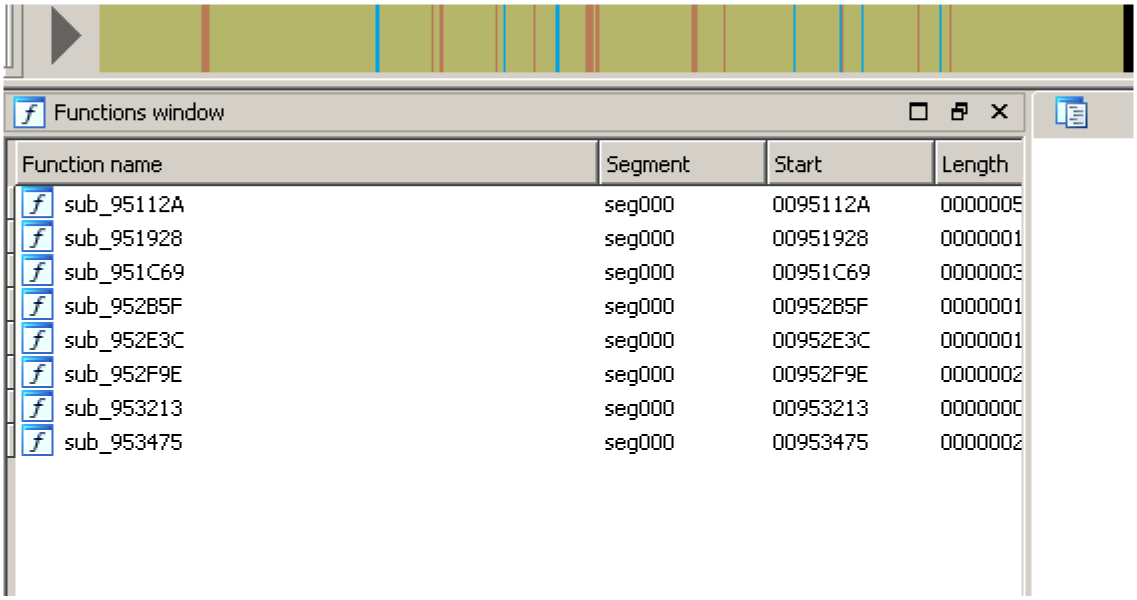
Knowledge Fragment: Unwrapping Fobber

byte-atlas.blogspot.ch/2015/08/knowledge-fragment-unwrapping-fobber.html

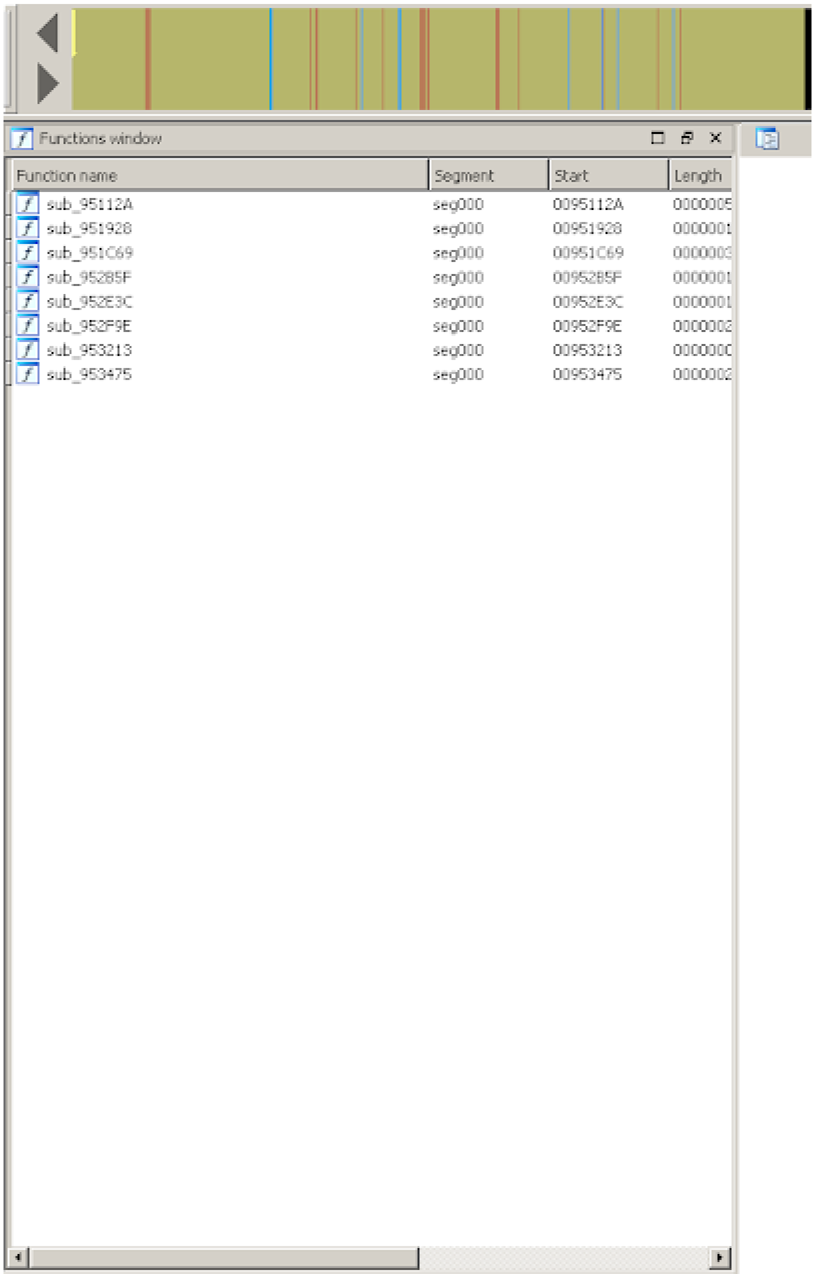


About two weeks ago I came across an interesting sample using an interesting anti-analysis pattern.
The anti-analysis technique can be best described as "runtime-only code decryption". This means prior to execution of a function, the code is decrypted, then executed and finally encrypted again, but with a different key.
Malwarebytes has already published an analysis on this family they called "Fobber". However, in this blog post I wanted to share how to "unwrap" the sample's encrypted functions for easier analysis. There is also another blog post detailing how to work around the string encryption.

The sample and code related to this blog post can be found on bitbucket.

Fobber's Function Encryption Scheme

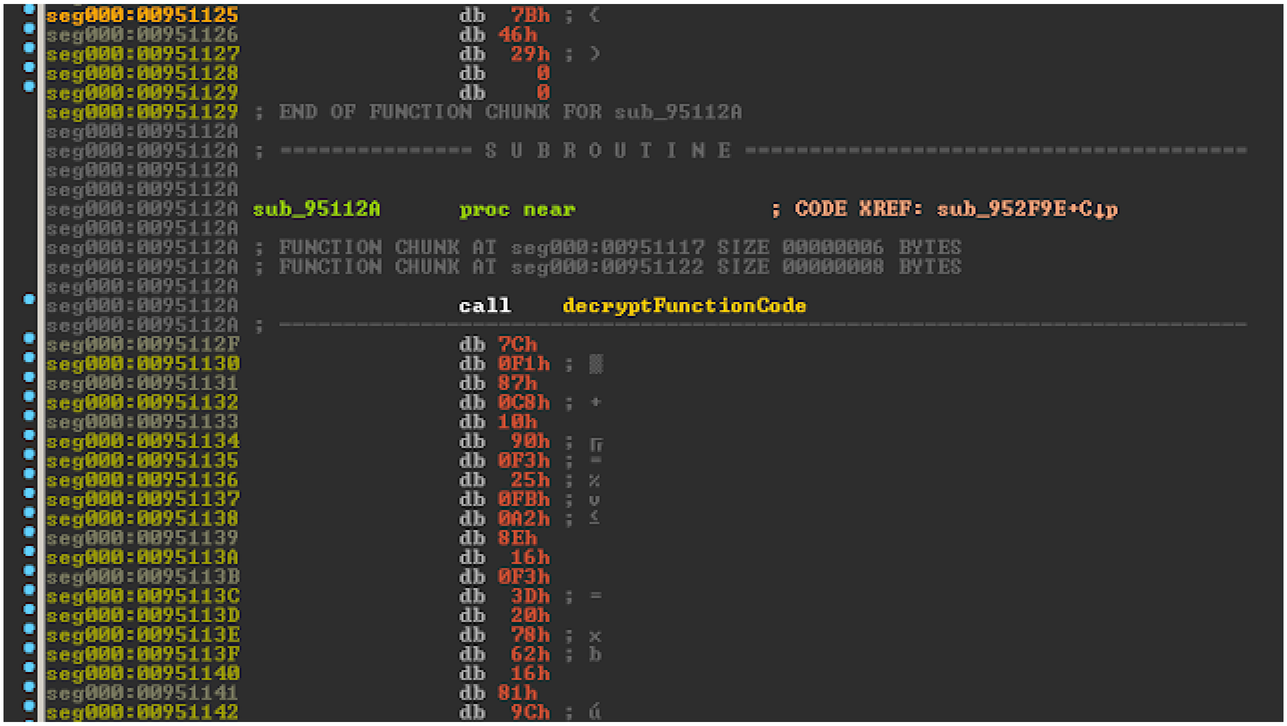
First off, let's have a look how Fobber looks in memory, visualized by IDA's function analysis:



IDA's first view on Fobber.

IDA only recognizes a handful of functions. Among these is the actual code decryption routine, as well as some code handling translating relevant addresses of the position independent code into absolute offsets.

Next, a closer look at how the on-demand decryption/encryption of functions works:



The Fobber-encrypted function sub_95112A, starting with call to decryptFunctionCode.

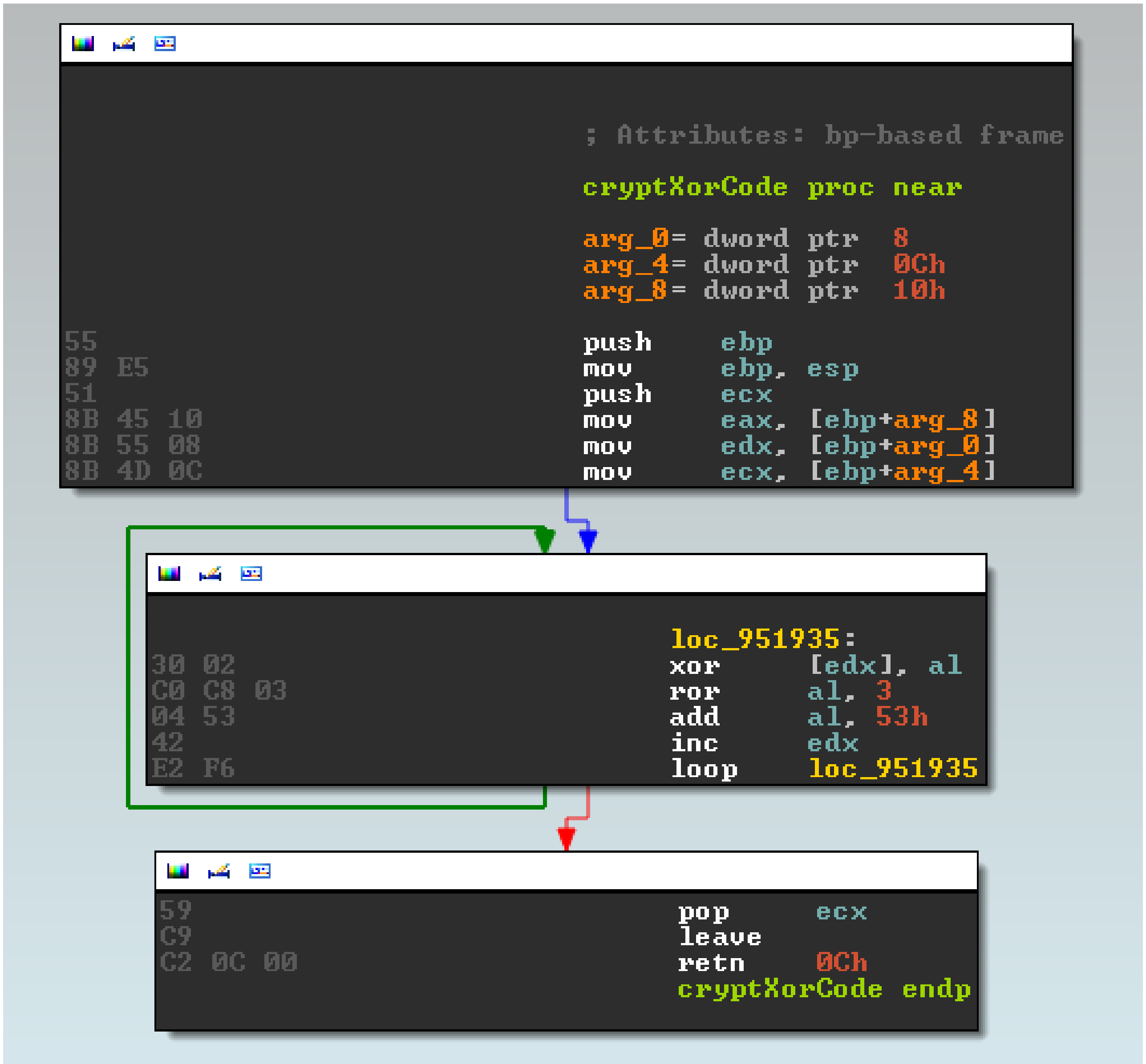
We can see that function sub_95112A starts with a call to what I renamed "decryptFunctionCode":

Fobber's on-demand decryption code for functions, revealing the parameter offsets neccessary for decryption.

This function does not make use of the stack, thus it is surrounded by a simple pushad/popad prologue/epilogue. We can see that some references are made relative to the return address (initially put into esi by copying from [esp+20h]):

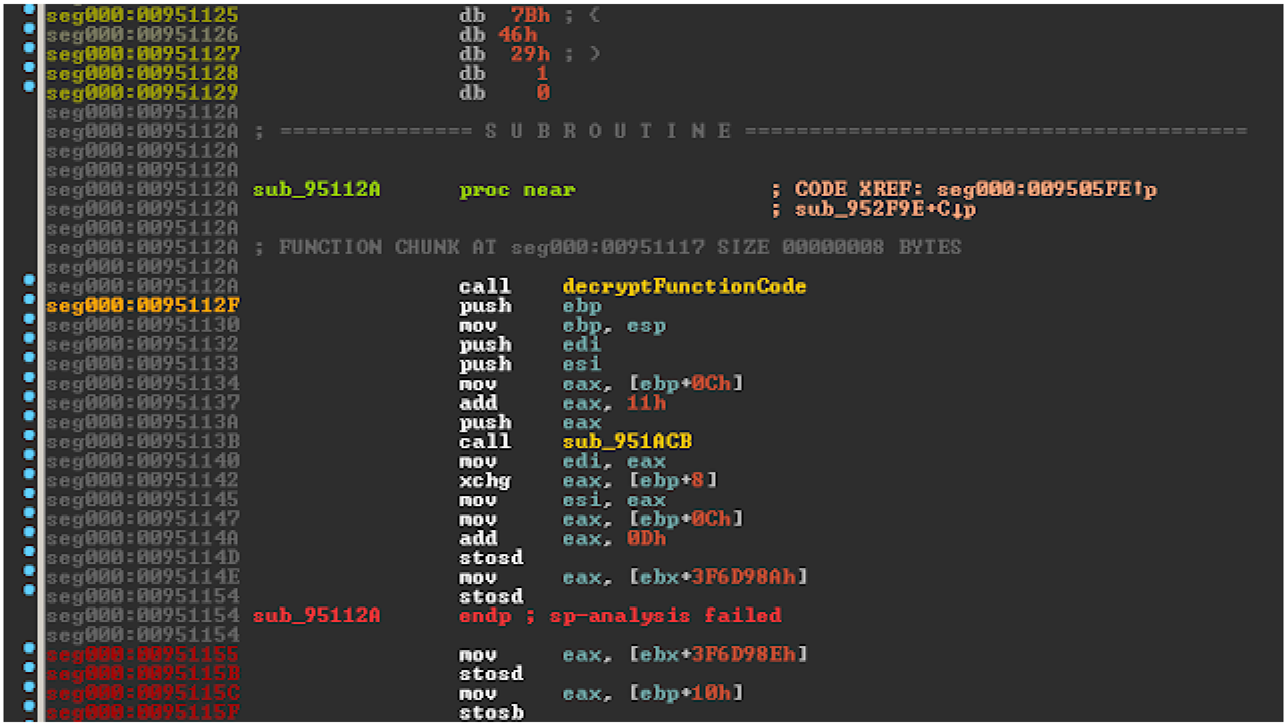
- Field [esi-7] contains a flag indicating whether or not the function is already decrypted.
- Field [esi-8h] contains the single byte key for encryption, while
- field [esi-Ah] contains the length of the encrypted function, stored xor'ed with 0x461F.

The actual cryptXorCode takes those values as parameters and then loops over the encrypted function body, xor'ing with the current key and then updating the key by rotating 3bit and adding 0x53.



Function for decrypting one function, given the neccessary parameters.

After decryption, our function makes a lot more sense and we can see the default function prologue (push ebp; mov ebp, esp) among other things.



```
seg000:00951125                 db  7Bh ; {
seg000:00951126                 db 46h
seg000:00951127                 db  29h ; )
seg000:00951128                 db    1
seg000:00951129                 db    0
seg000:0095112A
seg000:0095112A ; =============== S U B R O U T I N E =======================================
seg000:0095112A
seg000:0095112A
seg000:0095112A sub_95112A      proc near               ; CODE XREF: seg000:009505FE↑p
seg000:0095112A                                         ; sub_952F9E+C↓p
seg000:0095112A
seg000:0095112A ; FUNCTION CHUNK AT seg000:00951117 SIZE 00000008 BYTES
seg000:0095112A
seg000:0095112A                 call    decryptFunctionCode
seg000:0095112F                 push    ebp
seg000:00951130                 mov     ebp, esp
seg000:00951132                 push    edi
seg000:00951133                 push    esi
seg000:00951134                 mov     eax, [ebp+0Ch]
seg000:00951137                 add     eax, 11h
seg000:0095113A                 push    eax
seg000:0095113B                 call    sub_951ACB
seg000:00951140                 mov     edi, eax
seg000:00951142                 xchg    eax, [ebp+8]
seg000:00951145                 mov     esi, eax
seg000:00951147                 mov     eax, [ebp+0Ch]
seg000:0095114A                 add     eax, 0Dh
seg000:0095114D                 stosd
seg000:0095114E                 mov     eax, [ebx+3F6D98Ah]
seg000:00951154                 stosd
seg000:00951154 sub_95112A      endp ; sp-analysis failed
seg000:00951154
seg000:00951155                 mov     eax, [ebx+3F6D98Eh]
seg000:0095115B                 stosd
seg000:0095115C                 mov     eax, [ebp+10h]
seg000:0095115F                 stosb
```

The decrypted equivalent of function sub_95112A, revealing some "real" code.

Also note the parameters:

- 0x951125 - key: 0x7B
- 0x951126 - length: 0x4629^0x461F -> 0x36 bytes
- 0x951128 - encryption flag: 0x01

So far so good. Now let's decrypt all of those functions automatically.

Decrypt All The Things

First, we want to find our decryption function. For all Fobber samples I looked at, the regex r"\x60\x8B.\x24\x20\x66" was delivering unique results for locating the decryption function.

Next, we want to find all calls to this decryption function. For this we can use the regex r"\xE8" to find all potential "call rel_offset" instructions.
Then we just need to do some address math and check if the call destination (calculated as: image_base + call_origin + relative_call_offset + 5) is equal to the address of our decryption function.
Should this be the case, we can extract the parameters as described above and decrypt the code.

We then only need to exchange the respective bytes in our binary with the decrypted bytes. In the following code I also set the decryption flag and fix the function ending with a "retn" (0xC3) instruction to ease IDA's job of identifying functions afterwards. Otherwise, rinse/repeat until all functions are decrypted.

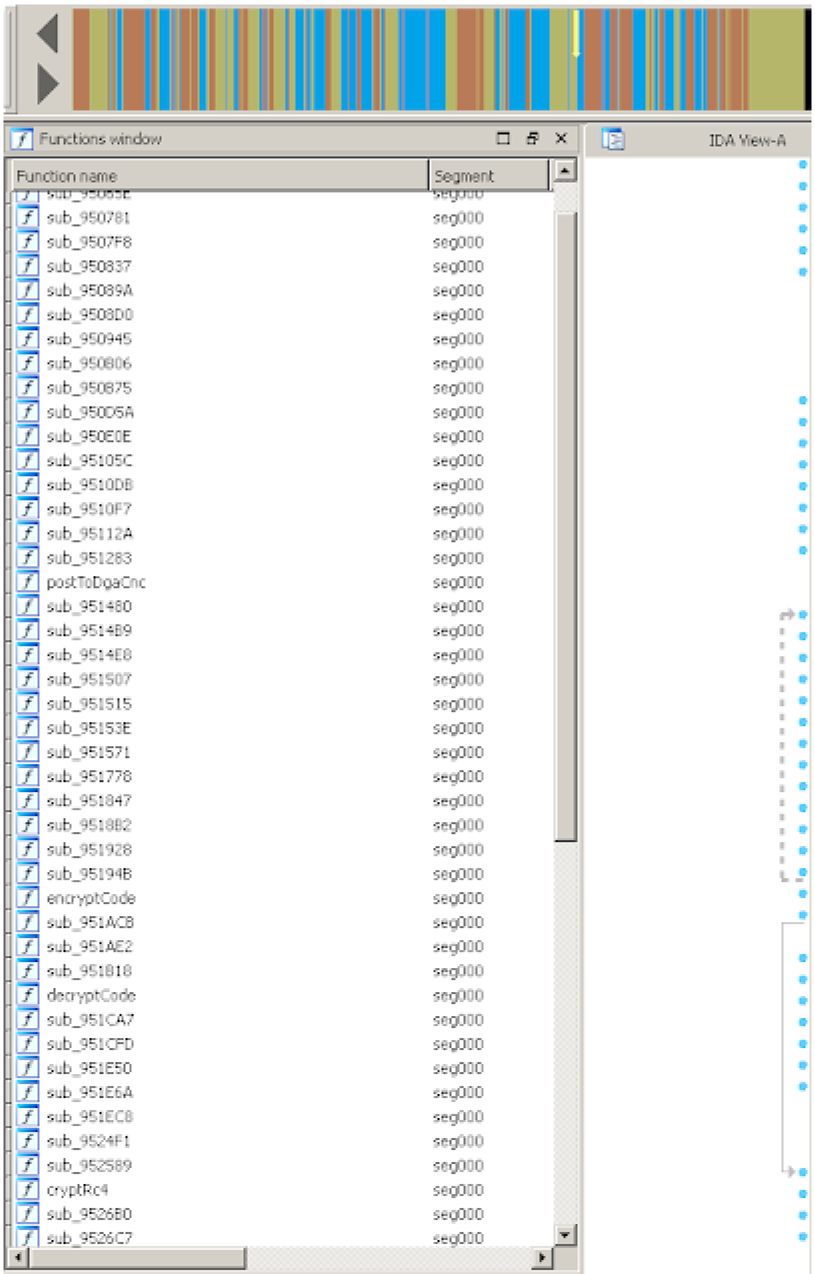
Code:

```
#!/usr/bin/env python

import re
import struct

def decrypt(buf, key):
    decrypted = ""
    for char in buf:
        decrypted += chr(ord(char) ^ key)
        # rotate 3 bits
        key = ((key >> 3) | (key << (8 - 3))) & 0xFF
        key = (key + 0x53) & 0xFF
    return decrypted

def replace_bytes(buf, offset, bytes):
    return buf[:offset] + bytes + buf[offset + len(bytes):]

def decrypt_all(binary, image_base):
    # locate decryption function
    decrypt_function_offset = re.search(r"\x60\x8B.\x24\x20\x66", binary).start()
    # locate all calls to decryption function
    regex_call = r"\xe8(?P<rel_call>.{4})"
    for match in re.finditer(regex_call, binary):
        call_origin = match.start()
        packed_call = binary[call_origin + 1:call_origin + 1 + 4]
        rel_call = struct.unpack("I", packed_call)[0]
        call_destination = (image_base + call_origin + rel_call + 5) & 0xFFFFFFFF
        if call_destination == image_base + decrypt_function_offset:
            # decrypt function and replace/fix
            decrypted_flag = ord(binary[call_origin - 0x2])
            if decrypted_flag == 0x0:
                key = ord(binary[call_origin - 0x3])
                size = struct.unpack("H", binary[call_origin - 0x5:call_origin - 0x3])[0] ^ 0x461F
                buf = binary[call_origin + 0x5:call_origin + 0x5 + size]
                decrypted_function = decrypt(buf, key)
                binary = replace_bytes(binary, call_origin + 0x5, decrypted_function)
                binary = replace_bytes(binary, call_origin + len(decrypted_function), "\xC3")
```

```
            binary = replace_bytes(binary, call_origin - 0x2, "\x01")
    return binary
```

[...]

IDA likes this this already better:



IDA's view on a code-decrypted Fobber sample.

However, we are not quite done yet, as IDA still barfs on a couple of functions.

Conclusion

After decrypting all functions, we can already start analyzing the sample effectively. But we are not quite done yet, and the second post looks closer at the inline usage of encrypted strings.

sample used:
  md5: 49974f869f8f5d32620685bc1818c957
  sha256: 93508580e84d3291f55a1f2cb15f27666238add9831fd20736a3c5e6a73a2cb4

Repository with memdump + extraction code