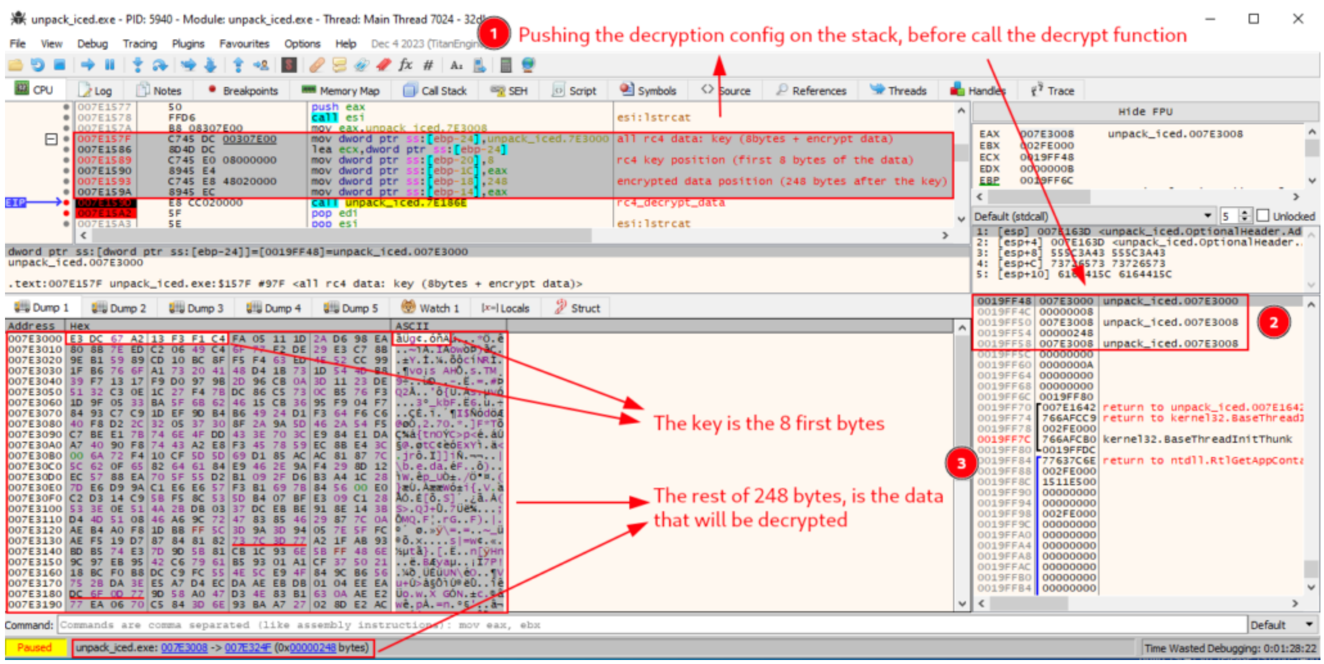
Dynamically Analysis of IcedID Unpacked

In this dynamic analysis, we will focus on understanding the decryption routines and network communication with the C2 server.

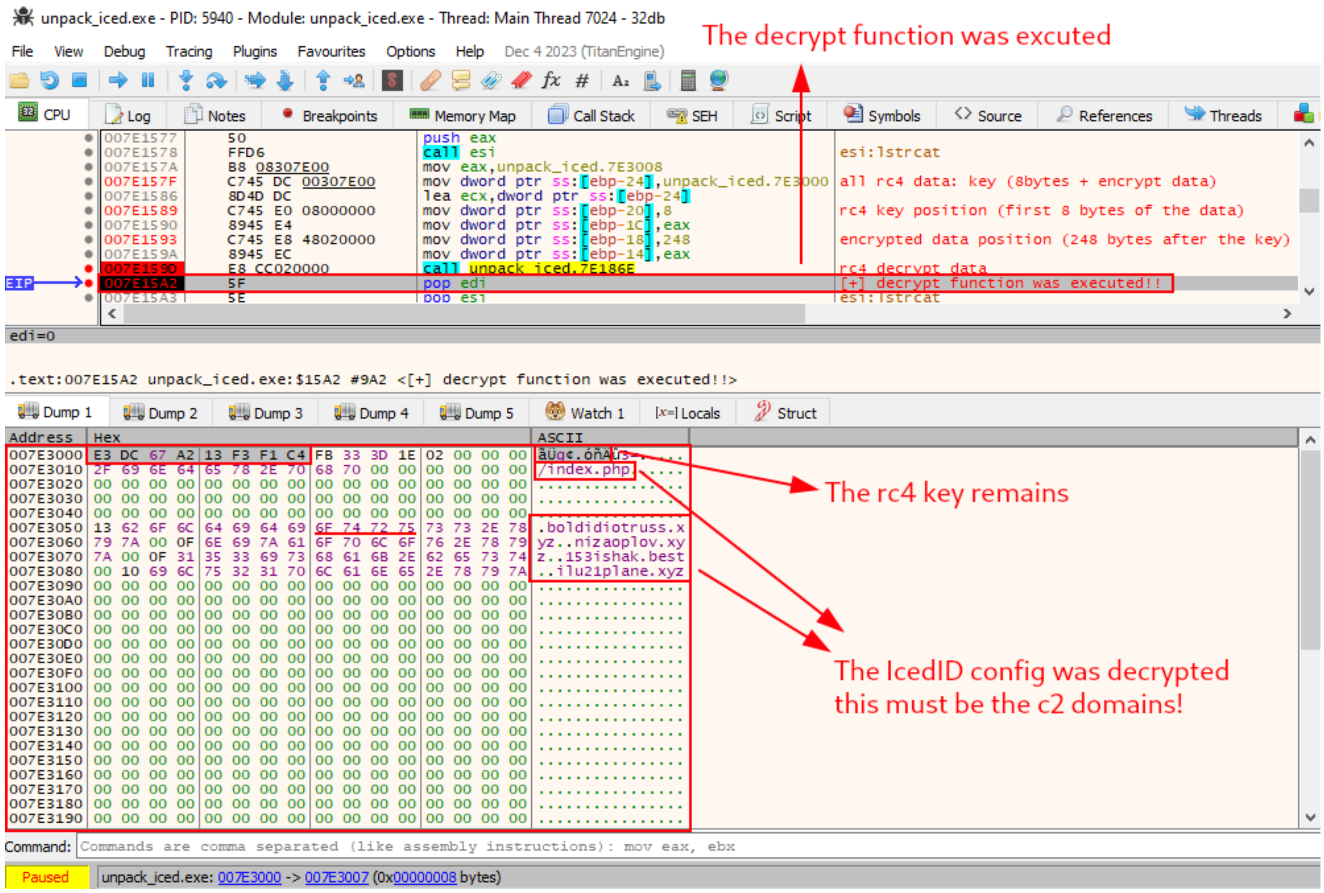
Below, we can now see the exact prologue instructions that we identified through the disassembler. When following the data from address **7E3000** in the dump (the same data as **.data**, identified in Disassembler by **0x403000**), we are able to observe that our assumption becomes possible.

That is, in the image below, we can see that after the first **8 bytes**, only **248 bytes** remain. Exactly the value we observe in Disassembler. Therefore, we can validate our assumption that the first 8 bytes of the .data data are the **RC4 decryption key**, and the remaining ***248 bytes*** are the data to be decrypted.

To test this assumption, let’s set a breakpoint exactly after calling the decryption function, and execute the function.



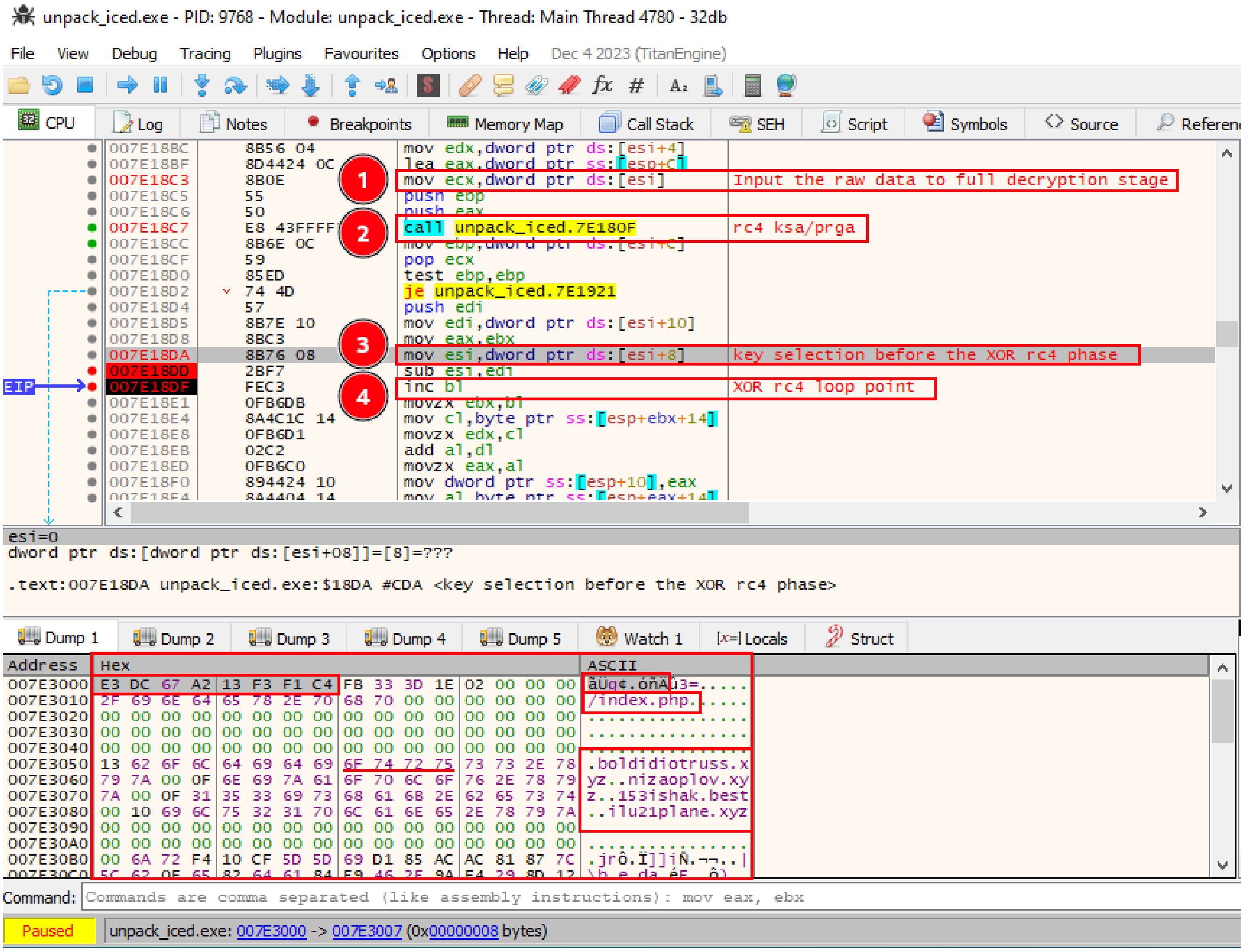
Exactly after executing the decryption function, we can observe the network communication configuration of IcedID (an index.php, and some c2 server domains) in plain text.



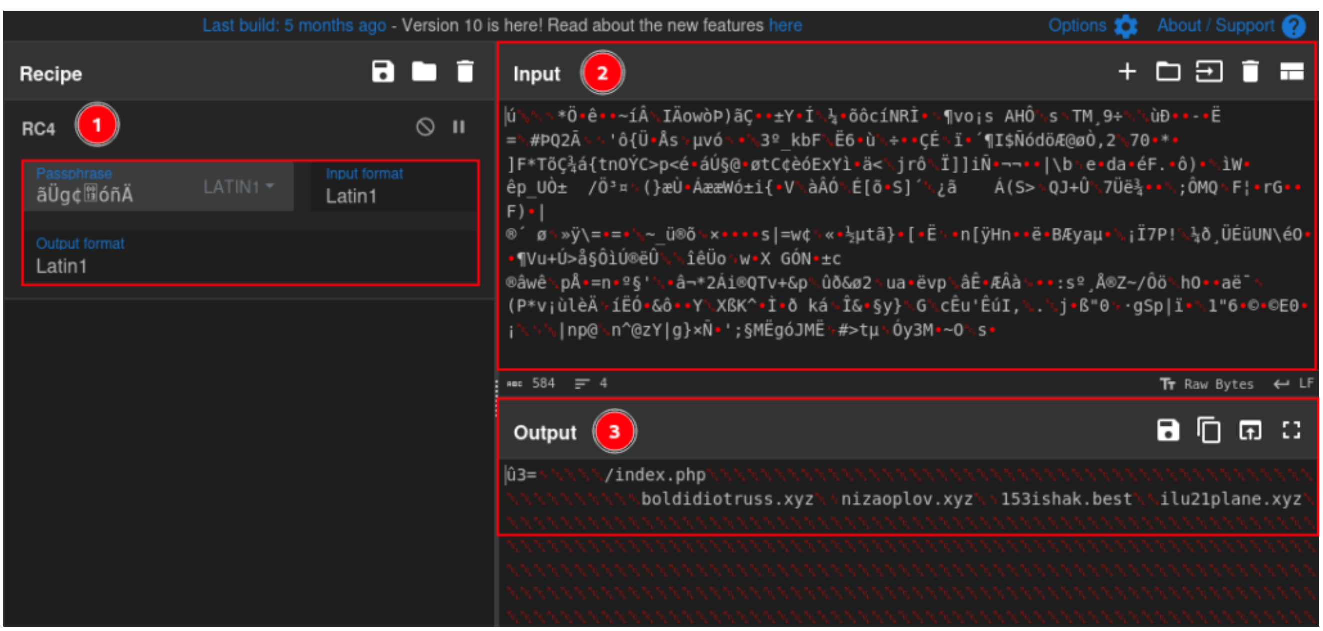
Let’s restart the sample in the debugger, and analyze the decryption process in more detail.

As we can see in the image below, the CPU moves the data address from **.data** to the **ECX** register, and immediately after that, the function executes the first two stages of **rc4** (*KSA* and *PRGA*). Then, the CPU performs the third phase of the **RC4** algorithm, which is the ***XOR*** operation between the keystream and the data.

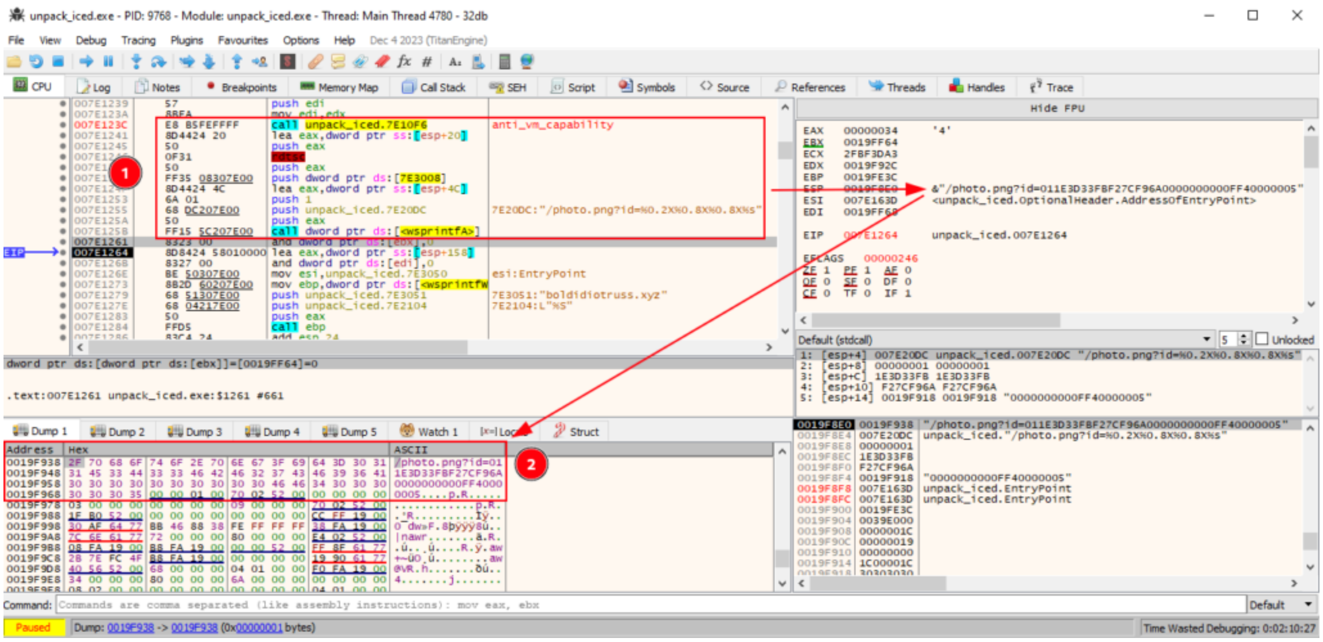
I set a breakpoint at the exact restart point of the *XOR loop*, and ran it several times, until enough data was decrypted and became clear text. If we observe, the first 8 bytes have not been modified, which in fact means that these first 8 bytes are the decryption key.



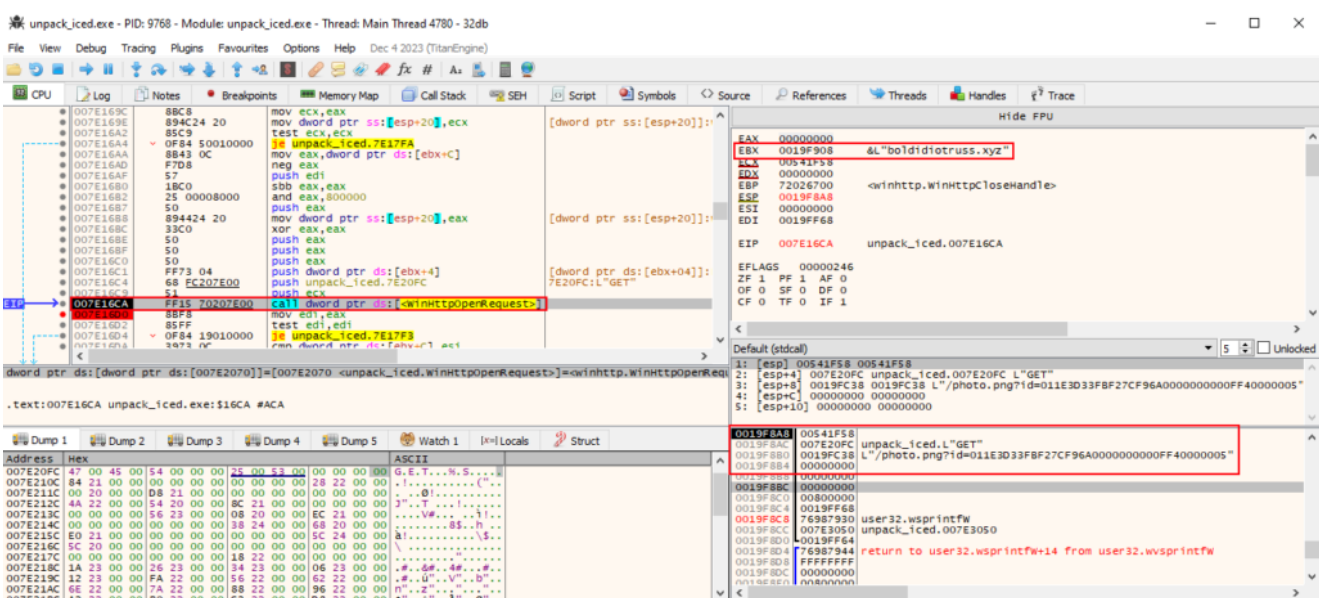
To validate once and for all, I went to **[CyberChef](#)** and put the first **8 bytes** as the key, and the next **248 bytes** as data. And indeed, the data was successfully decrypted!!



Now shifting the focus to the hardware information that the sample collects, we can now observe the true usefulness of this information for adversaries. Below, we can see that after executing the functions that we identified in the reverse engineering process, such as **hardware_info_collection** function, the collected values are concatenated in a way that resembles a URI.



If we analyze the HTTP request construction function, we have confirmation that in fact the hardware information that was collected is sent to one of the c2 domains present in the previously decrypted configuration.



We now know that this IcedID sample uses the **RC4** encryption algorithm to encrypt communication settings with c2 servers. But, we know even more, we know where the sample stores the key and data that will be decrypted, and how it will be decrypted.

With this knowledge, we can produce a script that automates the process of decrypting the network communication configuration with the c2 servers. In the next section, we will cover developing a configuration extractor for IcedID. If successful, we will be able to reuse this script to extract the configuration of network communication with c2 servers from other samples, without having to carry out the entire debugging process after the sample is unpacked.

Configuration Extractor Development – IcedID

Well, we have all the information needed to automate the IcedID configuration extraction process. We need a script that:

- **Receive a PE artifact**
- **Read the .data section of the PE file, through the *pefile* library**
- **Select the first *8 bytes* for the RC4 decryption key**
- **Select the remaining *248 bytes* of data encrypted with RC4**
- **Treat the raw data in hexadecimal, using a library like *binascii***
- **Perform the RC4 decryption process, using the *arc4* library**
- **Print the key, encrypted data, and decrypted data in a formatted format after executing the above processes.**

You can find the complete configuration extraction script on my Github, or just by clicking **aqui**.

With the configuration extractor developed, we can test on other unpacked samples, from the IcedID family, in the hope that our script will perform the configuration extraction process automatically.

In order to test our script on different samples from IcedID, I added two samples, in addition to the one that was already the subject of our analysis. All three samples you can find at the links below:

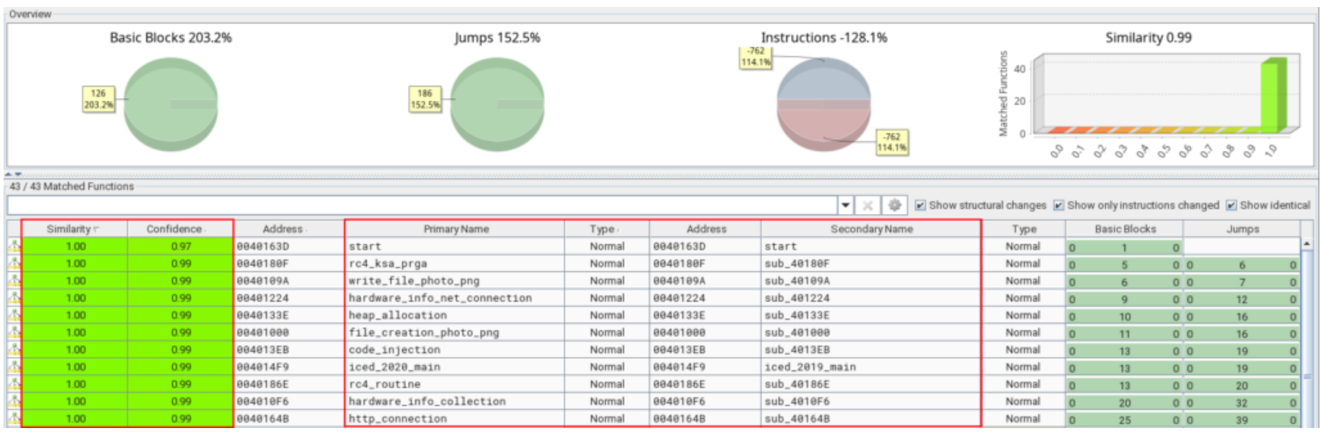
With that, below is the PoC video of the execution of the configuration extractor I developed, tested on three different samples from the IcedID family. And as you can see below, the script managed to extract the settings successfully!

Code Patterns between Samples from Different Years

In this section, we will analyze two more unpacked samples from **2019** and **2023**, with the aim of identifying *IcedID* code reuse over the years. Allowing us to understand the familiarity between samples, and identify opportunities for creating signatures, to detect samples that follow the same pattern. To perform this analysis, we will use the ***BinDiff*** plugin in IDA.

We will perform this analysis, using the same samples that we tested with the config extractor, in the previous section.

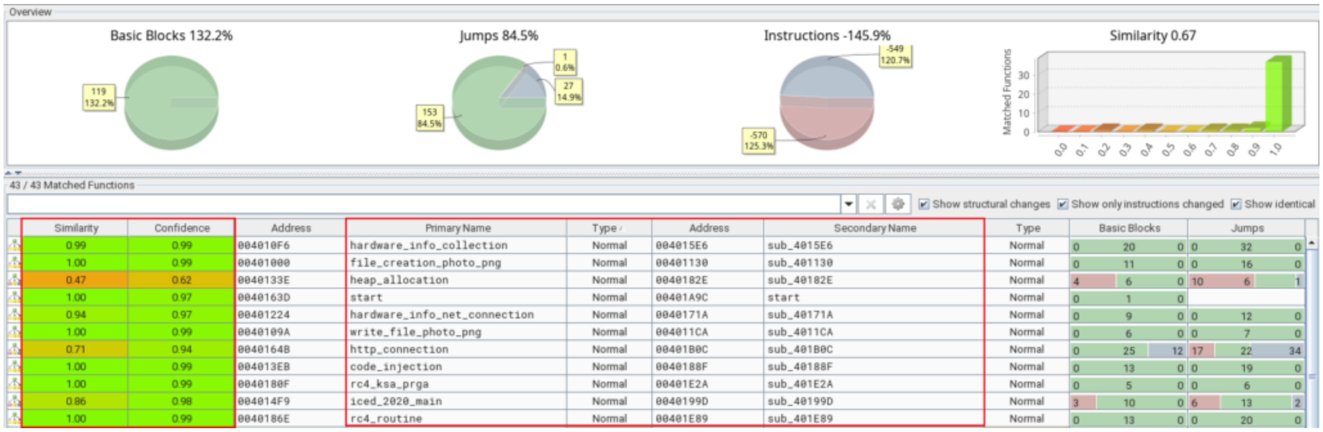
When we run ***BinDiff*** between the sample we analyzed in this article (**unpacked_icedid.exe**) that was reported in *2020*, with the **unpacked_1648556** sample from *2019*, we can already notice the great similarities between the internal functions of the samples.



Similarity	Confidence	Address	Primary Name	Type	Address	Secondary Name	Type	Basic Blocks			Jumps		
1.00	0.97	0040163D	start	Normal	0040163D	start	Normal	0	1	0			
1.00	0.99	0040180F	rc4_ksa_prga	Normal	0040180F	sub_40180F	Normal	0	5	0	0	6	0
1.00	0.99	0040109A	write_file_photo_png	Normal	0040109A	sub_40109A	Normal	0	6	0	0	7	0
1.00	0.99	00401224	hardware_info_net_connection	Normal	00401224	sub_401224	Normal	0	9	0	0	12	0
1.00	0.99	0040133E	heap_allocation	Normal	0040133E	sub_40133E	Normal	0	10	0	0	16	0
1.00	0.99	00401000	file_creation_photo_png	Normal	00401000	sub_401000	Normal	0	11	0	0	16	0
1.00	0.99	004013EB	code_injection	Normal	004013EB	sub_4013EB	Normal	0	13	0	0	19	0
1.00	0.99	004014F9	iced_2020_main	Normal	004014F9	iced_2019_main	Normal	0	13	0	0	19	0
1.00	0.99	0040186E	rc4_routine	Normal	0040186E	sub_40186E	Normal	0	13	0	0	20	0
1.00	0.99	004010F6	hardware_info_collection	Normal	004010F6	sub_4010F6	Normal	0	20	0	0	32	0
1.00	0.99	0040164B	http_connection	Normal	0040164B	sub_40164B	Normal	0	25	0	0	39	0

In the table in the image above, we should focus our attention on the **Similarity** and **Confidence** columns. Basically, how close it is to the value **1.0** is how similar each function is. And as we can see in the image above, the internal functions of the **unpacked_1648556** sample (from ***2019***) are identical to the functions of the **unpacked_icedid.exe** sample (from *2020*).

Now if we compare the **unpacked_icedid.exe** (from ***2020***) and **winme_sc_carved.bin** (from ***2023***) samples, we will observe several similarities, but some differences between certain functions. Below, we can see this in *BinDiff*.



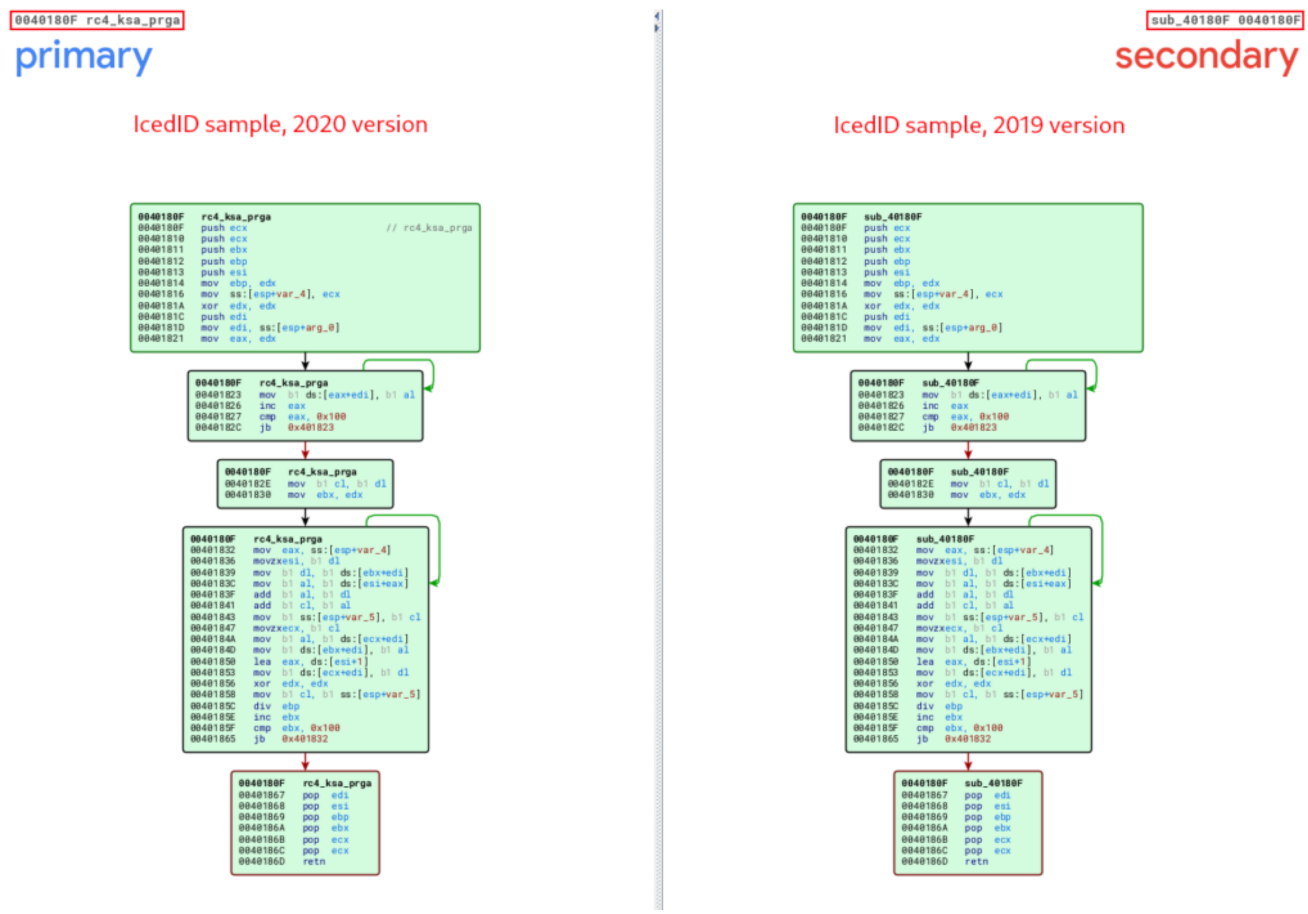
Similarity	Confidence	Address	Primary Name	Type	Address	Secondary Name	Type	Basic Blocks	Jumps
0.99	0.99	004010F6	hardware_info_collection	Normal	004015E6	sub_4015E6	Normal	0 20 0	0 32 0
1.00	0.99	00401000	file_creation_photo_png	Normal	00401130	sub_401130	Normal	0 11 0	0 16 0
0.47	0.62	0040133E	heap_allocation	Normal	0040182E	sub_40182E	Normal	4 6 0	10 6 1
1.00	0.97	0040163D	start	Normal	00401A9C	start	Normal	0 1 0	
0.94	0.97	00401224	hardware_info_net_connection	Normal	0040171A	sub_40171A	Normal	0 9 0	0 12 0
1.00	0.99	0040109A	write_file_photo_png	Normal	004011CA	sub_4011CA	Normal	0 6 0	0 7 0
0.71	0.94	0040164B	http_connection	Normal	00401B0C	sub_401B0C	Normal	0 25 12	17 22 34
1.00	0.99	004013EB	code_injection	Normal	0040188F	sub_40188F	Normal	0 13 0	0 19 0
1.00	0.99	0040180F	rc4_ksa_prga	Normal	00401E2A	sub_401E2A	Normal	0 5 0	0 6 0
0.86	0.98	004014F9	iced_2020_main	Normal	0040199D	sub_40199D	Normal	3 10 0	6 13 2
1.00	0.99	0040186E	rc4_routine	Normal	00401E89	sub_401E89	Normal	0 13 0	0 20 0

Analyzing the image above, we can see a slight difference between the ***main*** functions, a slightly larger difference in the ***http_connection*** function, and a considerable difference in the ***heap_allocation*** function.

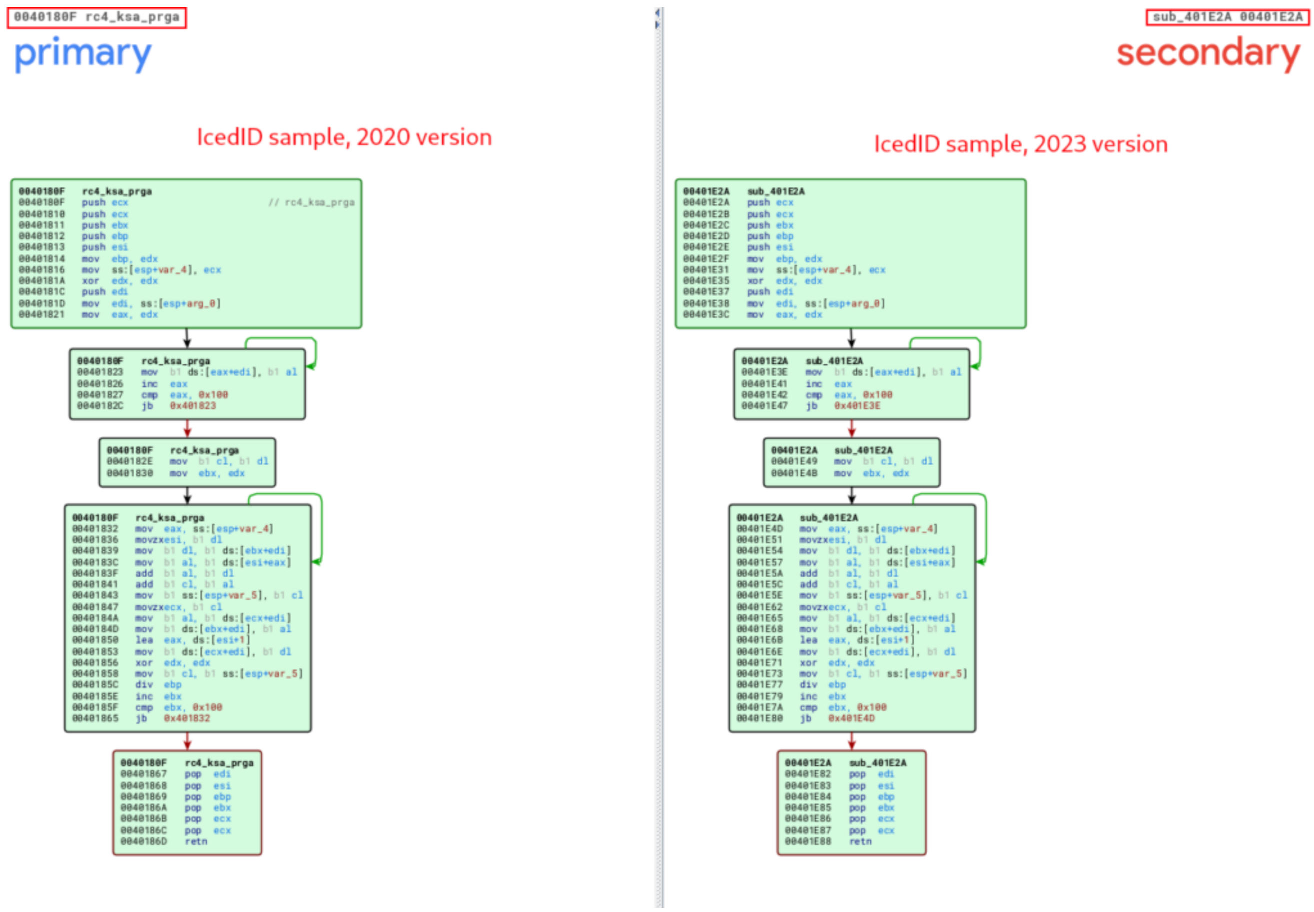
Now that we know that the **unpacked_1648556** sample is identical to the sample we analyzed in this article, let's note the important similarity between **unpacked_icedid.exe** (from ***2020***) and **winme_sc_carved.bin** (from ***2023***) in the **hardware_info_net_connection** function. Below, we can see the similarity in the code structure between the two versions.

The functions that have an important functionality, and which are also identical between all versions analyzed in this article, are the decryption routine functions through **RC4**.

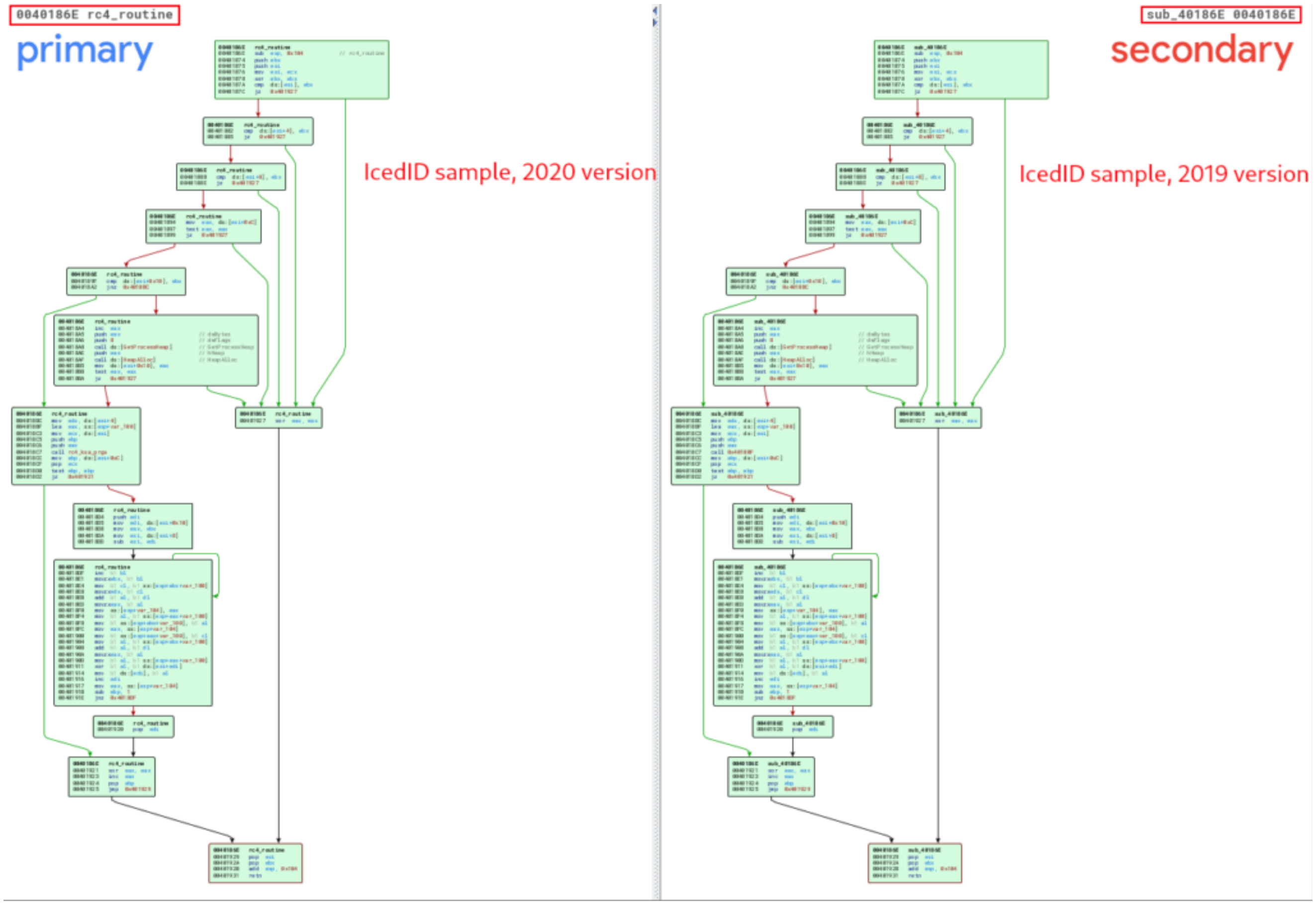
Below, we can observe the similarity between the **unpacked_iced.exe** and **unpacked_1648556.exe** samples, referring to the routine function of the **RC4** *KSA* and *PRGA* stages being executed. It is also possible to observe the pattern of these **RC4** phases, through the presence of the value **0x100** in loops, followed by **XOR** operations.



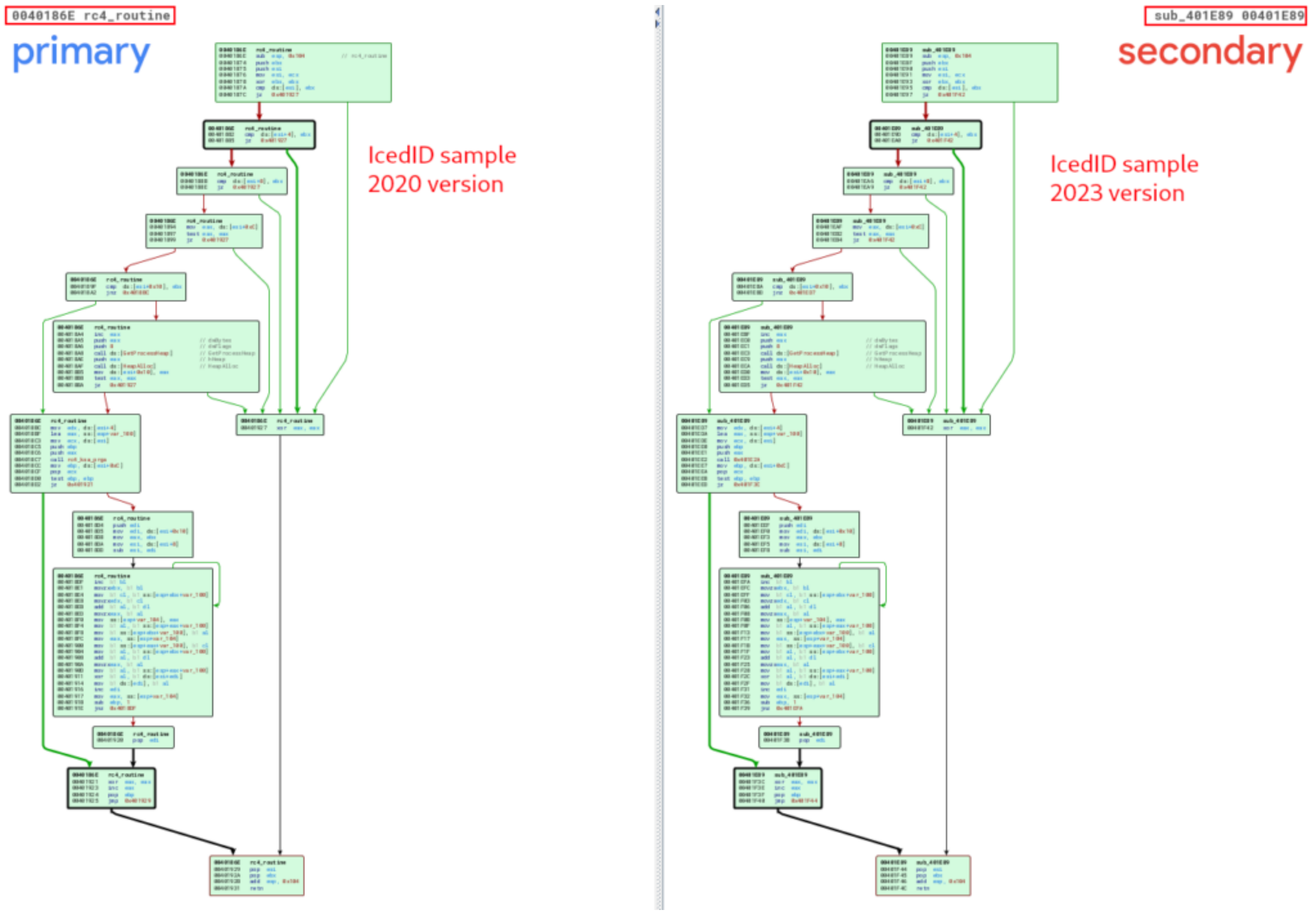
In the following image, we can see the same pattern being observed between the **unpacked_iced.exe** and **winme_sc_carved.bin** samples.



Below, we can observe the similarity between the **unpacked_iced.exe** and **unpacked_1648556.exe** samples, referring to the routine function of the **RC4** routine after executing the first two stages (***KSA*** and ***PRGA***), and finally executing the **XOR** operation that will decrypt the data that we observed in previous sections.



In the following image, we can see the same pattern being observed between the **unpacked_iced.exe** and **winme_sc_carved.bin** samples.



This information is extremely useful, both for identifying code reuse between samples, and consequently the identification of new strains of malware families (or use of malware by different malicious actors), and for the development of *Yara* signatures, to detect samples of more effective way.

That's what we'll do in the next section.

Development of Yara Detection Rules

In this section we will use the intelligence we collected through our analysis, and use it to create a detection rule, which can detect samples from the IcedID family.

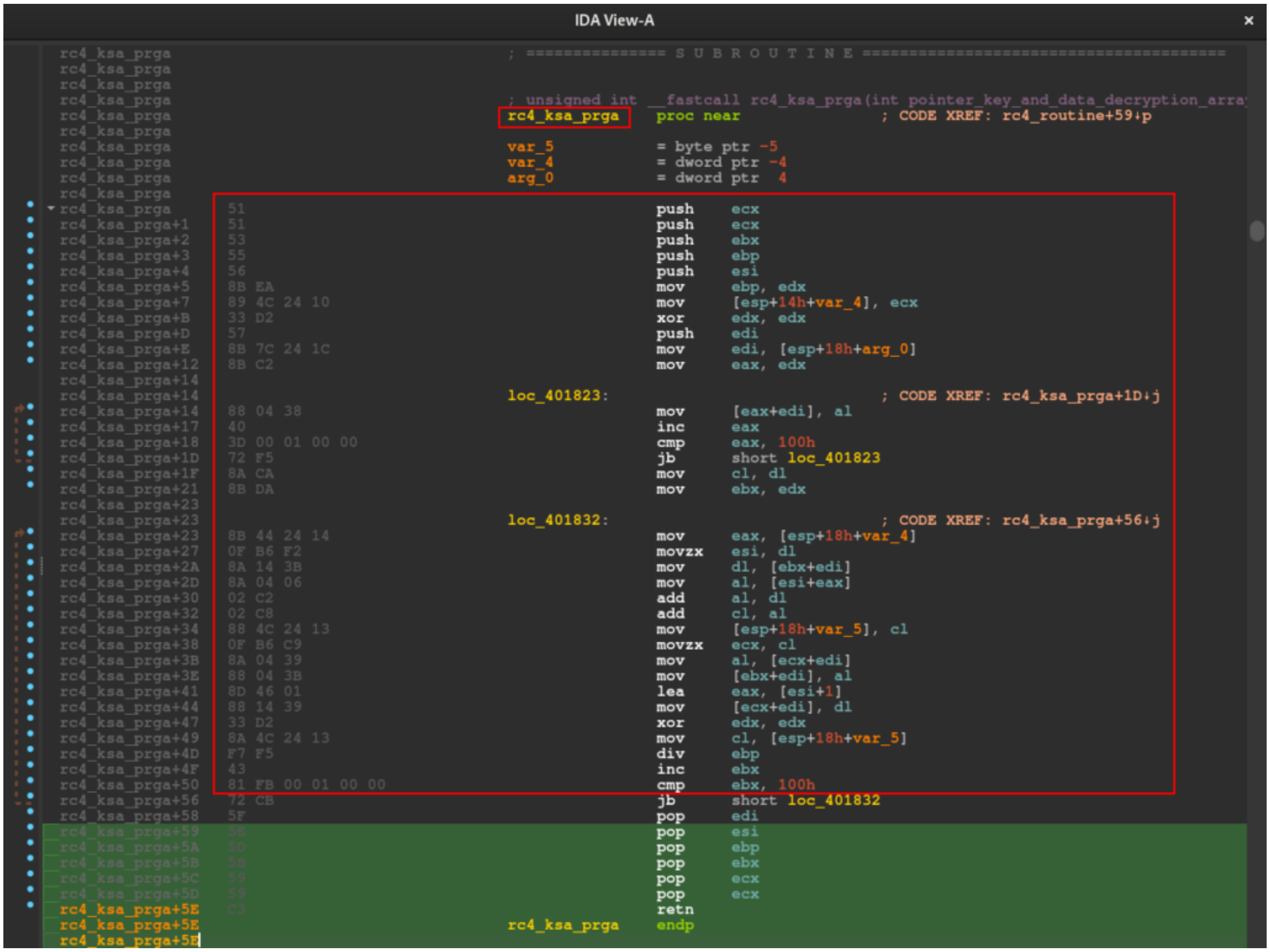
In addition to creating our Yara detection rules, we will use the **Unpac.me** platform to carry out a *Yara Hunt*, with the purpose of validating the quality of our detection rule, by detecting other samples in the **Unpac.me** database.

As we can see in the previous section, we identified code reuse in some of the main functions. This will be decisive for the production of our detection rule, because, if the IcedID family reuses the code of primary functions, we can use these patterns in our detection rules.

The primary functions for the operation of both samples analyzed in the previous section are:

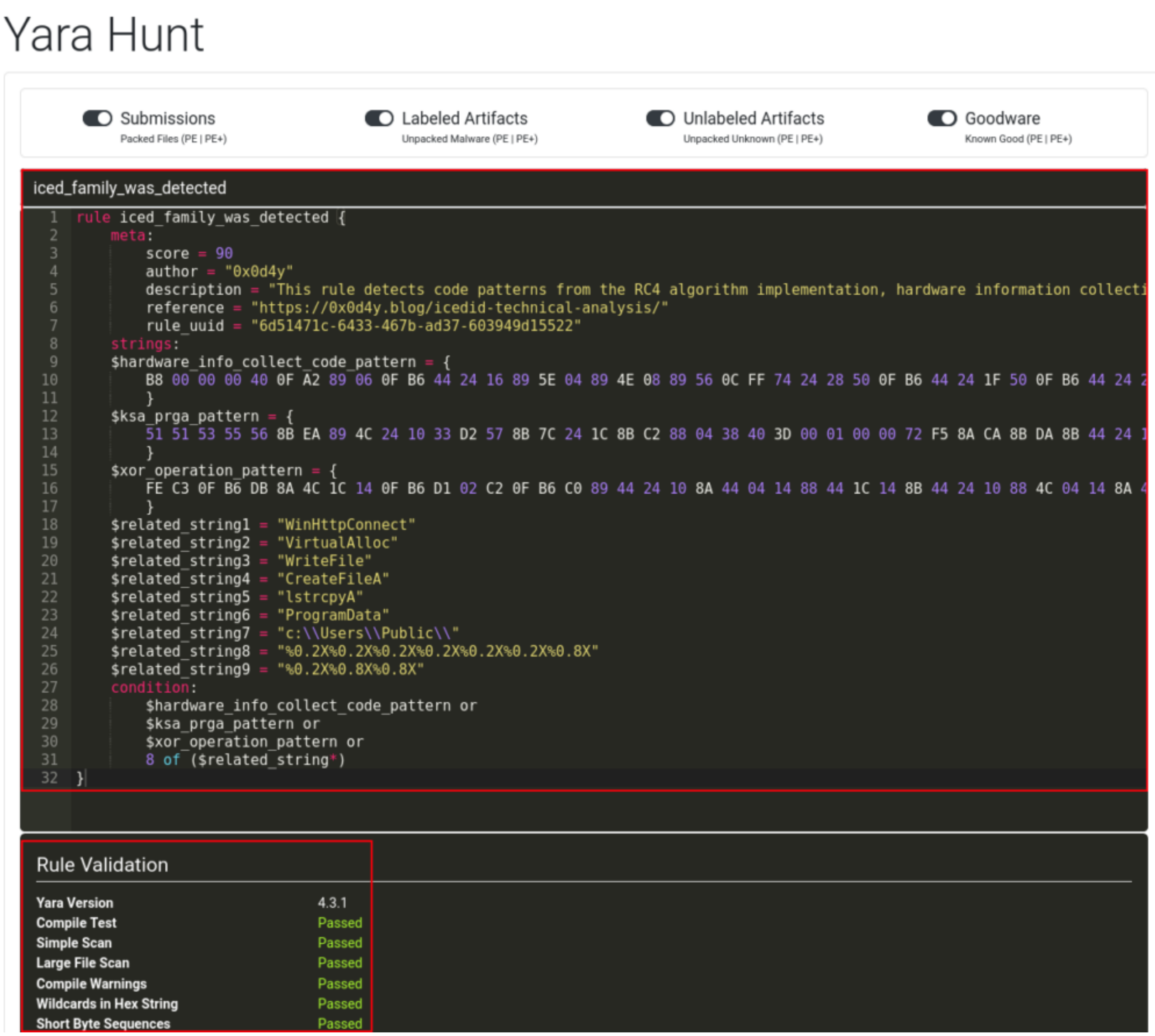
- **rc4_ksa_prga**
- **rc4_routine**
- **hardware_info_collection**

In our analysis, these functions had their codes reused in both samples, therefore, they will be part of our detection rule. The code reuse pattern is collected using the Disassembler, where we will identify the same sequences of bytes (in hexadecimal) being used in the functions mentioned above. Below, we can see the sequence of bytes referring to the **rc4_ksa_prga** function. This sequence is the same in all samples analyzed in this article.



Furthermore, we also selected some strings that also appear constantly in the three samples analyzed.

Having this information, we created our detection rule, which I called ***iced_family_was_detected***, and validated its syntax in **Unpac.me**, as we can see in the image below. The Yara detection rule has all the information collected and analyzed in this article.



After performing the validation, I started Yara Hunt on Unpac.me. This run returned *5 different samples* from the **Unpac.me** database, just labeled as part of the *IcedID* family, and without false positives.

Hunt Results

Launched	Rule	Matches				Status
09/01/2024 13:38:56	iced_family_was_detected	0 Submissions	0 Unpacked Malware	1 Unpacked Unknown	0 Goodware	complete (1m 31s)

T-11 T-10 T-9 T-8 T-7 T-6 T-5 T-4 T-3 T-2 T-1 T-0

Lookback Window
(12/12 weeks)

Yara Rule

Rule Validation: Passed

Matches: 1
In **12 week** lookback window

Associated Analysis	5
Matches Distribution	1

Scan Coverage: 98 %

Goodware (81%)
Artifacts Labeled (100%)
Artifacts Unlabeled (100%)
Submissions (100%)

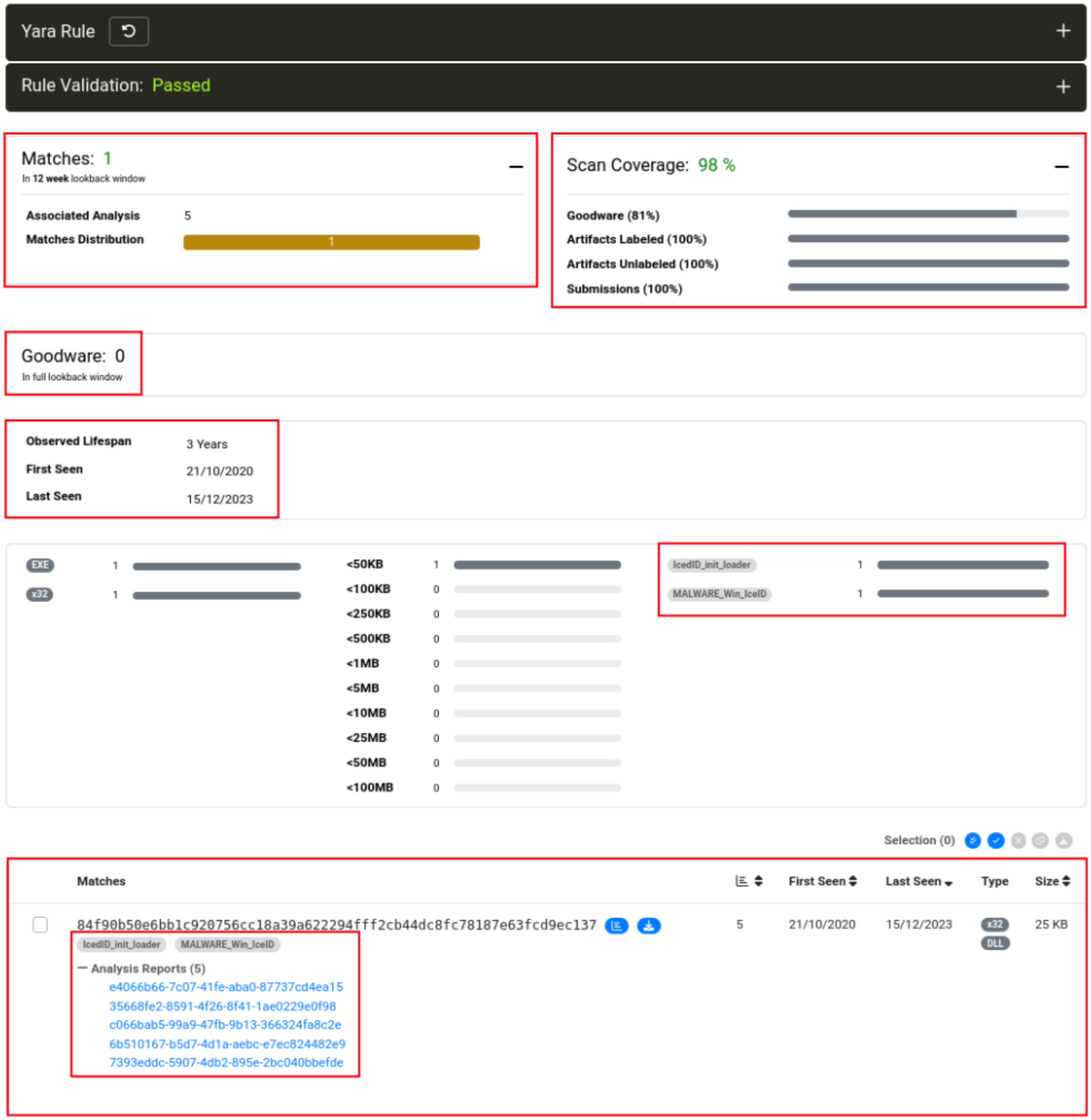
Goodware: 0
In full lookback window

Observed Lifespan	3 Years
First Seen	21/10/2020
Last Seen	15/12/2023

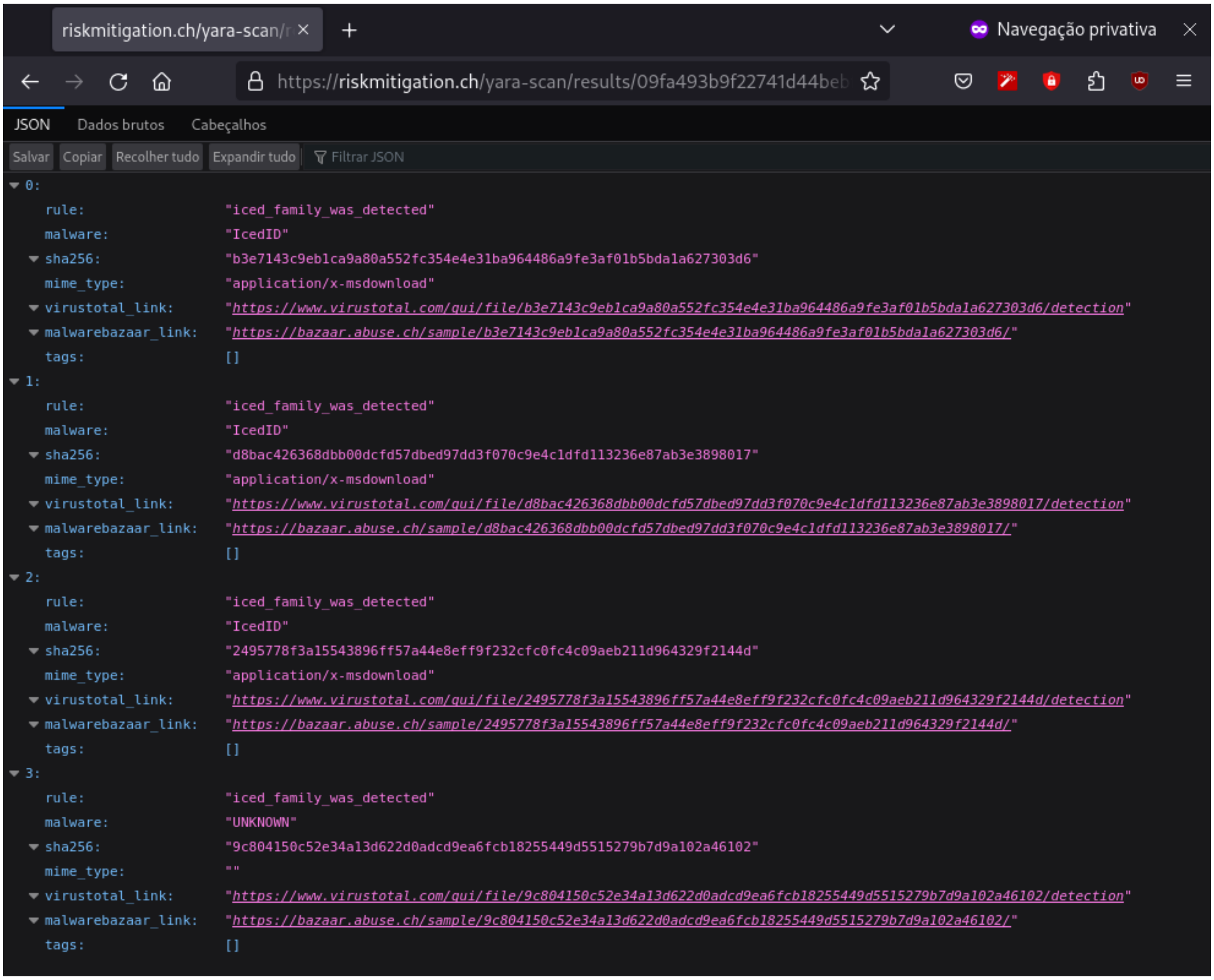
EXE	1
x32	1

<50KB	1
<100KB	0
<250KB	0
<500KB	0
<1MB	0
<5MB	0
<10MB	0
<25MB	0
<50MB	0
<100MB	0

IcedID_init_loader	1
MALWARE_Win_IcedID	1



I also carried out the validation using the **Yara Scan Service** platform, and below, we can see the result.



Obviously, the validation was also performed with the samples that we analyzed, I didn't pay much attention to them, as it is obvious that it would work, since I made the Yara detection rule based on them. But, just to show the functionality, below are the matches in my laboratory.

Conclusion

I hope that in this article I have exposed my sample analysis and reverse engineering methodology, as well as the entire process of identifying patterns between samples and detection engineering. And I hope that you who are reading this article may have learned something new, or may have gained some insight. Until next time, feedback is always welcome.

You can access the Yara rule and the config extractor at the following links.

See you later!!