A Case of Vidar Infostealer - Part 1 (Unpacking)

0x00-0x7f.github.io/A-Case-of-Vidar-Infostealer-Part-1-(-Unpacking-)/

0x00-0x7F blog March 27, 2022

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Hi, in this post, I'll be unpacking and analyzing Vidar infostealer from my **BSides Islamabad 2021** talk. Initial stage sample comes as .xll file which is Excel Add-in file extension. It allows third party applications to add extra functionality to Excel using Excel-DNA, a tool or library that is used to write .NET Excel add-ins. In this case, xll file embeds malicious downloader dll which further drops packed Vidar infostealer executable on victim machine, investigating whole infection chain is out of scope for this post, however I'll be digging deep the dropped executable (Packed Vidar) in Part1 of this blogpost and final infostealer payload in Part2.

SHA256: 5cd0759c1e566b6e74ef3f29a49a34a08ded2dc44408fccd41b5a9845573a34c

Technical Analysis

I usually start unpacking general malware packers/loaders by looking it first into basic static analysis tools, then opening it into IDA and taking a bird's eye view of different sections for variables with possible encrypted strings, keys, imports or other global variables containing important information, checking if it has any crypto signatures identified and then start debugging it. After loading it into x64dbg, I first put breakpoint on memory allocation APIs such as LocalAlloc, GlobalAlloc, VirtualAlloc and memory protection API: VirtualProtect, and hit run button to see if any of the breakpoints hits. If yes, then it is fairly simple to unpack it and extract next stage payload, otherwise it might require in-depth static and dynamic analysis. Let's hit run button to see where it takes us next.

Shellcode Extraction

Here we go, the first breakpoint hits in this case, is **VirtualProtect**, being called on a **stack** memory region of size **0x28A** to grant it **E**xecute **R**ead **W**rite (0x40) protection, strange enough right!

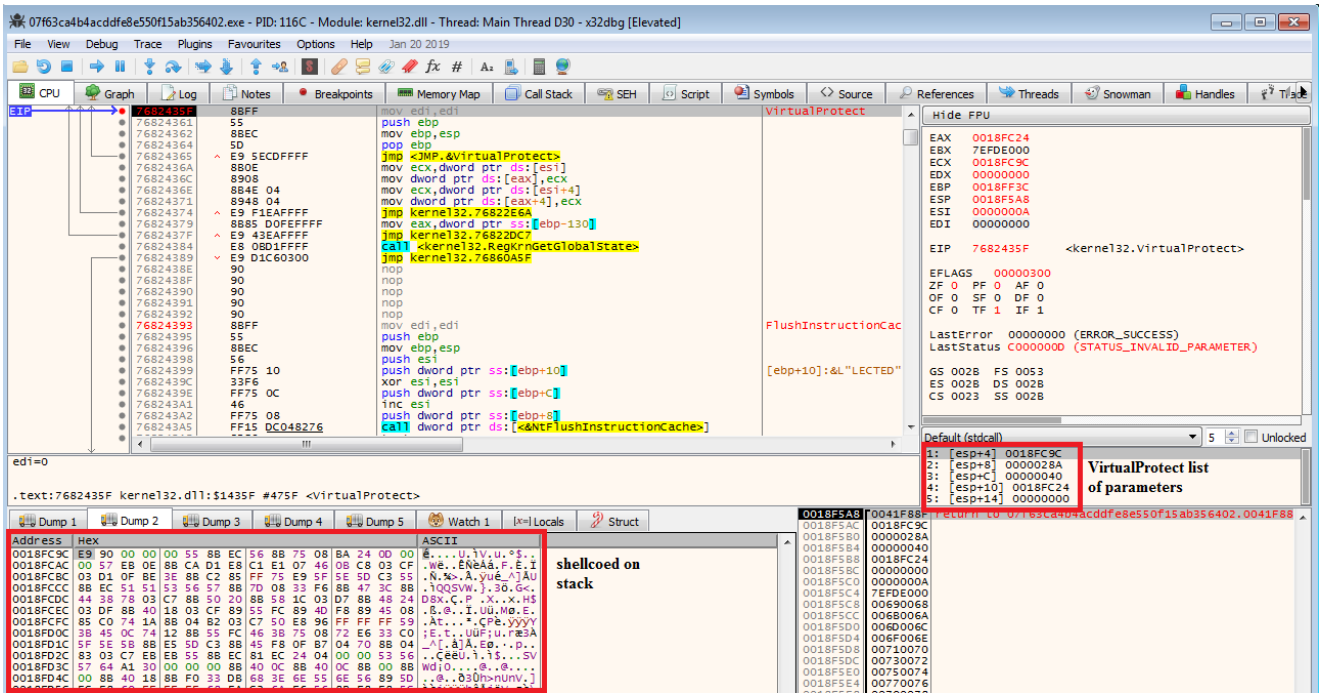
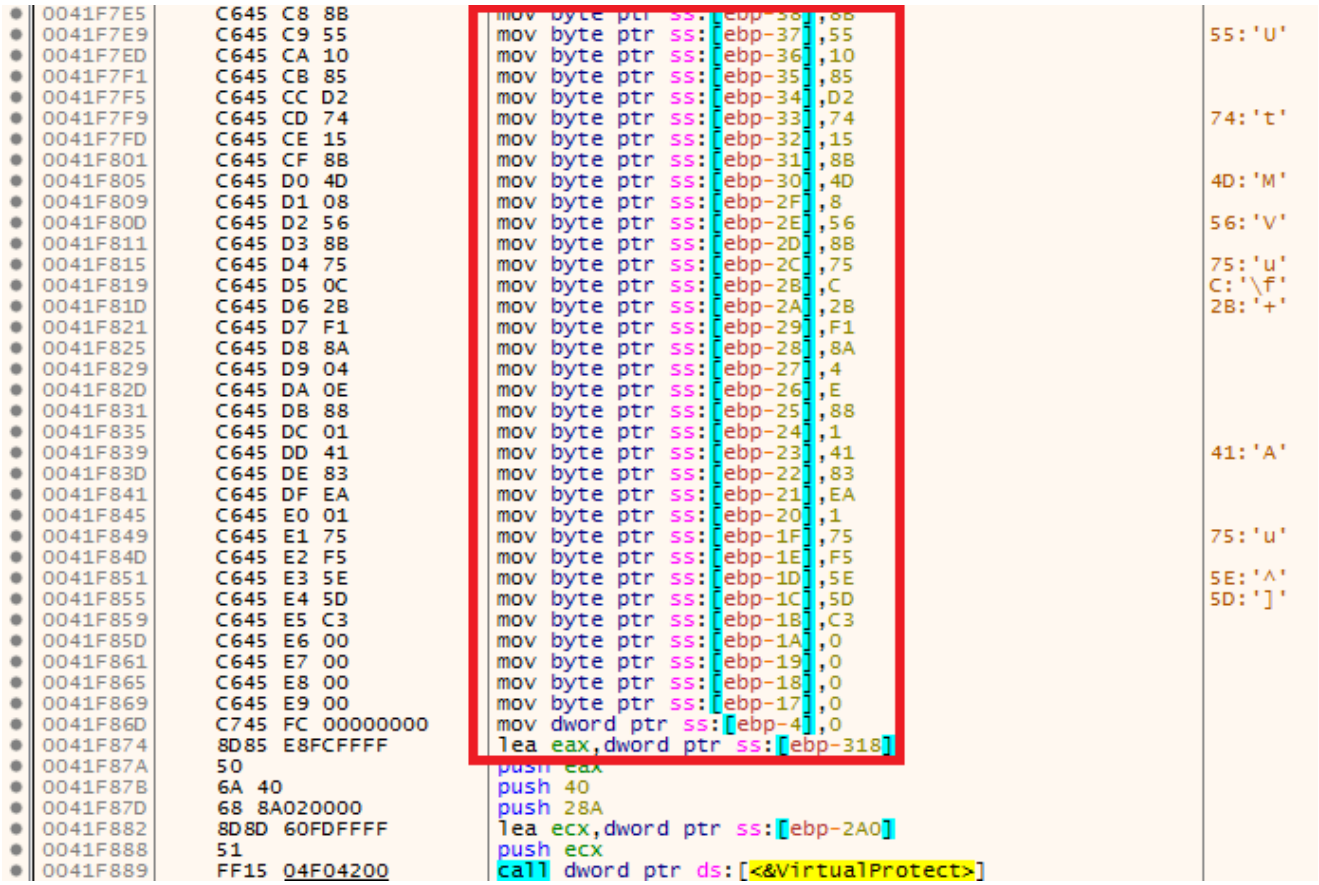
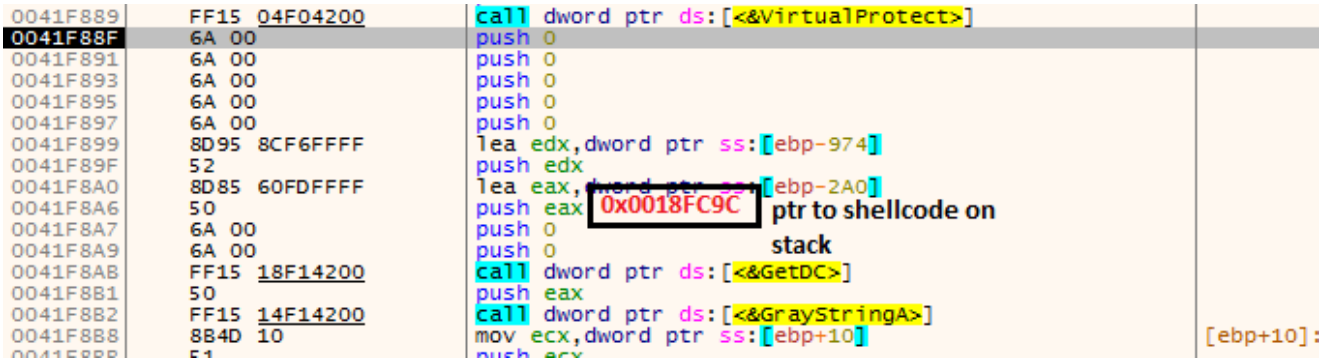


Figure1

first few opcodes **E9**, **55**, **8B** in dumped data on stack correspond to **jmp**, **push** and **mov** instructions respectively, so it can be assumed it is shellcode being pushed on stack and then granted Execute protection to later execute it, If I hit execute till return button on VirtualProtect and trace back from it into disassembler, I can see shellcode stored as **stack strings** right before VirtualProtect call and list of arguments are pushed as shown in the figure below



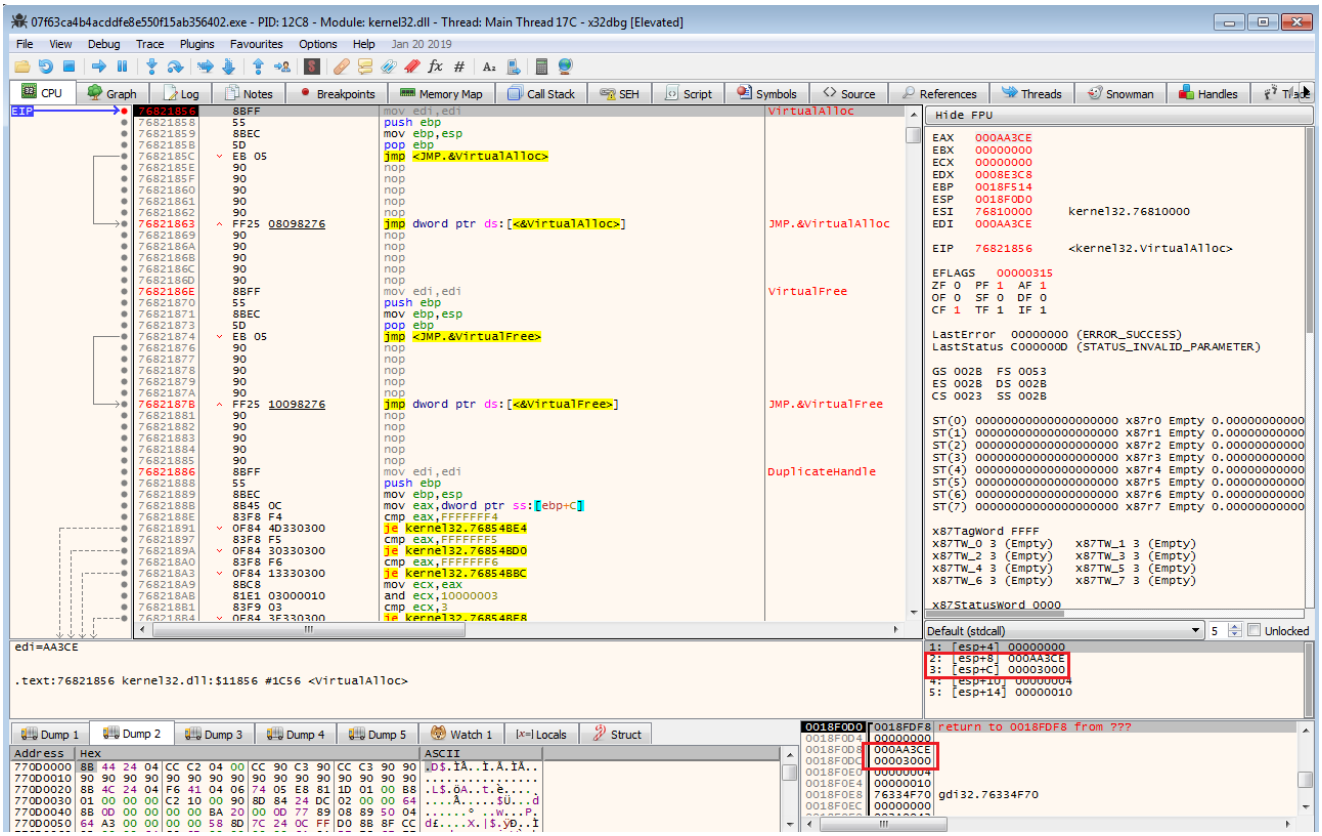
following few statements are preparing to execute shellcode on stack by retrieving a handle to a device context (DC) object and passing this handle to GrayStringA to execute shellcode from stack (ptr value in eax taken from Figure1)



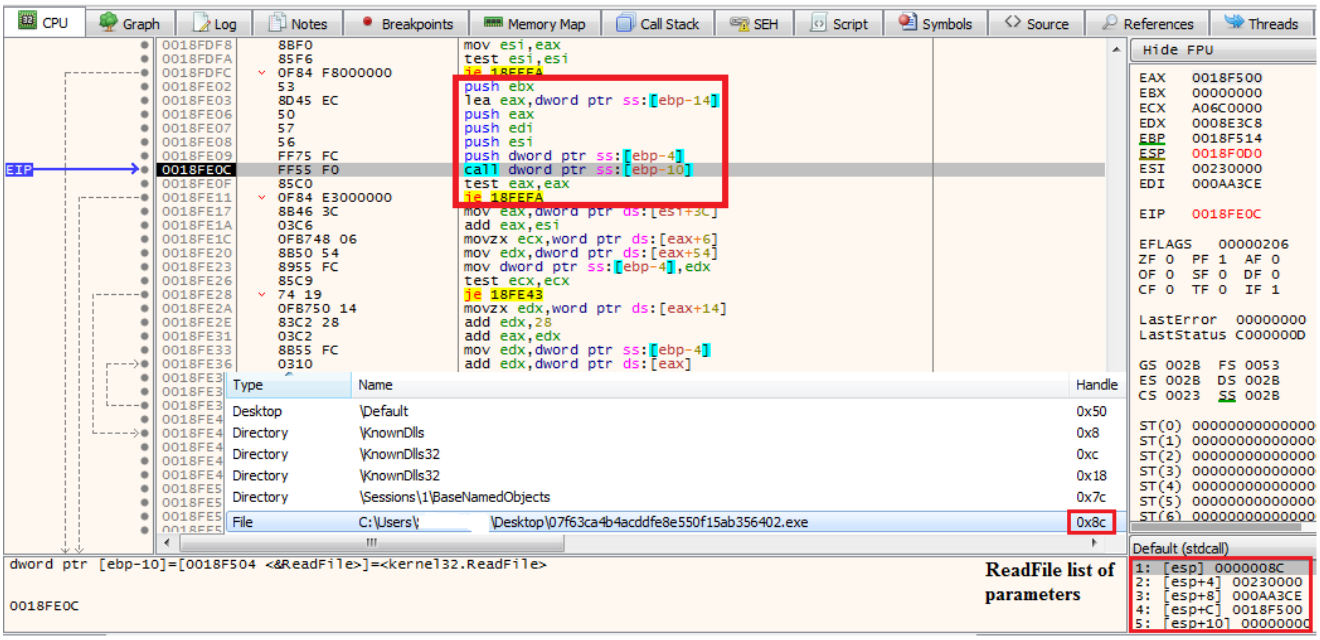
let's now start exploring the shellcode.

Debugging shellcode to extract final payload

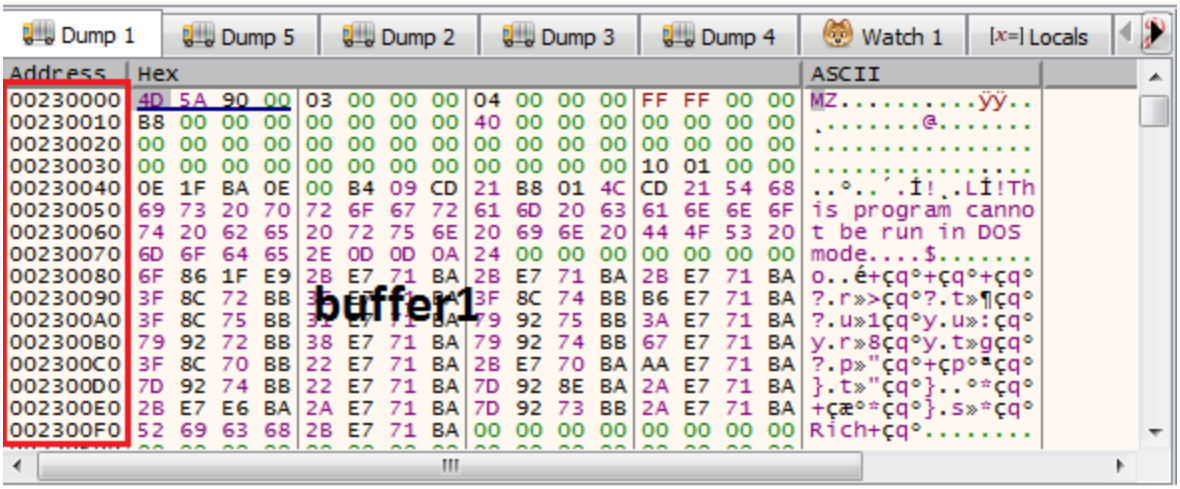
As soon as, **GrayStringA** executes, it hits on **VirtualAlloc** breakpoint set in the debugger, which is being called to reserver/commit 0xAA3CE size of memory with **MEM_COMMIT | MEM_RESERVE** (0x3000) memory allocation type



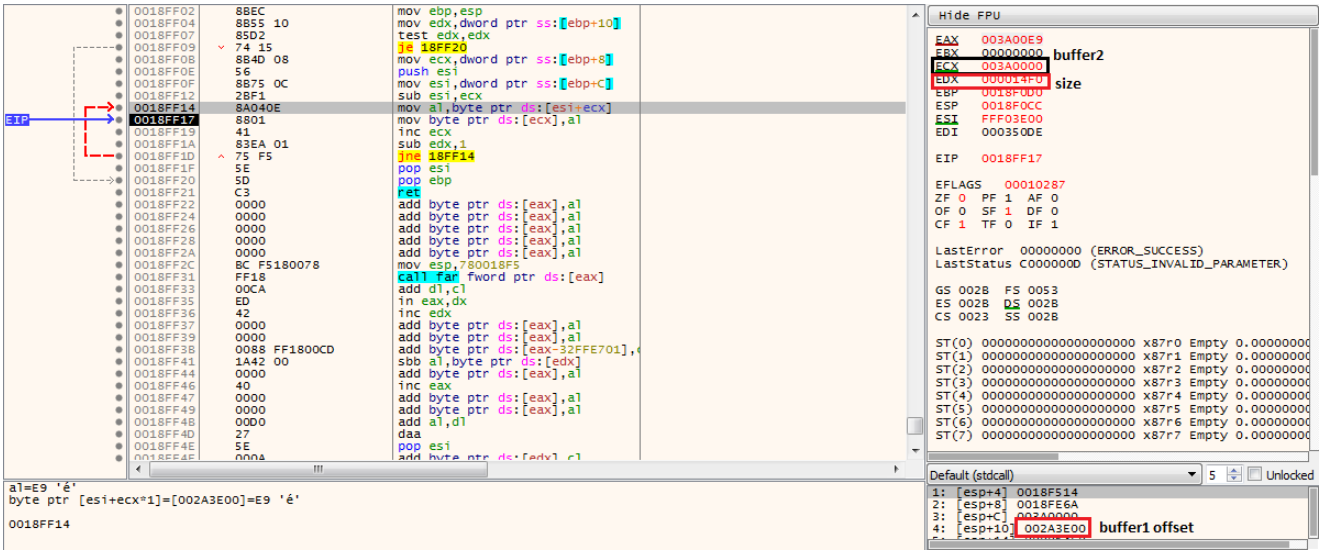
returning control from **VirtualAlloc** and stepping over one more time from ret, leads us to the shellcode, next few statements after VirtualAlloc call are pushing pointer to newly created buffer, size of the buffer and the file handle for currently loaded process on stack to call **ReadFile**



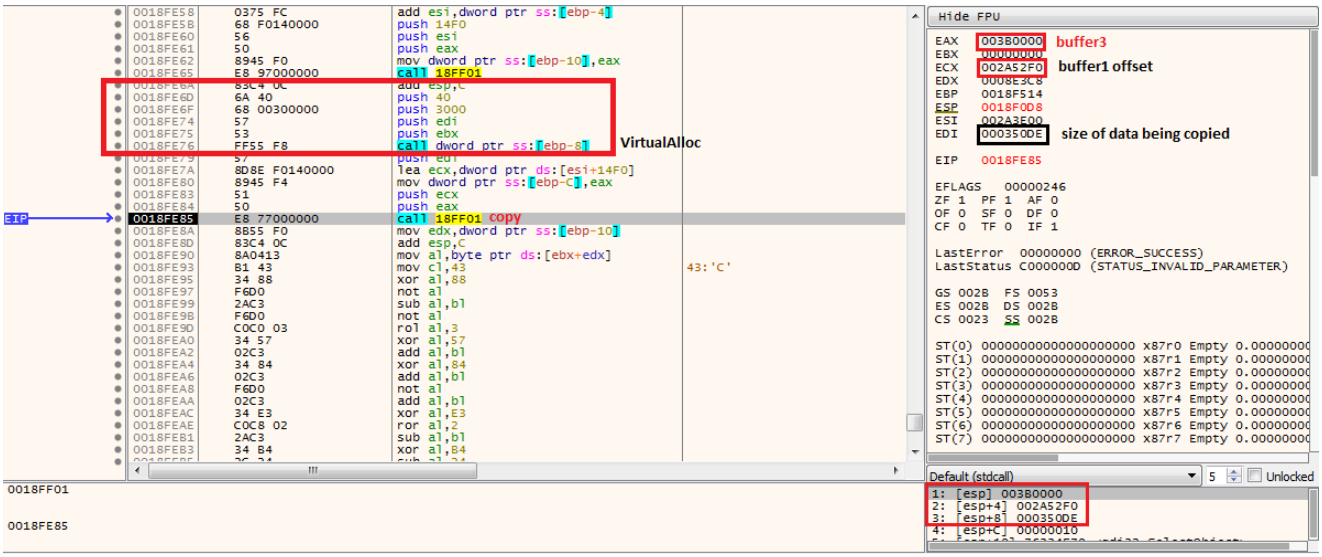
which reads 0xAA3CE bytes of data from parent process image into the buffer, let's say it **buffer1**



further execution again hits at **VirtualAlloc** breakpoint, this time allocating **0x14F0** bytes of memory, I'll now put a write breakpoint in the memory region reserved/committed by second VirtualAlloc API call to see what and how data gets dumped into second buffer, **buffer2**. Hitting Run button once more will break at instruction shown in the figure below



this loop is copying 0x14F0 bytes of data from a certain offset of buffer1 into buffer2, next few statements are agaian calling VirtualAlloc to allocate another 0x350DE bytes of memory say **buffer3**, pushing returned buffer address along with an offset from buffer1 on stack to copy 0x350DE bytes of data from buffer1 into buffer3



loop in the following figure is decrypting data copied to buffer2, next push instruction is pushing the buffer3 pointer on stack as an argument of the routine being called from buffer2 address in edx which is supposed to process buffer3 contents

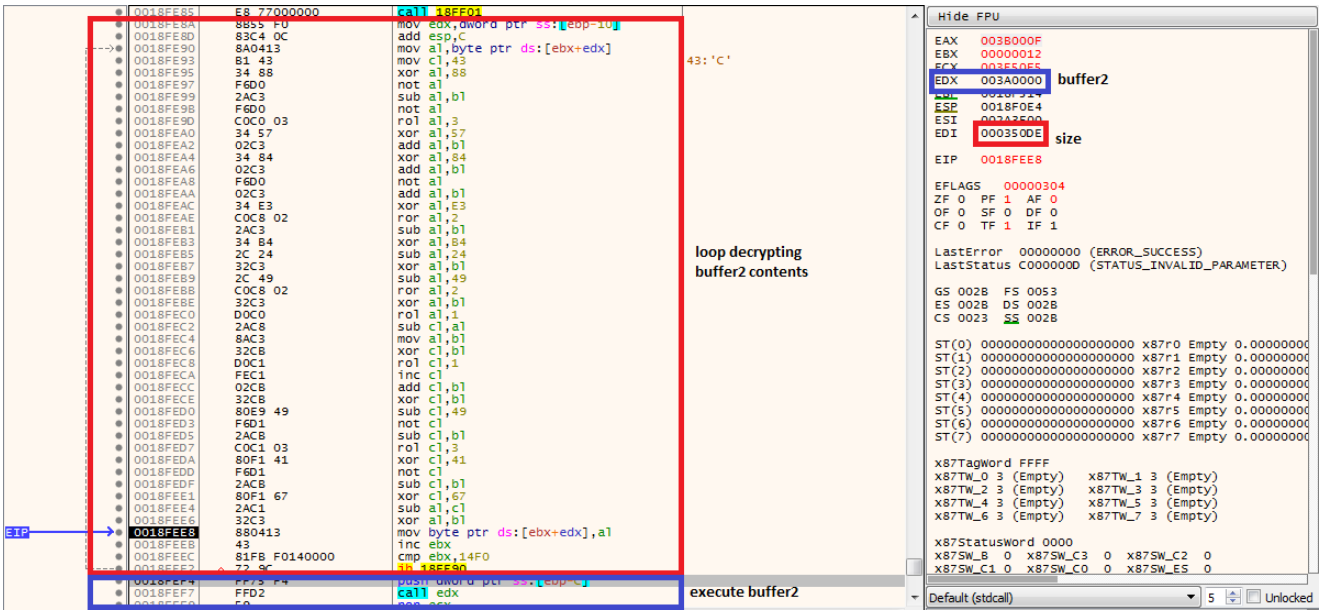
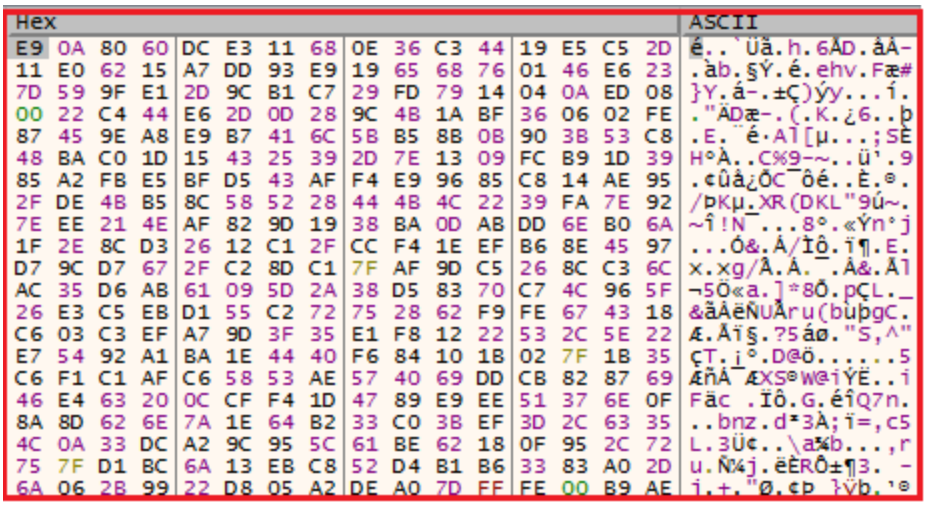
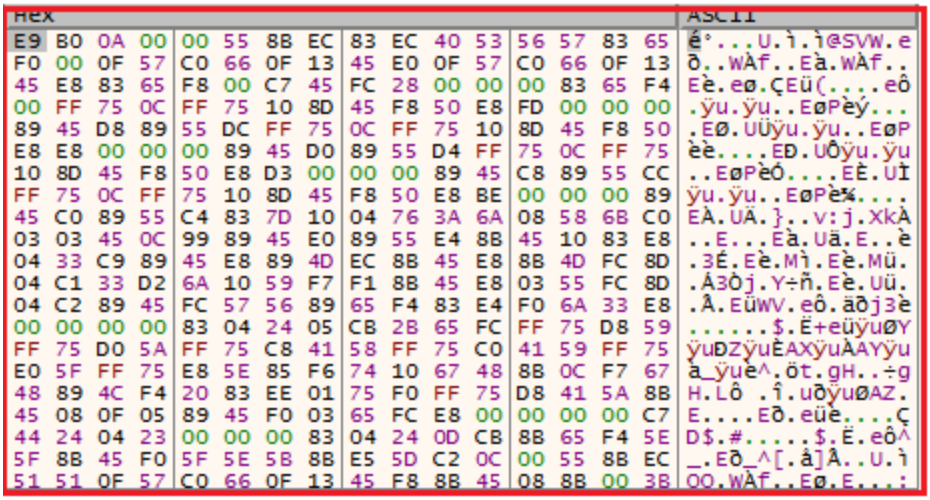


figure below is showing final buffer2 decrypted contents



Hex																ASCII
E9	0A	80	60	DC	E3	11	68	0E	36	C3	44	19	E5	C5	2D	é.. `Üã.h.6ÃD.åÅ-
11	E0	62	15	A7	DD	93	E9	19	65	68	76	01	46	E6	23	.àb.§Ý.é.ehv.Fæ#
7D	59	9F	E1	2D	9C	B1	C7	29	FD	79	14	04	0A	ED	08	}Y.á-.±Ç)ýy...í.
00	22	C4	44	E6	2D	0D	28	9C	4B	1A	BF	36	06	02	FE	."ÄDæ-.(.K.¿6..þ
87	45	9E	A8	E9	B7	41	6C	5B	B5	8B	0B	90	3B	53	C8	.E.¨é·Al[µ...;SÈ
48	BA	C0	1D	15	43	25	39	2D	7E	13	09	FC	B9	1D	39	Hºà..C%9-~..ü'.9
85	A2	FB	E5	BF	D5	43	AF	F4	E9	96	85	C8	14	AE	95	.¢ûå¿ÕC¯ôé..È.®.
2F	DE	4B	B5	8C	58	52	28	44	4B	4C	22	39	FA	7E	92	/ÞKµ.XR(DKL"9ú~.
7E	EE	21	4E	AF	82	9D	19	38	BA	0D	AB	DD	6E	B0	6A	~î!N¯...8º.«Ýn°j
1F	2E	8C	D3	26	12	C1	2F	CC	F4	1E	EF	B6	8E	45	97	...Ó&.Á/Ìô.ï¶.E.
D7	9C	D7	67	2F	C2	8D	C1	7F	AF	9D	C5	26	8C	C3	6C	x.xg/Â.Á.¯.Å&.Ãl
AC	35	D6	AB	61	09	5D	2A	38	D5	83	70	C7	4C	96	5F	¬5Ö«a.]*8Õ.pÇL._
26	E3	C5	EB	D1	55	C2	72	75	28	62	F9	FE	67	43	18	&ãÅëÑUÂru(bùþgC.
C6	03	C3	EF	A7	9D	3F	35	E1	F8	12	22	53	2C	5E	22	Æ.Ãï§.?5áø."S,^"
E7	54	92	A1	BA	1E	44	40	F6	84	10	1B	02	7F	1B	35	çT.¡º.D@ö.....5
C6	F1	C1	AF	C6	58	53	AE	57	40	69	DD	CB	82	87	69	ÆñÁ¯ÆXS®W@iÝË..i
46	E4	63	20	0C	CF	F4	1D	47	89	E9	EE	51	37	6E	0F	Fäc .Ïô.G.éîQ7n.
8A	8D	62	6E	7A	1E	64	B2	33	C0	3B	EF	3D	2C	63	35	..bnz.d²3À;ï=,c5
4C	0A	33	DC	A2	9C	95	5C	61	BE	62	18	0F	95	2C	72	L.3Ü¢..\a¾b...,r
75	7F	D1	BC	6A	13	EB	C8	52	D4	B1	B6	33	83	A0	2D	u.Ñ¼j.ëÈRÔ±¶3.ƒ -
6A	06	2B	99	22	D8	05	A2	DE	A0	7D	FF	FE	00	B9	AE	j.+.™"Ø.¢Þ }ÿþ.¹®

encrypted buffer2



Hex																ASCII
E9	B0	0A	00	00	55	8B	EC	83	EC	40	53	56	57	83	65	é°...U.ì.ì@SVW.e
F0	00	0F	57	C0	66	0F	13	45	E0	0F	57	C0	66	0F	13	ð..WÀf..Eà.WÀf..
45	E8	83	65	F8	00	C7	45	FC	28	00	00	00	83	65	F4	Eè.eø.ÇEü(....eô
00	FF	75	0C	FF	75	10	8D	45	F8	50	E8	FD	00	00	00	.ÿu.ÿu..EøPèý...
89	45	D8	89	55	DC	FF	75	0C	FF	75	10	8D	45	F8	50	.EØ.UÜÿu.ÿu..EøP
E8	E8	00	00	00	89	45	D0	89	55	D4	FF	75	0C	FF	75	èè....EÐ.UÔÿu.ÿu
10	8D	45	F8	50	E8	D3	00	00	00	89	45	C8	89	55	CC	..EøPèÓ....EÈ.UÌ
FF	75	0C	FF	75	10	8D	45	F8	50	E8	BE	00	00	00	89	ÿu.ÿu..EøPè¾....
45	C0	89	55	C4	83	7D	10	04	76	3A	6A	08	58	6B	C0	EÀ.UÄ.}..v:j.XkÀ
03	03	45	0C	99	89	45	E0	89	55	E4	8B	45	10	83	E8	..E...Eà.Uä.E..è
04	33	C9	89	45	E8	89	4D	EC	8B	45	E8	8B	4D	FC	8D	.3É.Eè.Mì.Eè.Mü.
04	C1	33	D2	6A	10	59	F7	F1	8B	45	E8	03	55	FC	8D	.Á3Òj.Y÷ñ.Eè.Uü.
04	C2	89	45	FC	57	56	89	65	F4	83	E4	F0	6A	33	E8	.Â.EüWV.eô.äðj3è
00	00	00	00	83	04	24	05	CB	2B	65	FC	FF	75	D8	59	......$.Ë+eüÿuØY
FF	75	D0	5A	FF	75	C8	41	58	FF	75	C0	41	59	FF	75	ÿuÐZÿuÈAXÿuÀAYÿu
E0	5F	FF	75	E8	5E	85	F6	74	10	67	48	8B	0C	F7	67	à_ÿuè^.öt.gH..÷g
48	89	4C	F4	20	83	EE	01	75	F0	FF	75	D8	41	5A	8B	H.Lô .î.uðÿuØAZ.
45	08	0F	05	89	45	F0	03	65	FC	E8	00	00	00	00	C7	E....Eð.eüè....Ç
44	24	04	23	00	00	00	83	04	24	0D	CB	8B	65	F4	5E	D$.#.....$.Ë.eô^
5F	8B	45	F0	5F	5E	5B	8B	E5	5D	C2	0C	00	55	8B	EC	_.Eð_^[.å]Â..U.ì
51	51	0F	57	C0	66	0F	13	45	F8	8B	45	08	8B	00	3B	QQ.WÀf..Eø.E...;

decrypted buffer2

stepping into **edx** starts executing buffer2 contents, where it seems to push stack strings for kernel32.dll first and then retrieves kernel32.dll handle by parsing PEB (Process Environment Block) structure

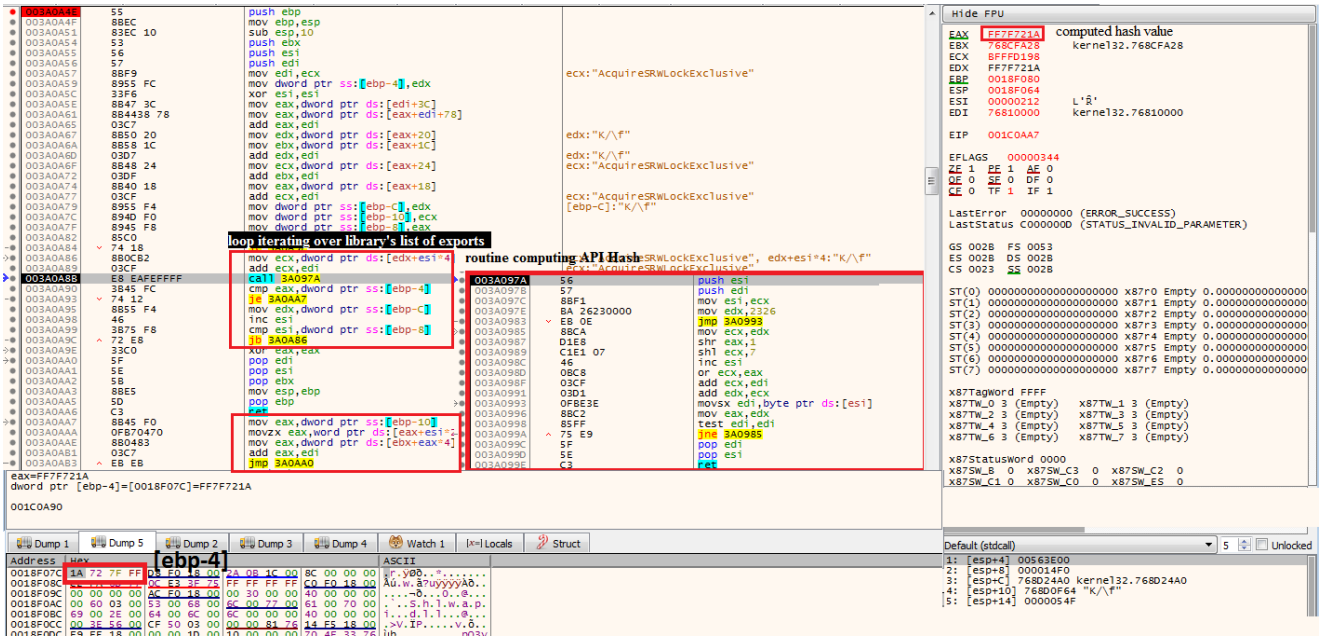
```
003A0AA7    8B45 F0          mov eax,dword ptr ss:[ebp-10]
003A0AAA    0FB70470         movzx eax,word ptr ds:[eax+esi*2]
003A0AAE    8B0483           mov eax,dword ptr ds:[ebx+eax*4]
003A0AB1    03C7             add eax,edi
003A0AB3    EB EB            jmp 3A0AA0
003A0AB5    55               push ebp
003A0AB6    8BEC             mov ebp,esp
003A0AB8    83EC 50          sub esp,50
003A0ABB    6A 53            push 53
003A0ABD    58               pop eax
003A0ABE    66:8945 D8       mov word ptr ss:[ebp-28],ax
003A0AC2    6A 68            push 68
003A0AC4    58               pop eax
003A0AC5    66:8945 DA       mov word ptr ss:[ebp-26],ax
003A0AC9    6A 6C            push 6C
003A0ACB    58               pop eax
003A0ACC    66:8945 DC       mov word ptr ss:[ebp-24],ax
003A0AD0    6A 77            push 77
003A0AD2    58               pop eax
003A0AD3    66:8945 DE       mov word ptr ss:[ebp-22],ax
003A0AD7    6A 61            push 61
003A0AD9    58               pop eax
003A0ADA    66:8945 E0       mov word ptr ss:[ebp-20],ax
003A0ADE    6A 70            push 70
003A0AE0    58               pop eax
003A0AE1    66:8945 E2       mov word ptr ss:[ebp-1E],ax
003A0AE5    6A 69            push 69
003A0AE7    58               pop eax
003A0AE8    66:8945 E4       mov word ptr ss:[ebp-1C],ax
003A0AEC    6A 2E            push 2E
003A0AEE    58               pop eax
003A0AEF    66:8945 E6       mov word ptr ss:[ebp-1A],ax
003A0AF3    6A 64            push 64
003A0AF5    58               pop eax
003A0AF6    66:8945 E8       mov word ptr ss:[ebp-18],ax
003A0AFA    6A 6C            push 6C
003A0AFC    58               pop eax
003A0AFD    66:8945 EA       mov word ptr ss:[ebp-16],ax
003A0B01    6A 6C            push 6C
003A0B03    58               pop eax
003A0B04    66:8945 EC       mov word ptr ss:[ebp-14],ax
003A0B08    33C0             xor eax,eax
003A0B0A    66:8945 EE       mov word ptr ss:[ebp-12],ax
003A0B0E    C745 F8 CF500300 mov dword ptr ss:[ebp-8],350CF
003A0B15    E8 85FEFFFF      call <kernel32_handle>
003A0B1A    8945 FC          mov dword ptr ss:[ebp-4

                                          parsing PEB structure
                                 mov eax,dword ptr fs:[30]
                                 mov eax,dword ptr ds:[eax+C]
                                 mov eax,dword ptr ds:[eax+C]
                                 mov eax,dword ptr ds:[eax]
                                 mov eax,dword ptr ds:[eax]
                                 mov eax,dword ptr ds:[eax+18]
                                 ret
```

retrieved kernel32.dll handle is passed to next call along with another argument with constant **FF7F721A** value, a quick Google search for this constant results in some public sandbox links but not clear what is this exactly about. Let's dig into it further, stepping over this routine **0x0A4E** results in **GetModuleFileNameW** API's resolved address from Kernel32.dll stored in eax which means this routine is meant to resolve hashed APIs

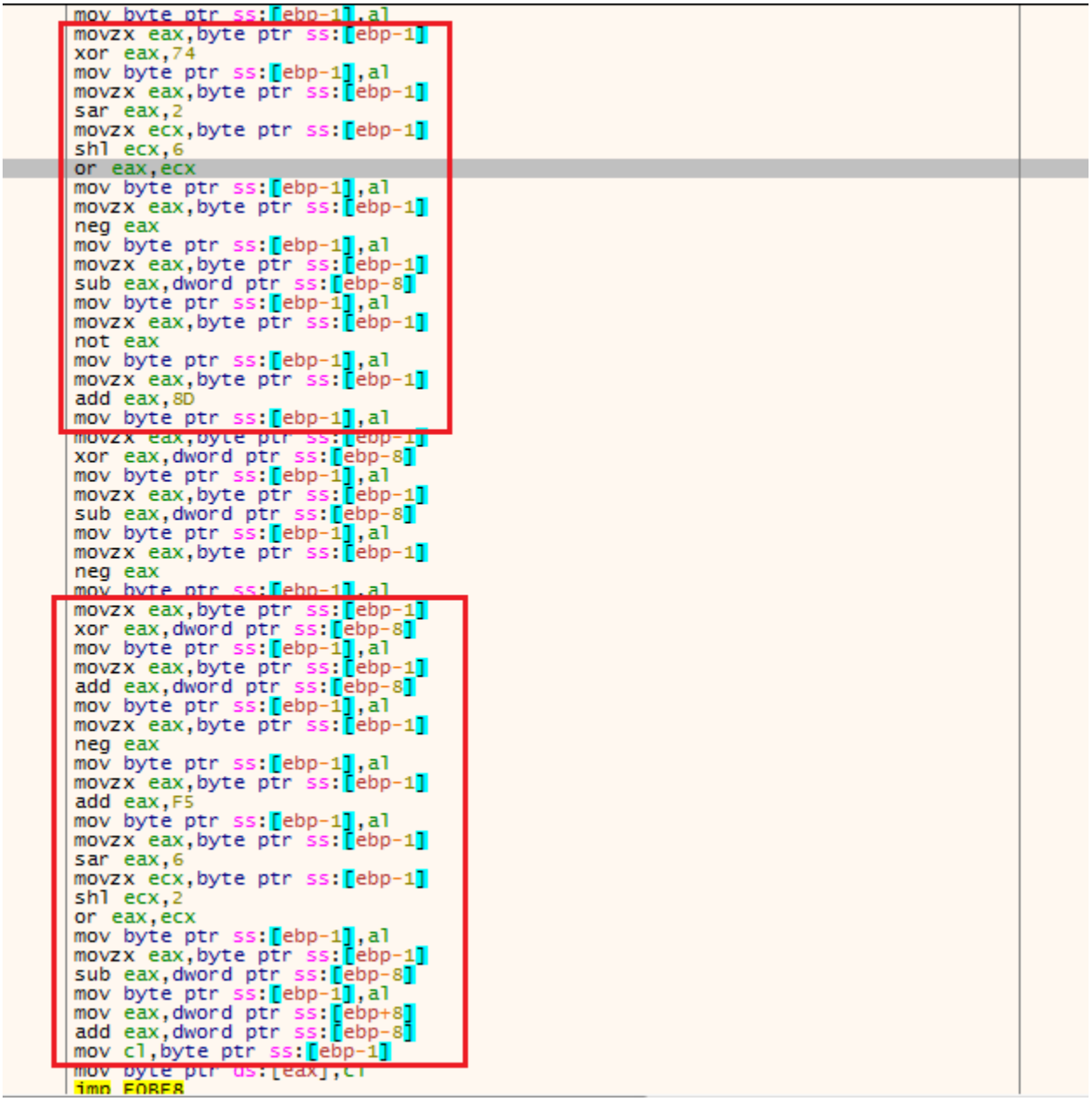
```
003A0AF6    66:8945 E8       mov word ptr ss:[ebp-18],ax
003A0AFA    6A 6C            push 6C
003A0AFC    58               pop eax
003A0AFD    66:8945 EA       mov word ptr ss:[ebp-16],ax
003A0B01    6A 6C            push 6C
003A0B03    58               pop eax
003A0B04    66:8945 EC       mov word ptr ss:[ebp-14],ax
003A0B08    33C0             xor eax,eax
003A0B0A    66:8945 EE       mov word ptr ss:[ebp-12],ax
003A0B0E    C745 F8 CF500300 mov dword ptr ss:[ebp-8],350CF
003A0B15    E8 85FEFFFF      call <kernel32_handle>
003A0B1A    8945 FC          mov dword ptr ss:[ebp-4],eax
003A0B1D    BA 1A727FFF      mov edx,FF7F721A
003A0B22    8B4D FC          mov ecx,dword ptr ss:[ebp-4]
003A0B25    E8 24FFFFFF      call 3A0A4E
003A0B2A    8945 F0          mov dword ptr ss:[ebp-10],eax
003A0B2D    BA 78A0917F      mov edx,7F91A078
003A0B32    8B4D FC          mov ecx,dword ptr ss:[ebp-4]
003A0B35    E8 14FFFFFF      call 3A0A4E

Hide FPU
EAX   76824950   <kernel32.GetModuleFileNameW>
EBX   000014F0
ECX   BFFFD198
EDX   FF7F721A
EBP   0018F0D8
ESP   0018F088
ESI   002A3E00
EDI   000350DE

EIP   003A0B2A

EFLAGS   00000206
ZF 0  PF 1  AF 0
OF 0  SF 0  DF 0
CF 0  TF 0  IF 1
```

similarly second call resolves **7F91A078** hash value to **ExitProcess** API, wrapper routine **0x0A4E** iterates over library exports and routine **0x097A** is computing hash against input export name parameter. Shellcode seems to be using a custom algorithm to hash API,

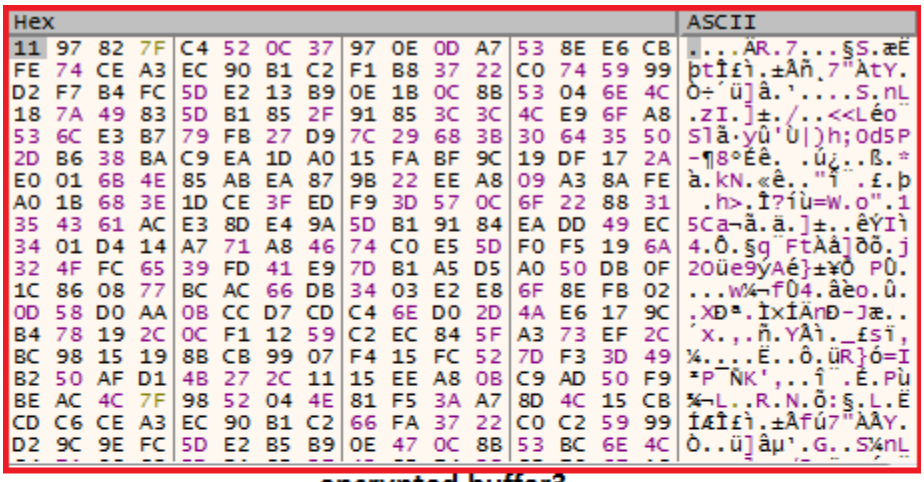
computed hash value is retuned back into **eax** which is compared to the input hash value stored at [ebp-4], if both hash values are equal, API is resolved and its address is stored in eax



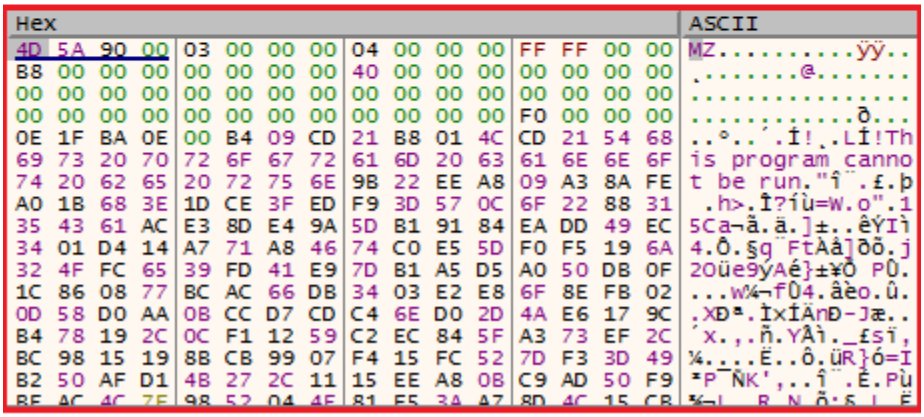
next few instructions write some junk data on stack followed by pushing pointer to buffer3 and total size of buffer3 contents (0x350C0) on stack and execute routine **0x0BE9** for decryption - this custom decryption scheme works by processing each byte from buffer3 using repetitive neg, sub, add, sar, shl, not, or and xor set of instructions with hard-coded values in multiple layers, intermediate result is stored in [ebp-1]



and final value overwrites the corresponding buffer3 value at [eax] offset



encrypted buffer3



buffer3 in processing

once buffer3 contents are decrypted, it continues to resolve other important APIs in next routine **0x0FB6**

```
mov dword ptr ss:[ebp-C],eax
mov edx,FF7F721A  -> GetModuleFileNameW
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-78],eax
mov edx,7FE2736C  -> CreateProcessW
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-80],eax
mov edx,7FA1F993  -> GetThreadContext
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-84],eax
mov edx,7FA3EF6E  -> ReadProcessMemory
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-88],eax
mov edx,7FE1F1FB  -> CloseHandle
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-1C],eax
mov edx,FF31BF16  -> Wow64SetThreadContext
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-90],eax
mov edx,7FB6C905  -> GetCommandLineW
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-7C],eax
mov edx,7FE7F9C0  -> TerminateProcess
mov ecx,dword ptr ss:[ebp-C]
call 230A4E
mov dword ptr ss:[ebp-94],eax
```

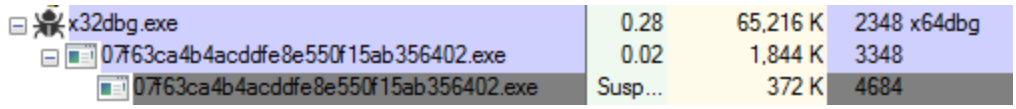
I wrote a simple POC python script for hashing algorithm implemented by decrypted shellcode which can be found here

```
In [22]: apis = ["CreateProcessW", "ReadProcessMemory", "GetCommandLineW"]

In [23]: for api in apis:
    ...:     seed = 0x2326
    ...:     for c in api:
    ...:         shr = seed >> 1
    ...:         shl = seed << 7
    ...:         bitwiseor = shr|shl
    ...:         add_char = bitwiseor + ord(c)
    ...:         new_seed = add_char+seed
    ...:         seed = new_seed
    ...:     hash = hex(seed)
    ...:     hash = hash[:-1]
    ...:     hash =  hash[-8:]
    ...:     print hash
    ...:
7fe2736c
7fa3ef6e
7fb6c905
```

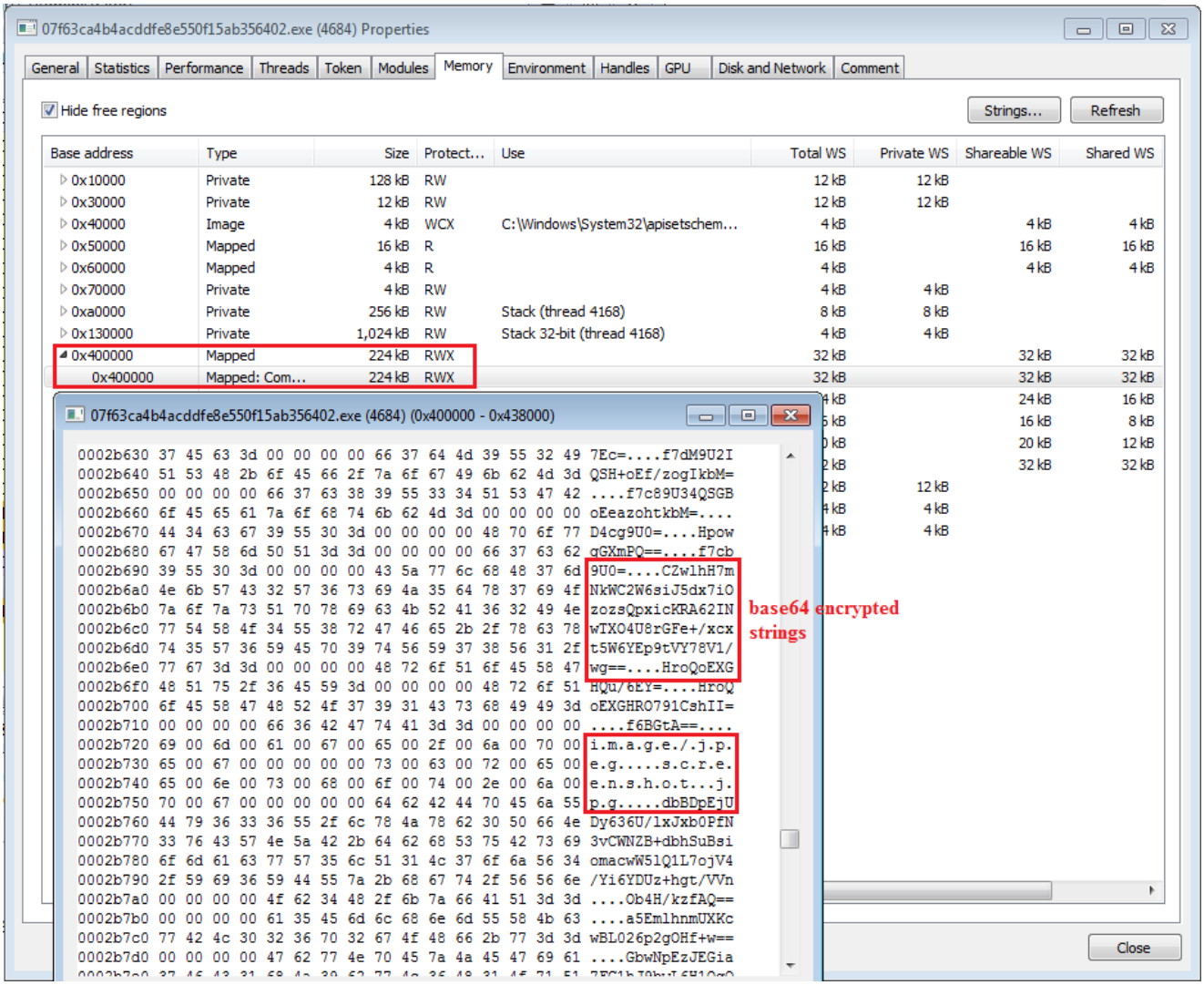
after all required APIs have been resolved, it proceeds to create a new process

```
and dword ptr ss:[ebp-70],0
mov eax,dword ptr ss:[ebp-70]
mov dword ptr ss:[ebp-8C],eax
push 103
lea eax,dword ptr ss:[ebp-7BC]
push eax
push 0
call dword ptr ss:[ebp-78]      GetModuleFileNameW
test eax,eax
jne F1168
xor eax,eax
inc eax
jmp F14E7
mov dword ptr ss:[ebp-6C],1
lea eax,dword ptr ss:[ebp-34]
push eax
lea eax,dword ptr ss:[ebp-E0]
push eax
push 0
push 0
push 8000004
push 0
push 0
push 0
call dword ptr ss:[ebp-7C]      GetCommandLineW
push eax
lea eax,dword ptr ss:[ebp-7BC]
push eax
call dword ptr ss:[ebp-80]      CreateProcessW
test eax,eax
jne F11A0
jmp F149B
```

using **CreateProcessW** in suspended mode



and then final payload is injected into newly created process using SetThreadContext API, **CONTEXT** structure for remote thread is set up with ContextFlag and required memory buffers and **SetThreadContext** API is called with current thread handle and remote thread CONTEXT structure for code injection



main process terminates right after launching this process, we can now take a dump of this process to extract final payload.

That's it for unpacking! see you soon in the next blogpost covering detailed analysis of Vidar infostealer.