Reversing Golang Developed Ransomware: SNAKE

0ffset.net/reverse-engineering/analysing-snake-ransomware/

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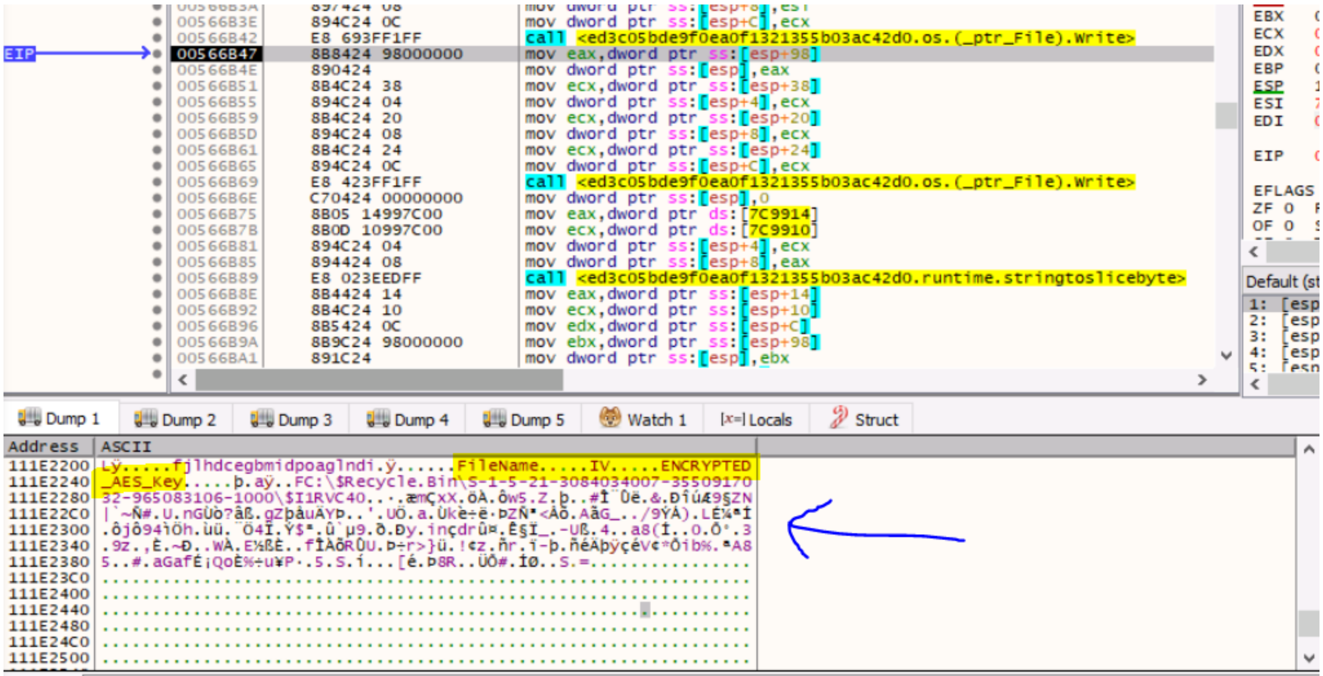

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- 3rd August 2022
- No Comments

Introduction

Snake Ransomware (or EKANS Ransomware) is a Golang ransomware which in the past has affected several companies such as Enel and Honda. The MD5 hashing of the analyzed sample is ED3C05BDE9F0EA0F1321355B03AC42D0. This sample in particular is obfuscated with Gobfuscate, an open source obfuscation project available on Github.

Let's start by quickly summarizing the functionality of the malware:

- First, the sample checks the domain to which the infected host belongs to, before continuing execution
- Next, it checks whether the computer is a Backup Domain Controller or Primary Domain Controller, and if so will only drop the ransom note, rather than encrypting the machine
- SNAKE will then isolate the host machine from the network by leveraging the netsh tool
- The shadow copies on the system are deleted using WMI
- SNAKE attempts to terminate any running AV, EDR, and SIEM components

- Finally, local files on the system are encrypted
  For each file, a unique AES encryption key is generated, which is later encrypted with an RSA-2048 public key and stored within the encrypted file.

Let’s start reversing this sample with IDA!

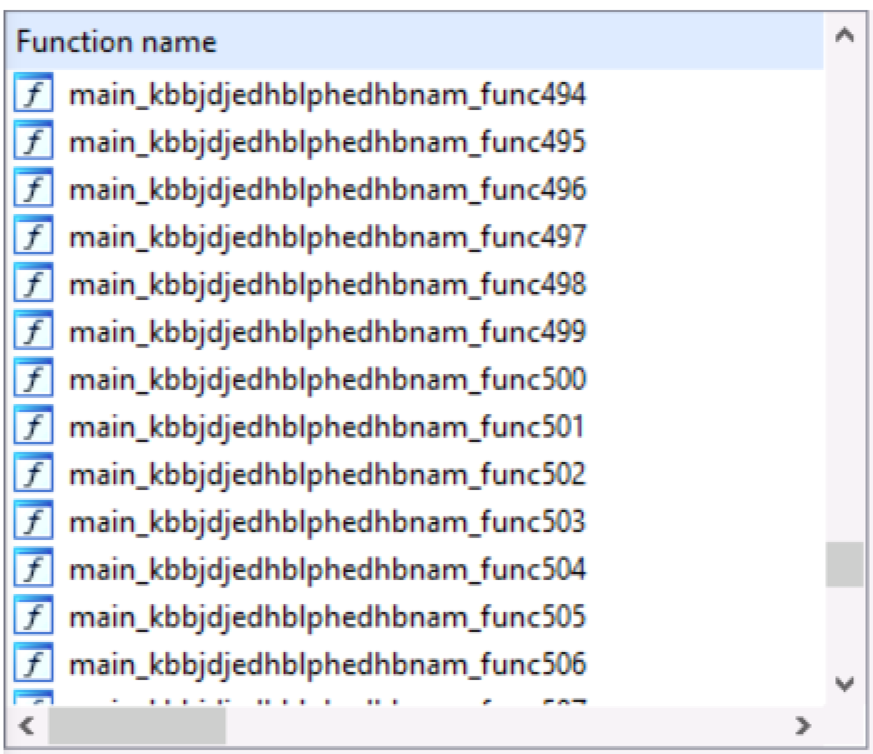
Static Analysis

There are some differences of Go from other languages to keep in mind:

- Functions can return multiple values.
- Function parameters are passed on the stack.
- Strings are typically a sequence of bytes with a fixed length, that are not null terminated; the string is represented by a structure formed by a pointer to a byte array, and the length of the string.
- The constants are stored in one large buffer and sorted by length.
- Many stack manipulations are present within the binaries, that can make the analysis complex.

Obfuscation

Opening the sample with IDA we immediately notice that the function names are very obfuscated:

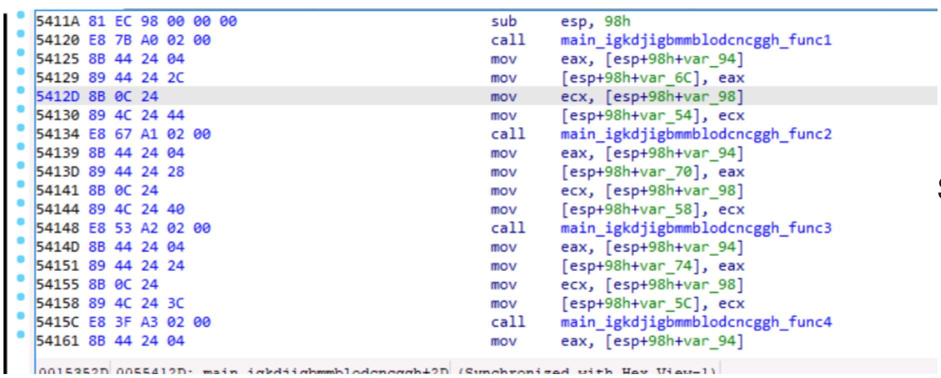


Gobfuscate obfuscates almost all function names within the binary

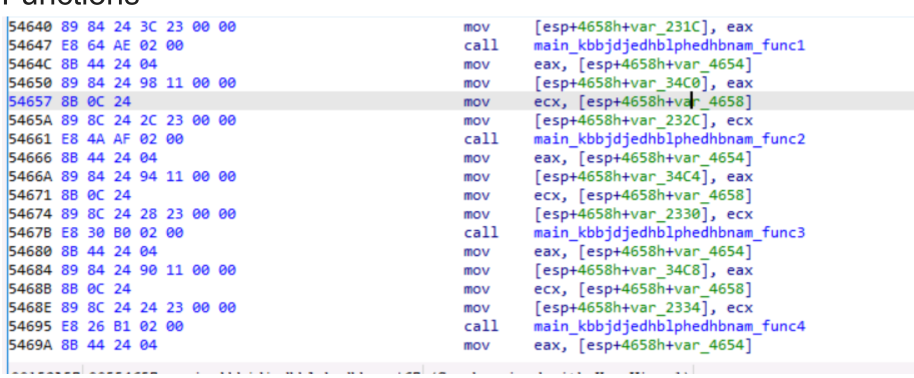
Performing a quick search, I found that the malware is obfuscated with **Gobfuscate**. This project performs obfuscation of several components: Global names, Package names, Struct methods, and Strings.

Each string in the binary is replaced by a function call. Each function contains two arrays that are xored to get the original string. When implementing the decryption function, keep in mind that there are different ways in which these arrays are passed to the function **runtime.stringtoslicebyte** – either via a variable, a pointer or a hardcoded value).

Analyzing the sample, you will usually find the call to a main function that contains a large number of other calls within it, where each subroutine performs decryption of only one string. Sometimes only the decryption operations are found within these subroutines, other times additional operations are performed on the decrypted string.



String Decryption Functions



String Decryption Functions

As mentioned, the string encryption is fairly basic, XORing the contents of two arrays together to retrieve the final string.

```
.text:0057BC2A                 lea     eax, unk_63113A
.text:0057BC30                 mov     [esp+20Ch+var_208], eax
.text:0057BC34                 mov     [esp+20Ch+var_204], 1AAh
.text:0057BC3C                 call    runtime_stringtoslicebyte
.text:0057BC41                 mov     eax, [esp+20Ch+var_200]
.text:0057BC45                 mov     [esp+20Ch+var_4], eax
.text:0057BC4C                 mov     ecx, [esp+20Ch+var_1FC]
.text:0057BC50                 mov     [esp+20Ch+var_1F4], ecx
.text:0057BC54                 mov     [esp+20Ch+decrypted_buffer], 0
.text:0057BC5C                 lea     edi, [esp+20Ch+decrypted_buffer+2]
.text:0057BC60                 xor     eax, eax
.text:0057BC62                 call    loc_44AEA6
.text:0057BC67                 lea     eax, [esp+20Ch+var_1EE]
.text:0057BC6B                 mov     [esp+20Ch+var_20C], eax
.text:0057BC6E                 lea     eax, unk_630F90
.text:0057BC74                 mov     [esp+20Ch+var_208], eax
.text:0057BC78                 mov     [esp+20Ch+var_204], 1AAh
.text:0057BC80                 call    runtime_stringtoslicebyte
```

Loading the two arrays for decryption

```
.text:0057BCA3 decryptionLoop:                         ; CODE XREF: decryptAESPublicKey+9A↑j
.text:0057BCA3                 cmp     ebp, edx
.text:0057BCA5                 jge     short loc_57BCC2
.text:0057BCA7                 movzx   esi, byte ptr [ebx+ebp]
.text:0057BCAB                 lea     esi, [esi+ebp*2]
.text:0057BCAE                 cmp     ebp, eax
.text:0057BCB0                 jnb     short loc_57BD03
.text:0057BCB2                 movzx   edi, byte ptr [ecx+ebp]
.text:0057BCB6                 xor     esi, edi
.text:0057BCB8                 cmp     ebp, 1AAh
.text:0057BCBE                 jb      short loc_57BC9C
.text:0057BCC0                 jmp     short loc_57BD03
```

XORing the arrays together to get the decrypted string

Due to the simplicity of the algorithm, we can develop a simple Python script utilising some regular expressions to locate and decrypt 90% of the encrypted strings within the binary! The script can be found at the end of this post.

```
startDecryptFunction = b"\x64\x8B\x0D\x14\x00\x00\x00"
sliceStr = b"(" + b"\x8D.....\x89.\$\x04\xC7\x44\$\b...." + b")"
xorLoop = b"\x0F\xB6<\)1\xFE(\x83|\x81)\xFD"
```

With the majority of the strings decrypted, let's continue the analysis!

Check Environment

One of the first operations I perform when analyzing malware in GO is to jump to the **main.init** function.

The **main.init** is generated for each package by the compiler to initialise all other packages that this sample relies on, as well as the global variables; analysing this function is very important because it allows us to understand a large amount of the malware's functionality and speed up subsequent analysis.

In the **main.init** function we can find, for example, references to encryption: **AES, RSA, SHA1, X509**. In addition, there are several functions for decryption of strings and function names.

```
005CDD3C                 call    crypto_aes_init
005CDD41                 call    crypto_cipher_init
005CDD46                 call    crypto_rand_init
005CDD4B                 call    crypto_rsa_init
005CDD50                 call    crypto_sha1_init
005CDD55                 call    crypto_x509_init
005CDD5A                 call    encoding_pem_init
005CDD5F                 call    io_init
005CDD64                 call    log_init
005CDD69                 call    os_init
005CDD6E                 call    path_filepath_init
```

Initialisations performed within main.init function

```
8 2C FB FF FF                    call    decryptCreateToolhelp32Snapshot
B 05 F8 92 7C 00                 mov     eax, dword_7C92F8
B 0C 24                          mov     ecx, [esp+10h+var_10]
B 54 24 04                       mov     edx, [esp+10h+var_C]
9 04 24                          mov     [esp+10h+var_10], eax
9 4C 24 04                       mov     [esp+10h+var_C], ecx
9 54 24 08                       mov     [esp+10h+var_8], edx
8 0F 91 F3 FF                    call    syscall___ptr_LazyDLL__NewProc
B 05 50 A9 7D 00                 mov     eax, dword_7DA950
B 4C 24 0C                       mov     ecx, [esp+10h+var_4]
5 C0                             test    eax, eax
F 85 A5 00 00 00                 jnz     loc_523AD8
9 0D 08 93 7C 00                 mov     fCreateToolhelp32Snapshot, ecx

                  loc_523A39:                    ; CODE XREF: FindProcess+18A↓j
8 F2 FB FF FF                    call    decryptProcess32FirstW
B 05 F8 92 7C 00                 mov     eax, dword_7C92F8
B 0C 24                          mov     ecx, [esp+10h+var_10]
B 54 24 04                       mov     edx, [esp+10h+var_C]
9 04 24                          mov     [esp+10h+var_10], eax
9 4C 24 04                       mov     [esp+10h+var_C], ecx
9 54 24 08                       mov     [esp+10h+var_8], edx

00122E2B 00523A2B: FindProcess+CB (Synchronized with Pseudocode-A)
```

API function decryption and loading through NewProc

Now we move on to analyze the **main.main** function. One of the first activities the malware performs is to check the environment before continuing with encryption.

```
00552A30
00552A30    mov     ecx, large fs:14h
00552A37    mov     ecx, [ecx+0]
00552A3D    cmp     esp, [ecx+8]
00552A40    jbe     loc_552BE1
00552A46    sub     esp, 48h
00552A49    call    time_Now
00552A4E    lea     edi, [esp+48h+var_14]
00552A52    mov     esi, esp
00552A54    call    loc_44B3EE
00552A59    mov     eax, STRING_EKANS
00552A5F    mov     ecx, SIZE_EKANS
00552A65    mov     [esp+48h+var_48], ecx
00552A68    mov     [esp+48h+decryptedLenght], eax
00552A6C    call    CheckEnvironment
00552A71    movzx   eax, byte ptr [esp+48h+decryptedString]
00552A76    test    al, al
00552A78    jz      loc_552BBB
```

Call to CheckEnvironment within main.main

The function **CheckEnvironment** starts by attempting to resolve the hostname **mds.honda.com** and compare the returned value with **172[.]108[.]71[.]153**.This check is used to confirm that the infected machine is part of the correct domain. In fact, it is important to remember that this ransomware is deployed at the end of the infection chain by other loaders, and thus it is likely custom-built for the victim.

```
:00553D50    mov     ecx, large fs:14h
:00553D57    mov     ecx, [ecx+0]
:00553D5D    cmp     esp, [ecx+8]
:00553D60    jbe     loc_553EB0
:00553D66    sub     esp, 4Ch
:00553D69    lea     eax, aMdsHondaCom ; "MDS.HONDA.COM"
:00553D6F    mov     [esp+4Ch+var_4C], eax
:00553D72    mov     [esp+4Ch+var_48], 0Dh
:00553D7A    call    net_LookupIP
:00553D7F    mov     eax, [esp+4Ch+var_44]
:00553D83    mov     ecx, [esp+4Ch+var_38]
:00553D87    mov     edx, [esp+4Ch+var_40]
:00553D8B    test    ecx, ecx
:00553D8D    jnz     loc_553EA7
:00553D93    test    edx, edx
:00553D95    jz      loc_553EA7
:00553D9B    mov     [esp+4Ch+var_2C], edx
```

Resolving hostname via DNS

```
:00553DF7 ; ---------------------------------------------------------------------------
:00553DF7
:00553DF7 loc_553DF7:                             ; CODE XREF: checkIPAddress+9E↑j
:00553DF7                 mov     [esp+4Ch+var_4C], ecx
:00553DFA                 lea     ecx, a17010871153 ; "170.108.71.153"
:00553E00                 mov     [esp+4Ch+var_48], ecx
:00553E04                 mov     [esp+4Ch+var_44], eax
:00553E08                 call    runtime_memequal
:00553E0D                 movzx   eax, byte ptr [esp+4Ch+var_40]
:00553E12                 test    al, al
:00553E14                 jz      short loc_553DF0
:00553E16                 mov     eax, 1
:00553E1B                 jmp     short loc_553DA5
:00553E1D ; ---------------------------------------------------------------------------
```

Comparing resolved address to hardcoded address

After the first environment check, the malware executes the API calls **CoInitializeEx**, **CoInitializeSecurity** and **CoCreateInstance** to instantiate an object of the **SWbemLocator** interface. Using the **SWbemLocator** object, SNAKE then invokes the method **SWbemLocator::ConnectServer** and obtains a pointer to an **SWbemServices** object. Finally, with this object, it will execute **ExecQuery** with the following query:

```
select DomainRole from Win32_ComputerSystem
```

In an attempt to determine whether the infected computer is a server or a workstation.

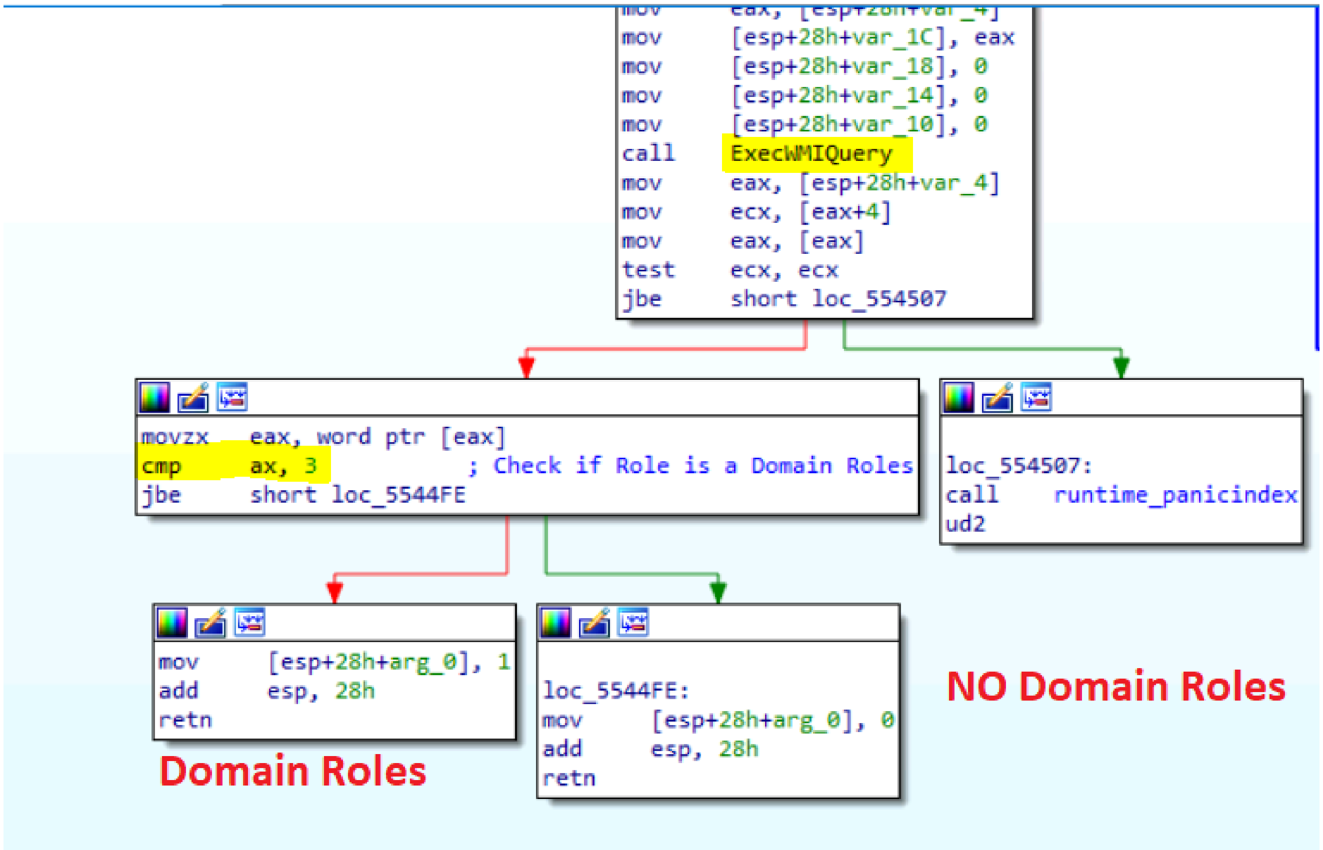
```
:0051CB50
:0051CB50                 mov     ecx, large fs:14h
:0051CB57                 mov     ecx, [ecx+0]
:0051CB5D                 cmp     esp, [ecx+8]
:0051CB60                 jbe     loc_51CC44
:0051CB66                 sub     esp, 7Ch
:0051CB69                 lea     eax, [esp+7Ch+var_24]
:0051CB6D                 mov     [esp+7Ch+var_7C], eax
:0051CB70                 lea     eax, aWbemscriptingS ; "WbemScripting.SWbemLocator"
:0051CB76                 mov     [esp+7Ch+var_78], eax
:0051CB7A                 mov     [esp+7Ch+var_74], 1Ah
:0051CB82                 call    runtime_stringtoslicebyte
:0051CB87                 mov     eax, [esp+7Ch+var_70]
:0051CB8B                 mov     [esp+7Ch+var_4], eax
:0051CB8F                 mov     ecx, [esp+7Ch+var_6C]
:0051CB93                 mov     [esp+7Ch+var_64], ecx
:0051CB97                 mov     [esp+7Ch+var_5E], 0
:0051CB9F                 lea     edi, [esp+7Ch+var_5E+2]
```

Decryption of object used to perform WMI query

```
:0057F3B4                 jbe     loc_57F4A4
:0057F3BA                 sub     esp, 8Ch
:0057F3C0                 lea     eax, [esp+8Ch+var_4F]
:0057F3C4                 mov     [esp+8Ch+var_8C], eax
:0057F3C7                 lea     eax, aSelectDomainro ; "select DomainRole FROM Win32_ComputerSy"...
:0057F3CD                 mov     [esp+8Ch+var_88], eax
:0057F3D1                 mov     [esp+8Ch+var_84], 2Bh ; '+'
:0057F3D9                 call    runtime_stringtoslicebyte
:0057F3DE                 mov     eax, [esp+8Ch+var_80]
:0057F3E2                 mov     [esp+8Ch+var_4], eax
```

Decryption of WMI query to retrieve DomainRole

After making the query, the malware only continues execution if the **DomainRole** value is equal to or less than 3.



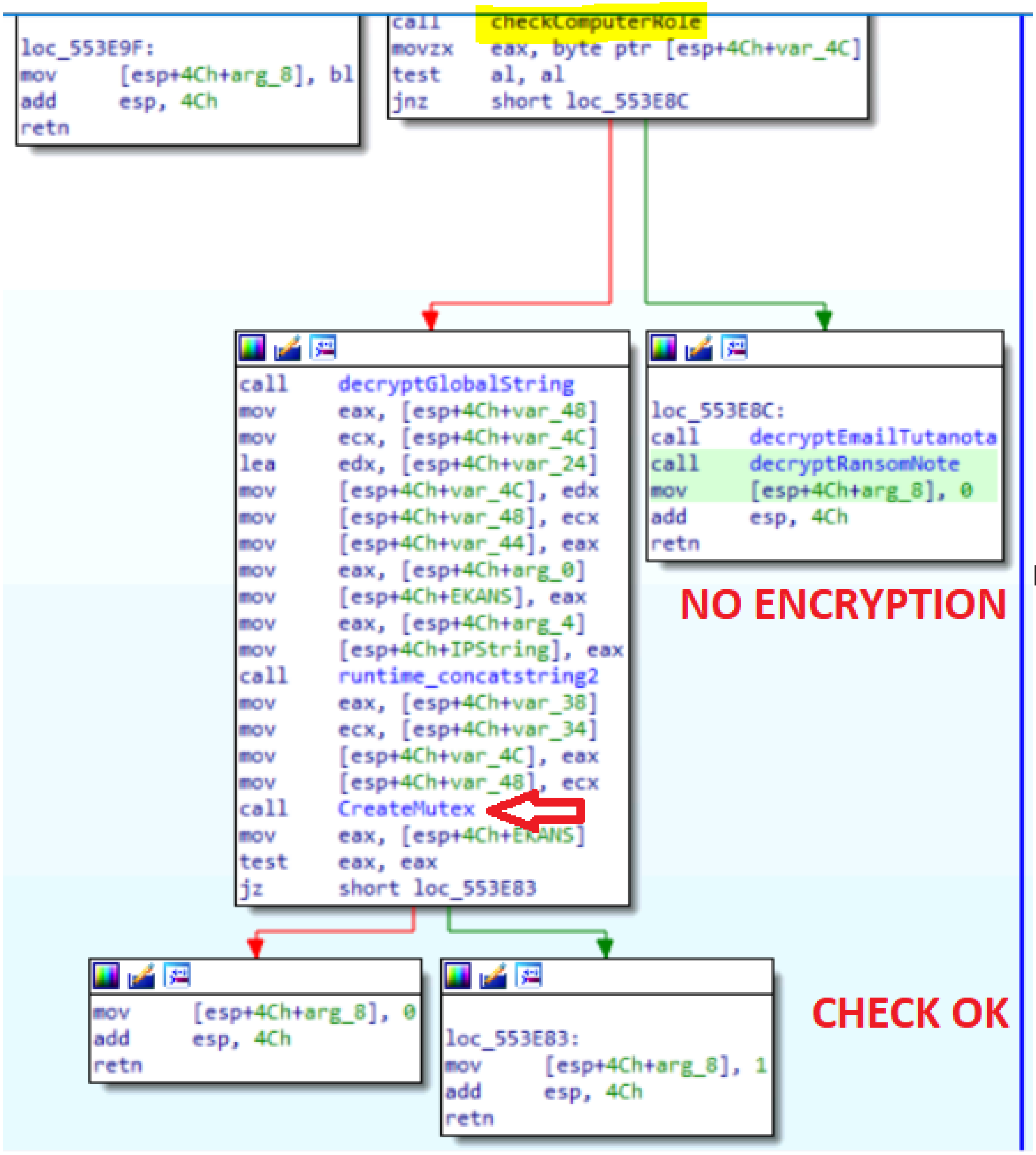
Execution of WMI query and checking of result

According to Microsoft documentation, the integers returned by the call correspond to different values:

VALUE	MEANING
0	Standalone Workstation
1	Member Workstation
2	Standalone Server
3	Member Server
4	Backup Domain Controller
5	Primary Domain Controller

Therefore, the malware performs the infection only if the role obtained of the computer is **Standalone Workstation**, **Member Workstation**, **Standalone Server**, or **Member Server.**

If this check is successful, the mutex **Global\EKANS** is created, and presuming the mutex is created successfully, the sample continues executing.



Execution flow depending on the result of the DomainRole

If, on the other hand, the computer role is either a backup domain controller or primary domain controller, a ransom note is dropped to C:\Users\Public\Desktop, and files are not encrypted. Within the ransom note is an email on how to contact the threat actors, with the email used in this sample being **CarrolBidell@tutanota.com**.

```
------------------------------------------

| What happened to your files?

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

We breached your corporate network and encrypted the data on your computers. The encrypted data includes documents, databases, photos and more -

all were encrypted using a military grade encryption algorithms (AES-256 and RSA-2048). You cannot access those files right now. But dont worry!

You can still get those files back and be up and running again in no time.


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

| How to contact us to get your files back?

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

The only way to restore your files is by purchasing a decryption tool loaded with a private key we created specifically for your network.

Once run on an effected computer, the tool will decrypt all encrypted files - and you can resume day-to-day operations, preferably with

better cyber security in mind. If you are interested in purchasing the decryption tool contact us at CarrolBidell@tutanota.com


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

| How can you be certain we have the decryption tool?

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

In your mail to us attach up to 3 non critical files (up to 3MB, no databases or spreadsheets).

We will send them back to you decrypted.

-----------------------------------------------------
```

Ransom note

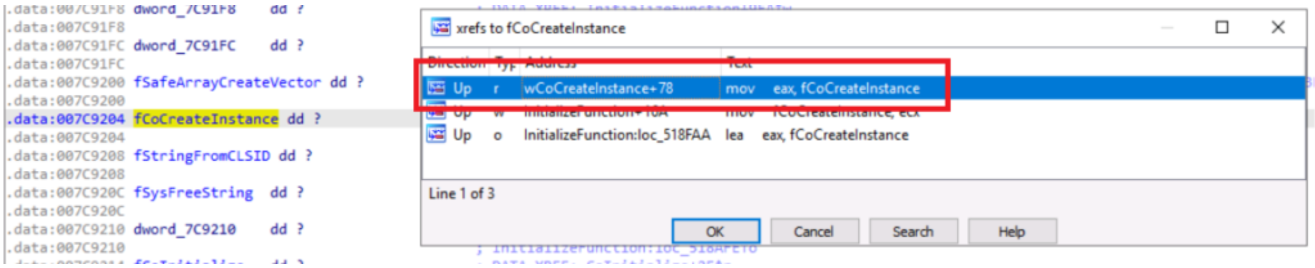
When analyzing Go developed programs, two functions to pay attention to are **NewLazyDll** (essentially LoadLibrary), and **NewProc** (as you may have guessed, basically GetProcAddress). With the use of Gobfuscate to obfuscate this sample, the names of the libraries and API functions to be passed to the described functions. Pointers to the loaded libraries/functions are stored within DWORDs for later reference.

For example, we can see in the sample we have the function that performs the decryption of a function name before calling **LazyDLL.NewProc**:

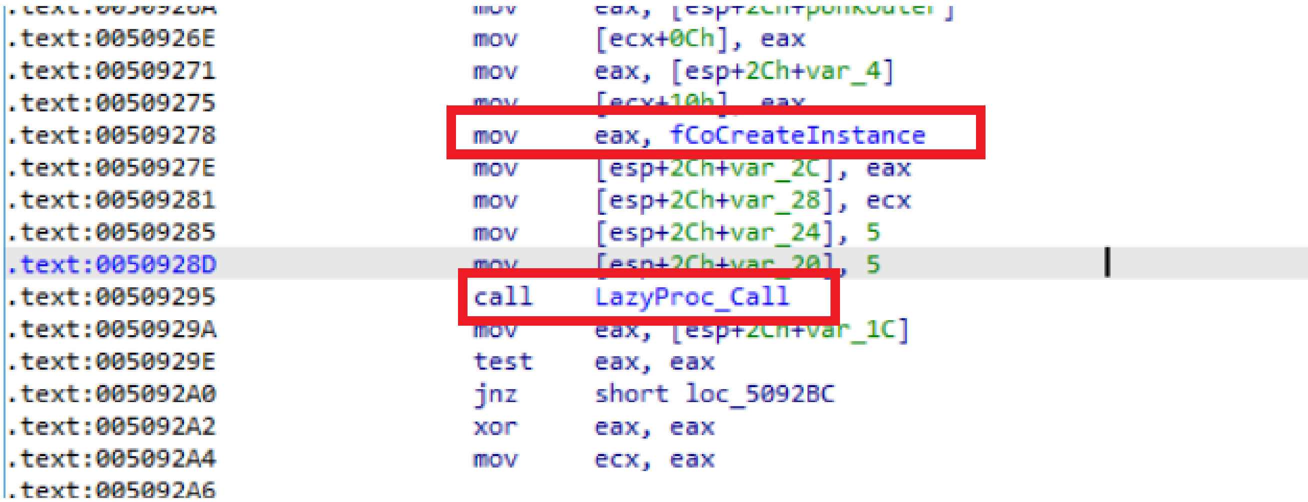
```
loc_517666:                             ; CODE XREF: lfaajlodidnplgehhlkp_inkogifkdegjbllhdpph_inkogifkdegjbllhdpph_i
                call    decryptCoCreateInstance
                mov     eax, dword_7C92AC
                mov     ecx, [esp+10h+var_C]
                mov     edx, [esp+10h+var_10]
                mov     [esp+10h+var_10], eax
                mov     [esp+10h+var_C], edx
                mov     [esp+10h+var_8], ecx
                call    __ptr_LazyDLL__NewProc
                mov     eax, dword_7DA950
                mov     ecx, [esp+10h+var_4]
                test    eax, eax
                jnz     loc_518FAA
                mov     fCoCreateInstance, ecx
```

API function decryption and loading via NewProc

A pointer to the function is saved in a DWORD, so that we can trace to see where the function is called within the binary.



Cross references for API functions



Execution of previously loaded API function

Endpoint Isolation

After the function *CheckEnvironment* has finished, the strings “**netsh advfirewall set allprofiles state on**” and “**netsh advfirewall set allprofiles firewallpolicy blockinbound,blockoutbound**” are decrypted and executed via **cmd.run**. The first command enables Windows Firewall for all network profiles, while the second blocks all incoming and outgoing connections. This is fairly unusual behaviour for ransomware, which typically performs lateral movement across a network to infect additional machines.

```
.text:00554120                 call    decryptNetSh2   ; netsh
.text:00554125                 mov     eax, [esp+98h+var_94]
.text:00554129                 mov     [esp+98h+var_6C], eax
.text:0055412D                 mov     ecx, [esp+98h+var_98]
.text:00554130                 mov     [esp+98h+var_54], ecx
.text:00554134                 call    decryptAdvFirewall2 ; advfirewall
.text:00554139                 mov     eax, [esp+98h+var_94]
.text:0055413D                 mov     [esp+98h+var_70], eax
.text:00554141                 mov     ecx, [esp+98h+var_98]
.text:00554144                 mov     [esp+98h+var_58], ecx
.text:00554148                 call    decryptSet2     ; set
.text:0055414D                 mov     eax, [esp+98h+var_94]
.text:00554151                 mov     [esp+98h+var_74], eax
.text:00554155                 mov     ecx, [esp+98h+var_98]
.text:00554158                 mov     [esp+98h+var_5C], ecx
.text:0055415C                 call    decryptAllProfiles2 ; allprofiles
.text:00554161                 mov     eax, [esp+98h+var_94]
.text:00554165                 mov     [esp+98h+var_78], eax
.text:00554169                 mov     ecx, [esp+98h+var_98]
.text:0055416C                 mov     [esp+98h+var_60], ecx
.text:00554170                 call    decryptFirewallPolicy ; firewallpolicy
.text:00554175                 mov     eax, [esp+98h+var_98]
```

Decryption of netsh commands to alter the firewall

```
:00554441              mov     [esp+6Ch+var_68], eax
:00554445              lea     eax, [esp+6Ch+var_28]
:00554449              mov     [esp+8], eax
:0055444D              mov     dword ptr [esp+0Ch], 5
:00554455              mov     dword ptr [esp+10h], 5
:0055445D              call    os_exec_Command
:00554462              mov     eax, [esp+6Ch+var_58]
:00554466              mov     [esp+6Ch+var_6C], eax
:00554469              call    os_exec___ptr_Cmd__Run
:0055446E              add     esp, 6Ch
:00554471              retn
```

Execution of above commands through os.exec

Terminate Process and Services

Prior to encryption, the ransomware terminates a number of processes, to reduce the amount of interference with the encryption (for example any open file handles), as well as disable any running EDR/SIEM software on the machine.

```
.text:0055462B                 mov     [esp+4658h+var_2328], eax
.text:00554632                 mov     [esp+4658h+var_2324], eax
.text:00554639                 mov     [esp+4658h+var_2320], eax
.text:00554640                 mov     [esp+4658h+var_231C], eax
.text:00554647                 call    decryptccflic0_exe ; ccflic0.exe
.text:0055464C                 mov     eax, [esp+4658h+var_4654]
.text:00554650                 mov     [esp+4658h+var_34C0], eax
.text:00554657                 mov     ecx, [esp+4658h+var_4658]
.text:0055465A                 mov     [esp+4658h+var_232C], ecx
.text:00554661                 call    decryptccflic4_exe ; ccflic4.exe
.text:00554666                 mov     eax, [esp+4658h+var_4654]
.text:0055466A                 mov     [esp+4658h+var_34C4], eax
.text:00554671                 mov     ecx, [esp+4658h+var_4658]
.text:00554674                 mov     [esp+4658h+var_2330], ecx
.text:0055467B                 call    decrypthealthservice_exe ; healthservice.exe
.text:00554680                 mov     eax, [esp+4658h+var_4654]
.text:00554684                 mov     [esp+4658h+var_34C8], eax
.text:0055468B                 mov     ecx, [esp+4658h+var_4658]
.text:0055468E                 mov     [esp+4658h+var_2334], ecx
.text:00554695                 call    decryptilicensesvc_exe ; ilicensesvc.exe
.text:0055469A                 mov     eax, [esp+4658h+var_4654]
.text:0055469E                 mov     [esp+4658h+var_34CC], eax
.text:005546A5                 mov     ecx, [esp+4658h+var_4658]
```

Decryption of target processes to be terminated

Processes are terminated using **syscall.OpenProcess** and **syscall.TerminateProcess** calls. In order for SNAKE to retrieve the PIDs of the target processes, the usual calls of CreateToolhelp32Snapshot, Process32FirstW, and Process32NextW are performed.

```
:00554536                 sub     esp, 1Ch
:00554539                 mov     [esp+1Ch+arg_8], 0
:00554541                 mov     [esp+1Ch+arg_C], 0
:00554549                 mov     [esp+1Ch+var_1C], 1
:00554550                 mov     byte ptr [esp+1Ch+var_18], 0
:00554555                 mov     eax, [esp+1Ch+arg_0]
:00554559                 mov     [esp+1Ch+var_14], eax
:0055455D                 call    syscall_OpenProcess
:00554562                 mov     eax, [esp+1Ch+var_10]
:00554566                 mov     ecx, [esp+1Ch+var_8]
:0055456A                 mov     edx, [esp+1Ch+var_C]
:0055456E                 test    edx, edx
:00554570                 jnz     short loc_5545CC
:00554572                 mov     [esp+1Ch+var_4], eax
:00554576                 mov     [esp+1Ch+var_14], eax
:0055457A                 mov     [esp+1Ch+var_1C], 0Ch
:00554581                 lea     ecx, off_632340
:00554587                 mov     [esp+1Ch+var_18], ecx
:0055458B                 call    runtime_deferproc
:00554590                 test    eax, eax
:00554592                 jnz     short loc_5545C2
:00554594                 mov     eax, [esp+1Ch+var_4]
:00554598                 mov     [esp+1Ch+var_1C], eax
:0055459B                 mov     eax, [esp+1Ch+arg_4]
:0055459F                 mov     [esp+1Ch+var_18], eax
:005545A3                 call    syscall_TerminateProcess
:005545A8                 mov     eax, [esp+1Ch+var_10]
:005545AC                 mov     ecx, [esp+1Ch+var_14]
:005545B0                 mov     [esp+1Ch+arg_8], ecx
:005545B4                 mov     [esp+1Ch+arg_C], eax
:005545B8                 nop
```

Terminating processes with OpenProcess and TerminateProcess

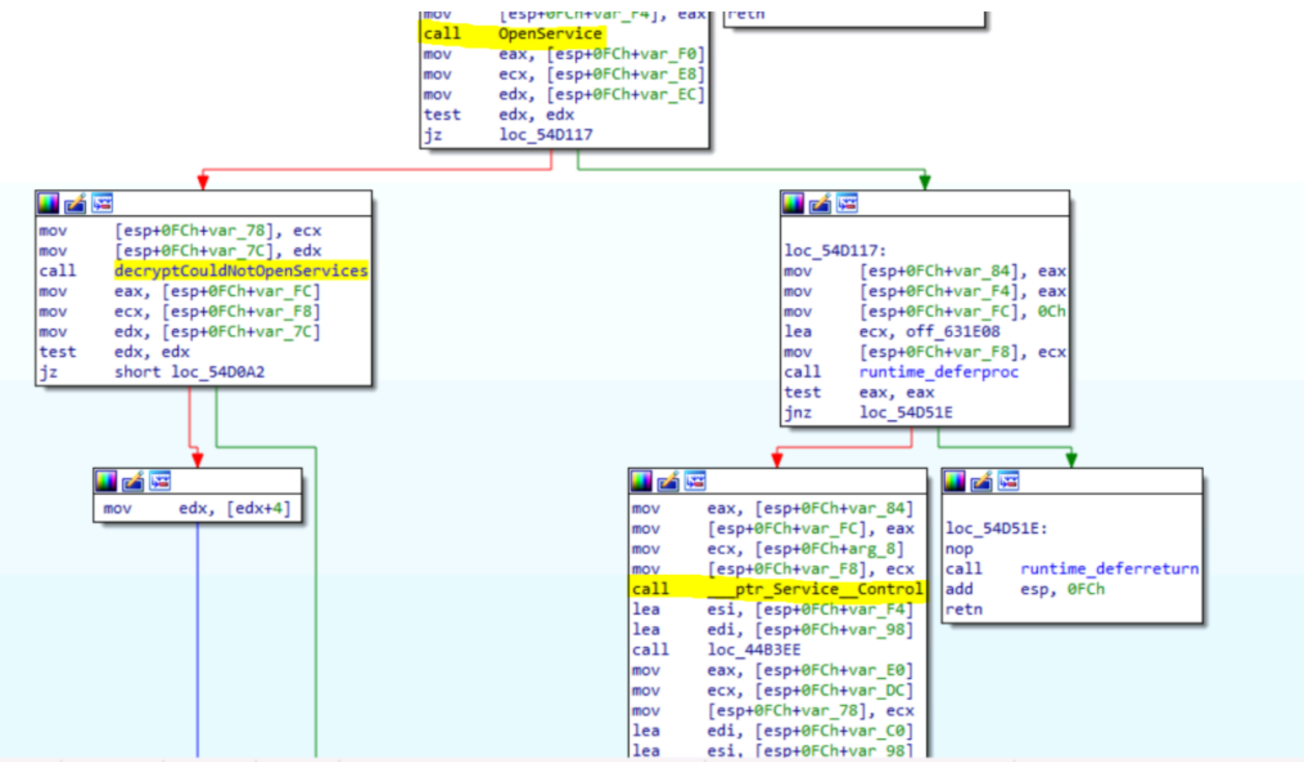
In addition to terminating processes, the ransomware stops more than 200 services related to EDR, SIEM, AV, etc.

```
.text:0054D58A                 jbe     loc_551CFE
.text:0054D590                 sub     esp, 13ACh
.text:0054D596                 mov     eax, 0
.text:0054D59B                 lea     edi, [esp+13ACh+var_9F8]
.text:0054D5A2                 call    loc_44AF08
.text:0054D5A7                 call    decryptAcronis  ; Acronis VSS Provider
.text:0054D5AC                 mov     eax, [esp+13ACh+var_13A8]
.text:0054D5B0                 mov     [esp+13ACh+var_115C], eax
.text:0054D5B7                 mov     ecx, [esp+13ACh+var_13AC]
.text:0054D5BA                 mov     [esp+13ACh+var_C98], ecx
.text:0054D5C1                 call    decryptEnterpriseClientService ; Enterprise Client Service
.text:0054D5C6                 mov     eax, [esp+13ACh+var_13A8]
.text:0054D5CA                 mov     [esp+13ACh+var_1160], eax
.text:0054D5D1                 mov     ecx, [esp+13ACh+var_13AC]
.text:0054D5D4                 mov     [esp+13ACh+var_C9C], ecx
.text:0054D5DB                 call    decryptSophosAgent ; Sophos Agent
.text:0054D5E0                 mov     eax, [esp+13ACh+var_13A8]
.text:0054D5E4                 mov     [esp+13ACh+var_1164], eax
```

Decryption of target service names to be terminated

In order to terminate services, the following API function calls are made:

- **OpenSCManagerA**: gets a service control manager handle for subsequent calls.
- **EnumServicesStatusEx**: enumeration of services.
- **OpenServiceW**: gets a service handle for subsequent calls.
- **QueryServiceStatusEx**: check the status of services.
- **ControlService:** used to stop the service (flag SERVICE_CONTROL_STOP).



Termination of services using OpenService and ControlService

Shadow Copy Deletion

The ransomware executes the WMI query **"SELECT * FROM Win32_ShadowCopy"** to get the IDs of Shadow Copies and will always use WMI for deletion (remember that there are many ways to perform shadow copy deletion).

In addition to the **Wbemscripting.SWbemLocator** object, **WbemScripting.SWbemNamedValueSet** is also created.

For deletion, SNAKE uses the **DeleteInstance** method by passing the ID of previously obtained Shadow Copies.

```
.text:0057C037                 mov     ecx, [ecx+0]
.text:0057C03D                 cmp     esp, [ecx+8]
.text:0057C040                 jbe     loc_57C122
.text:0057C046                 sub     esp, 80h
.text:0057C04C                 lea     eax, [esp+80h+var_24]
.text:0057C050                 mov     [esp+80h+var_80], eax
.text:0057C053                 lea     eax, aWbemscriptingS_0 ; "WbemScripting.SWbemNamedValueSet"
.text:0057C059                 mov     [esp+80h+var_7C], eax
.text:0057C05D                 mov     [esp+80h+var_78], 20h ; ' '
.text:0057C065                 call    runtime_stringtoslicebyte
.text:0057C06A                 mov     eax, [esp+80h+var_74]
.text:0057C06E                 mov     [esp+80h+var_4], eax
.text:0057C072                 mov     ecx, [esp+80h+var_70]
```

Decryption of WbemScripting.SWbemNamedValueSet

```
xt:0057D066                 sub     esp, 80h
xt:0057D06C                 lea     eax, [esp+80h+var_24]
xt:0057D070                 mov     [esp+80h+var_80], eax
xt:0057D073                 lea     eax, aSelectFromWin3 ; "SELECT * FROM Win32_ShadowCopy"
xt:0057D079                 mov     [esp+80h+var_7C], eax
xt:0057D07D                 mov     [esp+80h+var_78], 1Eh
xt:0057D085                 call    runtime_stringtoslicebyte
xt:0057D08A                 mov     eax, [esp+80h+var_74]
xt:0057D08E                 mov     [esp+80h+var_4], eax
xt:0057D092                 mov     ecx, [esp+80h+var_70]
xt:0057D096                 mov     [esp+80h+var_68], ecx
xt:0057D09A                 mov     [esp+80h+var_62], 0
xt:0057D0A2                 lea     edi, [esp+80h+var_62+2]
xt:0057D0A6                 xor     eax, eax
```

Decryption of WMI Query

```
xt:0057CB86                 sub     esp, 6Ch
xt:0057CB89                 lea     eax, [esp+6Ch+var_24]
xt:0057CB8D                 mov     [esp+6Ch+var_6C], eax
xt:0057CB90                 lea     eax, aRootCimv2 ; "root\\cimv2"
xt:0057CB96                 mov     [esp+6Ch+var_68], eax
xt:0057CB9A                 mov     [esp+6Ch+var_64], 0Ah
xt:0057CBA2                 call    runtime_stringtoslicebyte
xt:0057CBA7                 mov     eax, [esp+6Ch+var_60]
xt:0057CBAB                 mov     [esp+6Ch+var_4], eax
xt:0057CBAF                 mov     ecx, [esp+6Ch+var_5C]
```

Decryption of WMI namespace

Encryption Process

SNAKE first encrypts all the various files by initializing 8 go-routines (**runtime.newproc**), before beginning to rename the files.

The offset of the function that does the encryption is passed to **runtime.newproc** (**OffsetStartEncryption**).

```
while ( v6 <= 8 )
{
  v11 = v6;
  v9 = v5;
  v7 = a2;
  runtime_newproc(16, (char)&OffsetStartEncryption);
  v6 = v11 + 1;
  v5 = v13;
}
startRenameFile(a3, a4, v12, v5, v7, v9);
runtime_closechan(v12);
sync___ptr_WaitGroup__Wait(v13);
renameFile(v8, v10);
sync___ptr_WaitGroup__Done(a5);
```

Initialisation of go-routines prior to file renaming function
Before beginning encryption of the file, it’s checked that it has not already been encrypted by checking for the presence of the string **EKANS** at the end of the file.

```
  os___ptr_File__Read(file, v15, sizeFileReaded, v13);
  if ( v11 )
  {
    if ( dword_7C9848 != v11 )
      return v13;
    runtime_ifaceeq();
    if ( !v3 )
      return v13;
  }
  if ( sizeFileReaded == SIZE_STRING_EKANS )
  {
    runtime_memequal(v15, STRING_EKANS);
    if ( v3 )
      return v8;
  }
  os___ptr_File__Seek(file, 0, 0, 0, v5, v8);
  return v14;
}
```

Checking if file is already encrypted

If the file hasn’t yet been encrypted and the files are among those to be encrypted (there is an allowlist and a denylist), encryption is initiated, which takes care of:

- Generating AES key for each file; this key is encrypted with an RSA public key in OAEP Mode.
- Encryption of file via AES in CTR mode, with Random Key (32 bytes) and Random IV (16 bytes).
- A random 5 character is appended to the file extension of encrypted files.
- Adds data to the end of the file: encrypted AES Key, IV and EKANS string.

```
sliceIV = runtime_makeslice64(dword_5F0E80, 16, 0, 16, 0, v17, v21);
pIV = IV;
crypto_rand_Read(IV, IVSize, sliceIV);
helpFunction2(fileb, IV);
sliceKeyAES = runtime_makeslice(dword_5F0E80, 32, 32, cpSliceKey, fileb);
pAESKeySize = AES_KEY_SIZE;
pAESKey = cpSliceKeya;
pSliceKeyAES = sliceKeyAES;
crypto_rand_Read(cpSliceKeya, AES_KEY_SIZE, sliceKeyAES);
helpFunction2(AES_KEY_SIZE, sliceKeyAES);
EncryptFileViaCTR(pFile2, cpSliceKeya, AES_KEY_SIZE, sliceKeyAES, pIV, IVSize, sliceIV);
if ( !sliceIV )
{
  encryptRSAKey(RSAKey, pAESKey, pAESKeySize, pSliceKeyAES);
  ((void (*)(void))loc_44AF07)();
  ((void (*)(void))loc_44B3C6)();
  AddToEndOfFile(cpFile2a, fileClose2, cpAESKeySize, cpSliceKeyb, file, v20, v23, 0, v25, pFile2);
}
```

Key generation, encryption, and metadata being added to file

After instantiating the CTR cipher with **cipher.NewCTR,** encryption is performed with the **XORKeyStream** method of that class.

The function reads 0x19000 bytes at a time and after encryption the file is rewritten using **WriteAt**.

```
.text:00551F29    mov     eax, [esp+70h+arg_18]
.text:00551F30    mov     [esp+70h+var_60], eax
.text:00551F34    call    crypto_cipher_NewCTR
.text:00551F39    mov     eax, [esp+70h+var_58]
.text:00551F3D    mov     [esp+70h+var_18], eax
.text:00551F41    mov     ecx, [esp+70h+var_5C]
.text:00551F45    mov     [esp+70h+var_1C], ecx
.text:00551F49    lea     edx, dword_5F0E80
.text:00551F4F    mov     [esp+70h+var_70], edx
.text:00551F52    mov     [esp+70h+var_6C], 19000h
.text:00551F5A    mov     [esp+70h+var_68], 19000h
.text:00551F62    call    runtime_makeslice
.text:00551F67    mov     eax, [esp+70h+var_64]
.text:00551F6B    mov     [esp+70h+var_14], eax
.text:00551F6F    mov     ecx, [esp+70h+var_5C]
.text:00551F73    mov     [esp+70h+var_34], ecx
.text:00551F77    mov     edx, [esp+70h+var_60]
.text:00551F7B    mov     [esp+70h+var_38], edx
```

Generating the buffer to hold bytes read from the file

```
.text:00552073                 mov     ebp, [esp+70h+var_18]
.text:00552077                 mov     [esp+70h+var_70], ebp
.text:0055207A                 call    esi             ; XORKeyStream
.text:0055207C                 mov     eax, [esp+70h+pFile]
.text:00552080                 mov     [esp+70h+var_70], eax
.text:00552083                 mov     ecx, [esp+70h+var_28]
.text:00552087                 mov     [esp+70h+var_6C], ecx
.text:0055208B                 mov     ecx, [esp+70h+var_4C]
.text:0055208F                 mov     [esp+70h+var_68], ecx
.text:00552093                 mov     ecx, [esp+70h+var_48]
.text:00552097                 mov     [esp+70h+var_64], ecx
.text:0055209B                 mov     ecx, dword ptr [esp+70h+var_40]
.text:0055209F                 mov     [esp+70h+var_60], ecx
.text:005520A3                 mov     edx, dword ptr [esp+70h+var_40+4]
.text:005520A7                 mov     [esp+70h+var_5C], edx
.text:005520AB                 call    os___ptr_File__WriteAt
.text:005520B0                 mov     eax, [esp+70h+var_44]
.text:005520B4                 mov     ecx, eax
```

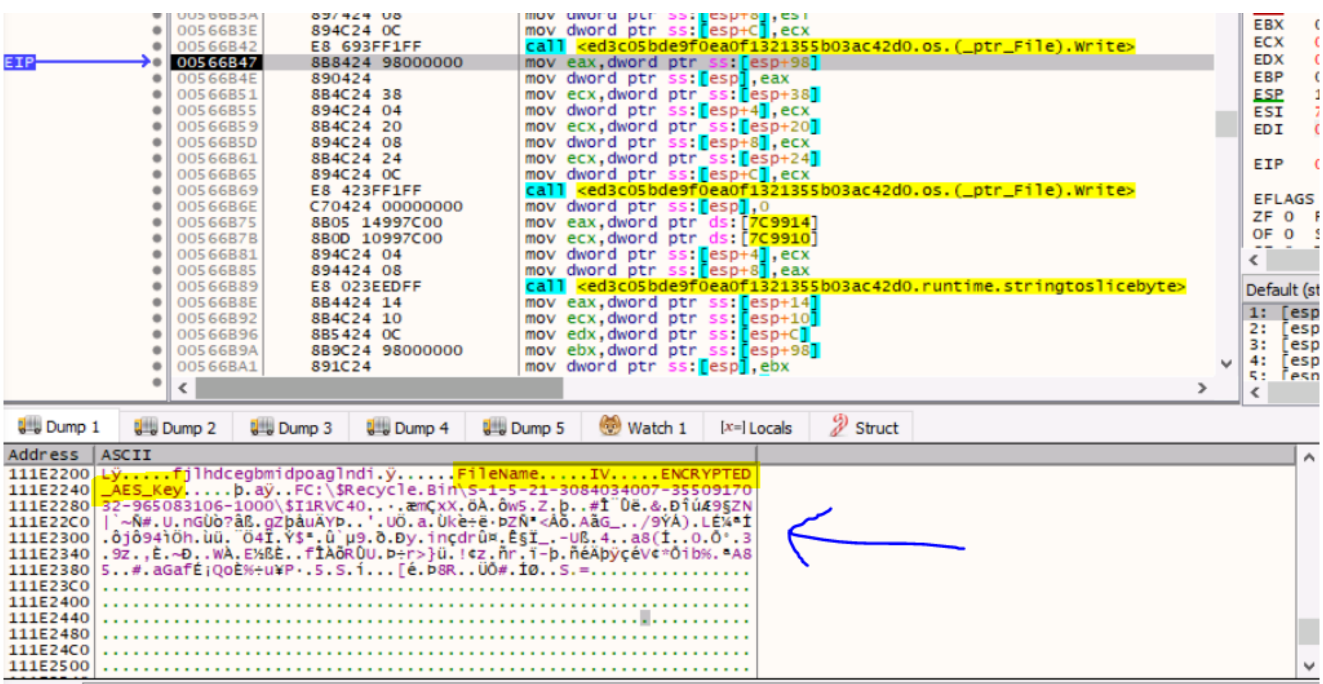
Encrypting buffer data and overwriting file

After finishing the encryption, three more writes are performed on the file:

```
os___ptr_File__Write(a10, *v40 + (v12 & ((int)(v12 - v40[2]) >> 31)), v11 - v12, v40[2] - v12, v24, v28, 0);
os___ptr_File__Write(a10, v41, v35, v36, v25, v29, v31);
v21 = runtime_stringtoslicebyte(0, STRING_EKANS, SIZE_STRING_EKANS);
os___ptr_File__Write(a10, v21, v26, v30, v26, v30, v32);
```

Adding metadata to the file

It's easy to see that in the last one the string **EKANS** is written (which is used to determine if the file has already been encrypted), while it is much more complex to figure out what is written in the first two. As a result, let's jump over to a debugger.



Observing metadata being written to end of file using a debugger

The first write adds the following to the file:

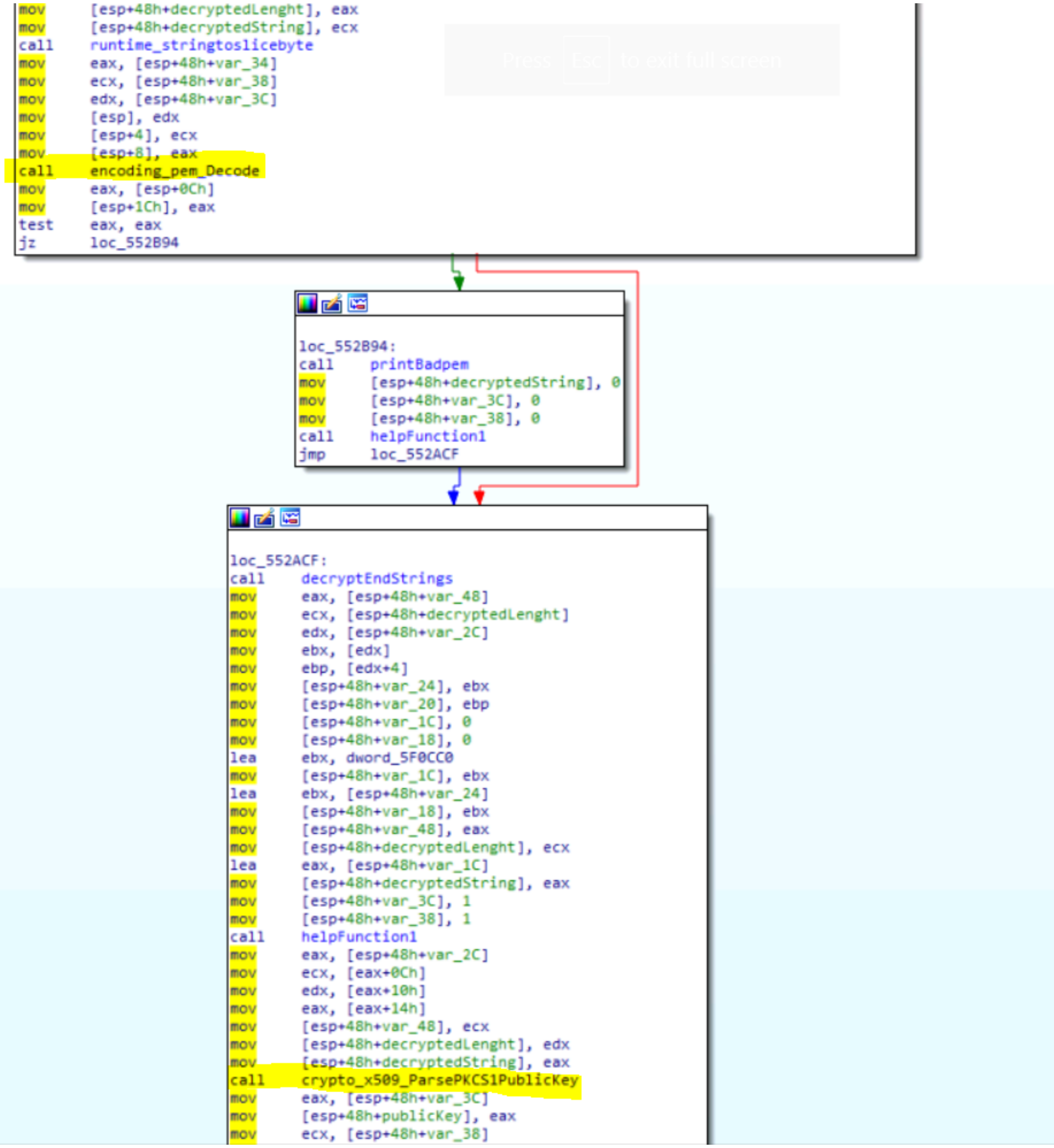
- The encrypted AES Key

- The random IV
- The path of encrypted file

The AES Key for each file is encrypted with a public RSA key. After decryption, the public key is parsed with **pem.decode** and **x509.ParsePKCS1PublicKey**.

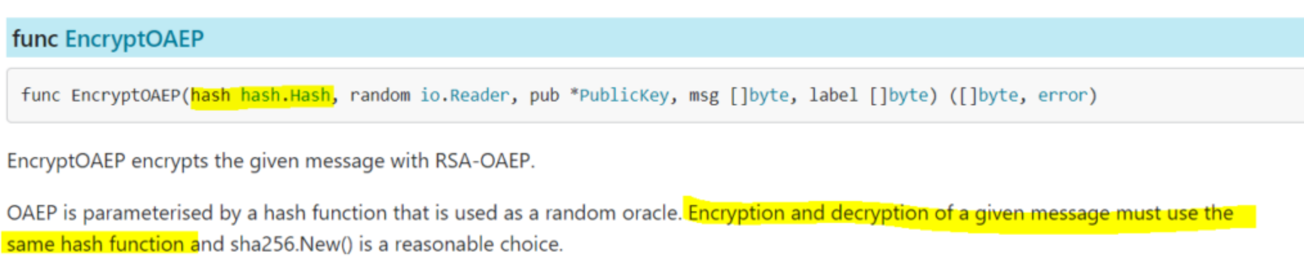
```
.text:00552A83                 call    decryptAESPublicKey ; -----BEGIN RSA PUBLIC KEY-----.MIIBCgKCAQEAt1GCKUHXITsiWc1d8V0vo
.text:00552A83                                         ; 1117C3C0  1Y9Jm18RDZEmMS6OkHI7pZT0RHAThlR.BFITZY9bXrl6RFdUwmIX0WYn5ZqIlhLA
.text:00552A83                                         ; 1117C400  Ee1cqd8RpJ/KK2OeiTn0CJ1CGmOOJvfm.5rFa8whVAU9cnh/iVCcf+aEHJVcHhzB
.text:00552A83                                         ; 1117C440  5tTtiT3lBIdfzaLL6GR5EmytbQ3V3O1Uk.Y4FCKxYOMVoPzPtRG3vo3688uUWpZI
.text:00552A83                                         ; 1117C480  KBV7e6dht/mAhuCEIlRGcdpAEf6f4zUUYf.dtHcDafMVEA4Sy/DDsd76wAyBIM0X
.text:00552A83                                         ; 1117C4C0  KLv1+vH476TN1K1tIRBrR98QFl5mlXkgqz6.h+Wpb/5KYWWvG0ZLZcu6eWOCGmLE
.text:00552A83                                         ; 1117C500  morvWQIDAQAB.-----END RSA PUBLIC KEY-----.......................
.text:00552A88                 mov     eax, [esp]
.text:00552A8B                 mov     ecx, [esp+4]
.text:00552A8F                 mov     [esp+48h+var_48], 0
.text:00552A96                 mov     [esp+48h+decryptedLenght], eax
```

Decryption of RSA public key



Parsing of the RSA key

The first parameter of the **EncryptOAEP** function must be the hash function, which in this case is **sha1**:



EncryptOAEP Function

```
sha1 = (_DWORD *)runtime_newobject(dword_601BE0);
*sha1 = 0x67452301;
sha1[1] = 0xEFCDAB89;
sha1[2] = 0x98BADCFE;
sha1[3] = 0x10325476;
sha1[4] = 0xC3D2E1F0;
sha1[21] = 0;
sha1[22] = 0;
sha1[23] = 0;
crypto_rsa_EncryptOAEP(&off_6C5E40, sha1, rand1, rand2, RSAKey, AESKey, AESKeySize, sliceKeyAes, 0, 0, 0);
```
Call to EncryptOAEP function

Various extensions, file and folders are excluded for file encryption, also using a regex.

Partially excluded Files:

Iconcache.db	**Ntuser.dat**	**Desktop.ini**
Ntuser.ini	**Usrclass.dat**	**Usrclass.dat.log1**
Usrclass.dat.log2	**Bootmgr**	**Bootnxt**
Ntuser.dat.log1	**Ntuser.dat.log2**	**Boot.ini**
ctfmon.exe	**bootsect.bak**	**ntdlr**

Partially excluded extensions:

Exe	**Dll**	**Sys**
Mui	**Tmp**	**Lnk**
config	**settingcontent-ms**	**Tlb**
Olb	**Bfl**	**ico**
regtrans-ms	**devicemetadata-ms**	**Bat**
Cmd	**Ps1**	

Excluded Paths:

\ProgramData
\Users\All Users
\Temp
\AppData
\Boot
\Local Settings

\Recovery
\Program Files
\System Volume Information
\$Recycle.Bin
.+\\Microsoft\\(User Account Pictures|Windows\\(Explorer|Caches)|Device

And that just about wraps up this post on the SNAKE Ransomware!

Decryption Script

```
#!/usr/bin/env python3

import re, struct, pefile, sys

pe = None
imageBase = None


def GetRVA(va):
    return pe.get_offset_from_rva(va - imageBase)


def GetVA(raw):
    return imageBase + pe.get_rva_from_offset(raw)


def main():

    global pe, imageBase

    filename = sys.argv[1]

    with open(filename, 'rb') as sample:
        data = bytearray(sample.read())


    pe = pefile.PE(filename)
    imageBase = pe.OPTIONAL_HEADER.ImageBase


    startDecryptFunction = b"\x64\x8B\x0D\x14\x00\x00\x00"
    sliceStr = b"(" + b"\x8D.....\x89.\$\x04\xC7\x44\$\b...." + b")"
    xorLoop = b"\x0F\xB6<\)1\xFE(\x83|\x81)\xFD"


    regex = startDecryptFunction + b".{10,100}" + sliceStr + b".{10,100}" + sliceStr
+ b".{10,100}" + xorLoop
    pattern = re.compile(regex, re.MULTILINE|re.DOTALL)
    found = pattern.finditer(bytes(data))

    for m in found:

        va = GetVA(m.start())

        funcVA = GetVA(m.start())
        str1VA = struct.unpack("<L", data[m.start(1) + 2 : m.start(1) + 2 + 4])[0]
        str1Len = struct.unpack("<L", data[m.start(1) + 0xE : m.start(1) + 0xE + 4])
[0]
        str2VA = struct.unpack("<L", data[m.start(2) + 2 : m.start(2) + 2 + 4])[0]

        str1RVA = GetRVA(str1VA)
        str2RVA = GetRVA(str2VA)
```

```
        decrypted = ""
        for i in range(str1Len):
            decrypted += chr ( ( data[str2RVA+i] ^ (data[str1RVA+i] + i * 2)) & 0xFF)

        print(f"## (hex(funcVA))  - {decrypted}")


if __name__ == "__main__":
        main()
```