Reverse Engineering Challenges Documentation for Hexacon 2023

Windows Challenge

Linux Challenge

Windows Challenge

In this challenge, we are presented with a Windows executable.
The goal in this challenge is to decrypt the flag that we will find inside the executable.

Description for the players:

- This challenge consists of a flag checker that takes a flag as input and uses internal checks to validate it.

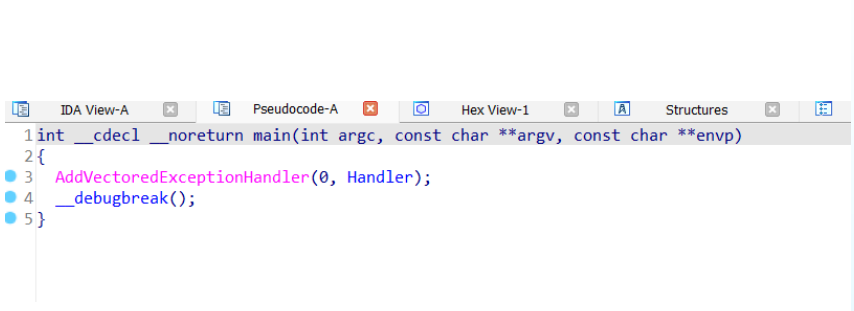
Flag: FLAG{upNwCXbxOtlDOybElsWEHJixsmgoreOznusN0}
Difficulty: Medium
Needed Software: A Windows debugger(IDA preferably) and VS code

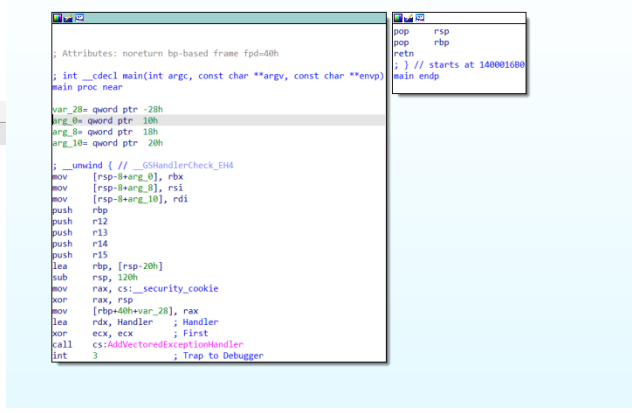
Solution:

We start by running the program. At first, it waited for an input, and after we gave it a random one it gave us a message that indicated that our input was wrong.

```
C:\Users\arfao\OneDrive\Desktop\work\Yogosha\Hexacon\Windows_chall>.\Windows_chall.exe
Welcome to my flag checking tool
Give me the flag and i will check if it's correct or not
adsdad
Wrong, try again.
```

So we dig right into Dynamic analysis using IDA:





Using Ida we notice something weird the program has only a few instructions and it ends with an int3 instruction which is used to make a software breakpoint.

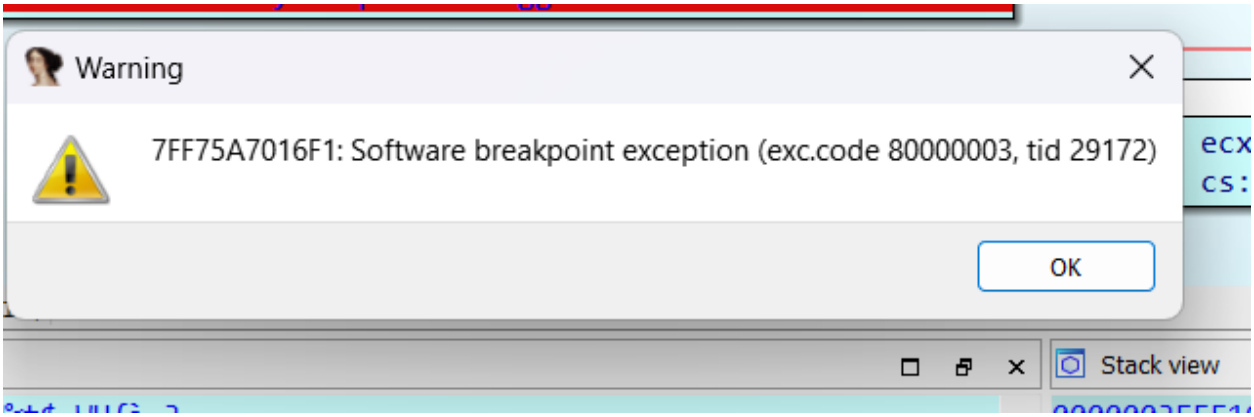
```
.text:00000001400016DE                mov     [rbp+40h+var_28], rax
.text:00000001400016E2                lea     rdx, Handle     ; Handler
.text:00000001400016E9                xor     ecx, ecx        ; First
.text:00000001400016EB                call    cs:AddVectoredExceptionHandler
.text:00000001400016F1                int     3               ; Trap to Debugger
.text:00000001400016F2 ; ---------------------------------------------------------------------------
.text:00000001400016F2                lea     rcx, Handle     ; Handle
.text:00000001400016F9                call    cs:RemoveVectoredExceptionHandler
.text:00000001400016FF                call    cs:IsDebuggerPresent
.text:0000000140001705                test    eax, eax
.text:0000000140001707                jz      short loc_140001712
.text:0000000140001709                xor     ecx, ecx        ; Code
.text:000000014000170B                call    cs:__imp_exit
.text:000000014000170B ; ---------------------------------------------------------------------------
.text:0000000140001711                db 0CCh ; Ì
.text:0000000140001712 ; ---------------------------------------------------------------------------
.text:0000000140001712
.text:0000000140001712 loc_140001712:                         ; CODE XREF: main+57↑j
.text:0000000140001712                mov     rax, gs:58h
.text:000000014000171B                mov     rdi, [rax]
.text:000000014000171E                mov     ecx, 1D8h
.text:0000000140001723                mov     eax, [rcx+rdi]
```

Changing to text view we find the rest of the program but according to IDA execution flow the program will never go there so it must be some kind of protection.

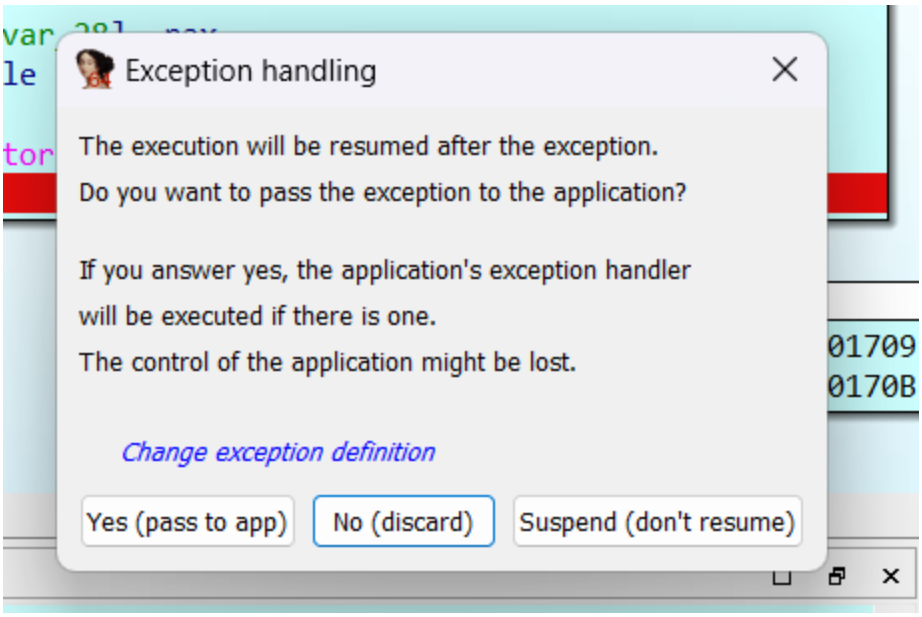
So now we go to debugging so we can understand more:

```
.text:00007FF75A7016D4 mov     rax, cs:__security_cookie
.text:00007FF75A7016DB xor     rax, rsp
.text:00007FF75A7016DE mov     [rbp+40h+var_28], rax
.text:00007FF75A7016E2 lea     rdx, Handle     ; Handler
.text:00007FF75A7016E9 xor     ecx, ecx        ; First
.text:00007FF75A7016EB call    cs:AddVectoredExceptionHandler
.text:00007FF75A7016F1 int     3               ; Trap to Debugger
```

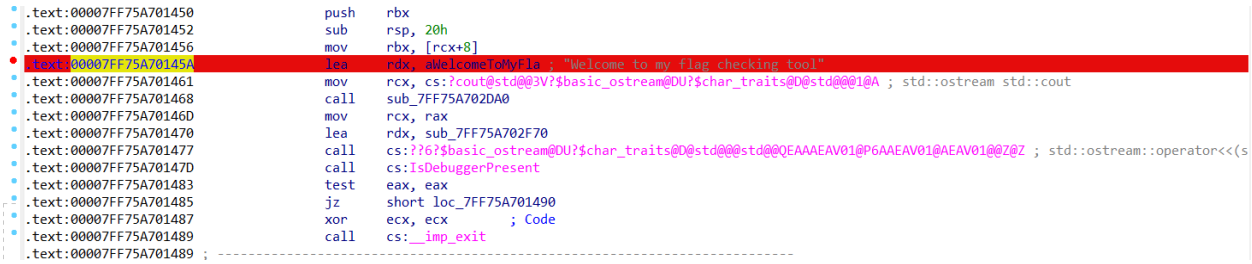
We've set a breakpoint at the int3 now we are going to follow along



After executing the int3 instruction an exception is invoked.

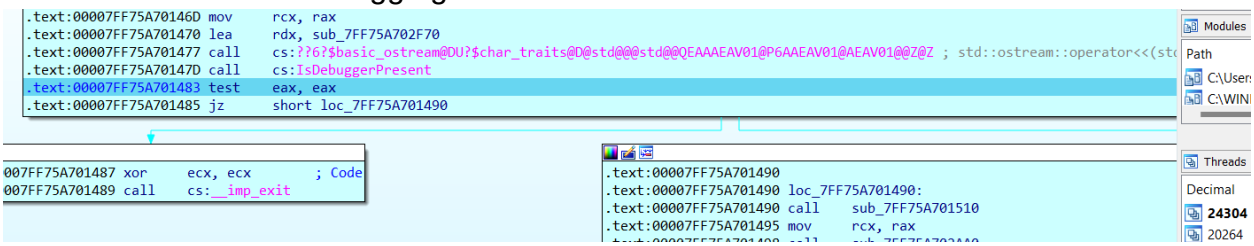


We let the program handle the exception. And when we do that the app terminates so it must continue executing without doing anything so the solution we try to breakpoint before every exit we find.
After trying it out we find that this is the function that handles the exception:



It also has the message that prints out at the beginning.

So now we continue debugging:



We run into our first anti-debugging technique but it's quite easy it calls the IsDebuggerPresent function and compares the result so an easy bypass is to zero the EAX register so we can pass the if statement

SO continuing debugging we notice that the function doesn't do anything besides taking us in a loophole so the best fix is to change the int3 with nop instruction so the exception doesn't happen and the program continues normally.

```
6DB5716E2                lea     rdx, Handle     ; Handler
6DB5716E9                xor     ecx, ecx        ; First
6DB5716EB                call    cs:AddVectoredExceptionHandler
6DB5716F1                nop
6DB5716F2                lea     rcx, Handle     ; Handle
6DB5716F9                call    cs:RemoveVectoredExceptionHandler
6DB5716FF                call    cs:IsDebuggerPresent
6DB571705                test    eax, eax
6DB571707                jz      short loc_7FF6DB571712
6DB571709                xor     ecx, ecx        ; Code
6DB57170B                call    cs:__imp_exit
```

Now moving on we can see that the program is checking for a file existence:

```
.text:00007FF6DB57177C xor     byte ptr [rbx+6], 17h
.text:00007FF6DB571780 xor     byte ptr [rbx+7], 0D5h
.text:00007FF6DB571784 xor     byte ptr [rbx+8], 0E5h
.text:00007FF6DB571788 xor     byte ptr [rbx+9], 13h
.text:00007FF6DB57178C xor     byte ptr [rbx+0Ah], 7Dh
.text:00007FF6DB571790 xor     byte ptr [rbx+0Bh], 9Dh
.text:00007FF6DB571794 xor     byte ptr [rbx+0Ch], 77h
.text:00007FF6DB571798 mov     byte ptr [rbx+0Dh], 0
.text:00007FF6DB57179C
.text:00007FF6DB57179C loc_7FF6DB57179C:                       ; CODE XREF: main+B3↑j
.text:00007FF6DB57179C lea     rdx, [rbp+40h+var_C0]           ; Stat
.text:00007FF6DB5717A0 mov     rcx, rbx                        ; FileName
.text:00007FF6DB5717A3 call    cs:_stat64i32
.text:00007FF6DB5717A9 test    eax, eax
.text:00007FF6DB5717AB jnz     loc_7FF6DB5719AC
.text:00007FF6DB5717B1 mov     ecx, 539h                       ; Seed
.text:00007FF6DB5717B6 call    cs:srand
.text:00007FF6DB5717BC movdqa  xmm0, cs:xmmword_7FF6DB575770
.text:00007FF6DB5717C4 movdqa  [rsp+140h+var_120], xmm0
```

A simple bypass is to change the register before the if statement.

Now everything is clear we can use the decompiler to see the code:

```
for ( i = v10; ; ++i )
{
  v15 = &v29;
  if ( v9 )
  {
    do
      ++v15;
    while ( *v15 );
  }
  if ( v12 >= (int)((_DWORD)v15 - (unsigned int)&v29) )
    break;
  if ( IsDebuggerPresent() )
    goto LABEL_38;
  *i = (unsigned __int8)*v13 + (~(unsigned __int8)*(v13 - 1) << 8);
  v12 += 2;
  v13 += 2;
}
v16 = v25;
v17 = (char *)v10 - (char *)v25;
while ( 1 )
{
  v18 = &v29;
  if ( v9 )
  {
    do
      ++v18;
    while ( *v18 );
  }
  if ( v11 >= (int)((_DWORD)v18 - (unsigned int)&v29) / 2 )
    break;
```

At first, it loads a vector with some values we can get from debugging and then checks the length which is 43 and the remaining is to to decipher this code:

cipher[j] = (~(flag[i]) << 8) + flag[i + 1];

This is a simple script that does it:

```
enc = [-18100,-16825,-31627,-28850,-30653,-22686,-30897,-29844,-17585,-
31134,-17812,-29609,-17848,-19095,-30861,-28057,-28558,-26033,-31378,-
30093,-20176,-32256]
flag1=""
c = 0
for i in range(len(enc)):
    flag1+=chr(enc[i] & 0xFF)
    enc[i]=enc[i]-(enc[i] & 0xFF)
flag2=""
c=0
for i in range(len(enc)):
    flag2+= chr((~(enc[i]))>>8)
    c+=2
```

```
flag=""
for i in range(len(flag1)):
    flag+=flag2[i]+flag1[i]
print(flag)
```

Linux Challenge

The first layer of protection involves an obfuscated loader. The challenge lies in deciphering the code, which is not clear until execution time. Once you've uncovered the code, your task is to generate a flag based on the conditions specified within it.

Description for the players:

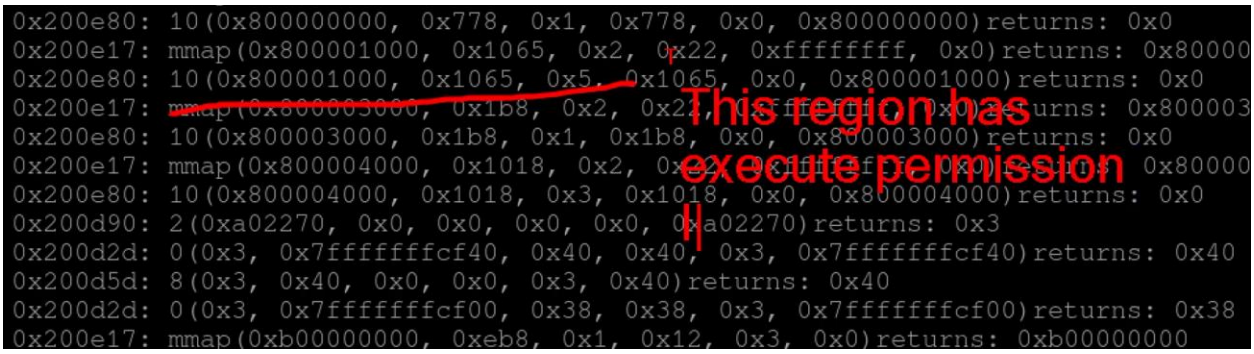
- This challenge is a keygen where you need to generate a flag that satisfies certain conditions. The binary is protected.

Flag: FLAG{DC_I_th1nk_y0u_mad3_4_B1G_mil3ston3_R3V3RS3R_K33p_G01ng}
Difficulty: Hard
Needed Software: A Linux debugger(IDA preferably) and VS code and intel pintool

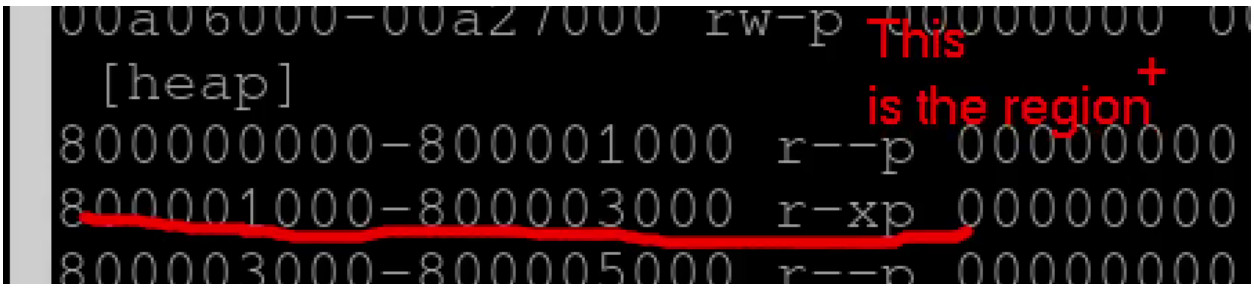
Solution:
this challenge consists of two main part the first is the loader bypass:

the first thing to do to bypass the loader is to disable aslr in your system.
then you need strace the binary to trace system calls because there is heavy use of mmap indicating some kind of unpacker used.
Using intelpintool:

This is the dump file of strace
Know we look for the executable part



So the solution here is to dump that memory region at runtime after the program has done unpacking:
We run the binary and we cat the code:



After we dump we will have a normal binary readable by IDA

```
    && dest[30] + *dest == 183
    && dest[30] + dest[27] + 1337 + dest[34] == 1608
    && dest[31] + 2 * dest[34] - dest[32] - dest[33] == -3
    && dest[10] == dest[14]
    && dest[2] + dest[35] + 1337 + dest[33] == 1637
    && dest[37] - dest[2] == -44
    && dest[36] + dest[15] + 1337 + *dest == 1596
    && dest[37] + dest[36] + 1337 * dest[2] == 127148
    && dest[34] == dest[39]
    && dest[14] == dest[19]
    && dest[37] + dest[34] - dest[38] == 16
    && 2 * dest[39] + dest[36] == 184
    && (dest[40] ^ (dest[39] >> 1) & (2 * dest[38])) != (dest[1] == 25)
    && dest[39] + 2 * dest[41] - dest[40] - dest[43] == 53
    && dest[45] + dest[42] + 1337 * dest[37] == 68313
    && dest[41] == 83
    && dest[46] == 51
    && dest[19] == dest[21]
    && dest[55] == 125
    && (char)(dest[39] ^ dest[27] ^ dest[18] ^ dest[21] ^ dest[52] ^ dest[31] ^ dest[25] ^ dest[14] ^ dest[49]) != (dest[53] == 66)
    && dest[55] - dest[47] == 74
    && dest[45] == 75
    && dest[21] == dest[25]
    && (dest[49] ^ (dest[48] >> 1) & (2 * dest[46])) != (dest[47] == 76)
    && ~(49374 * dest[48]) + dest[55] == -5529764
    && dest[49] + 2 * dest[51] - dest[50] - dest[53] == 10
    && dest[54] + dest[55] - dest[52] == 179
    && 2 * dest[55] + dest[52] == 299
    && dest[25] == dest[35]
    && dest[54] + dest[46] + 1337 * dest[51] == 64330
    && dest[53] + dest[55] + 1337 + *dest == 1640 )
```

We can see now all the conditions with IDA know using Z3 we write a solution (in the files you will find the solver.py)