Malware Tales: Sodinokibi

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Tag:
Malware, sodinokibi, gandcrab

Hi everyone! Today we are looking at a threat that appeared recently: a new ransomware called **Sodinokibi**.

Summary

1. The Threat

The first noteworthy appearance was at the end of April (Talos Research).

Then, at the start of this month, we gathered different reports of this threat being spread in Italy (eg: JAMESWT_MHT's tweet), both via malspam and known server vulnerabilities.

Also, there was the announcement of the shutdown of the GandCrab Operation (Bleeping Computer), just some days earlier.

Coincidence? We’ll see.

Our guess is that this new payload could be used as a replacement of **GandCrab** in the RAAS (Ransomware-as-a-service) panorama.

Therefore, in order to protect our customers effectively, we went deep into the analysis of this ransomware.

Mainly we analyzed two different samples:

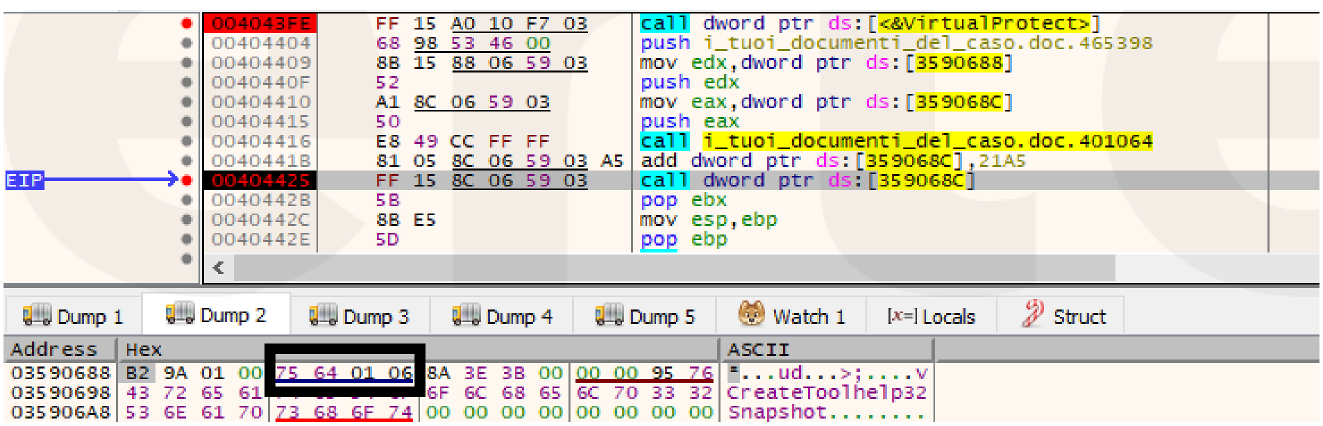
- version 1.01: md5: e713658b666ff04c9863ebecb458f174
- version 1.00: md5: bf9359046c4f5c24de0a9de28bbabd14

2. The Loader

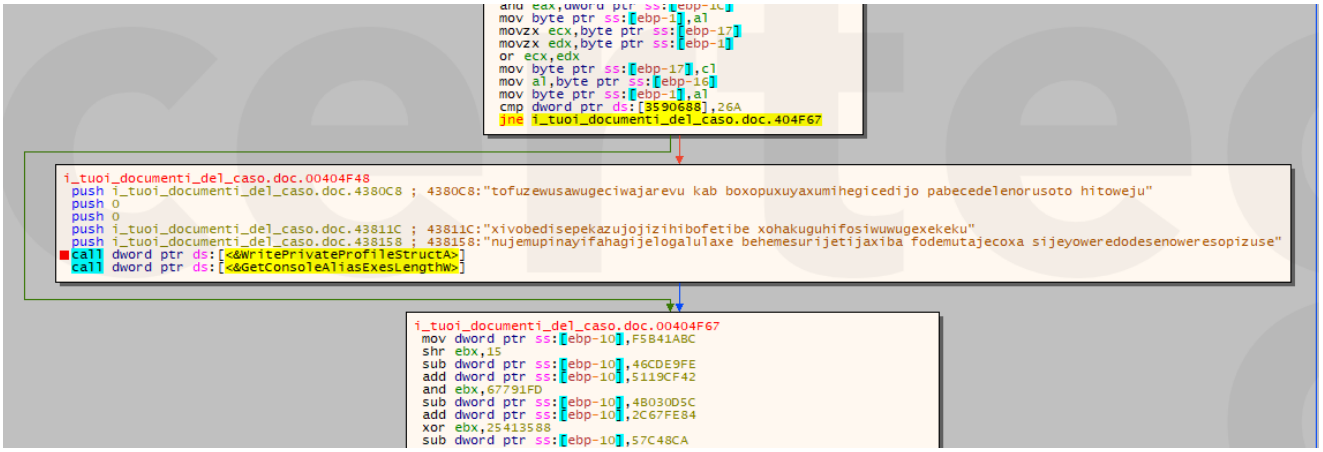
Like every malware who deserves respect, **Sodinokibi** is protected by a custom *packer* that is different for each sample.

The method used by the version 1.01 sample to reconstruct the original payload is called “**PE overwrite**”.

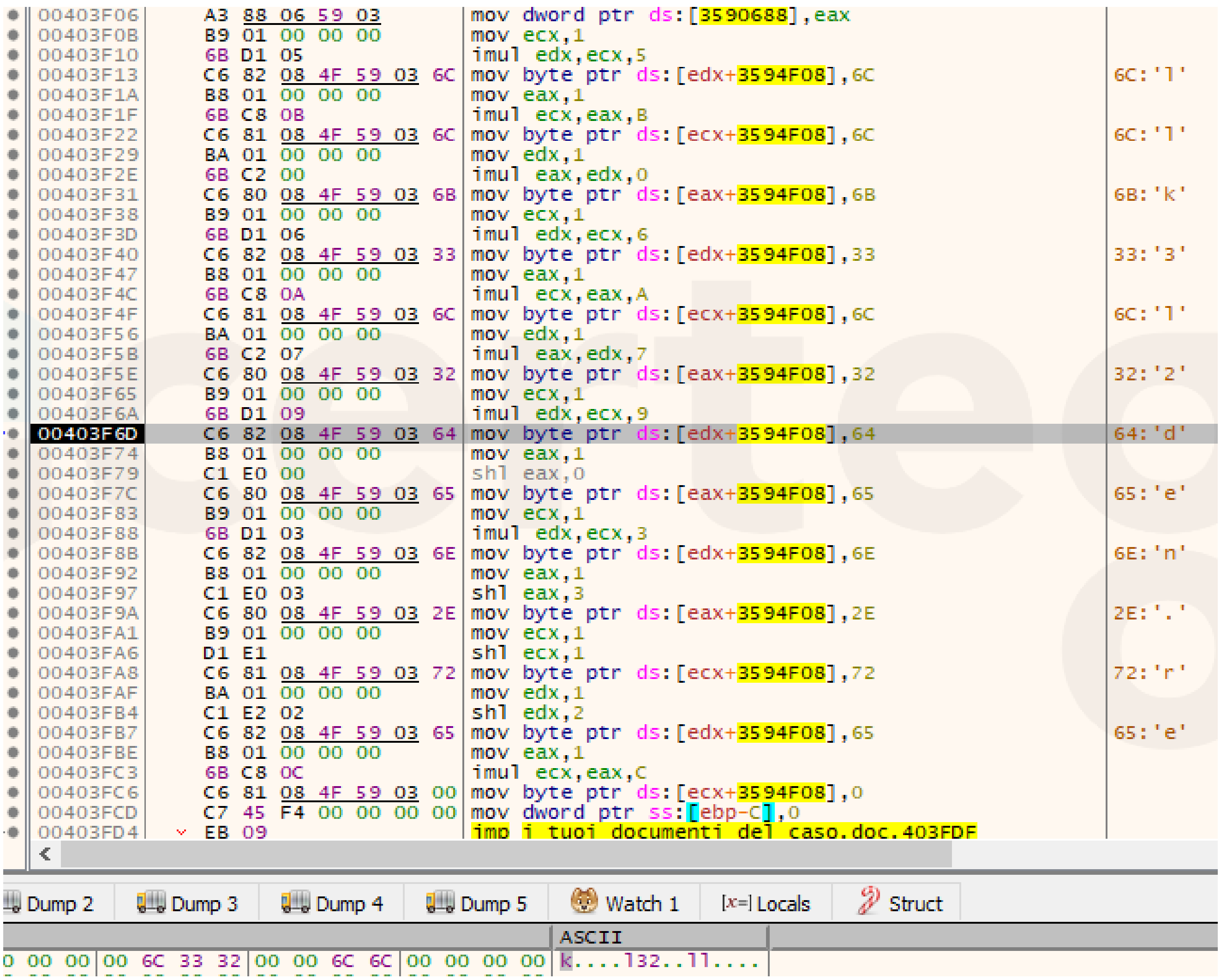
To perform this technique, the malicious software must allocate a new area inside its process memory and fill it with the code that has the duty to overwrite the mapped image of the original file with the real malware payload. In this case, first the process allocates space in the *Heap* via *LocalAlloc*, then it writes the “**unpacking stub**” code, it signs that space as executable with *VirtualProtect* and finally it redirects the execution flow to the new memory space



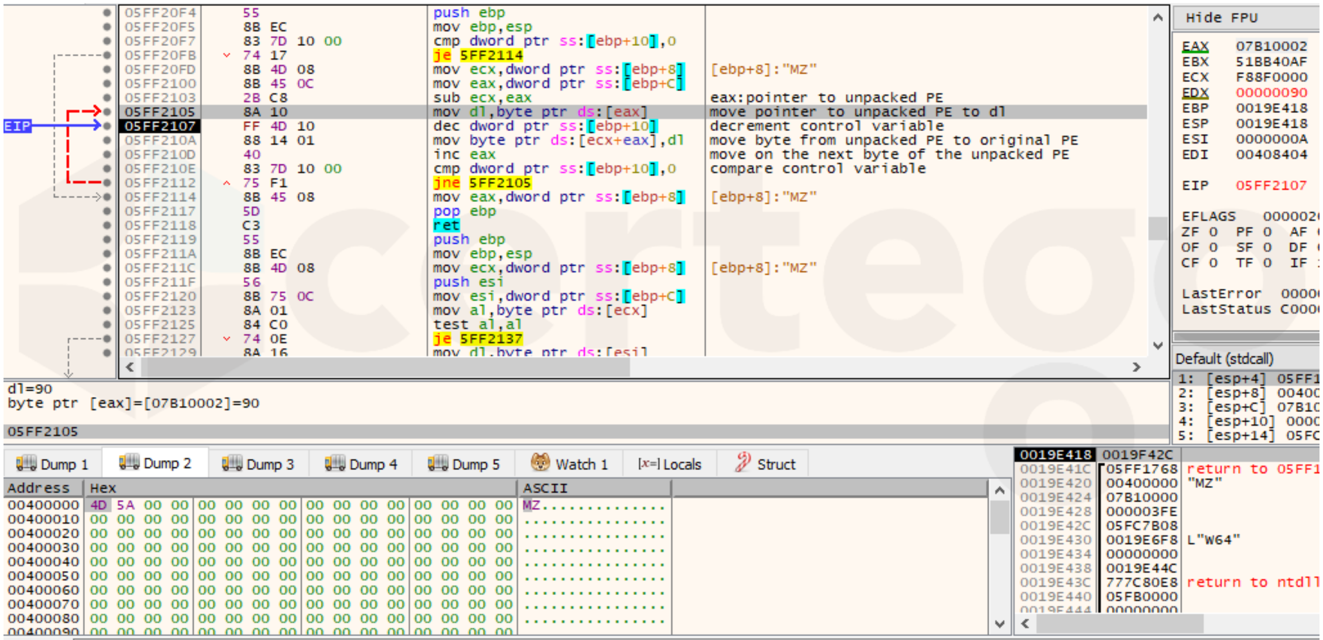
In order to slow the analysis, the loader contains a lot of junk code that will be never executed.



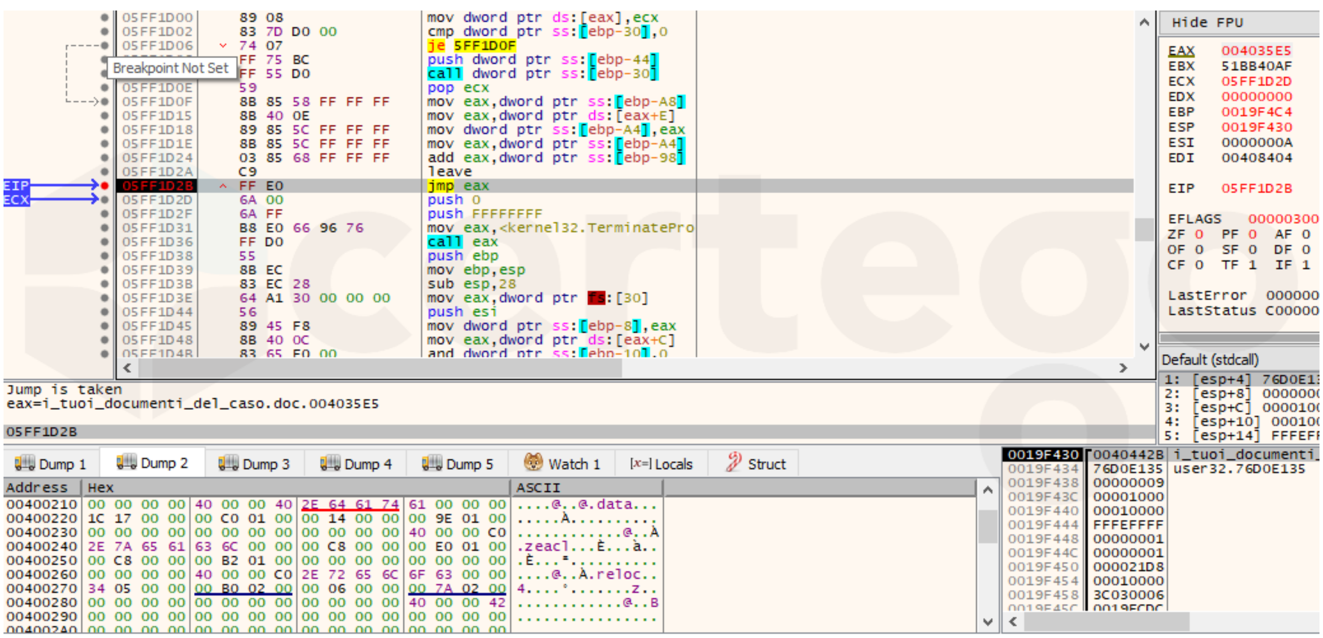
Also, in the following image, we can see that it tries to hide some important strings from the static analysis like " *kernel32.dll*". It leverages "**stack strings**" plus the randomization of the order of the characters.



At this point, the unpacking stub resolves dynamically the functions that he needs like *VirtualAlloc*. Then it performs the overwrite of the original image base with the new decrypted payload.

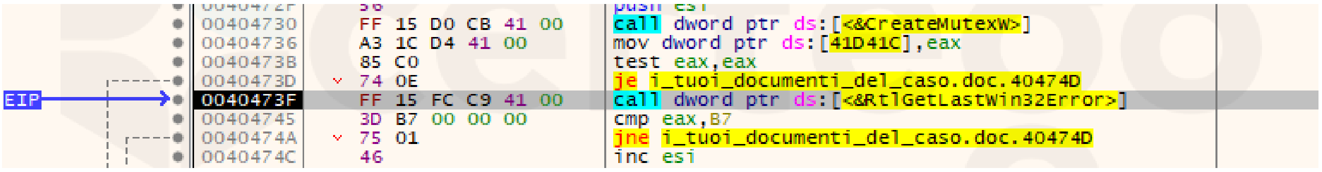


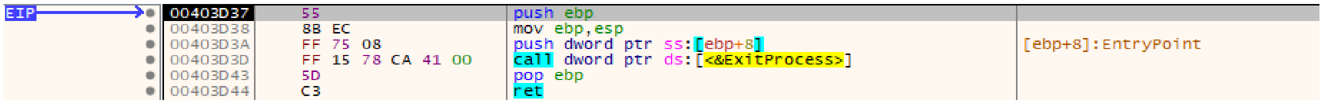
Finally, it transfers the execution to the *OEP* (Original Entry Point) of the unpacked Sodinokibi payload.



3. Mutex and Configuration

Once unpacked, the sample tries to create a **mutex** object. It calls *CreateMutexW*, then, if there was an error, with *RtlGetLastWin32Error* it would extract the generated error. Indeed, if the mutex already existed, the error would have been “0xB7” ("*ERROR_ALREADY_EXISTS*" ref docs). In that case a function is called that terminates the process.





We found that the mutex name is different for each sample but following this pattern: “**Global\{UUID}**”. Therefore it’s a method to detect the malware or to vaccinate the endpoint (Zeltser blog) that is reliable only for a specific sample.

Going forward, we found the configuration in an encrypted form in the section “ **.zeacl**” for v.1.01 or “**.grrr**” for v.1.00. Once extracted, we noticed that it’s a JSON file.

These are the keys found in the configuration.

- “**pk**” -> base64 encoded key used to encrypt files
- “**pid**” -> personal id of the actor
- “**sub**” -> another id, maybe related to the specific campaign
- “**dbg**” -> debug mode
- “**fast**” -> fast mode
- “**wipe**” -> enable wipe of specific directories
- “**wht**” -> whitelist dictionary
  - “**fld**” -> keyword in whitelisted directories
  - “**fls**” -> whitelisted filenames
  - “**ext**” -> whitelisted file extensions
- “**wfld**” -> directories to wipe
- “**prc**” -> processes to kill before the encryption
- “**dmn**” -> domains to contact after encryption
- “**net**” -> check network resources
- “**nbody**” -> base64 encoded ransom note body
- “**nname**” -> ransom note file name
- “**exp**” -> unknown, expert mode?
- “**img**” -> base64 encoded message on desktop background

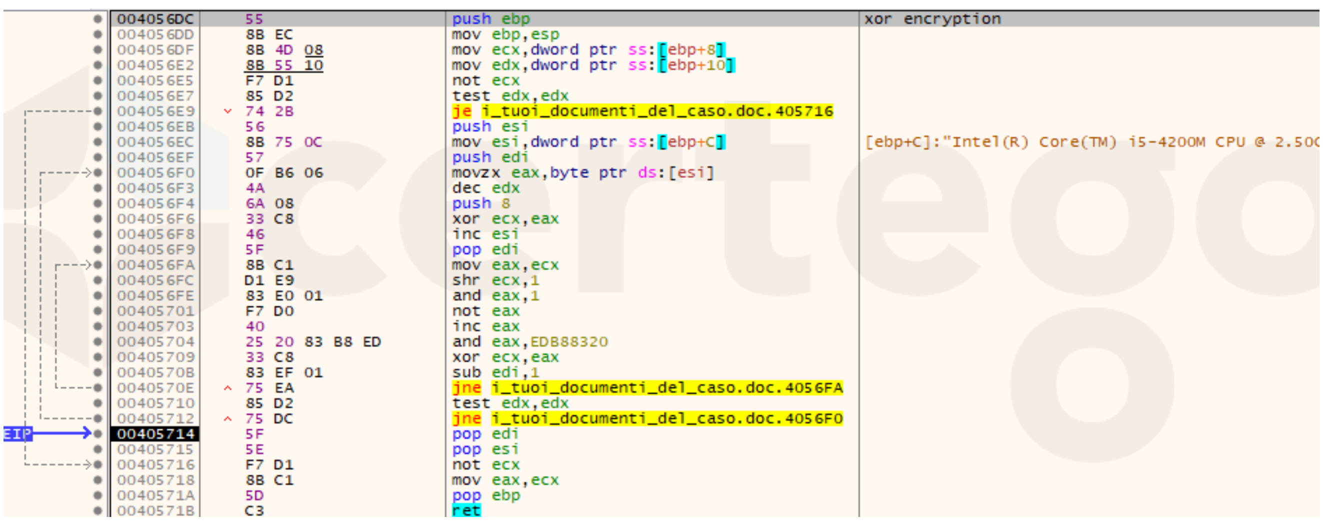
If you are interested in manually checking the configuration files we have extracted in the samples we have analyzed, follow this link and download the archive (password:sodinokibi): sodinokibi_config_files.zip

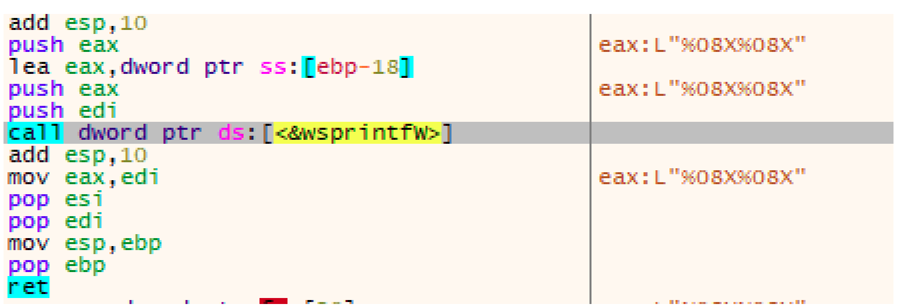
4. Machine information recovery

Afterwards, Sodinokibi starts to gather information about the infected machine and builds another JSON structure that stores in an encrypted form in the “*HKEY_LOCAL_MACHINE\SOFTWARE\recfg\stat*” registry key.

Keys:

- "**ver**": version (100 or 101)
- "**pid**": previous config "pid"
- "**sub**": previous config "sub"
- "**pk**": previous config "pk"
- "**uid**": user ID. It's a 8 byte hexadecimal value generated with XOR encryption. First 4 bytes are created from the processor name, while the others are created from the volume serial number extracted with a "*GetVolumeInformationW*" API call.





- "**sk**": secondary key, base64 encoded key generated at runtime
- "**unm**": username
- "**net**" : hostname
- "**grp**": windows domain

```
push ebx
push dword ptr ss:[ebp+C]                    [ebp+C]:L"SYSTEM\\CurrentControlSet\\services\\Tcpip\\Parameters
mov esi,ebx
push dword ptr ss:[ebp+8]
call dword ptr ds:[<&RegOpenKeyExW>]
test eax,eax
jne i_tuoi_documenti_del_caso.doc.4046A9
push edi
mov edi,dword ptr ss:[ebp+18]
push edi
push ebx
push dword ptr ss:[ebp+14]
push ebx
push dword ptr ss:[ebp+10]                   [ebp+10]:L"Domain"
push dword ptr ss:[ebp-4]
call dword ptr ds:[<&RegQueryValueExW>]
```

"**lng**": language

```
0040463F   6A 01              push 1
00404641   53                 push ebx
00404642   FF 75 0C           push dword ptr ss:[ebp+C]       [ebp+C]:L"Control Panel\\International"
00404645   8B F3              mov esi,ebx
00404647   FF 75 08           push dword ptr ss:[ebp+8]
0040464A   FF 15 E8 CA 41 00  call dword ptr ds:[<&RegOpenKeyExW>]
00404650   85 C0              test eax,eax
00404652   75 55              jne i_tuoi_documenti_del_caso.doc.4046A9
00404654   57                 push edi
00404655   8B 7D 18           mov edi,dword ptr ss:[ebp+18]
00404658   57                 push edi
00404659   53                 push ebx
0040465A   FF 75 14           push dword ptr ss:[ebp+14]
0040465D   53                 push ebx
0040465E   FF 75 10           push dword ptr ss:[ebp+10]      [ebp+10]:L"LocaleName"
00404661   FF 75 FC           push dword ptr ss:[ebp-4]
00404664   FF 15 EC CA 41 00  call dword ptr ds:[<&RegQueryValueExW>]
```

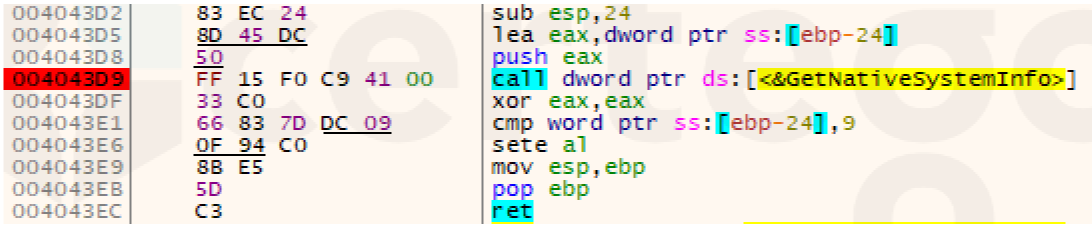
"**bro**": brother? Sodinokibi retrieves the keyboard language with *GetKeyboardLayoutList*. Then it implements an algorithm that gives "*True*" as value for this key only if the nation code ends with a byte between 0x18 and 0x2c. It's not odd that inside this range there are the majority of the East-Europe language codes, like Russian, Cyrillic and Romanian. It's a clear indication of the origin of the malware authors.

```
00404372   55                    push ebp                                   eax is code language, eg. 410 Italian
00404373   8B EC                 mov ebp,esp
00404375   0F B6 45 08           movzx eax,byte ptr ss:[ebp+8]
00404379   83 C0 E8              add eax,FFFFFFE8
0040437C   83 F8 2C              cmp eax,2C                                 2C:','
0040437F   77 13                 ja i_tuoi_documenti_del_caso.doc.404394
00404381   0F B6 80 A2 43 40 00  movzx eax,byte ptr ds:[eax+4043A2]
00404388   FF 24 85 9A 43 40 00  jmp dword ptr ds:[eax*4+40439A]
0040438F   33 C0                 xor eax,eax
00404391   40                    inc eax
00404392   5D                    pop ebp
00404393   C3                    ret
00404394   33 C0                 xor eax,eax
00404396   5D                    pop ebp
00404397   C3                    ret
```

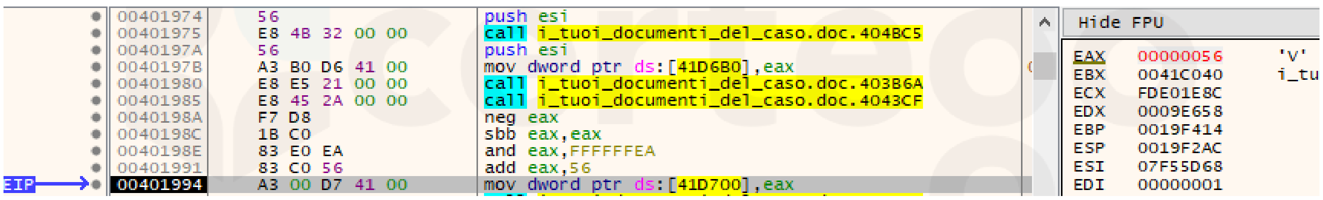
"**os**": full OS name

```
push dword ptr ss:[ebp+C]                    [ebp+C]:L"SOFTWARE\\Microsoft\\Windows NT\\CurrentVersion"
mov esi,ebx
push dword ptr ss:[ebp+8]
call dword ptr ds:[<&RegOpenKeyExW>]
test eax,eax
jne i_tuoi_documenti_del_caso.doc.4046A9
push edi
mov edi,dword ptr ss:[ebp+18]
push edi
push ebx
push dword ptr ss:[ebp+14]
push ebx
push dword ptr ss:[ebp+10]                   [ebp+10]:L"productName"
push dword ptr ss:[ebp-4]
call dword ptr ds:[<&RegQueryValueExW>]
```

"**bit**": Sodinokibi extracts this value from "*GetNativeSystemInfo*" then it compares with 9 that corresponds to the x64 architecture. Further processing will generate "40" if the architecture is 64bit, "56" otherwise.



PROCESSOR_ARCHITECTURE_AMD64 9	x64 (AMD or Intel)

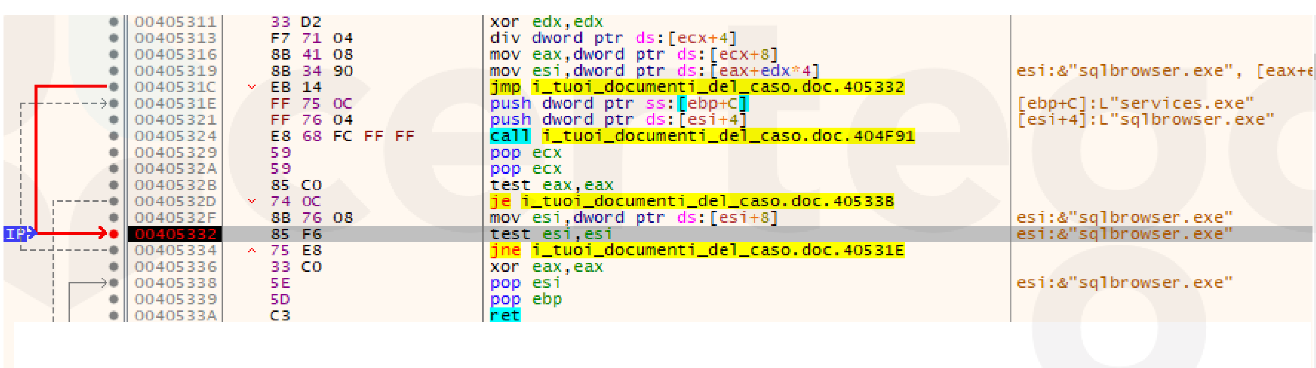


- "**dsk**": base64 encoded value generated based on the drives found on the machine.
- "**ext**": new in 1.01. The random extension used for encrypted files.

5. Encryption preparation inspired by GandCrab

At this time, before performing the encryption, Sodinokibi replicates a behavior that is very similar to what GandCrab performs, suggesting that Sodinokibi authors learned from GandCrab ones or that they are strictly related.

Sodinokibi extracts the running processes with the combination of *CreateToolhelp32Snapshot*, *Process32First* and *Process32First* and checks if they match the names in the configuration. In that case, those processes are killed. The reason is that these programs could hold write access on files and therefore they could not allow the ransomware to encrypt them.

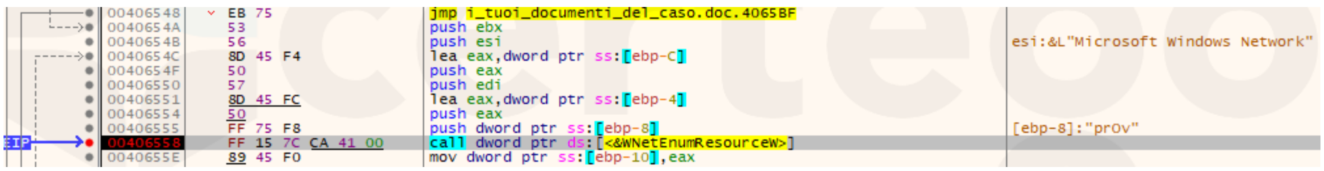


The list of the version 1.00 contains only the "*mysql.exe*" process, while the list of the version 1.01 is a lot longer and almost matches the ones used by GandCrab (source: Symantec).

Afterwards, like his predecessor, Sodinokibi deletes the shadow copies with the leverage of the "*vssadmin*" native utility. In addition, it uses "*bcdedit*" to disable windows error recovery on reboot.

```
cmd /c vssadmin.exe Delete Shadows /All /Quiet & bcdedit /set {{default}} r
ecoveryenabled No & bcdedit /set {{default}} bootstatuspolicy ignoreallfail
ures
```

Another check done by the ransomware is for available network resources with *WNetOpenEnumW* e *WNetEnumResourceW* with the aim to find other files to encrypt.

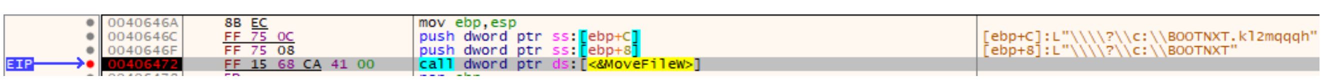


Last operation before the encryption is to find all the directories with a name that matches the configuration key "*wfld*" and to wipe them. In this case, the list contains only "*backup*". So, for example, Sodinokibi deletes Windows Defenders updates backups.

6. Ransomware attack

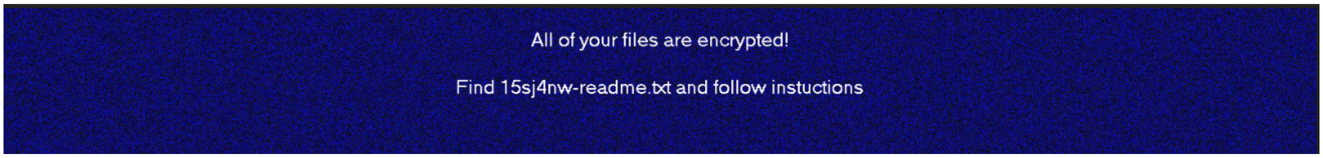
Finally (or not?) Sodinokibi starts to iterate over the available directories with *FindFirstFile* and *FindNextFile*.

It skips files and directories that match conditions on the whitelist configuration. The others are encrypted by the ransomware that adds the random generated key as extension to the name.



In each directory the malware also write the ransom note "**{ext}.readme.txt**" extracted from the configuration and a lock file.

Then it creates a file with a random name "*{random}.bmp*" in the *%TEMP%* which contains the image that will be put as a background with the help of *DrawTextW* and *FillRect* functions.



7. C2 Registration

Once the encryption is finished, Sodinokibi starts to iterate through a giant list of domains hardcoded in the configuration (about 1k). These domains are the same across the samples we analyzed but they are ordered differently in order to mislead the analysis.

At a first glance, these domains seem legit and most of them are correctly registered.

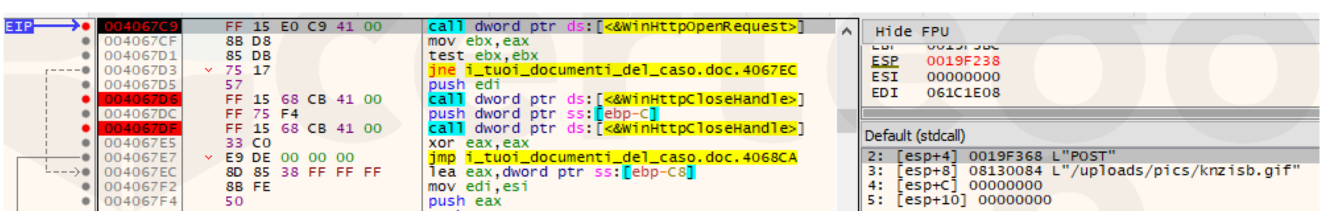
This is not a classic DGA but the result is almost the same because the purpose is to hide the real C&C Server used by cyber criminals.

For each domain listed, Sodinokibi generates a random URI. Then it uses the *winhttp.dll* library functions to perform HTTPS POST requests with the created URLs.

The data sent with the POST request is an encrypted form of the JSON configuration saved on the "*HKEY_LOCAL_MACHINE\SOFTWARE\recfg\stat*" registry key and described on the "Machine information recovery" section. In this way, malicious actors can collect important information of the infected machine.

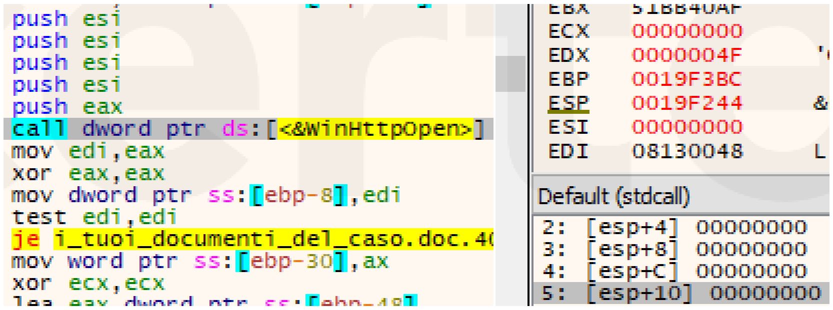
The following are examples of some of these URLs:

```
hxxps://schluesseldienste-hannover.de/admin/images/dcnzfpph.jpg
hxxps://alpesiberie.com/admin/tmp/sxuuaygb.png
hxxps://bratek-immobilien.de/uploads/image/bsxdfx.jpg
hxxps://bcmets.info/content/image/tjknaqfkuzxzny.jpg
```



Looking at an analysis of this sample in a sandbox (AnyRun), we noticed that HTTPS requests where not correctly listed. The malware can avoid traffic interception by proxies like *Fiddler* or *Mitmproxy* that are used for manual or automatic analysis.

How? The second parameter of the *WinHttpOpen* function is 0 which corresponds to "*WINHTTP_ACCESS_TYPE_DEFAULT_PROXY*": this means that the configured proxy is skipped and the HTTP connection won't be logged. This trick could mislead the analysis if not properly handled.



I suggest to read the following blog post where it's further explained how these URLs are generated and why also this routine is inspired by GandCrab code: Tesorion analysis

8. Conclusion

Sodinokibi could be the **heir** of **GandCrab**. It's still at version 1.01 so maybe it's not mature yet but is actively developed and updated

Malicious actors have started to use **Sodinokibi** to generate profit, even in Italy.

It's important to continuously **monitor** your own assets, both on a network and an endpoint level, to fight against these kind of threats.

Certego Threat Intelligence Team has been studying upcoming cyber threats for years in order to provide the best protection to their customers.

IOC

```
HKEY_LOCAL_MACHINE\SOFTWARE\recfg\stat
HKEY_LOCAL_MACHINE\SOFTWARE\recfg\pk_key
decryptor[.]top
aplebzu47wgazapdqks6vrcv6zcnjppkbxbr6wketf56nf6aq2nmyoyd[.]onion
```

About the author

Matteo Lodi, Cyber Threat Intelligence Team Leader

Twitter: https://twitter.com/matte_lodi