Analyzing KSL0T (Turla’s Keylogger), Part 1 – Reupload

0ffset.net/reverse-engineering/malware-analysis/analyzing-turlas-keylogger-1

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(This post is a reupload from my old site which is no longer available – you may have seen it before)

Whilst I’m working through the Hancitor write up and the Flare On challenges, I decided to take a short break and focus on a smaller piece of malware – such as a keylogger, which in this case is on a much larger scale than $32 keylog-as-a-service, as it has been attributed to a Russian Advanced Persistent Threat group known as **Turla**, or **Waterbug**. This APT group has been in the news quite frequently over the past month, after **compromising** European government foreign offices and creating an extremely **stealthy backdoor** that utilizes PDF files to exfiltrate data, via emails. I noticed a sample of malware uploaded to **VirusBay**, tagged with **Turla** and **Venomous Bear** (yet another moniker given to the group), and decided to analyze it. As I statically analyzed a lot of the Flare On challenges that I have completed, I decided I wanted to approach this sample primarily using static analysis, unless it became too difficult to do so. So, let’s begin cracking this sample open!

MD5: 59b57bdabee2ce1fb566de51dd92ec94

As per usual, I ran the **file** and **strings** command on the binary to see the format and if there was anything interesting that was visible. The binary is in fact a DLL, and a 64 bit one. The output of **strings** displayed a lot of junk, although we are able to see a few error messages and several Windows API calls, such as **IsDebuggerPresent**, **WriteFile**, and dynamic loading calls; **GetModuleHandle**, **LoadLibrary** and **GetProcAddress**.

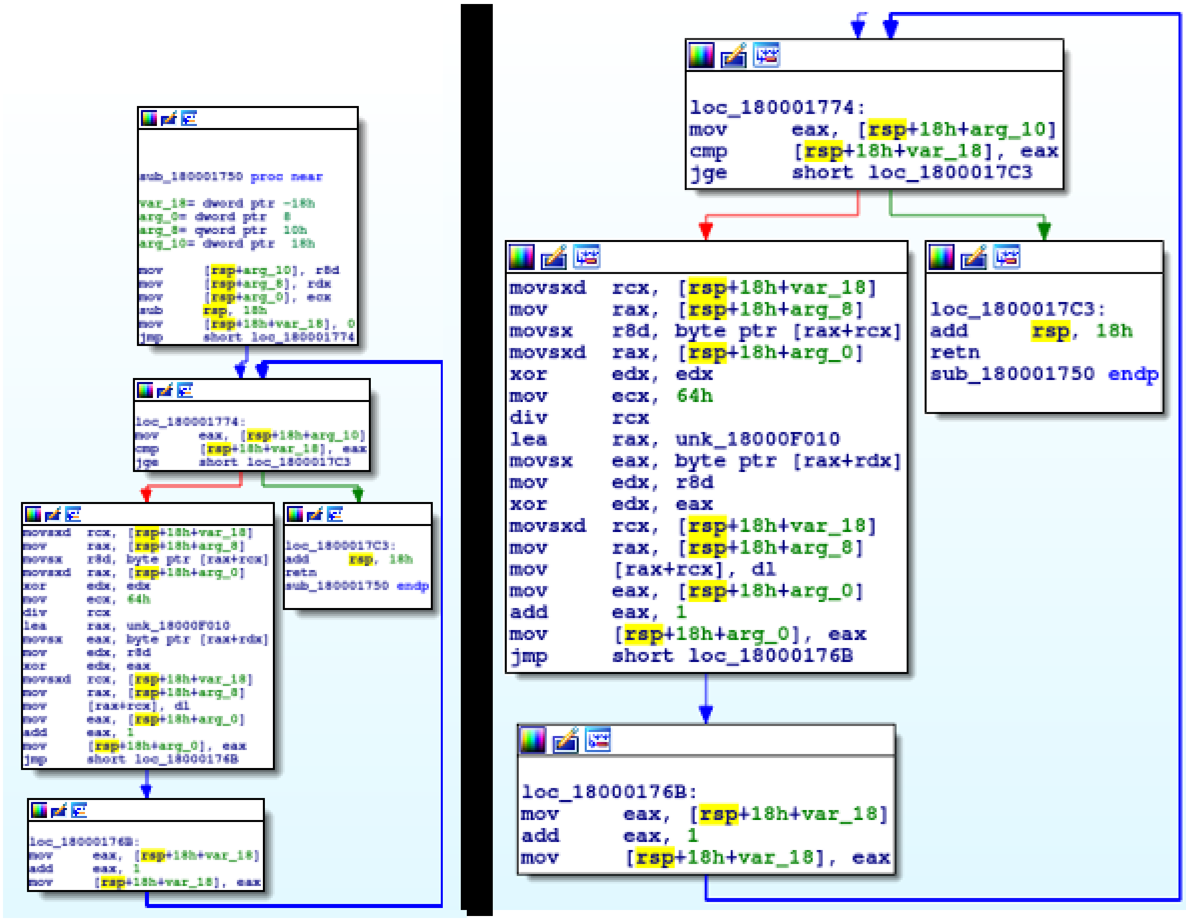
After opening the file in IDA, we are able to view the entry point of the user code, **DLLMain**. After a **cmp** operation, the program jumps to **0x1800019BD**, where an extremely important function at **0x1800017D0** is called. It might not look like much at a first glance, just multiple calls with 3 arguments passed to them – until you realize it is calling the same function each time, with the second argument being what seems to be pointing to some encrypted text …

```
GetProcessWindowStation
GetUserObjectInformationA
GetLastActivePopup
GetActiveWindow
MessageBoxA
USER32.DLL
SunMonTueWedThuFriSat
JanFebMarAprMayJunJulAugSepOctNovDec
GetProcAddress
GetModuleHandleW
Sleep
KERNEL32.dll
RtlUnwindEx
GetCurrentThreadId
FlsSetValue
GetCommandLineA
TerminateProcess
GetCurrentProcess
UnhandledExceptionFilter
SetUnhandledExceptionFilter
IsDebuggerPresent
RtlVirtualUnwind
RtlLookupFunctionEntry
RtlCaptureContext
EncodePointer
DecodePointer
FlsGetValue
FlsFree
SetLastError
GetLastError
FlsAlloc
```

```
mov     r8d, 1Ch
lea     rdx, unk_18000F078
mov     ecx, 37h
call    sub_180001750
mov     r8d, 16h
lea     rdx, unk_18000F0C8
mov     ecx, 22h
call    sub_180001750
mov     r8d, 38h
lea     rdx, unk_18000F0E0
mov     ecx, 7
call    sub_180001750
mov     r8d, 4Ch
lea     rdx, unk_18000F120
mov     ecx, 11h
call    sub_180001750
mov     r8d, 0Eh
lea     rdx, unk_18000F170
mov     ecx, 1Bh
call    sub_180001750
```

```
call    sub_180001750
mov     r8d, 14h
lea     rdx, unk_18000F098
mov     ecx, 47h
call    sub_180001750
mov     r8d, 10h
lea     rdx, unk_18000F0B0
mov     ecx, 3Dh
call    sub_180001750
mov     r8d, 6
lea     rdx, unk_18000F004
mov     ecx, 39h
call    sub_180001750
mov     r8d, 1Ch
lea     rdx, unk_18000F078
mov     ecx, 37h
call    sub_180001750
mov     r8d, 16h
lea     rdx, unk_18000F0C8
mov     ecx, 22h
call    sub_180001750
mov     r8d, 38h
lea     rdx, unk_18000F0E0
mov     ecx, 7
call    sub_180001750
mov     r8d, 4Ch
lea     rdx, unk_18000F120
mov     ecx, 11h
call    sub_180001750
mov     r8d, 0Eh
lea     rdx, unk_18000F170
mov     ecx, 1Bh
call    sub_180001750
mov     r8d, 46h
lea     rdx, unk_18000F180
mov     ecx, 25h
call    sub_180001750
mov     r8d, 40h
lea     rdx, unk_18000F1D0
mov     ecx, 26h
call    sub_180001750
mov     r8d, 12h
lea     rdx, unk_18000F218
mov     ecx, 2Fh
call    sub_180001750
```

As you may have guessed, this is in fact a decryption function. When we view the function called at **0x180001750**, we can determine that it is a decryption function based on both the arguments, and on the **xor edx, eax**. Also take note of the **for** loop, which compares the value in **eax** (value stored in **arg_10**) and the value in **var_18**.



We can further deduce that **var_18** is in fact the counter, based off of this section of code:

```
mov       eax, [var_18]
add       eax, 1
mov       [var_18], eax
```

As we now know this, we can rename **var_18** to **Counter**. Click on **var_18** and push '**n**', and a prompt will appear, allowing you to rename the variable. We now need to figure out what the counter value is being compared to, meaning we need to analyze **arg_10**. As it is **arg_*** and not **var_***, we have to look at the arguments passed to this specific function. In this case, the arguments are not passed using the **push** mnemonic and are instead **mov'd** into the arguments. As the value in the **r8d** register is being moved into **arg_10**, let's jump back the the calling function to view what was in **r8d** before executing the decryption function.

```
mov   r8d, 25Eh
lea   rdx, unk_18000F2F0
mov   ecx, 47h
call  sub_180001750
```

We can convert the hexadecimal number to decimal by pressing '**H**' while selecting it, resulting in the decimal value **606**. So for this particular call, the XOR algorithm loops **606** times, XORing each character. Now we have identified **arg_10**, we can go ahead and rename it. Next, let’s try and figure out the values that are being XOR’ed together, to see if we can locate the key used and the data being decrypted. The **xor** mnemonic performs the XOR operation on the value in **edx**, with the value in **eax**. The result of the operation is always stored in the first argument, in this case the result is stored in **edx**. We can assume that **edx** contains the data to be decrypted, and **eax** contains the key. In order to find these values out, we have to see what was moved (**mov**) or loaded (**lea**) into the **edx** and **eax** register.

```
movsxd  rcx, [rsp+18h+var_18]
mov     rax, [rsp+18h+arg_8]
movsx   r8d, byte ptr [rax+rcx]
movsxd  rax, [rsp+18h+arg_0]
xor     edx, edx
mov     ecx, 64h
div     rcx
lea     rax, unk_18000F010
movsx   eax, byte ptr [rax+rdx]
mov     edx, r8d
xor     edx, eax
movsxd  rcx, [rsp+18h+var_18]
mov     rax, [rsp+18h+arg_8]
mov     [rax+rcx], dl
mov     eax, [rsp+18h+arg_0]
add     eax, 1
mov     [rsp+18h+arg_0], eax
jmp     short loc_18000176B
```

As you can see, **r8d** is moved into **edx** before the XOR occurs, so we have to then see what was moved into **r8d** beforehand – which is seen in the third instruction of this segment: **movsx r8d, byte ptr [rax+rcx]**. Just above this, **[rsp+18h+counter]** is moved into **rcx**, and whatever is stored in **arg_8** is moved into **rax**. As we know **counter** is incremented by 1 each loop, we can determine that the **byte ptr [rax+rcx]** is iterating over *something* **606** times, with that *something* being encrypted characters. We can double check this by finding out what is stored in **arg_8**, the same way we discovered what was in **arg_10**: **unk_18000F2F0**, which contains a lot of encrypted data (specifically, 606 bytes of it).

```
.data:000000018000F2F0 unk_18000F2F0   db 0B9h ; ¹
.data:000000018000F2F0
.data:000000018000F2F1                 db  8Ch ; Œ
.data:000000018000F2F2                 db 0B2h ; ²
.data:000000018000F2F3                 db  88h ; ˆ
.data:000000018000F2F4                 db  0Bh
.data:000000018000F2F5                 db  0Ch
.data:000000018000F2F6                 db  52h ; R
.data:000000018000F2F7                 db  4Eh ; N
.data:000000018000F2F8                 db  52h ; R
.data:000000018000F2F9                 db  0Dh
.data:000000018000F2FA                 db  31h ; 1
.data:000000018000F2FB                 db  38h ; 8
.data:000000018000F2FC                 db  70h ; p
.data:000000018000F2FD                 db  91h ; '
.data:000000018000F2FE                 db  23h ; #
.data:000000018000F2FF                 db  7Eh ; ~
.data:000000018000F300                 db  56h ; V
.data:000000018000F301                 db  6Ah ; j
.data:000000018000F302                 db  69h ; i
.data:000000018000F303                 db  42h ; B
.data:000000018000F304                 db  76h ; v
.data:000000018000F305                 db  5Dh ; ]
.data:000000018000F306                 db  89h ; ‰
.data:000000018000F307                 db  9Eh ; ž
.data:000000018000F308                 db  1Dh
.data:000000018000F309                 db  17h
.data:000000018000F30A                 db  53h ; S
.data:000000018000F30B                 db  0Fh
.data:000000018000F30C                 db  2Bh ; +
.data:000000018000F30D                 db  0Ah
.data:000000018000F30E                 db  7Fh ; 
.data:000000018000F30F                 db  59h ; Y
.data:000000018000F310                 db  59h ; Y
.data:000000018000F311                 db  6Ch ; l
.data:000000018000F312                 db  67h ; g
.data:000000018000F313                 db  6Fh ; o
.data:000000018000F314                 db 0C6h ; Æ
```

Next, let's find out what is being stored in **eax**. In this instance, one byte of data at **[rax+rdx]** is being **movsx** into **eax**. Therefore, we need to locate the data stored in **rax** and **rdx**. The data in **rax** is quite easy to find out, as there is a **mov rax, unk_18000F010** before the **movsx**. When viewing the data at **0x18000F010**, we can see what seems to be more encrypted text – the key used to decrypt the data at **18000F2F0**. However, it is not that simple. Remember the **rdx** register that is used? Well we can assume that the value in **rdx** changes on each iteration. In order to figure this value, we need to look at the **div** instruction.

Key Array:

```
.data:000000018000F010 unk_18000F010   db  0Ah
.data:000000018000F010
.data:000000018000F011                 db  19h
.data:000000018000F012                 db  59h ; Y
.data:000000018000F013                 db  2Dh ; -
.data:000000018000F014                 db  6Ch ; l
.data:000000018000F015                 db  59h ; Y
.data:000000018000F016                 db  6Fh ; o
.data:000000018000F017                 db 0FAh ; ú
.data:000000018000F018                 db  8Bh ; ‹
.data:000000018000F019                 db  6Fh ; o
.data:000000018000F01A                 db  9Bh ; ›
.data:000000018000F01B                 db 0FFh ; ÿ
.data:000000018000F01C                 db  37h ; 7
.data:000000018000F01D                 db  9Bh ; ›
.data:000000018000F01E                 db 0BDh ; ½
.data:000000018000F01F                 db  7Bh ; {
.data:000000018000F020                 db  59h ; Y
.data:000000018000F021                 db  4Bh ; K
.data:000000018000F022                 db  7Bh ; {
.data:000000018000F023                 db 0DDh ; Ý
.data:000000018000F024                 db  0Fh
.data:000000018000F025                 db  64h ; d
.data:000000018000F026                 db  91h ; ‘
.data:000000018000F027                 db 0C7h ; Ç
.data:000000018000F028                 db 0D6h ; Ö
.data:000000018000F029                 db  9Ch ; œ
.data:000000018000F02A                 db  6Fh ; o
.data:000000018000F02B                 db  7Bh ; {
.data:000000018000F02C                 db  9Ch ; œ
.data:000000018000F02D                 db    1
.data:000000018000F02E                 db  9Ch ; œ
.data:000000018000F02F                 db  91h ; ‘
.data:000000018000F030                 db  79h ; y
.data:000000018000F031                 db 0C7h ; Ç
.data:000000018000F032                 db 0C8h ; È
.data:000000018000F033                 db 0C9h ; É
.data:000000018000F034                 db 0DFh ; ß
.data:000000018000F035                 db 0E1h ; á
.data:000000018000F036                 db 0FAh ; ú
.data:000000018000F037                 db 0FFh ; ÿ
```

```
mov  rax, arg_0
xor  edx, edx
mov  ecx, 100
div  ecx
```

The **div** instruction takes one operand – this contains the value to divide **rax** by. A division of **0x8003** by **0x100** in x64 Assembly would look something like this:

```
xor rdx, rdx      ; clear dividend
mov rax, 0x8003   ; dividend
mov rcx, 0x100    ; divisor
div rcx           ; rcx = 0x80, rdx = 0x3
```

It is basically a division, however the remainder value is stored in **rdx**, meaning **rdx** is equal to **0x3**. In the case of the keylogger, the XOR key is decided based on the value of **rdx**, and therefore we need to figure out what **rax** is, so we can divide it by **0x64** in order to get the first value of **rdx**. We know that **arg_0** contains the value of **ecx** before the function is executed, which is **0x47**. When we convert it to decimal format, it is **71 / 100**, leaving us with **0.71**. The value stored in **rdx** is **71**. Simply perform the modulo operation (%) on these two values and you will get **71**. This means that the 71st byte in the key array is the first byte to be used in the XOR: **0x85**. For each loop, the value inside of **arg_0** is incremented by 1, meaning the key byte is always changing – although now that we know how the algorithm works, we can automate the decryption statically, rather than relying on a debugger.

```
mov eax, [rsp+18h+arg_0]
add eax, 1
mov [rsp+18h+arg_0], eax
```

So how do we go about the static decryption? Well the answer is **IDC**, which is a scripting language incorporated inside of IDA. Another option is **IDAPython**, however that isn't available inside the IDA 7 Pro Free version, so we'll stick with IDC. So far, we know that the decryption part is all contained inside of a loop that loops a pre-determined amount of times, using a specific key array and a determined data array. In addition, the value that is used for the **div** operation is also passed as an argument. Therefore, we will require 3 arguments for our function: **base_data**, **div**, and **loop**. We will also need 6 variables: **index**, **x1**, **x2**, **data**, **i**, and **base_xor**. **index** will contain the result of the modulo operation, **x1** will contain a byte of data from the encrypted text, **x2** will contain a byte of data from the key, **data** will contain the result of the XOR, **i** will be the counter and **base_xor** will hold the address to the key array. To store an address, simply add an **0x** to the beginning of said address. The rest of the script will contain the necessary incrementations and XOR's.

```
static decrypt_data(base_data, div, loop) {
auto index, x1, x2, data, i, base_xor;
base_xor = 0x18000F010;

for (i = 0; i &lt; loop; i++) {

    index = div % 100; // Get value from div % 100
    x1 = Byte(base_data); // Get byte from encrypted data
    x2 = Byte(base_xor + index); // Get XOR key using value from div / 100
    data = x1 ^ x2; // XOR data
    PatchByte(base_data, data); // Replace enc. byte with dec. byte
    base_data = base_data + 1; // Increment Encrypted Data
    div = div + 1; // Increment Divider
}

}
```

In order to *install* this script into IDA, click **File -> Script Command**, and then paste it into the dialog box.To call the function, simply type (in the command line at the bottom) **decrypt_data(0x18000F2F0, 71, 606)** to decrypt the first section of data, which should look like the image below.

```
.data:000000018000F2F0 unk_18000F2F0   db  3Ch ; <
.data:000000018000F2F0
.data:000000018000F2F1                 db    0
.data:000000018000F2F2                 db  23h ; #
.data:000000018000F2F3                 db    0
.data:000000018000F2F4                 db  52h ; R
.data:000000018000F2F5                 db    0
.data:000000018000F2F6                 db  53h ; S
.data:000000018000F2F7                 db    0
.data:000000018000F2F8                 db  68h ; h
.data:000000018000F2F9                 db    0
.data:000000018000F2FA                 db  69h ; i
.data:000000018000F2FB                 db    0
.data:000000018000F2FC                 db  66h ; f
.data:000000018000F2FD                 db    0
.data:000000018000F2FE                 db  74h ; t
.data:000000018000F2FF                 db    0
.data:000000018000F300                 db  3Eh ; >
.data:000000018000F301                 db    0
.data:000000018000F302                 db  3Ch ; <
.data:000000018000F303                 db    0
.data:000000018000F304                 db  23h ; #
.data:000000018000F305                 db    0
.data:000000018000F306                 db  4Ch ; L
.data:000000018000F307                 db    0
.data:000000018000F308                 db  53h ; S
.data:000000018000F309                 db    0
.data:000000018000F30A                 db  68h ; h
.data:000000018000F30B                 db    0
.data:000000018000F30C                 db  69h ; i
.data:000000018000F30D                 db    0
.data:000000018000F30E                 db  66h ; f
.data:000000018000F30F                 db    0
.data:000000018000F310                 db  74h ; t
.data:000000018000F311                 db    0
.data:000000018000F312                 db  3Eh ; >
.data:000000018000F313                 db    0
.data:000000018000F314                 db  3Ch ; <
```

Select all of the data and press **A**, which should arrange it into more legible data, although every second byte is a 0, so we will need to remove them.

```
.data:000000018000F2F0 asc_18000F2F0   db '<',0,'#',0,'R',0,'S',0,'h',0,'i',0,'f',0,'t',0,'>',0,'<',0,'#',0,'L'
.data:000000018000F2F0                                         ; DATA XREF: sub_1800017D0+A↑o
.data:000000018000F2F0                                         ; sub_1800022C0+883↑o ...
.data:000000018000F2F0                 db 0,'S',0,'h',0,'i',0,'f',0,'t',0,'>',0,'<',0,'#',0,'R',0,'C',0,'t',0
.data:000000018000F2F0                 db 'r',0,'l',0,'>',0,'<',0,'#',0,'L',0,'C',0,'t',0,'r',0,'l',0,'>',0,'<'
.data:000000018000F2F0                 db 0,'!',0,'R',0,'S',0,'h',0,'i',0,'f',0,'t',0,'>',0,'<',0,'!',0,'L',0
.data:000000018000F2F0                 db 'S',0,'h',0,'i',0,'f',0,'t',0,'>',0,'<',0,'!',0,'R',0,'C',0,'t',0,'r'
.data:000000018000F2F0                 db 0,'l',0,'>',0,'<',0,'!',0,'L',0,'C',0,'t',0,'r',0,'l',0,'>',0,'-',0
.data:000000018000F2F0                 db '+',0,'[',0,']',0,'\',0,';',0,'/',0,'`',0,27h,0,',',0,'.',0,'<',0,'P'
.data:000000018000F2F0                 db 0,'a',0,'g',0,'e',0,'U',0,'p',0,'>',0,'<',0,'P',0,'a',0,'g',0,'e',0
.data:000000018000F2F0                 db 'D',0,'o',0,'w',0,'n',0,'>',0,'<',0,'N',0,'u',0,'m',0,'L',0,'o',0,'c'
.data:000000018000F2F0                 db 0,'k',0,'>',0,'<',0,'r',0,'/',0,'>',0,'<',0,'r',0,'*',0,'>',0,'<',0
.data:000000018000F2F0                 db 'r',0,'-',0,'>',0,'<',0,'r',0,'+',0,'>',0,'<',0,'r',0,'1',0,'>',0,'<'
.data:000000018000F2F0                 db 0,'r',0,'2',0,'>',0,'<',0,'r',0,'3',0,'>',0,'<',0,'r',0,'4',0,'>',0
.data:000000018000F2F0                 db '<',0,'r',0,'5',0,'>',0,'<',0,'r',0,'6',0,'>',0,'<',0,'r',0,'7',0,'>'
.data:000000018000F2F0                 db 0,'<',0,'r',0,'8',0,'>',0,'<',0,'r',0,'9',0,'>',0,'<',0,'r',0,'0',0
.data:000000018000F2F0                 db '>',0,'<',0,'r',0,'.',0,'>',0,'<',0,'F',0,'1',0,'>',0,'<',0,'F',0,'2'
.data:000000018000F2F0                 db 0,'>',0,'<',0,'F',0,'3',0,'>',0,'<',0,'F',0,'4',0,'>',0,'<',0,'F',0
.data:000000018000F2F0                 db '5',0,'>',0,'<',0,'F',0,'6',0,'>',0,'<',0,'F',0,'7',0,'>',0,'<',0,'F'
.data:000000018000F2F0                 db 0,'8',0,'>',0,'<',0,'F',0,'9',0,'>',0,'<',0,'F',0,'1',0,'0',0,'>',0
.data:000000018000F2F0                 db '<',0,'F',0,'1',0,'1',0,'>',0,'<',0,'F',0,'1',0,'2',0,'>',0,'<',0,'D'
.data:000000018000F2F0                 db 0,'o',0,'w',0,'n',0,'>',0,'<',0,'U',0,'p',0,'>',0,'<',0,'R',0,'i',0
.data:000000018000F2F0                 db 'g',0,'h',0,'t',0,'>',0,'<',0,'L',0,'e',0,'f',0,'t',0,'>',0,'<',0,'D'
.data:000000018000F2F0                 db 0,'e',0,'l',0,'>',0,'<',0,'P',0,'r',0,'i',0,'n',0,'t',0,'>',0,'<',0
.data:000000018000F2F0                 db 'E',0,'n',0,'d',0,'>',0,'<',0,'I',0,'n',0,'s',0,'e',0,'r',0,'t',0,'>'
.data:000000018000F2F0                 db 0,'<',0,'C',0,'a',0,'p',0,'s',0,'L',0,'o',0,'c',0,'k',0,'>',0,'<',0
.data:000000018000F2F0                 db 'E',0,'n',0,'t',0,'e',0,'r',0,'>',0,'<',0,'B',0,'a',0,'c',0,'k',0,'s'
.data:000000018000F2F0                 db 0,'p',0,'a',0,'c',0,'e',0,'>',0,'<',0,'E',0,'s',0,'c',0,'>',0,'<',0
.data:000000018000F2F0                 db 'T',0,'a',0,'b',0,'>',0
```

After removing the 0’s, we are left with this:

```
<#RShift> <#LShift> <#RCtrl> <#LCtrl> <!RShift> <!LShift> <!RCtrl> <!LCtrl> - + [] \
; / ` ' , . <PageUp> <PageDown> <NumLock> <r/> <r*> <r-> <r+> <r1> <r2> <r3> <r4>
<r5> <r6> <r7> <r8> <r9> <r0> <r.> <F1> <F2> <F3> <F4> <F5> <F6> <F7> <F8> <F9>
<F10> <F11> <F12> <Down> <Up> <Right> <Left> <Del> <Print> <End> <Insert> <CapsLock>
<Enter> <Backspace> <Esc> <Tab>
```

We can assume that this data is used to log keystrokes when pushing certain buttons such as Left Shift and NumLock, rather than regular characters. To double check that the decryption worked, we can run it in a debugger and check the output. Now that we have successfully decrypted the first part, we can do the same to each of the 19 sections of data that are encrypted. If you want to view each decrypted string, you can check them out **here**. One particularly interesting string in the data is **msimm.dat**, which could be the log file. In addition to **msimm**, one of the strings seemed to indicate the version of said keylogger, as well as a possible name for it: **KSLoT Ver = 21.0**, although I haven't found anything interesting linked to the name **KSLoT** – yet.

As this post is longer than what I planned it to be, I decided to split them into sections, as there is quite a lot of decryption and functions to analyze – especially since it is static analysis. I am focusing on this approach mainly to demonstrate and teach people that you can still get a lot done through static analysis methods, even if you can't afford the full version of IDA Pro (which I certainly can't!), as well as how to use IDC to automate time consuming tasks. In the next part we will be decrypting some more stuff, and then actually locating the loop that performs the keylogging – this should be out soon!

IOC (MD5):

> **Keylogger:** 59b57bdabee2ce1fb566de51dd92ec94