# There Is More Than One Way to Sleep: Dive Deep Into the Implementations of API Hammering by Various Malware Families

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## Executive Summary

Unit 42 has discovered Zloader and BazarLoader samples that had interesting implementations of a sandbox evasion technique. This blog post will go into details of the unique implementations of API Hammering in these types of malware. API Hammering involves the use of a massive number of calls to Windows APIs as a form of extended sleep to evade detection in sandbox environments.

Sandboxing is a popular technique used to detect if a sample is malicious. A sandbox analyzes the behaviors of the binary as it executes inside a controlled environment. Sandboxes have to deal with many challenges while analyzing a large number of binaries with limited computing resources. Malware sometimes abuses these challenges by “sleeping” in the sandbox before carrying out malicious procedures to hide its real intentions.

Palo Alto Networks customers receive protections from malware families using evasion techniques through Cortex XDR or the Next-Generation Firewall with WildFire and Threat Prevention security subscriptions.

## Common Ways for Malware to Sleep

The most common way for malware to sleep is to simply call the Windows API function Sleep. A sneakier way that we often see is the Ping Sleep technique where the malware constantly sends ICMP network packets to an IP address (ping) in a loop. To send and receive such useless ping messages takes a certain amount of time, thus the malware indirectly sleeps. However, all these methods are easily detected by many sandboxes.

## What Is API Hammering?

API Hammering has been a known sandbox bypass technique that is sometimes used by malware authors to evade sandboxes. We’ve recently observed Zloader – a dropper for multiple types of malware – and the backdoor BazarLoader using new and unique implementations of API Hammering to remain stealthy.

API Hammering consists of a large number of garbage Windows API function calls. The execution time of these calls delays the execution of the real malicious routines of the malware. This allows the malware to indirectly sleep during the sandbox analysis process.

## API Hammering in BazarLoader

An older variant of BazarLoader made use of a fixed number (1550) of printf function calls to time out malware analysis. While analyzing a newer version of BazarLoader, we found a new and more complex implementation of

API Hammering.

The following decompiled procedure shows how this new variant is implemented in the BazarLoader sample we analyzed. It makes use of a huge loop with a random count that repeatedly accesses a list of random registry keys in Windows.

```
1  bool __fastcall FN_API_hammering(_BYTE *encoded_file_blob)
2  {
3    unsigned __int64 v2; // rsi
4    _BYTE *v1; // rdi
5    _BYTE *lpSubkey; // rax MAPDST
6    int v6; // r8d
7    _BYTE *v7; // rcx
8    HKEY hKey; // [rsp+30h] [rbp-38h] BYREF
9    DWORD cbData; // [rsp+38h] [rbp-30h] BYREF
10
11   cbData = 12;
12   v2 = 0i64;
13   if ( FN_Look_4_Null_byte(encoded_file_blob) != 18 )
14   {
15     v1 = encoded_file_blob;
16     do
17     {
18       lpSubkey = operator new(0xCui64);
19       v6 = 11;
20       lpSubkey[11] = 0;
21       if ( v1 )
22       {
23         v7 = lpSubkey;
24         do
25         {
26           *v7 = v7[v1 - lpSubkey];              // Generate Subkey from encoded_file_blob
27           ++v7;
28           --v6;
29         }
30         while ( v6 );
31       }
32       if ( RegOpenKeyExA(HKEY_CURRENT_USER, lpSubkey, 0, KEY_READ, &hKey) != ERROR_FILE_NOT_FOUND
33         && hKey
34         && RegQueryValueExA(hKey, "zsadsgjea", 0i64, 0i64, "svogfiifotuz", &cbData)
35         && hKey )
36       {
37         ++v2;
38       }
39       v1 += 6;
40       j_j_free(lpSubkey);
41     }
42     while ( v1 - encoded_file_blob < (FN_Look_4_Null_byte(encoded_file_blob) - 18) );// loop count generated from encoded_file_blob
43                                                 //
44   }
45   return v2 > 0xA;
46 }
```

Figure 1. API Hammering loop in BazarLoader.

To generate the random loop count and list of registry keys, the sample reads the first file from the System32 directory that matches a defined size. This file is then encoded (see Figure 2) to remove most of its null bytes. The random count is then computed based on the offset of the first null byte in that file. The list of random registry keys are generated from fixed length chunks from the encoded file.

```
FileA = CreateFileA(FileName, 0x80000000, 0, 0i64, 3u, 0, 0i64);
FileSize = GetFileSize(FileA, 0i64);
Target_File_Blob = operator new(FileSize);
ReadFile(FileA, Target_File_Blob, FileSize, &NumberOfBytesRead, 0i64);
for ( j = 0; j < 0x249F0; ++j )
{
  v43 = j;
  if ( !Target_File_Blob[j] )
  {
    v44 = 0x17;
    v45 = 32 * j * (0x7C * j - 44);
    j = 0;
    v46 = v45 % 0xFF;
    if ( v46 )
      v44 = v46;
    Target_File_Blob[v43] = v44;
  }
}
Target_File_Blob[0x249EF] = 0;
CloseHandle(FileA);
return Target_File_Blob;
```

Figure 2. Encoding the selected file in BazarLoader.

With a different Windows version (Windows 7, 8, etc.) and a different set of applied updates, there is also a different set of files in the System32 directory. This results in a varying loop count and list registry keys used by BazarLoader when executed in different machines.

The API Hammering function is located in the packer of the BazarLoader sample (see Figure 3). It delays the payload unpacking process to evade detection of the aforementioned. Without completing the unpacking process, the BazarLoader sample would appear to be just accessing random registry keys, a behavior that can be also seen in many legitimate types of software.

```
.text:000007FEEE7F8540                call    FN_API_hammering
.text:000007FEEE7F8545                mov     ebx, [r13+28h]
.text:000007FEEE7F8549                mov     rcx, r14
.text:000007FEEE7F854C                mov     rsi, [rsp+78h+arg_0]
.text:000007FEEE7F8554                add     rbx, r14
.text:000007FEEE7F8557                mov     r13, [rsp+78h+var_38]
.text:000007FEEE7F855C                mov     r12, [rsp+78h+var_30]
.text:000007FEEE7F8561                cmp     byte ptr [rsi+8], 0
.text:000007FEEE7F8565                jnz     short loc_7FEEE7F85E3
.text:000007FEEE7F8567
.text:000007FEEE7F8567 loc_7FEEE7F8567:                        ; DATA XREF: .pdata:000007FEEE8556F0↓o
.text:000007FEEE7F8567                                         ; .pdata:000007FEEE8556FC↓o
.text:000007FEEE7F8567                mov     rdx, [rsi+10h]
.text:000007FEEE7F856B                call    sub_7FEEE7F7FB0
.text:000007FEEE7F8570                mov     rdi, rax
.text:000007FEEE7F8573                test    rax, rax
.text:000007FEEE7F8576                jz      short loc_7FEEE7F85EC
.text:000007FEEE7F8578                cmp     byte ptr [rsi+3Ch], 0
.text:000007FEEE7F857C                jz      short loc_7FEEE7F85B5
.text:000007FEEE7F857E                mov     r8, [rsi+40h]
.text:000007FEEE7F8582                test    r8, r8
.text:000007FEEE7F8585                jz      short loc_7FEEE7F85B5
.text:000007FEEE7F8587                mov     rcx, gs:60h
.text:000007FEEE7F8590                mov     rdx, [rcx+18h]
.text:000007FEEE7F8594                mov     rcx, [rdx+20h]
.text:000007FEEE7F8598                add     rdx, 20h ; ' '
.text:000007FEEE7F859C                cmp     rcx, rdx
.text:000007FEEE7F859F                jz      short loc_7FEEE7F85B5
.text:000007FEEE7F85A1
.text:000007FEEE7F85A1 loc_7FEEE7F85A1:                        ; CODE XREF: FN_Unpack_Payload+50D↓j
.text:000007FEEE7F85A1                cmp     [rcx+20h], r8
.text:000007FEEE7F85A5                jz      short loc_7FEEE7F85B1
.text:000007FEEE7F85A7                mov     rcx, [rcx]
.text:000007FEEE7F85AA                cmp     rcx, rdx
.text:000007FEEE7F85AD                jnz     short loc_7FEEE7F85A1
.text:000007FEEE7F85AF                jmp     short loc_7FEEE7F85B5
.text:000007FEEE7F85B1 ; ---------------------------------------------------------------------------
.text:000007FEEE7F85B1
.text:000007FEEE7F85B1 loc_7FEEE7F85B1:                        ; CODE XREF: FN_Unpack_Payload+505↑j
.text:000007FEEE7F85B1                mov     [rcx+20h], r14
.text:000007FEEE7F85B5
.text:000007FEEE7F85B5 loc_7FEEE7F85B5:                        ; CODE XREF: FN_Unpack_Payload+4DC↑j
.text:000007FEEE7F85B5                                         ; FN_Unpack_Payload+4E5↑j ...
.text:000007FEEE7F85B5                xor     r8d, r8d
.text:000007FEEE7F85B8                mov     rcx, r14
.text:000007FEEE7F85BB                lea     edx, [r8+1]
.text:000007FEEE7F85BF                call    rbx
.text:000007FEEE7F85C1                mov     r9d, [rsi+38h]
.text:000007FEEE7F85C5                mov     r8, [rsi+30h]
.text:000007FEEE7F85C9                mov     rdx, [rsi+28h]
.text:000007FEEE7F85CD                mov     rcx, [rsi+20h]
.text:000007FEEE7F85D1                call    rdi             ; Jumping to OEP of unpacked code
```

Figure 3. API Hammering delaying unpacking process in BazarLoader.

## API Hammering in Zloader

While the BazarLoader sample relied on a loop to carry out API Hammering, Zloader uses a different approach. It does not require a huge loop, but instead consists of 4 large functions which contain nested calls to multiple other smaller functions (see Figure 4).

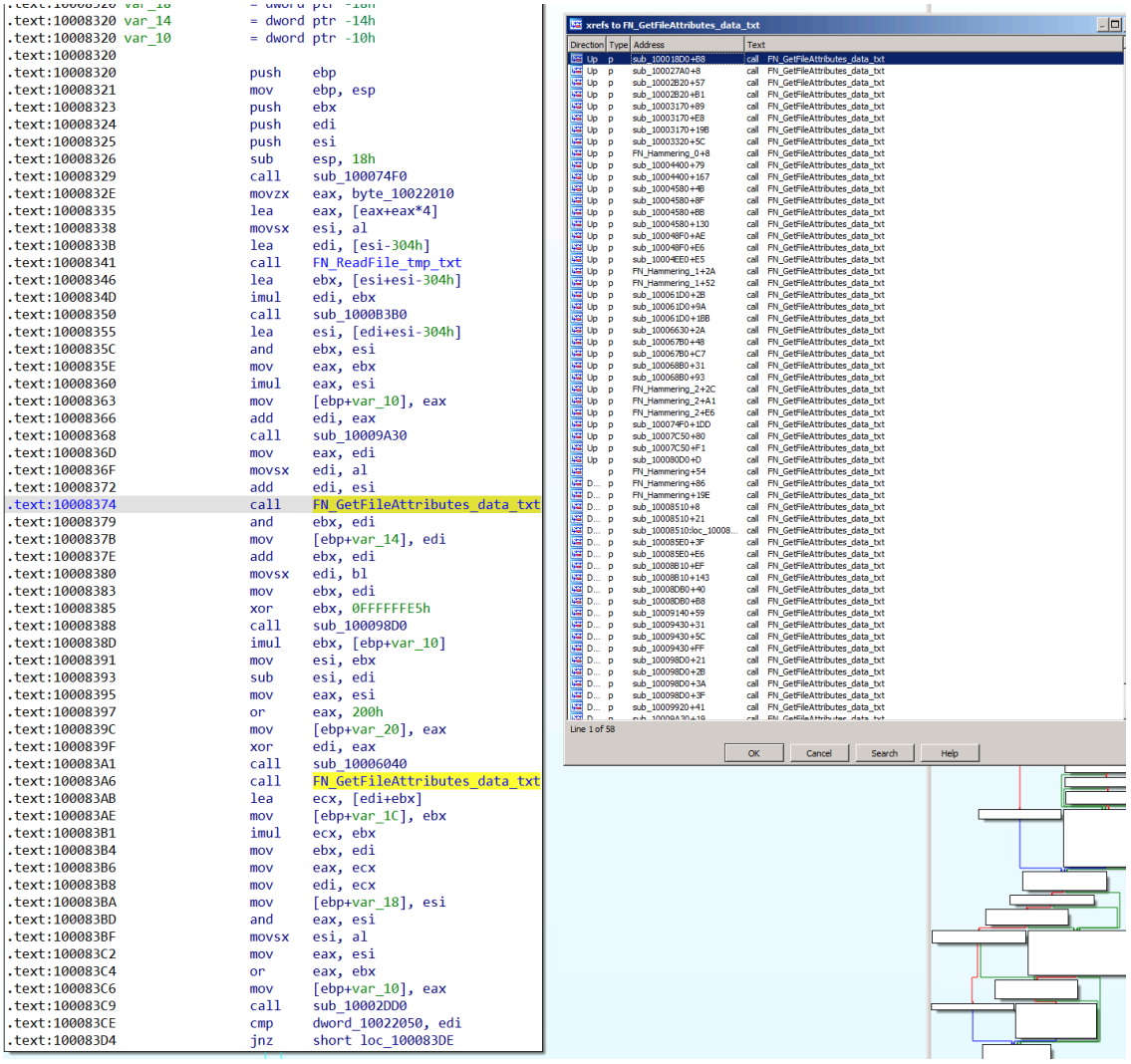



Figure 4. One of the large functions responsible for API Hammering in ZLoader.

Inside each of these small procedures are four API function calls related to file I/O. The functions are GetFileAttributesW, ReadFile, CreateFileW and WriteFile (see Figure 5).

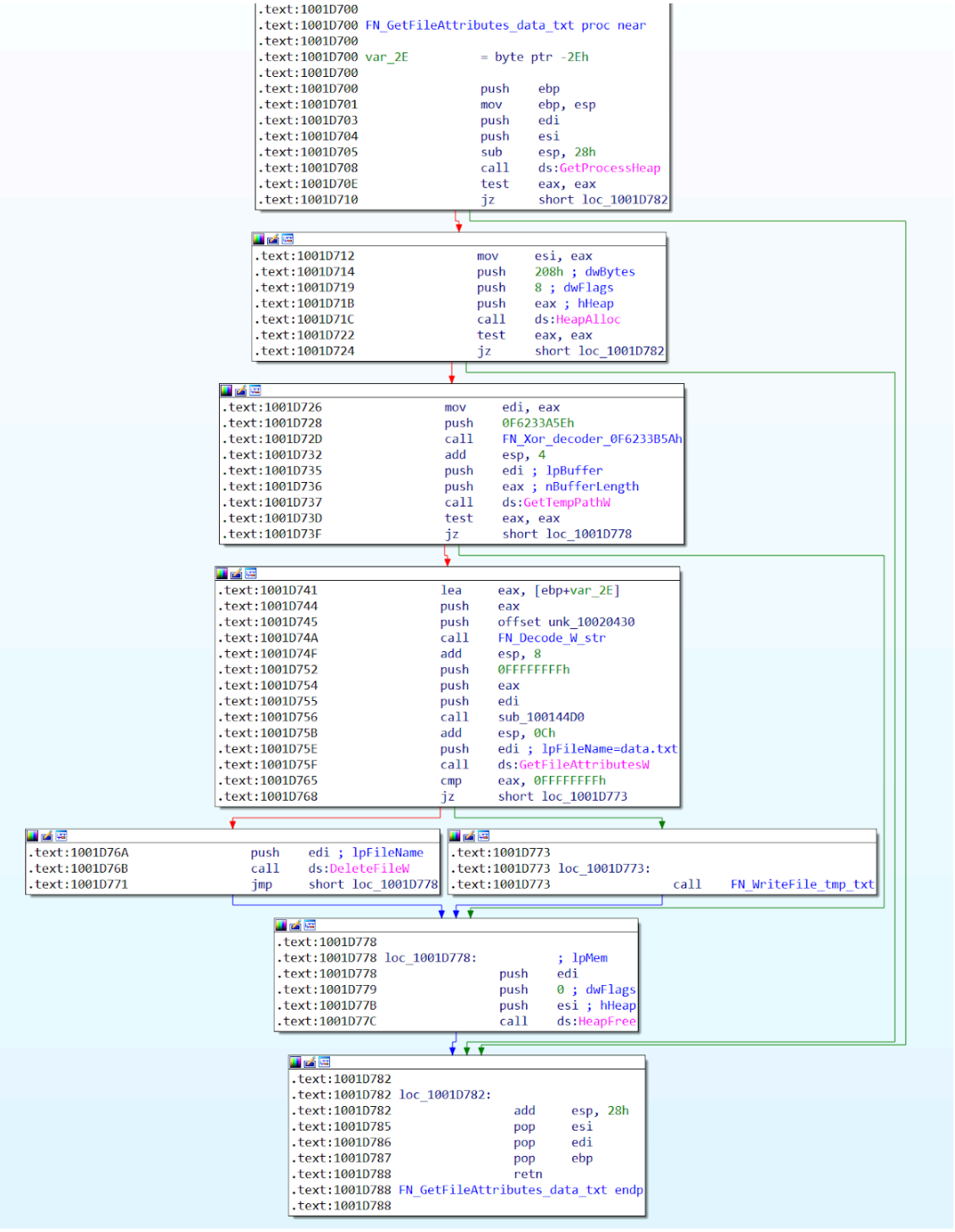



Figure 5. One of the small functions responsible for API Hammering in ZLoader.

By using a debugger, we could figure out the number of calls made to four file I/O functions (see Figure 6). The large and smaller functions together generate more than a million function calls in total, without the use of a single large loop as seen in BazarLoader.

```
1232934  "ReadFile"
1232935  "CreateFileW"
1232936  "WriteFile"
1232937  "CreateFileW"
1232938  "WriteFile"
1232939  "CreateFileW"
1232940  "WriteFile"
1232941  "CreateFileW"
1232942  "WriteFile"
1232943  "CreateFileW"
1232944  "WriteFile"
1232945  GetFileAttributesW
1232946  "CreateFileW"
1232947  "WriteFile"
1232948  GetFileAttributesW
1232949  "CreateFileW"
1232950  "WriteFile"
```

Figure 6. Debugger log for APIs responsible for API Hammering in ZLoader.

The following table shows the API function call counts made during our analysis process:

| I/O API function | Total Call Count |
|---|---|
| ReadFile | 278,850 |
| WriteFile | 280,921 |
| GetFileAttributesW | 113,389 |
| CreateFileW | 559,771 |

*Table 1. API function call counts.*

The execution time of the four large functions delays the injection of the Zloader payload. Without complete execution of these functions, the sample would appear to be a benign sample just carrying out file I/O operations.

The following disassembled code shows the four API hammering procedures followed by the injection procedures:

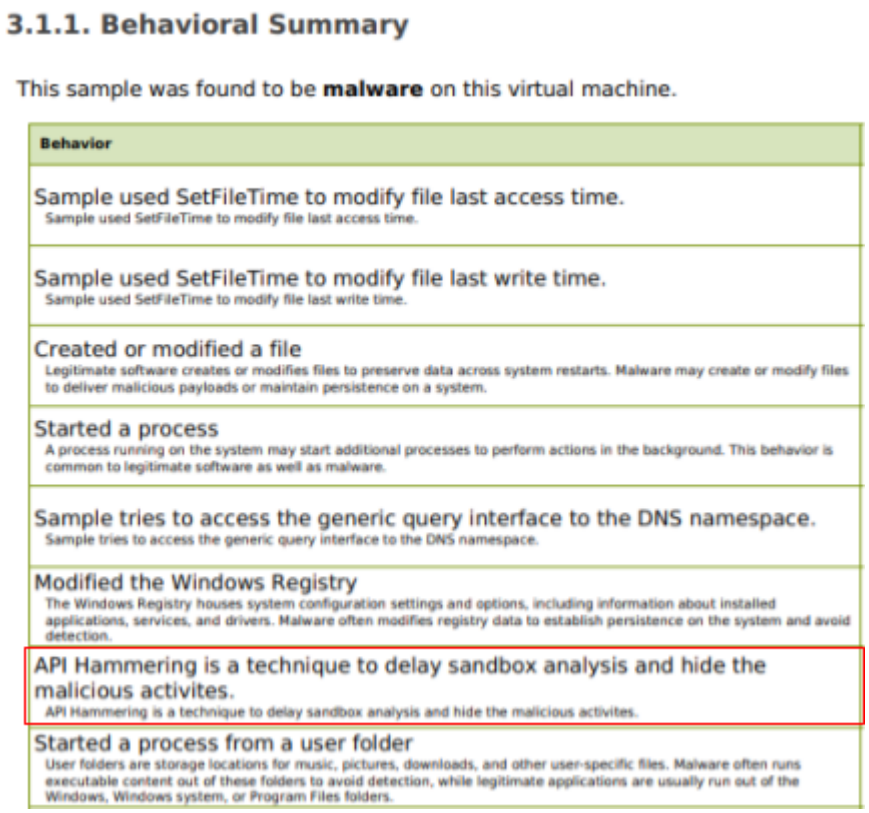
```
.text:1001026C                 call    FN_Hammering    ; Hammering start!
.text:10010271                 call    FN_Hammering_0
.text:10010276                 call    FN_Hammering_1
.text:1001027B                 call    FN_Hammering_2
.text:10010280                 mov     esi, 0FFFFFFFFh
.text:10010285                 call    sub_10001770
.text:1001028A                 test    al, al
.text:1001028C                 jz      loc_10010684
.text:10010292                 call    FN_GetProcessHeap
.text:10010297                 cmp     current_mod_base, 0
.text:1001029E                 jz      loc_1001066F
.text:100102A4                 push    0FDA8B77h       ; API_hash
.text:100102A9                 push    0               ; dll_selector
.text:100102AB                 call    FN_GetProcAddress
.text:100102B0                 add     esp, 8
.text:100102B3                 lea     esi, [ebp+var_578]
.text:100102B9                 push    104h
.text:100102BE                 push    esi
.text:100102BF                 push    current_mod_base
.text:100102C5                 call    eax
.text:100102C7                 mov     eax, current_mod_base
.text:100102CC                 test    eax, eax
.text:100102CE                 mov     [ebp+var_1C], eax
.text:100102D1                 jz      loc_1001066F
.text:100102D7                 lea     ebx, [ebp+StartupInfo] ; __int16
.text:100102DD                 push    44h ; 'D'
.text:100102DF                 push    ebx
.text:100102E0                 call    sub_1000E110
.text:100102E5                 add     esp, 8
.text:100102E8                 lea     eax, [ebp+enc_str]
.text:100102EE                 mov     [ebp+StartupInfo.cb], 44h ; 'D'
.text:100102F8                 push    eax             ; clear_str
.text:100102F9                 push    offset msiexec_exe ; msiexec.exe
.text:100102FE                 call    FN_Decode_C_str
.text:10010303                 add     esp, 8
.text:10010306                 lea     edi, [ebp+CommandLine]
.text:1001030C                 push    0FFFFFFFFh
.text:1001030E                 push    eax
.text:1001030F                 push    edi
.text:10010310                 call    sub_100171E0
.text:10010315                 add     esp, 0Ch
.text:10010318                 push    1E16041h        ; API_hash
.text:1001031D                 push    0               ; dll_selector
.text:1001031F                 call    FN_GetProcAddress
.text:10010324                 add     esp, 8
.text:10010327                 lea     ecx, [ebp-3Ch]
.text:1001032A                 push    ecx             ; lpProcessInformation
.text:1001032B                 push    ebx             ; lpStartupInfo
.text:1001032C                 push    0               ; lpCurrentDirectory
.text:1001032E                 push    0               ; lpEnvironment
.text:10010330                 push    CREATE_SUSPENDED ; dwCreationFlags
.text:10010332                 push    0               ; bInheritHandles
.text:10010334                 push    0               ; lpThreadAttributes
.text:10010336                 push    0               ; lpProcessAttributes
.text:10010338                 push    edi             ; lpCommandLine = msiexec.exe
.text:10010339                 push    0               ; lpApplicationName
.text:1001033B                 call    CreateProcessA
```

Figure 6. API Hammering before payload injection in ZLoader.

## Conclusion: WildFire vs API Hammering

Results from analyzing various implementations of API Hammering enabled the detection of malware samples using API Hammering for sandbox evasion in WildFire. WildFire detects the use of API Hammering by BazarLoader, Zloader, and other malware families.

The following excerpt from the WildFire report of our BazarLoader sample shows the detected entry for API Hammering.



### 3.1.1. Behavioral Summary

This sample was found to be **malware** on this virtual machine.

| Behavior |
| --- |
| Sample used SetFileTime to modify file last access time.<br>Sample used SetFileTime to modify file last access time. |
| Sample used SetFileTime to modify file last write time.<br>Sample used SetFileTime to modify file last write time. |
| Created or modified a file<br>Legitimate software creates or modifies files to preserve data across system restarts. Malware may create or modify files to deliver malicious payloads or maintain persistence on a system. |
| Started a process<br>A process running on the system may start additional processes to perform actions in the background. This behavior is common to legitimate software as well as malware. |
| Sample tries to access the generic query interface to the DNS namespace.<br>Sample tries to access the generic query interface to the DNS namespace. |
| Modified the Windows Registry<br>The Windows Registry houses system configuration settings and options, including information about installed applications, services, and drivers. Malware often modifies registry data to establish persistence on the system and avoid detection. |
| API Hammering is a technique to delay sandbox analysis and hide the malicious activites.<br>API Hammering is a technique to delay sandbox analysis and hide the malicious activites. |
| Started a process from a user folder<br>User folders are storage locations for music, pictures, downloads, and other user-specific files. Malware often runs executable content out of these folders to avoid detection, while legitimate applications are usually run out of the Windows, Windows system, or Program Files folders. |

Figure 7. WildFire detected API Hammering along with other behaviors in a Bazarloader sample.

Palo Alto Networks customers receive further protections against other malware families using similar sandbox evasion techniques through Cortex XDR or our Next-Generation Firewall with WildFire and Threat Prevention security subscriptions.

## Indicators of Compromise

BazarLoader Sample
ce5ee2fd8aa4acda24baf6221b5de66220172da0eb312705936adc5b164cc052

Zloader Sample
44ede6e1b9be1c013f13d82645f7a9cff7d92b267778f19b46aa5c1f7fa3c10b

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Source: https://unit42.paloaltonetworks.com/api-hammering-malware-families/