

[Emotet malware analysis. Part 2.]

 persianov.net/emotet-malware-analysis-part-2

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This is the Part 2 of my Emotet analysis. It covers phase 3 of the attack, specifically the PE file which is being dropped by infected websites, used in Phishing/Spam campaigns. Emotet is an advanced modular Trojan, predominantly used as Malware Distribution Platform, main goal being systems infection with other types of malware.

More information about phases 1 and 2: [HERE](#)

General information.

Phase 3 of this version of Emotet attack is characterized by the new version of executable. Malware authors spent some time to make it harder to analyze, by implementing multiple Anti-Debugging techniques, loading Windows DLLs dynamically, encrypting imported functions names, several unpacking stages, and so on.

File name	Checksum	Hosted at
DFDWiz.exe	cebb919d8d04f224b78181a4d3f0b10a315ae2f2	hxxp://biederman.net/leslie/IL/

Based on IAT information, there are several Windows DLLs this binary is loading: `kernel32.dll` , `user32.dll` , `gdi32.dll` , `advapi32.dll` , `shell32.dll` and `shlwapi.dll` .

Offset	Name	Func. Count	Bound?	OriginalFirstThun	TimeDateStamp	Forwarder	NameRVA	FirstThunk
23934	KERNEL32.dll	93	FALSE	247F4	0	0	250F4	1F034
23948	USER32.dll	17	FALSE	249F4	0	0	25238	1F234
2395C	GDI32.dll	7	FALSE	247D4	0	0	252AA	1F014
23970	ADVAPI32.dll	4	FALSE	247C0	0	0	252F4	1F000
23984	SHELL32.dll	28	FALSE	2496C	0	0	25544	1F1AC
23998	SHLWAPI.dll	4	FALSE	249E0	0	0	25580	1F220

At the first glance, the binary doesn't import any "red flag" functions, usually used by packers.

Name	Raw Addr.	Raw size	Virtual Addr.	Virtual Size
> .text	400	1DE00	1000	1DC68
> .rdata	1E200	6600	1F000	658C
> .data	24800	5C00	26000	5B14
> .rsrc	2A400	1C00	2C000	1BF0

Let's load this sample in IDA and check for any details that can help in upcoming dynamic analysis. From the multitude of imported functions, listed in IAT, there are only few used (visible at least). One of them is `VirtualAlloc` , which points to a possible custom packer.

```

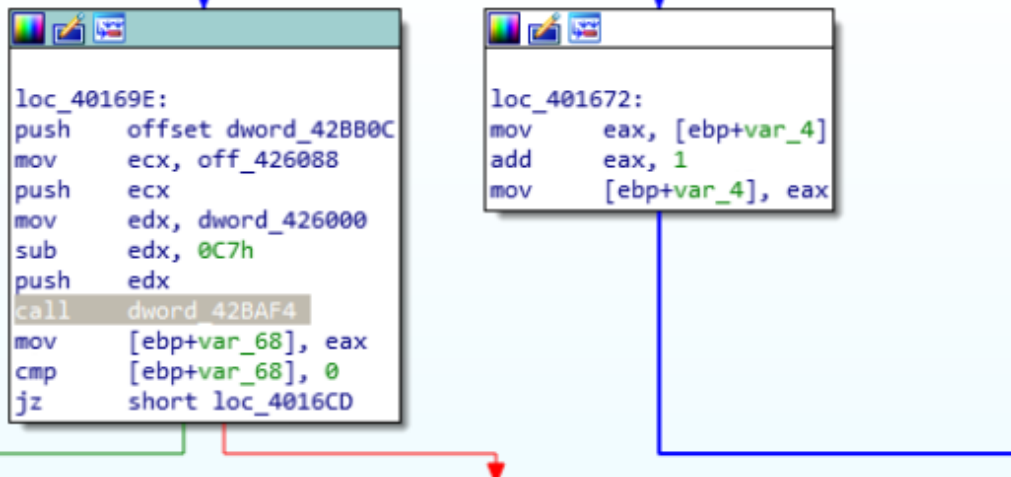
sub_401470 proc near

var_235= byte ptr -235h
var_1C3= byte ptr -1C3h
var_18= dword ptr -18h
var_14= dword ptr -14h
var_C= dword ptr -0Ch
var_8= dword ptr -8
var_4= dword ptr -4

push    ebp
mov     ebp, esp
sub     esp, 3D0h
mov     [ebp+var_4], 40h
mov     [ebp+var_C], 0
mov     eax, dword_42BA84
mov     [ebp+var_18], eax
mov     [ebp+var_8], 0FFFFFFFFh
mov     [ebp+var_1C3], 74h
mov     [ebp+var_235], 3Eh
mov     ecx, ds:VirtualAlloc
mov     dword_42BAF0, ecx
push    [ebp+var_4]
mov     eax, 3001h
dec     eax
push    eax
mov     eax, [ebp+var_18]
push    eax
push    [ebp+var_C]
mov     edx, dword_42BAF0
push    offset loc_4014CE
push    edx
retn

```

Some other clues showing that this binary is packed are `call` s to pointers to data segment:




Dynamic analysis. Unpacking.







For the dynamic analysis of this sample, I'm going to use `x32dbg`. Based on the report from Hybrid Analysis, looks like this sample creates 2 new processes, once executed: copy of itself and a second process with a different name. This is the packed PE file, which is embedded

into the first sample.

Hybrid Analysis

 **Tip:** Click an analysed process below to view more details.

Analysed 3 processes in total.

-  **DFDWiz.exe** (PID: 440)  42/65
 -  **DFDWiz.exe** (PID: 3092)  42/65
-  **neutraluuidgen.exe** (PID: 3260)  42/65

Most probably, parent process will call one of the `CreateProcess*` Windows API functions. Since 2018, Microsoft moved some functionality from `kernel32.dll` and `advapi32.dll` to new low-level binary, called `kernelbase.dll`. If we take a look at `CreateProcessA` and `CreateProcessAsUserA` in `kernel32.dll`, the only thing we can see are several `mov` and `push` instructions, followed by a jump, to `kernelbase.dll` equivalent function.

766C3D50	8BFF	mov edi,edi	CreateProcessA
766C3D52	55	push ebp	
766C3D53	8BEC	mov ebp,esp	
766C3D55	5D	pop ebp	
766C3D56	FF25 88147176	jmp dword ptr ds:[<&CreateProcessA>]	JMP.&CreateProcessA
766C3D5C	CC	int3	
766C3D5D	CC	int3	
766C3D5E	CC	int3	
766C3D5F	CC	int3	
766C3D60	CC	int3	
766C3D61	CC	int3	
766C3D62	CC	int3	
766C3D63	CC	int3	
766C3D64	CC	int3	
766C3D65	CC	int3	
766C3D66	CC	int3	
766C3D67	CC	int3	
766C3D68	CC	int3	
766C3D69	CC	int3	
766C3D6A	CC	int3	
766C3D6B	CC	int3	
766C3D6C	CC	int3	
766C3D6D	CC	int3	
766C3D6E	CC	int3	
766C3D6F	CC	int3	
766C3D70	8BFF	mov edi,edi	CreateProcessAsUserA
766C3D72	55	push ebp	
766C3D73	8BEC	mov ebp,esp	
766C3D75	5D	pop ebp	
766C3D76	FF25 1C0B7176	jmp dword ptr ds:[<&CreateProcessAsUserA>]	JMP.&CreateProcessAsUserA
766C3D7C	CC	int3	
766C3D7D	CC	int3	

Following the thread to `kernelbase.dll`, we see that `CreateProcessA` function contains a bunch of another push instructions followed by a `call` to `CreateProcessInternalA`. Same happens for `CreateProcessAsUserA`.

777C5EE0	88FF	mov edi,edi	CreateProcessA
777C5EE2	55	push ebp	
777C5EE3	88EC	mov ebp,esp	
777C5EE5	6A 00	push 0	
777C5EE7	FF75 2C	push dword ptr ss:[ebp+2C]	
777C5EEA	FF75 28	push dword ptr ss:[ebp+28]	
777C5EED	FF75 24	push dword ptr ss:[ebp+24]	
777C5EF0	FF75 20	push dword ptr ss:[ebp+20]	
777C5EF3	FF75 1C	push dword ptr ss:[ebp+1C]	
777C5EF6	FF75 18	push dword ptr ss:[ebp+18]	
777C5EF9	FF75 14	push dword ptr ss:[ebp+14]	
777C5EFC	FF75 10	push dword ptr ss:[ebp+10]	
777C5EFF	FF75 0C	push dword ptr ss:[ebp+0C]	
777C5F02	FF75 08	push dword ptr ss:[ebp+08]	
777C5F05	6A 00	push 0	
777C5F07	E8 94000000	call <kernelbase.CreateProcessInternalA>	
777C5F0C	5D	pop ebp	
777C5F0D	C2 2800	ret 28	

To keep this short, the overall call chain looks like this:

[kernel32.dll] CreateProcessA -> [kernelbase.dll] CreateProcessA ->
 [kernelbase.dll] CreateProcessInternalA -> [kernelbase.dll] CreateProcessInternalW

It means that for any `CreateProcess*` function call, we'll get `CreateProcessInternalW` called right before process creation. If we set a breakpoint at the beginning of this function, we possibly could find the **unpacked** binary, which is going to be injected into the new process. Once we hit the breakpoint, there are 4 memory regions with **ERW** (Execute-Read-Write) flags set. 3/4 are PE files, based on the header.

00318000	000E5000	Reserved (00200000)		PRV		-RW--
00400000	0001A000			PRV	ERW--	ERW--
00430000	000C5000	\Device\HarddiskVolume2\windows\System32\1c		MAP	-R---	-R---
00500000	00035000	Reserved		PRV		-RW--
00535000	00008000			PRV	-RW-G	-RW--
00540000	00015000			PRV	ERW--	ERW--
00560000	00014000			PRV	ERW--	ERW--
00580000	0001A000			PRV	ERW--	ERW--
005C0000	00006000			PRV	-RW--	-RW--
005C6000	0000A000	Reserved (005C0000)		PRV	-RW--	-RW--

Address	Hex	ASCII
005B0000	4D 5A 90 00 03 00 00 00 04 00 00 00 FF FF 00 00	MZ.....yy..
005B0010	B8 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00@.....
005B0020	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00A..
005B0030	00 00 00 00 00 00 00 00 00 00 00 00 C0 00 00 00
005B0040	0E 1F BA 0E 00 B4 09 CD 21 B8 01 4C CD 21 54 68	..°.!.Li!Th
005B0050	69 73 20 70 72 6F 67 72 61 6D 20 63 61 6E 6E 6F	is program canno
005B0060	74 20 62 65 20 72 75 6E 20 69 6E 20 44 4F 53 20	t be run in DOS
005B0070	6D 6F 64 65 2E 0D 0D 0A 24 00 00 00 00 00 00 00	mode...\$......

Once all of them are dumped and properly aligned, we can proceed with the second phase of analysis.

Dynamic analysis. Dumped binaries.

All 3 exported binaries look the same, even if they have different checksums. IAT table is empty, which means that malware loads dependencies in runtime. There are no API function names in binary's strings, which implies that all API function names are encrypted as well as library names.

The execution starts with 3 function calls.


```

public start
start proc near
push    ebp
mov     ebp, esp
and     esp, 0FFFFFF8h
call    sub_40D340
call    sub_40DF80
call    sub_401030
test    eax, eax
jz     short loc_40F5FE

```

First 2 functions contain encrypted names of the APIs this sample is going to load dynamically. These functions call another one, once all encrypted values are loaded to stack. The `sub_401550` looks to be responsible for decryption.

```

mov     [ebp+var_54], 9A171EFFh
mov     [ebp+var_50], 7A6259BFh
mov     [ebp+var_4C], 5988B28Eh
mov     [ebp+var_48], 80CA441Fh
mov     [ebp+var_44], 73AAB973h
mov     [ebp+var_40], 0AD728D54h
mov     [ebp+var_3C], 55B2FEBAh
mov     [ebp+var_38], 0EE9D51ABh
mov     [ebp+var_34], 6FA72180h
mov     [ebp+var_30], 0C59B6F09h
mov     [ebp+var_2C], 2915C1DEh
mov     [ebp+var_28], 0DF94CDB4h
mov     [ebp+var_24], 6E525C8Bh
mov     [ebp+var_20], 31C1921Ah
mov     [ebp+var_1C], 8F22AA15h
mov     [ebp+var_18], 0B64C044h
mov     [ebp+var_14], 62AEF5A2h
mov     [ebp+var_10], 4DE207Eh
mov     [ebp+var_C], 50099F52h
mov     [ebp+var_8], 7BFACF9Dh
mov     [ebp+var_4], 0B69B27D5h
call    sub_401550
test    eax, eax
jz     short loc_40DF78

```

So far, I was able to detect 4 DLLs loaded dynamically by this sample: `kernel32.dll`, `user32.dll`, `ntdll.dll`, `shell32.dll`.

In order to run just one copy of it, this sample checks if a specific MUTEX exists and creates it, if missing. MUTEX name is: `PEMF24`.

0040107E	50	push eax	eax:L"PEMF24"
0040107F	FF15 DC594100	call dword ptr ds:[<&_snwprintf>]	
00401085	83C4 10	add esp,10	esi:"x@w"
00401088	56	push esi	
00401089	57	push edi	
0040108A	FF15 C0524100	call dword ptr ds:[<&GetProcessHeap>]	
00401090	50	push eax	eax:L"PEMF24"
00401091	FF15 C4514100	call dword ptr ds:[<&HeapFree>]	
00401097	8D85 E8FEFFFF	lea eax,dword ptr ss:[ebp-118]	eax:L"PEMF24"
0040109D	50	push eax	
0040109E	6A 01	push 1	
004010A0	57	push edi	
EIP → 004010A1	FF15 904F4100	call dword ptr ds:[<&CreateMutex>]	eax:L"PEMF24"
004010A7	8B08	mov ebx,eax	
004010A9	85DB	test ebx,ebx	
004010AB	0F84 82000000	js 00400000_dump_aligned.401133	
004010B1	FF15 80544100	call dword ptr ds:[<&GetLastError>]	
004010B7	3D B7000000	cmp eax,B7	eax:L"PEMF24"
004010BC	75 66	jne 00400000_dump_aligned.401124	
004010BE	68 269FDA64	push 64DA9F26	
004010C3	8D50 1D	lea edx,dword ptr ds:[eax+1D]	
004010C6	89 20204100	mov ecx,00400000_dump_aligned.412020	
004010CB	E8 300C0000	call 00400000_dump_aligned.401D00	
004010D0	83C4 04	add esp,4	
004010D3	8BF0	mov esi,eax	esi:"x@w", eax:L"PEMF24"
004010D5	8D85 68FFFFFF	lea eax,dword ptr ss:[ebp-98]	
004010DB	FF75 FC	push dword ptr ss:[ebp-4]	

Once MUTEX is checked/created, malware looks for Windows directory to copy itself there, as well as into %APPDATA% folder. This time, the new binary is named differently and this name is generated in runtime by concatenating 2 strings (in my case it was `ipropslide.exe`). All possible strings are stored in memory at some point.

x32dbg.exe	5.24	56,336 K	85,076 K	488 x64dbg
DFDWiz.exe - Copy.mlwr	0.01	1,848 K	6,268 K	4912 Windows Disk Diagnostic Us... Microsoft Corporation
procexp.exe		3,024 K	10,596 K	2596 Sysintemals Process Explorer Sysintemals - www.sysinter...
procexp64.exe	2.40	28,240 K	47,572 K	8100 Sysintemals Process Explorer Sysintemals - www.sysinter...
usched.exe		2,136 K	11,492 K	7512 Java Update Scheduler Oracle Corporation
ipropslide.exe	< 0.01	1,740 K	6,740 K	7484 Windows Disk Diagnostic Us... Microsoft Corporation

Address	Hex	ASCII
005878F0	6E 6F 74 2C	ot,ripple,svcs,
00587900	73 65 72 76	serv,wab,shader,
00587910	73 69 6E 67	single,without,w
00587920	63 73 2C 64	cs,define,eap,cu
00587930	6C 74 75 72	lture,slide,zip,
00587940	74 6D 70 6C	tmpl,mini,polic,
00587950	70 61 6E 65	panes,earcon,men
00587960	75 73 2C 64	us,detect,form,u
00587970	75 69 64 67	uidgen,pnp,admin
00587980	2C 74 75 69	,tuip,avatar,sta
00587990	72 74 65 64	rted,dasmrc,alas
005879A0	68 61 2C 67	ka,guids,wfp,ada
005879B0	6D 2C 77 67	m,wgx,lime,index
005879C0	65 72 2C 72	er,repl,dev,mapi
005879D0	2C 72 65 73	,resw,daf,diag,i
005879E0	73 73 2C 76	ss,vsc,turned,ne
005879F0	75 74 72 61	utral,sat,source
00587A00	2C 65 6E 72	,enroll,mfidl,id
00587A10	6C 2C 62 61	l,based,right,cb
00587A20	73 2C 72 61	s,radar,avg,word
00587A30	70 61 64 2C	pad,metagen,mous
00587A40	65 2C 69 70	e,iproc,mdmmcd,j
00587A50	65 72 73 65	ersey,tunk,subs

Once the new process is created, it starts looking for host information like **Computer Name** and **Volume info** and C2 communication begins.

00400000_dump_aligned.mlwr - PID: 54C - Module: 00400000_dump_aligned.mlwr - Thread: Main Thread 1A44 - x32dbg

File View Debug Trace Plugins Favourites Options Help Mar 10 2019

CPU Graph Log Notes Breakpoints Memory Map Call Stack SEH Script Symbols Source

0040F911	50	push eax	
0040F912	8D45 CC	lea eax,dword ptr ss:[ebp-34]	
0040F915	50	push eax	
0040F916	FF15 04514100	call dword ptr ds:[k&GetComputerNamew>]	
0040F91C	85C0	test eax,eax	
0040F91E	0F84 89000000	je 00400000_dump_aligned.40F9AD	
0040F924	53	push ebx	
0040F925	8D4D CC	lea ecx,dword ptr ss:[ebp-34]	
EIP → 0040F928	E8 231AFFFF	call 00400000_dump_aligned.401350	
0040F92D	51	push ecx	
0040F92E	BA 58000000	mov edx,58	ecx:L"DESKTOP-OVF
0040F933	A3 0C614100	mov dword ptr ds:[41610C],eax	58:'X'
0040F938	B9 C03C4100	mov ecx,00400000_dump_aligned.413CC0	ecx:L"DESKTOP-OVF
0040F93D	E8 1E23FFFF	call 00400000_dump_aligned.401C60	

After some patching during debugging and several failures (=)) I was able to get some details about the C2 communication part. Sample tries to connect to 3 IP addresses (round robin?)

IP Address	Destination Port	Protocol	User Agent
------------	------------------	----------	------------

IP Address	Destination Port	Protocol	User Agent
45.36.20[.]17	8443	HTTP	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 2.0.50727; .NET CLR 3.0.04506.648; .NET CLR 3.5.21022)
103.39.131[.]88	80	HTTP	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 2.0.50727; .NET CLR 3.0.04506.648; .NET CLR 3.5.21022)
86.239.117[.]57	8090	HTTP	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 2.0.50727; .NET CLR 3.0.04506.648; .NET CLR 3.5.21022)

Conclusion.

Malware authors did a good effort in packing this malware and introducing different layers of defence. It wasn't too difficult to bypass those layers, however taking into consideration how often a new Emotet version is released and the changes to the binary, the analysis becomes time consuming in the long term. Sending HTTP traffic to non-standard destination ports, like **8090**, is not the best way to keep a low profile in a compromised network. Most businesses have to treat this type of traffic as suspicious nowadays and maintain a clean asset inventory.