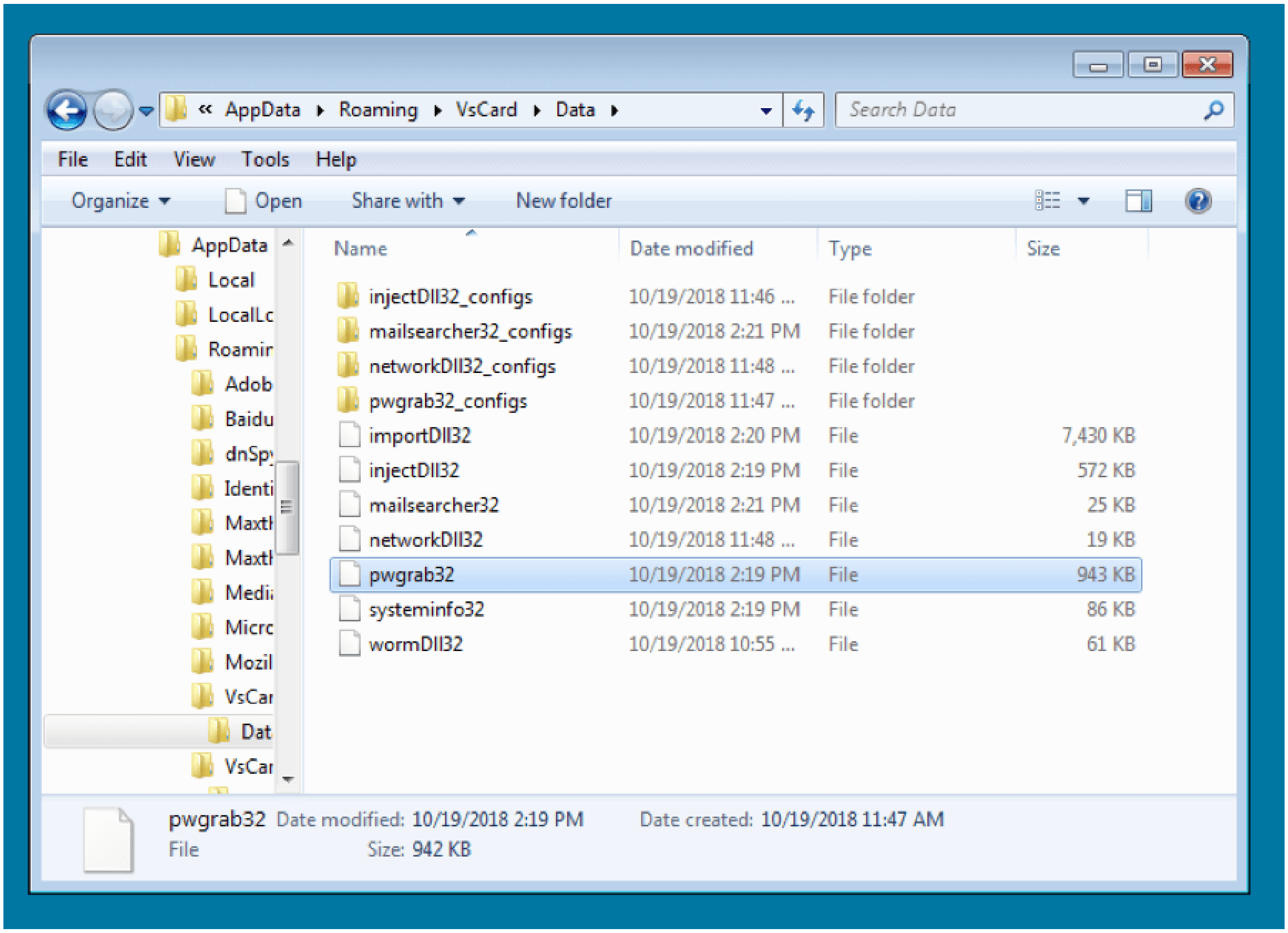
Deep Analysis of TrickBot New Module pwgrab

fortinet.com/blog/threat-research/deep-analysis-of-trickbot-new-module-pwgrab.html

November 8, 2018


« AppData ▸ Roaming ▸ VsCard ▸ Data ▸
Search Data
File Edit View Tools Help
Organize ▾ Open Share with ▾ New folder
AppData
Local
LocalLc
Roamir
Adob
Baidu
dnSpy
Identi
Maxtl
Maxtl
Medi
Micrc
Mozil
VsCar
Dat
VsCar

Name	Date modified	Type	Size
injectDll32_configs	10/19/2018 11:46 ...	File folder	
mailsearcher32_configs	10/19/2018 2:21 PM	File folder	
networkDll32_configs	10/19/2018 11:48 ...	File folder	
pwgrab32_configs	10/19/2018 11:47 ...	File folder	
importDll32	10/19/2018 2:20 PM	File	7,430 KB
injectDll32	10/19/2018 2:19 PM	File	572 KB
mailsearcher32	10/19/2018 2:21 PM	File	25 KB
networkDll32	10/19/2018 11:48 ...	File	19 KB
pwgrab32	10/19/2018 2:19 PM	File	943 KB
systeminfo32	10/19/2018 2:19 PM	File	86 KB
wormDll32	10/19/2018 10:55 ...	File	61 KB

pwgrab32 Date modified: 10/19/2018 2:19 PM Date created: 10/19/2018 11:47 AM
File Size: 942 KB

Threat Research

By Xiaopeng Zhang | November 08, 2018

The TrickBot malware family has been live for several years, mainly focused on stealing victim's online banking information. In new samples recently collected by FortiGuard Labs, we found a new TrickBot variant, with a new module pwgrab, which attempt to steal credentials, autofill data, history and so on from browsers as well as several software applications. I did a deep analysis on this pwgrab module, and in this blog I will explain how it works on a victim's system.

TrickBot downloaded by opening an excel file

The new TrickBot variant is spread by an Excel file (originally named "Sep_report.xls") using a malicious Macro VBS code that is executed when the victim opens the file in Microsoft Excel. We captured this sample on October 19th, 2018. Figure 1 shows that "Sep_report.xls" is opened in Microsoft Excel where it requests that the victim enable the embedded Macro by clicking on the “Enable Content” button.

Figure 1. Sep_report.xls opened in Microsoft Excel

The VBA code is password protected for viewing. To analyze the code, I manually modified the protected flag to bypass the password protection.

The VBA code starts with the function “Workbook_Open”, which is called automatically when the Excel file is opened. It then reads data from Text control, which is encoded Powershell code. In Figure 2 you can see part of the decoded Powershell code.

Figure 2. Decoded Powershell code

Finally, the Powershell code is executed to download the file from “*hxxp://excel-office.com/secure.excel*” and save it to a local temporary folder with the name “pointer.exe” whereupon it runs it. As you may have guessed, the “pointer.exe” file is actually TrickBot.

Task Schduler Starts TrickBot to load pwgrab32

When “pointer.exe” runs for the very first time, it creates the “%AppData%\VsCard” folder as its home folder, then copies “pointer.exe” into it and renames it as “pointe*s*.exe”. In this version it also changes its module folder: the new one is “%AppData%\VsCard\Data” instead of the previous “%AppData%\[random folder name]**Modules**”. Figure 3 is a screenshot of the new folder.

Figure 3. Screenshot of the new module folder “Data”

As with its previous version, it installs itself into the system “Task Scheduler” so it can run automatically by “Task Scheduler”.

After “pointes.exe” runs for a little while, it sends the command “5” request to its C&C server with the string “pwgrab32” for a 32-bit platform (or “pwgrab64” for a 64-bit platform) asking to download the new module of “pwgrab32”, just as it does for downloading other module files such as “systeminfo32” and “injectdll32”.

To learn more about the packet format of command “5” and the command’s purpose, you can refer to my previous blog. All files downloaded through command “5” in older versions are AES encrypted. Recent versions have added one more XOR encryption on AES encrypted data .So to get to the original pwgrab32 module we had to go through two-layer decryption. The pwgrab32 module was generated on October 16th, 2018 and was developed with Borland Delphi 3.0. Figure 4 shows the pwgrab32 module analyzed in a PE tool.

Figure 4. Decrypted pwgrab32 being analyzed in CFF Explorer

During my analysis of “pointes.exe” I can see that it uses some anti-analysis techniques to make it harder to be analyzed. For example, it encrypts all string information to protect itself from being analyzed statically and dynamically loads APIs during running time.

From the file name of “pwgrab32” we can guess it will grab password information from the victim’s system. Let’s go on to see how it will do this.

After downloading and decrypting “pwgrab32”, “pointes.exe” continues to load “pwgrab32”. Just like when loading other modules, it calls the API “CreateProcessAsUserW” to create a suspended “svchost.exe” process. It then injects a piece of code from the “pointes.exe” memory to this svchost.exe process memory by calling the API “WriteProcessMemory”. By calling the API “ZwQueryInformationProcess”, “pointes.exe” can get “svchost.exe”’s ProcessBasicInformation from which it can locate the OEP (Original Entry Point) of “svchost.exe” in its PE structure. Furthermore, it can modify the code at OEP to execute the copied piece of code. It then calls “ResumeThread” to resume running “svchost.exe”. Figure 5 is a code snippet of finding “svchost.exe”’s OEP.

Figure 5. Find svchost.exe OEP

Next, API “WriteProcessMemory”, “SignalObjectAndWait”, and “WaitForSingleObject” are called a number of times by both “pointes.exe” and “svchost.exe” to maintain synchronicity to finish copying the decrypted pwgrab32 and related information, such as copying the C&C server IP list from “pointes.exe” onto “svchost.exe”. Finally, “pwgrab32!10006634” (the OEP of pwgrab32) is called by the copied piece of code mentioned above.

From this point on, the pwgrab32 takes over the work to collect any password related data.

pwgrab32 Collects Credentials from Browsers of Victim’s System

At first “pwgrab32” decodes the “core-parser.dll” module , loads into the memory, and makes it ready for use. It has several export functions, as shown in Figure 6.

Figure 6. core-parser.dll export function list

Function “EnumDpostServer” returns the C&C server IP address, which will be called by “pwgrab32” when it wants to send data to the C&C server.

It launches three threads to grab credentials from three different browsers. They all share the same thread function but different parameters. From my analysis, parameter 1 is for Internet Explorer, 2 is for Firefox, 3 is for Chrome, and 4 is for Edge. However, in this version Edge is disabled.

There is also a very huge function, “pwgrab32!sub_100137F8”, which executes the operation of collecting saved credentials from all browsers. There are different code branches for different browsers. I will show you how it works.

One interesting thing I found in the “pwgrab32” code is that it encrypts plain text byte by byte, decrypts it back to plain text, and uses that decrypted plain text. Is this a joke by the Trickbot author? No, it should be an anti-analysis technique to hide plain text. However, I think the author simply forgot to remove the decryption function and replace the plain text with the encrypted one before compiling this module. This error appears many times throughout the pwgrab32 module. Figure 7 shows a code snippet of that.

Figure 7. Plain text “IE password” being encrypted first and decrypted later

1> Thread Parameter 1 for Internet Explorer:

According to the Windows system version, there are two different code branches for IE.

If a victim’s system version is Windows 2000, Windows XP, Windows Vista, Windows Server 2008, Windows 7, Windows 10, or Windows Server 2016, it reads and enumerates values from the system registry sub-key “HKEY_CURRENT_USER\Software\Microsoft\Internet Explorer\IntelliForms\Storage2”, which contains the SHA1 hash code list of saved website hosts and saved credentials for this website. Figure 8 is a screenshot of the “Storage2” sub-key on my Windows 7 system. Calling the APIs “FindFirstUrlCacheEntryW” and “FindNextUrlCacheEntryW”, this malware can enumerate all cached websites. Furthermore it can calculate SHA1 hash code for each website host (for example “http://www.fortinet.com/”) through comparison with the hash code from the sub-key “Storage2”, whereupon it can obtain the website’s host. It then parses the third column data to get the credential for the website. Finally, it saves the collected credentials in this format:

“Website host|Login ID|Login password”.

Figure 8. Screenshot of sub-key “Storage2”

When the victim’s system is another version, it calls some additional APIs to get credentials. Here is a pseudo code of this process for getting credentials.

```
if ( VaultEnumerateVaults(0, &a4, &a5) )
return 0;

 v70 = 0;  a2 = 0;
 if ( a4 )  {    v71 = 0;    a3 = 0;
while ( !VaultOpenVault(v71 + a5, 0, &vars0) && !VaultEnumerateItems(vars0, 512, &a1,
&retaddr) )
 {      v72 = 0;
   if ( a1 )  {
    v73 = lpCriticalSection;
    v74 = a7;
    do {
     memset(&a65, 0, 0xE08u);
     if ( v74 )
      v75 = sub_100133F2(v72, &a65);
     else
      v75 = sub_1001329C(v72, &a65);
     if ( v75 ) {
      wnsprintfA(&String, 1024, "%S|%S|%S\n", &a66, &a67, &a68);
      v76 = sub_1000CBB8(&String);
      sub_1000D1AA(v73, &String, v76);
     }
     ++v72;
    }
    while ( v72 < a1 );
    v70 = a2;    v71 = a3;
   }
   VaultFree(retaddr);
   VaultCloseVault(vars0);
```

2> Thread Parameter 2 for Mozilla Firefox:

This code thread reads the Firefox installation path from the system registry, and then calls the API “SetCurrentDirectoryA” with the installation path to set the current directory to the Firefox installation path so it can easily read the credential files of Firefox and load a dll which is used to handle Firefox credentials.

“pwgrab32” continues to load nss3.dll of Firefox and read some Firefox files from its AppData folder, such as "%AppData%\Mozilla\Firefox\Profiles\e375zm7t.default\logins.json". It then calls the APIs of nss3.dll, like “PK11_GetInternalKeySlot”, “PK11_Authenticate”, and “PK11SDR_Decrypt” to parse saved credentials in the file, “logins.json”. Below is a piece of data from “logins.json”.

```
{"id":5,"hostname":"https://api.twitter.com","httpRealm":null,"formSubmitURL":"https:/
 code**]ZrlGaGjQ","encryptedPassword":"M1Doc8NAwcEiCH[**hide
code**]jwG+/I/0+lBje8WVoEska","guid":"{24146e3a-321f-5e81-95d9-ab245208835f}"
```

Finally, it saves the credentials in a format like IE’s.

3> Thread Parameter 3 for Google Chrome:

Before the thread function is created, pwgrab32 makes two file backups of the files “Login Data” and “Web Data”. Both of them are located in the "%LocalAppData%\Google\Chrome\User Data\Default\” folder. Chrome stores the login credentials of the victim in the file “Login Data”, and saved autofill and credit card information is stored in the file “Web Data”. It makes a backup of the two files so it can read data from backup files instead of the original files to avoid a reading conflict when the victim is using Chrome. The two backup files are “Login Data.bak” and “Web Data.bak”. They are both SQLite database files.

“pwgrab32” uses the open source project SQLite database engine to handle the two SQLite files. In Figure 9, you can see that the data of the SQLite database engine is linked in “pwgrab32”.

Figure 9. SQLite database engine’s code

Next, “pwgrab32” executes an SQL expression like "*select origin_url, username_value, password_value, length(d_value) from logins where blacklisted_by_user = 0*" to obtain the credentials from “Login Data.bak”.

“pwgrab32” continues to execute three SQL expressions to grab autofill information, credit card information, email address, country, company, street address, full name, phone number, etc. from “Web Data.bak”.

The SQL expressions are decrypted from three local variables:

```
“SELECT name, value FROM autofill WHERE name<>"cd[Meta]"" AND name<>"cd[OpenGraph]"
AND name<>"cd[Schema.org]" AND name<>"cd[DataLayer]" AND name<>"cd[buttonFeatures]"
AND name<>"cd[buttonText]" AND name<>"cd[formFeatures]" ORDER BY name; “

“SELECT expiration_month, expiration_year, card_number_encrypted, use_date, origin
FROM credit_cards ORDER BY origin;”

“SELECT profiles.origin, profiles.company_name, profiles.street_address,
profiles.city, profiles.state, profiles.zipcode, profiles.country_code
,profiles.language_code, emails.email, names.first_name, names.middle_name,
names.last_name, names.full_name, phones.number FROM autofill_profiles AS profiles
INNER JOIN autofill_profile_emails AS emails ON(profiles.guid = emails.guid) INNER
JOIN autofill_profile_names AS names ON(profiles.guid = names.guid) INNER JOIN
autofill_profile_phones AS phones ON(profiles.guid = phones.guid); “
```

The grabbed credentials and form autofill information collected from the browsers is sent to the C&C server immediately when one is done.

Next, I’ll discuss the packet format and how it’s sent to its C&C server in the “Report Credentials” section below.

pwgrab32 Collects Credentials from some Clients

After all of the three threads above are finished, “pwgrab32” steals credentials from three client software sources: “Outlook”, “FileZilla”, and “WinSCP”. In Figure 10 you can see the functions being called to collect credentials from them.

Figure 10. Functions to collect credential from Outlook, FileZilla and WinSCP

“Outlook”’s profile is stored in the system registry. According to different versions, its registry paths are "*HKCU\Software\Microsoft\Windows NT\CurrentVersion\Windows Messaging Subsystem\Profiles\Outlook*",

"*HKCU\Software\Microsoft\Office\15.0\Outlook\Profiles\Outlook*" and

"*HKCU\Software\Microsoft\Office\16.0\Outlook\Profiles\Outlook*".

“pwgrab32” then goes through all the keys and reads and parses the values to grab the credentials.

Figure 11 shows an Outlook credential grabbed by “pwgrab32” from my test system. The format is “Host|Account name|Password”.

Figure 11. Grabbed credentials from Outlook

FileZilla is an FTP client software that stores its history as plain text in file "%APPDATA%\\filezilla\\recentservers.xml", and stores its login data as plain text in file "%APPDATA%\\filezilla\\sitemanager.xml". “pwgrab32” can easily obtain their history records and credentials by parsing these two XML files.

WinSCP is another FTP client software. Its credentials are stored in the system registry under the registry path “*HKCU\Software\Martin Prikryl\WinSCP 2\Sessions*\”. “pwgrab32” can grab its credentials by enumerating all of the sub-keys and reading out their values “HostName”, “PortNumber”, “UserName”, “Password”, and “FSProtocol”.

Report Credentials

Trickbot has many C&C commands. I have talked about these commands in detail in my previous blog.

In module “pwgrab32”, however, I observed that it has new command numbers: 81 and 83.

Command 81 is for reporting grabbed credentials of Browsers, FTP clients, and Outlook.

Command 83 is for reporting grabbed form autofill information from Google Chrome.

It uses HTTP POST method to report the plain text credentials to the C&C server.

The POST URI format is like this:

POST /[group tag]/[Client_ID]/[Command number]/

The body part is the grabbed credentials or form autofill information in plain text.

“group tag” is “auto1”.

“Client_ID” is generated with the computer name, Windows version and random string.

Figure 12 shows reporting “chrome password” using command 81.

Figure 13 shows reporting “chrome autofill information” using command 83.

Figure 12. Report grabbed credential data from Chrome

Figure 13. Report form autofill data from Chrome

Below is an IP list of the C&C servers that are used to handle the credential data. The IP list was decrypted by “pointes.exe” from the file “dpost”, and was passed to “pwgrab32” by calling the API WriteProcessMemory. Calling the API EnumDpostServer(fun_index) of core-parser.dll, we can get one IP of them by using the fun_index.

<dpost>

```
<handler>http://173.171.132.82:8082</handler>

<handler>http://66.181.167.72:8082</handler>

<handler>http://46.146.252.178:8082</handler>

<handler>http://97.88.100.152:8082</handler>

<handler>http://174.105.232.193:8082</handler>

<handler>http://23.142.128.34:80</handler>

<handler>http://177.0.69.68:80</handler>

<handler>http://5.228.72.17:80</handler>

<handler>http://174.105.232.193:80</handler>

<handler>http://177.0.69.68:80</handler>

<handler>http://23.226.138.220:443</handler>

<handler>http://23.226.138.196:443</handler>

<handler>http://23.226.138.221:443</handler>

<handler>http://92.38.135.151:443</handler>

<handler>http://198.23.252.204:443</handler>

</dpost>
```

Solutions

"hxxp://excel-office.com/secure.excel " is rated as **Malicious Websites** by the FortiGuard Webfilter service, and Sep_report.xls is detected as **VBA/Agent.JHAZ!tr.dldr** and pointer.exe as **W32/GenKryptik.COMA!tr** by the FortiGuard Antivirus service.

How to remove this malware:

1) Open Task Scheduler and go to Task Scheduler(Local) -> Task Scheduler Library

2) Select the item named “Msnetcs”, press the Delete key, and then click Yes.

3) Restart your system and delete the entire folder of %AppData%\VsCard.

IoC

URL:

"hxxp://excel-office.com/secure.excel "

Sample SHA256:

[Sep_report.xls]

41288C8A4E58078DC2E905C07505E8C317D6CC60E2539BFA4DF5D557E874CDEC

[secure.excel] or [pointer.exe] or [pointes.exe]

D5CADEF60EDD2C4DE115FFD69328921D9438ACD76FB42F3FEC50BDAAB225620D

Reference

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