# **Undressing the REvil**

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Contributors: Lloyd Macrohon and Rodel Mendrez

Recently, we got a chance to investigate a REvil Ransomware sample from one of our DFIR investigations. During analysis, we encountered a few stumbling blocks that made the investigation a little tricky, namely unpacking and string deobfuscation. In this blog, we will show how we manually unpacked the malware and then how we deobfuscated the strings used by the ransomware.

The particular sample we are going to investigate has the SHA256 Hash: 6ff970f1502347acd2d00e7746e40fba48995abbe26271d13102753c55694078.

### Manual Unpacking

Packers are essentially tools that are used to compress a Portable Executable (PE) file. Many malware authors utilize packers with their malware to obfuscate and make it a bit harder to statically analyze code. If you want to learn more about packers, you can read our blog about this here: <u>https://www.trustwave.com/en-us/resources/blogs/spiderlabsblog/basic-packers-easy-as-pie/</u>

We began by trying to determine what packer was used by this malware. The "Detect It Easy" tool failed to identify the packer and no signature was found. It also found no packed PE sections. Interestingly the sample had non-standard section names. We also took note of the entry point at <u>RVA</u> (relative virtual address) 0x9D58 which is within the *.text* section of the PE file.

File name: ≘Rat/De	.05 esktop/6ff970f	1502347acd2	2d00e7746e40	)fba48995abb	0e26271d1310	)2753c55694	1078	
Scan Scripts	Log							
Type:	PE	Size: 88	9344	Entro	py FLC	S H		
Export	Import	Resource	Overlay			PF		
E-to D-to to						400000		
EntryPoint:	00009d58	$\geq$		ImageBase		400000		
NumberOfSection	ns: 00	06 >		SizeOfImag	je: 00	121000		
								Options
Detect It Easy	100%		<ul> <li>Signat</li> </ul>	ures Ir	nfo 9 ms	Scan		About
Detect It Easy	100%	_	▼ Signat	rures Ir > 219	nfo 9 ms	Scan	?	About
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Detect It Easy	100% packed statu V.Address 0000 1000	s V.Size 00052000	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> </ul>	R.Size 00051800	nfo 9 ms Flags 60000020	Scan Entropy 6.09	? V Rea Packed no	About
Detect It Easy Sections Check Name .text .data	100% packed statu V.Address 00001000 00053000	s V.Size 00052000 00003000	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> <li>00051c00</li> </ul>	R.Size 00051800 00002600	nfo 9 ms Flags 6000020 c0000c0	Scan Entropy 6.09 4.65	₹	About
Detect It Easy Check Mame .text .data .rsrc	100% packed statu V.Address 00001000 00053000 00056000	s V.Size 00052000 00003000 00007000	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> <li>00051c00</li> <li>00054200</li> </ul>	R.Size 00051800 00006e00	Flags 6000020 c0000c0 40000040	Scan Entropy 6.09 4.65 4.40	₹ Rea Packed no no no	About
Detect It Easy Sections Check Name .text .data .rsrc .st	100% packed statu V.Address 00001000 00053000 00056000 0005d000	s V.Size 00052000 00003000 00007000 00044000	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> <li>00051c00</li> <li>00054200</li> <li>0005b000</li> </ul>	R.Size 00051800 00002600 00043600	nfo e ms Flags 6000020 c0000c0 40000040 c0000020	Scan Entropy 6.09 4.65 4.40 0.00	₹ Rea Packed no no no no	About
Detect It Easy Check Name .text .data .rsrc .st .st	100%	s V.Size 00052000 00003000 00007000 00044000 00062000	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> <li>00051c00</li> <li>00054200</li> <li>0005b000</li> <li>0009e600</li> </ul>	R.Size 00051800 00002600 000043600 0001d600	Flags 60000020 c0000020 c0000020 c0000020 c0000020	Scan Entropy 6.09 4.65 4.40 0.00 0.00	₹ Rea Packed no no no no no	About
Detect It Easy Sections Check Name .text .data .rsrc .st .st .st	100% packed statu V.Address 00001000 00053000 00056000 0005d000 000a1000 00103000	s V.Size 00052000 00003000 00007000 00044000 00062000 0001d454	<ul> <li>Signat</li> <li>Offset</li> <li>00000400</li> <li>00051c00</li> <li>00054200</li> <li>0005b000</li> <li>0009e600</li> <li>000bbc00</li> </ul>	R.Size 00051800 00002600 00043600 0001d600	nfo ems Flags 60000020 c0000020 c0000020 c0000020 c0000020 c0000020	Scan Entropy 6.09 4.65 4.40 0.00 0.00 0.00	₹ Rea Packed no no no no no no no	About d only

Figure 1. An overview of the malware's PE header information

Disassembling the executable, we can see right at the entry point the use of VirtualAlloc() API to allocate a new memory in the address space, then "*rep movsb*" opcode to copy data to the allocated memory, then, at the end of the function, is an opcode "*jmp eax*" that leads the instruction pointer to a new entry point in the allocated memory space. Now that looks interesting...

push	0	
mov	[esp+24h+var_24], ebp	
and	ebp, 0	
add	ebp, dwSize[ebx]	
mov	eax, ebp	
pop	ebp	1
mov	ecx, 40h ; '@'	1
push	ebx; flProtect	1
sub	[esp+24h+var_24], ebx	1 +



Here is what the code looks like when decompiled in IdaPro:

```
1void usercall start(int a1@<eax>, int a2@<edx>, int a3@<ecx>, int a4@<ebx>, int a5@<edi>, int a6@<esi>)
 2 {
 3
    int v6; // ebx
 4
    int v7; // edi
 5
    int v8; // ebx
 6
    int v9; // esi
 7
    int v10; // ebx
 8
    int new_base_address; // eax
 9
   int v12; // ebx
10
   int v13; // ecx
   int v14; // eax
11
12
13
    v6 = a5 + a2 + a4 + 1;
    v7 = a5 & 0xFFFFFF;
14
    v8 = v6 ^ a6;
15
   v9 = a6 & 0xFF00FFFF;
16
    v10 = v8 - a1;
17
    new base address = a1 & 0xFFFF00FF;
18
    v12 = a3 & v10;
19
20
    v13 = a3 & 0xFFFFFF00;
21
    if ( v12 )
22
      v12 &= v9 & v7;
    if ( v12 )
23
24
      v12 &= v13 & new_base_address;
25
    if ( !v12 )
26
    {
      new base address = sub 411E57(new base address, v13, 0, v9, 139383, 2116);
27
28
      if ( !new base address
        new base address = (int)VirtualAlloc(0, dwSize, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
29
30
     *(int *)((char *)&dword_45300C + v12) = 0;
31
    *(int *)((char *)&dword 45300C + v12) += new base address;
32
33
    if ( v12 )
34
    {
35
      *(int *)((char *)&revil_base_address + v12) += v12;
         _int16 **)((char *)&off_453068 + v12) = (__int16 *)(*(char **)((char *)&off_453068 + v12) + v12);
36
37
    3
                                        Copy data starting from base address
38
    qmemcpy(
      (void *)new_base_address,
                                            to new allocated memory space
39
      *(const void **)((char *)&revil_base_address + v12),
40
      *(int *)((char *)&dwSize + v12));
41
    v14 = *(int *)((char *)&dword_45300C + v12);
42
43 *(int *)((char *)&dword_45315C + v12) = (int)&new_jump_address;
    *(int *)((char *)&dword_45315C + v12) &= 0xFFFFFu;
44
45
    __asm { jmp
                    eax } ◀
                                                                 Jump to the new entry point
46 }
```

Next, we dynamically analyze the file using <u>x64dbg</u> (a PE debugger tool) to see what's being copied to the allocated memory. In the screenshot below, after calling VirtualAlloc() API, this instance allocated memory at the base address 0x1240000 (this memory address varies in each run).

edx= <ntd< th=""><th>11.K1</th><th>004 004 004 004 004 004 004 004 004 004</th><th>09DC 09DC 09DC 09DC 09DC 09DC 09DC 09DC</th><th>-7 D F F 00 55 06 55 06 55 06 55 06 55 56 57 7 8 8 8 8 7 7 8 8 8 7 00 00 55 50 6 50 55 50 6 55 50 50</th><th>0 8 5 2 2 0 0 6 5 5 8 8 5 5 8 8 3 3 5 5 8 8 3 3 5 5 5 8 8 8 3 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 5</th><th>3AB BC5 D 9 40 3 91C2 10C2 5 32422 9042 0 32422 11C2 F93 2 31422 BD0 3E7 BFA Et&gt; 1</th><th>203: 0000 4 4 1000 4 0 4 0 4 0 4 0 0 (778 91F7</th><th>1450 000 000 0 5450 8470</th><th>00 00 84)</th><th></th><th>ad mo mo mo su ad pu an mo an xo <b>ca</b> pu xo or an or</th><th>id et v ea p et v ec b dv d dv sh d d dv v dv sh d d dv v dv sh e d dv v dv sh e e d d dv e d d dv e d d dv e sh e sh e sh e sh e sh e sh e sh e sh</th><th>bp, ax, bp cx, ebx wor loo ebp wor eax wor edw wor edw wor edw wor edw wor i, e</th><th>dword ptr d ebp 40 c d ptr ss: e 00 c d ptr ss: e c d ptr ss: e c d</th><th>s:[ebx sp],eb sp],ec sp],e sp],eb sp],eb sp],eb ss],eb</th><th>14531 1X 1X 1X 1X 12 12 12 12 12 12 12 12 12 12 12 12 12</th><th>ret add: a alAllo</th><th>curn ress reg c&gt;] (</th><th>40:'@' ed base s of the cated pion</th><th>• •</th><th>HID EAX ECX EDX EBP ESI EDI EIP EFL OF OF C EFL 2: 3: 5:</th><th>le FPU 0124( 00000 00127 7781( 00120 00120 99143( 00000 00409 AGS 00 1 PF 1 0 SF 0 0 SF 0 0 SF 0 1 PF 1 0 SF 0 1 esp+4 [esp+4] [esp+6] [esp+10] [esp+110]</th><th>0000 F14 7084 F594 F60 280 F3 280 F3 28</th><th>0000 0246 0 0246 0 0000 22FF 32E8 4099</th></ntd<>	11.K1	004 004 004 004 004 004 004 004 004 004	09DC 09DC 09DC 09DC 09DC 09DC 09DC 09DC	-7 D F F 00 55 06 55 06 55 06 55 06 55 56 57 7 8 8 8 8 7 7 8 8 8 7 00 00 55 50 6 50 55 50 6 55 50 50	0 8 5 2 2 0 0 6 5 5 8 8 5 5 8 8 3 3 5 5 8 8 3 3 5 5 5 8 8 8 3 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 8 5 5 5 8 8 5	3AB BC5 D 9 40 3 91C2 10C2 5 32422 9042 0 32422 11C2 F93 2 31422 BD0 3E7 BFA Et> 1	203: 0000 4 4 1000 4 0 4 0 4 0 4 0 0 (778 91F7	1450 000 000 0 5450 8470	00 00 84)		ad mo mo mo su ad pu an mo an xo <b>ca</b> pu xo or an or	id et v ea p et v ec b dv d dv sh d d dv v dv sh d d dv v dv sh e d dv v dv sh e e d d dv e d d dv e d d dv e sh e sh e sh e sh e sh e sh e sh e sh	bp, ax, bp cx, ebx wor loo ebp wor eax wor edw wor edw wor edw wor edw wor i, e	dword ptr d ebp 40 c d ptr ss: e 00 c d ptr ss: e c d	s:[ebx sp],eb sp],ec sp],e sp],eb sp],eb sp],eb ss],eb	14531 1X 1X 1X 1X 12 12 12 12 12 12 12 12 12 12 12 12 12	ret add: a alAllo	curn ress reg c>] (	40:'@' ed base s of the cated pion	• •	HID EAX ECX EDX EBP ESI EDI EIP EFL OF OF C EFL 2: 3: 5:	le FPU 0124( 00000 00127 7781( 00120 00120 99143( 00000 00409 AGS 00 1 PF 1 0 SF 0 0 SF 0 0 SF 0 1 PF 1 0 SF 0 1 esp+4 [esp+4] [esp+6] [esp+10] [esp+110]	0000 F14 7084 F594 F60 280 F3 280 F3 28	0000 0246 0 0246 0 0000 22FF 32E8 4099
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Address	Hex						-							ASCII				_			-	0012FF4	18 0	0124
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01240030	00 0	0 00	00	00 (	00 00	00 0	00	00 (	00 0	00 00	00	00	00		• • • • •							0012FF5	c	0000
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01240060	00 0	ŏ ŏŏ	00	00 0	00 00	00 0	00	00	00 č	00 00	00	ŏŏ	ŏŏ									0012FF6	54 0	0000
01240070	00 0	0 00	00	00 (	00 00	00 (	00	00 (	00 0	00 00	00	00	00									0012FF6		0000
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01240080	00 0	0 00	00	00 0	00 00	00 0	00	00	00 0	00 00	00 0	00	00									0012FF7	8	0012
012400C0	00 0	0 00	00	00	00 00	00 0	00	00	00 0	00 00	00	00	00									0012FF7		503E
01240000	00 0	0 00	00	00 (	00 00	00 (	00	00	00 0	00 00	00	00	00									0012FF8	34 0	0000
012400E0	00 0	0 00	00	00 (	00 00	00 0	00	00 (	00 0	00 00	00	00	00									0012FF8	88	7777
012400F0	00 0	0 00	00	00 0		00	00	00	00 0		00	00	00									0012FF8	SC 7	7777
01240110	00 0	0 00	00	00 0	00 00	00 0	00	00	00 0	00 00	00	00	00									0012FF9	90	7FFD
01240120	00 0	0 00	00	00 (	00 00	00 0	00	00	00 0	00 00	00	00	00									0012FFS	24 C	77.84
01240130	00 0	0 00	00	00 (	00 00	00 (	00	00 (	00 0	00 00	00	00	00									0012FF9	i De	7FF
01240140	00 0	0 00	00	00 (	00 00	00 0	00	00 (	00 0	00 00	00	00	00									0012FFA	10	771
01240150	00 0	0 00	00	00 0		000	00	00			00	00	00									0012FF/	4	0000
01240170	00 0	0 00	00	00	00 00	00 0	00	00	00 0	00 00	00	00	00									0012FF/	18	0000
01240180	00 0	0 00	00	00 (	00 00	00 0	00	00	00 0	00 00	00	00	00									0012FFA	20	7FFL
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012401A0	00 0	0 00	00	00 (	00 00	00 0	00	00 (	00 0	00 00	00	00	00		• • • • •							0012FFE	88	0000
012401B0	00 0	0 00	00	00 (	10 00	00 0	00	00 (	00 0	00100	/ 00	00	00									0013555	100	001

By dumping that memory address, we can visually monitor what has been copied to that address. After the malware has copied the data to the memory address, it turns out that it was the PE image of itself.

•	00409E63	33CF	xor ecx,edi	
•	00409E65	5 F	pop edi 🗛	
	00409E66	F3:A4	rep movsb 🥌	
•	00409E68	B9 FFFF0F00	mov ecx, FFFFF	copy bytes starting
•	00409E6D	6A 00	push 0	from DEvil/a base
•	00409E6F	893C24	mov dword ptr	from REVIL'S Dase
•	00409E72	33FF	xor edi,edi	address to new
•	00409E74	0BBB 0C304500	or edi,dword	allocated base
•	00409E7A	8BC7	mov eax,edi	
•	00409E7C	5 F	pop edi	address
•	00409E7D	68 A09E4000	push revil.40	9EA0
•	00409E82	8F83 5C314500	pop dword ptr	ds:[ebx+ <mark>45315C</mark> ]
	•	111		
	,			

#### .text:00409E66 revil.exe:\$9E66 #9266

💷 Dump 🛙	1		Dur	np 2			Dum	р3			Dump	94	ų	D	ump	5	👹 Watch 1	[ <i>x</i> =] Lo	cals	2 Struct
Address	He	ĸ															ASCII	1	1	
01240000	4D	5A	90	00	03	00	00	00	04	00	00	00	FF	FF	00	00	MZ	.ÿÿ		
01240010	<b>B</b> 8	00	00	00	00	00	00	00	40	00	00	00	00	00	00	00				
01240020	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240030	00	00	00	00	00	00	00	00	00	00	00	00	80	00	00	00		· · · · · /	1	
01240040	OE	1F	BA	0E	00	Β4	09	CD	21	B8	01	4C	CD	21	54	68	°'.I!	LI!Th		
01240050	69	73	20	70	72	6F	67	72	61	6D	20	63	61	6E	6E	6F	is program	canno	1	
01240060	74	20	62	65	20	72	75	6E	20	69	6E	20	44	4F	53	20	t be run in	DOS		
01240070	6D	61	64	65	2E	OD	00	0A	24	00	00	00	00	00	00	00	mode	; · · · ·		
01240080	50	45	00	00	40	01	06	00	40	7E	EO	50	00	20	11	00	PEL@~a	1		
1240090	00	00	00	00	EU	20	UP 00	01		01	06	06	00	30	10	00	d			
12400A0	00	20	00	00	00	20	40	00	100	10	00	00	00	02	10	00	0 a			
1240060	04	00	00	00	00	00	40	00	04	10	00	00	00	02	00	00		•••••		
1240000	00	10	12	00	00	04	00	00	04	00	00	00	02	00	00	00				
12400E0	00	00	10	00	00	10	00	00	00	00	10	00	00	10	00	00				
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01240100	84	38	05	00	70	01	00	00	P	Еi	mag	je (	of	60	00	00	.8	.p1		
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01240130	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240150	00	00	00	00	00	00	00	00	00	34	05	00	84	04	00	00	4.			
01240160	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240170	00	00	00	00	00	00	00	00	2E	74	65	78	74	00	00	00	te	xt		
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01240190	00	00	00	00	00	00	00	00	00	00	00	00	20	00	00	60		· · · `		
012401A0	<u>2E</u>	64	61	74	61	00	00	00	00	30	00	00	00	30	05	00	.data0.	0		
012401B0	00	26	00	00	00	1C	05	00	00	00	00	00	00	00	00	00	.&			
012401C0	00	00	00	00	CO	00	00	C0	2E	72	73	72	63	00	00	00	AA.rs	rc		
012401D0	00	70	00	00	00	60	05	00	00	6E	00	00	00	42	05	00	.pn.	B		
012401E0	00	00	00	00	00	00	00	00	00	00	00	00	40	00	00	40		.ee		
012401F0	ZE	73	74	00	00	00	00	00	00	40	04	00	00	DO	05	00	.st@.	Ð		
01240200	00	36	04	00	00	BO	05	00	00	00	00	00	00	00	00	00	.6	•••••		
01240210	00	00	00	00	20	00	00	CO	2E	13	74	00	00	00	00	00	A.St	···_··		
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1240290	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240240	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240280	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
01240200	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
1240200	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00				

However, the *jmp eax* we mentioned earlier - jumps to a new entry point at RVA 0x9EA0 (virtual address is therefore - 0x1240000 (base address) + 0x9EA0 = 0x1249ea0):

0	00409E82	8F83 5	C314500	pop dword ptr ds:[ebx+45315C]	Hide	FPU
	00409E88	2188 5	C314500	and dword ptr ds:[ebx+45315C],ecx		
	00409E8E	6A 00		push o	EAX	01249EA0
	00409E90	312024		xor dword ptr ss:[esp],eop	EBX	00000000
	00409E93	50		push cax	ECX	000FFFFF
	00409294	0248 50	C 21 45 00	add abo dword oto ds: Caby+4521563	EDX	778470B4
	00409E98	8805	1314300	mov eav.ebp	EBP	0012FF94
	00409E9D	50		pop ebp	ESP	0012FF6C
3TC	00409E9E	V FFEO	and a second	1mp eax	ESI	00456000
	00409EA0	50		push eax	EDI	01296000
	00409EA1	8BC 3		mov eax.ebx	· · · /	
	00409EA3	OBC 3		or eax,ebx	EIP	00409E9E
	00409EA5	8BD 8		mov ebx,eax	1	
	00409EA7	58		pop eax	EEL AC	ss 00000206
·0	00409EA8	✓ 75 2A		jne revil.409ED4	ZE 0	PE 1 AE 0
	00409EAA	68 000	OFFFF	push FFFF0000		
	00409EAF	E8 061	10000	call revil.40AFBA	CF 0	TEO TE 1
	00409EB4	53		push ebx		
•	00409EB5	091C24		or dword ptr ss: espi,ebx	Default	(stdcall)
	•		11		de Ca	(00000)
lump is taken	1				1: [e	sp+4] 00000000
eax=01249EA0					2. 10	Sp+8] 0012FF94
					4. 6	Spite 0012FF8C
.text:00409E9	e revil.ex	<pre>ke:\$9E9E #92</pre>	29E		5. 6	sp+14] 0040905
					J. [C	
Dump 1	Dump 2	📒 Dump 3	Ump 4	Dump 5 🛞 Watch 1 🛛 🖉 Locals 🧷 Struct		012FF40 FFFFFF
Address				AFCTT	in a là	012FF48 012400
Address Hex			75 34 65 00 00		- A G	0012FF4C 000010
01249EA0 50 8	SE C3 OE C	3 88 D8 58 7	75 ZA 68 00 00	FF FF ES E.A.A. ØXU"n yye	0	0012FF50 000000
01249250 06 1		3 09 1C 24 5	38 74 19 6A 04	68 00 10 S S[[.].n]	0	0012FF54 0012FF
01249200 00 0	00 52 66 9	4 24 6	0 37 14 24 64	00 FF 95	0	0012FF58 00409D
01249550	New ent	ry 5 00		83 EE 00 E C 1E U 8	0	0012FF5C 000000
01249550 33	point of	the 5 00	00 31 AB 48 30	45 00 5D 3A FHOE 1/HOE 1		0012FF60 000560
01249600 80	came DF (	file 3 31 1	1C 24 09 04 24	64 40 56 15 51 \$ \$18V	0	012FF64 012400
01249510 88	Same FL I	7 34 2	24 50 88 83 14	30 45 00 1 15 45P 05	0	0012FF68 0012FF
01249520 87 0	14 24 FE 9	3 BB 35 45 (	0 83 FB 00 0F	86 83 00 \$V 5F 0		0012FF6C 000000
01249530 00 0	0 57 88 9	3 10 30 45 0	0 87 14 24 03		0	0012FF70 000000
01249540 45 0	0 51 28 8	8 68 30 45 0	00 29 0C 24 E8	64 61 00 F 0+ b0F ) \$èda	0	0012FF74 0012FF
01249550 00 5	6 83 E6 0	0 08 83 20 3	31 45 00 83 F1	00 33 CE V. #. * 1E. 4.31	0	0012FF78 0012FF
01249560 55 6	5A 00 89 00	24 83 F1 0	00 33 88 14 30	45 00 88 A1\$. á. 30F	0	0012FF7C 803E8D
01249F70 F9 5	9 56 88 F	0 33 F0 88 0	6 SE ES AA EE	93 AC 35 UYV. 030. 440 V5	0	0012FF80 00409D
01249F80 45 0	00 3B C3 74	4 15 03 AB 1	10 30 45 00 55	28 AB 10 E. At., «, 0E, U+«,	0	0012FF84 000000
01249F90 30 4						
	45 00 29 20	24 E8 AC	95 00 00 51 8B	8B 10 30 0E.), \$00		J012FF88 77773C
01249FA0 45 0	45 00 29 20 00 87 0C 24	24 E8 AC 9	95 00 00 51 88	88 10 30 0E.),\$≥¬Q0 10 61 FF E\$≥\$0ÿÿ.\\$.aÿ		0012FF8C 77773C
01249FA0 45 0 01249FB0 A3 5	45 00 29 20 00 87 0C 24 5C 31 45 00	24 E8 AC 9 4 E8 C6 D5 F 0 C3 55 88 E	95 00 00 51 88 F FF 89 5C 24 FC 83 C4 F0 50	8B 10 30 0E.), \$ÈQ0 10 61 FF E\$È&Öyy, \$s.aÿ 51 52 56 f./1F.&U.), È&PORV		0012FF8C 77773C 0012FF8C 77773C 0012FF90 7FFDF0

Next we follow that jump to virtual address 0x1249ea0, and yet again we encounter another VirtualAlloc() API call. So we dump the new allocated memory address and monitor it:



The malware then starts to decrypt a blob of data embedded in the PE file starting at RVA 0x13DE2 and writes it to the allocated memory. That blob of packed data (at 0ffset 0x13DE2) is within *.text* section of the PE file.

Dè	Sections		- 1	-				?	x
	Check p	oacked statu	s					✓ Read	only
	Name	V.Address	V.Size	Offset	R.Size	Flags	Entropy	Packed	•
	.text	00001000	00052000	00000400	00051800	60000020	6.09	no	
	.data	00053000	00003000	00051c00	00002600	c00000c0	4.65	no	
	.rsrc	00056000	00007000	00054200	00006e00	40000040	4.40	no	
	.st	0005d000	00044000	0005b000	00043600	c0000020	0.00	no	
	.st	000a1000	00062000	0009e600	000 1d600	c0000020	0.00	no	
	.st	00103000	0001d454	000bbc00	0001d600	c0000020	0.00	no	•
	Add new	section	Delete la	st section	)			ОК	

After unpacking, another PE file is revealed. This time, it is the ultimate payload – a REvil Ransomware. You will notice the new section names, and standing out is a non-standard section name *.raimo*.

HD       SA       90       00       03       00       00       04       00       00       00       00       MZ	Hep	ĸ															ASCII
B8       00 <td< td=""><td>4D</td><td>5A</td><td>90</td><td>00</td><td>03</td><td>00</td><td>00</td><td>00</td><td>04</td><td>00</td><td>00</td><td>00</td><td>FF</td><td>FF</td><td>00</td><td>00</td><td>Mzÿÿ</td></td<>	4D	5A	90	00	03	00	00	00	04	00	00	00	FF	FF	00	00	Mzÿÿ
00       00 <td< td=""><td>B8</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>40</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>00</td><td>@</td></td<>	B8	00	00	00	00	00	00	00	40	00	00	00	00	00	00	00	@
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0E       IF       BA 0E       00       B4 09 CD       21       B8 01 4C       CD       21       54       68  <	00	00	00	00	00	00	00	00	00	00	00	00	F8	00	00	00	ø
69       73       20       70       72       6F       67       72       61       6D       20       63       61       6E       6F       1s       program       canno         74       20       62       65       20       72       75       6E       20       69       62       04       44       4F       53       20       t       be       run in DOS         60       67       64       65       20       00	OE	1F	BA	0E	00	Β4	09	CD	21	B8	01	4C	CD	21	54	68	ºI!.LI!Th
74 20 62 65 20 72 75 6E 20 69 6E 20 44 4F 53 20 t be run in DOS         60 6F 64 65 2E 00 00 0A 24 00 00 00 00 00 00 00 00 00         73 67 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         74 75 65 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         85 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         85 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         85 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         85 73 07 B7 04 1D 54 87 04 1D 54 87 04 1D 54         86 04 1D 54 87 04 1D 54 87 04 1D 54         86 04 1D 54 87 04 1C 54 A1 04 1D 54         74 FB D6 54 86 04 1D 54 52 69 63 68 87 04 1D 54         70 00 00 00 00 00 00 00 00 00 00 00 00 0	69	73	20	70	72	6F	67	72	61	6D	20	63	61	6E	6E	6F	is program canno
GD 6F 64 65       2E 0D 0D 0A 24 87 04 1D 54 87 04 1D 54       GO 00 00 00 00 00 00 00         F3 65 73 07       B7 04 1D 54 87 04 1D 54 87 04 1D 54       GO 00 00 00 00       SesTTTT         SC 5A 18 55       B6 04 1D 54 87 04 1C 54 A1 04 1D 54       JUT.Z.UUT       Z.UUT.Z.UUT         SC 5A 19 55       B6 04 1D 54 87 04 1C 54 A1 04 1D 54       JUT.J.UT       JUT.J.UT         GA FB D6 54       B4 04 1D 54 87 04 1C 54 A1 04 1D 54       JUTT.J.UT       JUT.J.UT         GA FB CD 54 86 04 1D 54 20 5A 19 55       AC 04 1D 54       JUTT.J.UT         O0 00 00 00 00 00 00 00 00 00 00 00 00 0	74	20	62	65	20	72	75	6E	20	69	6E	20	44	4F	53	20	t be run in Dos
F3 65 73 07       B7 04 1D 54       B7 04 1D 54       B7 04 1D 54       B7 04 1D 54       Cest1       Cest1         BC 5A 18 55       B6 04 1D 54       BC 5A 1E 55       B5 04 1D 54       Z.U¶T.Z.UµT         SC 5A 19 55       B6 04 1D 54       BC 04 1D 54       B6 04 1D 54       Z.U¶T.JÜÖT¶T         GA FB D6 54       B4 04 1D 54       B7 04 1C 54       A1 04 1D 54       JÜÜTTT.UT         GA FB CD 54       B6 04 1D 54       S2 69 63 68       B7 04 1D 54       JÜÜTT.T.UT         C0 00 00 00 00 00 00 00 00 00 00 00 00 0	6D	6F	64	65	ZE	OD	OD	OA	24	00	00	00	00	00	00	00	mode\$
8C 5A 18 55       86 04 1D 54       8A FB D3 54       86 04 1D 54       .Z.09T.2.00T         8C 5A 19 55       86 04 1D 54       6A FB D3 54       86 04 1D 54       .Z.09T       .T.00T         6A FB D6 54       86 04 1D 54       87 04 1C 54       A1 04 1D 54      T      T      T         6A FB CD 54       86 04 1D 54       20 5A 19 55       AC 04 1D 54      T      T      T         20 5A 1F 55       86 04 1D 54       52 69 63 68       87 04 1D 54      T      T      T         00 00 00 00 00 00 00 00 00 00 00 00 00	15	65	13	22	B/	04	10	54	B/	04	10	54	B/	04	10	54	0es
8c SA 19 55       8c 04 1D 54       87 04 1C 54       A1 04 1D 54       10 54	80	5A	18	22	86	04	10	54	SC .	54	1E	25	85	04	10	54	2.01.1.2.0µ.1
6A FB CD 54 B6 04 1D 54 20 5A 19 55 AC 04 1D 54 juit 1.T.T.UT         20 5A 1F 55 B6 04 1D 54 52 69 63 68 B7 04 1D 54 juit 1.T.T.UT         20 00 00 00 00 00 00 00 00 00 00 00 00 0	SC.	5A	19	55	66	04	10	54	6A	FB 04	10	54	66	04	10	54	1007 T. T. T. T
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OO         OO<	2E	/4 AE	65	/8	00	00	00	00	24	AC	00	00	00	10	00	00	.text
2E 2B 00 notice the new section 2 00 00 .+À	00	AE	00	00	00	04	00	00	00	00	00	00	00	00	00	00	, ndata
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	00	00	00	n	ame	s d	of	the	117	nna	cke	d f	51 L	a .	00	40	a a
2E 64 61 74/61 00 00 00/A8 E9 00 00/00 F0 00,00/.data eo/	2E	64	61	74	61	00	00	00	AB	EU	00	00	00	FO	00	00	.data éð
00 E8 00 00 00 DE 00 00 00 00 00 00 00 00 00 00 èp	00	E8	00	00	00	DE	00	00	00	00	00	00	00	00	00	00	è. p.
00 00 00 00 40 00 00 CO 2E 72 61 69 6D 6F 00 00 AA.raimo	00	00	00	00	40	00	00	CO	2E	72	61	69	6D	6F	00	00	A.raimo
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ZE 72 65 6C 6F 63 00 00 DC 05 00 00 00 BO 02 00 .relocܰ	2E	72	65	6C	6F	63	00	00	DC	05	00	00	00	BO	02	00	.relocܰ
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We can dump this unpacked PE image and manually fix the IAT (Import Address Table) so that we can continue analyzing it statically. You can reconstruct and fix the IAT with Scylla (this is available in x64dbg) or ImportRec.

## **Reversing Encrypted Strings**

Now that we have manually unpacked the file, we can statically analyze it. However, another stumbling block is that it leverages string obfuscation to hide the nature of what it's doing. You can see in the screenshot below a bunch of cross-references – these are calls to the decode\_string function:

mov	[ebptyan 20] 0						
lea	eax, [ebp+var_30]	4	🗳 xrefs t	to deco	de string		
push	eax ; pOut						
push	edi ; dataLen	Di	rection	Туре	Address	Text	
push	10h ; keyLen	5	Down	p	f_parse_configuration+536	call	decode_string
push	offset encrypted data table :	. 🕫	Down	р	f_parse_configuration+555	call	decode_string
call	decode string	5	Down	p	get Exp value+6A	call	decode string
lea	eax, [ebp+var_50]		Down	D D	sub 1321C29+1C	call	decode string
mov	[ebp+var_2D], 0		Down	r n	sub 1321C20+35	call	decode string
push	eax ; pOut		Down	۲	sub_1321023+35	Call	decode_string
push	5 ; dataLen	-	Down	р	sub_1321D59+1F	call	decode_string
push	0Ah ; keyLen	15	Down	р	sub_1321D59+38	call	decode_string
push	offect encounted data table in	. 🗠	Down	р	sub_1321D59+C1	call	decode_string
call	decode string	5	Down	р	sub_1321F2D+56	call	decode_string
lea	eax, [ebp+var 58]	4	Down	р	sub_1321F2D+6E	call	decode_string
mov	[ebp+var_4B], 0	5	Down	р	sub_1321F2D+86	call	decode_string
push	eax ; pOut	5	Down	р	sub_1321F2D+A2	call	decode_string
push	5 ; dataLen	5	Down	p	sub 1321F2D+C0	call	decode string
push	7 ; KeyLen 578b : keyOffcet		Down	n	sub_1321E2D+DC	call	decode string
push	offset encrypted data table :		Down	Р р	sub_1321F2D+E5	call	decode_string
call	decode string		Dava	٢	sub_12220E0+F5	call	decode_string
lea	eax, [ebp+var_34]		Down	P	SUD_15220D9+30	Call	decode_string
mov	[ebp+var_53], 0	-	Down	р	SUD_13220B9+09	call	decode_string
push	eax ; pOut	4	Down	р	sub_13220B9+82	call	decode_string
push	edi ; dataLen	4	Down	р	sub_13221A3+19	call	decode_string
push	778h ; keyOffset	4	Down	р	sub_132222F+22	call	decode_string
push	offset encrypted data table ;	- 5	Down	р	sub_132222F+3B	call	decode_string
call	decode_string	5	Down	р	sub_132222F+54	call	decode_string
add	esp, 50h	5	Down	p	sub_132222F+6D	call	decode_string
mov	[ebp+var_31], 0	4	Down	D.	sub 132222F+89	call	decode string
lea	eax, [ebp+var_40]		Down	r n	text:01322771	call	decode string
push	eax ; pOut		Down	۲	Accel 01322771	Call	decode_string
push	4 ; datateri 4 : kevien		Down	Р	.text(01522/AF	call	decode_string
push	0A5Ch ; keyOffset	1	Down	р	.text:01322805	call	decode_string
push	offset encrypted data table ;	1	N D		L		deserves and a section of
call	decode_string					OK	Cancel
11	and Fabrican bol						

The encrypted strings are stored in parts of the binary. One part is a table of the encrypted strings that the malware uses and another part is the ransomware configuration. Each function call to decode\_string is preceded by its parameters, by passing them through the

stack, these are: pointer to the output address, the key offset, key length and encoded data length. We will follow this example:

loc_132	1E02:	
lea	eax, [ebp+format]	
push	eax ;	p0ut
push	13Ah ;	dataLen
push	0Dh ;	keyLen
push	7B4h ;	keyOffset
push	offset encrypted_	data_table ; Virtual Address = 0x132F060
call	decode_string	

At relative virtual address 0xF060 is the data table base address which we named as **encrypted\_data\_table** which is 3048 bytes long. This is found in the **.data** section of the PE image.

De	Sections			"encr	ypted_dat	a table" is	at	2	x
	Check p	oacked statu	s	F W	RVA offset ithin .data	0xf060 section		✓ Read o	only
	Name	V.Address	V.Size	Offset	R.Size	Flags	Entropy	Packed	•
	.text	00001000	0000Ь000	00000400	0000ae00	60000020	6.59	no	
	.rdata	0000c000	00003000	0000b200	00002c00	c0000040	7.88	yes	
	.data	0000f000	0000f000	0000de00	0000e800	c0000040	7.99	yes	
	.raimo	0001e000	0000d000	0001c600	00006c00	c0000040	7.99	yes	
	.reloc	0002Ь000	00001000	00023200	00000600	42000040	6.57	no	
	.SCY	0002c000	00003000	00023800	00002400	e0000060	4.76	no	-
	Add new	section	Delete la:	st section	)			ОК	

For this example, the encrypted data is at offset 0x91B from the base address of the data table, or 0xF060 + 0x7B4

And the following parameters are hardcoded:

- offset address (from the base address 0xf060) of the encrypted string: 0x7B4
- key length: 0x0D (13 bytes)
- string length: 0x13A (314 bytes)

Here is the encrypted\_data\_table (truncated) after we re-based it to Zero:

аааааааа :	FF	F3	F3	25 - 81	BF	82	71-03	A2 32	98-65	29	<b>R4</b>	CØ.	OTTIvita é a 162 ile ) - L
00000010-	ño	čõ	65	70_00	60	00	EB_00	66 DO	AD_CP	DC	65	64	J LILIPUS TE - Palla
00000010.	22	GE.	Hr.	DD 00		07	AT TO	TO CC	25 (0)	20	10	10	
00000020-	36	UL.	DU DU	DD-HH	L DO	7E	HE-70	E2 00	35-06	23	10	17	
00000030:	<b>N</b> E	E8	D2	54-FD	80	3D	E2-DC	36 B4	HF-19	E3	DQ	64	\$2π1 ± 1=σ∎61»+11**
00000040:	-E4	86	63	7B-DD	-70	<b>4</b> C	91-30	C6 04	57-20	- A 8	DD	49	Σăc{ LæØ⊧♦₩,ċ I
00000050:	-96	7E	FF	7D-34	DA	D3	BF-2A	F1 4E	D4-84	-94	54	-76	û∼}¥rĽn⊭äöTv
00000060:	1 D	DA	65	A5-DD	8B	FD	ED-71	ЕЙ ВЙ	Ø7-4F	93	38	49	+ reÑ 1°2øαα⊗●0ô:Ι
00000070:	2R	FF	CE	8F-6F	34	FD	78-9F	FØ 10	80-60	<b>ØR</b>	26	FF	< 18040x for 1480
000000000	CF.	âħ	DD	CP-06	41	62	07_01	20 20	CP_07	ED	DD.	62	1 P 190 - 1 - 7 - 98 - B
000000000	- CE	60	DF	GF-HD	31	64	TO OD	AL 30		ED	L D	84	
00000070:	30	68	22	33-02	DC	73	50-8F	C5 0Z	88-82	P.C.	8H	Fb	=noutes retere
ипппппнп:	BC	GE	46	68-73	-87	2E	74-F3	85 45	82-87	<b>B</b> 6	8D	8C	⊐GFhsç.t≤āE≌-∥iĩ
000000B0:	-94	C5	61	93-4F	- 4E	2C	9F-0D	54 ØD	E7-36	ØB	BF	C5	ötaôON, fFTF1681+
000000000	21	03	D8	AB-A6	DC	19	83-CC	B2 EA	46-02	<b>F3</b>	50	8C	!♥╪%♀ <b></b> ↓⦉ΩF <b>e</b> ≤Pî
аааааата :	BB	32	<b>C3</b>	6F-5F	56	2F	DC-69	A8 81	NO-AC	46	12	44	a2 to UZ-ižii %F±D
GOOGOGEG -	0.2	62	R1	08-50	OR	20	10-00	10 58	B9-FF	22	ÔP.	ĉŝ.	
000000000	BC	BC.	8 <b>6</b>	EC_C2		DO	10 00	70 60	D0 PL	DE	OT OT	ar.	
000000100-	DU 000	<b>DD</b>	- 66	EG-02	HE	FO	(0 <sup>-</sup> 44	10 00	D7-07	<b>P</b> S	DD DD	SE.	
00000100:	63	EA.	вр	BD-45	DH	<b>UE</b>	3E-F8	3B 3E	30-04	58	37	63	
00000110:	33	BE	43	3F-F1	DC	3F	RA-28	07 E8	ND-2C	BD	D.5	53	3ªC?±;;?{[j•2,F, #[[S
00000120:	19	71	53	80-15	8D	ØC	3C-4A	4E BA	F5-03	10	30	C8	↓qSC§ì♀ <jn  j♥⊏<╚< td=""></jn  j♥⊏<╚<>
00000130:	-71	E5	<b>2B</b>	1F-1E	3A	06	DD-E3	B4 69	F5-D5	CA	<b>5</b> E	92	ασ+ <b>▼</b> ▲: 🛃 TH iJ 💾 Æ
00000140:	84	50	<b>Ø9</b>	8A-D9	FЙ	65	26-96	26 D5	49-06	28	<b>B1</b>	88	a loè-reêûu ci c(%)
00000150-	82	ΫŘ	64	98-B4	ĒĔ	02	70-81	87 05	04_0h	06	30	56	\$7 AUJ 116-200 ABV 97 1
00000130+	60	48	DE	70 02	55	16	D0_34		(D_0)	- PO	4 10		
00000100-	20	10	TE.	CD-BZ	114	24	10 54	SH 74	00-73	FO	11	HH	AF JZ G-46PK0-77
00000170:	-20	<b>B</b> 8	65	8B-CP	62	<u>5</u> E	1C-E6	45 EH	ZD-BH	FD	D2	<u>1</u> F	Pd f 1 Ep., chen.ell. EA
00000180:	DD	CØ	-90	F4-57	16	ЕØ	2C-13	13 35	10-B5	-37	AC	BØ	4É ſ₩ <b>_α, !!!!5</b> ▶‡7‰
00000190:	-7E	24	A4	F7-84	80	54	FØ-12	AE 3A	F4-3B	07	5B	EE	^^\$ñ≈äCT≡‡«: r;•[€
00000100:	Ø9	5D	78	19-EC	96	DИ	20-1B	80 9F	B1-6F	E6	70	8E	olz↓∞û <sup>⊥</sup> +C.f oună
000001 RO :	FC	80	CO.	98-8F	59	20	61-52	FR 44	46-22	99	94	28	willing yamu TIP 1687
00000100-	no	62	25	45-10	20	- cõ	D2-EC	1E DO	20-00	54	ĉĉ	EQ	-LNN-t-lot-1040
00000100+	60	66	E A	-TC -C -	20	EE.	47-04	ID OP	E0_C4	20	36	20	$T_{1}$ $T_{1$
000001100:	<b>NH</b>	80	: 2번	(0-54	JE	E5	17-61	TD YF	E0-61	60	30	20	
NONNOTEN:	-72	UU -	Н5	60-01	- FD	-55	BA-55	-7D -7H	FD-D8	- U1	<b>U</b> 5	65	PHIN ©≜UHW≯Z≜≑÷9e
	_												
000001F0:	6A	7B	6C	DA-FE	9B	E7	DD-02	30 C4	6C-FE	<b>E4</b>	71	44	jζ1 <sub>Γ</sub> ι¢τ <b>80-1</b> ίΣqD
000001F0: 00000200:	6A 91	7B 3D	6C F3	DA-FE FC-65	9B AF	E7 4E	DD-02 E9-30	30 C4 37 3C	6C-FE FF-B3	E4 BE	71 D9	44 5C	jζl <sub>Γ</sub> ∎¢τ 80-1∎ΣqD æ=≤ <sup>n</sup> e≫N007<  ± <sup>1</sup> ∖
000001F0: 00000200: 00000210:	6A 91 4C	7B 3D 1A	6C F3 83	DA-FE FC-65 60-1F	9B AF ØB	E7 4E A3	DD-02 E9-30 6B-6F	30 C4 37 3C 96 4A	6C-FE FF-B3 48-F2	E4 BE 7D	71 D9 71	44 5C ØA	jζ1_∎¢τ @0−1∎ΣqD æ=≤ <sup>n</sup> e≫N007<  4 <sup>J</sup> \ L→â`▼ðúkoûJH2>α⊡
000001F0: 00000200: 00000210: 00000210:	6A 91 4C	7B 3D 1A 18	6C F3 83 D9	DA-FE FC-65 60-1F 43-8F	9B AF ØB 24	Е7 4Е АЗ ØD	DD-02 E9-30 6B-6F FB-56	30 C4 37 3C 96 4A 96 FC	6C-FE FF-B3 48-F2 16-20	E4 BE 7D 79	71 D9 71 87	44 5C ØA A4	j{1 μ¢τ( 00−1 μΣαD æ=≤ <sup>n</sup> e≫N007<  J <sup>1</sup> L→â`▼ðúkoûJH≥>α ▲+ <sup>1</sup> Cö\$₽δUii <sup>n</sup> - μeñ
000001F0: 00000200: 00000210: 00000220:	6A 91 4C 1E	7B 3D 1A 18 09	6C F3 83 D9	DA-FE FC-65 60-1F 43-8E FR-C8	9B AF ØB 24	E7 4E A3 ØD 2B	DD-02 E9-30 6B-6F EB-56 48-4B	30 C4 37 3C 96 4A 9A FC	6C-FE FF-B3 48-F2 16-20	E4 BE 7D 72	71 D9 71 87	44 5C ØA A4 E9	j{1 μ¢τ 00−1 ΣαD æ=≤°e>>N007<  J <sup>1</sup> L→â`♥δάkoûJH≥>q0 ▲↑ <sup>1</sup> Câ\$Ĵ6Uin_ yçñ
000001F0: 00000200: 00000210: 00000220: 00000220:	6A 91 4C 1E	7B 3D 1A 18 C8 E	6C F3 83 D9 A5	DA-FE FC-65 60-1F 43-8E FB-C8	9B AF ØB 24	E7 4E A3 ØD 2B	DD-02 E9-30 6B-6F EB-56 48-4B	30 C4 37 3C 96 4A 9A FC 9E DE	6C-FE FF-B3 48-F2 16-20 14-PP	E4 BE 70 79	71 D9 71 87 1	44 5C ØA A4 F9	j{1 μ¢τ 00−1 ΣαD æ=≤ <sup>n</sup> e>N807<  ± L→â <sup>*</sup> ▼δάkoûJH≥>α0 ▲t <sup>3</sup> Câ\$ ⊁δUÜ <sup>*</sup> yc <sup>3</sup> α <sup>⊥</sup> δά <sup>±</sup> ) +HKR, Π½9→
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220:	6A 91 4C 1E	7B 3D 1A 18 C8 F	6C F3 83 D9 A5 3F	DA-FE FC-65 60-1F 43-8E FB-C8 -3	9B AF ØB 24 29	E7 4E A3 0D 2B	DD-02 E9-30 6B-6F EB-56 48-4B	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2	6C-FE FF-B3 48-F2 16-20 14-0P 52	E4 BE 70 79	71 D9 71 87 1	44 5C ØA A4 F9 2	j{1 μ¢τ 00−1 ΣαD æ=≤"e>N807<  4-1 L→â`▼ðúkoûJH≥ንα ▲↑ <sup>3</sup> Cä\$JδUÜ"_ ycñ αμῆδΔ>+HKR, Π29→ ό1 ₩ <u>8</u> 0€×/
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220:	6A 91 4C 1E	7B 3D 1A 18 C8 F	6C F3 83 D9 A5 3F	DA-FE FC-65 60-1F 43-8E FB-C8	9B AF 0B 24 29 4	E7 4E A3 0D 2B	DD-02 E9-30 6B-6F EB-56 48-4B 6-9	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8	6C-FE FF-B3 48-F2 16-20 14-9P	E4 BE 70 79	71971870 810	44 5C ØA A4 F9 2	j{1 [ [¢τ] @0-1 [ΣqD æ=≤"e>N807< [4] L→â`▼ðúkoûJH≥}q0 ▲↑¹Cä\$JδUÜ" ycñ qĽĩδĽ>+HKR Π½9→ ó1 ?Æ R©€×/
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220:	6A 91 4C 1E	7B 3D 1A 18 C8 F	6C F3 83 D9 A5 3F	DA-FE FC-65 60-1F 43-8E FB-C8	9B AF 0B 24 99 4	E7 4E A3 0D 2B	DD-02 E9-30 6B-6F EB-56 48-4B 5-9	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8	6C-FE FF-B3 48-F2 16-20 14-0-9 52	E4 BE 779	71 D9 71 87 10	44 50 0A A4 F9 2	j{1 μ¢τ 00−1 ΣαD æ=≤ <sup>n</sup> e≫N807<  4 <sup>-1</sup> L→â '▼ðúkoûJH2>α ▲↑ <sup>1</sup> Cä\$₽δUÜ <sup>n</sup> ycñ αμἕδΔ>+HKR, Π½9→ ό1 200 800×20 Ω
000001F0: 00000200: 00000210: 00000220: 00000220: 00000230: 00000230:	6A 91 4C 1E 4 88	7B 3D 1A 18 C8 F	6C F3 83 D9 A5 3F	DA-FE FC-65 60-1F 43-8E FB-C8 -3	9B AF 0B 24 29 4	E7 4E A3 0D 2B	DD-02 E9-30 6B-6F EB-56 48-4B 6-9 4E-0	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8 31 C	6C-FE FF-B3 48-F2 16-20 14-9P 52	E4 BE 7D 79	71 D9718710	44 5C 0A A4 F9 2	jči ruć t 00-1 1ΣqD æ=≤"e>>N807<  ±'\ L→â` ₩ởúkoûJH≥>q0 ▲↑²Cä\$₽ŏUÜ"= ycñ q╚ãõĽ>+HKR 11%9→ ó1 ?ff 80€×× 9¥ 100 ytN0;H 2=
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000020: 0000002: 0000000:	6A 91 4C 1E 48 FD	7B 3D 1A 18 C8 F 93 91	6C F3 83 D9 A5 3F	DA-FE FC-65 60-1F 43-8E FB-C8 -3- 16 62 96-C2	9BF 0B 24 94 79 9F	E7 4E A3 0D 2B	DD-02 E9-30 6B-6F EB-56 48-4B 5-9 4E-0 4C-5B	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8 3L C FA FC	6C-FE FF-B3 48-F2 16-20 14-9P 52 84-FE D0-05	E4 BE 7D 79 2 AC AC	71 D9 71 87 10 CF 36	44 5C 0A A4 F9 2	jč1 r∎¢ τ @ 0-1 1ΣqD æ=≤"e>N807<  ±'\ L→â`∀ðúkoûJH≥>q0 ▲↑ <sup>2</sup> Câ\$FðUÜ"= ycñ qĽãôĽ)+HKR ¶%9→ ó1 ?ff R@€× ý1 ?ff R@€× y1 160. ytN0;H 1%== 2moût fiL: "4606¶
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 00000020: 0000002: 0000000: 0000000: 0000000: 0000000: 000000	6A 91 4C 1E 488 FD 5	7B 3D 1A 18 C8 F 93 91	6C F3 83 D9 A5 3F 7F 24	DA-FE FC-65 60-1F 43-8E FB-C8 -3- -3- -3- -3- -3- -3- -3- -3- -3- -3	9BF08494 79F7	E7 4E A3 0D 2B 6A 74	DD-02 E9-30 6B-6F EB-56 48-4B 5-9 4E-0 4C-5B 82-04	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8 3L C FA FC 9B 34	6C-FE FF-B3 48-F2 16-20 14-07 52 48 40-FE 52-56	E4 BE 7D 79 AC ØE	71971871 CF 36 40	44 5C 0A 44 F9 2 14 F9	jζ1 μ¢τ 00-1 ΣαD æ=≤ <sup>n</sup> e»N807<  ± <sup>1</sup> L→â <sup>*</sup> VởúkoûJH2>q0 ▲↑ <sup>1</sup> Cä\$ FõUÜ <sup>n</sup> ycñ qĽöδ <sup>L</sup> )+HKR 11/29→· 61 ?ff R©€× <sup>61</sup> ?ff R©€× <sup>10</sup>
000001F0: 00000200: 00000210: 00000220: 00000220: 00000220: 00000220: 00000220: 00000220: 000008D0: 000008D0: 000008E0:	6A 91 4C 1E 48 FD 75	7B 3D 1A 18 C8 F 93 91 19	6C F3 83 D9 A5 3F 24 7F 24	DA-FE FC-65 60-1F 43-8E FB-C8 -3 96-C2 DC-C2	9BF 0B2294 79F27	E7 4E A3 0D 2B 6A 74	DD-02 E9-30 6B-6F EB-56 48-4B 15-9 4E-30 4E-30 4C-5B 87-6F	30 C4 37 3C 96 4A 9A FC 9E DE D2 D2 8 3L C 9B 34 FA FC 9B 34	6C-FE FF-B3 48-F2 16-20 14-97 52 64-FE D0-05 62-56	E4 BE 7D 79 AC 05 9D 15	71971871 CF 36 407	44 5C ØA A4 F9 2 14 E9	j{1, r€¢t @0-1 EqD æ=≤"e>N807<  4-1 L→â`♥ðúkoûJH≥>q0 ▲↑ <sup>3</sup> Cä\$₽δUÜ" ycñ qĽšŏĽ>+HKR M29→ \$1 ?# R0€× \$1 ?# R0€× \$2 160 ytN0;H 84= 2æoûŢĴLC:"45 \$2 #568 160 ytN0;H 84= 2æoûŢĴLC:"45 \$688 1699 1609 1709 1609 1
000001F0: 00000210: 00000220: 00000220: 00000230: 00000230: 00000230: 00000850: 000008E0: 000008E0:	6A 91 4C 1E 48 FD 752	7B 3D 1A 18 C8 F 393 91 19 12	6C F3 83 D9 A5 F 24 C5 C	DA-FE FC-65 60-1F 43-8E FB-C8 -3 96-C2 DC-5C 61-68	9BF ØB2294 79F767	E7 4E A3 0D 2B 6A 74 E1	DD-02 E9-30 6B-6F EB-56 48-4B 5-9 4E-3 4C-5B 87-A4 C8-5D	30 C4 37 3C 96 4A 9A FC 9E D2 D2 D2 D2 D2 D2 D2 S4 5A FC 9B 34 6E 6E	6C-FE FF-B3 48-F2 16-20 14-9 52 84-FE D0-05 62-56 AC-CE	E4 BED 79 27 AC 09 D 71	71971871 CF364071	44 5C 0A 44 F9 2 14 E9 3C	j{1, ru¢ t @0-1 1ΣqD æ=≤"e>N807<  ±'\ L→â '∀ởúkoûJH≥>q0 ▲↑ <sup>3</sup> Cä\$ <sub>7</sub> 5UÜ" ycñ qĽšốĽ>+HKR 17/3→ ó1 ?ff R@E×/ eyy1 160 ytN0;¦  84== <sup>2</sup> æoûŢĴLI:" <sup>4</sup> 4569 u↓\$ \~tcñ¢4bU¥M0 T <sup>‡</sup> tačg8Ľ]nn×!!±°.
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The encrypted string block is therefore at 0x7B4:

	0.0.714	BB	-50		-	1	84	-	1	~		AA	22		61	TN2\$Fca2#RI 40 0
Ō	0000724:	10	AB	55	92-54	DD	86	58-	-49	40	48	A3-DD	54	.12	98	Ë <sup>′</sup> <sup>−</sup> ×∪ÆT &XICHú T⊠ÿ
Ø	0000734:	83	CE	26	86-FA	32	DØ	A4-	-17	55	42	D8-20	50	ØA	93	a¦¦&a ∙24ñ ±UB‡ P⊡ô
Ø	0000744:	11	25	80	70-E7	BØ	<b>C8</b>	19-	- <b>4</b> B	5B	ØC	3D-DF	48	8F	5C	<b>▲%Çpτ</b> 测╙↓K[♀≐ <b>■</b> HÄ∖
Ø	Key (le	nath	=13		B9-65	A4	20	ED-	-37	74	<b>1B</b>	3C-62	D7	63	99	<u>'</u> ¥%¦eñ ø7t← <b cö< td=""></b cö<>
Ø	Key (le	igu	-15	'	6B-73	<b>1D</b>	20	3E-	-8D	76	00	C6-5D	27	<b>7</b> E	53	-I(fks⇔ >ìu  ‡]"~S
Ø	by	tes)			B6-E3	7D	18	16-	-32	<b>E1</b>	39	CE-F9	C2	22	DE	
Ø	0000784 👔	- 36	68	-67	BB-EØ	D6	BF	BC-	-86	47	18	90-06	<b>2E</b>	-71	A9	6 gηαm <sup>⊥</sup> låGté <b>±.</b> q−
Ø	0000794:\	- 44	9B	15	19-24	9D	03	63-	- <b>F1</b>	02	71	60-04	34	<b>B8</b>	D8	D¢§↓\$¥♥c±@q`◆4╕÷
Ø	00007A4:	53	86	33	DC-33	25	52	EB-	-D8	<b>B8</b>	FD	19-32	23	- <u>6</u> E	-1F-	_ \$&3 <u>_</u> 3%R6台 212#n▼
Ø	00007B4:	82	7D	AE	B7-37	35	9D	60-	-DA	<b>8</b> D	DB	CA-E3	ØC	67	57	é}«╖ア5¥`┎ὶ┛╩╢¥gW
Ø	00007C4:	04	37	69	34-07	F7	16	37	33	30	88	EC-E3	46	13	61	♦7i4•≈_730ê∞IIF!!a
Ø	00007D4:	ØD	75	D6	5B-0A	54	2A	D5	-7E	1 D	32	9D-79	<b>C8</b>	8C	B9	Funcor * F~+2¥yĽî
Ø	00007E4:	<b>E1</b>	23	50	90-B5	6A	84	8 B	-F9	80	16	9A-99	58	11	24	₿#Pé‡jäï•Ç=UOX∢\$
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Q	0000804:	<b>B</b> 5	<u>A8</u>	<u>2C</u>	F2-14	D4	74	13	- <u>6</u> F	2B	AF	1F-FA	28	ЕØ	58	{c,2¶⊑t‼o+»▼ (αX
Q	0000814:	34	BE	2C	D7-2D	<b>79</b>	90	94	-DE	<b>4</b> A	01	13-71	FA	E6	36	4ª I   −y£ö J⊡‼q · µ6
Q	0000824:	CA	88	CD	3B-82	<b>4</b> D	AC	63	-02	18	<b>E8</b>	05-7E	<b>71</b>	44	3C	lle=;éM‰c⊟→፬⊉~°qD<
Q	0000834:	75	<b>4</b> A	60	93-2D	58		- 10	0.4		in a	E5-7A	<u>9 B</u>	3F	43	uJ`ô−X©:Şÿ]σz¢?C
Q	0000844:	6F	E2	3A	69-36	51	EUC	сгур	otea	str	ing	FF-41	59	<u>C3</u>	22	of∶i6[ſá∭× AY_w
Ø	0000854:	88	<u>C3</u>	41	DF-2A	41(	leng	gth=	:314	by	tes)	53-98	1E	DF	56	ê HA ≕×MΩ[ æaZSija U
Q	0000864:	DA	<b>4</b> E	EA	EØ-51	<b>E</b> 8	92	24		1.2	44	79-23	FD	36	ØD	_NΩαQQiWq"Ey#26J
Q	0000874:	14	24	<b>E</b> 5	30-4D	87	CF	23	-06	<b>C</b> 2	28	2D-11	11	EA	EC	<b>Ϥ</b> 与ϭͶϤ⋍⋕ <b>Ŧ</b> Ţ౽− <b>⋖</b> ∢Ωα
Q	0000884:	318	CB	8D	FC-CØ	06	5D	80	-FF	A2	82	D8-3A	ØD	39	A2	;
N	0000894:	40	15	6F	53-93	<u>E2</u>	D4	35	55	5A	F5	02-D8	E3	<b>A</b> 3	CB	LãoSôl, EDZI B÷llú
N N	0000884:	28	28	<b>4</b> B	65-1F	FC	AA	14	-210	84	D2	EC-34	23	60	23	*+Ke ¶"¬" n F <sup>00</sup> 4# s
N N	NNNN884:	03	<b>B4</b>	65	AB-E2	RD	<b>C4</b>	GF	- <u>1 F</u>	EZ	37	24-B8	93	ИĤ	16	₩1e½I''-=▼Υ?\$100
ЫN	UUUU8C4:	BZ	22	24	4E-30	3.8	GE	84	FE	AC	CF	3D-FD	21	ZF	26	∭ytNU;;;;II Ma==*æoù
Ŋ	00008D4:	62	<b>YF</b>	6A	4C-5B	FA	FC	DN	5	<b>NE</b>	36	14-75	19	24	DC	TJLL
Q	00008E4:	50	涯	74	87-14	ÅR	34	62	-56	AD.	40	EA-05	12	65	61	TCnC4bU¥MUπ‡†a
Q	00008F4:	HR	67	EI	C8 5D	ЬE	ЬE	변달-	-CE	17	117	30-60	HH	na	8H	cgpre Inn and I and
Ŋ	Biglow A Ridt :	рВ	84	<b>D4</b>	57-45	107	FU	H2-	-GN			0.2-1-M	14	ÄМ	20	EWBO-NEWag SE-

The key is 13 bytes long :

[82 7D AE B7 37 35 9D 60 DA 8D DB CA E3]

And the encrypted string is 314 bytes long:

[Oc 67 57 04 37 69 34 07 f7 16 37 33 30 88 ec e3 46 13 61 0d 75 d6 5b 0a 54 2a d5 7e 1d 32 9d 79 c8 8c b9 e1 23 50 90 b5 6a 84 8b f9 80 16 9a 99 58 11 24 30 d1 ac 3f 5c b6 77 b0 14 37 ad 69 be 81 d6 ea b5 a8 2c f2 14 d4 74 13 6f 2b af 1f fa 28 e0 58 34 be 7c d7 2d 79 90 94 de 4a 01 13 71 fa e6 36 ca 88 cd 3b 82 4d ac 63 02 1a e8 05 7e 71 44 3c 75 4a 60 93 2d 58 01 3a 24 98 b3 e5 7a 9b 3f 43 6f e2 3a 69 36 5b f4 a0 b1 2a dd ff 41 59 c3 77 88 c3 41 df 2a 4d ea d7 91 61 5a 53 98 1e df 56 da 4e ea e0 51 e8 8d 57 71 fc 90 79 23 fd 36 0d 14 24 e5 30 4d a7 cf 23 06 c2 7a 2d 11 11 ea ec 3b cb 8d fc c0 06 5d 8c ff a2 82 d8 3a 0d 39 a5 4c 15 6f 53 93 e2 d4 35 55 5a f5 02 d8 e3 a3 cb 2a 2b 4b 65 1f fc aa 14 20 a4 d5 ec 34 23 60 73 03 b4 65 ab e2 bd c4 cf 1f e7 37 24 b8 93 0a 16 b2 79 74 4e 30 3b ce b4 fe ac cf 3d fd 91 7f 96 c2 9f 6a 4c 5b fa fc d0 05 0e 36 14 75 19 24 dc 5c 7e 74 87 a4 9b 34 62 56 9d 4d e9 d2 12 c5 61 a8 67 e1 c8 5d 6e 6e]

Reverse engineering the decryption code in the malware shows that it's actually just the stream cipher RC4. Code snippet below is the RC4 algorithm: initialize sbox and key scheduling

```
char cdecl sbox_init(char *sbox, char *key, unsigned int keyLen)
{
 int v3; // esi
 unsigned int i; // eax
 unsigned int v5; // ecx
 char v6; // bl
 char result; // al
 unsigned int v8; // [esp+Ch] [ebp-4h]
 LOBYTE(v3) = 0;
 for (i = 0; i < 256; ++i)
   sbox[i] = i;
 v5 = 0;
 v8 = 0;
 do
  {
   v6 = sbox[v5];
   v3 = (unsigned __int8)(v3 + key[v5 % keyLen] + sbox[v5]);
   result = sbox[v3];
   sbox[v8] = result;
   v5 = v8 + 1;
   sbox[v3] = v6;
   v8 = v5;
 }
 while ( v5 < 0x100 );</pre>
  return result;
}
```

Code snippet below is the actual decryption of data:

```
int __cdecl data_decrypt(char *sbox, char *keyEndPtr, int end, _BYTE *output)
{
 int j; // edi
 int v5; // esi
 int result; // eax
 int v7; // ecx
 char *keyLen; // [esp+14h] [ebp+Ch]
 int enda; // [esp+18h] [ebp+10h]
  i = end;
 LOBYTE(v5) = 0;
  result = 0;
 if ( end )
  ł
   keyLen = (char *)(keyEndPtr - output);
   do
    {
     v7 = (unsigned __int8)(result + 1);
      enda = v7;
      LOBYTE(v7) = sbox[v7];
     v5 = (unsigned __int8)(v5 + v7);
sbox[(unsigned __int8)(result + 1)] = sbox[v5];
      sbox[v5] = v7;
      *output = output[(_DWORD)keyLen] ^ sbox[(unsigned __int8)(sbox[(unsigned __int8)(result + 1)] + v7)];// keystream generator
     result = enda;
     ++output;
     --j;
   }
   while ( j );
  }
  return result;
}
```

After reversing this to C, it was pretty straightforward to convert it to Python so we could run it in IDA Pro.

```
def decode(key, data):
    """ REvil string decoder, this is just RC4 """
    # initialize sbox and key scheduling
    sbox, j = [a for a in range(256)], 0
    for i in range(256):
        j = (j + key[i % len(key)] + sbox[i]) & 0xff
        sbox[i], sbox[j] = sbox[j], sbox[i]
    # this is the actual decryption of data to output
    i, j, output = 0, 0, bytearray(len(data))
    for k in range(len(data)):
        i = (i + 1) \& 0xff
        j = (j + sbox[i]) \& 0xff
        sbox[i], sbox[j] = sbox[j], sbox[i]
        t = (sbox[i] + sbox[j]) \& 0xff
        # here is the actual decryption of the data
        output[k] = sbox[t] ^ data[k]
    return output
```

This now allows us to take the encrypted block above with the following parts:

key = '\x82\x7D\xAE\xB7\x37\x35\x9D\x60\xDA\x8D\xDB\xCA\xE3'
data = '\x0c\x67\x57\x04\x37\x69\x34\x07\xf7\x16\x37\x33\x30\x88\xec\xe3\x46\
print(decode(key,data))

This decodes a Unicode string as seen in the screenshot below:

{.".v.e.r.".:.%.d.,.".p.i.d.".:.".%.s.".,.".s.u.b.".:.".%.s.".,.".p.k.".:.".%.s."., .".u.i.d.".:.".%.s.".,.".s.k.".:.".%.s.".,.".u.n.m.".:.".%.s.".,.".n.e.t.".:.".%.s. ".,.".g.r.p.".:.".%.s.".,.".l.n.g.".:.".%.s.".,.".b.r.o.".:.%.s.,.".o.s.".:.".%.s." .,.".b.i.t.".:.%.d.,.".d.s.k.".:.".%.s.".,.".e.x.t.".:.".%.s.".}.

Because each encoded string has its own unique key and variable length, it becomes cumbersome to decode every string. But fret not, at the end of this blog, we share the IDAPython script to aid you with the decoding process.

The second part of the obfuscated data is the ransomware configuration which basically uses the same RC4 algorithm. This encrypted configuration is stored in the non-standard named section called *.raimo*.

In the screenshot below we highlight the RC4 key

"VNz47r3Wz2xT7DP1XqPa2MYcwUx8uRex", the CRC hash of the encoded data which is 0xB6C2E135, and the length of the data is 0x6B02 (27394 bytes).

.raimo:0133E000	key dł	<pre>vNz47r3Wz2xT7DP1XqPa2MYcwUx8uRex' RC4 key</pre>
.raimo:0133E000		; DATA XREF: sub_1321B1C+40↑o
.raimo:0133E020	enc_conf_hash do	d 0B6C2E135h ; DATA XREF: sub_1321B1C+17↑r
.raimo:0133E024	; SIZE_T enc_conf_	size
.raimo:0133E024	enc_conf_size do	d 6B02h ; DATA XREF: sub_1321B1C+1↑r
.raimo:0133E024		; sub_1321B1C+24↑r
.raimo:0133E028	; char enc_config	data[]
.raimo:0133E028	enc_config_data db	o 8,'¤-ËFKæ"qÜH@',15h,'ÞfI.i}œÄ²ZàèµÒ:T¦',0Fh,'fY-M',17h,8Fh,'\$',0,'Ù'
.raimo:0133E028		; DATA XREF: sub_1321B1C+7↑o
.raimo:0133E028	dł	o 13h,'  ',16h,'ëÌ',15h,'`æäìª',27h,0Dh,'_kâ',17h,'*…Ù',1Eh,'³@',6,'è'
.raimo:0133E028	dł	o 'Õ•',90h,'T',3,'z',90h,'Ð',17h,'+š',18h,'†Ì',14h,'Ý_Æ•ZŒ',16h,'†º¢'
.raimo:0133E028	dŁ	o 8Fh,'zï0/çÇ…5Šù}ã <mark>Encrypted COnfiguration</mark> <sup>=</sup> h,'~r&¦',8Fh,' <vý8s¾≅´'< th=""></vý8s¾≅´'<>
.raimo:0133E028	dŁ	o 'A²',1,';öi',1,'áMqhç€w+t‴≐U#÷V=O‱יוָ',1Eh,18h,90h,1Eh,'Ò'',9,0Eh,'-
.raimo:0133E028	dł	b 'xŸ«i`ž,Đ®Ša',6,'L0',27h,'A_‱%',7,'7 <v',8dh,'½c£',0ah< th=""></v',8dh,'½c£',0ah<>
.raimo:0133E028	dŁ	ס '^¡',1Bh,'äwß;d?_Ü¥ ßa}J×',8Fh,'v',1Bh,11h,1Ah,'«AÜ≧NÁ†',8Fh,'+Y‹E'
.raimo:0133E028	dł	ɔ '?Õùžl]š',1Eh,'™÷[7üYýÃ',16h,'jÑê¬æŠ[€',16h,'<',12h,'e',6,'V"ÏÞœ£Ý'
.raimo:0133E028	dł	o 'f~ð',3,90h,'°"a×Ý*xFk3^Rz',9,'ÊHV&ÿ',2,'†bBµ^Ë&Oœh'("ñ–XÍÈ€íØD¹ø¿'
.raimo:0133E028	dł	, '≂éžžš', 13h, 'ÜêO1ó', 27b, '%', 7Eh, '/', 1Eh, 'r=;>âÌÐW',0Ah

The resulting decrypted configuration file looks like this:



When we finally unpack the file and deobfuscate the string, the process of reversing the code statically is so much easier. We won't, however, go into further detail about the Ransomware itself as there are very good analyses on this malware elsewhere, such as: <u>https://www.acronis.com/en-eu/articles/sodinokibi-ransomware/</u>

As mentioned earlier, we also wrote an IDAPython script to help deobfuscate strings hidden by this malware which may aid in the analysis process. You can find it here: <u>https://github.com/bizdak/malware-analysis/blob/master/revil/revil.py</u>

Decoded string after running the IdaPython script:

```
decode_string(encrypted_data, 1319, 12, 20, s_wpContent);// wp-content
zwpContent = 0;
decode_string(encrypted_data, 1450, 7, 12, s_static);// static
null0 = 0;
decode_string(encrypted_data, 2707, 9, 14, s_content);// content
v21 = 0;
decode_string(encrypted_data, 197, 7, 14, s_include);// include
v19 = 0;
decode_string(encrypted_data, 231, 5, 14, s_uplo);// uploads
v17 = 0;
decode_string(encrypted_data, 1826, 7, 8, s_news);// news
v41 = 0;
decode_string(encrypted_data, 2845, 16, 8, s_data);// data
v39 = 0;
decode string(encrypted data, 2514, 7, 10, s admin);// admin
v31 = 0;
```

Happy reversing!