Analysis of CaddyWiper - Wiper Targeting Ukraine

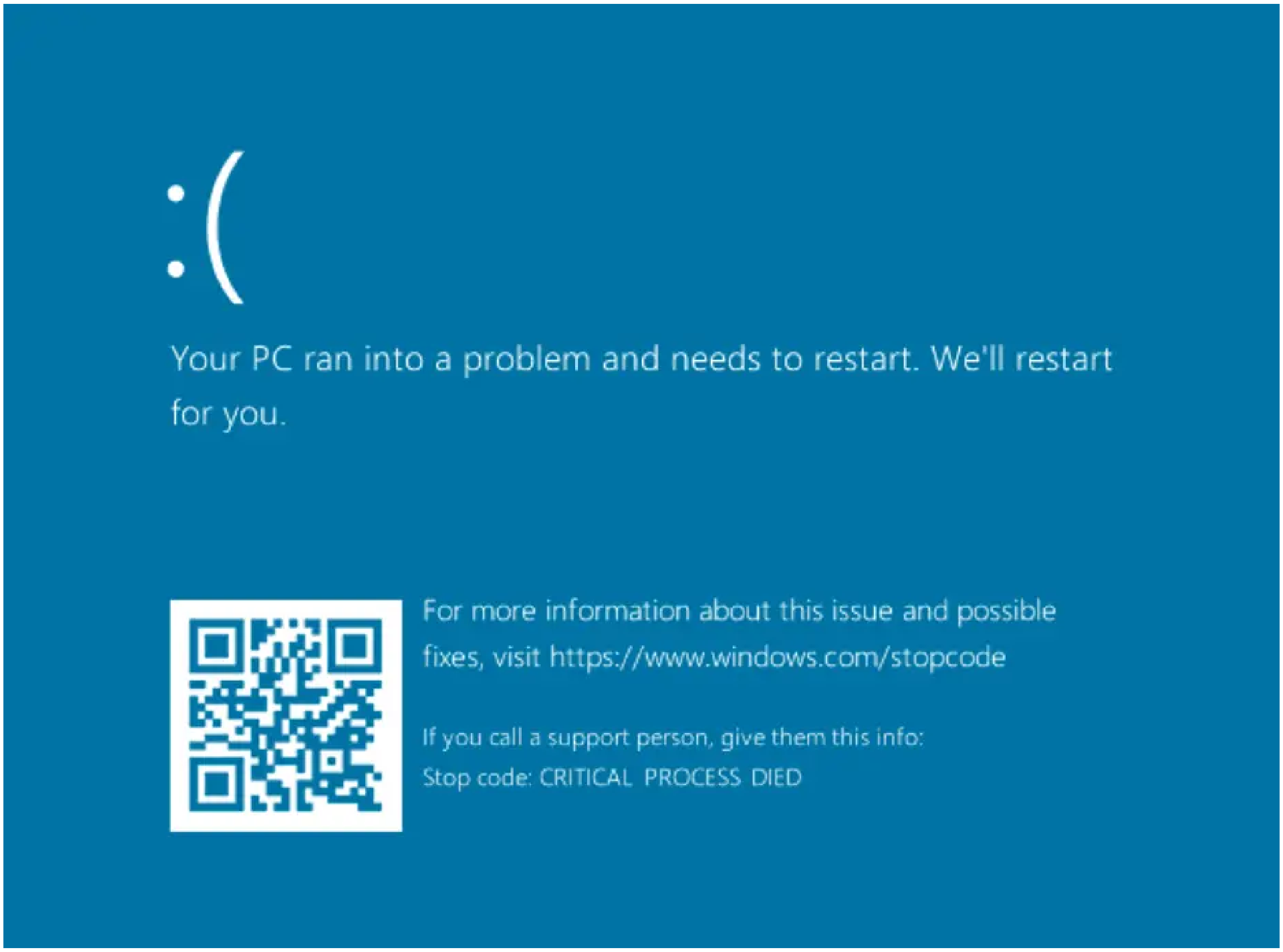
truesec.com/hub/blog/analysis-of-caddywiper-wiper-targeting-ukraine

On the March 14, 2022, security company ESET found a third destructive wiper that has been deployed in Ukraine, called CaddyWiper. It has parts that are created to destroy data quickly and in several ways. ESET published their first initial analysis on Twitter
Sample analyzed, SHA256:
a294620543334a721a2ae8eaaf9680a0786f4b9a216d75b55cfd28f39e9430ea

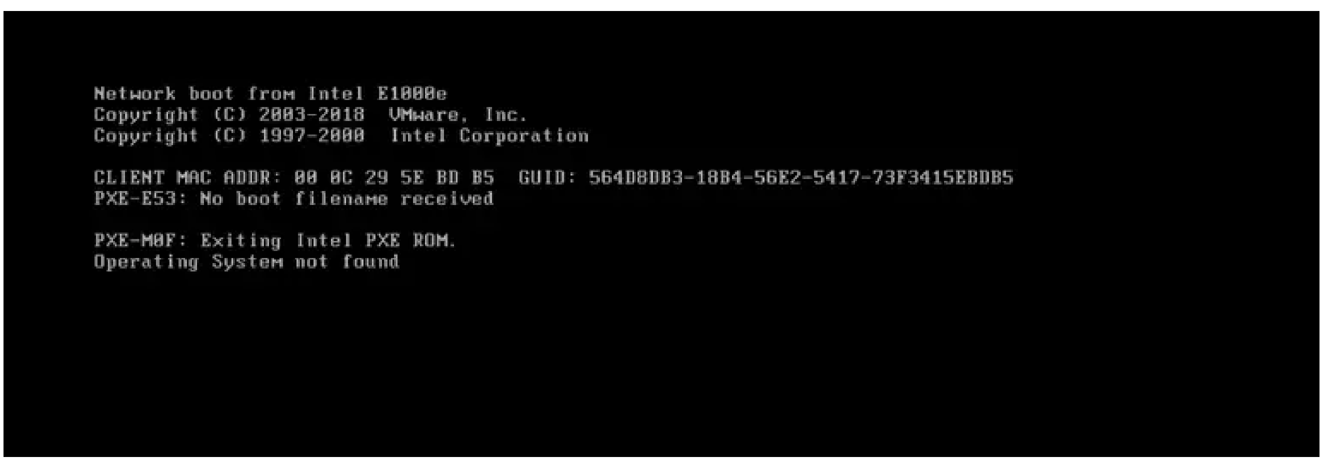
Truesec has looked into the wiper to understand its inner workings and find ways to detect the malware.

Malware Execution

According to the Twitter post by ESET the wiper is deployed by group policy to the infected system. Once run, as administrator, the system will crash and the following screen will be displayed.

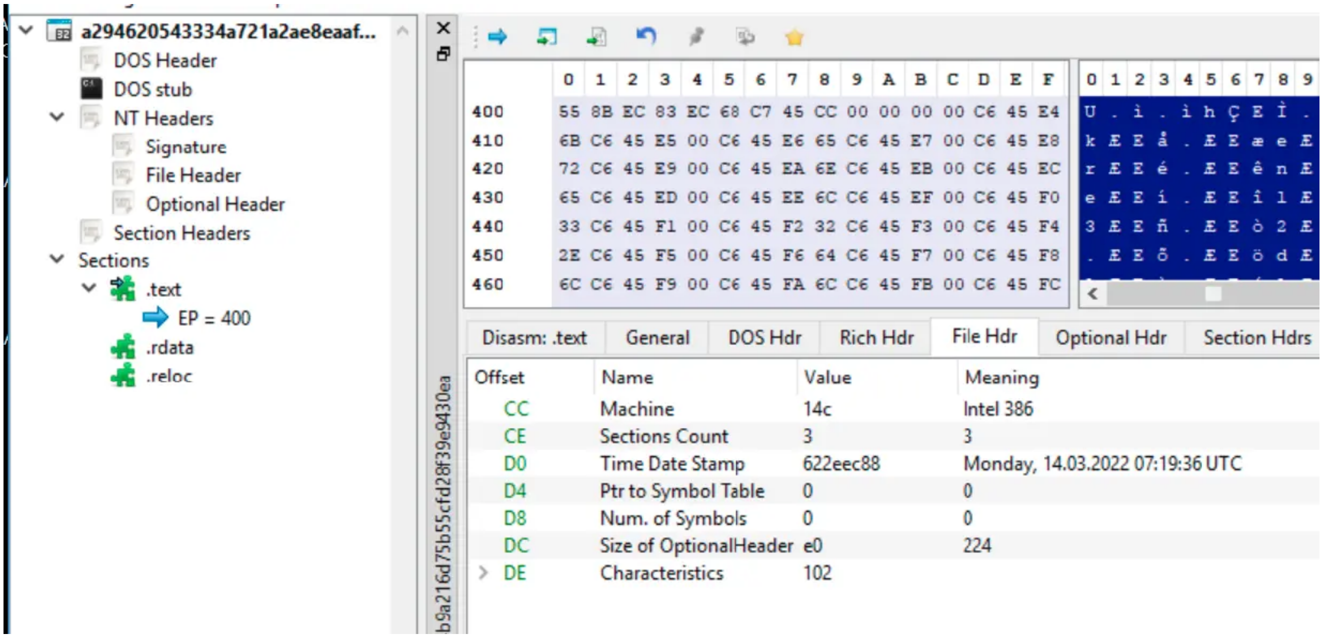


Once the computer is rebooted it crashes and will not start anymore and prompt that it cannot locate the operating system.

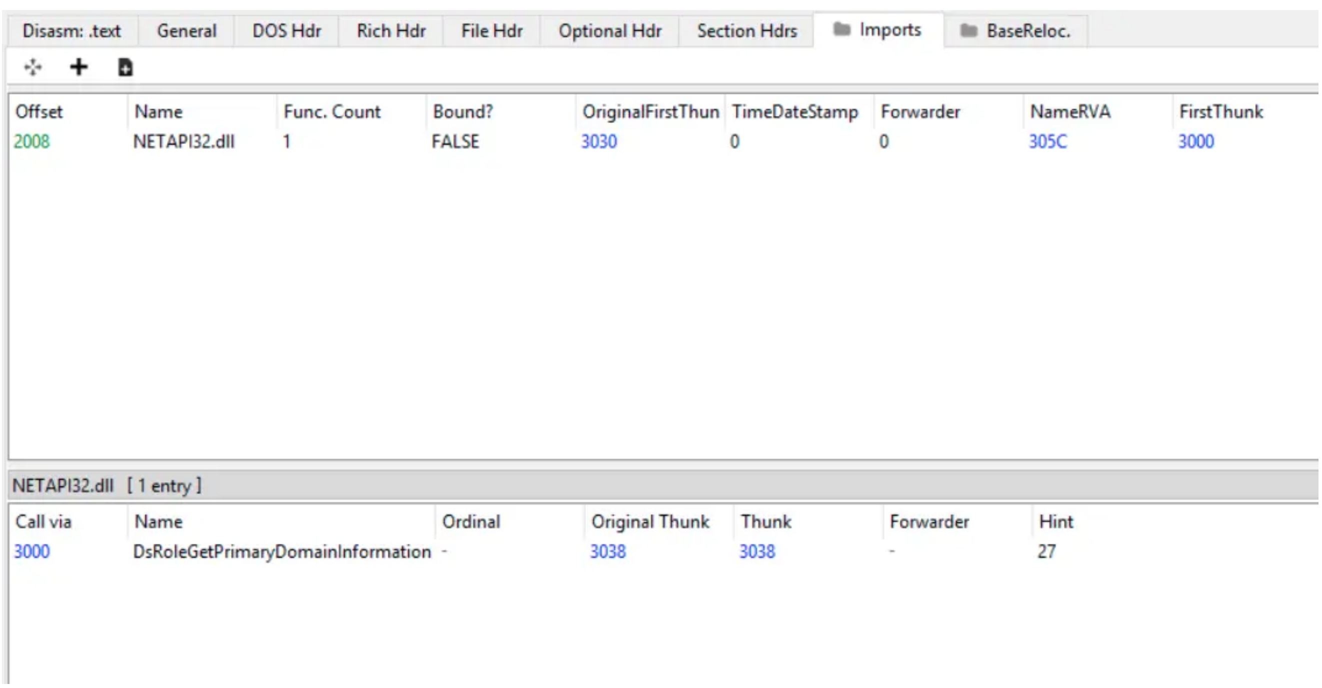


Static Analysis

Investigating the time stamp for the sample, it indicates that is compiled on March 14, 2022, showing that it was done just before the attack was conducted.



Looking at the Import Address table, there is only one function called, DsRoleGetPrimaryDomainInformation, indicating that there are more functionalities in the malware that are hidden from static tools.



If the sample is opened in a disassembler, in this case Ghidra, it can be seen that it uses a lot of stack strings for obfuscation.

```
00401000    PUSH    EBP
00401001    MOV     EBP, ESP
00401003    SUB     ESP, 0x68
00401006    MOV     dword ptr [EBP + local_38], 0x0
0040100d    MOV     byte ptr [EBP + local_20], 0x6b
00401011    MOV     byte ptr [EBP + local_1f], 0x0
00401015    MOV     byte ptr [EBP + local_1e], 0x65
00401019    MOV     byte ptr [EBP + local_1d], 0x0
0040101d    MOV     byte ptr [EBP + local_1c], 0x72
00401021    MOV     byte ptr [EBP + local_1b], 0x0
00401025    MOV     byte ptr [EBP + local_1a], 0x6e
00401029    MOV     byte ptr [EBP + local_19], 0x0
0040102d    MOV     byte ptr [EBP + local_18], 0x65
00401031    MOV     byte ptr [EBP + local_17], 0x0
00401035    MOV     byte ptr [EBP + local_16], 0x6c
00401039    MOV     byte ptr [EBP + local_15], 0x0
0040103d    MOV     byte ptr [EBP + local_14], 0x33
00401041    MOV     byte ptr [EBP + local_13], 0x0
00401045    MOV     byte ptr [EBP + local_12], 0x32
00401049    MOV     byte ptr [EBP + local_11], 0x0
0040104d    MOV     byte ptr [EBP + local_10], 0x2e
00401051    MOV     byte ptr [EBP + local_f], 0x0
00401055    MOV     byte ptr [EBP + local_e], 0x64
00401059    MOV     byte ptr [EBP + local_d], 0x0
0040105d    MOV     byte ptr [EBP + local_c], 0x6c
00401061    MOV     byte ptr [EBP + local_b], 0x0
00401065    MOV     byte ptr [EBP + local_a], 0x6c
00401069    MOV     byte ptr [EBP + local_9], 0x0
0040106d    MOV     byte ptr [EBP + local_8], 0x0
00401071    MOV     byte ptr [EBP + local_7], 0x0
00401075    MOV     byte ptr [EBP + local_4c], 0x61
```

To investigate the stack strings, and reveal what they are hiding, first the tool FLOSS was run on the sample that gave the following output.

```
FLOSS static ASCII strings
!This program cannot be run in DOS mode.
Rich%
.text
`.rdata
@.reloc
DsRoleGetPrimaryDomainInformation
NETAPI32.dll

FLOSS static Unicode strings
jjjjjjj0040113A
jjjjjj
FLOSS decoded 13 strings
C:\Users\
C:\Users\*
FindFirstFileA
kernel32.dll
D:\\
D:\\*
WriteFile\
advapi32.dll
SetEntriesInAclA
LookupPrivilegeValueA
DeviceIoControl
CreateFileW
Wkernel32.dll
FLOSS extracted 38 stackstrings
C:\Users
netapi32.dll
kernel32.dll
advapi32.dll
CreateFileA
kernel32.dll
FindFirstFileA
OpenProcessToken
CreateFileW
AdjustTokenPrivileges
Wkernel32.dll
FreeSid
SetEntriesInAclA
AllocateAndInitializeSid
LocalFree
SetFilePointer
LookupPrivilegeValueA
LocalAlloc
LoadLibraryA
GetLastError
advapi32.dll
FindClose
kernel32.dll
DeviceIoControl
CloseHandle
CloseHandle
\kernel32.dll
CloseHandle
```

```
SeTakeOwnershipPrivilege
advapi32.dll
\\.\PHYSICALDRIVE9
kernel32.dll
LocalFree
FindNextFileA
GetFileSize
GetCurrentProcess
WriteFile
SetNamedSecurityInfoA
```

To give context for the stacked strings the tool CAPA was used to find the different locations in the code where stacked strings are used.

```
contain obfuscated stackstrings (8 matches)
namespace anti-analysis/obfuscation/string/stackstring
scope basic block
matches 0x401000
0x40114A
0x4011D0
0x401750
0x401A10
0x402025
0x40215E
0x4022A0
```

To get an overview of the intent of each function in relation to where the different stack strings are used for obfuscation, API calls and libraries are mapped to every function that CAPA found in the sample.

```
0x401000 kernel32.dll, advapi32.dll, LoadLibraryA, netapi32.dll
0x40114A netapi32.dll, netapi32.dll
0x4011D0 DeviceIoControl, kernel32.dll, CreateFileW, CloseHandle, \\.\PHYSICALDRIVE9
0x401750 advapi32.dll, LookupPrivilegeValueA, AdjustTokenPrivileges, GetLastErrorc
0x401A10 advapi32.dll, SetEntriesInAclA, AllocateAndInitializeSid,
SetNamedSecurityInfoA, kernel32.dll, GetCurrentProcess, OpenProcessToken
0x402025 SeTakeOwnershipPrivilege, FreeSid, LocalFree, CloseHandle
0x40215E FreeSid, LocalFree, CloseHandle
0x4022A0 FindFirstFileA, kernel32.dll, FindNextFileA, CreateFileA, GetFileSize,
LocalAlloc, SetFilePointer, WriteFile, LocalFree, CloseHandle, FindClose
```

Execution Flow

Upon start the wiper uses the API call DsRoleGetPrimaryDomainInformation to check if the computer is the primary domain controller by comparing to the hard coded value 0x5, that comes from the struct DSROLE_MACHINE_ROLE. If it is the primary domain controller it will exit. This is probably done because the threat actor is using the domain controller as the source of distribution of the wiper and not to ruin its own foothold.

```
00401135    PUSH    EAX
00401136    PUSH    0x1
00401138    PUSH    0x0
0040113a    CALL    dword ptr [->NETAPI32.DLL::DsRoleGetPrimaryDomainInformation]
00401140    MOV     ECX, dword ptr [EBP + local_3c]
00401143    CMP     dword ptr [ECX], 0x5
00401146    JNZ     LAB_0040114a
00401148    JMP     LAB_004011c4
```

The next part of the wiper is the file destruction part. It calls the function 0x4022A0 that iterates over the files, using the API calls that are resolved from the stack strings, and writes over the first 0xA00000 bytes with zeros.

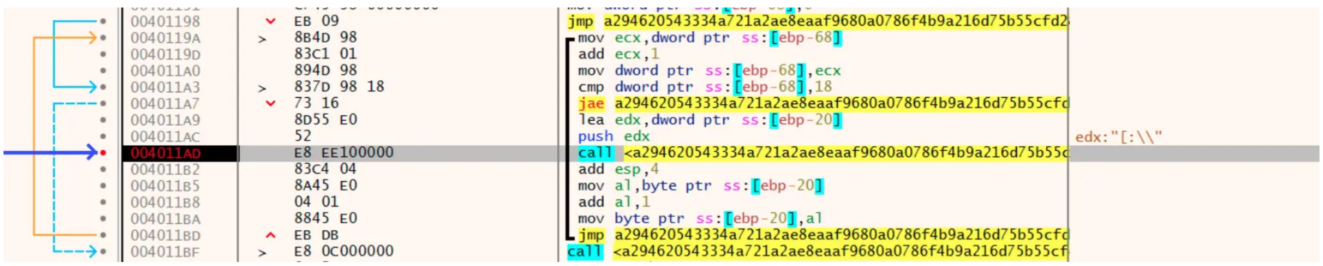
```
004029aa    CMP    dword ptr [EBP + local_e60], 0x0
004029b1    JNC    LAB_004029b8
004029b3    JMP    LAB_00402a51

                LAB_004029b8                          XREF[1]:    004029b1(j)
004029b8    CMP    dword ptr [EBP + local_e60], 0xa00000
004029c2    JBE    LAB_004029ce
004029c4    MOV    dword ptr [EBP + local_e60], 0xa00000
```

Untitled (C:) | paddedFile.bin

```
Offset(h) 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F  Decoded text
009FFE70  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFE80  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFE90  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFEA0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFEB0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFEC0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFED0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFEE0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFEF0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF00  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF10  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF20  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF30  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF40  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF50  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF60  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF70  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF80  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFF90  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFA0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFB0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFC0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFD0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFE0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
009FFFF0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00A00000  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00010  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00020  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00030  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00040  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00050  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00060  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00A00070  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
```

Then the wiper loops through the alphabet (0x18), starting with D all the way up to Z and then one additional iteration, and applies the data destruction from the function in 0x4022A0 to the files in every partition it finds.

This is the last iteration and has gone past Z to Z+1.



Lastly the wiper loops through a list of open raw access to \\\\.\\PHYSICALDRIVE9 - \\\\.\\PHYSICALDRIVE0 and writing to it using IOCTL_DISK_SET_DRIVE_LAYOUT_EX (0x7c054) by using the API DeviceIoControl. By doing so it erases the Master Boot Record.

Detection

Since the wiper is using stack strings for obfuscation of the part that interacts with the disk, that part can be used as Yara rule for detection.

```
rule caddy_wiper {
 meta:
 description = "Search for caddy wiper"
 author = "Truesec"
 reference = "truesec.se"
 date = "2022-03-14"
 hash1 = "a294620543334a721a2ae8eaaf9680a0786f4b9a216d75b55cfd28f39e9430ea"
 strings:
 $x1 = {c6 45 ?? 5c c6 45 ?? 00 c6 45 ?? 5c c6 45 ?? 00 c6 45 ?? 2e c6 45 ?? 00 c6 45
?? 5c c6 45 ?? 00 c6 45 ?? 50 c6 45 ?? 00 c6 45 ?? 48 c6 45 ?? 00 c6 45 ?? 59 c6 45
?? 00 c6 45 ?? 53 c6 45 ?? 00 c6 45 ?? 49 c6 45 ?? 00 c6 45 ?? 43 c6 45 ?? 00 c6 45
?? 41 c6 45 ?? 00 c6 45 ?? 4c c6 45 ?? 00 c6 45 ?? 44 c6 45 ?? 00 c6 45 ?? 52 c6 45
?? 00 c6 45 ?? 49 c6 45 ?? 00 c6 45 ?? 56 c6 45 ?? 00 c6 45 ?? 45} //Stack strings
for \\.\PHYSICALDRIVE
 $x2 = {c6 45 ?? 44 c6 45 ?? 65 c6 45 ?? 76 c6 45 ?? 69 c6 45 ?? 63 c6 45 ?? 65 c6 45
?? 49 c6 45 ?? 6f c6 45 ?? 43 c6 45 ?? 6f c6 45 ?? 6e c6 45 ?? 74 c6 45 ?? 72 c6 45
?? 6f c6 45 ?? 6c c6 45 ?? 00 c6 45 ?? 6b c6 45 ?? 00 c6 45 ?? 65 c6 45 ?? 00 c6 45
?? 72 c6 45 ?? 00 c6 45 ?? 6e c6 45 ?? 00 c6 45 ?? 65 c6 45 ?? 00 c6 45 ?? 6c c6 45
?? 00 c6 45 ?? 33 c6 45 ?? 00 c6 45 ?? 32 c6 45 ?? 00 c6 45 ?? 2e c6 45 ?? 00 c6 45
?? 64 c6 45 ?? 00 c6 45 ?? 6c c6 45 ?? 00 c6 45 ?? 6c c6 45 ?? 00 c6 45 ?? 00 c6 45
?? 00 c6 45 ?? 43 c6 45 ?? 72 c6 45 ?? 65 c6 45 ?? 61 c6 45 ?? 74 c6 45 ?? 65 c6 45
?? 46 c6 45 ?? 69 c6 45 ?? 6c c6 45 ?? 65 c6 45 ?? 57} //Stack strings for
DeviceIoControl, kernel32.dll, CreateFileW

 $a1 = {c6 85 ?? fe ff ff 61 c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 64 c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 76 c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 61 c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 70 c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 69 c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 33 c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 32 c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 2e c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 64 c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 6c c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 6c c6 85 ?? fe ff
ff 00 c6 85 ?? fe ff ff 00 c6 85 ?? fe ff ff 00 c6 85 ?? ff ff ff 53 c6 85 ?? ff ff
ff 65 c6 85 ?? ff ff ff 74 c6 85 ?? ff ff ff 45 c6 85 ?? ff ff ff 6e c6 85 ?? ff ff
ff 74 c6 85 ?? ff ff ff 72 c6 85 ?? ff ff ff 69 c6 85 ?? ff ff ff 65 c6 85 ?? ff ff
ff 73 c6 85 ?? ff ff ff 49 c6 85 ?? ff ff ff 6e c6 85 ?? ff ff ff 41 c6 85 ?? ff ff
ff 63 c6 85 ?? ff ff ff 6c c6 85 ?? ff ff ff 41} //Stack strings for advapi32.dll
SetEntriesinAclA

 $a2 = {c6 85 ?? ff ff ff 41 c6 85 ?? ff ff ff 6c c6 85 ?? ff ff ff 6c c6 85 ?? ff ff
ff 6f c6 85 ?? ff ff ff 63 c6 85 ?? ff ff ff 61 c6 85 ?? ff ff ff 74 c6 85 ?? ff ff
ff 65 c6 85 ?? ff ff ff 41 c6 85 ?? ff ff ff 6e c6 85 ?? ff ff ff 64 c6 85 ?? ff ff
ff 49 c6 85 ?? ff ff ff 6e c6 85 ?? ff ff ff 69 c6 85 ?? ff ff ff 74 c6 85 ?? ff ff
ff 69 c6 45 ?? 61 c6 45 ?? 6c c6 45 ?? 69 c6 45 ?? 7a c6 45 ?? 65 c6 45 ?? 53 c6 45
?? 69 c6 45 ?? 64} //Stack strings for AllocateAndInitializeSid

 condition:
 uint16(0) == 0x5A4D
 and any of ($x*)
 or all of ($a*) and filesize < 50000
}
```