API Hooking - Custom Code

Introduction

So far, open source libraries have been used to implement API hooking. However, a major issue with this approach is that the source code for these libraries is publicly available, making it straightforward for security researchers and security product vendors to build IoCs. For this reason, API hooking will be implemented manually in this module, although not as sophisticated as the previously demonstrated libraries, but enough to achieve the desired result without IoCs.

Custom hooking code can be a better option if the intent is to hook a single function. This avoids the additional effort of linking other libraries, and avoiding the additional weight these libraries add to the binary's size.

Creating The Trampoline Shellcode

One of the ways to hook a function is to overwrite its first few instructions with new ones. These new instructions are the trampoline which is responsible for altering the execution flow of the function to the replacement function. This trampoline is typically a small jump shellcode that executes a `jmp` instruction to the address of the function to be executed. To execute the `jmp` instruction, the address that needs to be jumped to must be saved inside of a register. In the presented example, the register will be `eax` on a 32-bit processor and `r10` on a 64-bit processor. A `mov` instruction will be used to save the address inside of these registers.

This is all that is needed for the trampoline, a `mov` and a `jmp` instruction. Diving deeper into how these instructions are used is not the focus of this module. If one would like to explore them further, felixcloutier.com/x86/mov and felixcloutier.com/x86/jmp can provide more details.

64-bit Jump Shellcode

The 64-bit jump shellcode should be as follows:

```
mov r10, pAddress
jmp r10
```

Where `pAddres` is the address of the function to jump to (e.g. `0x0000FFFEC32A300`). To use these instructions in the code they must first be converted to *opcode*.

```
0x49, 0xBA, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // mov r10,
pAddress
0x41, 0xFF, 0xE2                                            // jmp r10
```

32-bit Jump Shellcode

And the 32-bit version:

```
mov eax, pAddress
jmp eax
```

Again, convert the instructions to opcode.

```
0xB8, 0x00, 0x00, 0x00, 0x00,     // mov eax, pAddress
0xFF, 0xE0                        // jmp eax
```

Note that `pAddress` is represented as `NULL`, which explains the `0x00` sequence. These `0x00` opcodes are placeholders that will be overwritten during runtime.

Retrieving pAddress

Since the hooks are installed during runtime, the `pAddress` value must be retrieved and added to the shellcode during runtime. The retrieval of the address can be done using `GetProcAddress` and once that's completed, `memcpy` is used to copy the address to the correct location in the shellcode.

64-bit Patching

```
uint8_t         uTrampoline[] = {
                          0x49, 0xBA, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, // mov r10, pFunctionToRun
                          0x41, 0xFF, 0xE2
// jmp r10
};

uint64_t uPatch = (uint64_t)pAddress;
memcpy(&uTrampoline[2], &uPatch, sizeof(uPatch)); // copying the address to
the offset '2' in uTrampoline
```

32-bit Patching

```
uint8_t         uTrampoline[] = {
           0xB8, 0x00, 0x00, 0x00, 0x00,     // mov eax, pFunctionToRun
           0xFF, 0xE0                        // jmp eax
};

uint32_t uPatch = (uint32_t)pAddress;
memcpy(&uTrampoline[1], &uPatch, sizeof(uPatch)); // copying the address to
the offset '1' in uTrampoline
```

As previously mentioned, `pAddress` is the address of the function to jump to. The `uint32_t` and `uint64_t` data types are used to ensure that the address is the correct number of bytes, that is 4 bytes for 32-bit machines and 8 bytes for 64-bit machines. `uint32_t` is of size 4 bytes, and `uint64_t` is of size 8 bytes. `memcpy` will then place the address into the trampoline by overwriting the `0x00` placeholder bytes.

Writing The Trampoline

Before overwriting the target function's first few instructions with the prepared shellcode, it is important to mark the memory where the trampoline will be written as writable. In most cases, the memory region will not be writable, requiring the `VirtualProtect` WinAPI to change the memory permissions to `PAGE_EXECUTE_READWRITE`. It is worth noting that it must be writable and executable because when the program calls the function, it needs to execute instructions that will not be permitted on write-only memory.

With that in mind, the trampoline should first modify the permissions of the target function and then copy the shellcode over.

```
// Changing the memory permissons at 'pFunctionToHook' to be
PAGE_EXECUTE_READWRITE
if (!VirtualProtect(pFunctionToHook, sizeof(uTrampoline),
PAGE_EXECUTE_READWRITE, &dwOldProtection)) {
        return FALSE;
}

// Copying the trampoline shellcode to 'pFunctionToHook'
memcpy(pFunctionToHook, uTrampoline, sizeof(uTrampoline));
```

Where `pFunctionToHook` is the address of the function to hook, and `uTrampoline` is the jump shellcode.

Unhooking

When the hooked function is called, the trampoline shellcode should be able to work for both 64-bit and 32-bit architectures. However, the unhooking of the hooked function has not been discussed. To do this, the original bytes which were overwritten by the trampoline should be restored by using a buffer containing these bytes that were created prior to the installation of the trampoline shellcode. This buffer should then be used as the source buffer in the `memcpy` function when unhooking the function.

```
memcpy(pFunctionToHook, pOriginalBytes, sizeof(pOriginalBytes));
```

Where `pFunctionToHook` is the address of the hooked function and `pOriginalBytes` is the buffer that's holding the original bytes of the function which should have been saved before hooking, and can be done via a `memcpy` call. The size of the `pOriginalBytes` buffer should be the same as the trampoline shellcode size that way only the shellcode is overwritten. Lastly, it's recommended to revert the memory permissions which can be done via the code snippet below.

```
if (!VirtualProtect(pFunctionToHook, sizeof(uTrampoline), dwOldProtection,
&dwOldProtection)) {
        return FALSE;
}
```

Where `dwOldProtection` is the old memory permission returned by the first `VirtualProtect` call.

HookSt Structure

To make the implementation easier, the `HookSt` structure was created. This structure will contain the needed information to hook and unhook a certain function. The value `TRAMPOLINE_SIZE` is set to *13* if the program is set to be compiled as a 64-bit application, and its set to *7* if the program is to be compiled in 32-bit mode. The values 13 and 7 are the sizes of the trampoline shellcode, denoted in the `uTrampoline` variable previously shown, in 64-bit and 32-bit systems, respectively.

```
typedef struct _HookSt{

        PVOID   pFunctionToHook;                  // address of the
function to hook
        PVOID   pFunctionToRun;                   // address of the
function to run instead
        BYTE    pOriginalBytes[TRAMPOLINE_SIZE];  // buffer to keep some
original bytes (needed for cleanup)
        DWORD   dwOldProtection;                  // holds the old memory
protection of the "function to hook" address (needed for cleanup)

}HookSt, *PHookSt;
```

Setting the `TRAMPOLINE_SIZE` value is done via the following preprocessor code

```
// if compiling as 64-bit
#ifdef _M_X64
#define TRAMPOLINE_SIZE         13
#endif // _M_X64

// if compiling as 32-bit
#ifdef _M_IX86
#define TRAMPOLINE_SIZE         7
#endif // _M_IX86
```

Installing Hooks

The following function uses `HookSt` to install hooks.

```
BOOL InstallHook (IN PHookSt Hook) {

#ifdef _M_X64
        // 64-bit trampoline
        uint8_t uTrampoline [] = {
                        0x49, 0xBA, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, // mov r10, pFunctionToRun
                        0x41, 0xFF, 0xE2
// jmp r10
        };

        // Patching the shellcode with the address to jump to
(pFunctionToRun)
        uint64_t uPatch = (uint64_t)(Hook->pFunctionToRun);
        // Copying the address of the function to jump to, to the offset
'2' in uTrampoline
        memcpy(&uTrampoline[2], &uPatch, sizeof(uPatch));
#endif // _M_X64


#ifdef _M_IX86
        // 32-bit trampoline
        uint8_t uTrampoline[] = {
           0xB8, 0x00, 0x00, 0x00, 0x00,     // mov eax, pFunctionToRun
           0xFF, 0xE0                        // jmp eax
        };

        // Patching the shellcode with the address to jump to
(pFunctionToRun)
        uint32_t uPatch = (uint32_t)(Hook->pFunctionToRun);
        // Copying the address of the function to jump to, to the offset
'1' in uTrampoline
        memcpy(&uTrampoline[1], &uPatch, sizeof(uPatch));
#endif // _M_IX86


        // Placing the trampoline function - installing the hook
        memcpy(Hook->pFunctionToHook, uTrampoline, sizeof(uTrampoline));

        return TRUE;
}
```

Removing Hooks

The function below uses `HookSt` to remove hooks.

```
BOOL RemoveHook (IN PHookSt Hook) {

        DWORD   dwOldProtection         = NULL;

        // Copying the original bytes over
        memcpy(Hook->pFunctionToHook, Hook->pOriginalBytes,
TRAMPOLINE_SIZE);
        // Cleaning up our buffer
        memset(Hook->pOriginalBytes, '\0', TRAMPOLINE_SIZE);
        // Setting the old memory protection back to what it was before
hooking
        if (!VirtualProtect(Hook->pFunctionToHook, TRAMPOLINE_SIZE, Hook-
>dwOldProtection, &dwOldProtection)) {
                printf("[!] VirtualProtect Failed With Error : %d \n",
GetLastError());
                return FALSE;
        }

        // Setting all to null
        Hook->pFunctionToHook   = NULL;
        Hook->pFunctionToRun    = NULL;
        Hook->dwOldProtection   = NULL;

        return TRUE;
}
```

Populating The HookSt Structure

The `InitializeHookStruct` function is used to populate the `HookSt` structure with the necessary information to perform hooking.

```
BOOL InitializeHookStruct(IN PVOID pFunctionToHook, IN PVOID
pFunctionToRun, OUT PHookSt Hook) {

        // Filling up the struct
        Hook->pFunctionToHook   = pFunctionToHook;
        Hook->pFunctionToRun    = pFunctionToRun;

        // Save original bytes of the same size that we will overwrite
(that is TRAMPOLINE_SIZE)
```

```
        // This is done to be able to do cleanups when done
        memcpy(Hook->pOriginalBytes, pFunctionToHook, TRAMPOLINE_SIZE);

        // Changing the protection to RWX so that we can modify the bytes
        // We are saving the old protection to the struct (to re-place it
at cleanup)
        if (!VirtualProtect(pFunctionToHook, TRAMPOLINE_SIZE,
PAGE_EXECUTE_READWRITE, &Hook->dwOldProtection)) {
                printf("[!] VirtualProtect Failed With Error : %d \n",
GetLastError());
                return FALSE;
        }

        return TRUE;
}
```

The Main function

The main function below calls the previously demonstrated functions and hooks the `MessageBoxA` WinAPI.

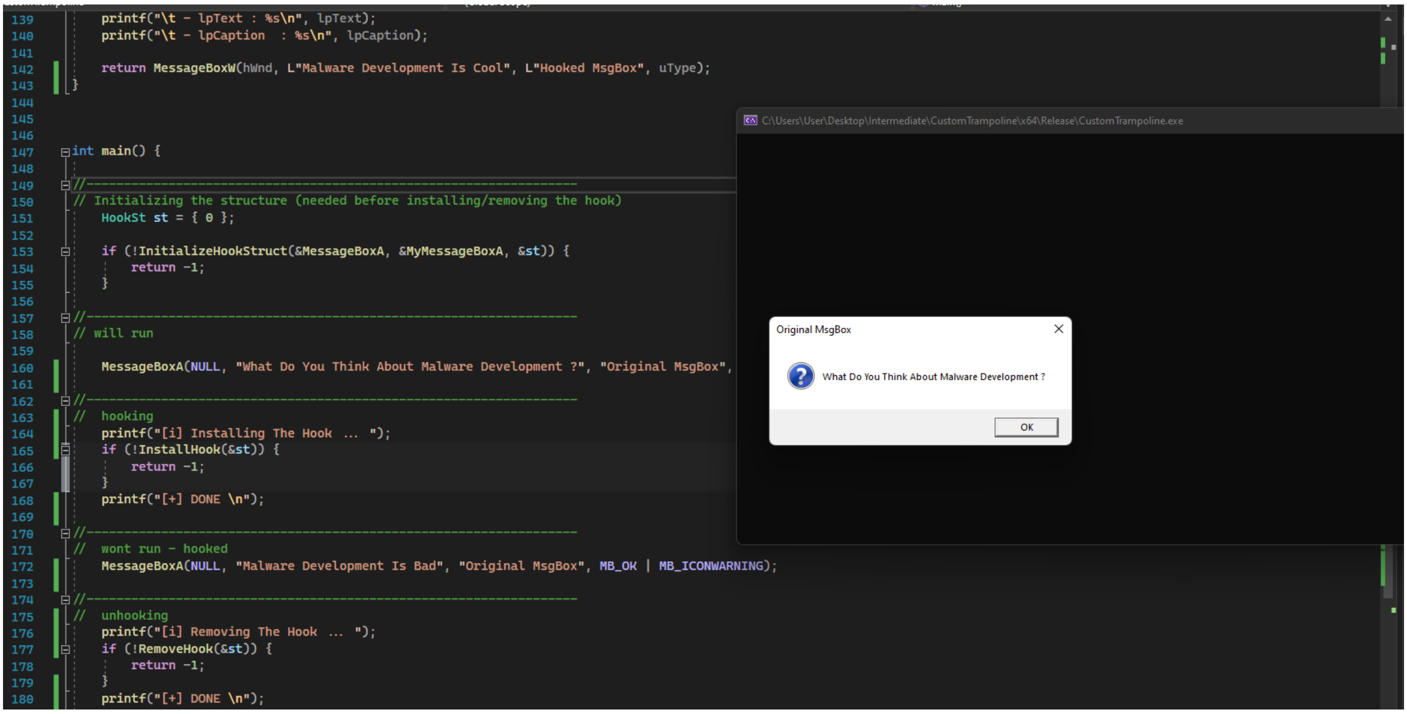
```
int main() {

        // Initializing the structure (needed before installing/removing
the hook)
        HookSt st = { 0 };

        if (!InitializeHookStruct(&MessageBoxA, &MyMessageBoxA, &st)) {
                return -1;
        }

        // will run
        MessageBoxA(NULL, "What Do You Think About Malware Development ?",
"Original MsgBox", MB_OK | MB_ICONQUESTION);

        //  hooking
        if (!InstallHook(&st)) {
                return -1;
        }

        //  wont run - hooked
        MessageBoxA(NULL, "Malware Development Is Bad", "Original MsgBox",
MB_OK | MB_ICONWARNING);

```

```
        //  unhooking
        if (!RemoveHook(&st)) {
                return -1;
        }


        //  will run - hook disabled
        MessageBoxA(NULL, "Normal MsgBox Again", "Original MsgBox", MB_OK |
MB_ICONINFORMATION);


        return 0;
}
```

Demo

Due to the trampoline-based hook, it is impossible to have a global original function pointer be called to resume execution. Therefore, the `MessageBoxW` WinAPI will be called in the `MyMessageBoxA` detour function.

Running the first `MessageBoxA` (Unhooked).



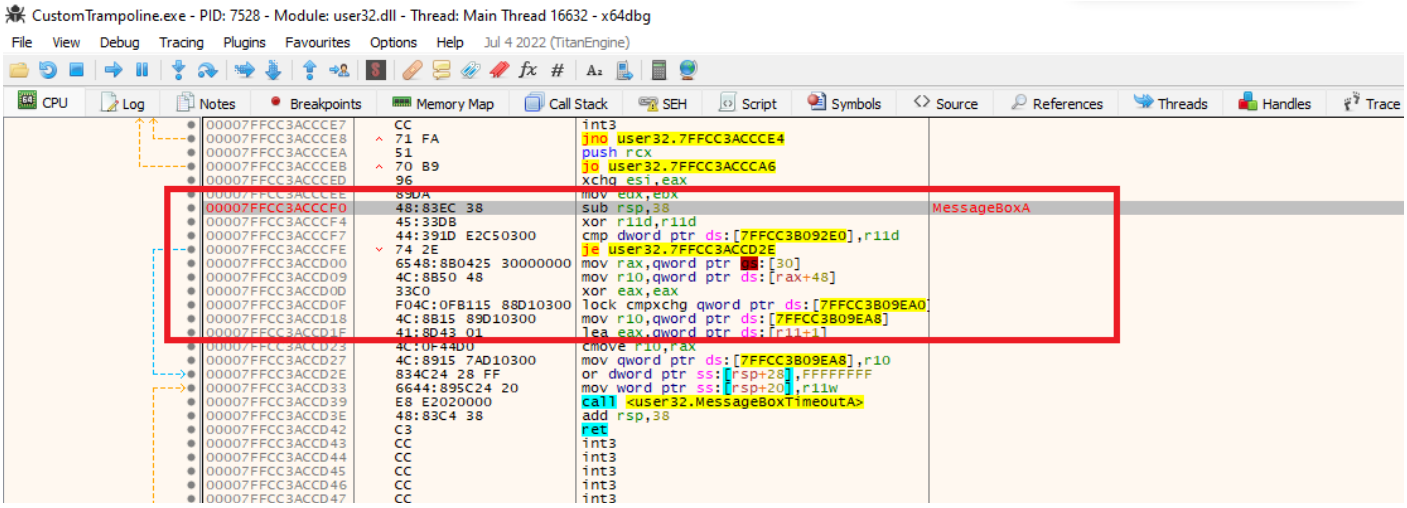
```
    printf("\t - lpText : %s\n", lpText);
    printf("\t - lpCaption  : %s\n", lpCaption);

    return MessageBoxW(hWnd, L"Malware Development Is Cool", L"Hooked MsgBox", uType);
}



int main() {

//-----------------------------------------------------------------
// Initializing the structure (needed before installing/removing the hook)
    HookSt st = { 0 };

    if (!InitializeHookStruct(&MessageBoxA, &MyMessageBoxA, &st)) {
        return -1;
    }

//-----------------------------------------------------------------
// will run

    MessageBoxA(NULL, "What Do You Think About Malware Development ?", "Original MsgBox",

//-----------------------------------------------------------------
//  hooking
    printf("[i] Installing The Hook ... ");
    if (!InstallHook(&st)) {
        return -1;
    }
    printf("[+] DONE \n");

//-----------------------------------------------------------------
//  wont run - hooked
    MessageBoxA(NULL, "Malware Development Is Bad", "Original MsgBox", MB_OK | MB_ICONWARNING);

//-----------------------------------------------------------------
//  unhooking
    printf("[i] Removing The Hook ... ");
    if (!RemoveHook(&st)) {
        return -1;
    }
    printf("[+] DONE \n");
```

C:\Users\User\Desktop\Intermediate\CustomTrampoline\x64\Release\CustomTrampoline.exe

Original MsgBox

What Do You Think About Malware Development ?

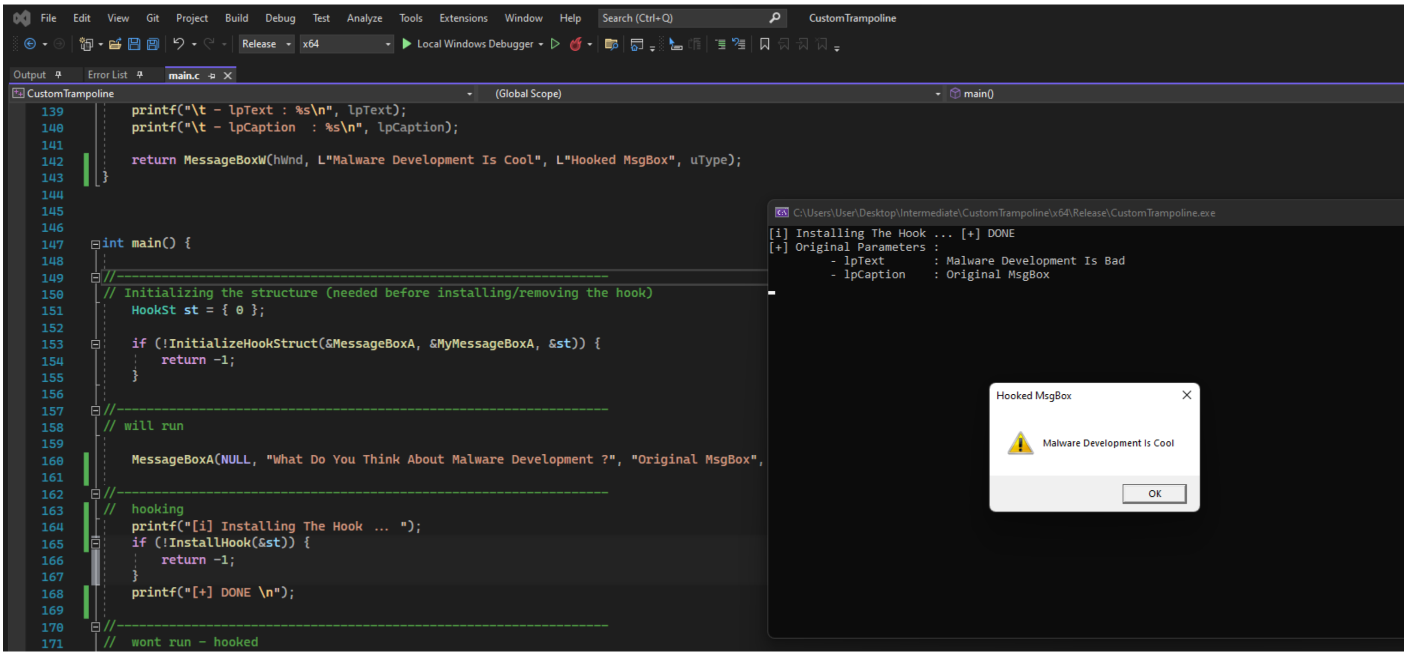
The original `MessageBoxA` instructions before hooking.



CustomTrampoline.exe - PID: 7528 - Module: user32.dll - Thread: Main Thread 16632 - x64dbg

```
00007FFCC3ACCCE7   CC                   int3
00007FFCC3ACCCE8   71 FA                jno user32.7FFCC3ACCCE4
00007FFCC3ACCCEA   51                   push rcx
00007FFCC3ACCCEB   70 B9                jo user32.7FFCC3ACCCA6
00007FFCC3ACCCED   96                   xchg esi,eax
00007FFCC3ACCCEE   89DA                 mov edx,ebx
00007FFCC3ACCCF0   48:83EC 38           sub rsp,38                                         MessageBoxA
00007FFCC3ACCCF4   45:33DB              xor r11d,r11d
00007FFCC3ACCCF7   44:391D E2C50300     cmp dword ptr ds:[7FFCC3B092E0],r11d
00007FFCC3ACCCFE   74 2E                je user32.7FFCC3ACCD2E
00007FFCC3ACCD00   6548:8B0425 30000000 mov rax,qword ptr gs:[30]
00007FFCC3ACCD09   4C:8B50 48           mov r10,qword ptr ds:[rax+48]
00007FFCC3ACCD0D   33C0                 xor eax,eax
00007FFCC3ACCD0F   F04C:0FB115 88D10300 lock cmpxchg qword ptr ds:[7FFCC3B09EA0]
00007FFCC3ACCD18   4C:8B15 89D10300     mov r10,qword ptr ds:[7FFCC3B09EA8]
00007FFCC3ACCD1F   41:8D43 01           lea eax,qword ptr ds:[r11+1]
00007FFCC3ACCD23   4C:0F44D0            cmove r10,rax
00007FFCC3ACCD27   4C:8915 7AD10300     mov qword ptr ds:[7FFCC3B09EA8],r10
00007FFCC3ACCD2E   834C24 28 FF         or dword ptr ss:[rsp+28],FFFFFFFF
00007FFCC3ACCD33   6644:895C24 20       mov word ptr ss:[rsp+20],r11w
00007FFCC3ACCD39   E8 E2020000          call <user32.MessageBoxTimeoutA>
00007FFCC3ACCD3E   48:83C4 38           add rsp,38
00007FFCC3ACCD42   C3                   ret
00007FFCC3ACCD43   CC                   int3
00007FFCC3ACCD44   CC                   int3
00007FFCC3ACCD45   CC                   int3
00007FFCC3ACCD46   CC                   int3
00007FFCC3ACCD47   CC                   int3
```

Running the second `MessageBoxA` (Hooked).



```c
    printf("\t - lpText : %s\n", lpText);
    printf("\t - lpCaption  : %s\n", lpCaption);

    return MessageBoxW(hWnd, L"Malware Development Is Cool", L"Hooked MsgBox", uType);
}


int main() {

//-------------------------------------------------------------------------------
// Initializing the structure (needed before installing/removing the hook)
    HookSt st = { 0 };

    if (!InitializeHookStruct(&MessageBoxA, &MyMessageBoxA, &st)) {
        return -1;
    }

//-------------------------------------------------------------------------------
// will run

    MessageBoxA(NULL, "What Do You Think About Malware Development ?", "Original MsgBox",

//-------------------------------------------------------------------------------
//  hooking
    printf("[i] Installing The Hook ... ");
    if (!InstallHook(&st)) {
        return -1;
    }
    printf("[+] DONE \n");

//-------------------------------------------------------------------------------
//  wont run - hooked
```

C:\Users\User\Desktop\Intermediate\CustomTrampoline\x64\Release\CustomTrampoline.exe

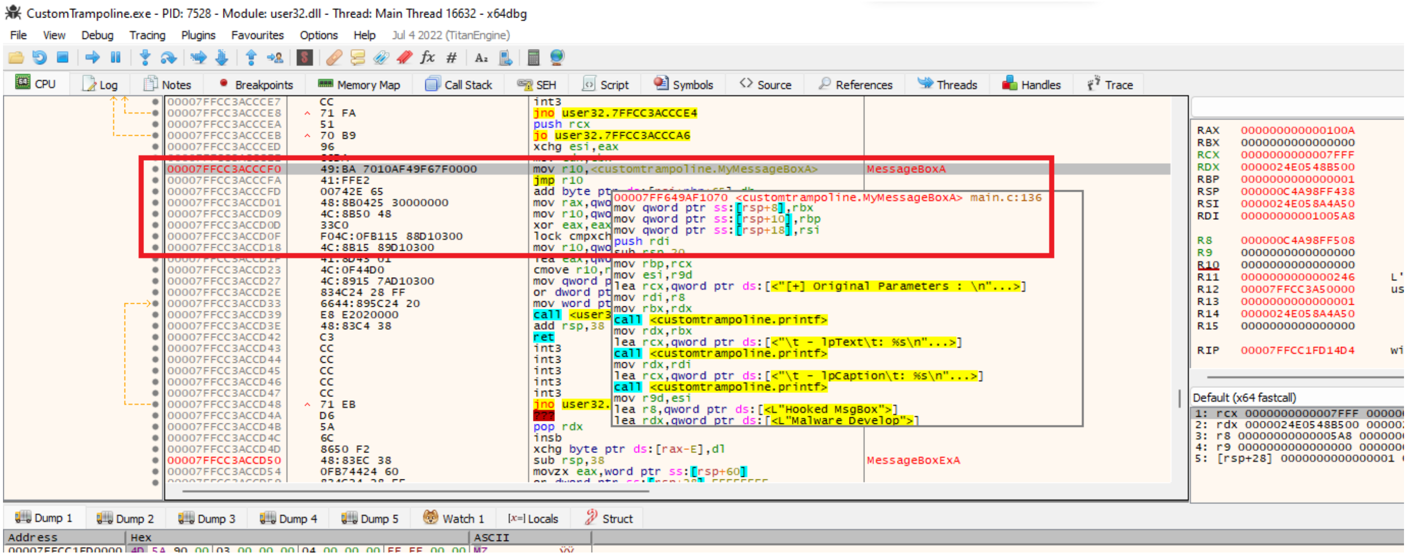
```
[i] Installing The Hook ... [+] DONE
[+] Original Parameters :
        - lpText       : Malware Development Is Bad
        - lpCaption    : Original MsgBox
```

Hooked MsgBox

Malware Development Is Cool

OK

The trampoline shellcode is in memory.



CustomTrampoline.exe - PID: 7528 - Module: user32.dll - Thread: Main Thread 16632 - x64dbg

```
00007FFCC3ACCCE7   CC                   int3
00007FFCC3ACCCE8   71 FA                jno user32.7FFCC3ACCCE4
00007FFCC3ACCCEA   51                   push rcx
00007FFCC3ACCCEB   70 B9                jo user32.7FFCC3ACCCA6
00007FFCC3ACCCED   96                   xchg esi,eax
00007FFCC3ACCCF0   49:BA 7010AF49F67F0000 mov r10,<customtrampoline.MyMessageBoxA>    MessageBoxA
00007FFCC3ACCCFA   41:FFE2              jmp r10
00007FFCC3ACCCFD   00742E 65            add byte pt
00007FFCC3ACCD01   48:8B0425 30000000   mov rax,qwo
00007FFCC3ACCD09   4C:8B50 48           mov r10,qwo
00007FFCC3ACCD0D   33C0                 xor eax,eax
00007FFCC3ACCD0F   F04C:0FB115 88D10300 lock cmpxch
00007FFCC3ACCD18   4C:8B15 89D10300     mov r10,qwo
00007FFCC3ACCD23   4C:0F44D0            cmove r10,r
00007FFCC3ACCD27   4C:8915 7AD10300     mov qword p
00007FFCC3ACCD2E   834C24 28 FF         or dword pt
00007FFCC3ACCD33   6644:895C24 20       mov word pt
00007FFCC3ACCD39   E8 E2020000          call <user3
00007FFCC3ACCD3E   48:83C4 38           add rsp,38
00007FFCC3ACCD42   C3                   ret
00007FFCC3ACCD43   CC                   int3
00007FFCC3ACCD44   CC                   int3
00007FFCC3ACCD45   CC                   int3
00007FFCC3ACCD46   CC                   int3
00007FFCC3ACCD47   CC                   int3
00007FFCC3ACCD48   71 EB                jno user32.
00007FFCC3ACCD4A   D6                   ???
00007FFCC3ACCD4B   5A                   pop rdx
00007FFCC3ACCD4C   6C                   insb
00007FFCC3ACCD4D   8650 F2              xchg byte ptr ds:[rax-E],dl
00007FFCC3ACCD50   48:83EC 38           sub rsp,38                                         MessageBoxExA
00007FFCC3ACCD54   0FB74424 60          movzx eax,word ptr ss:[rsp+60]
```

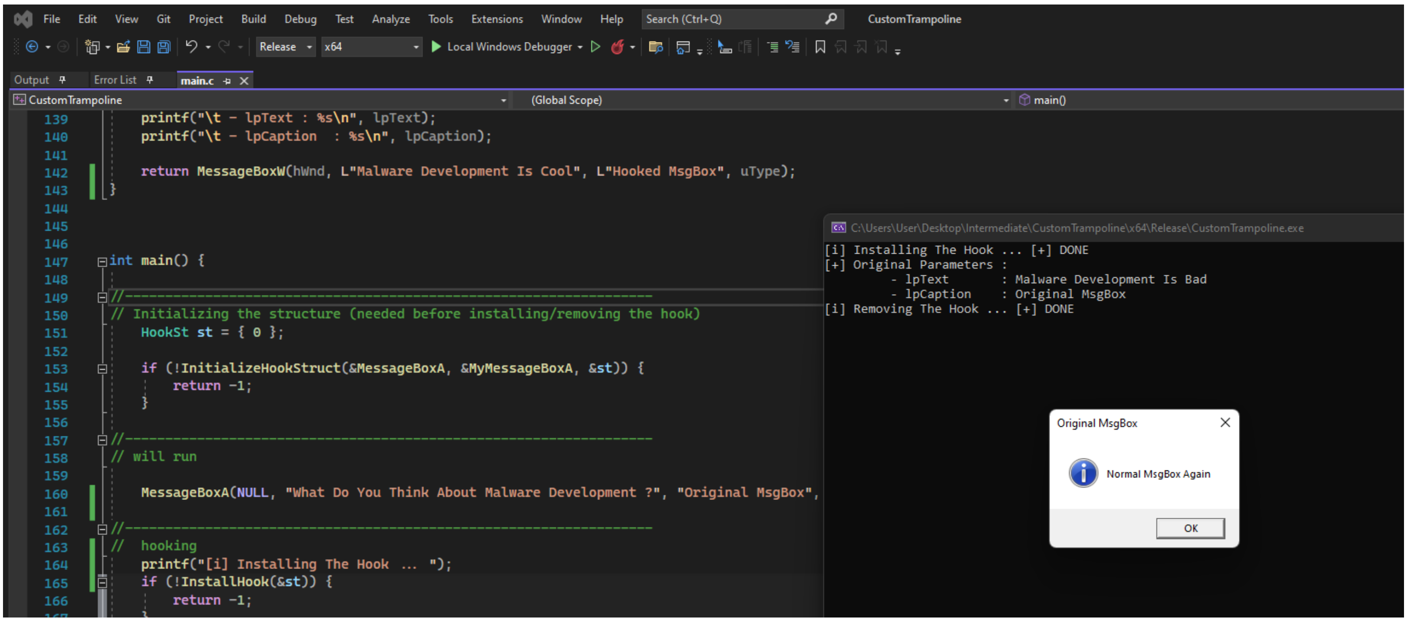
```
00007FF649AF1070 <customtrampoline.MyMessageBoxA> main.c:136
mov qword ptr ss:[rsp+8],rbx
mov qword ptr ss:[rsp+10],rbp
mov qword ptr ss:[rsp+18],rsi
push rdi
sub rsp,20
mov rbp,rcx
mov esi,r9d
lea rcx,qword ptr ds:[<"[+] Original Parameters : \n"...>]
mov rdi,r8
mov rbx,rdx
call <customtrampoline.printf>
mov rdx,rbx
lea rcx,qword ptr ds:[<"\t - lpText\t: %s\n"...>]
call <customtrampoline.printf>
mov rdx,rdi
lea rcx,qword ptr ds:[<"\t - lpCaption\t: %s\n"...>]
call <customtrampoline.printf>
mov r9d,esi
lea r8,qword ptr ds:[<L"Hooked MsgBox">]
lea rdx,qword ptr ds:[<L"Malware Develop">]
```

```
RAX   000000000000100A
RBX   0000000000000000
RCX   0000000000007FFF
RDX   0000024E0548B500
RBP   0000000000000001
RSP   000000C4A98FF438
RSI   0000024E058A4A50
RDI   00000000001005A8

R8    000000C4A98FF508
R9    0000000000000000
R10   0000000000000000
R11   0000000000000246
R12   00007FFCC3A50000
R13   0000000000000001
R14   0000024E058A4A50
R15   0000000000000000

RIP   00007FFCC1FD14D4
```

Default (x64 fastcall)

```
1: rcx 0000000000007FFF
2: rdx 0000024E0548B500
3: r8 00000000000005A8
4: r9 0000000000000000
5: [rsp+28] 0000000000000001
```

Running the third `MessageBoxA` (Unhooked).



```c
    printf("\t - lpText : %s\n", lpText);
    printf("\t - lpCaption  : %s\n", lpCaption);

    return MessageBoxW(hWnd, L"Malware Development Is Cool", L"Hooked MsgBox", uType);
}



int main() {

//------------------------------------------------------------------
// Initializing the structure (needed before installing/removing the hook)
    HookSt st = { 0 };

    if (!InitializeHookStruct(&MessageBoxA, &MyMessageBoxA, &st)) {
        return -1;
    }

//------------------------------------------------------------------
// will run

    MessageBoxA(NULL, "What Do You Think About Malware Development ?", "Original MsgBox",

//------------------------------------------------------------------
//  hooking
    printf("[i] Installing The Hook ... ");
    if (!InstallHook(&st)) {
        return -1;
```

```
[i] Installing The Hook ... [+] DONE
[+] Original Parameters :
        - lpText       : Malware Development Is Bad
        - lpCaption    : Original MsgBox
[i] Removing The Hook ... [+] DONE
```