GAME: Evolva
Protection: Laserlock
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<u>You will need:</u>
- Windows XP VM (I used VMware)
- x64dbg (x32dbg)
- Python 3
- Original game disc (you need the ORIGINAL, otherwise this will not work)

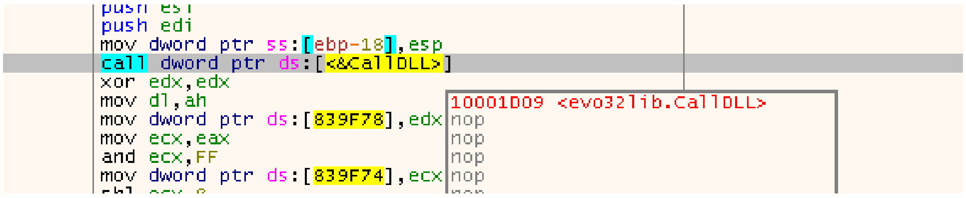
<u>Before you start:</u>
Laserlock was a widely used copy-protection scheme during the late 1990s and early 2000s.
The way it works is simple: some API calls will be replaced with a call to a function located in a DLL that is called like [gamearchlib].dll (in our case it is evo32lib.dll), that will retrieve the real API address, by checking the address where the call originated from.
To defeat this protection, we will need to obtain all the correct API addresses used by the game and replace all the calls to the Laserlock DLL inside the game's binary. Unfortunately, this is made a bit complicated due to numerous CRC checks in this library.

<u>Let's begin:</u>
Install the game and load Evolva.exe into the debugger (make sure to keep the original disc in the drive), click RUN and the game should start just like usually: there isn't any anti-debugging checks in place.

Reload the debugger. Once at the entry point of the module, you will see this:

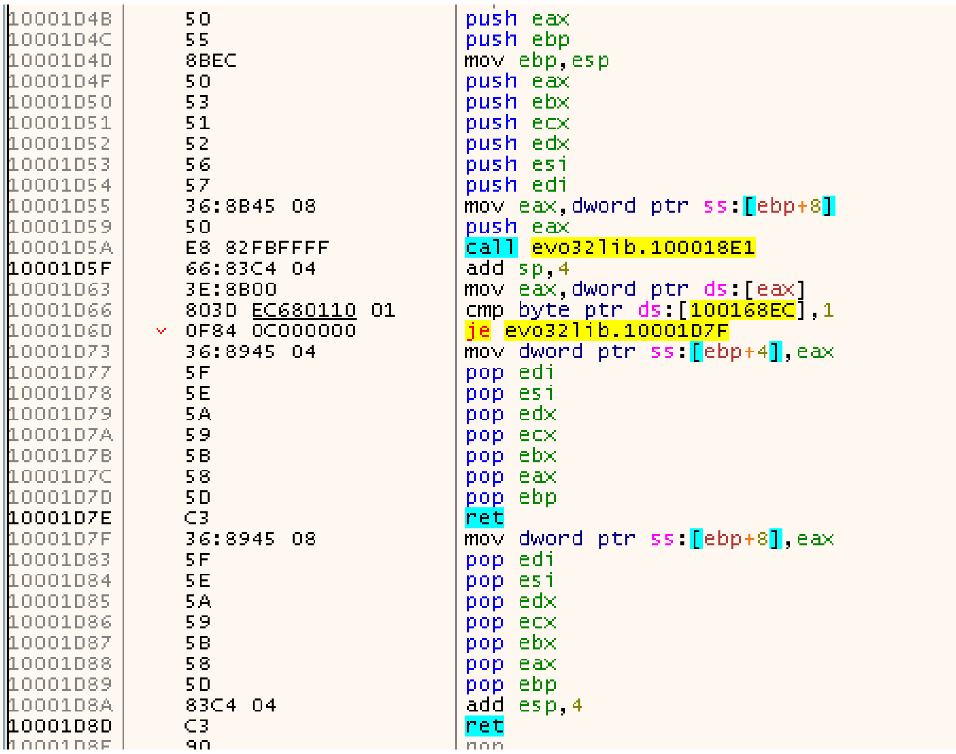
```
 .  55                  push ebp                              Entry
 .  8BEC                mov ebp,esp
 .  6A FF               push FFFFFFFF
 .  68 F8827800         push evolva.7882F8
 .  68 60B17000         push evolva.70B160
 .  64:A1 00000000      mov eax,dword ptr fs:[0]
 .  50                  push eax
 .  64:8925 00000000    mov dword ptr fs:[0],esp
 .  83EC 58             sub esp,58
 .  53                  push ebx                              ebx:&
 .  56                  push esi
 .  57                  push edi
 .  8965 E8             mov dword ptr ss:[ebp-18],esp
 .  FF15 F8D57E00       call dword ptr ds:[<&CallDLL>]
 .  33D2                xor edx,edx
 .  8AD4                mov dl,ah
```

The first call is very suspicious: it would have been reasonable to expect a call to GetVersion, but instead we have a call to a function called CallDLL in the evo32lib.dll library:



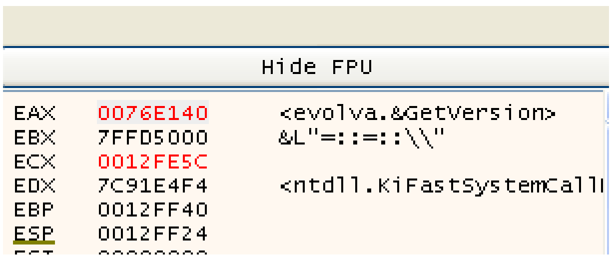
```
push esi
push edi
mov dword ptr ss:[ebp-18],esp
call dword ptr ds:[<&CallDLL>]
xor edx,edx
mov dl,ah
mov dword ptr ds:[839F78],edx
mov ecx,eax
and ecx,FF
mov dword ptr ds:[839F74],ecx

10001D09 <evo32lib.CallDLL>
nop
nop
nop
nop
```

Let’s try to proceed by stepping within the disassembly and by entering into the call to check what's happening there.
After some NOPs we'll get to the interesting part:



```
10001D4B  50              push eax
10001D4C  55              push ebp
10001D4D  8BEC            mov ebp,esp
10001D4F  50              push eax
10001D50  53              push ebx
10001D51  51              push ecx
10001D52  52              push edx
10001D53  56              push esi
10001D54  57              push edi
10001D55  36:8B45 08      mov eax,dword ptr ss:[ebp+8]
10001D59  50              push eax
10001D5A  E8 82FBFFFF     call evo32lib.100018E1
10001D5F  66:83C4 04      add sp,4
10001D63  3E:8B00         mov eax,dword ptr ds:[eax]
10001D66  803D EC680110 01  cmp byte ptr ds:[100168EC],1
10001D6D  0F84 0C000000   je evo32lib.10001D7F
10001D73  36:8945 04      mov dword ptr ss:[ebp+4],eax
10001D77  5F              pop edi
10001D78  5E              pop esi
10001D79  5A              pop edx
10001D7A  59              pop ecx
10001D7B  5B              pop ebx
10001D7C  58              pop eax
10001D7D  5D              pop ebp
10001D7E  C3              ret
10001D7F  36:8945 08      mov dword ptr ss:[ebp+8],eax
10001D83  5F              pop edi
10001D84  5E              pop esi
10001D85  5A              pop edx
10001D86  59              pop ecx
10001D87  5B              pop ebx
10001D88  58              pop eax
10001D89  5D              pop ebp
10001D8A  83C4 04         add esp,4
10001D8D  C3              ret
```

Let’s keep stepping until we reach the instruction right after the call located at 0x10001D5A. Now check the return value stored in the EAX register:

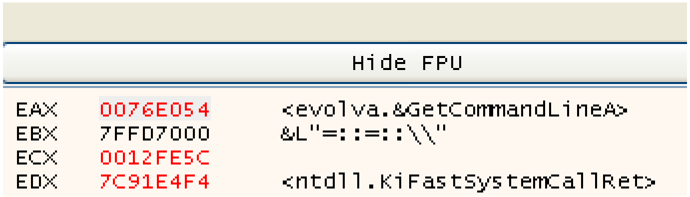


```
Hide FPU
EAX 0076E140  <evolva.&GetVersion>
EBX 7FFD5000  &L"=::=::\\"
ECX 0012FE5C
EDX 7C91E4F4  <ntdll.KiFastSystemCallR
EBP 0012FF40
ESP 0012FF24
```

As expected, this call was originally a GetVersion call 😊

If we continue stepping, we will notice that the conditional jump located at 0x10001D6D will not be taken, and the function will end at the RET located at 0x10001D7E. Afterwards GetVersion will be called (directly from the RET, since its address was moved on the stack)

We still don't know the meaning of that conditional jump, but we will be back to this soon.
When we will be back at the main module, we can continue stepping over all the instructions until we can follow the second call to CallDLL.
Again, let's keep stepping over all the instructions until we reach the one just right after the call located at 0x10001D5A. Then check the EAX register, again:



Now it is quite clear what's happening: these APIs, called by the game, were all replaced with the same function called CallDLL located in the evo32lib.dll. The CallDLL function will check from where the call was originated and will provide the correct API address needed by the game, which will then be executed using the RET instruction (because that address was moved on the stack at the right position).

The first thing that would come to our minds is to find some free space to write a simple assembly routine to parse the .text segment finding all the calls to CallDLL, jumping into each of them and once we retrieved the correct API address (stored in EAX), patch the code to jump back to our assembly routine and finally fix the initial call with the correct address.
Unfortunately, this will not work...

Let's try to put breakpoint at 0x10001D5F (right after the call that retrieves the correct API address), click RUN on the debugger each time it will break at that address and after a couple of iterations, the game will crash...

Why? Because Laserlock will do some CRC checks on the game's binary in memory, and if it will notice any modification (like patches, hooks and software breakpoints) it will return wrong API addresses.

We can use hardware breakpoints (even if it only is possible to use at max 4 of them at the same time. They don't alter the code at all, so they will not be detected!) to break at the right address and to fix the calls to make them point to the right functions, but there is another problem:

Laserlock will also check the .text segment and if any patch is detected (like, obviously our patched bytes needed to fix the calls) the result will be a game crash.

Let's take a moment to assess the overall situation:

1) We know that the original API calls were all replaced with the same function called CallDLL inside the Laserlock DLL
2) We know that CallDLL, after its checks, will retrieve the correct API based on the address where the original call originated from (this value is retrieved from the stack).
3) The CallDLL code is checked against any modification.
4) The .text segment code is also checked against any modification preventing us to fix the calls by patching them.
5) Due to 3) and 4), we CAN'T use software breakpoints and we CAN'T patch anything.
6) We still don't know what's the purpose of the conditional jump that takes place just after the call that retrieves the original API addresses

This situation is a bit complex, huh? Welcome to the reverse engineering world 😛

Let's start from point number 6: once we will understand what's going on there, we can think of a way to solve everything else.

The most practical method to figure out the difference between these two RETs, is to put a hardware breakpoint on the address of the last one (0x10001D8D):

```
10001D8A    83C4 04        add esp,4
10001D8D    C3             ret
10001D8E    90             nop
10001D8F    90             nop
```

Once the execution will break, continue by stepping inside the API code until the return to the main module is reached. Once there, scroll up a few lines above and you will notice that the call to CallDLL has been modified (at 0x6E9764):

```
006E9761    8943 38        mov dword ptr ds:[ebx+38],eax
006E9764    E8 47430400    call <JMP.&GetFileVersionInfoA>
006E9769    85C0           test eax,eax
006E976B  v 75 0E          jne evolva.6E977B
```

It isn't the usual call, indeed if we follow it, we will find this:

```
0072DAB0  v FF25 B4E27600  jmp dword ptr ds:[<&GetFileVersionInfoA>]
```

Let's restart the debugger and go straight to that address, we will see:

```
0072DAB0    FF15 F8D57E00  call dword ptr ds:[<&CallDLL>]
```

During the execution, that call turned into a jump.

What does this mean? The conditional jump we were analysing decides whether the current API must be reached via a call or a jump!

We need to pay attention to this behaviour, because when we will fix all the calls, the ones that will take this conditional jump, needs to be turned into jumps!

We now have everything we need to know. Keep in mind that we CANNOT patch anything and we CANNOT use software breakpoints. Instead, we will use hardware breakpoints in a creative way. We will log the address of the correct API, the address where the call originated from and the boolean value that decides whether the current API should be reached by a call or by a jump. Next, we will write a little Python script that will patch the binary, removing Laserlock.

This is what we will do:

1) We will write some assembly code to parse the .text segment, looking for all the calls to fix
2) Once we will find a call to CallDLL we will jump at that address
3) We will set the first hardware breakpoint at 0x10001D5F (right after the call that will retrieve the correct API, inside the CallDLL function), in order to get a log of the data that we need to fix the call later.
4) We will set the second hardware breakpoint on the first RET, in order to alter the execution flow to jump back to our assembly code
5) We will set the third hardware breakpoint on the second RET, in order to alter the execution flow to jump back to our assembly code (remember that if this RET is executed, the API will be reached from a JMP)
6) Once we will have all the needed data logged, using some Python code we will “cold-patch” the game’s executable. Finally, we can remove the evo32lib.dll dependency from the EXE file.

The first thing to do is to look for some free space where we can put our assembly code. I’ve found a nice code cave starting from 0x350000. Let’s click on the Memory Map tab, select the right entry (the one that starts from 0x350000) and right-click and select “Set Page Memory Rights”. Then select FULL ACCESS and click on Set Rights.
Let’s return to the CPU View Tab, go to 0x350000, and carefully write this code:

```
00350000   B9 00104000      mov ecx,evolva.401000
00350005   8139 FF15F8D5    cmp dword ptr ds:[ecx],D5F815FF
0035000B   75 0E            jne 35001B
0035000D   890D 50003500    mov dword ptr ds:[350050],ecx
00350013   FFE1             jmp ecx
00350015   8B0D 50003500    mov ecx,dword ptr ds:[350050]
0035001B   41               inc ecx
0035001C   81F9 00E07600    cmp ecx,<evolva.&?Xm_New@@YAPAVXM_HANDLE@@XZ>
00350022   75 E1            jne 350005
00350024   90               nop
00350025   0000             add byte ptr ds:[eax],al
```

The first line stores the starting address of the .text segment in the ecx register.
The CMP opcode checks if the dword pointed to by the address currently stored in ecx is a CallDLL call (if you pay attention to the bytes compared, you will notice that they are written in reverse, as the byte order is little endian). If there is no match, then ecx will be incremented by 1 in order to point to the next address.

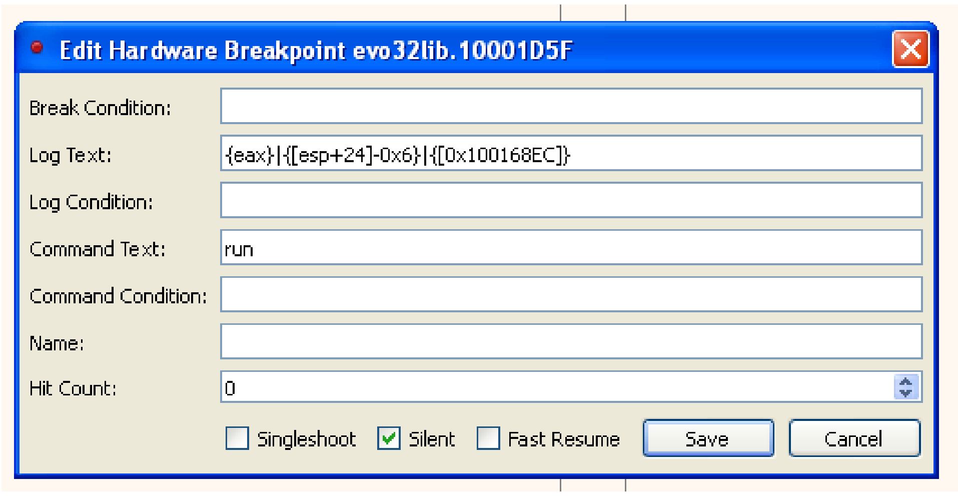
Then there's another CMP, to check if we arrived at the end of .text segment. If there is a match, and we are in front of a call to CallDLL, we will first store the current address in some free memory (I've chosen 0x350050) and then we will jump into it, with the jmp ecx located at 0x350013.
Once we will correctly set the hardware breakpoints inside CallDLL, we will jump back exactly at 0x350015 and we will restore the previously saved address in ecx in order to continue our parsing of the .text segment.
Let's right-click on 0x350000 and select Set New Origin Here, so we can tell the debugger that it has to start from this address when we will hit RUN. Let's put a breakpoint at 0x350024, so we can break here once all the APIs are logged. DO NOT USE int 3 here, otherwise the game will crash.

Before we launch our assembly code, we have to properly set the hardware breakpoints in CallDLL:

```
10001D4B   50                 push eax
10001D4C   55                 push ebp
10001D4D   8BEC               mov ebp,esp
10001D4F   50                 push eax
10001D50   53                 push ebx
10001D51   51                 push ecx
10001D52   52                 push edx
10001D53   56                 push esi
10001D54   57                 push edi
10001D55   36:8B45 08         mov eax,dword ptr ss:[ebp+8]
10001D59   50                 push eax
10001D5A   E8 82FBFFFF        call evo32lib.100018E1
10001D5F   66:83C4 04         add sp,4
10001D63   3E:8B00            mov eax,dword ptr ds:[eax]
10001D66   803D EC680110 01   cmp byte ptr ds:[100168EC],1
10001D6D   0F84 0C000000      je evo32lib.10001D7F
10001D73   36:8945 04         mov dword ptr ss:[ebp+4],eax
10001D77   5F                 pop edi
10001D78   5E                 pop esi
10001D79   5A                 pop edx
10001D7A   59                 pop ecx
10001D7B   5B                 pop ebx
10001D7C   58                 pop eax
10001D7D   5D                 pop ebp
10001D7E   C3                 ret
10001D7F   36:8945 08         mov dword ptr ss:[ebp+8],eax
10001D83   5F                 pop edi
10001D84   5E                 pop esi
10001D85   5A                 pop edx
10001D86   59                 pop ecx
10001D87   5B                 pop ebx
10001D88   58                 pop eax
10001D89   5D                 pop ebp
10001D8A   83C4 04            add esp,4
10001D8D   C3                 ret
```

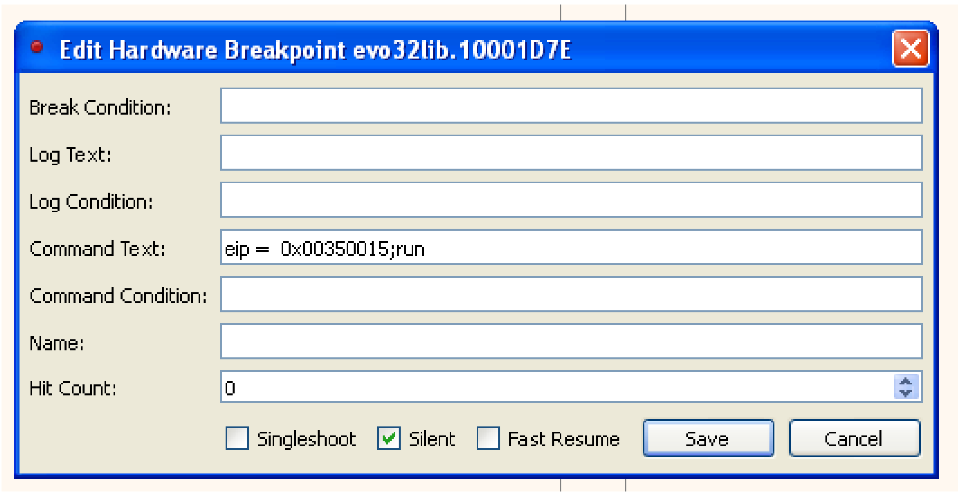
We have to set the first hardware breakpoint at 0x10001D5F in order to log the retrieved API, the address where the call was originated (located in the .text segment) from and the byte stored at 0x100168EC (which will tell us if the API should be reached from a call or a jump).

So, let's right-click that address and select Breakpoint->Set Hardware on Execution, then head over to the Breakpoint tab, right-click the newly created breakpoint and select Edit. Let's configure it this way in order to log all the data we need:

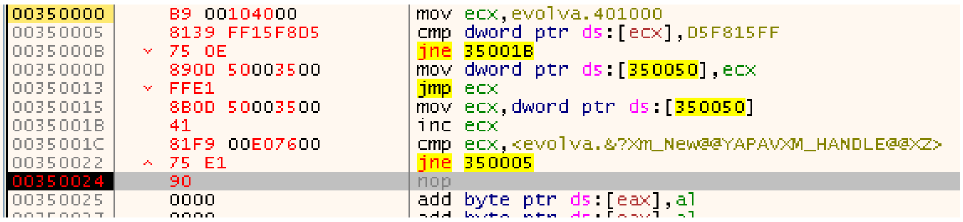


If you are wondering why 0x6 is subtracted from the return address remember that we need the address from which the call originated. In [ESP+24] the address of the next instruction AFTER the call is stored so we need to subtract 6 bytes in relation to this address in order to get the correct one we need. The call to CallDLL code is indeed 6 bytes long. The “run” command in Command Text is needed to automatically resume the execution after having logged the data we are looking for.

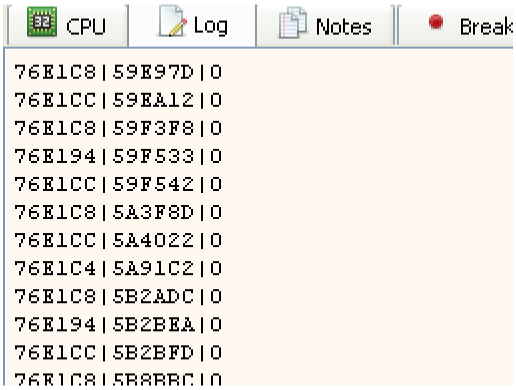
It's time to set the last two hardware breakpoints on the RET instructions respectively located at 0x10001D7E and 0x10001D8D. Since we want the execution flow to jump back to our assembly code, we need to configure both of them in this way:



We are ready to execute our code! Let's go to the 0x350000 address and click RUN. Once the execution is completed, we will be stopped at 0x350024:



Perfect, let's click on the Log tab and you will find all the calls to CallDLL logged there 😊



Let's copy all the entries into a new document called calls.txt, and we are finally ready to write a Python script to patch the executable.

This is the Python code that I’ve written for our purpose:

```python
class Patch:
    def __init__(self, api_addr, call_addr, is_jmp):
        self.api_addr = api_addr
        self.call_addr = call_addr
        self.is_jmp = is_jmp

    def get_api_addr(self):
        return self.api_addr

    def get_call_addr(self):
        return self.call_addr

    def is_jump(self):
        return self.is_jmp


def read_patches_from_file(file_path):
    f = open(file_path, 'r')
    lines = f.readlines()
    f.close()
    return lines


def parse_patches(txt_patches, imagebase):
    patches = []
    for txt_patch in txt_patches:
        patch_parts = txt_patch.split('|')
        patches.append(Patch(int(patch_parts[0], 16),
int(patch_parts[1], 16) - imagebase, bool(int(patch_parts[2]))))
    return patches


def apply_patches_to_file(file_path, patches):
    f = open(file_path, 'r+b')
    for patch in patches:
        f.seek(patch.get_call_addr() + 0x2)
        f.write(patch.get_api_addr().to_bytes(4, "little"))
        if(patch.is_jump()):
            f.seek(patch.get_call_addr() + 0x1)
            f.write(bytes([0x25]))
    f.close()



if __name__ == "__main__":
    txt_patches = read_patches_from_file('calls.txt')
    patches = parse_patches(txt_patches, 0x400000)
    apply_patches_to_file("Evolva.exe", patches)
```

Everything here is really simple: we will read all the data from calls.txt. Every single line will be split using '|' character as a separator, and every patch will be applied to the .text segment.
If the API should be reached by a jump, we will patch the corresponding byte turning that call in a jmp (by replacing the 0x15 opcode with 0x25).

Please keep in mind that we have to subtract the imagebase address (0x400000) from the address of the calls we will patch in order to obtain the corresponding file offset.
We can then load our new executable into the debugger and check it out:

```
0070B285  .  FF15 40E17600   call dword ptr ds:[<&GetVersion>]
0070B28B  .  33D2            xor edx,edx
0070B28D  .  8AD4            mov dl,ah
0070B28F  .  8915 789F8300   mov dword ptr ds:[839F78],edx
0070B295  .  8BC8            mov ecx,eax
0070B297  .  81E1 FF000000   and ecx,FF
0070B29D  .  890D 749F8300   mov dword ptr ds:[839F74],ecx
0070B2A3  .  C1E1 08         shl ecx,8
0070B2A6  .  03CA            add ecx,edx
0070B2A8  .  890D 709F8300   mov dword ptr ds:[839F70],ecx
0070B2AE  .  C1E8 10         shr eax,10
0070B2B1  .  A3 6C9F8300     mov dword ptr ds:[839F6C],eax
0070B2B6  .  33F6            xor esi,esi
0070B2B8  .  56              push esi
0070B2B9  .  E8 2DB10000     call evolva.7163EB
0070B2BE  .  59              pop ecx
0070B2BF  .  85C0            test eax,eax
0070B2C1  .v 75 08           jne evolva.70B2CB
0070B2C3  .  6A 1C           push 1C
0070B2C5  .  E8 B0000000     call evolva.70B37A
0070B2CA  .  59              pop ecx
0070B2CB  >  8975 FC         mov dword ptr ss:[ebp-4],esi
0070B2CE  .  E8 F2A40000     call evolva.7157C5
0070B2D3  .  FF15 54E07600   call dword ptr ds:[<&GetCommandLineA>]
```

Where the CallDLL calls used to be now there are the correct APIs.
Well done, you successfully removed Laserlock copy protection scheme from this executable 😊
However, the work isn't yet finished...

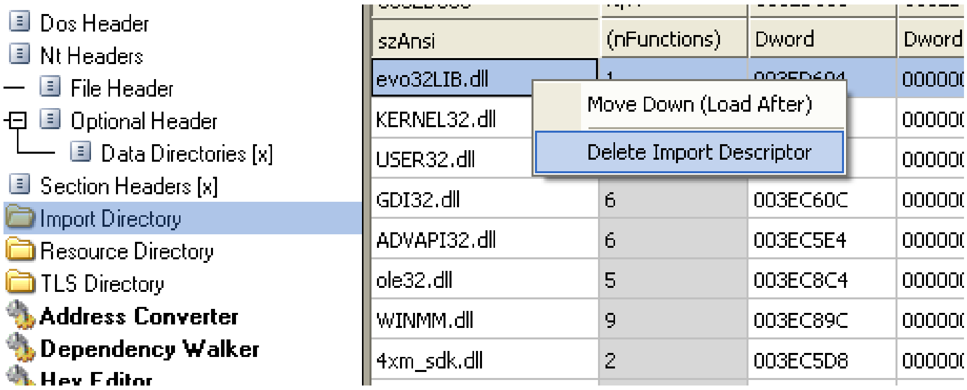
<u>Cutscenes fix:</u>
If you launch the game without the disc in the drive you will find that the initial cutscenes aren't played back. Well, if you carefully check the game's directory, you will find that they aren't there.

Let's put the original game disc into the drive and copy the FMV directory to the game installation folder. Then open the Registry Editor (cmd+r -> regedit [RETURN]) and edit the value of this key:
HKEY_LOCAL_MACHINE\SOFTWARE\Computer Artworks\Evolva\1.0\FMVDir
To: .\\FMV
Now the cutscenes will be loaded from the game's directory.

Removing the evo32lib.dll dependency:

Everything is working perfectly but our binary still depends on the evo32lib.dll library that was once needed by Laserlock. We don't need this dependency anymore.

Let's load Evolva.exe into CFF Explorer and then click on Import Directory. Now select evo32lib.dll and click on Delete Import Descriptor:



Let's save it and we will finally have a totally Laserlock-free binary 😊

Credits:

I'd like to thank m00k00 who helped my A LOT by reviewing this paper and correcting all the spelling and grammar errors! You are AWESOME!

Conclusion:

I hope that you liked this technical paper. Reversing these very old DRMs is quite fun and you learn a lot!

Luca