What's new in TrickBot? Deobfuscating elements

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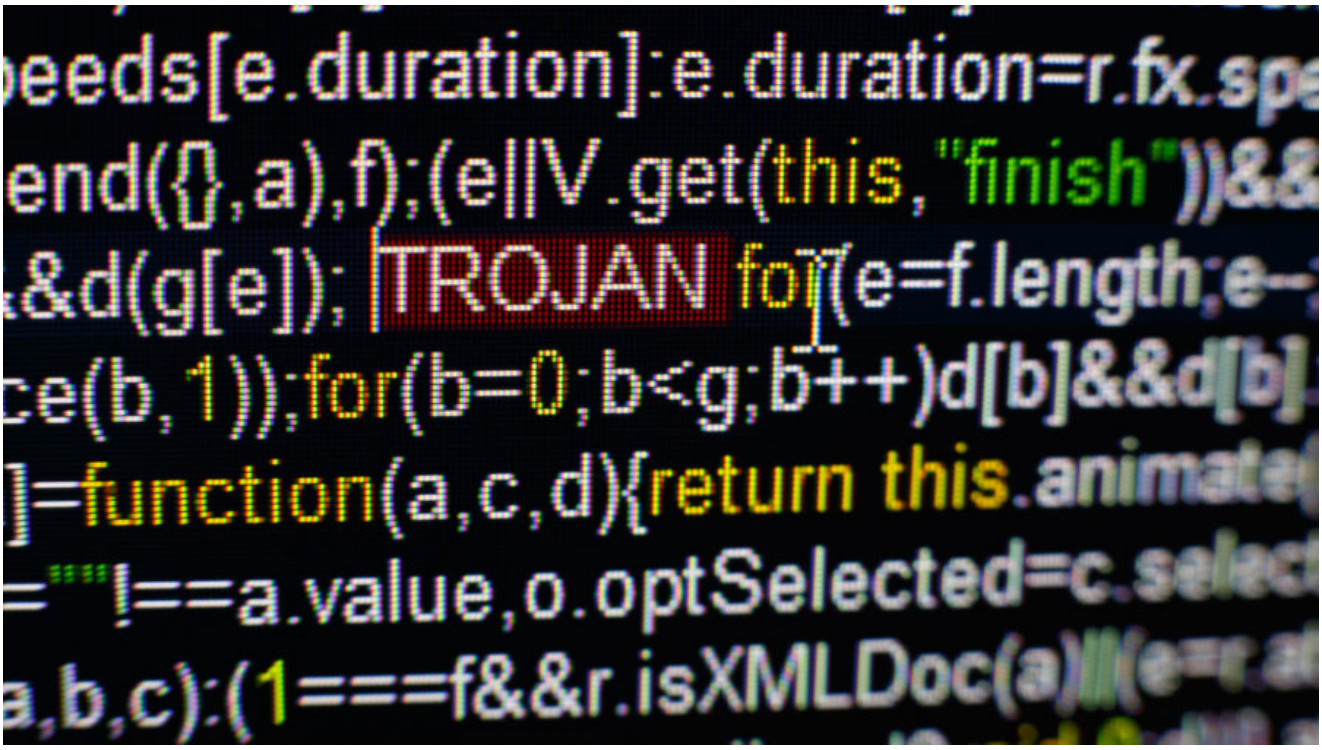
hasherezade November 12, 2018



Trojan.TrickBot has been present in the threat landscape from quite a while. We wrote about its first version in October 2016. From the beginning, it was a well organized modular malware, written by developers with mature skills. It is often called a banker, however its modular structure allows to freely add new functionalities without modifying the core bot. In fact, the functionality of a banker is represented just by one of many of its modules.

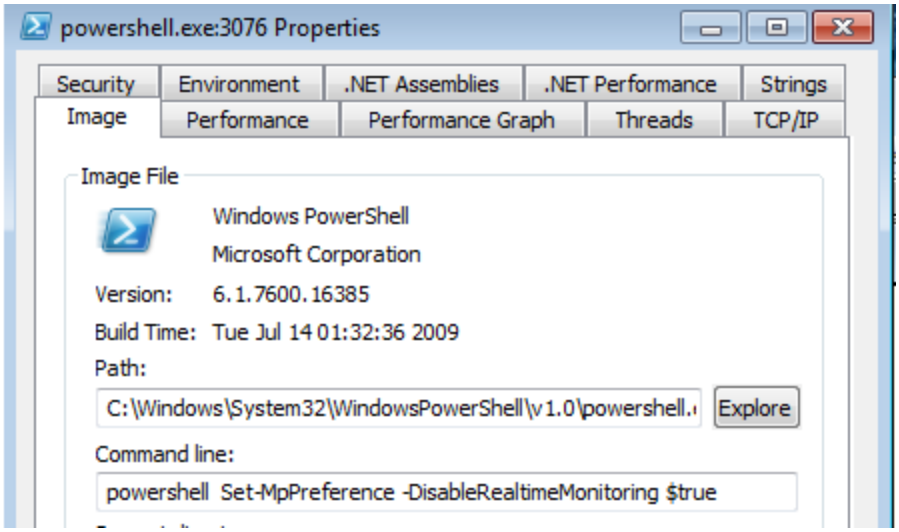
With time, developers extended TrickBot capabilities by implementing new modules – for example, the one for stealing Outlook credentials. But the evolution of the core bot, that was used for the deployment of those modules, was rather slow. The scripts written to decode modules from the first version worked till recent months, showing that the encryption schema used to protect them stayed unchanged.

October 2018 marks end of the second year since TrickBot's appearance. Possibly the authors decided to celebrate the anniversary by a makeover of some significant elements of the core.

This post will be an analysis of the updated obfuscation used by TrickBot's main module.

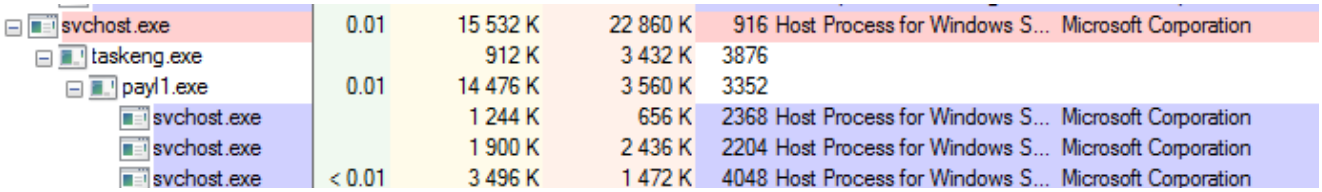
Behavioral analysis

The latest TrickBot starts its actions from disabling Windows Defender's real-time monitoring. It is done by deploying a PowerShell command:

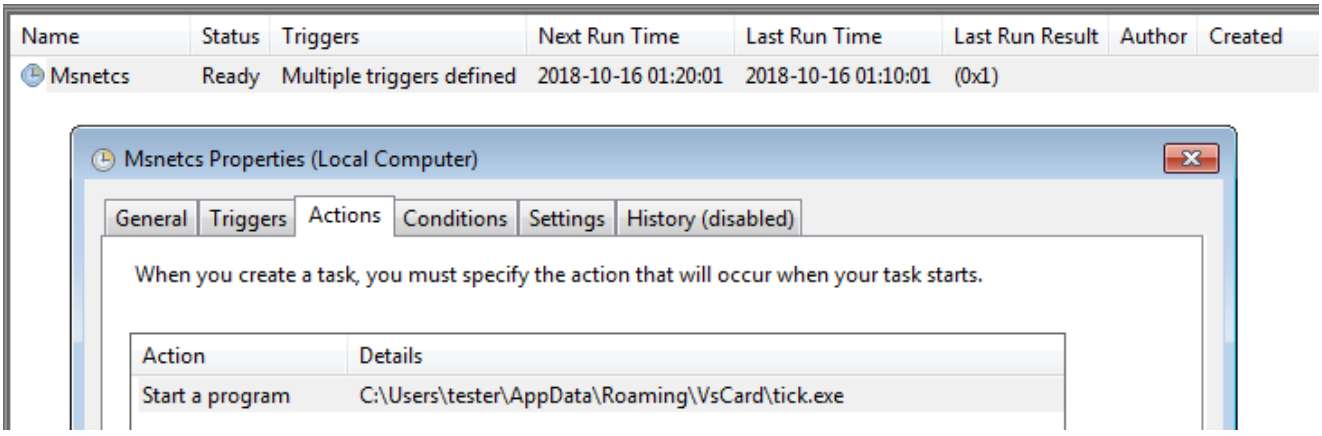


After that, we can observe behaviors typical for TrickBot.

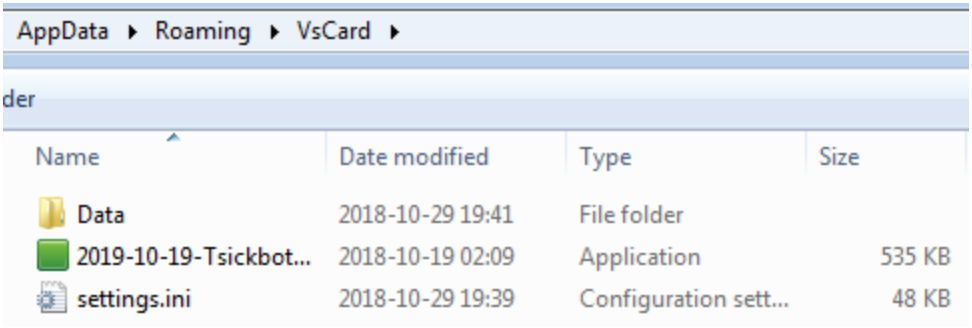
As before, the main bot deploys multiple instances of svchost, where it injects the modules.



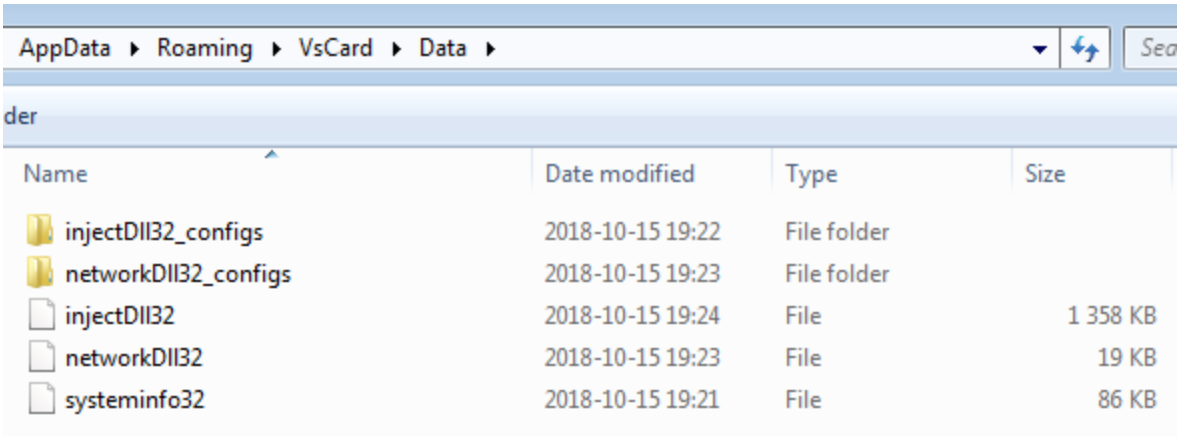
Persistence is achieved by adding a scheduled task:



It installs itself in %APPDATA%, in a folder with a name that depends on the bot's version.

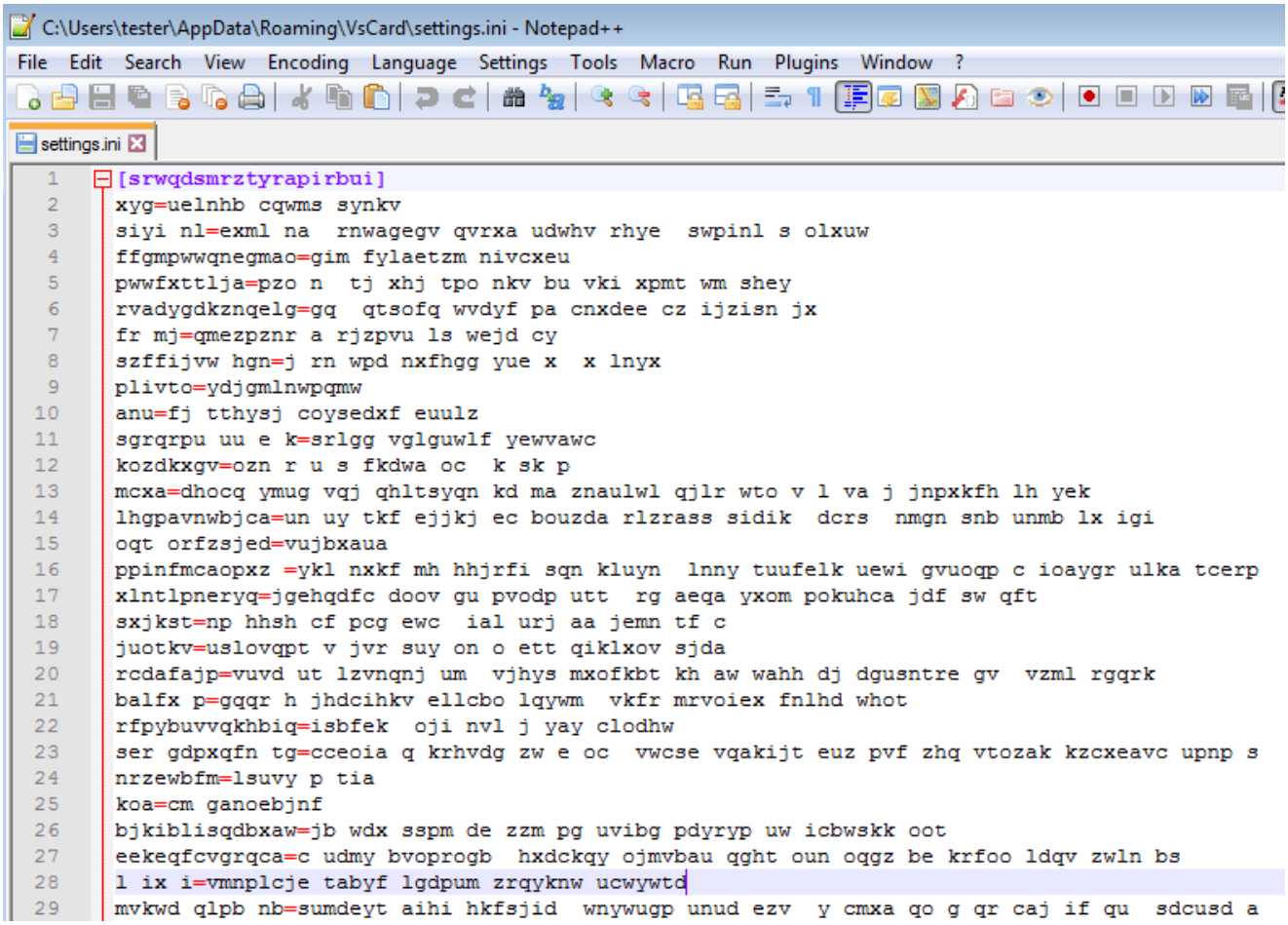


Encrypted modules are stored in the Data folder (old name: Modules), along with their configuration:



As it turns out, recently the encryption of the modules has changed (and we had to update the scripts for decoding).

The new element in the main installation folder is the settings file, that comes under various names, that seems to be randomly chosen from some hardcoded pool. It's most commonly occurring name is settings.ini (hardcoded), but there are other variants such as: profiles.ini, SecurityPreloadState.txt, pkcs11.txt. The format of the file looks new for the TrickBot:



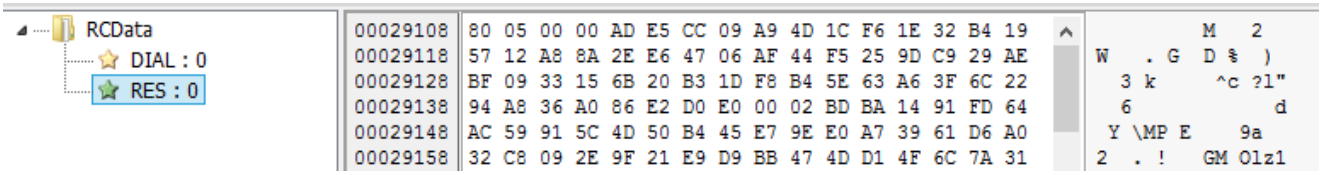
We can see many strings, that at first looks scrambled/encrypted. But as it turns out, they are junk entries that are added for obfuscation. The real configuration is stored in between of them, in a string that looks like base64 encoded. Its meaning will be explained in the further part of this post.

```
gkdqmyvzaas =lbvkse ihp eq qeclqa ovnumdj sdju  tgs  xsmfwu ht cyto wwi x  a fow  vu
gsbkrzugq=gqe dsfcl zry evr oweu jjaq soipxm o
ayjq=f uyr  swiq xqbrs rji ko
[ConfigUration]
luyispgm=RV/1PUCJN2R4OmVzSUFQPUiBP/VzPAZ1SAh7O1eBNAR8N1fIS/OJRUOCRkR2PAOAOkF2P/CBNAWJSkFQO2V4PlH1NUZoNUmoOAF9FAhhPlH9PH
enli=sfut gcj sw bsvwcroc kw glkck he mub  qney bnavxmvt qjcnj pmyv ufz b m xbf
cwppxxnfrpslcd=tvynmfoy kql ldk ne
eh grmymiax=nnzs jqddtq dhxucgj pqtg v wbq soun pqggkjt  obm gcxkje bl
qjr=kjzd zfcgx be  vfrms pjqh
sviqwpa cap=epst sc lt gsdc kx yvve e qb ae iwb ymeprp q
lobnqfuel =hvhi zvscitw pk zxfg xquaz ex af ykupfdf
```

Inside

In order to better understand the changes, we need to take a deep dive in the code. As always, the original sample comes packed – this time there are two layers of protection to be removed before we get the main bot.

The main bot comes with 2 resources: RES and DIAL, that are analogical to the resources used before.



RES – is an encrypted configuration file, in XML format. It is encrypted in the same way as before (using AES, with key derived by hashing rounds), and we can decode it using an old script: trickbot_config_decoder.py. (Mind the fact that the first DWORD in the resource is a size, and not a part of the encrypted data – so, it needs to be removed before using the script).

DIAL – is an elliptic curve public key (ECC curve p-384), that is used to verify the signature of the aforementioned encrypted configuration, after it is decrypted.

Obfuscation

In the first edition, TrickBot was not at all obfuscated – we could even find all the strings in clear. During the two years of evolution, it has slowly changed. Several months ago, the authors decided to obfuscate all the strings, using a custom algorithm (based on base64). All the obfuscated strings are aggregated from a single hardcoded list:

```
.rdata:00427C44 ; int str_list
.rdata:00427C44 str_list        dd 4F6633h              ; DATA XREF: decode_from_the_list+9↑r
.rdata:00427C44                                         ; .rdata:00427C48↓o
.rdata:00427C48                 dd offset str_list
.rdata:00427C4C                 dd offset a3b           ; "3b"
.rdata:00427C50                 dd offset aKinywv       ; "KInyWv"
.rdata:00427C54                 dd offset aW4pobt1qcKdxo ; "W4PoBt1QC+KDxO"
.rdata:00427C58                 dd offset aSdp9fxf4     ; "sdP9FXf4"
.rdata:00427C5C                 dd offset aC609sluqbxnBxn ; "C609sLuQBXn/BXNneXnAs5yUbfb"
.rdata:00427C60                 dd offset aC609sluqbxnBxu ; "C609sLuQBXn/BXuT15ymsL89FdbMW4Po"
.rdata:00427C64                 dd offset aKiuwb4o      ; "KIuWb4O"
.rdata:00427C68                 dd offset aFxnLxf4      ; "FXn/lXf4"
.rdata:00427C6C                 dd offset aFdvqbx09xyknsv ; "FdVQBX09xYKnsv"
.rdata:00427C70                 dd offset aOqnusm       ; "oQnUSM"
.rdata:00427C74                 dd offset aN3mn3        ; "N+3MN+3"
.rdata:00427C78                 dd offset aXyyc         ; "xYyc"
.rdata:00427C7C                 dd offset aLxdo         ; "lXDO"
.rdata:00427C80                 dd offset aWzkaxv       ; "wzKaxv"
.rdata:00427C84                 dd offset aC6vasdnzwd1tfd ; "C6VAsdnzwd1TFdC"
.rdata:00427C88                 dd offset aL1nxm        ; "l+1nxM"
.rdata:00427C8C                 dd offset aO4fw         ; "o4fW"
.rdata:00427C90                 dd offset aSyntlYglxpz  ; "sYNTl+yglXPz"
.rdata:00427C94                 dd offset aN3mxdk8xzb   ; "N+3MxDK8xzb"
.rdata:00427C98                 dd offset aOdnwfif1     ; "oDnWfIf1"
.rdata:00427C9C                 dd offset aJpv7flomldfhx6 ; "JpV7FLOMldfHx6nTFqQm3S7OBmynFd1TsXnAs/Q"...
.rdata:00427CA0                 dd offset aJpk9flfoxdnzs6 ; "JPK9FLfoxdnzs6fHJMjkodfOs+K91XnTFq7RJIn"...
```

When any of them is needed, it is selected by its index and passed to the decoding function:

```
0040E930 decode_from_the_list proc near
0040E930
0040E930 arg_0= dword ptr  8
0040E930 arg_4= dword ptr  0Ch
0040E930
0040E930 push    ebp
0040E931 mov     ebp, esp
0040E933 mov     eax, [ebp+arg_4]
0040E936 mov     ecx, [ebp+arg_0]
0040E939 mov     edx, ds:str_list[ecx*4]
0040E940 push    eax             ; int
0040E941 push    edx             ; Src
0040E942 call    decode_string
0040E947 add     esp, 8
0040E94A pop     ebp
0040E94B retn
0040E94B decode_from_the_list endp
```

Example – string fetched by the index 162:

```
00402E4D push    esi
00402E4E lea     eax, [ebp+Dest]
00402E54 push    162             ; "D:(A;;GA;;;WD)(A;;GA;;;BA)(A;;GA;;;SY)(A;;GA;;;RC)"
00402E59 push    eax
00402E5A call    decode_and_convert_to_wchar
00402E5F mov     eax, dword_42A648
00402E64 add     esp, 8
00402E67 push    0
00402E69 lea     ecx, [ebp+var_4]
00402E6C push    ecx
00402E6D mov     ecx, [eax+174h]
00402E73 push    1
00402E75 lea     edx, [ebp+Dest]
00402E7B push    edx
00402E7C call    ecx             ; ADVAPI32.ConvertStringSecurityDescriptorToSecurityDescriptorW
00402E7E test    eax, eax
```

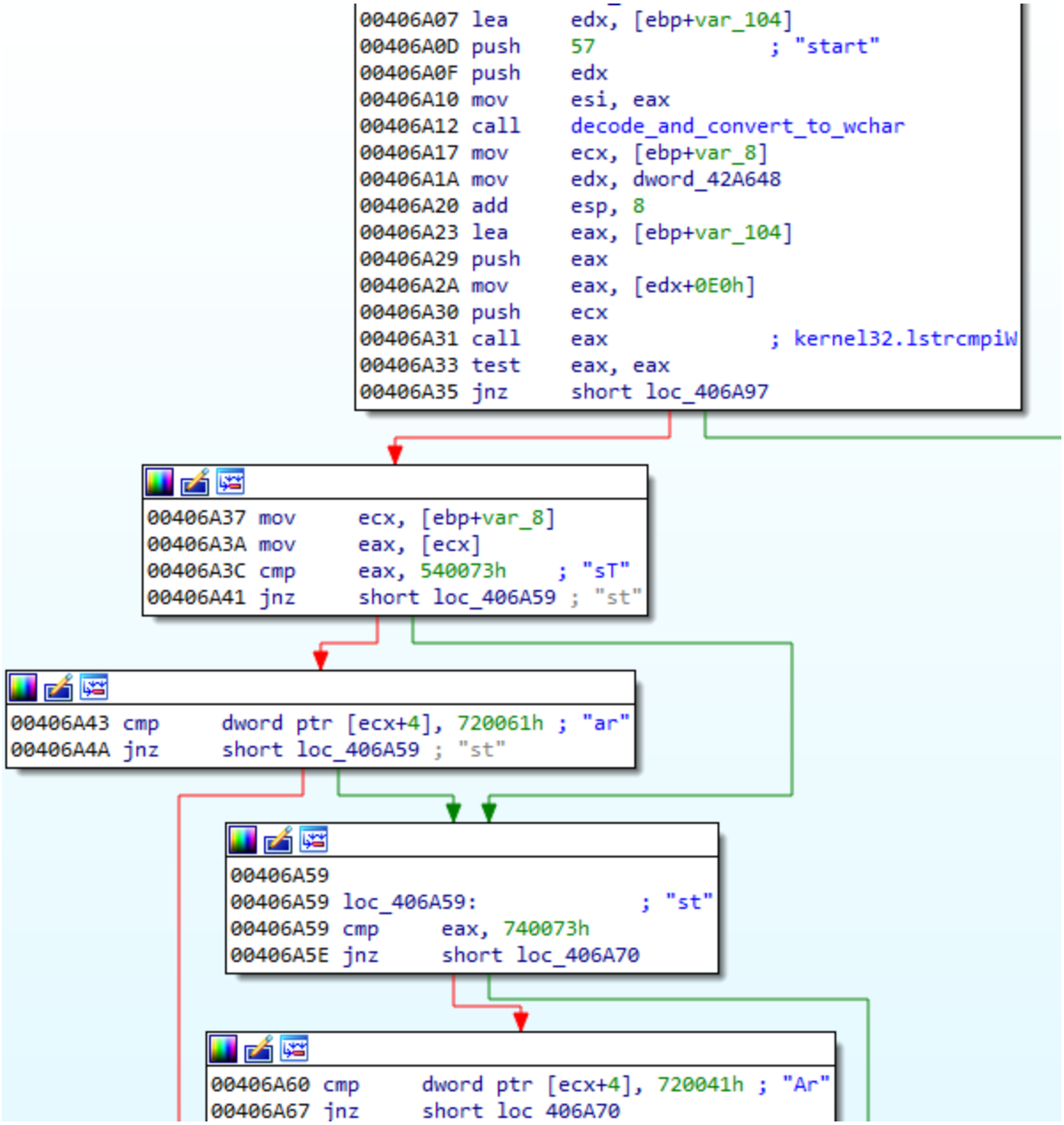
The deobfuscation process, along with the used utility, was described here. Due to the fact that the API of the decoding functions didn't change since then, the same method can be used until today. The list of deobfuscated strings, extracted from the currently analyzed sample can be found here.

Additionally, we can find other, more popular methods of strings obfuscation. For example, some of the strings that are divided into chunks, one DWORD per each:

```
0041F2D1 push    0FDE9h
0041F2D6 push    edx
0041F2D7 mov     [ebp+var_80], 7261h ; ar
0041F2DE mov     [ebp+var_84], 7A61622Eh ; .baz
0041F2E8 mov     [ebp+var_88], 74737572h ; rust
0041F2F2 mov     [ebp+var_8C], 74656661h ; afet
0041F2FC mov     [ebp+var_90], edi
0041F302 call    multibyte_to_wide
0041F307 add     esp, 10h
```

The same method was used by GandCrab, and can be deobfuscated with the following script.

Similarly, the Unicode strings are divided:



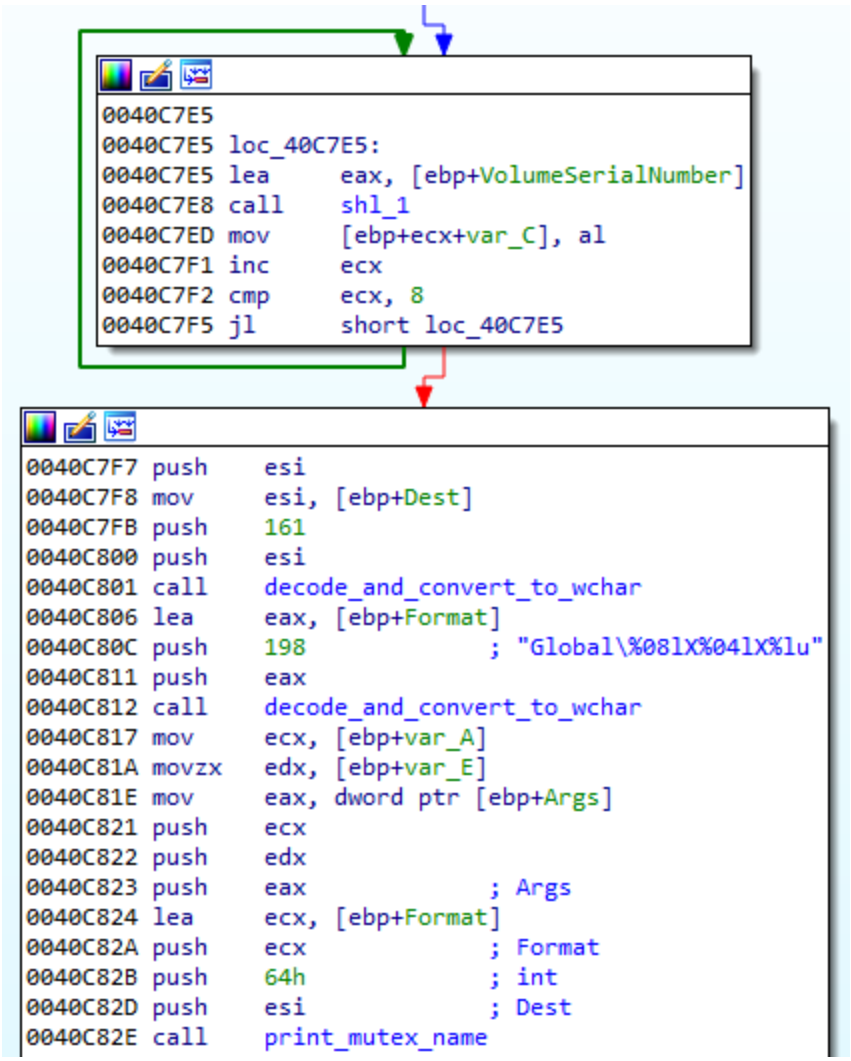
Most of the imports used by TrickBot are loaded dynamically. That makes static analysis more difficult, because we cannot directly see the full picture: the pointers are retrieved just before they are used.

We can solve this problem in various ways, i.e. by adding tags by an automated tracer. Created CSV/tags file for one of the analyzed samples is available here (it can be loaded to the IDA database with the help of IFL plugin).

The picture given below shows the fragment of TrickBot's code after the tags are loaded. As we can see, the addresses of the imported functions are retrieved from the internal structure rather than from the standard Import Table, and then they are called via registers.

```
0040BA8B mov     ecx, my_context
0040BA91 mov     edx, [ecx+80h]
0040BA97 push    eax
0040BA98 call    edx             ; kernel32.ResetEvent
0040BA9A mov     eax, [esi+80h]
0040BAA0 mov     ecx, my_context
0040BAA6 mov     edx, [ecx+80h]
0040BAAC push    eax
0040BAAD call    edx             ; kernel32.ResetEvent
0040BAAF mov     eax, [ebp+arg_4]
0040BAB2 mov     ecx, my_context
0040BAB8 mov     edx, [ecx+94h]
0040BABE push    eax
0040BABF call    edx             ; kernel32.ResumeThread
0040BAC1 test    eax, eax
0040BAC3 jz      short loc_40BB02
```

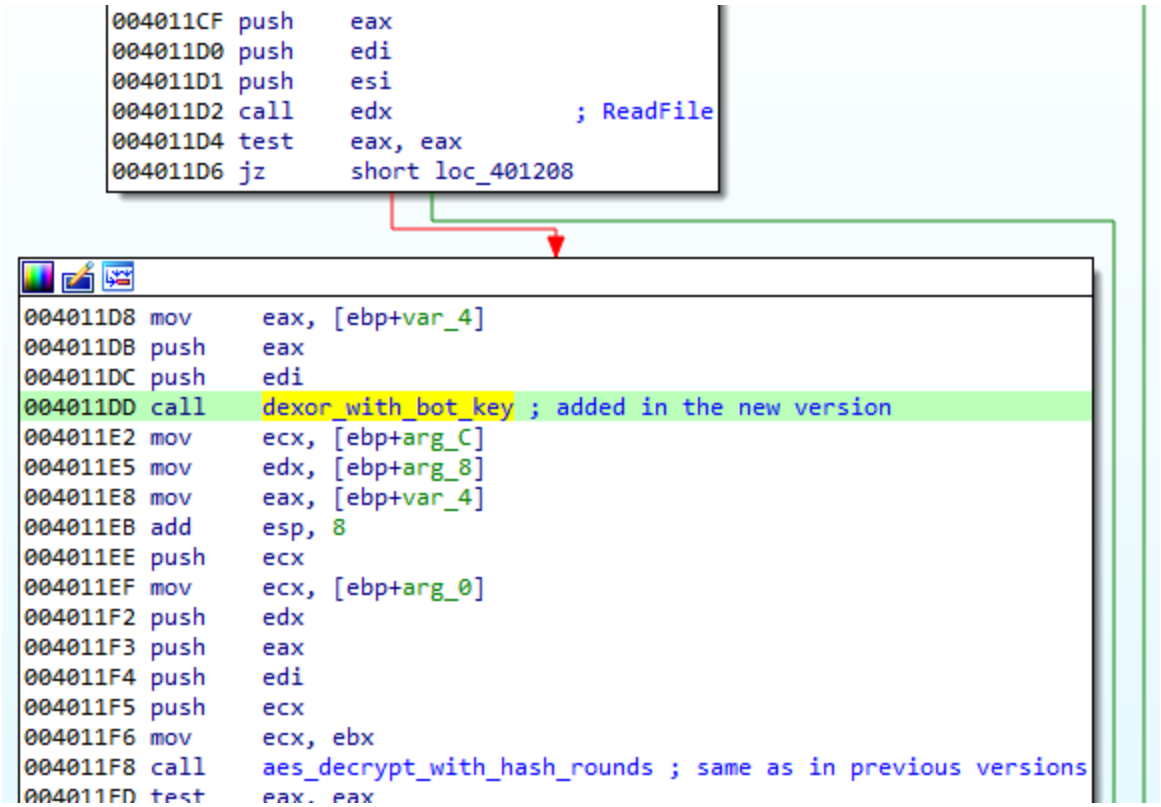
Apart from the mentioned obfuscation methods, on the way of its evolution, TrickBot is going in the direction of string randomization. Many strings that were hardcoded in the initial versions are now randomized or generated per victim machine. For example the mutex name:



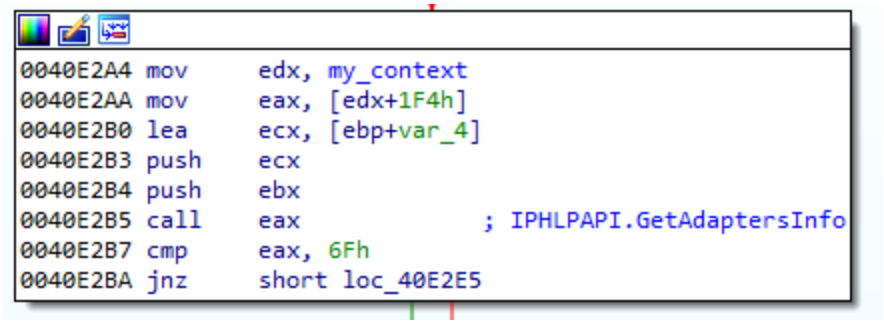
Used encryption

In the past, modules were encrypted by AES in CBC mode. The key used for encryption was derived by hashing initial bytes of the buffer. Once knowing the algorithm, we could easily decrypt the stored modules along with their configuration.

In the recent update the authors decided to complicate it a bit. Yet they didn't change the main algorithm, but just introduced an additional XOR layer. Before the data is passed to the AES, it is first XORed with a 64 character long, dynamically generated string, that we will refer as the bot key:



The mentioned bot key is generated per victim machine. First, GetAdapterInfo function is used:



The retrieved structure (194 bytes) is hashed by SHA256 and then the hash is converted into string:

```
0040E2E5 loc_40E2E5:             ; CALG_SHA_256
0040E2E5 push    800Ch
0040E2EA lea     edx, [ebp+var_C]
0040E2ED push    edx
0040E2EE lea     eax, [ebp+var_8]
0040E2F1 push    eax
0040E2F2 push    194h            ; size to be hashed
0040E2F7 lea     ecx, [ebx+8]
0040E2FA push    ecx             ; *IPADAPTER_INFO + 8
0040E2FB lea     ecx, [edi+4FCh]
0040E301 call    crypt_hash_data
0040E306 test    eax, eax
```

The reconstructed algorithm to generate the Bot Key (and the utility to generate the keys) can be found here.

This key is then stored in the dropped settings file.

```
00423D03 push    edi
00423D04 push    ebx
00423D05 push    esi
00423D06 call    eax             ; ReadFile
00423D08 test    eax, eax
00423D0A jz      short loc_423D32

00423D0C mov     ecx, my_context
00423D12 mov     edx, [ecx+0F8h]
00423D18 push    esi
00423D19 call    edx             ; KiFastSystemCallRet
00423D1B mov     eax, [ebp+arg_4]
00423D1E mov     ecx, [ebp+var_8]
00423D21 push    eax
00423D22 push    ecx
00423D23 push    ebx
00423D24 or      esi, 0FFFFFFFFh
00423D27 call    parse_settings_file
```

Encoding settings

As mentioned before, new editions of TrickBot drop a new settings file, containing some encoded information. Example of the information that is stored in the settings:

```
0441772F66559A1C71F4559DC4405438FC9B8383CE1229139257A7FE6D7B8DE9 1085117245 5 6 13
```

The elements:

1. the BotKey (generated per machine)

2. a checksum of a test string: (0-256 bytes encoded with the same charset) – used for the purpose of a charset validation

3. three random numbers

The whole line is base64 encoded using a custom charset, that is generated basing on the hardcoded one:
“HJIA/CB+FGKLNOP3RSlUVWXYZfbcdeaghi5kmn0pqrstuvwx89o12467MEDyzQjT”.

```
00422110 push    ebp
00422111 mov     ebp, esp
00422113 sub     esp, 5ACh
00422119 push    ebx
0042211A push    esi
0042211B mov     esi, charset    ; "HJIA/CB+FGKLNOP3RSlUVWXYZfbcdeaghi5kmn0pqrstuvwx89o12467MEDyzQjT"
00422121 push    edi
00422122 mov     ecx, 10h
00422127 lea     edi, [ebp+var_68]
0042212A rep movsd
0042212C mov     ecx, dword_42A668
00422132 xor     ebx, ebx
00422134 call    load_my_botkey  ; eax = botkey
00422139 xor     esi, esi
```

Yet, even at this point we can see the effort of the authors to avoid using repeatable patterns. The last 8 characters of the charset are swapped randomly. The pseudocode of the generation algorithm:

```
if ( !g_Charset_copy )
{
  g_Charset_copy = alloc_on_heap(64, 0);
  qmemcpy((void *)g_Charset_copy, base64_charset, 64u);
  random_swap_last_n_characters(g_Charset_copy, 8u);
  v9 = out_buffer_1;
}
```

Randomization of the n characters:

```
char __cdecl random_swap_last_n_characters(int charset, unsigned int num)
{
  char result; // al
  unsigned int charset_n_bgn; // edi
  unsigned int indx; // esi
  int v5; // ebx
  unsigned int rand_val; // edx

  result = num;
  charset_n_bgn = charset - num;
  indx = 0;
  if ( num )
  {
    do
    {
      do
      {
        v5 = rand();
        rand_val = (v5 + (unsigned int)randval_rdtsc()) % num;
      }
      while ( rand_val == indx );
      result = *(_BYTE *)(indx + charset_n_bgn + 64);
      *(_BYTE *)(indx++ + charset_n_bgn + 64) = *(_BYTE *)(rand_val + charset_n_bgn + 64);
      *(_BYTE *)(rand_val + charset_n_bgn + 64) = result;
    }
    while ( indx < num );
  }
  return result;
}
```

Example of the transformation:

inp: “HJIA/CB+FGKLNOP3RSlUVWXYZfbcdeaghi5kmn0pqrstuvwx89o12467**M**E**Dyz**Q**jT**”

out: “HJIA/CB+FGKLNOP3RSlUVWXYZfbcdeaghi5kmn0pqrstuvwx89o12467**jD**E**zTy**Q**M**”

The decoder can be found here: trick_settings_decoder.py

Slowly improving obfuscation

The authors of TrickBot never cared much about obfuscation. With time they slowly started to introduce its elements, but, apart from some twists, it’s still nothing really complex. We can rather expect that this trend will not change rapidly, and after updating the scripts for new additions, decoding Trick Bot elements will be as easy for the analysts as it was before.

It seems that the authors believe in a success based on quantity of distribution, rather than on attempts of being stealthy in the system. They also focus on constant adding new modules, to diversify the functionality (i.e. recently, they added a new module for attacking Point-Of-Sale systems).

Scripts

Updated scripts for decoding TrickBot modules for malware analysts: https://github.com/hasherezade/malware_analysis/tree/master/trickbot

Indicators of compromise

Sample hash:

```
9b6ff6f6f45a18bf3d05bba18945a83da2adfbe6e340a68d3f629c4b88b243a8
```