IAT Hiding & Obfuscation - Custom GetModuleHandle

Introduction

The `GetModuleHandle` function retrieves a handle for a specified DLL. The function returns a handle to the DLL or `NULL` if the DLL does not exist in the calling process.

In this module, a function that will replace `GetModuleHandle` will be implemented. The new function's prototype is shown below.

```
HMODULE GetModuleHandleReplacement(IN LPCWSTR szModuleName){}
```

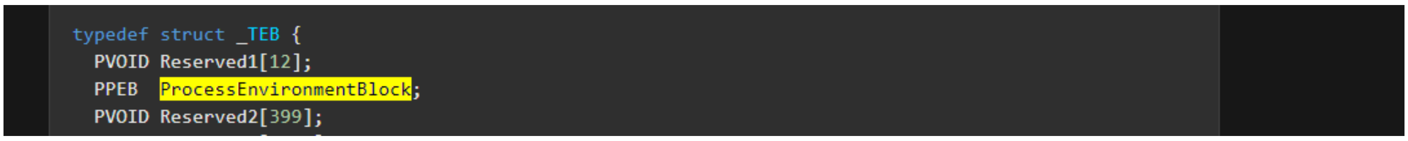
How GetModuleHandle Works

The `HMODULE` data type is the base address of the loaded DLL which is where the DLL is located in the address space of the process. Therefore, the goal of the replacement function is to retrieve the base address of a specified DLL.

The Process Environment Block (PEB) contains information regarding the loaded DLLs, notably the `PEB_LDR_DATA Ldr` member of the PEB structure. Thus, the initial step is to access this member through the PEB structure.

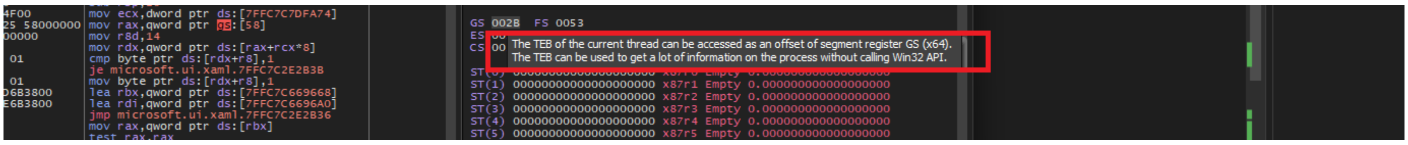
PEB In 64-bit Systems

Recall that a pointer to the PEB structure is found within the Thread Environment Block (TEB) structure.



```
typedef struct _TEB {
  PVOID Reserved1[12];
  PPEB  ProcessEnvironmentBlock;
  PVOID Reserved2[399];
```

In 64-bit systems, an offset to the pointer of the TEB structure is stored in the *GS* register. The following image is from x64dbg.



```
4F00              mov ecx,dword ptr ds:[7FFC7C7DFA74]
25 58000000       mov rax,qword ptr gs:[58]
00000             mov r8d,14
                  mov rdx,qword ptr ds:[rax+rcx*8]
 01               cmp byte ptr ds:[rdx+r8],1
                  je microsoft.ui.xaml.7FFC7C2E2B3B
 01               mov byte ptr ds:[rdx+r8],1
D6B3800           lea rbx,qword ptr ds:[7FFC7C669668]
E6B3800           lea rdi,qword ptr ds:[7FFC7C6696A0]
                  jmp microsoft.ui.xaml.7FFC7C2E2B36
                  mov rax,qword ptr ds:[rbx]
                  test rax,rax
```

```
GS 002B  FS 0053
ES
CS 00  The TEB of the current thread can be accessed as an offset of segment register GS (x64).
       The TEB can be used to get a lot of information on the process without calling Win32 API.
ST(1) 0000000000000000000 x87r1 Empty 0.000000000000000000
ST(2) 0000000000000000000 x87r2 Empty 0.000000000000000000
ST(3) 0000000000000000000 x87r3 Empty 0.000000000000000000
ST(4) 0000000000000000000 x87r4 Empty 0.000000000000000000
ST(5) 0000000000000000000 x87r5 Empty 0.000000000000000000
```

Method 1: Retrieving The PEB In 64-Bit Systems

There are two different approaches to retrieving the PEB. The first method involves retrieving the TEB structure and then getting a pointer to the PEB. This approach can be performed using the __readgsqword(0x30) macro in Visual Studio which reads `0x30` bytes from the GS register to reach a pointer to the TEB structure.

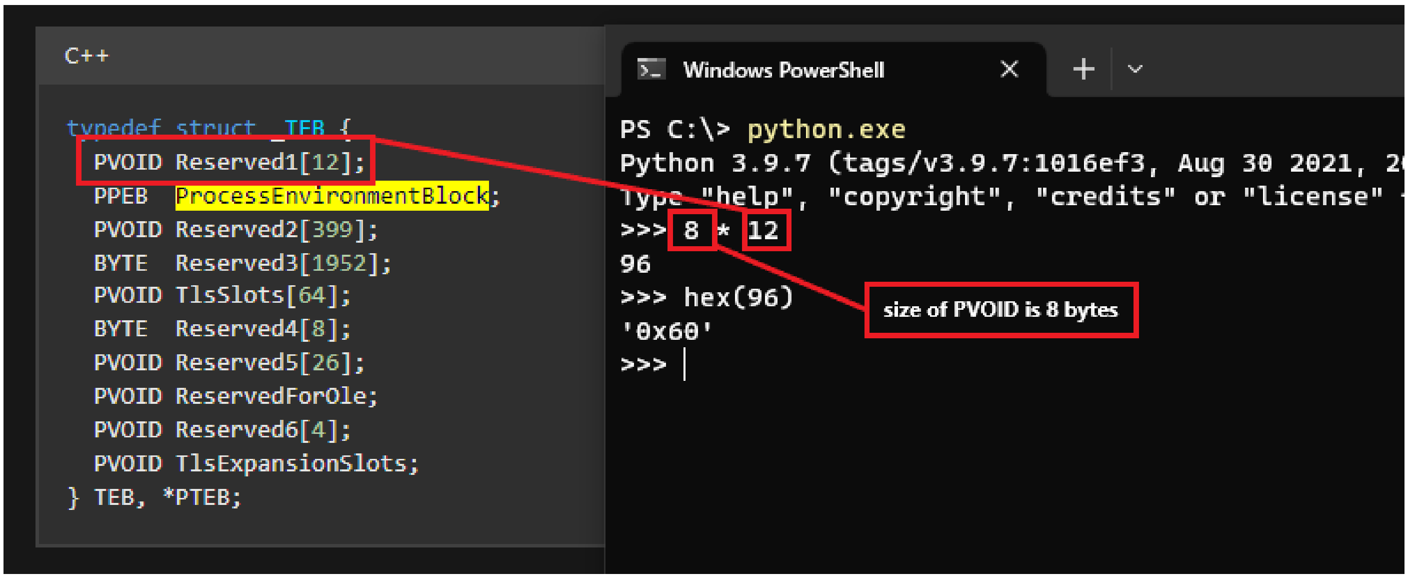
```
// Method 1
PTEB pTeb = (PTEB)__readgsqword(0x30);
PPEB pPeb = (PPEB)pTeb->ProcessEnvironmentBlock;
```

Method 2: Retrieving The PEB In 64-Bit Systems

The next method retrieves the PEB structure directly by skipping the TEB structure using __readgsqword(0x60) macro in Visual Studio which reads `0x60` bytes from GS register.

```
// Method 2
PPEB pPeb2 = (PPEB)(__readgsqword(0x60));
```

This can be done because the `ProcessEnvironmentBlock` element is `0x60` (hex) or 96 bytes from the start of the TEB structure

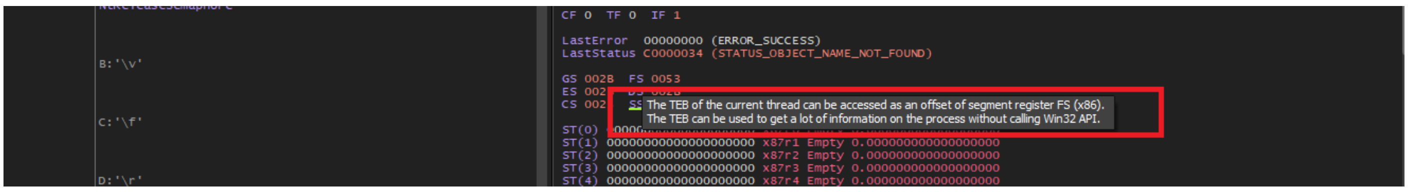


```
C++

typedef struct _TEB {
  PVOID Reserved1[12];
  PPEB  ProcessEnvironmentBlock;
  PVOID Reserved2[399];
  BYTE  Reserved3[1952];
  PVOID TlsSlots[64];
  BYTE  Reserved4[8];
  PVOID Reserved5[26];
  PVOID ReservedForOle;
  PVOID Reserved6[4];
  PVOID TlsExpansionSlots;
} TEB, *PTEB;
```

```
PS C:\> python.exe
Python 3.9.7 (tags/v3.9.7:1016ef3, Aug 30 2021, 2
Type "help", "copyright", "credits" or "license"
>>> 8 * 12
96
>>> hex(96)
'0x60'
>>>
```

PEB In 32-bit Systems

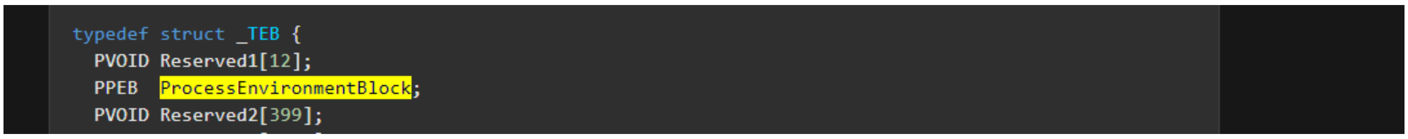
In 32-bit systems, an offset to the pointer of the TEB structure is stored in the `FS` register. The following image is from x32dbg.



```
B:'\v'
C:'\f'
D:'\r'

CF 0  TF 0  IF 1

LastError  00000000 (ERROR_SUCCESS)
LastStatus C0000034 (STATUS_OBJECT_NAME_NOT_FOUND)

GS 002B  FS 0053
ES 002
CS 002
ST(0) 0000
ST(1) 0000000000000000000 x87r1 Empty 0.000000000000000000
ST(2) 0000000000000000000 x87r2 Empty 0.000000000000000000
ST(3) 0000000000000000000 x87r3 Empty 0.000000000000000000
ST(4) 0000000000000000000 x87r4 Empty 0.000000000000000000
```

The TEB of the current thread can be accessed as an offset of segment register FS (x86).
The TEB can be used to get a lot of information on the process without calling Win32 API.

And recall that a **pointer** of the PEB structure is in the TEB.



```
typedef struct _TEB {
  PVOID Reserved1[12];
  PPEB  ProcessEnvironmentBlock;
  PVOID Reserved2[399];
```

Method 1: Retrieving The PEB In 32-Bit Systems

Similarly to 64-bit systems, there are two methods to retrieve the PEB.

The first method involves getting the TEB structure and then getting the PEB structure using the __readfsdword(0x18) macro in Visual Studio which reads `0x18` bytes from the FS register.

```
// Method 1
PTEB pTeb = (PTEB)__readfsdword(0x18);
PPEB pPeb = (PPEB)pTeb->ProcessEnvironmentBlock;
```

Method 2: Retrieving The PEB In 32-Bit Systems

The second method gets the PEB directly by skipping the TEB structure using the __readfsdword(0x30) macro in Visual Studio which reads `0x30` bytes from the FS register.

```
// Method 2
PPEB pPeb2 = (PPEB)(__readfsdword(0x30));
```

`0x30` (hex) is 48 bytes which is the offset of the `ProcessEnvironmentBlock` element from the 32-bit TEB structure. The `PVOID` data type is 4 bytes in 32-bit systems.

Enumerating DLLs

Once the PEB structure has been retrieved, the next step is to access the `PEB_LDR_DATA Ldr` member. Recall that this member contains information regarding the loaded DLLs in the process.

PEB_LDR_DATA Structure

The `PEB_LDR_DATA` structure is shown below. The important member in this structure is `LIST_ENTRY InMemoryOrderModuleList`.

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

LIST_ENTRY Structure

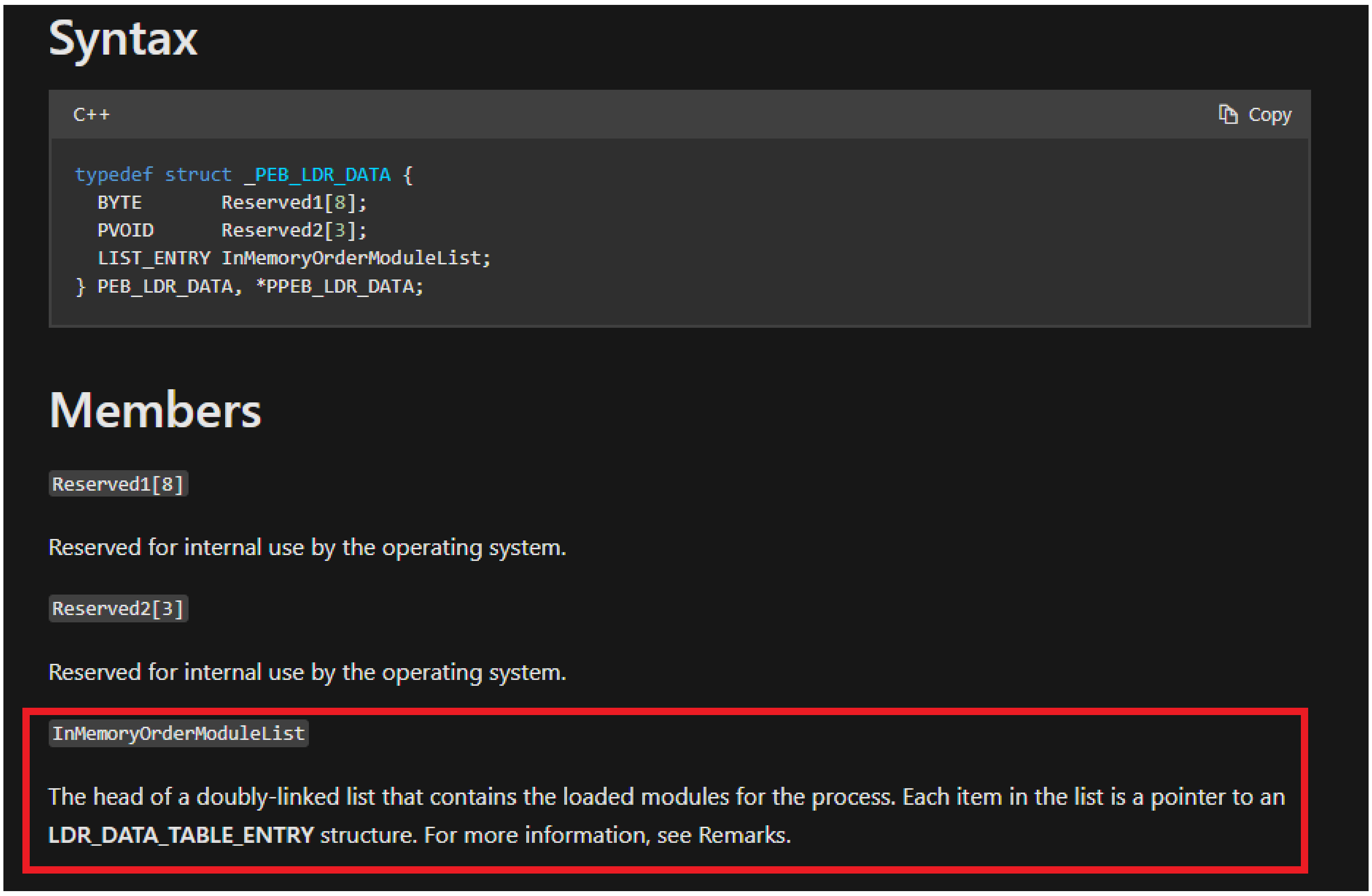
The `LIST_ENTRY` structure shown below is a doubly-linked list, which is essentially the same as arrays but easier to access adjacent elements.

```
typedef struct _LIST_ENTRY {
   struct _LIST_ENTRY *Flink;
```

```
    struct _LIST_ENTRY *Blink;
} LIST_ENTRY, *PLIST_ENTRY, *RESTRICTED_POINTER PRLIST_ENTRY;
```

Doubly-linked lists use the `Flink` and `Blink` elements as the head and tail pointers, respectively. This means `Flink` points to the next node in the list whereas the `Blink` element points to the previous node in the list. These pointers are used to traverse the linked list in both directions. Knowing this, to start enumerating this list, one should start by accessing its first element, `InMemoryOrderModuleList.Flink`.

According to Microsoft's definition for the `InMemoryOrderModuleList` member, it states that each item in the list is a pointer to an `LDR_DATA_TABLE_ENTRY` structure.



Syntax

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

Members

`Reserved1[8]`

Reserved for internal use by the operating system.

`Reserved2[3]`

Reserved for internal use by the operating system.

`InMemoryOrderModuleList`

The head of a doubly-linked list that contains the loaded modules for the process. Each item in the list is a pointer to an **LDR_DATA_TABLE_ENTRY** structure. For more information, see Remarks.

LDR_DATA_TABLE_ENTRY Structure

The `LDR_DATA_TABLE_ENTRY` structure represents a DLL inside the linked list of loaded DLLs for the process. Every `LDR_DATA_TABLE_ENTRY` represents a unique DLL.

```
typedef struct _LDR_DATA_TABLE_ENTRY {
    PVOID Reserved1[2];
    LIST_ENTRY InMemoryOrderLinks;      // doubly-linked list that contains
the in-memory order of loaded modules
    PVOID Reserved2[2];
    PVOID DllBase;
    PVOID EntryPoint;
    PVOID Reserved3;
    UNICODE_STRING FullDllName;          // 'UNICODE_STRING' structure that
contains the filename of the loaded module
    BYTE Reserved4[8];
    PVOID Reserved5[3];
    union {
        ULONG CheckSum;
        PVOID Reserved6;
    };
    ULONG TimeDateStamp;
} LDR_DATA_TABLE_ENTRY, *PLDR_DATA_TABLE_ENTRY;
```

Implementation Logic

Based on everything mentioned so far, the required actions are:

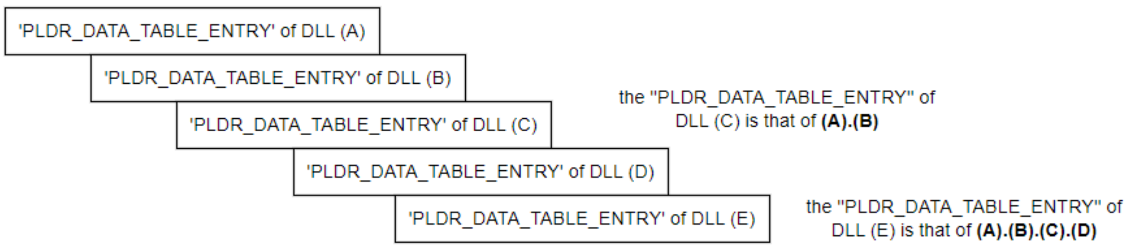
1. Retrieve the PEB
2. Retrieve the Ldr member from the PEB
3. Retrieve the first element in the linked list

```
HMODULE GetModuleHandleReplacement(IN LPCWSTR szModuleName) {

// Getting peb
#ifdef _WIN64 // if compiling as x64
        PPEB                    pPeb    = (PEB*)(__readgsqword(0x60));
#elif _WIN32 // if compiling as x32
        PPEB                    pPeb    = (PEB*)(__readfsdword(0x30));
#endif

        // Getting the Ldr
        PPEB_LDR_DATA               pLdr        = (PPEB_LDR_DATA)(pPeb-
>Ldr);

        // Getting the first element in the linked list which contains
information about the first module
        PLDR_DATA_TABLE_ENTRY   pDte    = (PLDR_DATA_TABLE_ENTRY)(pLdr-
>InMemoryOrderModuleList.Flink);

}
```

Since every `pDte` represents a unique DLL inside of the linked list, it's possible to get to the next element using the following line of code:

```
pDte = *(PLDR_DATA_TABLE_ENTRY*)(pDte);
```

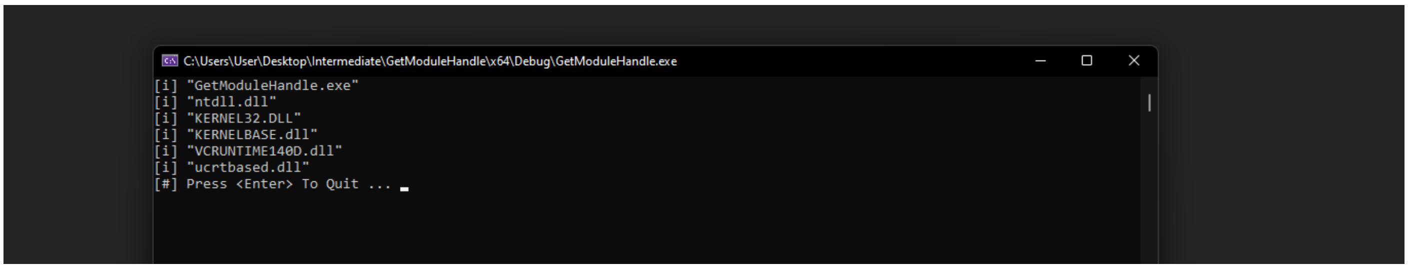
The above line of code may look complex but all it is doing is dereferencing the value stored at the address pointed to by `pDte` and then casting the result to a pointer to the `PLDR_DATA_TABLE_ENTRY` structure. This is simply how linked lists work, which is something like the following image


'PLDR_DATA_TABLE_ENTRY' of DLL (A)
'PLDR_DATA_TABLE_ENTRY' of DLL (B)
'PLDR_DATA_TABLE_ENTRY' of DLL (C)
'PLDR_DATA_TABLE_ENTRY' of DLL (D)
'PLDR_DATA_TABLE_ENTRY' of DLL (E)
the "PLDR_DATA_TABLE_ENTRY" of DLL (C) is that of (A).(B)
the "PLDR_DATA_TABLE_ENTRY" of DLL (E) is that of (A).(B).(C).(D)

Enumerate DLLs - Code

The code snippet below will retrieve the name of the DLLs already loaded inside the calling process. The function searches for the target module, `szModuleName`. If there is a match, the function returns a handle to the DLL (`HMODULE`), otherwise, it returns `NULL`.

```
HMODULE GetModuleHandleReplacement(IN LPCWSTR szModuleName) {

// Getting PEB
#ifdef _WIN64 // if compiling as x64
        PPEB                    pPeb    = (PEB*)(__readgsqword(0x60));
#elif _WIN32 // if compiling as x32
        PPEB                    pPeb    = (PEB*)(__readfsdword(0x30));
#endif

        // Getting Ldr
        PPEB_LDR_DATA               pLdr        = (PPEB_LDR_DATA)(pPeb-
>Ldr);

        // Getting the first element in the linked list which contains
information about the first module
        PLDR_DATA_TABLE_ENTRY   pDte    = (PLDR_DATA_TABLE_ENTRY)(pLdr-
>InMemoryOrderModuleList.Flink);

        while (pDte) {

                // If not null
                if (pDte->FullDllName.Length != NULL) {
                // Print the DLL name
                        wprintf(L"[i] \"%s\" \n", pDte-
>FullDllName.Buffer);
                }
                else {
                        break;
                }

                // Next element in the linked list
                pDte = *(PLDR_DATA_TABLE_ENTRY*)(pDte);

        }

        return NULL;
}
```



```
C:\Users\User\Desktop\Intermediate\GetModuleHandle\x64\Debug\GetModuleHandle.exe
[i] "GetModuleHandle.exe"
[i] "ntdll.dll"
[i] "KERNEL32.DLL"
[i] "KERNELBASE.dll"
[i] "VCRUNTIME140D.dll"
[i] "ucrtbased.dll"
[#] Press <Enter> To Quit ...
```

Case Sensitive DLL Names

By examining the output in the previous image, one can easily observe that some DLL names are capitalized and others are not, which affects the ability to obtain the DLL base address (`HMODULE`). For example, if one is searching for the `KERNEL32.DLL` DLL and passes `Kernel32.DLL` instead, the wcscmp function will treat both as different strings.

To address this, the helper function `IsStringEqual` was created to take two strings and convert them into a lower-case representation, then compare them in this state. It returns true if both strings are equal and false otherwise.

```
BOOL IsStringEqual (IN LPCWSTR Str1, IN LPCWSTR Str2) {

        WCHAR   lStr1   [MAX_PATH],
                lStr2   [MAX_PATH];

        int             len1    = lstrlenW(Str1),
                        len2    = lstrlenW(Str2);

        int             i               = 0,
                        j               = 0;
        // Checking length. We dont want to overflow the buffers
        if (len1 >= MAX_PATH || len2 >= MAX_PATH)
                return FALSE;

    // Converting Str1 to lower case string (lStr1)
        for (i = 0; i < len1; i++){
                lStr1[i] = (WCHAR)tolower(Str1[i]);
        }
        lStr1[i++] = L'\0'; // null terminating

    // Converting Str2 to lower case string (lStr2)
        for (j = 0; j < len2; j++) {
                lStr2[j] = (WCHAR)tolower(Str2[j]);
        }
        lStr2[j++] = L'\0'; // null terminating

        // Comparing the lower-case strings
        if (lstrcmpiW(lStr1, lStr2) == 0)
                return TRUE;

        return FALSE;
}
```

DLL Base Address

Obtaining the DLL base address requires referencing the `LDR_DATA_TABLE_ENTRY` structure. Unfortunately, large chunks of the structure are missing in Microsoft's official documentation. Therefore, to gain a better understanding of the structure, a search was conducted on Windows Vista Kernel Structures. The results for the structure can be found here.

```
typedef struct _LDR_DATA_TABLE_ENTRY {
    LIST_ENTRY InLoadOrderLinks;
    LIST_ENTRY InMemoryOrderLinks;
    LIST_ENTRY InInitializationOrderLinks;
    PVOID DllBase;
    PVOID EntryPoint;
    ULONG SizeOfImage;
    UNICODE_STRING FullDllName;
    UNICODE_STRING BaseDllName;
    ULONG Flags;
    WORD LoadCount;
    WORD TlsIndex;
    union {
        LIST_ENTRY HashLinks;
        struct {
            PVOID SectionPointer;
            ULONG CheckSum;
        };
    };
    union {
        ULONG TimeDateStamp;
        PVOID LoadedImports;
    };
    PACTIVATION_CONTEXT EntryPointActivationContext;
    PVOID PatchInformation;
    LIST_ENTRY ForwarderLinks;
    LIST_ENTRY ServiceTagLinks;
    LIST_ENTRY StaticLinks;
} LDR_DATA_TABLE_ENTRY, * PLDR_DATA_TABLE_ENTRY;
```

The DLL base address is `InInitializationOrderLinks.Flink`, although the name does not suggest that, but unfortunately Microsoft likes to confuse people. By comparing this member to Microsoft's official documentation of `LDR_DATA_TABLE_ENTRY`, it can be seen that the base address of the DLL is a reserved element (`Reserved2[0]`).

With this in mind, the `GetModuleHandle` replacement function can be completed.

GetModuleHandle Replacement Function

`GetModuleHandleReplacement` is the function that replaces `GetModuleHandle`. It will search for the given DLL name and if it's loaded by the process it returns a handle to the DLL.

```
HMODULE GetModuleHandleReplacement(IN LPCWSTR szModuleName) {

// Getting PEB
#ifdef _WIN64 // if compiling as x64
        PPEB                                    pPeb            = (PEB*)
(__readgsqword(0x60));
#elif _WIN32 // if compiling as x32
        PPEB                                    pPeb            = (PEB*)
(__readfsdword(0x30));
#endif

        // Getting Ldr
        PPEB_LDR_DATA                   pLdr            = (PPEB_LDR_DATA)
(pPeb->Ldr);
        // Getting the first element in the linked list (contains
information about the first module)
        PLDR_DATA_TABLE_ENTRY   pDte            = (PLDR_DATA_TABLE_ENTRY)
(pLdr->InMemoryOrderModuleList.Flink);

        while (pDte) {

                // If not null
                if (pDte->FullDllName.Length != NULL) {

                        // Check if both equal
                        if (IsStringEqual(pDte->FullDllName.Buffer,
szModuleName)) {
                                wprintf(L"[+] Found Dll \"%s\" \n", pDte-
>FullDllName.Buffer);
#ifdef STRUCTS
                                return (HMODULE)(pDte-
>InInitializationOrderLinks.Flink);
#else
                                return (HMODULE)pDte->Reserved2[0];
#endif // STRUCTS

                        }

                        // wprintf(L"[i] \"%s\" \n", pDte-
>FullDllName.Buffer);
                }
                else {
                        break;
                }

                // Next element in the linked list
                pDte = *(PLDR_DATA_TABLE_ENTRY*)(pDte);

        }

        return NULL;
}
```

One part of the code which was not explained is shown below. This part of the code determines whether Microsoft's version of the `LDR_DATA_TABLE_ENTRY` structure is being used or the one from Windows Vista Kernel Structures. Depending on which one was used, the name of the member changes.

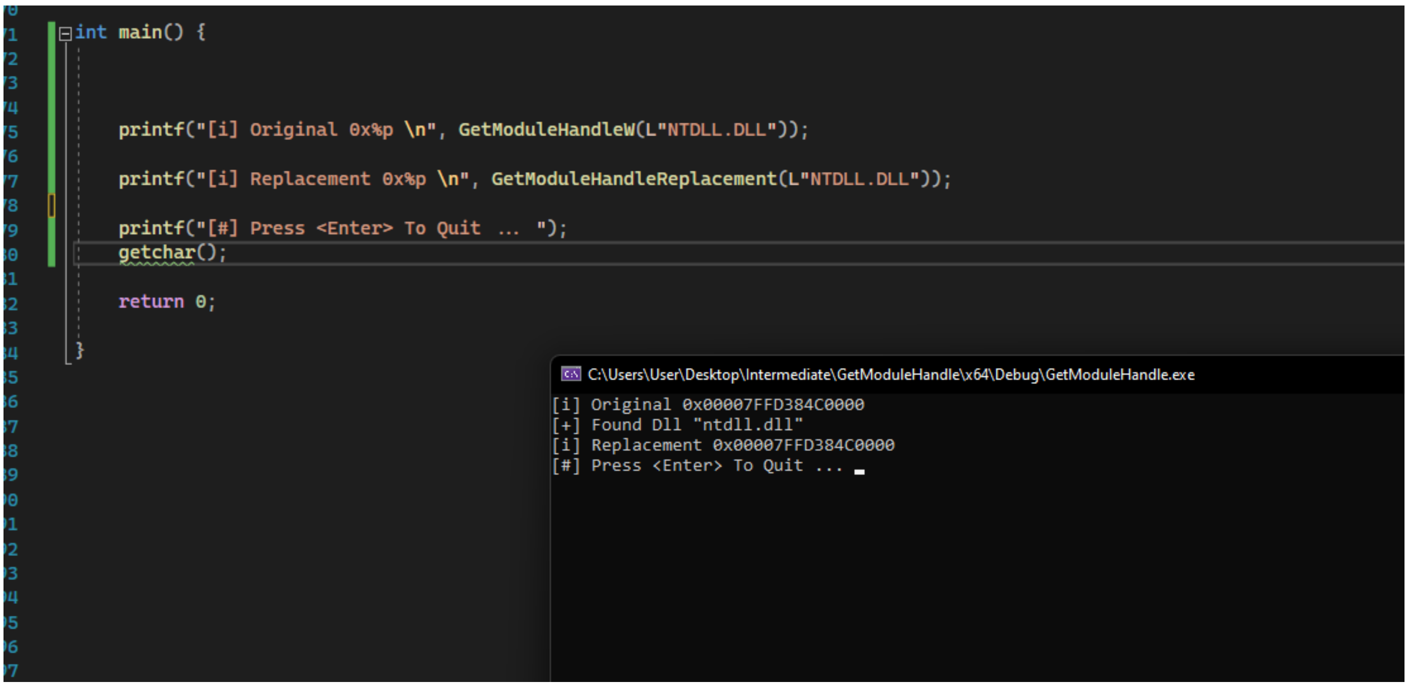
```
#ifdef STRUCTS
                                return (HMODULE)(pDte-
>InInitializationOrderLinks.Flink);
#else
```

```
                                                     return (HMODULE)pDte->Reserved2[0];
#endif // STRUCTS
```

GetModuleHandleReplacement2

Another implementation of the `GetModuleHandleReplacement` function can be found in this module's code. `GetModuleHandleReplacement2` performs DLL enumeration using the head and the linked list's elements which utilize the doubly linked list concept. This function was created for users that are familiar with linked lists.

Demo



```
int main() {


    printf("[i] Original 0x%p \n", GetModuleHandleW(L"NTDLL.DLL"));

    printf("[i] Replacement 0x%p \n", GetModuleHandleReplacement(L"NTDLL.DLL"));

    printf("[#] Press <Enter> To Quit ... ");
    getchar();

    return 0;

}
```

C:\Users\User\Desktop\Intermediate\GetModuleHandle\x64\Debug\GetModuleHandle.exe

```
[i] Original 0x00007FFD384C0000
[+] Found Dll "ntdll.dll"
[i] Replacement 0x00007FFD384C0000
[#] Press <Enter> To Quit ...
```