API Hooking - Using Windows APIs

Introduction

The SetWindowsHookEx WinAPI call is an alternate method of API hooking. It is mainly employed to keep track of certain types of system events, which is distinct from the techniques used in earlier modules, as `SetWindowsHookExW/A` does not modify the functionality of a function, instead it executes a callback function whenever a certain event is triggered. The type of events is limited to those provided by Windows.

SetWindowsHookEx Usage

The `SetWindowsHookExW` WinAPI is shown below.

```
HHOOK SetWindowsHookExW(
  [in] int       idHook,      // The type of hook procedure to be installed
  [in] HOOKPROC  lpfn,        // A pointer to the hook procedure (function to execute)
  [in] HINSTANCE hmod,        // Handle to the DLL containing the hook procedure (this is kept as NULL)
  [in] DWORD     dwThreadId   // A thread Id with which the hook procedure is to be associated with (this is kept as NULL)
);
```

- `idHook` - The event that will be monitored. For example, the `WH_KEYBOARD_LL` flag is used to monitor keystroke messages which can act as a keylogger. Note that using `SetWindowsHookEx` to perform keylogging is an old trick. For this module, the `WH_MOUSE_LL` flag will be used to monitor mouse clicks.

- `lpfn` - A pointer to the callback function that executes whenever the specified event occurs. In this case, the function will execute whenever there is a mouse click.

Callback Function

The callback function should be of type `HOOKPROC`, which is shown below.

```
typedef LRESULT (CALLBACK* HOOKPROC)(int nCode, WPARAM wParam, LPARAM lParam);
```

Therefore a callback function should be defined like the function below.

```
LRESULT HookCallbackFunc(int nCode, WPARAM wParam, LPARAM lParam){
  // function's code
}
```

The callback function should also use the CallNextHookEx WinAPI and return its output. `CallNextHookEx` passes the hook information to the next hook procedure in the hook chain. In other words, it will pass the hook's information to the callback function the next time it is executed.

The callback function is updated to include `CallNextHookEx`.

```
LRESULT HookCallbackFunc(int nCode, WPARAM wParam, LPARAM lParam){
  // Function's code

  return CallNextHookEx(NULL, nCode, wParam, lParam)
}
```

Based on Microsoft's Remark section, calling `CallNextHookEx` is optional but highly recommended. Otherwise, other applications that have installed hooks will not receive hook notifications and may behave incorrectly.

Finally, the last part is the callback function's code. The code will be monitoring the action therefore in this example the function is checking what mouse button was clicked via the following code.

```
LRESULT HookCallbackFunc(int nCode, WPARAM wParam, LPARAM lParam){

    if (wParam == WM_LBUTTONDOWN){
        printf("[ # ] Left Mouse Click \n");
    }

    if (wParam == WM_RBUTTONDOWN) {
        printf("[ # ] Right Mouse Click \n");
    }

    if (wParam == WM_MBUTTONDOWN) {
        printf("[ # ] Middle Mouse Click \n");
    }

  return CallNextHookEx(NULL, nCode, wParam, lParam)
}
```

Processing Messages

Having obtained the code required to monitor the user's mouse clicks, the next step is to ensure that the hooking process is maintained. This is achieved by executing the monitoring code over a specific period.

To do so, `SetWindowsHookExW` is called within a thread, which is kept active for the desired duration using the `WaitForSingleObject` WinAPI.

```
// The callback function that will be executed whenever the user clicks a
mouse button
LRESULT HookCallback(int nCode, WPARAM wParam, LPARAM lParam){

    if (wParam == WM_LBUTTONDOWN){
        printf("[ # ] Left Mouse Click \n");
    }

    if (wParam == WM_RBUTTONDOWN) {
        printf("[ # ] Right Mouse Click \n");
    }

    if (wParam == WM_MBUTTONDOWN) {
        printf("[ # ] Middle Mouse Click \n");
    }

    // moving to the next hook in the hook chain
    return CallNextHookEx(NULL, nCode, wParam, lParam);
}



BOOL MouseClicksLogger(){

    // Installing hook
    HHOOK hMouseHook = SetWindowsHookExW(
        WH_MOUSE_LL,
        (HOOKPROC)HookCallback,
        NULL,
        NULL
    );
    if (!hMouseHook) {
        printf("[!] SetWindowsHookExW Failed With Error : %d \n",
GetLastError());
        return FALSE;
    }

    // Keeping the thread running
    while(1){

    }
    return TRUE;
}


int main() {

    HANDLE hThread = CreateThread(NULL, NULL,
(LPTHREAD_START_ROUTINE)MouseClicksLogger, NULL, NULL, NULL);
    if (hThread)
        WaitForSingleObject(hThread, 10000); // Monitor mouse clicks for 10
seconds

    return 0;
}
```

Improving The Implementation

The issue with the prior code was that the while loop fails to process hooked mouse messages, which resulted in a laggy mouse movement on the target machine. To resolve this issue, it is necessary to process all message events using DefWindowProc. This will ensure that the event is properly handled by the system and that any associated default behavior is carried out. `DefWindowProcW` calls the default window procedure to provide default processing for any window messages that an application does not process.

To get the message's details, GetMessageW must be called first, which retrieves a message from the calling thread's message queue. This message is then passed to `DefWindowProcW`, which will process it. `GetMessageW` returns the message information in an MSG structure which includes everything required for the following `DefWindowProcW` call.

All of this should be performed within a loop to ensure every unprocessed message is manually handled.

```
// The callback function that will be executed whenever the user clicked a
mouse button
LRESULT HookCallback(int nCode, WPARAM wParam, LPARAM lParam){

    if (wParam == WM_LBUTTONDOWN){
        printf("[ # ] Left Mouse Click \n");
    }

    if (wParam == WM_RBUTTONDOWN) {
        printf("[ # ] Right Mouse Click \n");
    }

    if (wParam == WM_MBUTTONDOWN) {
        printf("[ # ] Middle Mouse Click \n");
    }

    // Moving to the next hook in the hook chain
    return CallNextHookEx(NULL, nCode, wParam, lParam);
}



BOOL MouseClicksLogger(){

    MSG         Msg         = { 0 };

    // Installing hook
    HHOOK hMouseHook = SetWindowsHookExW(
        WH_MOUSE_LL,
        (HOOKPROC)HookCallback,
        NULL,
        NULL
    );
    if (!hMouseHook) {
        printf("[!] SetWindowsHookExW Failed With Error : %d \n",
GetLastError());
        return FALSE;
    }

    // Process unhandled events
    while (GetMessageW(&Msg, NULL, NULL, NULL)) {
        DefWindowProcW(Msg.hwnd, Msg.message, Msg.wParam, Msg.lParam);
    }

    return TRUE;
}



int main() {

    HANDLE hThread = CreateThread(NULL, NULL,
(LPTHREAD_START_ROUTINE)MouseClicksLogger, NULL, NULL, NULL);
    if (hThread)
        WaitForSingleObject(hThread, 10000); // Monitor mouse clicks for 10
seconds

    return 0;
}
```

Removing Hooks

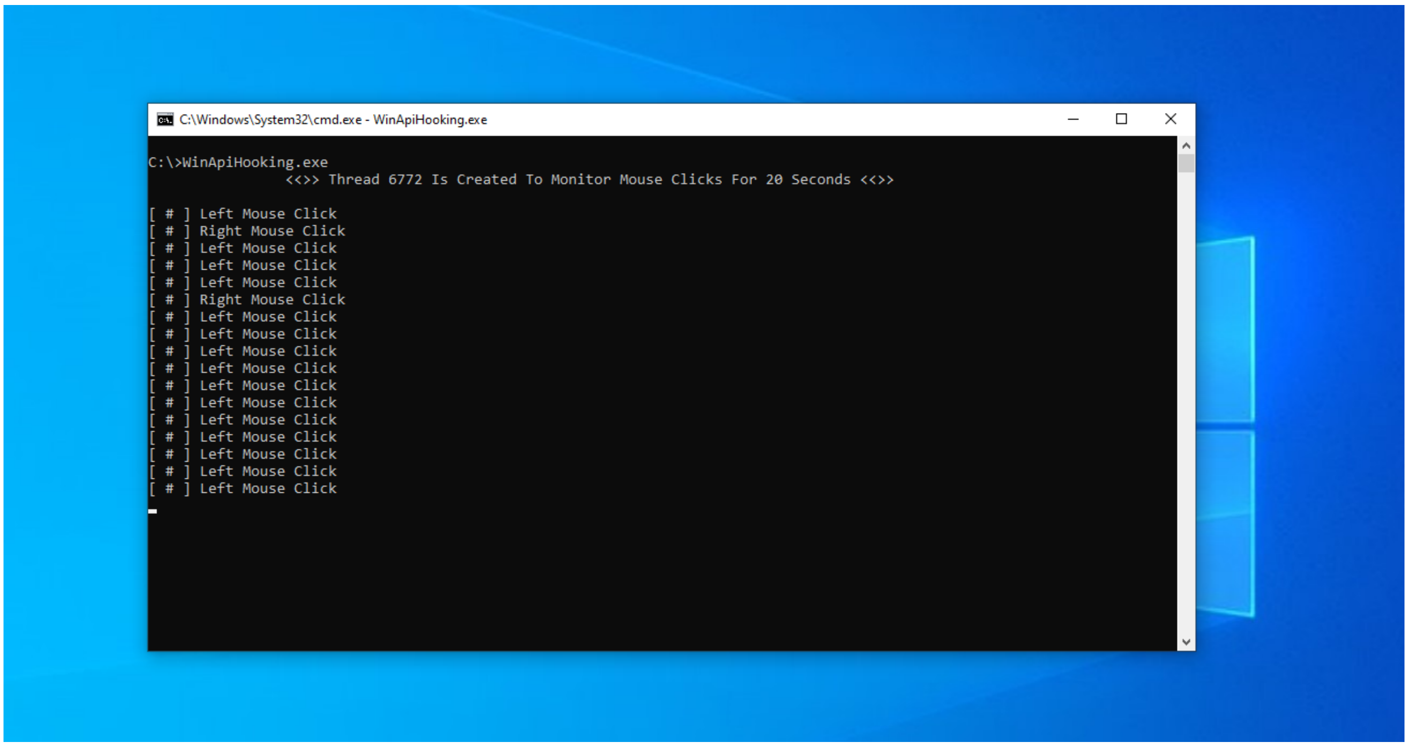
To remove any hook installed by the `SetWindowsHookEx` function, the UnhookWindowsHookEx WinAPI must be called. `UnhookWindowsHookEx` only takes a handle to the hook to be removed.

SetWindowsHookEx Hooking Code

The code snippet below puts everything discussed in this module to perform hooking on mouse click events and then removes the hook.

```
// Global hook handle variable
HHOOK g_hMouseHook      = NULL;


// The callback function that will be executed whenever the user clicked a
mouse button
LRESULT HookCallback(int nCode, WPARAM wParam, LPARAM lParam){

    if (wParam == WM_LBUTTONDOWN){
        printf("[ # ] Left Mouse Click \n");
    }

    if (wParam == WM_RBUTTONDOWN) {
        printf("[ # ] Right Mouse Click \n");
    }

    if (wParam == WM_MBUTTONDOWN) {
        printf("[ # ] Middle Mouse Click \n");
    }

    // Moving to the next hook in the hook chain
    return CallNextHookEx(NULL, nCode, wParam, lParam);
}


BOOL MouseClicksLogger(){

    MSG         Msg         = { 0 };

    // Installing hook
    g_hMouseHook = SetWindowsHookExW(
        WH_MOUSE_LL,
        (HOOKPROC)HookCallback,
        NULL,
        NULL
    );
    if (!g_hMouseHook) {
        printf("[!] SetWindowsHookExW Failed With Error : %d \n",
GetLastError());
        return FALSE;
    }

    // Process unhandled events
    while (GetMessageW(&Msg, NULL, NULL, NULL)) {
        DefWindowProcW(Msg.hwnd, Msg.message, Msg.wParam, Msg.lParam);
    }

    return TRUE;
}


int main() {

    HANDLE hThread = CreateThread(NULL, NULL,
(LPTHREAD_START_ROUTINE)MouseClicksLogger, NULL, NULL, NULL);
    if (hThread)
        WaitForSingleObject(hThread, 10000); // Monitor mouse clicks for 10
seconds

    // Unhooking
    if (g_hMouseHook && !UnhookWindowsHookEx(g_hMouseHook)) {
        printf("[!] UnhookWindowsHookEx Failed With Error : %d \n",
GetLastError());
    }
    return 0;
}
```

Demo



```
C:\>WinApiHooking.exe
                <<>> Thread 6772 Is Created To Monitor Mouse Clicks For 20 Seconds <<>>

[ # ] Left Mouse Click
[ # ] Right Mouse Click
[ # ] Left Mouse Click
[ # ] Left Mouse Click
[ # ] Left Mouse Click
[ # ] Right Mouse Click
[ # ] Left Mouse Click
[ # ] Left Mouse Click
[ # ] Left Mouse Click
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```