From OSINT to Disk: Wave Stealer Analysis

By montysecurity

Published: 2024-05-08 · Archived: 2026-04-05 18:10:42 UTC

Introduction

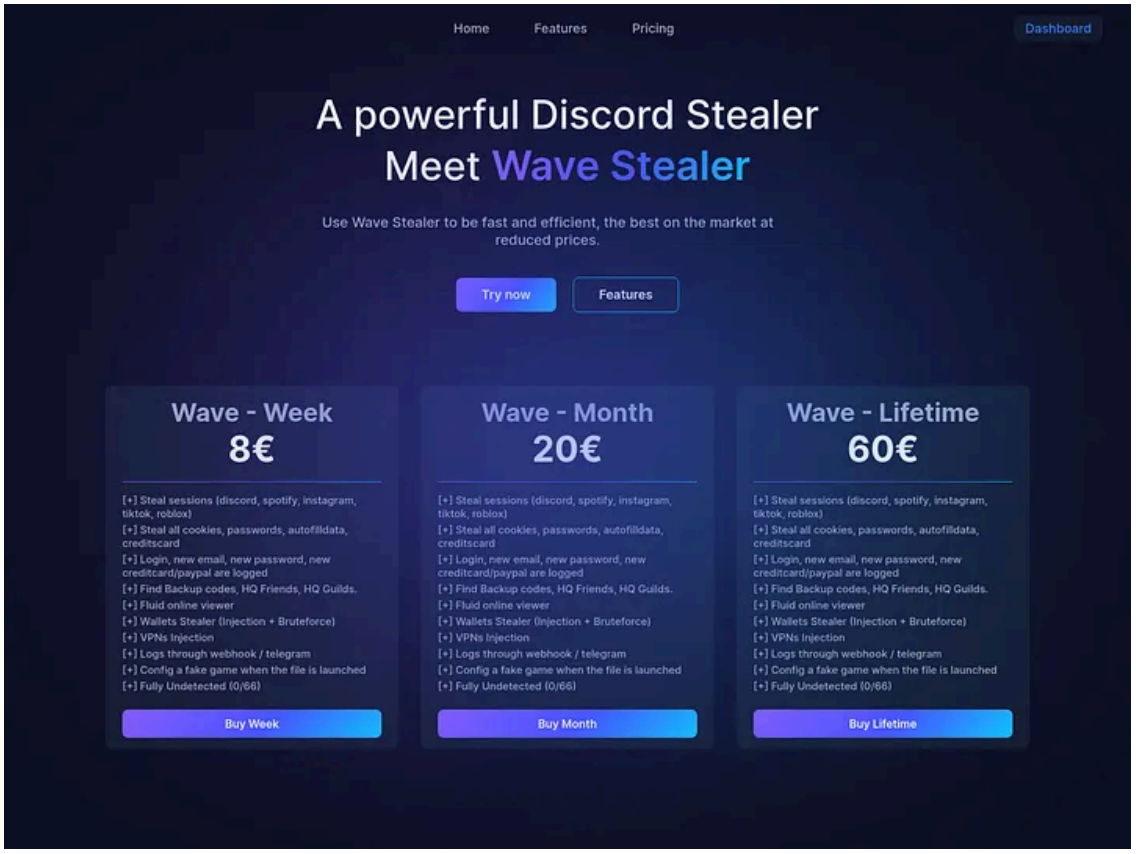
In this post, I will be walking through finding the Wave Stealer advertisement page, getting a sample, then analyzing it and determining its execution and persistence methods. We will also briefly explore how the persistence is broken in this particular sample.

Quick shoutout to crep1x on Twitter/X for posting about this sample, it was instrumental in this analysis — https://twitter.com/crep1x

OSINT

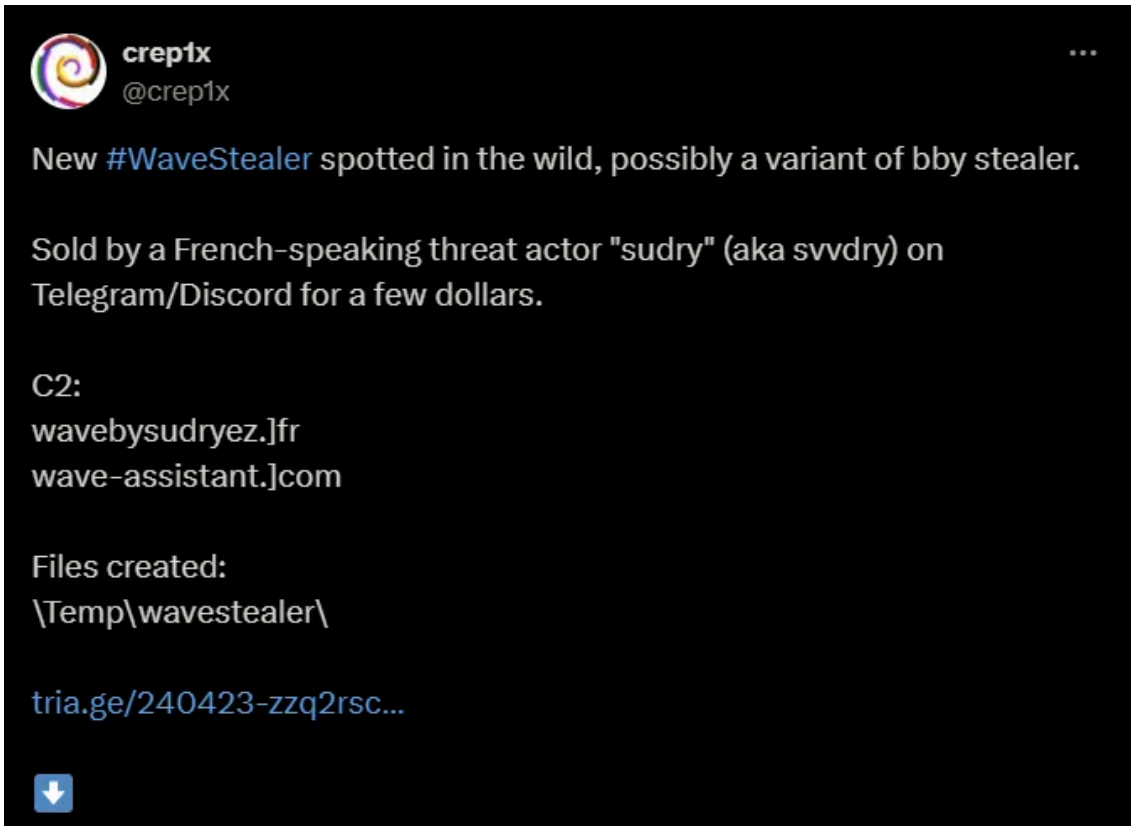
Using my InfraHunter tool, I found the following website advertising a new infostealer. I used one of the built-in searches in the tool, “generic-infostealer-1” which runs the following query on Shodan: `http.title:stealer http.html:login`

Press enter or click to view image in full size



https://urlscan.io/result/013cd1f2-d55b-469a-9f2d-3556311fc3b4/

Turning to Twitter/X I saw this analysis from crep1x and retrieved the sample.
https://twitter.com/crep1x/status/1782887599788486787



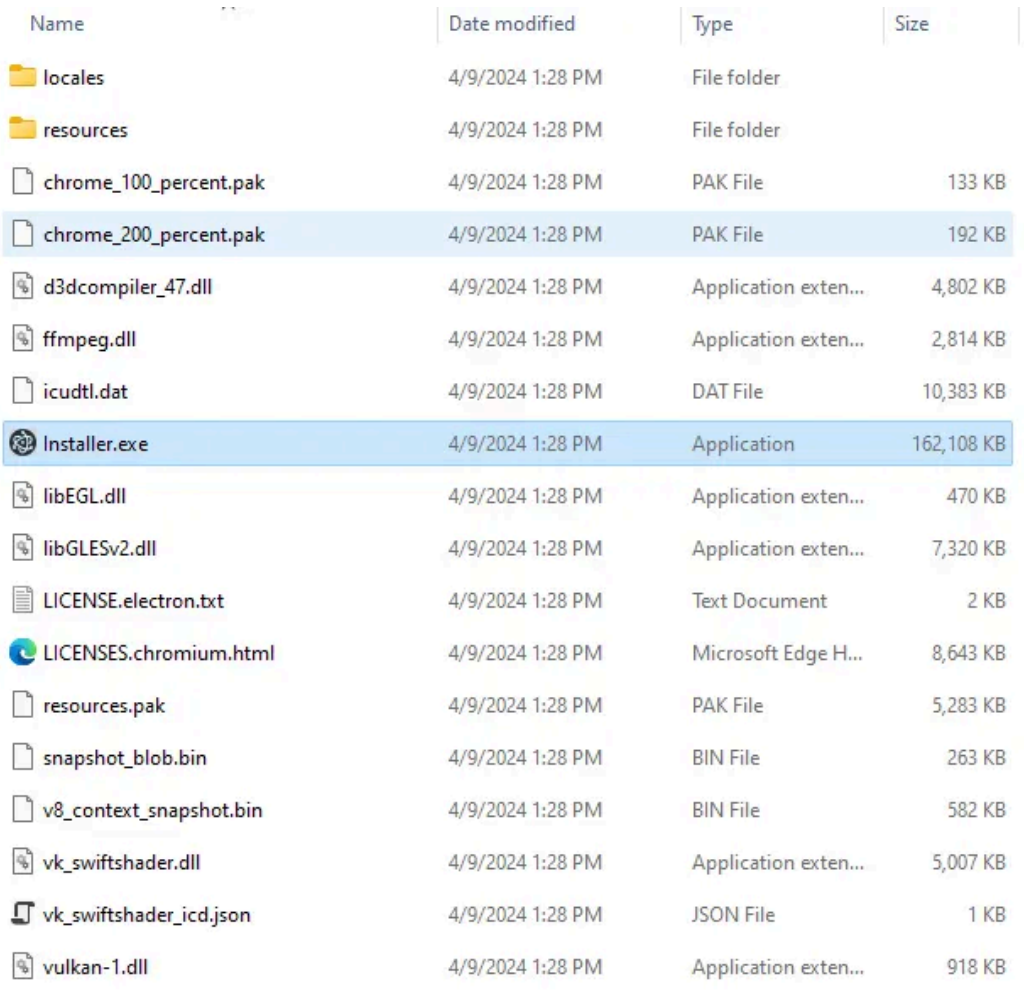
SHA256: eadcf660e731fd3de0a5a8bee2f2337e7d78438f4e9293d2c90d5e63a2d9368e

One thing to note here is the VT comments for this sample are also calling it PrivateLoader.

Malware Analysis

After getting the sample, I loaded it into a FLARE VM. The main tools I used in this analysis were as follows: Wireshark, ProcMon, ProcessExplorer, FakeNet-NG, AutoRuns, HashMyFiles, pestudio, and DetectItEasy

The first thing I noticed in ProcMon is that it created a folder at `C:\Users\User\AppData\Local\Temp\nsmB92D.tmp\7z-out\`



Name	Date modified	Type	Size
locales	4/9/2024 1:28 PM	File folder	
resources	4/9/2024 1:28 PM	File folder	
chrome_100_percent.pak	4/9/2024 1:28 PM	PAK File	133 KB
chrome_200_percent.pak	4/9/2024 1:28 PM	PAK File	192 KB
d3dcompiler_47.dll	4/9/2024 1:28 PM	Application exten...	4,802 KB
ffmpeg.dll	4/9/2024 1:28 PM	Application exten...	2,814 KB
icudtl.dat	4/9/2024 1:28 PM	DAT File	10,383 KB
Installer.exe	4/9/2024 1:28 PM	Application	162,108 KB
libEGL.dll	4/9/2024 1:28 PM	Application exten...	470 KB
libGLESv2.dll	4/9/2024 1:28 PM	Application exten...	7,320 KB
LICENSE.electron.txt	4/9/2024 1:28 PM	Text Document	2 KB
LICENSES.chromium.html	4/9/2024 1:28 PM	Microsoft Edge H...	8,643 KB
resources.pak	4/9/2024 1:28 PM	PAK File	5,283 KB
snapshot_blob.bin	4/9/2024 1:28 PM	BIN File	263 KB
v8_context_snapshot.bin	4/9/2024 1:28 PM	BIN File	582 KB
vk_swiftshader.dll	4/9/2024 1:28 PM	Application exten...	5,007 KB
vk_swiftshader_icd.json	4/9/2024 1:28 PM	JSON File	1 KB
vulkan-1.dll	4/9/2024 1:28 PM	Application exten...	918 KB

At this point it runs `Installer.exe` which is seen collecting data from Discord and web browser directories.

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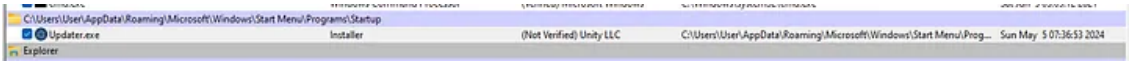
7:34:3...	Installer.exe	2384	CreateFile	C:\Windows\Fonts\ariali.ttf
7:34:3...	Installer.exe	2384	CreateFile	C:\Windows\Fonts\ariblk.ttf
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\index
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\index
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_0
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_0
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_0
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_1
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_1
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_1
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_2
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_2
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_2
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_3
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_3
7:34:3...	Installer.exe	3900	CreateFile	C:\Users\User\AppData\Roaming\game\Cache\Cache_Data\data_3
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\discord\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\discordcanary\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\discordptb\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\discorddevelopment\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\lightcord\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Default\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 1\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 2\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 3\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 4\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 5\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Guest Profile\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Default\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 1\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 2\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 3\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 4\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Profile 5\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Google\Chrome\User Data\Guest Profile\Network\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\Opera Software\Opera Stable\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Roaming\Opera Software\Opera GX Stable\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Default\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Profile 1\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Profile 2\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Profile 3\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Profile 4\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Profile 5\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\BraveSoftware\Brave-Browser\User Data\Guest Profile\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Yandex\YandexBrowser\User Data\Profile 1\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Yandex\YandexBrowser\User Data\Profile 2\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Yandex\YandexBrowser\User Data\Profile 3\Web Data
7:34:3...	Installer.exe	2384	CreateFile	C:\Users\User\AppData\Local\Yandex\YandexBrowser\User Data\Profile 4\Web Data

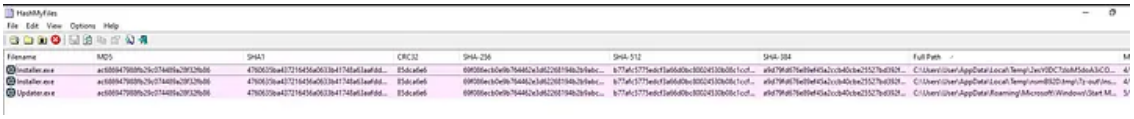
It also attempts to maintain persistence in the Startup folder as `Updater.exe`

Press enter or click to view image in full size



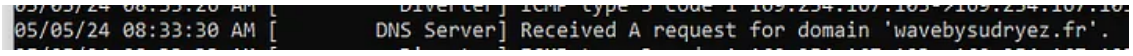
Verified the hashes are the same. Also seen in another AppData\Local\Temp directory.

Press enter or click to view image in full size

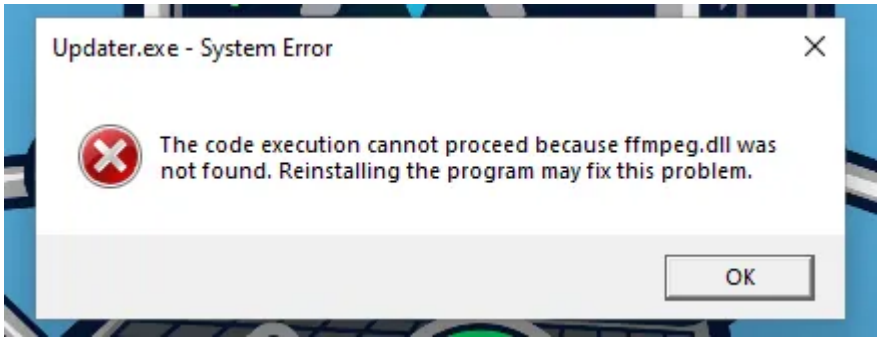


Reviewing the FakeNet-NG logs shows this suspicious domain.

Press enter or click to view image in full size



Curiously, when the VM was rebooted, this error message popped up, showing `Updater.exe` failed to launch from Startup.



Manually launching `Updater.exe` and examining under ProcMon suggests it has a DLL injection vulnerability (DLL Search Order Hijacking) regarding `ffmpeg.dll` . This is indicated by the numerous successive CreateFile attempts where the result is Name Not Found and the Path ends in `ffmpeg.dll` ; `Updater.exe` is “searching” for the missing DLL. The very first place searched is the Startup folder (there `Updater.exe` resides), this is because the search routine starts with the directory where the program is located. So if an attacker places the malicious DLL in the same folder as the vulnerable program, the search routine will find it and load it.

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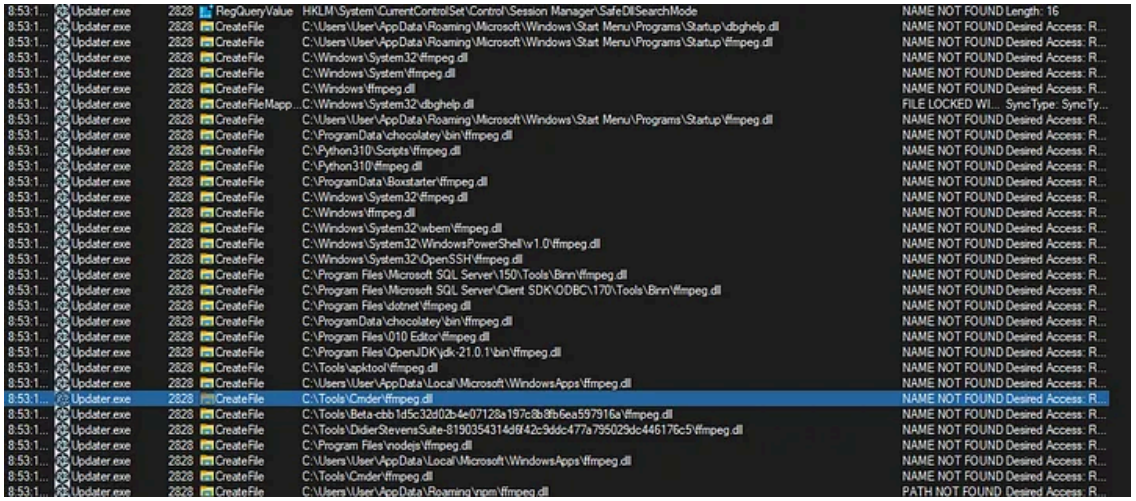

For a more in-depth look at Search Order Hijacking checkout https://book.hacktricks.xyz/windows-hardening/windows-local-privilege-escalation/dll-hijacking#dll-search-order

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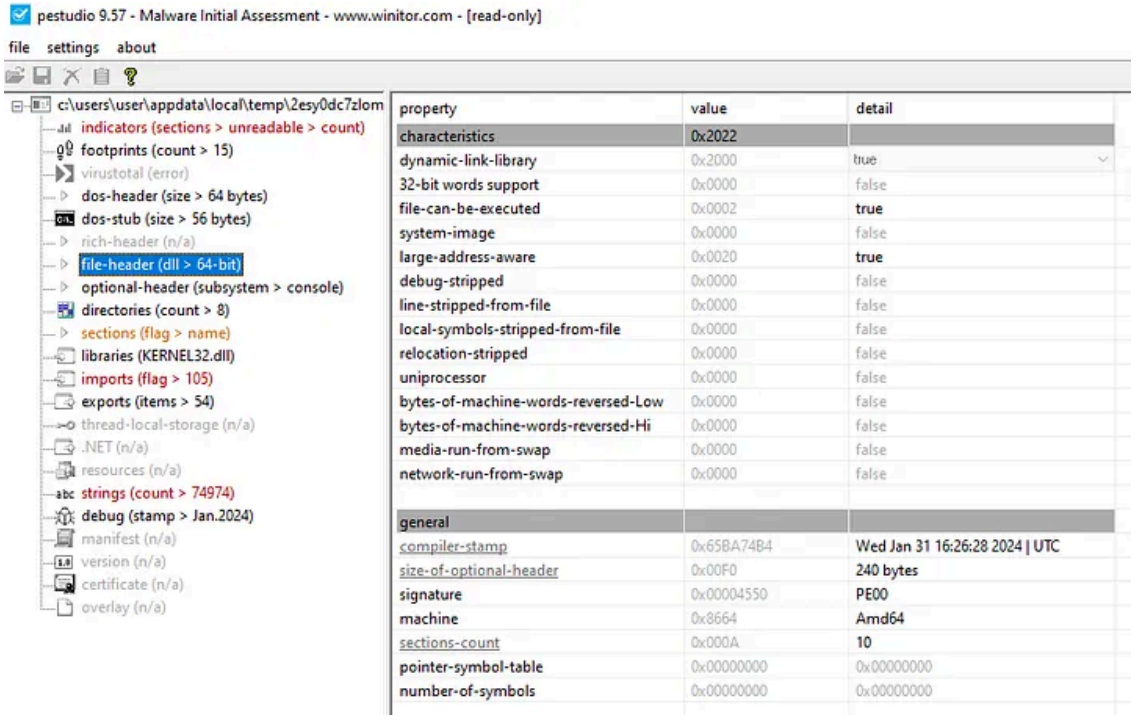
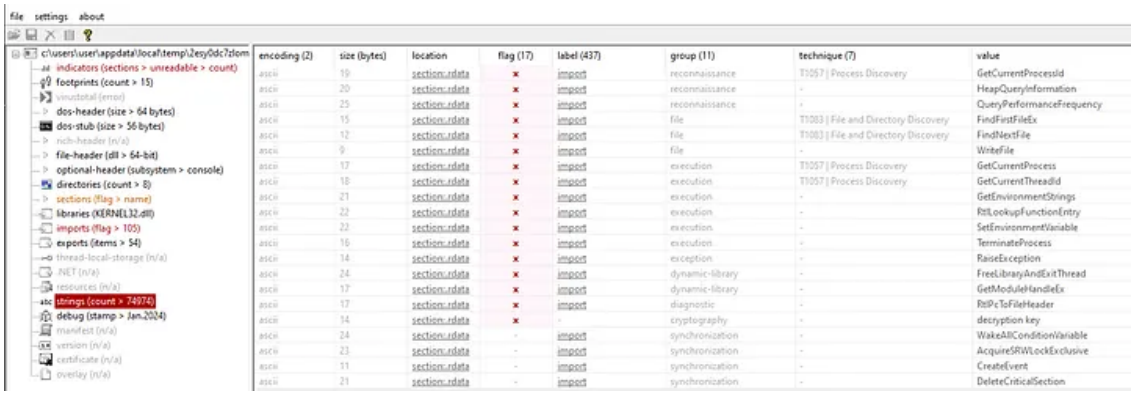
Looking at the `ffmpeg.dll` that is dropped by the first stage shows it was created in January 2024.

Press enter or click to view image in full size



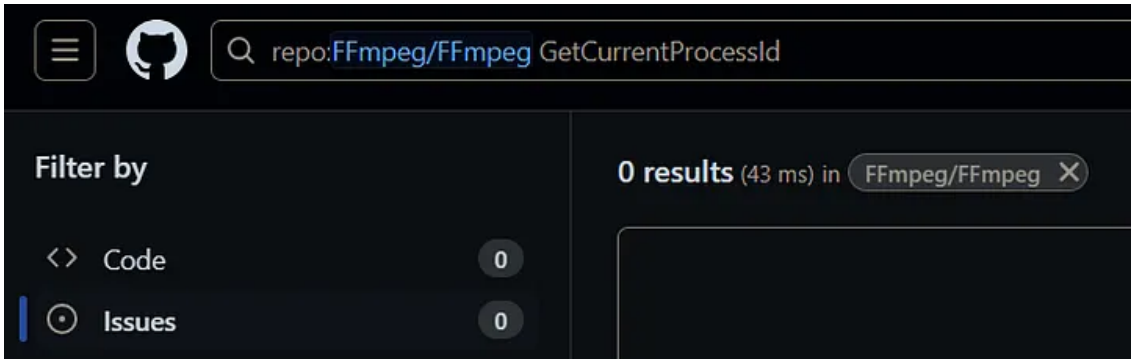
Looking at the strings present in `ffmpeg.dll` shows it has some capabilities that does not appear necessary for something claiming to be related to FFmpeg.

Press enter or click to view image in full size



Also searched through the FFmpeg source code on GitHub for various strings seen above, none were found, suggesting this is not a genuine `ffmpeg.dll`.

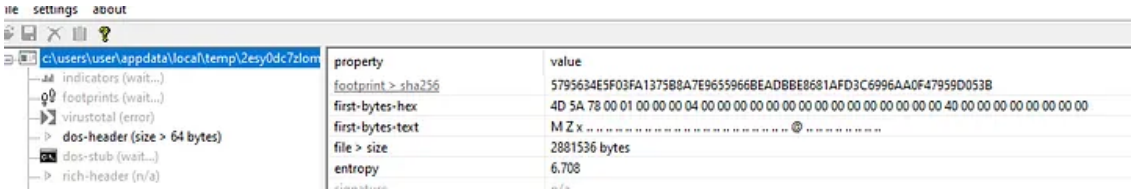
Press enter or click to view image in full size



At this point, I put `ffmpeg.dll` in the startup folder and ran `Updater.exe` and it triggered the domain callback. When I removed `ffmpeg.dll` and restarted the program, the callback does not happen and we see the same error as before where `Updater.exe` just crashes. So we have a high degree of confidence that DLL Hijacking is the execution method.

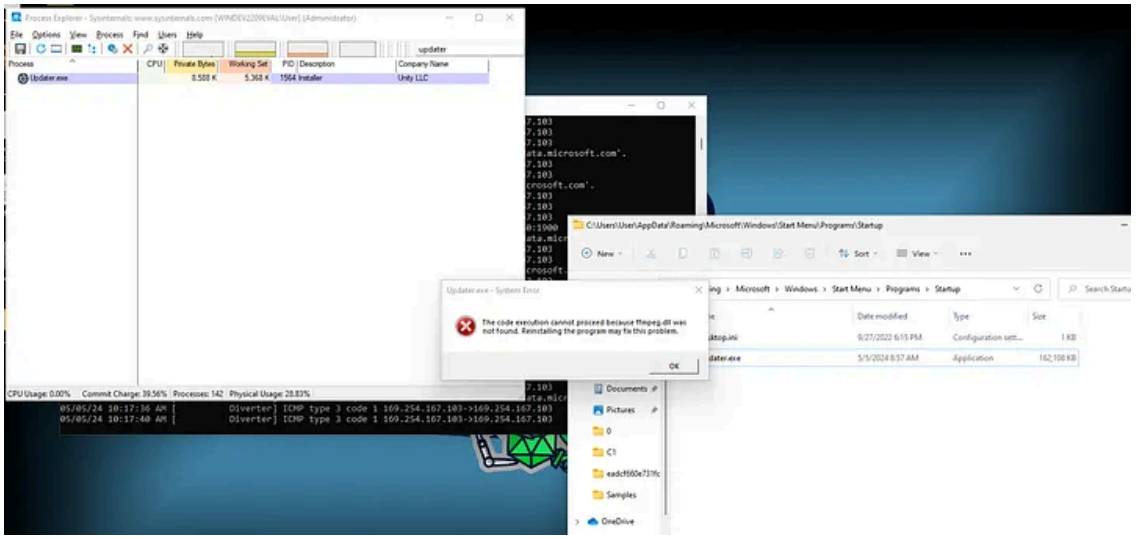
Grabbing the hash for `ffmpeg.dll` : 5795634e5f03fa1375b8a7e9655966beadbbe8681afd3c6996aa0f47959d053b

Press enter or click to view image in full size

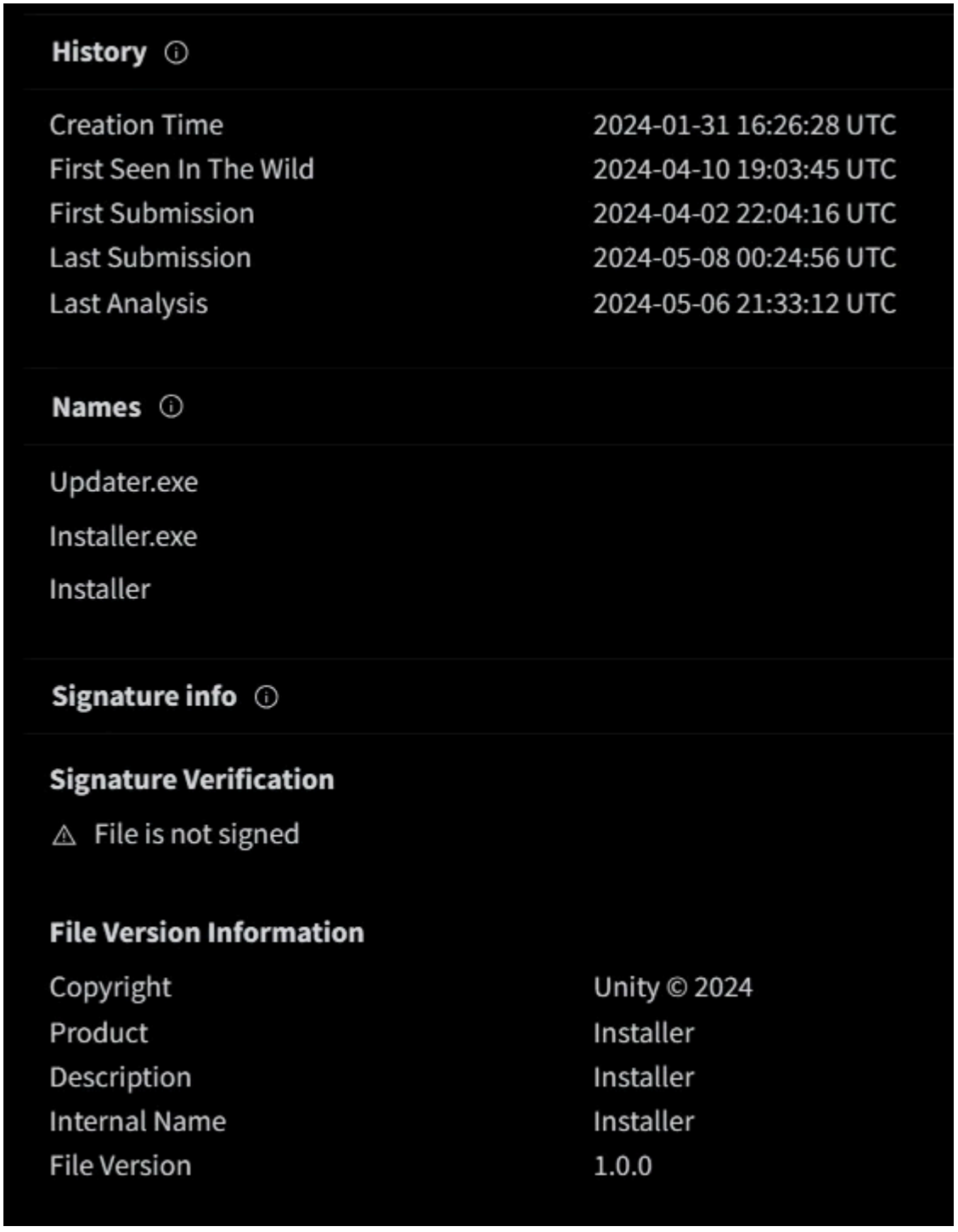


Looking at `Updater.exe` shows it has “Unity LLC” listed as its Company.

Press enter or click to view image in full size

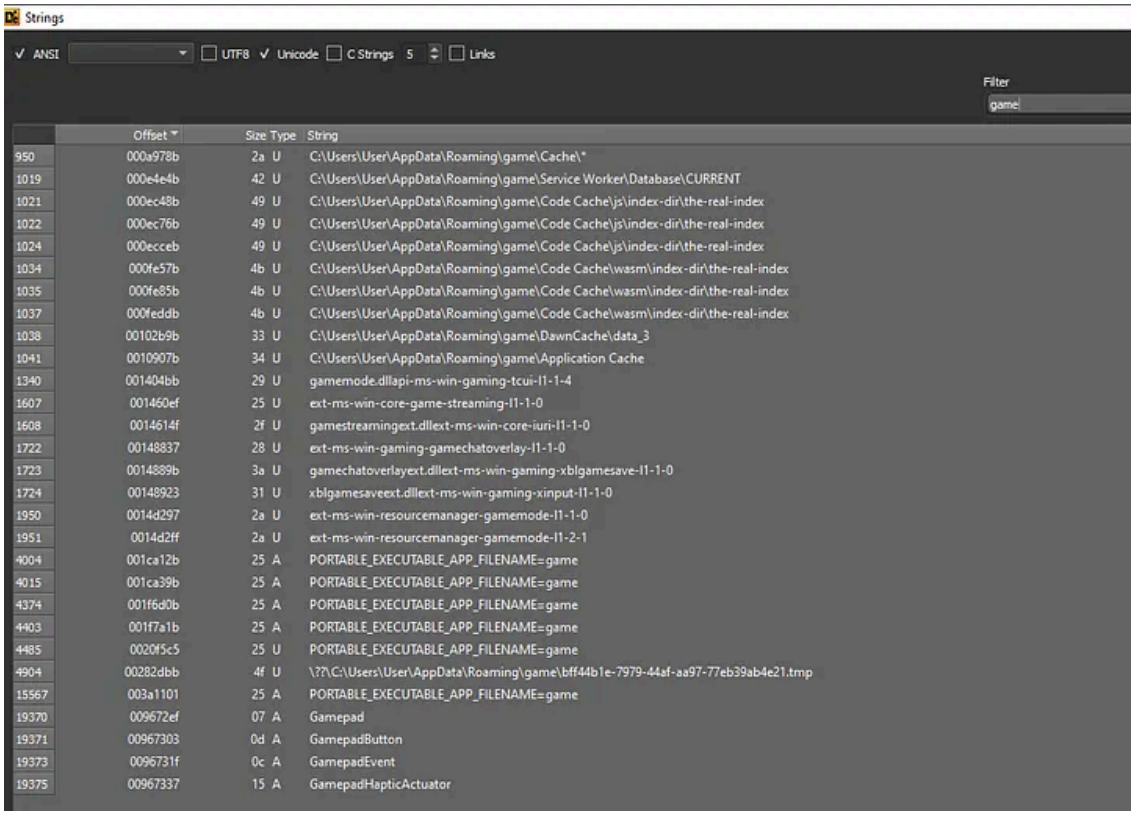


The hash for `Updater.exe` is 69f086ecb0e9b764462e3d62268194b2b9abc8e4492b6c5b38472e1b7897436d and looking at it in VT shows it was also compiled in January 2024 and has a copyright of “Unity @ 2024”



I re-added `ffmpeg.dll` into the startup folder and launched `Updater.exe` again, created a process dump, and found some strings related to gaming. (i.e. I added the DLL back in so the EXE does not crash)

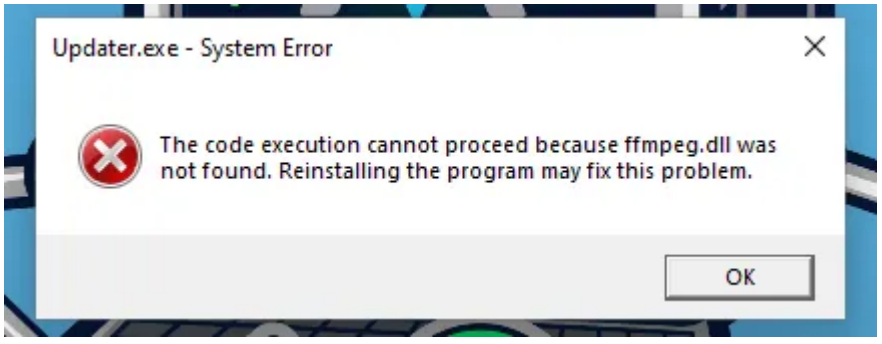
Press enter or click to view image in full size



The “Unity @ 2024” copyright, “Unity LLC” company, and the strings above lead me to believe this is the Unity program for gaming. However, the compilation time being the same month as `ffmpeg.dll` is also curious. It appears one can buy/download the Unity source code (https://unity.com/products/source-code). It is unclear if the threat actor compiled a custom version Unity or not, but either way, the malicious activity relies on the `ffmpeg.dll` (which is not related to the actual FFmpeg project).

Not-So-Persistent

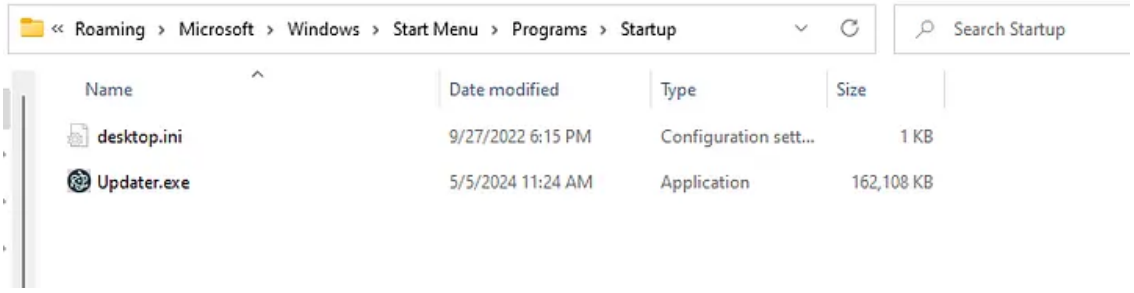
So if you remember, about halfway through this I mentioned when I rebooted the VM I got this error message.



This message hints at the existence of the DLL injection vulnerbility discussed in detail above. It also suggests the persistence mechanism for this sample was broken.

When the first stage is executed, it dropped `Updater.exe` into the Startup folder. However, `Updater.exe` crashes if it is unable to load `ffmpeg.dll` and the first stage never copied `ffmpeg.dll` into the startup folder, hence why `Updater.exe` crashed on startup.

Press enter or click to view image in full size



Conclusion

Wave Stealer is an infostealer that takes advantage of a DLL Injection vulnerability for `ffmpeg.dll` in what appears to be a Unity-related product, possibly a custom-compiled version of Unity. The program attempts to maintain persistence in the Startup folder. In this particular sample, the persistence was broken, causing the program to crash on startup.

IOCs

eadcf660e731fd3de0a5a8bee2f2337e7d78438f4e9293d2c90d5e63a2d9368e (stage 1; sample.exe)

69f086ecb0e9b764462e3d62268194b2b9abc8e4492b6c5b38472e1b7897436d (stage 2; Installer.exe, Updater.exe)

5795634e5f03fa1375b8a7e9655966beadbbe8681afd3c6996aa0f47959d053b (malicious ffmpeg.dll)

wavebysudryez[.]fr
