MODERN MALWARE:

OBFUSCATION AND EMULATION

DEF CON CHINA 1.0 (2019)

by Alexandre Borges

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Agenda:

- ❖ Introduction
- ❖ Anti-reversing
- ❖ METASM
- ❖ MIASM
- ❖ TRITON
- ❖ Radare2 + MIASM
- ❖ DTRACE on Windows
- ❖ Anti-VM
- ❖ Conclusion

INTRODUCTION

- ✓ Every single day we handle malware samples that use several known packers such as ASPack, Armadillo, Petite, FSG, UPX, MPRESS, NSPack, PECompact, WinUnpack and so on. For most of them, it is easy to write scripts to unpack them.

- ✓ We also know the main API functions, which are used to create and allocate memory such as:

  - ✓ VirtualAlloc/Ex( )
  - ✓ HeapCreate( ) / RtlCreateHeap( )
  - ✓ HeapReAlloc( )
  - ✓ GlobalAlloc( )
  - ✓ RtlAllocateHeap( )

- ✓ Additionally, we know how to unpack them using debuggers, breakpoints and dumping unpacked content from memory. Furthermore, pe-sieve from Hasherezade is excellent. ☺

- ✓ When we realize that the malware use some customized packing techniques, it is still possible to dump it from memory, fix the ImageAddress field using few lines in Python and its respective IAT using impscan plugin to analyze it in IDA Pro:

```
✓ export VOLATILITY_PROFILE=Win7SP1x86
✓ python vol.py -f memory.vmem procdump -p 2096 -D . --memory  (to keep slack space)
✓ python vol.py -f memory.vmem impscan --output=idc -p 2096
```

x64dbg script 1/3

```
//######################################################################
//  FileName      :  dumpexe.txt (first draft)
//  Comment       :  Dump memory segments containing executables
//  Author        :  Alexandre Borges
//  Date          :  today
//######################################################################

entry:

msg "Program to dump modules containing executables."
msg "You must be at EP before continuing"
bc                   // Clear existing breakpoints
bphwc                // Clear existing hardbreakpoints
bp VirtualAlloc      // Set up a breakpoint at VirtualAlloc
erun                 // run and pass all first exceptions to the application

core:

sti                  // Single-step
sti                  // Single-step
sti                  // Single-step
sti                  // Single-step
sti                  // Single-step
```

x64dbg script 2/3

```
find cip,"C2 1000“   // find the return point of VirtualAlloc
bp $result           // set a breakpoint
erun                 // run and pass all first exceptions to the application
cmp eax,0                       // test if eax (no allocated memory) is equal to zero
je pcode             // jump to pcode label
bpm eax,0,x          // set executable memory breakpoint and restore it once hit.
erun                 // run and pass all first exceptions to the application

//try to find if there is the “This program” string within the module’s memory.
findall $breakpointexceptionaddress,"546869732070726F6772616D”

cmp $result,0        // check if there isn’t any hit
je pcode             // jump to pcode label
$dumpaddr = mem.base($breakpointexceptionaddress)      //find the memory base.
$size = mem.size($breakpointexceptionaddress)          //find the size of memory base.
savedata :memdump:,$dumpaddr,$size                     //dump the segment.
msgyn "Memory dumped! Do you want continue?“           //show a dialog
cmp $result,1                                          //check your choice
je scode             // jump to scode label
bc                   // clear existing breakpoints
bphwc                // clear existing hardware breakpoints
ret                  // exit
```

x64dbg script 3/3

```
pcode:

msgyn "There isn't a PE file! Do you want continue?"
cmp $result,0                  // check if we don’t want continue
je final
sti                            //single step.
erun                           // run and pass all first exceptions to the application
jmp core                       // jump to core label

scode:

msg "Let's go to next dump“    // shows a message box
erun                           // run and pass all first exceptions to the application
jmp core                       // jump to core label

final:

bc                             // clear existing breakpoints
bphwc                          // clear existing hardware breakpoints
ret                            // exit
```

ANTI-REVERSING

- ✓ Obfuscation aims to protect software of being reversed, intellectual property and, in our case, malicious code too. ☺ Honestly, obfuscation does not really protect the program, but it can make the reverser's life harder than usual.

- ✓ Thus, at end, obfuscation buys time by enforcing reversers to spend resources and time to break a code.

- ✓ We see obfuscated code every single day when we analyze commom userland malware, droppers written in VBA and Powershell, so it mightn't seem to be a big deal.

- ✓ We can use IDA Pro SDK to write plugins to extend the IDA Pro functionalities, analyze some code and data flow and even automatizing unpacking of strange malicious files.

- ✓ Additionally, if you are facing problems to analyze a modified MBR, so you could even write a loader to load the MBR structure and analyze it in IDA Pro. ☺

- ✓ Unfortunately, there are packers and protectors such as VMprotect, Themida, Arxan and Agile .NET that use modern obfuscation techniques, so making the procedure of reversing a code very complicated.

- ✓ Most protectors have used with 64-bit code (and malware).

- ✓ Original IAT is removed from the original code (as usually applied by any packer). However, IAT from packers like Themida keeps only one function (TlsSetValue).

- ✓ Almost all of them provide string encryption.

- ✓ They protect and check the memory integrity. Thus, it is not possible to dump a clean executable from the memory (using Volatility, for example) because original instructions are not decoded in the memory.

- ✓ Instructions (x86/x64 code) are virtualized and transformed into virtual machine instructions (RISC instructions).

- ✓ .NET protectors rename classes, methods, fields and external references.

- ✓ Some packers can use instruction encryption on memory as additional memory layer.

- ✓ Obfuscation is stack based, so it is hard to handle virtualized code statically.

- ✓ Virtualized code is polymorphic, so there are many representations referring the same CPU instruction.

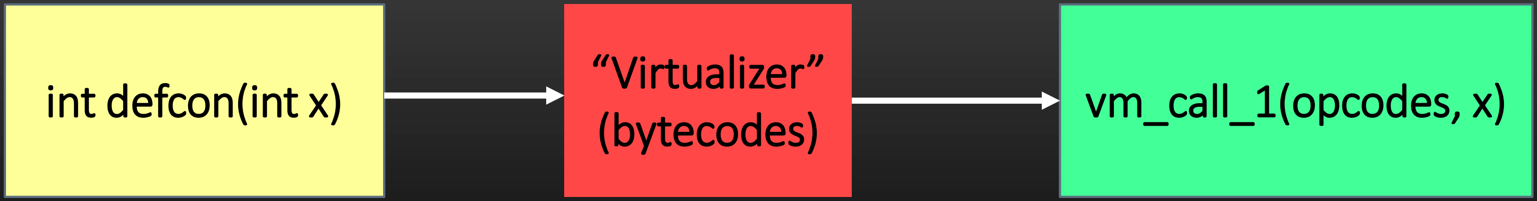
- ✓ There are also fake push instructions.

- ✓ There are many dead and useless codes.

- ✓ There is some code reordering using unconditional jumps.

- ✓ All obfuscators use code flattening.

- ✓ Packers have few anti-debugger and anti-vm tricks. However, few months ago, I saw a not so common anti-virtual machine trick based on temperature (more about it later).



Fetches bytes, decodes them to instructions and dispatches them to handlers

- ❖ Protectors using virtual machines introduces into the obfuscated code:

  - ✓ A context switch component, which “transfers” registry and flag information into VM context (virtual machine). The oposite movement is done later from VM machine and native (x86/x64) context (suitable to keep within C structures during unpacking process ☺)

  - ✓ This “transformation” from native register to virtualized registers can be one to one, but not always.

- ✓ Inside of the virtual machine, the cycle is:

  - ✓ fetch instruction
  - ✓ decode it
  - ✓ find the pointer to instruction and lookup the associate opcode in a handler table
  - ✓ call the target handler

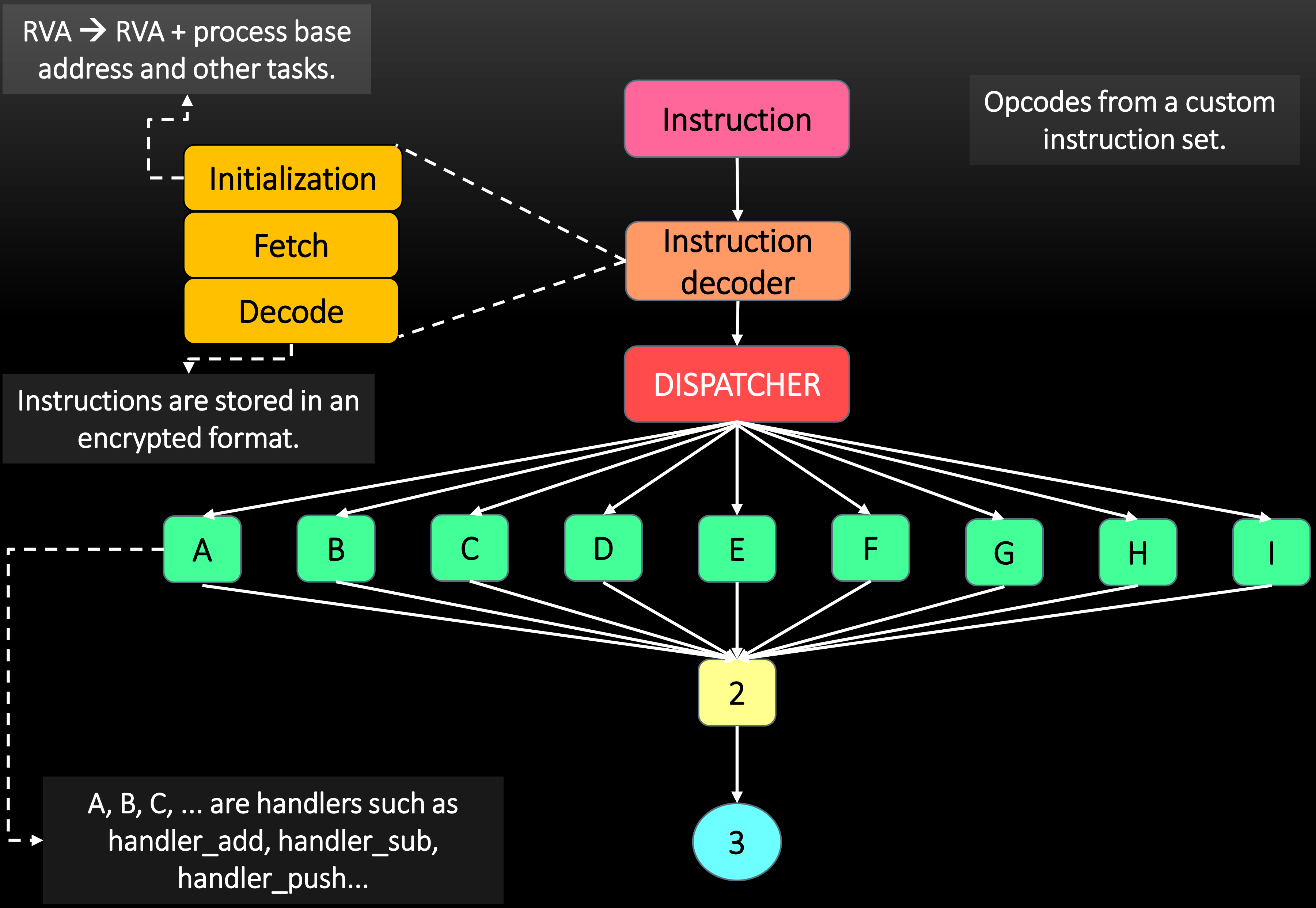
- ✓ Few interesting concepts:

  - ✓ Fetching: the instruction to be executed by Virtual Machine is fetched.

  - ✓ Decoding: the target x86 instruction is decoded using rules from Virtual Machine (remember: usually, the architecture is usually based on RISC instructions)

  - ✓ Dispatcher: Once the handler is determined, so jump to the suitable handler. Dispatchers could be made by a jump table or switch case structure.

  - ✓ Handler: In a nutshell, a handler is the implementation of the Virtual Machine instruction set.

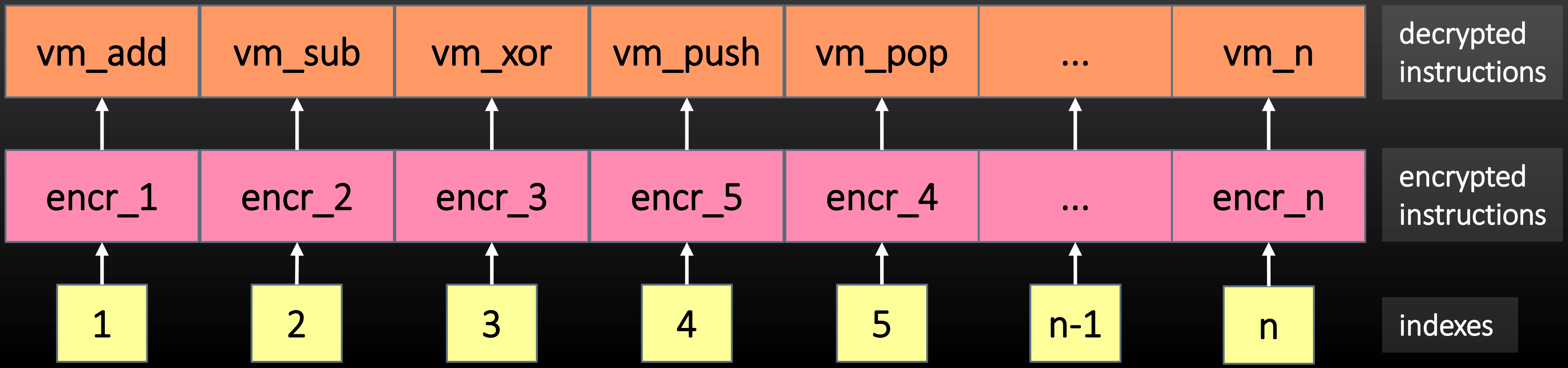


RVA → RVA + process base address and other tasks.

Opcodes from a custom instruction set.

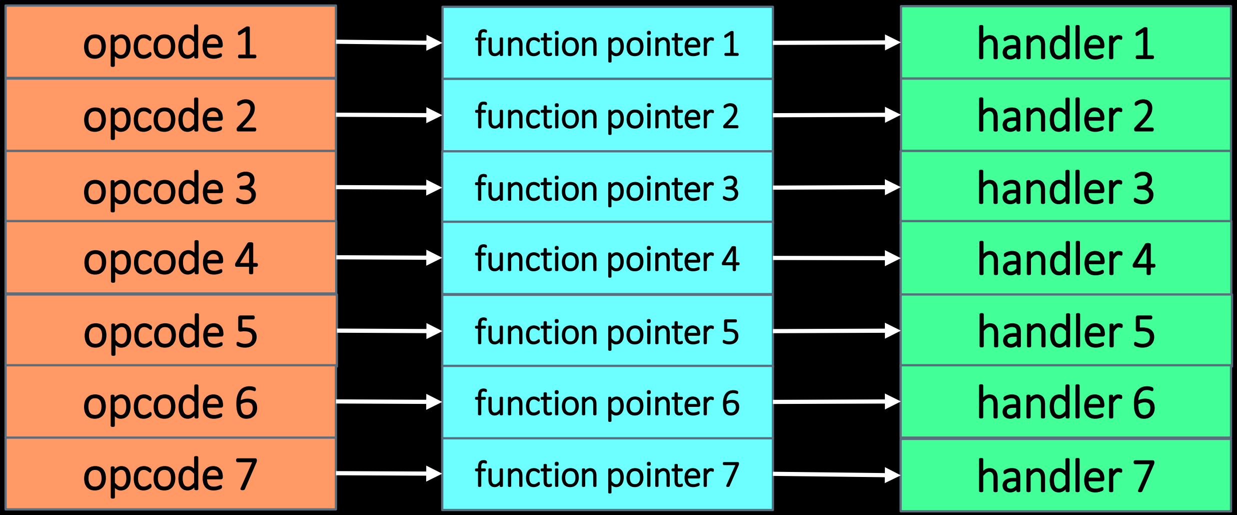
Instructions are stored in an encrypted format.

A, B, C, ... are handlers such as handler_add, handler_sub, handler_push...



vm_add	vm_sub	vm_xor	vm_push	vm_pop	...	vm_n	decrypted instructions
encr_1	encr_2	encr_3	encr_5	encr_4	...	encr_n	encrypted instructions
1	2	3	4	5	n-1	n	indexes

recovering and
decrypting funcions



opcode 1	function pointer 1	handler 1
opcode 2	function pointer 2	handler 2
opcode 3	function pointer 3	handler 3
opcode 4	function pointer 4	handler 4
opcode 5	function pointer 5	handler 5
opcode 6	function pointer 6	handler 6
opcode 7	function pointer 7	handler 7

function pointer table
(likely encrypted)

- ✓ Constant unfolding: technique used by obfuscators to replace a contant by a bunch of code that produces the same resulting constant's value.

- ✓ Pattern-based obfuscation: exchange of one instruction by a set of equivalent instructions.

- ✓ Abusing inline functions.

- ✓ Anti-VM techniques: prevents the malware sample to run inside a VM.

- ✓ Dead (garbage) code: this technique is implemented by inserting codes whose results will be overwritten in next lines of code or, worse, they won't be used anymore.

- ✓ Code duplication: different paths coming into the same destination (used by virtualization obfuscators).

- ✓ Control indirection 1: call instruction → stack pointer update → return skipping some junk code after the call instruction (RET x).

- ✓ Control indirection 2: malware trigger an exception → registered exception is called → new branch of instructions.

- ✓ Opaque predicate: Although apparently there is an evaluation (conditional jump: jz/jnz), the result is always evaluated to true (or false), which means an unconditional jump. Thus, there is a dead branch.

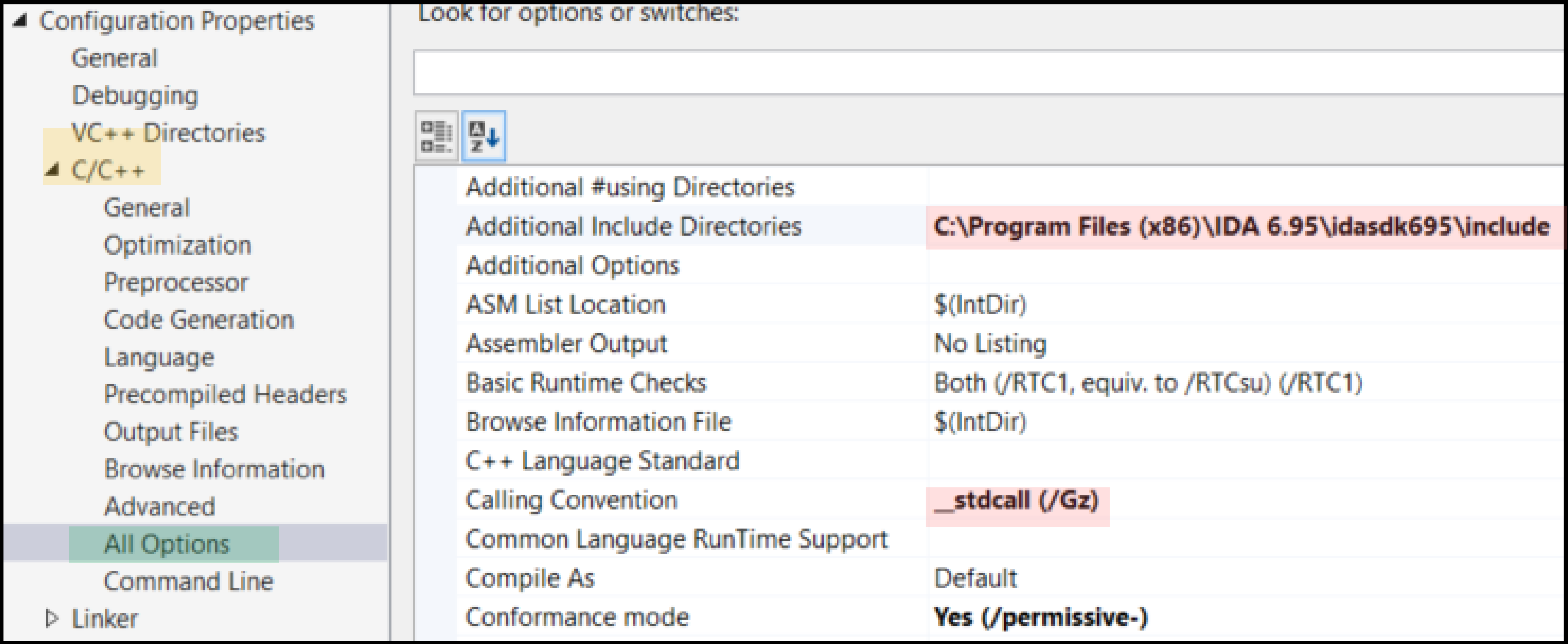
- ✓ Anti-debugging: used as irritating techniques to slow the process analysis.

- ✓ Polymorphism: it is produced by self-modification code (like shellcodes) and by encrypting resources (similar most malware samples).

- ✓ It is quick to create a simple IDA Pro plugin. Download the IDA SDK from https://www.hex-rays.com/products/ida/support/download.shtml (likely, you will need a professional account). Copy it to a folder (idasdk695/) within the IDA Pro installation directory.

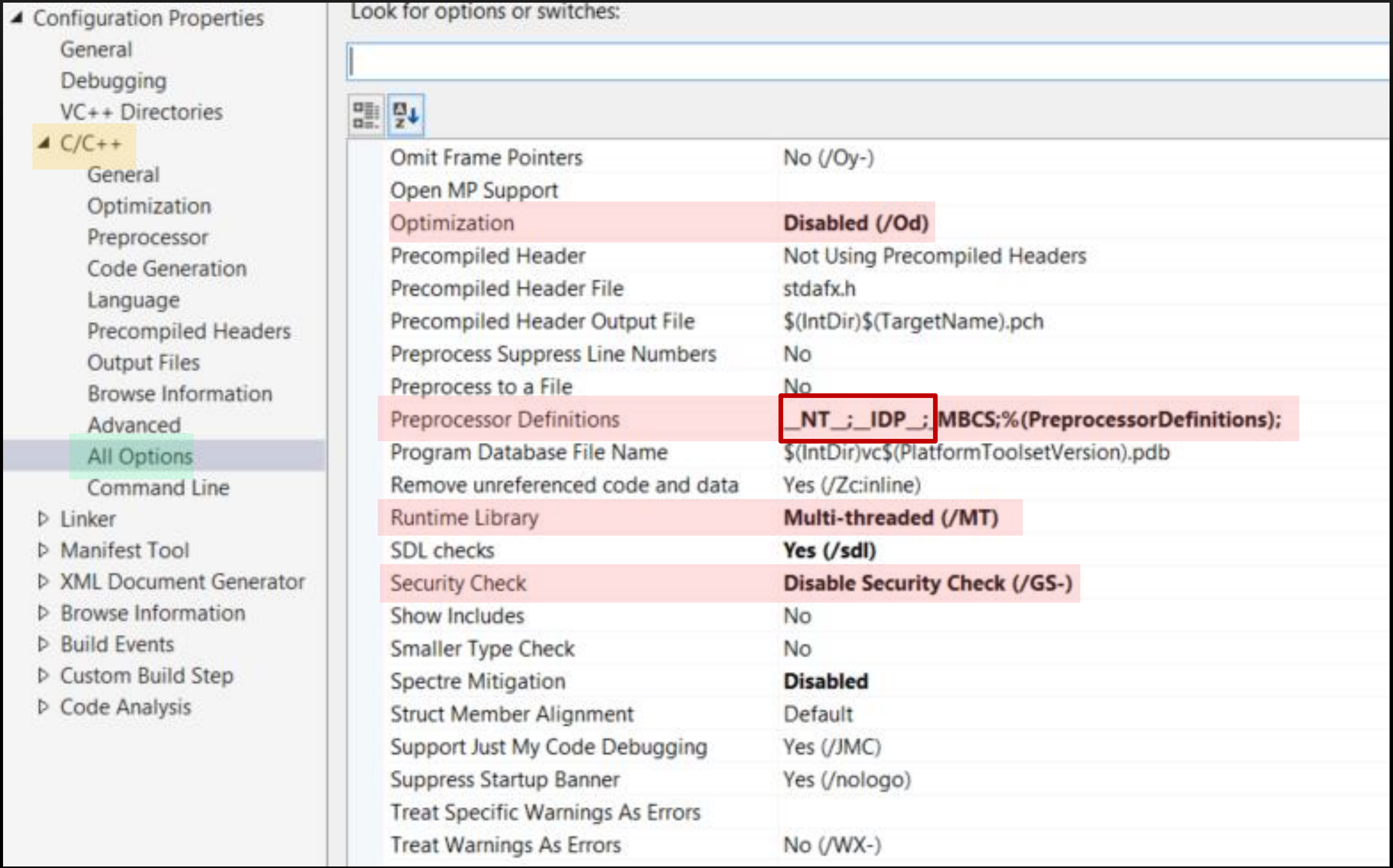
- ✓ Create a project in Visual Studio 2017 (File → New → Create Project → Visual C++ → Windows Desktop → Dynamic-Link Library (DLL)).

- ✓ Change few project properties as shown in this slide and next ones.



Additional #using Directories	
Additional Include Directories	C:\Program Files (x86)\IDA 6.95\idasdk695\include
Additional Options	
ASM List Location	$(IntDir)
Assembler Output	No Listing
Basic Runtime Checks	Both (/RTC1, equiv. to /RTCsu) (/RTC1)
Browse Information File	$(IntDir)
C++ Language Standard	
Calling Convention	__stdcall (/Gz)
Common Language RunTime Support	
Compile As	Default
Conformance mode	**Yes (/permissive-)**

✓ Include the "__NT__;__IDP__" in Processor Definitions and change Runtime Library to "Multi-threaded" (MT) (take care: it is NOT /MTd).



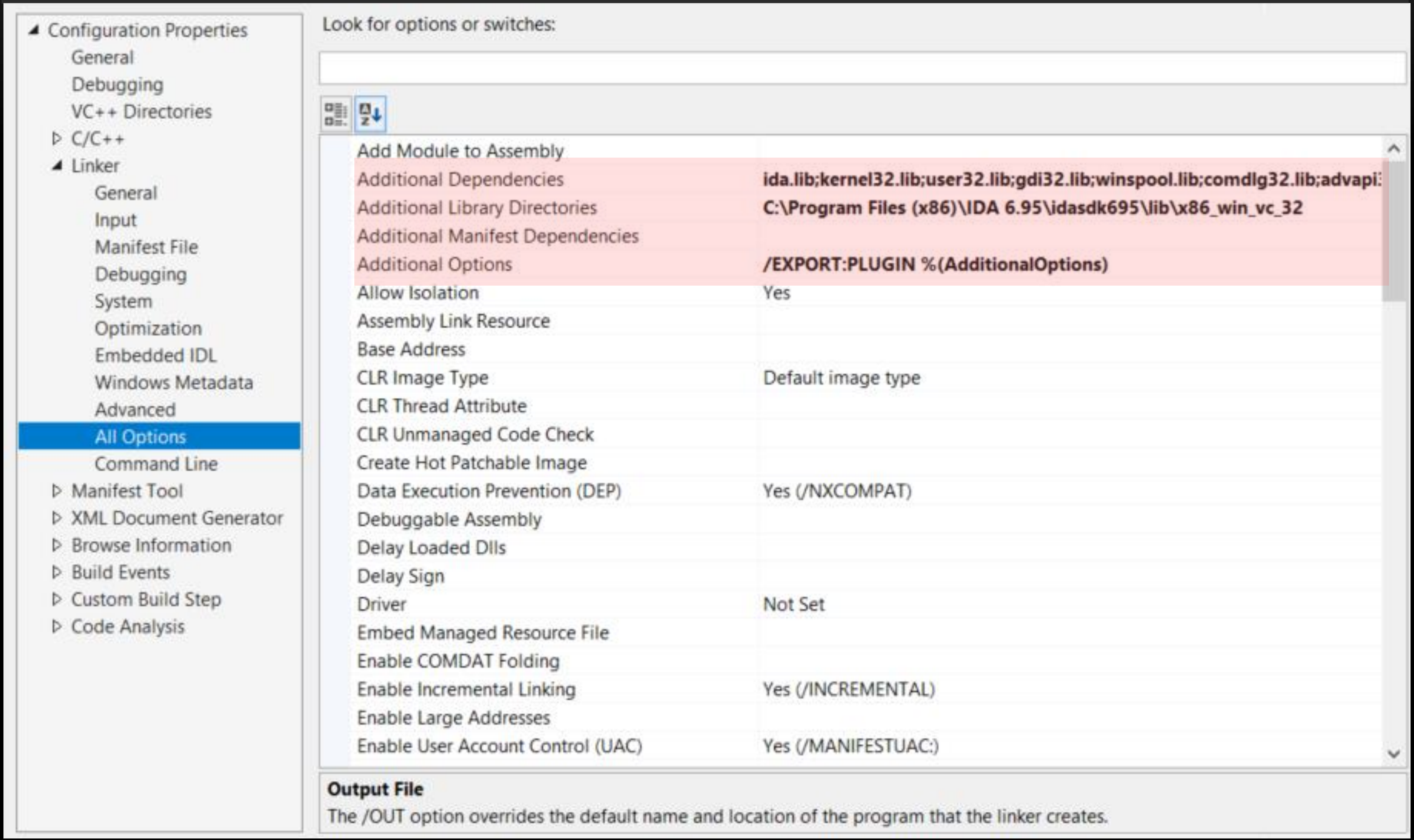
- Configuration Properties
  - General
  - Debugging
  - VC++ Directories
  - C/C++
    - General
    - Optimization
    - Preprocessor
    - Code Generation
    - Language
    - Precompiled Headers
    - Output Files
    - Browse Information
    - Advanced
    - All Options
    - Command Line
  - Linker
  - Manifest Tool
  - XML Document Generator
  - Browse Information
  - Build Events
  - Custom Build Step
  - Code Analysis

Look for options or switches:

Omit Frame Pointers	No (/Oy-)
Open MP Support	
Optimization	**Disabled (/Od)**
Precompiled Header	Not Using Precompiled Headers
Precompiled Header File	stdafx.h
Precompiled Header Output File	$(IntDir)$(TargetName).pch
Preprocess Suppress Line Numbers	No
Preprocess to a File	No
Preprocessor Definitions	**__NT__;__IDP__;_MBCS;%(PreprocessorDefinitions);**
Program Database File Name	$(IntDir)vc$(PlatformToolsetVersion).pdb
Remove unreferenced code and data	Yes (/Zc:inline)
Runtime Library	**Multi-threaded (/MT)**
SDL checks	**Yes (/sdl)**
Security Check	**Disable Security Check (/GS-)**
Show Includes	No
Smaller Type Check	No
Spectre Mitigation	**Disabled**
Struct Member Alignment	Default
Support Just My Code Debugging	Yes (/JMC)
Suppress Startup Banner	Yes (/nologo)
Treat Specific Warnings As Errors	
Treat Warnings As Errors	No (/WX-)

✓ Add ida.lib (from C:\Program Files (x86)\IDA 6.95\idasdk695\lib\x86_win_vc_32) to Additional Dependencies and its folder to Additional Library Directories.

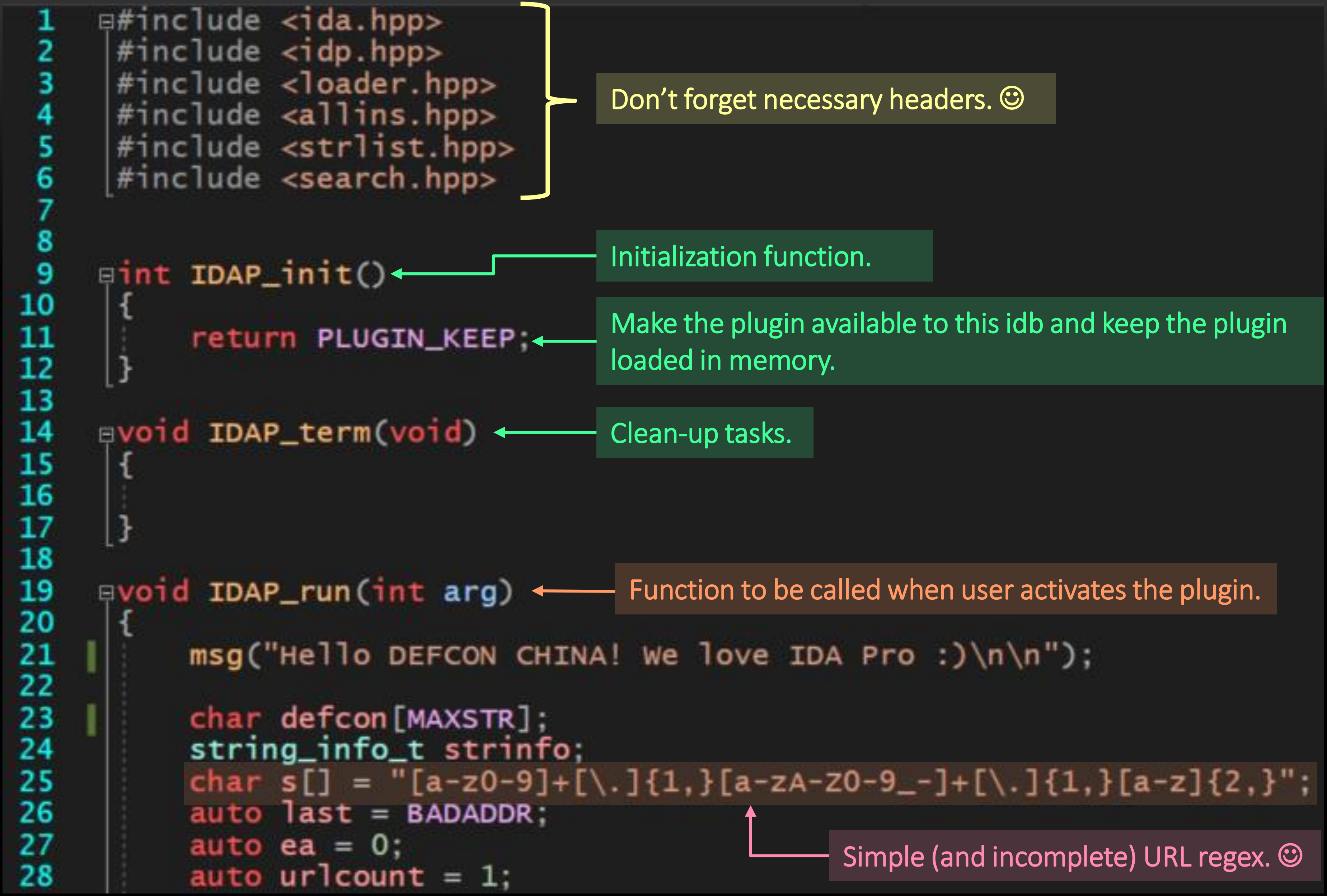
✓ Add "/EXPORT:PLUGIN" to Additional Options.



Add Module to Assembly	
Additional Dependencies	ida.lib;kernel32.lib;user32.lib;gdi32.lib;winspool.lib;comdlg32.lib;advapi
Additional Library Directories	C:\Program Files (x86)\IDA 6.95\idasdk695\lib\x86_win_vc_32
Additional Manifest Dependencies	
Additional Options	/EXPORT:PLUGIN %(AdditionalOptions)
Allow Isolation	Yes
Assembly Link Resource	
Base Address	
CLR Image Type	Default image type
CLR Thread Attribute	
CLR Unmanaged Code Check	
Create Hot Patchable Image	
Data Execution Prevention (DEP)	Yes (/NXCOMPAT)
Debuggable Assembly	
Delay Loaded Dlls	
Delay Sign	
Driver	Not Set
Embed Managed Resource File	
Enable COMDAT Folding	
Enable Incremental Linking	Yes (/INCREMENTAL)
Enable Large Addresses	
Enable User Account Control (UAC)	Yes (/MANIFESTUAC:)

Output File

The /OUT option overrides the default name and location of the program that the linker creates.



```
#include <ida.hpp>
#include <idp.hpp>
#include <loader.hpp>
#include <allins.hpp>
#include <strlist.hpp>
#include <search.hpp>


int IDAP_init()
{
    return PLUGIN_KEEP;
}

void IDAP_term(void)
{

}

void IDAP_run(int arg)
{
    msg("Hello DEFCON CHINA! We love IDA Pro :)\n\n");

    char defcon[MAXSTR];
    string_info_t strinfo;
    char s[] = "[a-z0-9]+[\.]{1,}[a-zA-Z0-9_-]+[\.]{1,}[a-z]{2,}";
    auto last = BADADDR;
    auto ea = 0;
    auto urlcount = 1;
```

Don’t forget necessary headers. ☺

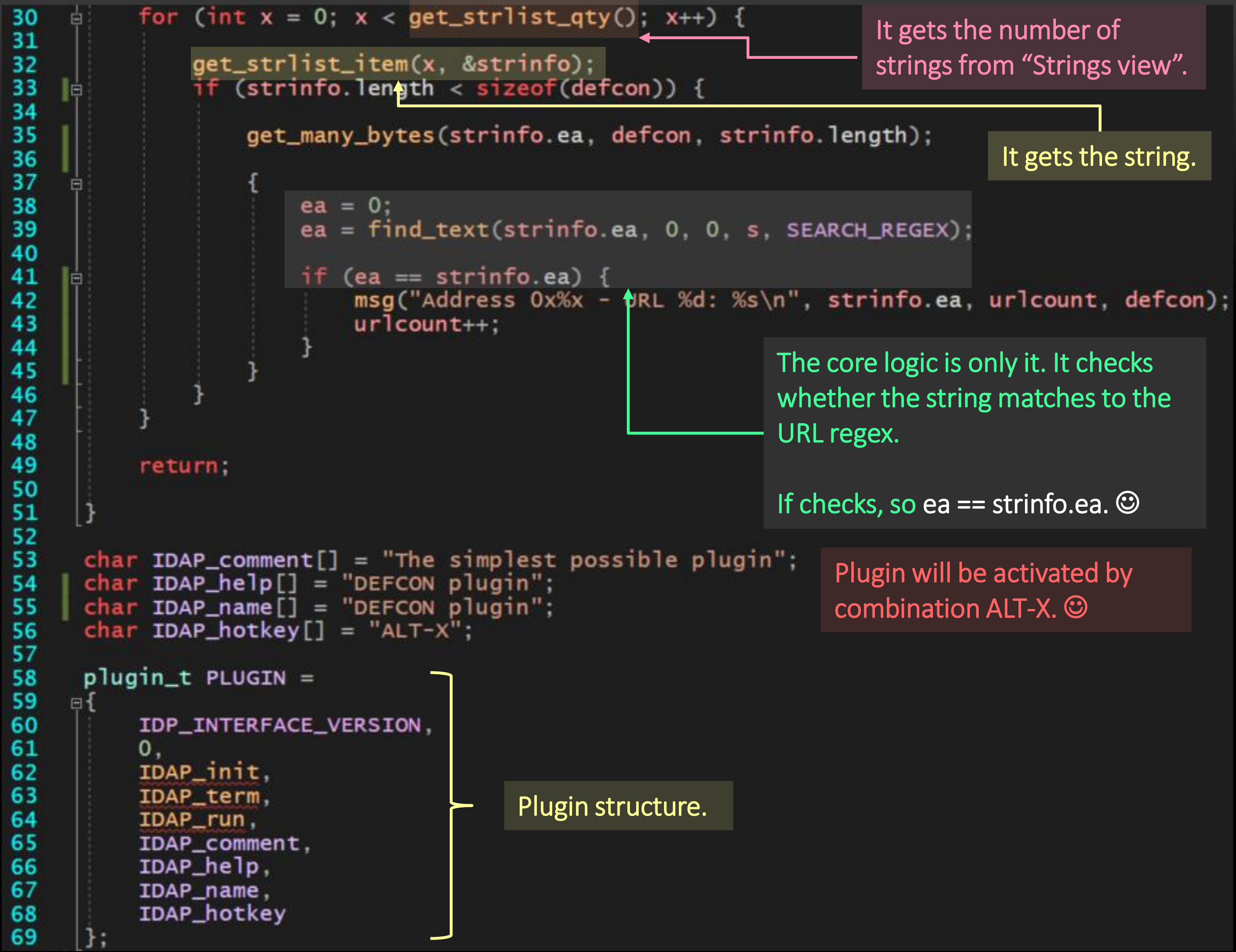
Initialization function.

Make the plugin available to this idb and keep the plugin loaded in memory.

Clean-up tasks.

Function to be called when user activates the plugin.

Simple (and incomplete) URL regex. ☺



```
    for (int x = 0; x < get_strlist_qty(); x++) {

        get_strlist_item(x, &strinfo);
        if (strinfo.length < sizeof(defcon)) {

            get_many_bytes(strinfo.ea, defcon, strinfo.length);

            {
                ea = 0;
                ea = find_text(strinfo.ea, 0, 0, s, SEARCH_REGEX);

                if (ea == strinfo.ea) {
                    msg("Address 0x%x - URL %d: %s\n", strinfo.ea, urlcount, defcon);
                    urlcount++;
                }
            }
        }
    }

    return;

}

char IDAP_comment[] = "The simplest possible plugin";
char IDAP_help[] = "DEFCON plugin";
char IDAP_name[] = "DEFCON plugin";
char IDAP_hotkey[] = "ALT-X";

plugin_t PLUGIN =
{
    IDP_INTERFACE_VERSION,
    0,
    IDAP_init,
    IDAP_term,
    IDAP_run,
    IDAP_comment,
    IDAP_help,
    IDAP_name,
    IDAP_hotkey
};
```

It gets the number of strings from “Strings view”.

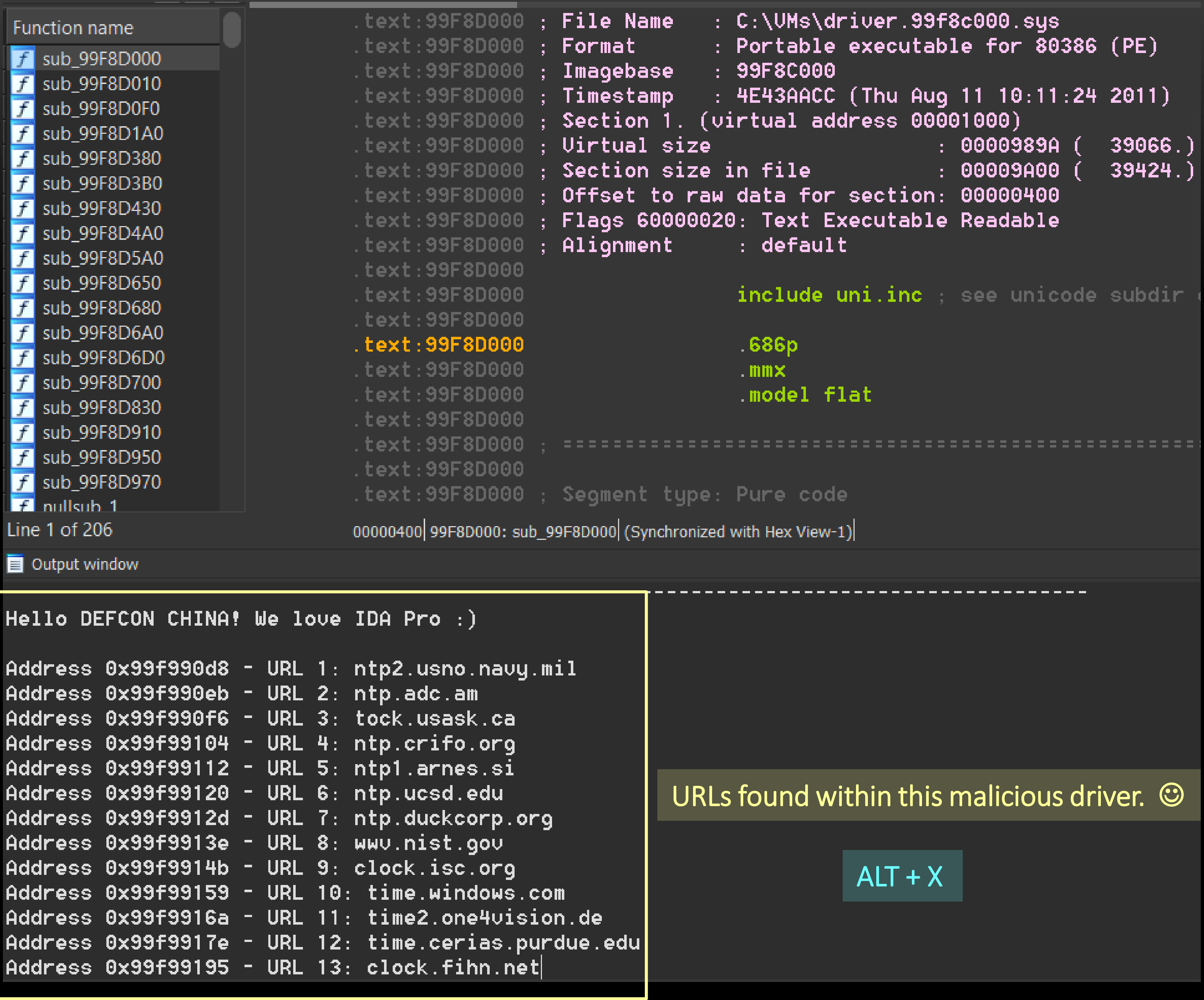
It gets the string.

The core logic is only it. It checks whether the string matches to the URL regex.

If checks, so ea == strinfo.ea. ☺

Plugin will be activated by combination ALT-X. ☺

Plugin structure.



```
sub_99F8D000
sub_99F8D010
sub_99F8D0F0
sub_99F8D1A0
sub_99F8D380
sub_99F8D3B0
sub_99F8D430
sub_99F8D4A0
sub_99F8D5A0
sub_99F8D650
sub_99F8D680
sub_99F8D6A0
sub_99F8D6D0
sub_99F8D700
sub_99F8D830
sub_99F8D910
sub_99F8D950
sub_99F8D970
nullsub_1
Line 1 of 206
```

```
.text:99F8D000 ; File Name    : C:\VMs\driver.99f8c000.sys
.text:99F8D000 ; Format       : Portable executable for 80386 (PE)
.text:99F8D000 ; Imagebase    : 99F8C000
.text:99F8D000 ; Timestamp    : 4E43AACC (Thu Aug 11 10:11:24 2011)
.text:99F8D000 ; Section 1. (virtual address 00001000)
.text:99F8D000 ; Virtual size                  : 0000989A (  39066.)
.text:99F8D000 ; Section size in file          : 00009A00 (  39424.)
.text:99F8D000 ; Offset to raw data for section: 00000400
.text:99F8D000 ; Flags 60000020: Text Executable Readable
.text:99F8D000 ; Alignment    : default
.text:99F8D000
.text:99F8D000                 include uni.inc ; see unicode subdir
.text:99F8D000
.text:99F8D000                 .686p
.text:99F8D000                 .mmx
.text:99F8D000                 .model flat
.text:99F8D000
.text:99F8D000 ; ===========================================================
.text:99F8D000
.text:99F8D000 ; Segment type: Pure code
```

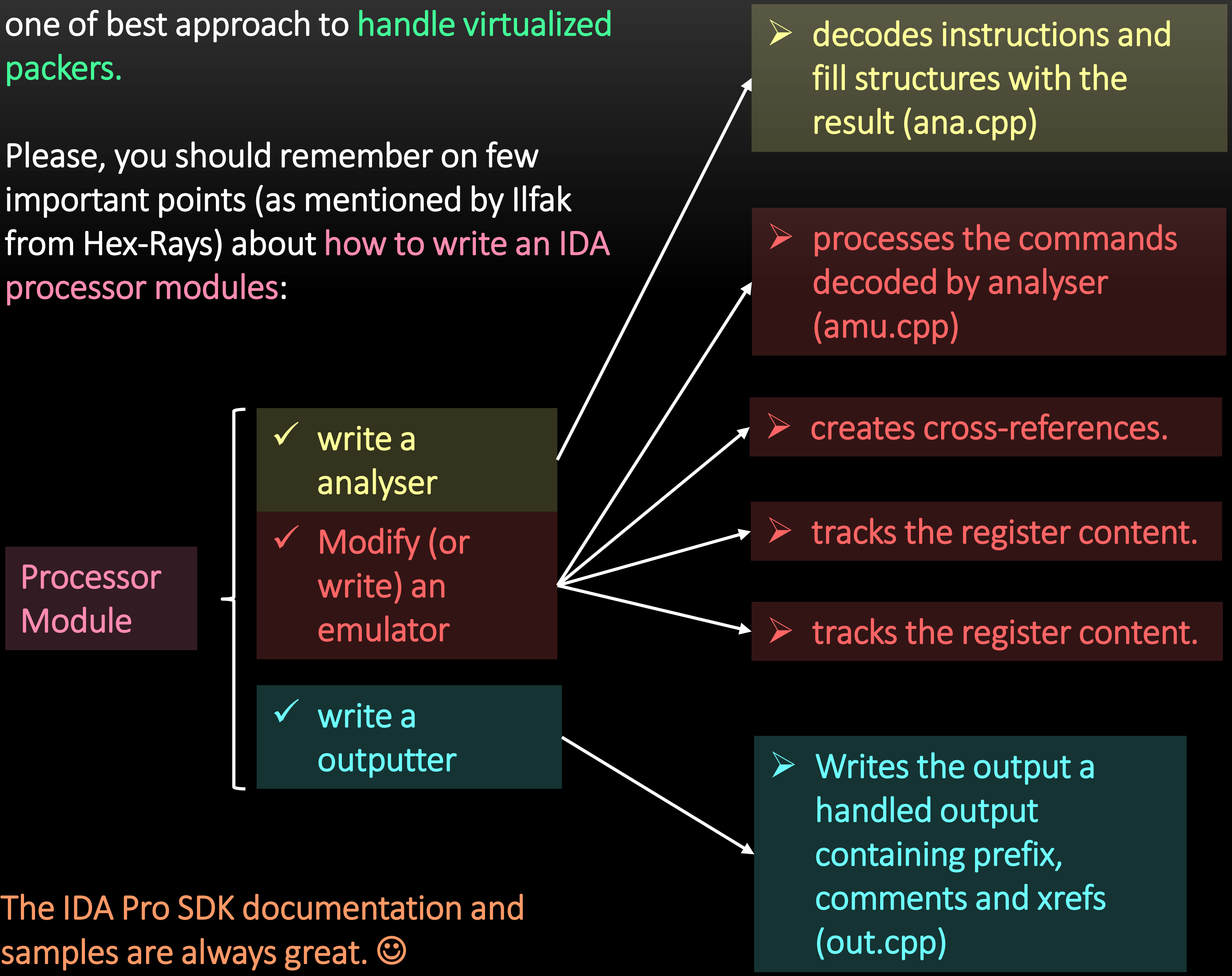
```
00000400 99F8D000: sub_99F8D000 (Synchronized with Hex View-1)
```

```
Hello DEFCON CHINA! We love IDA Pro :)

Address 0x99f990d8 - URL 1: ntp2.usno.navy.mil
Address 0x99f990eb - URL 2: ntp.adc.am
Address 0x99f990f6 - URL 3: tock.usask.ca
Address 0x99f99104 - URL 4: ntp.crifo.org
Address 0x99f99112 - URL 5: ntp1.arnes.si
Address 0x99f99120 - URL 6: ntp.ucsd.edu
Address 0x99f9912d - URL 7: ntp.duckcorp.org
Address 0x99f9913e - URL 8: wwv.nist.gov
Address 0x99f9914b - URL 9: clock.isc.org
Address 0x99f99159 - URL 10: time.windows.com
Address 0x99f9916a - URL 11: time2.one4vision.de
Address 0x99f9917e - URL 12: time.cerias.purdue.edu
Address 0x99f99195 - URL 13: clock.fihn.net
```

URLs found within this malicious driver. ☺

ALT + X

- ✓ IDA processor modules continue being the one of best approach to handle virtualized packers.
- ✓ Please, you should remember on few important points (as mentioned by Ilfak from Hex-Rays) about how to write an IDA processor modules:

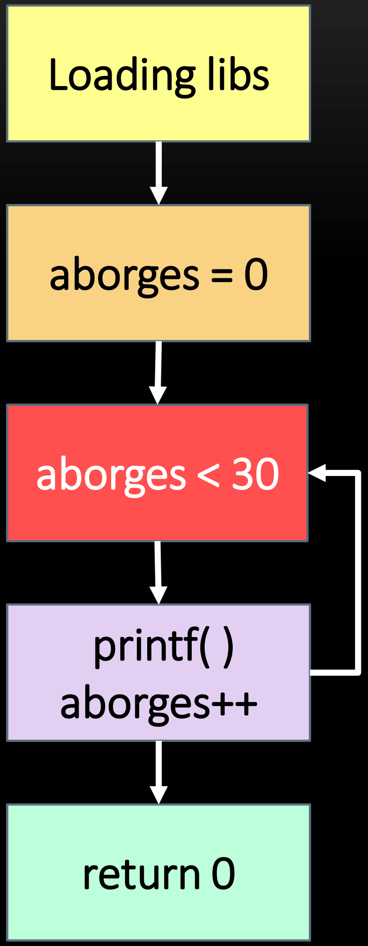


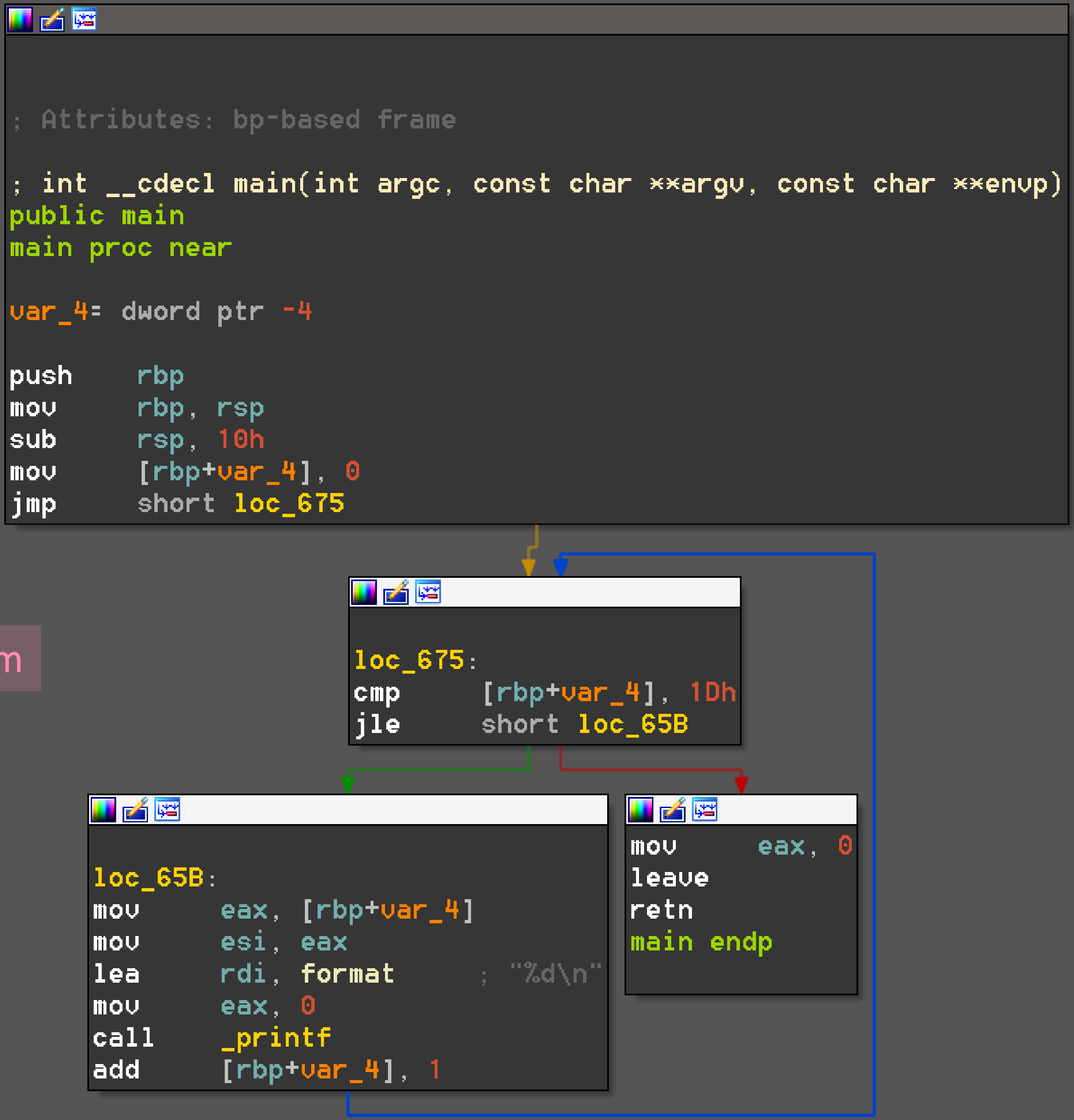
Processor Module

- ✓ write a analyser
  - ➢ decodes instructions and fill structures with the result (ana.cpp)
- ✓ Modify (or write) an emulator
  - ➢ processes the commands decoded by analyser (amu.cpp)
  - ➢ creates cross-references.
  - ➢ tracks the register content.
  - ➢ tracks the register content.
- ✓ write a outputter
  - ➢ Writes the output a handled output containing prefix, comments and xrefs (out.cpp)

- ✓ The IDA Pro SDK documentation and samples are always great. ☺

```
#include <stdio.h>

int main (void)

{
        int aborges = 0;
        while (aborges <  30)
        {
                printf(“%d\n”, aborges);
                aborges++;
        }

        return 0;

}
```





```
; Attributes: bp-based frame

; int __cdecl main(int argc, const char **argv, const char **envp)
public main
main proc near

var_4= dword ptr -4

push    rbp
mov     rbp, rsp
sub     rsp, 10h
mov     [rbp+var_4], 0
jmp     short loc_675
```

```
loc_675:
cmp     [rbp+var_4], 1Dh
jle     short loc_65B
```

```
loc_65B:
mov     eax, [rbp+var_4]
mov     esi, eax
lea     rdi, format     ; "%d\n"
mov     eax, 0
call    _printf
add     [rbp+var_4], 1
```

```
mov     eax, 0
leave
retn
main endp
```

Original Program

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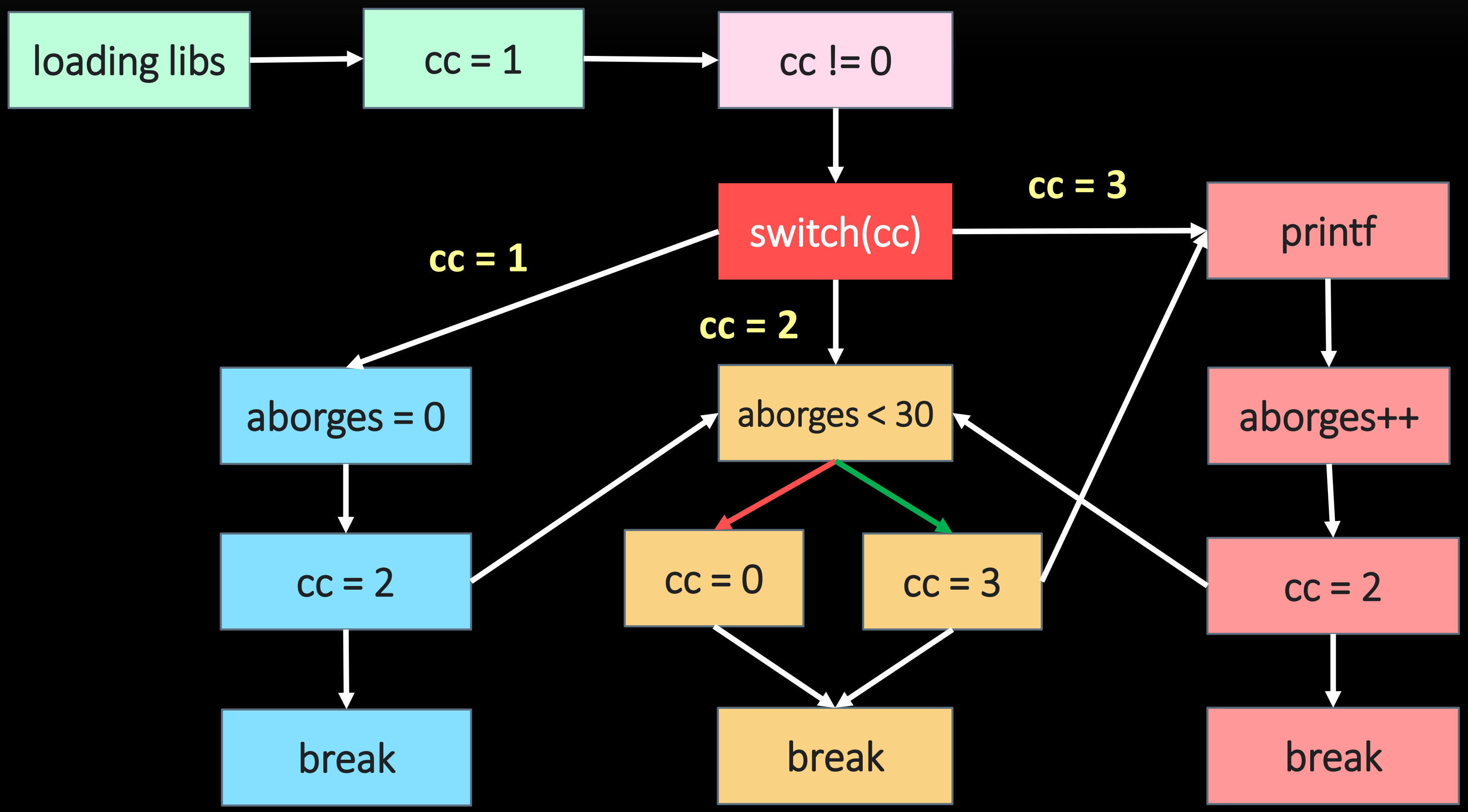
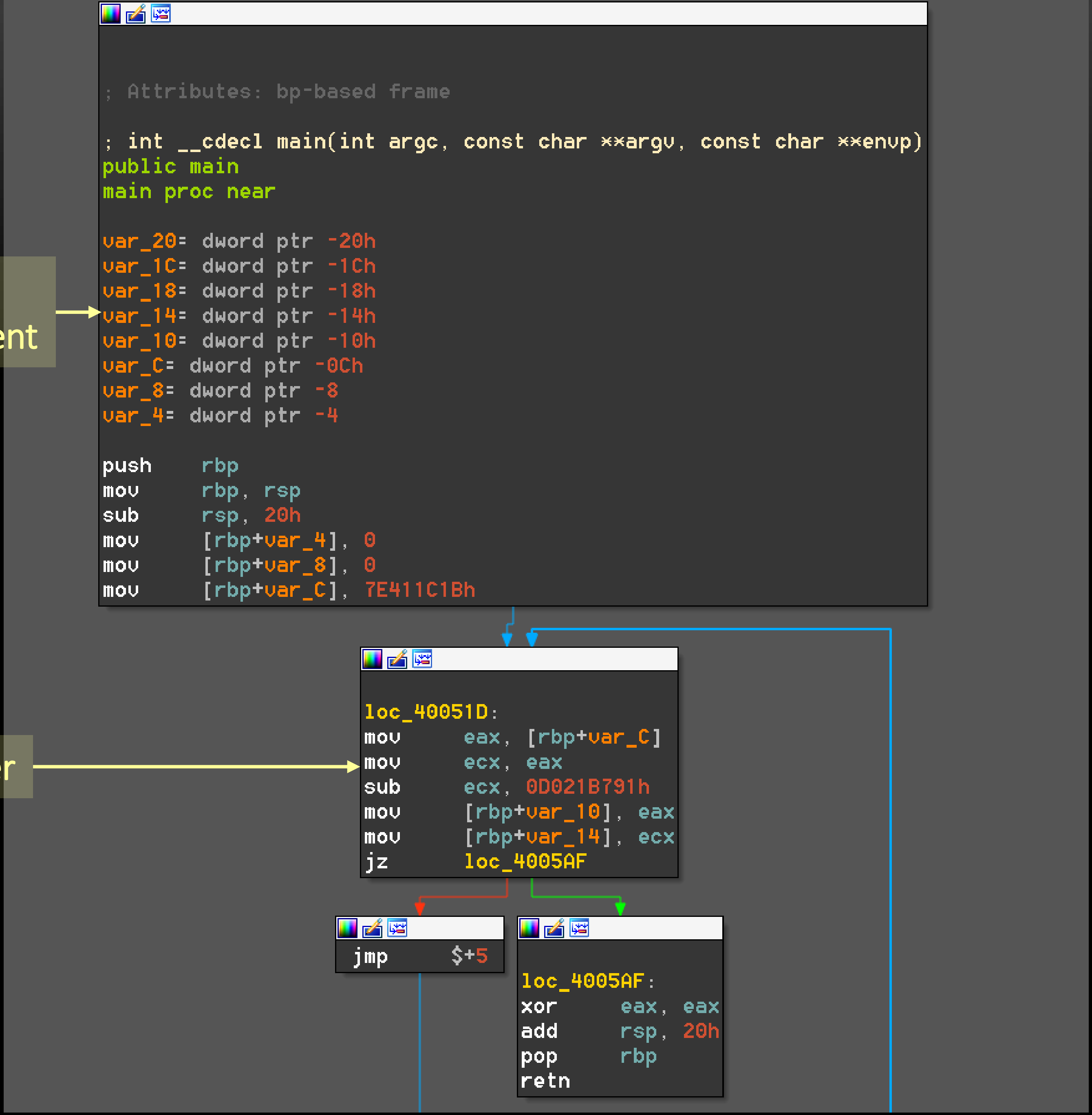
❖ Disavantages:

- ✓ Loss of performance
- ✓ Easy to identify the CFG flattening



- ✓ The obfuscator-llvm is an excellent project to be used for code obsfuscation. To install it, it is recommended to add a swap file first (because the linkage stage):
  - ✓ fallocate -l 8GB /swapfile
  - ✓ chmod 600 /swapfile
  - ✓ mkswap /swapfile
  - ✓ swapon /swapfile
  - ✓ swapon --show
  - ✓ apt-get install llvm-4.0
  - ✓ apt-get install gcc-multilib (install gcc lib support to 32 bit)
  - ✓ git clone -b llvm-4.0 https://github.com/obfuscator-llvm/obfuscator.git
  - ✓ mkdir build ; cd build/
  - ✓ cmake -DCMAKE_BUILD_TYPE=Release -DLLVM_INCLUDE_TESTS=OFF ../obfuscator/
  - ✓ make -j7
- ✓ Possible usages:
  - ✓ ./build/bin/clang alexborges.c -o alexborges -mllvm -fla
  - ✓ ./build/bin/clang alexborges.c -m32 -o alexborges -mllvm -fla
  - ✓ ./build/bin/clang alexborges.c -o alexborges -mllvm -fla -mllvm -sub



```
; Attributes: bp-based frame

; int __cdecl main(int argc, const char **argv, const char **envp)
public main
main proc near

var_20= dword ptr -20h
var_1C= dword ptr -1Ch
var_18= dword ptr -18h
var_14= dword ptr -14h
var_10= dword ptr -10h
var_C= dword ptr -0Ch
var_8= dword ptr -8
var_4= dword ptr -4

push    rbp
mov     rbp, rsp
sub     rsp, 20h
mov     [rbp+var_4], 0
mov     [rbp+var_8], 0
mov     [rbp+var_C], 7E411C1Bh
```

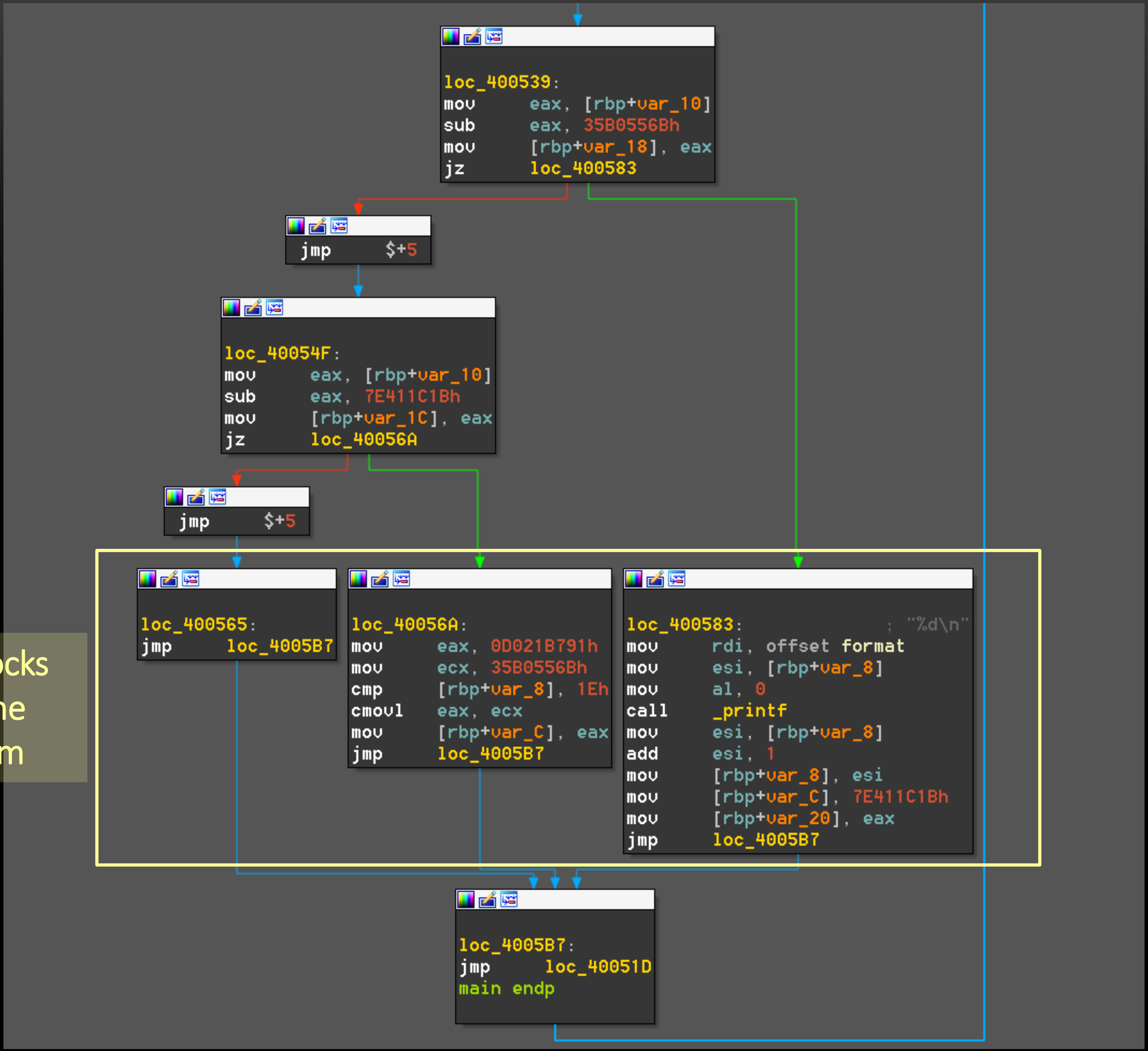
```
loc_40051D:
mov     eax, [rbp+var_C]
mov     ecx, eax
sub     ecx, 0D021B791h
mov     [rbp+var_10], eax
mov     [rbp+var_14], ecx
jz      loc_4005AF
```

```
jmp     $+5
```

```
loc_4005AF:
xor     eax, eax
add     rsp, 20h
pop     rbp
retn
```

Prologue and initial assignment

Main dispatcher



```
loc_400539:
mov     eax, [rbp+var_10]
sub     eax, 35B0556Bh
mov     [rbp+var_18], eax
jz      loc_400583
```

```
jmp     $+5
```

```
loc_40054F:
mov     eax, [rbp+var_10]
sub     eax, 7E411C1Bh
mov     [rbp+var_1C], eax
jz      loc_40056A
```

```
jmp     $+5
```

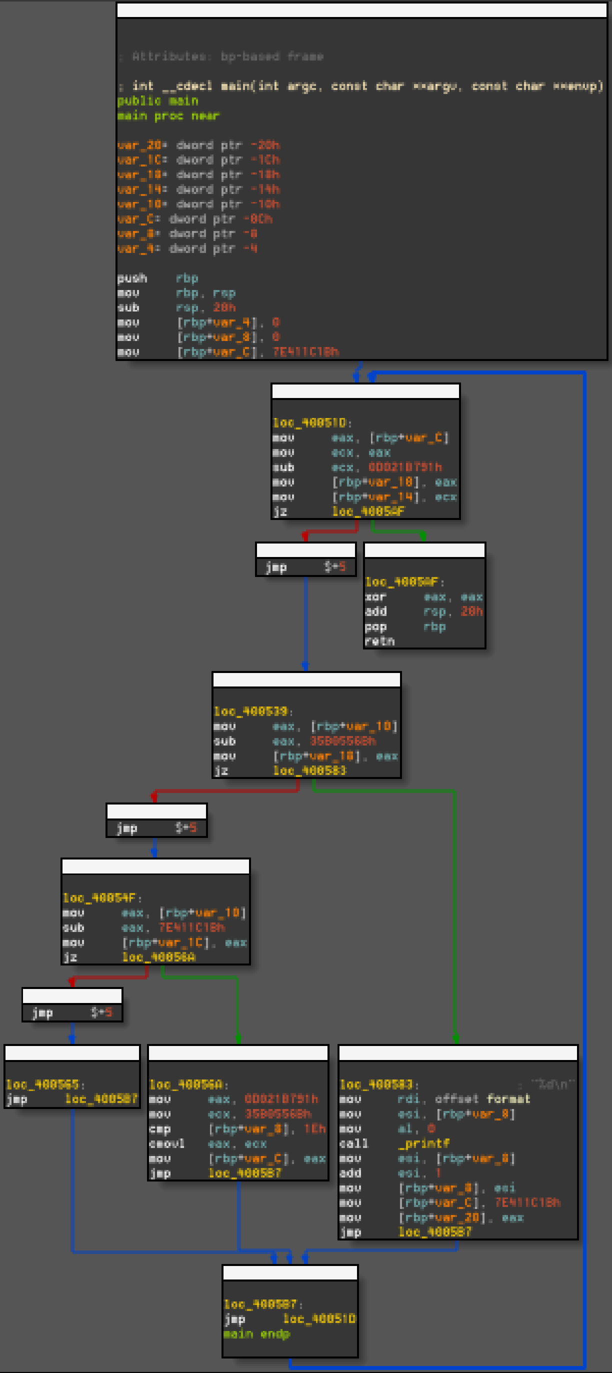
```
loc_400565:
jmp     loc_4005B7
```

```
loc_40056A:
mov     eax, 0D021B791h
mov     ecx, 35B0556Bh
cmp     [rbp+var_8], 1Eh
cmovl   eax, ecx
mov     [rbp+var_C], eax
jmp     loc_4005B7
```

```
loc_400583:                             ; "%d\n"
mov     rdi, offset format
mov     esi, [rbp+var_8]
mov     al, 0
call    _printf
mov     esi, [rbp+var_8]
add     esi, 1
mov     [rbp+var_8], esi
mov     [rbp+var_C], 7E411C1Bh
mov     [rbp+var_20], eax
jmp     loc_4005B7
```

```
loc_4005B7:
jmp     loc_40051D
main endp
```

Main blocks from the program



```
; Attributes: bp-based frame

; int __cdecl main(int argc, const char **argv, const char **envp)
public main
main proc near

var_20= dword ptr -20h
var_1C= dword ptr -1Ch
var_18= dword ptr -18h
var_14= dword ptr -14h
var_10= dword ptr -10h
var_C= dword ptr -0Ch
var_8= dword ptr -8
var_4= dword ptr -4

push    rbp
mov     rbp, rsp
sub     rsp, 20h
mov     [rbp+var_4], 0
mov     [rbp+var_8], 0
mov     [rbp+var_C], 7E411C18h
```

```
loc_40051D:
mov     eax, [rbp+var_C]
mov     ecx, eax
sub     ecx, 0DD21B791h
mov     [rbp+var_18], eax
mov     [rbp+var_14], ecx
jz      loc_4005AF
```

```
jmp     $+5
```

```
loc_4005AF:
xor     eax, eax
add     rsp, 20h
pop     rbp
retn
```

```
loc_400539:
mov     eax, [rbp+var_18]
sub     eax, 35B05568h
mov     [rbp+var_10], eax
jz      loc_400583
```

```
jmp     $+5
```

```
loc_40054F:
mov     eax, [rbp+var_18]
sub     eax, 7E411C18h
mov     [rbp+var_1C], eax
jz      loc_40056A
```

```
jmp     $+5
```

```
loc_400565:
jmp     loc_400587
```

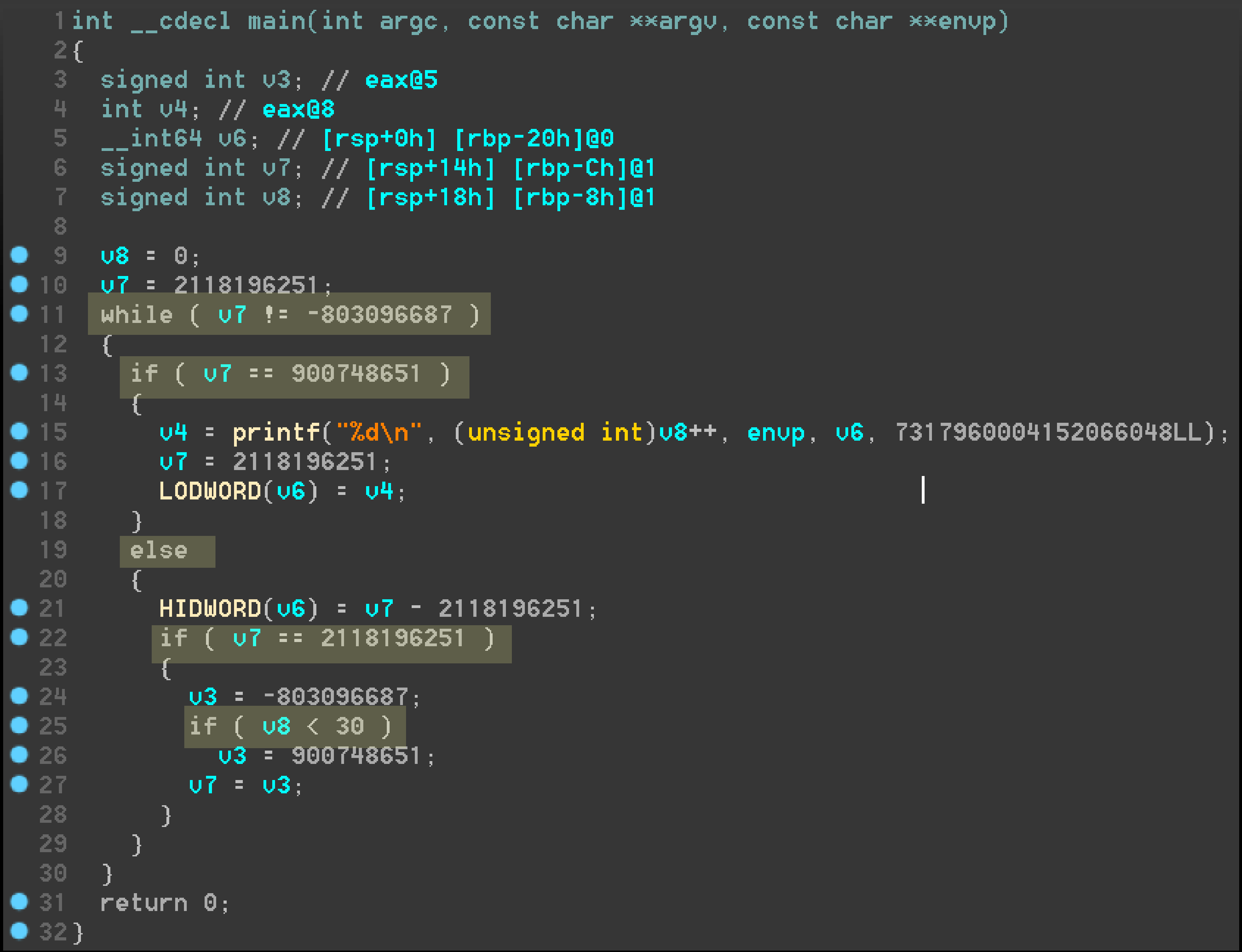
```
loc_40056A:
mov     eax, 0DD21B791h
mov     ecx, 35B05568h
cmp     [rbp+var_8], 1Eh
cmovl   eax, ecx
mov     [rbp+var_C], eax
jmp     loc_400587
```

```
loc_400583:                             ; "%d\n"
mov     rdi, offset format
mov     esi, [rbp+var_8]
mov     al, 0
call    _printf
mov     esi, [rbp+var_8]
add     esi, 1
mov     [rbp+var_8], esi
mov     [rbp+var_C], 7E411C18h
mov     [rbp+var_20], eax
jmp     loc_400587
```

```
loc_400587:
jmp     loc_40051D
main endp
```

General overview of the obfuscated code

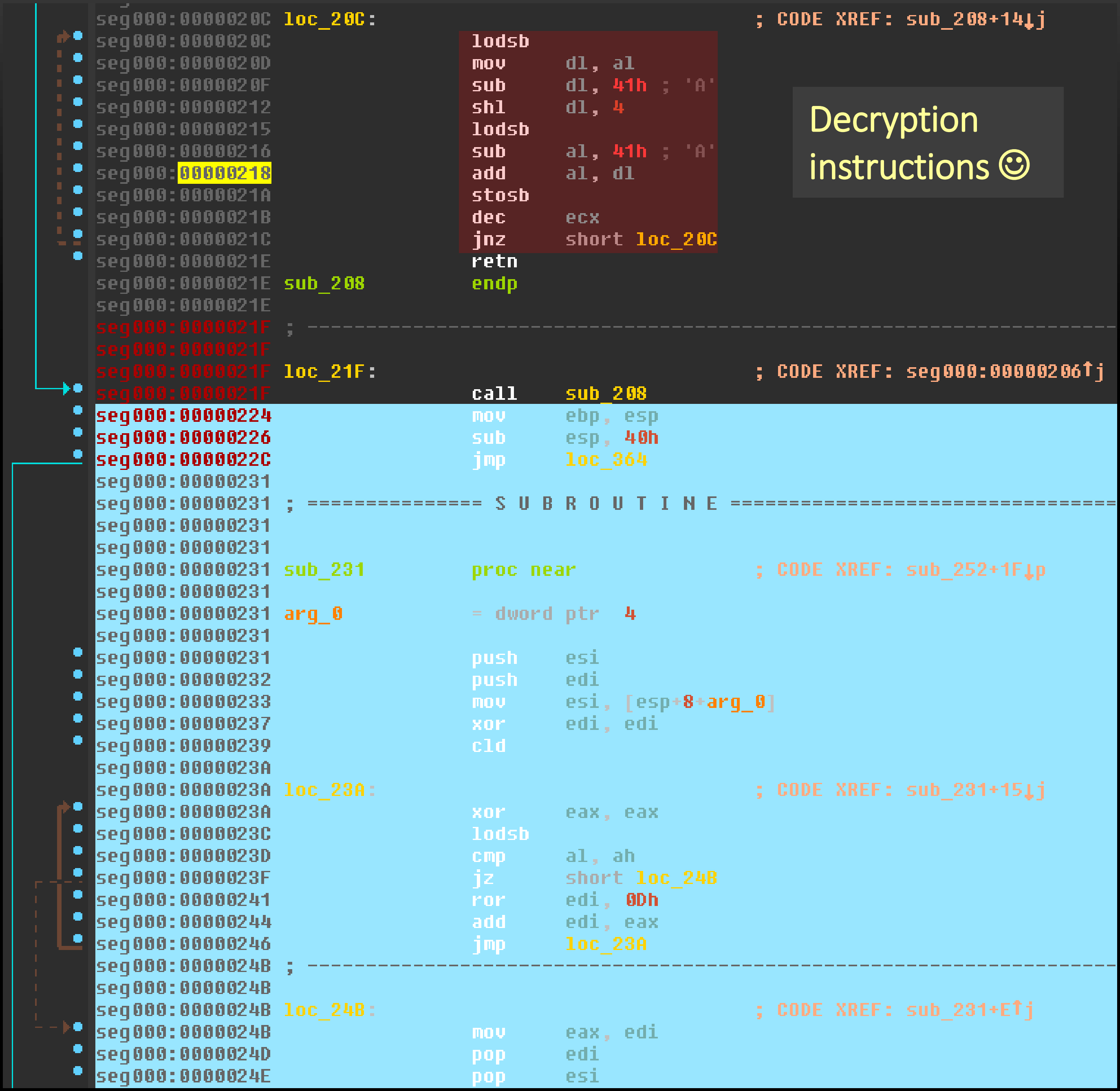
ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER



```
int __cdecl main(int argc, const char **argv, const char **envp)
{
  signed int v3; // eax@5
  int v4; // eax@8
  __int64 v6; // [rsp+0h] [rbp-20h]@0
  signed int v7; // [rsp+14h] [rbp-Ch]@1
  signed int v8; // [rsp+18h] [rbp-8h]@1

  v8 = 0;
  v7 = 2118196251;
  while ( v7 != -803096687 )
  {
    if ( v7 == 900748651 )
    {
      v4 = printf("%d\n", (unsigned int)v8++, envp, v6, 7317960004152066048LL);
      v7 = 2118196251;
      LODWORD(v6) = v4;
    }
    else
    {
      HIDWORD(v6) = v7 - 2118196251;
      if ( v7 == 2118196251 )
      {
        v3 = -803096687;
        if ( v8 < 30 )
          v3 = 900748651;
        v7 = v3;
      }
    }
  }
  return 0;
}
```

Simple opaque predicate and anti-disassembly technique

```
.text:00401000 loc_401000:                              ; CODE XREF: _main+Fp

.text:00401000                     push     ebp
.text:00401001                     mov      ebp, esp
.text:00401003                     xor      eax, eax
.text:00401005                     jz       short near ptr loc_40100D+1
.text:00401007                     jnz      near ptr loc_40100D+4

.text:0040100D
.text:0040100D loc_40100D:                         ; CODE XREF: .text:00401005j
.text:0040100D                                    ; .text:00401007j

.text:0040100D                     jmp    near ptr 0D0A8837h
```



```
seg000:0000020C loc_20C:                                ; CODE XREF: sub_208+14↓j
seg000:0000020C                 lodsb
seg000:0000020D                 mov     dl, al
seg000:0000020F                 sub     dl, 41h ; 'A'
seg000:00000212                 shl     dl, 4
seg000:00000215                 lodsb
seg000:00000216                 sub     al, 41h ; 'A'
seg000:00000218                 add     al, dl
seg000:0000021A                 stosb
seg000:0000021B                 dec     ecx
seg000:0000021C                 jnz     short loc_20C
seg000:0000021E                 retn
seg000:0000021E sub_208         endp
seg000:0000021E
seg000:0000021F ; ---------------------------------------------------------------------------
seg000:0000021F
seg000:0000021F loc_21F:                                ; CODE XREF: seg000:00000206↑j
seg000:0000021F                 call    sub_208
seg000:00000224                 mov     ebp, esp
seg000:00000226                 sub     esp, 40h
seg000:0000022C                 jmp     loc_364
seg000:00000231
seg000:00000231 ; =============== S U B R O U T I N E =======================================
seg000:00000231
seg000:00000231
seg000:00000231 sub_231         proc near               ; CODE XREF: sub_252+1F↓p
seg000:00000231
seg000:00000231 arg_0           = dword ptr  4
seg000:00000231
seg000:00000231                 push    esi
seg000:00000232                 push    edi
seg000:00000233                 mov     esi, [esp+8+arg_0]
seg000:00000237                 xor     edi, edi
seg000:00000239                 cld
seg000:0000023A
seg000:0000023A loc_23A:                                ; CODE XREF: sub_231+15↓j
seg000:0000023A                 xor     eax, eax
seg000:0000023C                 lodsb
seg000:0000023D                 cmp     al, ah
seg000:0000023F                 jz      short loc_24B
seg000:00000241                 ror     edi, 0Dh
seg000:00000244                 add     edi, eax
seg000:00000246                 jmp     loc_23A
seg000:0000024B ; ---------------------------------------------------------------------------
seg000:0000024B
seg000:0000024B loc_24B:                                ; CODE XREF: sub_231+E↑j
seg000:0000024B                 mov     eax, edi
seg000:0000024D                 pop     edi
seg000:0000024E                 pop     esi
```

Decryption instructions ☺

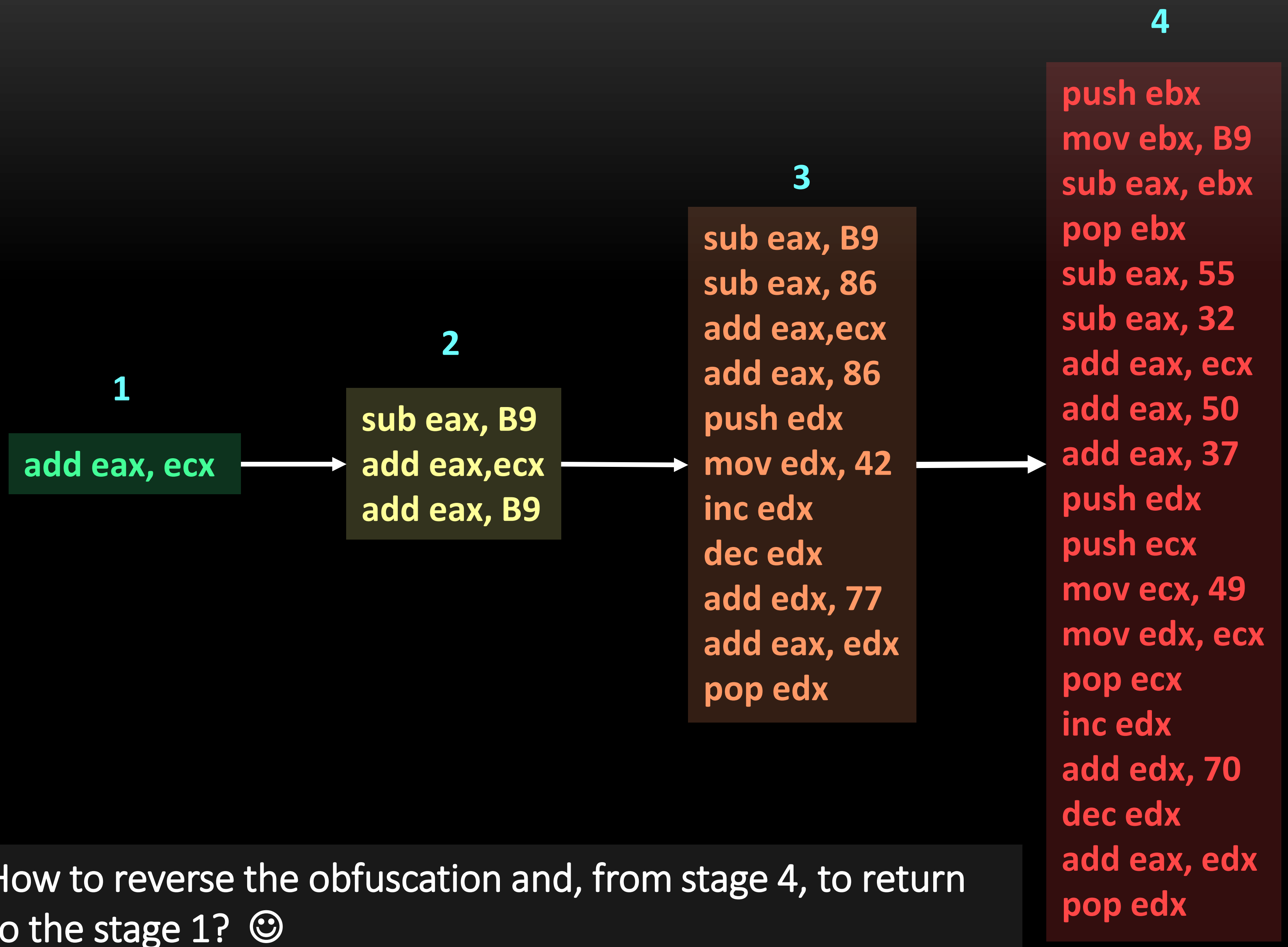
Decrypted shellcode

```
00401040        call + $5
00401045        pop ecx
00401046        inc ecx
00401047        inc ecx
00401048        add ecx, 4
00401049        add ecx, 4
0040104A        push ecx
0040104B        ret
0040104C        sub ecx, 6
0040104D        dec ecx
0040104E        dec ecx
0040104F        jmp 0x401320
```

- Call stack manipulation:
  - ✓ Do you know what’s happening here? ☺

METASM

(keystone + capstone + unicorn)



1

```
add eax, ecx
```

2

```
sub eax, B9
add eax,ecx
add eax, B9
```

3

```
sub eax, B9
sub eax, 86
add eax,ecx
add eax, 86
push edx
mov edx, 42
inc edx
dec edx
add edx, 77
add eax, edx
pop edx
```

4

```
push ebx
mov ebx, B9
sub eax, ebx
pop ebx
sub eax, 55
sub eax, 32
add eax, ecx
add eax, 50
add eax, 37
push edx
push ecx
mov ecx, 49
mov edx, ecx
pop ecx
inc edx
add edx, 70
dec edx
add eax, edx
pop edx
```

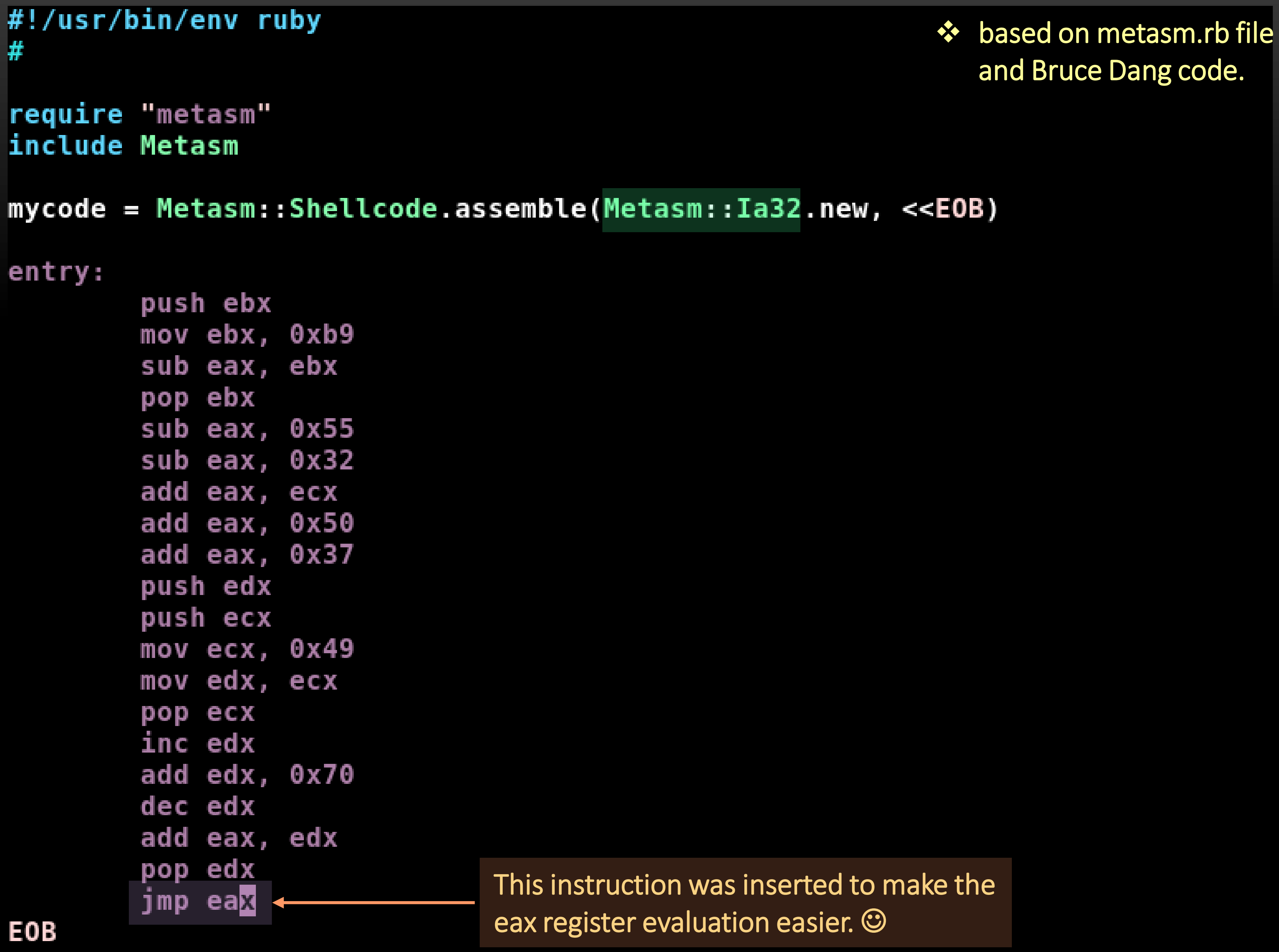
How to reverse the obfuscation and, from stage 4, to return to the stage 1? ☺

- ✓ METASM works as disassembler, assembler, debugger, compiler and linker.

- ✓ Key features:
  - ✓ Written in Ruby
  - ✓ C compiler and decompiler
  - ✓ Automatic backtracking
  - ✓ Live process manipulation
  - ✓ Supports the following architecture:
    - ✓ Intel IA32 (16/32/64 bits)
    - ✓ PPC
    - ✓ MIPS
  - ✓ Supports the following file format:
    - ✓ MZ and PE/COFF
    - ✓ ELF
    - ✓ Mach-O
    - ✓ Raw (shellcode)

```
root@kali:~/programs# git clone https://github.com/jjyg/metasm.git
root@kali:~/programs# cd metasm/
root@kali:~/programs/metasm# make
root@kali:~/programs/metasm# make all
```

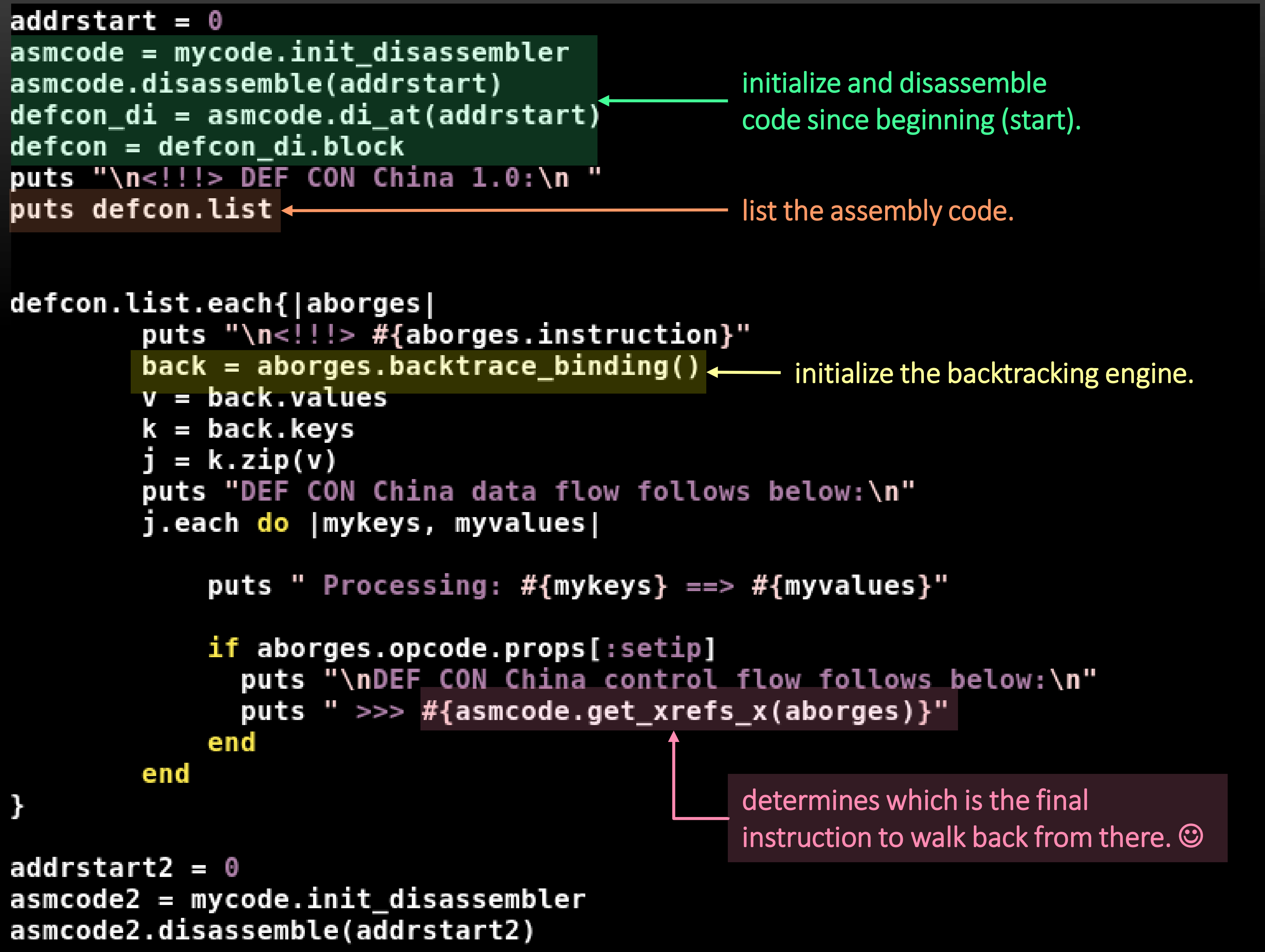
- ✓ Include the following line into .bashrc file to indicate the Metasm directory installation:
  - ✓ export RUBYLIB=$RUBYLIB:~/programs/metasm



```
#!/usr/bin/env ruby
#

require "metasm"
include Metasm

mycode = Metasm::Shellcode.assemble(Metasm::Ia32.new, <<EOB)

entry:
        push ebx
        mov ebx, 0xb9
        sub eax, ebx
        pop ebx
        sub eax, 0x55
        sub eax, 0x32
        add eax, ecx
        add eax, 0x50
        add eax, 0x37
        push edx
        push ecx
        mov ecx, 0x49
        mov edx, ecx
        pop ecx
        inc edx
        add edx, 0x70
        dec edx
        add eax, edx
        pop edx
        jmp eax
EOB
```

- ❖ based on metasm.rb file and Bruce Dang code.

This instruction was inserted to make the eax register evaluation easier. ☺



```
addrstart = 0
asmcode = mycode.init_disassembler
asmcode.disassemble(addrstart)
defcon_di = asmcode.di_at(addrstart)
defcon = defcon_di.block
puts "\n<!!!> DEF CON China 1.0:\n "
puts defcon.list


defcon.list.each{|aborges|
        puts "\n<!!!> #{aborges.instruction}"
        back = aborges.backtrace_binding()
        v = back.values
        k = back.keys
        j = k.zip(v)
        puts "DEF CON China data flow follows below:\n"
        j.each do |mykeys, myvalues|

            puts " Processing: #{mykeys} ==> #{myvalues}"

            if aborges.opcode.props[:setip]
              puts "\nDEF CON China control flow follows below:\n"
              puts " >>> #{asmcode.get_xrefs_x(aborges)}"
            end
        end
}

addrstart2 = 0
asmcode2 = mycode.init_disassembler
asmcode2.disassemble(addrstart2)
```

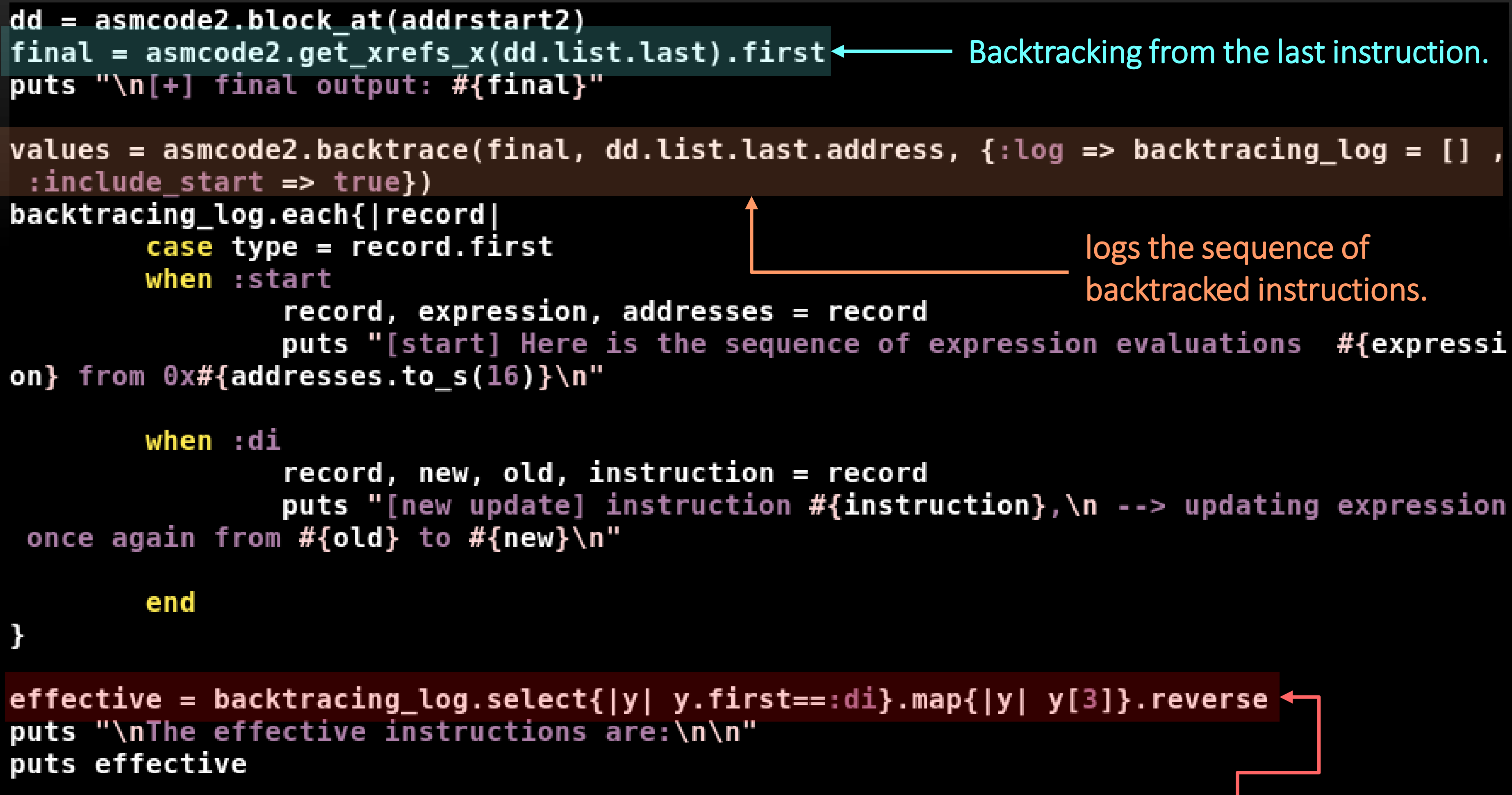
initialize and disassemble code since beginning (start).

list the assembly code.

initialize the backtracking engine.

determines which is the final instruction to walk back from there. ☺

ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER

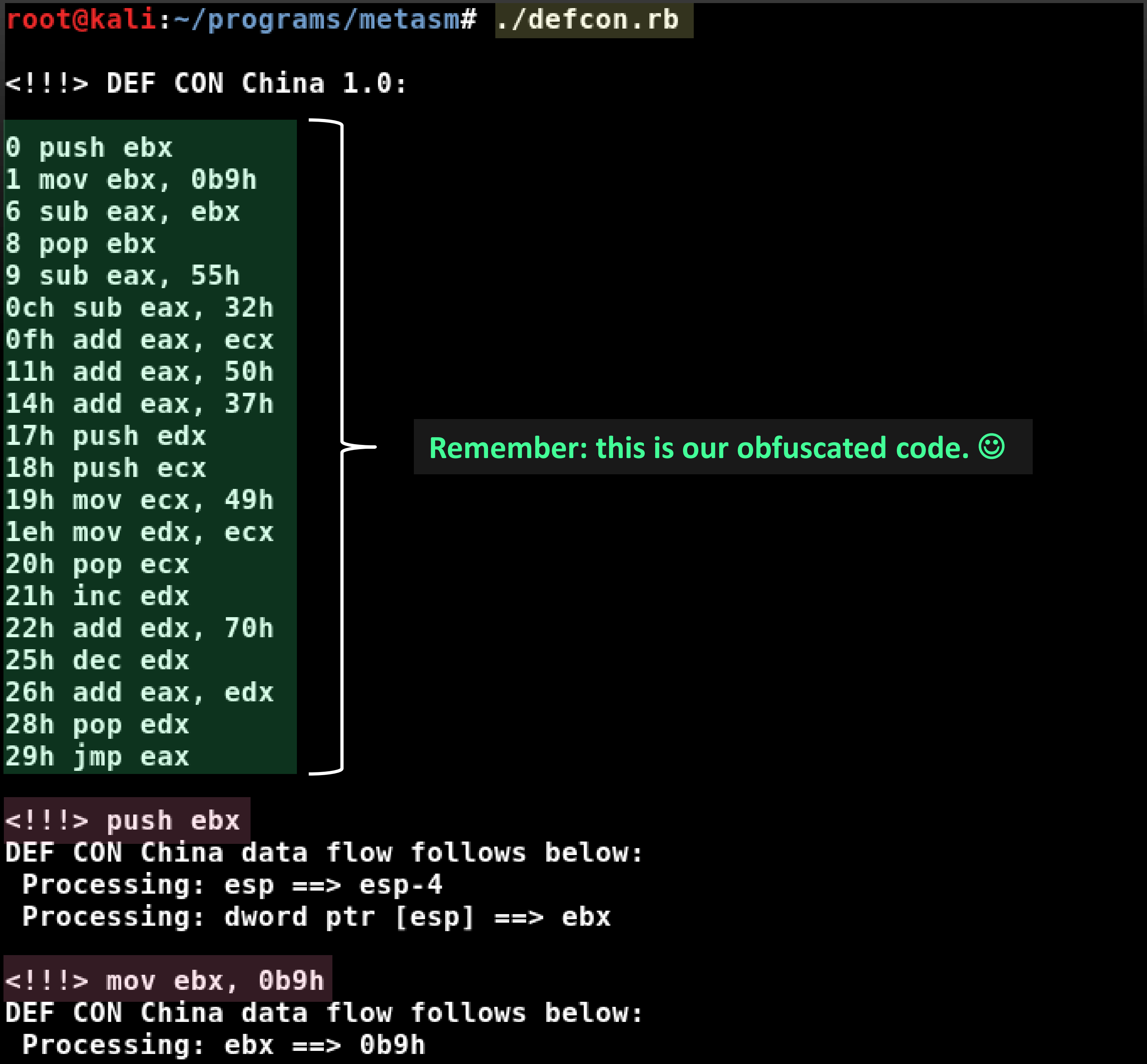


```
dd = asmcode2.block_at(addrstart2)
final = asmcode2.get_xrefs_x(dd.list.last).first
puts "\n[+] final output: #{final}"

values = asmcode2.backtrace(final, dd.list.last.address, {:log => backtracing_log = [] ,
 :include_start => true})
backtracing_log.each{|record|
        case type = record.first
        when :start
                record, expression, addresses = record
                puts "[start] Here is the sequence of expression evaluations  #{expressi
on} from 0x#{addresses.to_s(16)}\n"

        when :di
                record, new, old, instruction = record
                puts "[new update] instruction #{instruction},\n --> updating expression
 once again from #{old} to #{new}\n"

        end
}

effective = backtracing_log.select{|y| y.first==:di}.map{|y| y[3]}.reverse
puts "\nThe effective instructions are:\n\n"
puts effective
```

Backtracking from the last instruction.

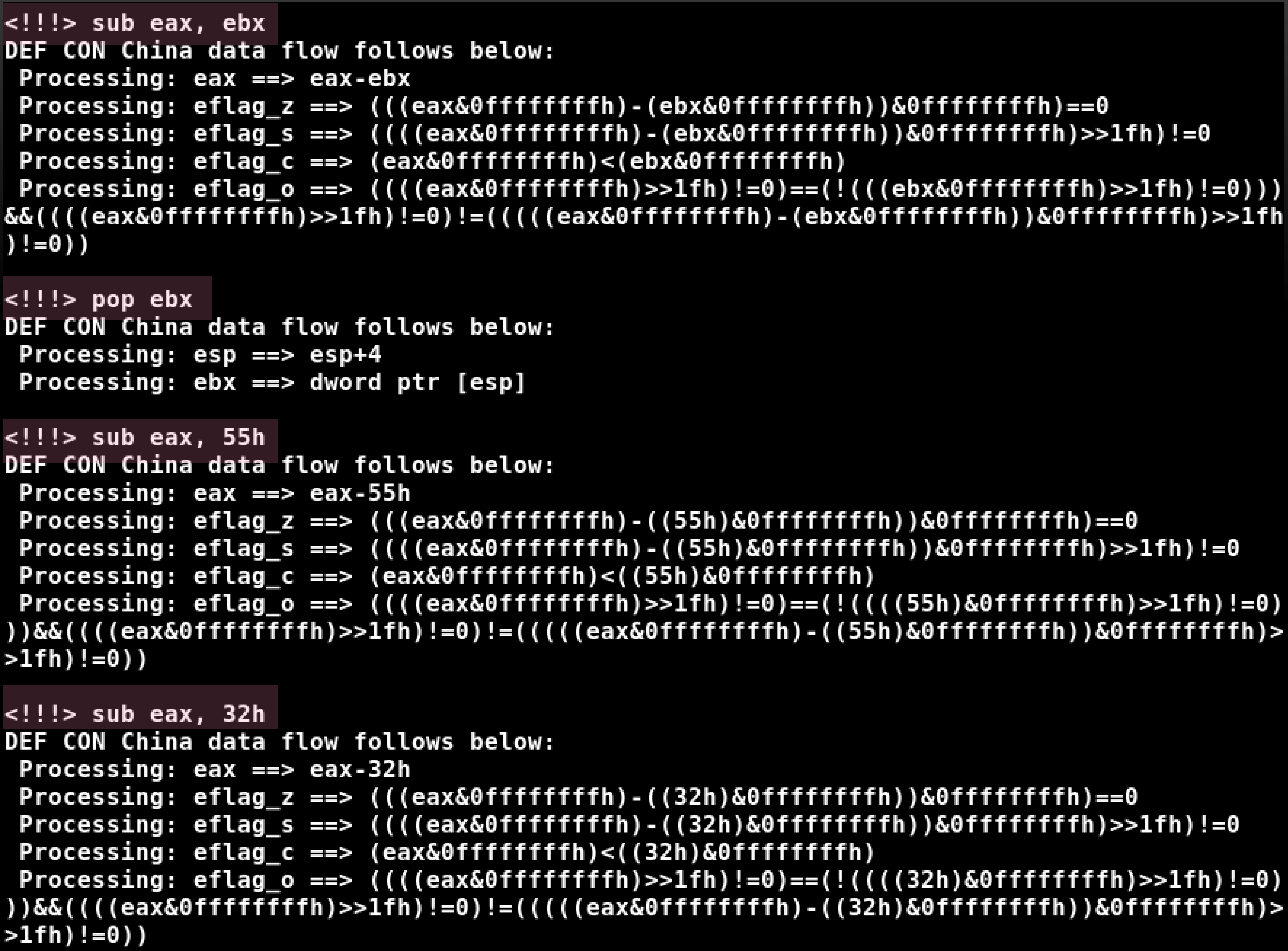
logs the sequence of backtracked instructions.

Show only the effective instructions, which really can alter the final result.

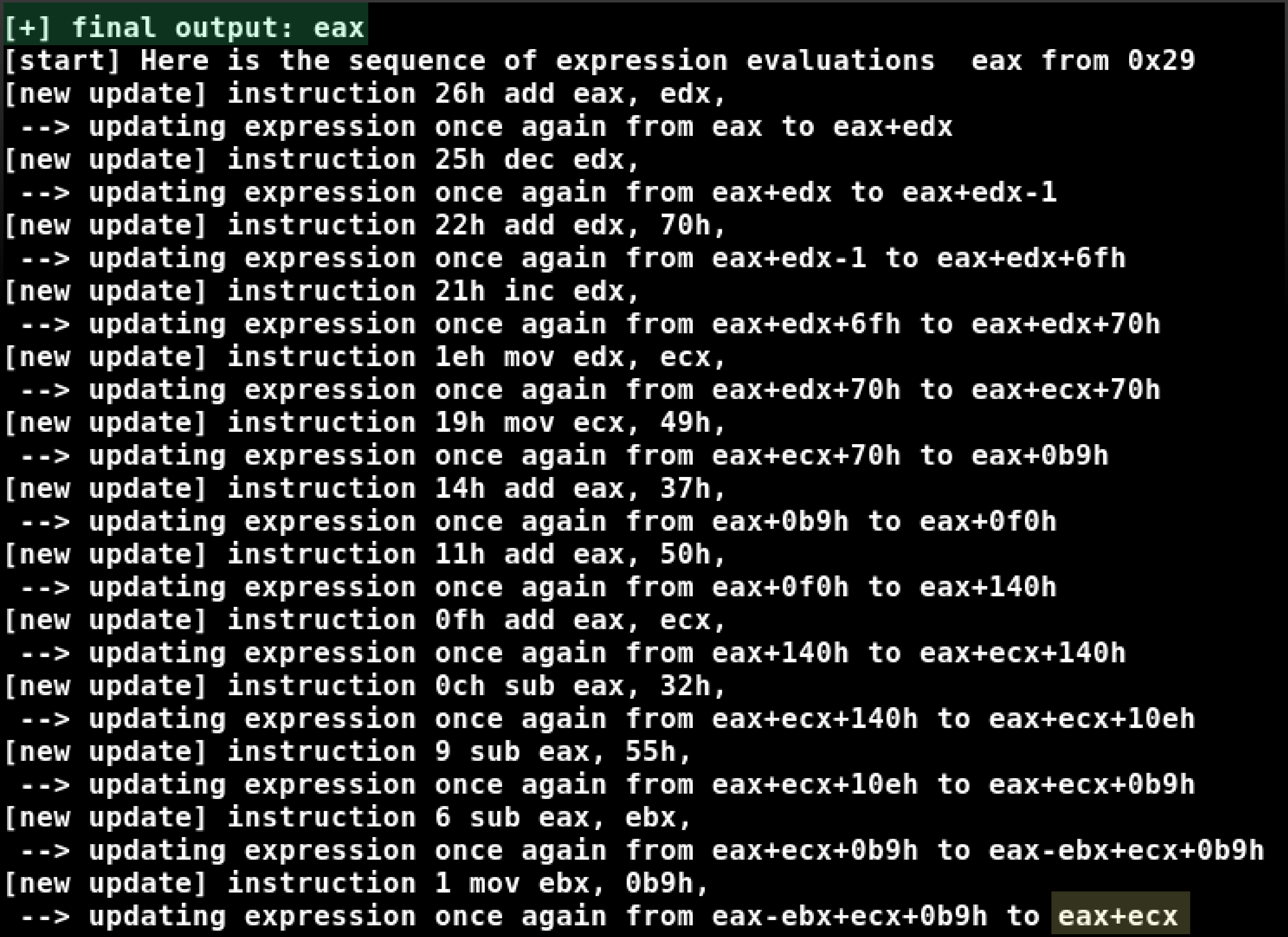


```
root@kali:~/programs/metasm# ./defcon.rb

<!!!> DEF CON China 1.0:

0 push ebx
1 mov ebx, 0b9h
6 sub eax, ebx
8 pop ebx
9 sub eax, 55h
0ch sub eax, 32h
0fh add eax, ecx
11h add eax, 50h
14h add eax, 37h
17h push edx
18h push ecx
19h mov ecx, 49h
1eh mov edx, ecx
20h pop ecx
21h inc edx
22h add edx, 70h
25h dec edx
26h add eax, edx
28h pop edx
29h jmp eax

<!!!> push ebx
DEF CON China data flow follows below:
 Processing: esp ==> esp-4
 Processing: dword ptr [esp] ==> ebx

<!!!> mov ebx, 0b9h
DEF CON China data flow follows below:
 Processing: ebx ==> 0b9h
```

Remember: this is our obfuscated code. ☺

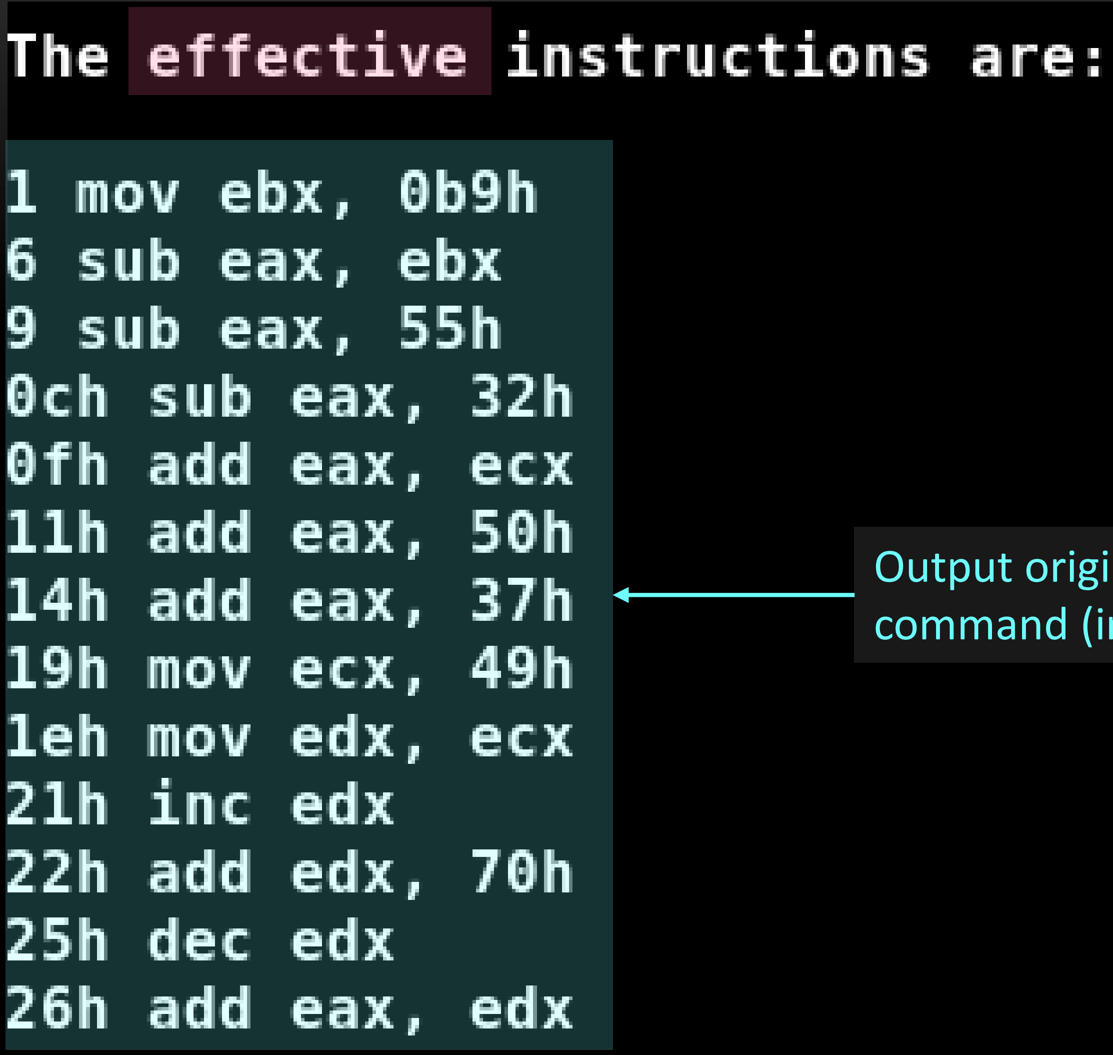


```
<!!!> sub eax, ebx
DEF CON China data flow follows below:
 Processing: eax ==> eax-ebx
 Processing: eflag_z ==> (((eax&0ffffffffh)-(ebx&0ffffffffh))&0ffffffffh)==0
 Processing: eflag_s ==> ((((eax&0ffffffffh)-(ebx&0ffffffffh))&0ffffffffh)>>1fh)!=0
 Processing: eflag_c ==> (eax&0ffffffffh)<(ebx&0ffffffffh)
 Processing: eflag_o ==> ((((eax&0ffffffffh)>>1fh)!=0)==(!(((ebx&0ffffffffh)>>1fh)!=0)))
&&((((eax&0ffffffffh)>>1fh)!=0)!=(((((eax&0ffffffffh)-(ebx&0ffffffffh))&0ffffffffh)>>1fh
)!=0))

<!!!> pop ebx
DEF CON China data flow follows below:
 Processing: esp ==> esp+4
 Processing: ebx ==> dword ptr [esp]

<!!!> sub eax, 55h
DEF CON China data flow follows below:
 Processing: eax ==> eax-55h
 Processing: eflag_z ==> (((eax&0ffffffffh)-((55h)&0ffffffffh))&0ffffffffh)==0
 Processing: eflag_s ==> ((((eax&0ffffffffh)-((55h)&0ffffffffh))&0ffffffffh)>>1fh)!=0
 Processing: eflag_c ==> (eax&0ffffffffh)<((55h)&0ffffffffh)
 Processing: eflag_o ==> ((((eax&0ffffffffh)>>1fh)!=0)==(!((((55h)&0ffffffffh)>>1fh)!=0)
))&&((((eax&0ffffffffh)>>1fh)!=0)!=(((((eax&0ffffffffh)-((55h)&0ffffffffh))&0ffffffffh)>
>1fh)!=0))

<!!!> sub eax, 32h
DEF CON China data flow follows below:
 Processing: eax ==> eax-32h
 Processing: eflag_z ==> (((eax&0ffffffffh)-((32h)&0ffffffffh))&0ffffffffh)==0
 Processing: eflag_s ==> ((((eax&0ffffffffh)-((32h)&0ffffffffh))&0ffffffffh)>>1fh)!=0
 Processing: eflag_c ==> (eax&0ffffffffh)<((32h)&0ffffffffh)
 Processing: eflag_o ==> ((((eax&0ffffffffh)>>1fh)!=0)==(!((((32h)&0ffffffffh)>>1fh)!=0)
))&&((((eax&0ffffffffh)>>1fh)!=0)!=(((((eax&0ffffffffh)-((32h)&0ffffffffh))&0ffffffffh)>
>1fh)!=0))
```



```
[+] final output: eax
[start] Here is the sequence of expression evaluations  eax from 0x29
[new update] instruction 26h add eax, edx,
 --> updating expression once again from eax to eax+edx
[new update] instruction 25h dec edx,
 --> updating expression once again from eax+edx to eax+edx-1
[new update] instruction 22h add edx, 70h,
 --> updating expression once again from eax+edx-1 to eax+edx+6fh
[new update] instruction 21h inc edx,
 --> updating expression once again from eax+edx+6fh to eax+edx+70h
[new update] instruction 1eh mov edx, ecx,
 --> updating expression once again from eax+edx+70h to eax+ecx+70h
[new update] instruction 19h mov ecx, 49h,
 --> updating expression once again from eax+ecx+70h to eax+0b9h
[new update] instruction 14h add eax, 37h,
 --> updating expression once again from eax+0b9h to eax+0f0h
[new update] instruction 11h add eax, 50h,
 --> updating expression once again from eax+0f0h to eax+140h
[new update] instruction 0fh add eax, ecx,
 --> updating expression once again from eax+140h to eax+ecx+140h
[new update] instruction 0ch sub eax, 32h,
 --> updating expression once again from eax+ecx+140h to eax+ecx+10eh
[new update] instruction 9 sub eax, 55h,
 --> updating expression once again from eax+ecx+10eh to eax+ecx+0b9h
[new update] instruction 6 sub eax, ebx,
 --> updating expression once again from eax+ecx+0b9h to eax-ebx+ecx+0b9h
[new update] instruction 1 mov ebx, 0b9h,
 --> updating expression once again from eax-ebx+ecx+0b9h to eax+ecx
```

Game over. ☺



The effective instructions are:

```
1 mov ebx, 0b9h
6 sub eax, ebx
9 sub eax, 55h
0ch sub eax, 32h
0fh add eax, ecx
11h add eax, 50h
14h add eax, 37h
19h mov ecx, 49h
1eh mov edx, ecx
21h inc edx
22h add edx, 70h
25h dec edx
26h add eax, edx
```

Output originated from backtracing_log.select command (in reverse)

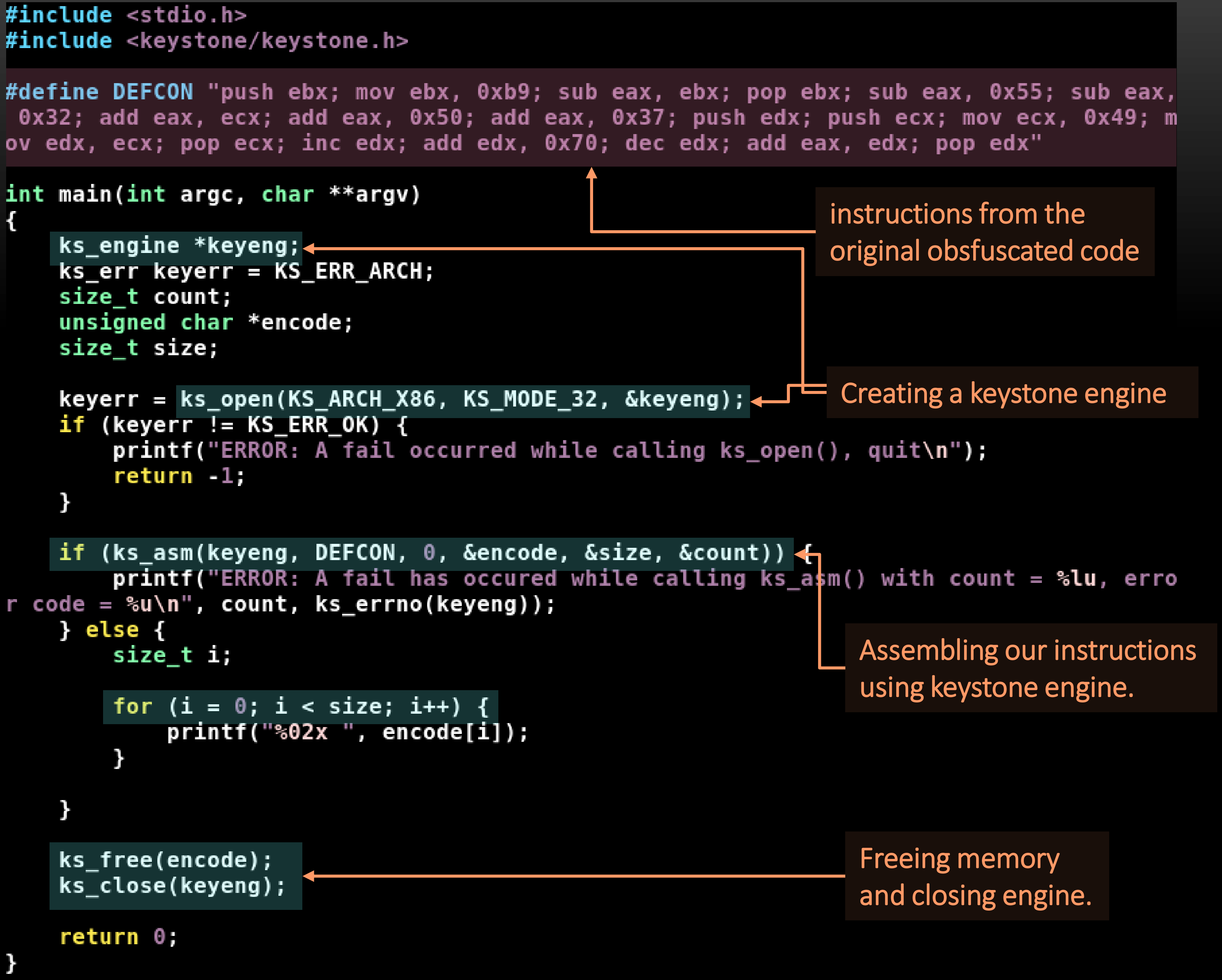
✓ Emulation is always an excellent method to solve practical reverse engineering problems and , fortunately, we have the uEmu and also could use the Keystone Engine assembler and Capstone Engine disassembler. ☺

✓ Keystone Engine acts an assembler and:

- ✓ Supports x86, Mips, Arm and many other architectures.
- ✓ It is implemented in C/C++ and has bindings to Python, Ruby, Powershell and C# (among other languages).

✓ Installing Keystone:

```
✓ root@kali:~/Desktop# wget https://github.com/keystone-engine/keystone/archive/0.9.1.tar.gz
✓ root@kali:~/programs# cp /root/Desktop/keystone-0.9.1.tar.gz .
✓ root@kali:~/programs# tar -zxvf keystone-0.9.1.tar.gz
✓ root@kali:~/programs/keystone-0.9.1# apt-get install cmake
✓ root@kali:~/programs/keystone-0.9.1# mkdir build ; cd build
✓ root@kali:~/programs/keystone-0.9.1/build# apt-get install time
✓ root@kali:~/programs/keystone-0.9.1/build# ../make-share.sh
✓ root@kali:~/programs/keystone-0.9.1/build# make install
✓ root@kali:~/programs/keystone-0.9.1/build# ldconfig
✓ root@kali:~/programs/keystone-0.9.1/build# tail -3 /root/.bashrc
✓ export PATH=$PATH:/root/programs/phantomjs-2.1.1-linux-x86_64/bin:/usr/local/bin/kstool
✓ export RUBYLIB=$RUBYLIB:~/programs/metasm
✓ export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/usr/local/lib
```



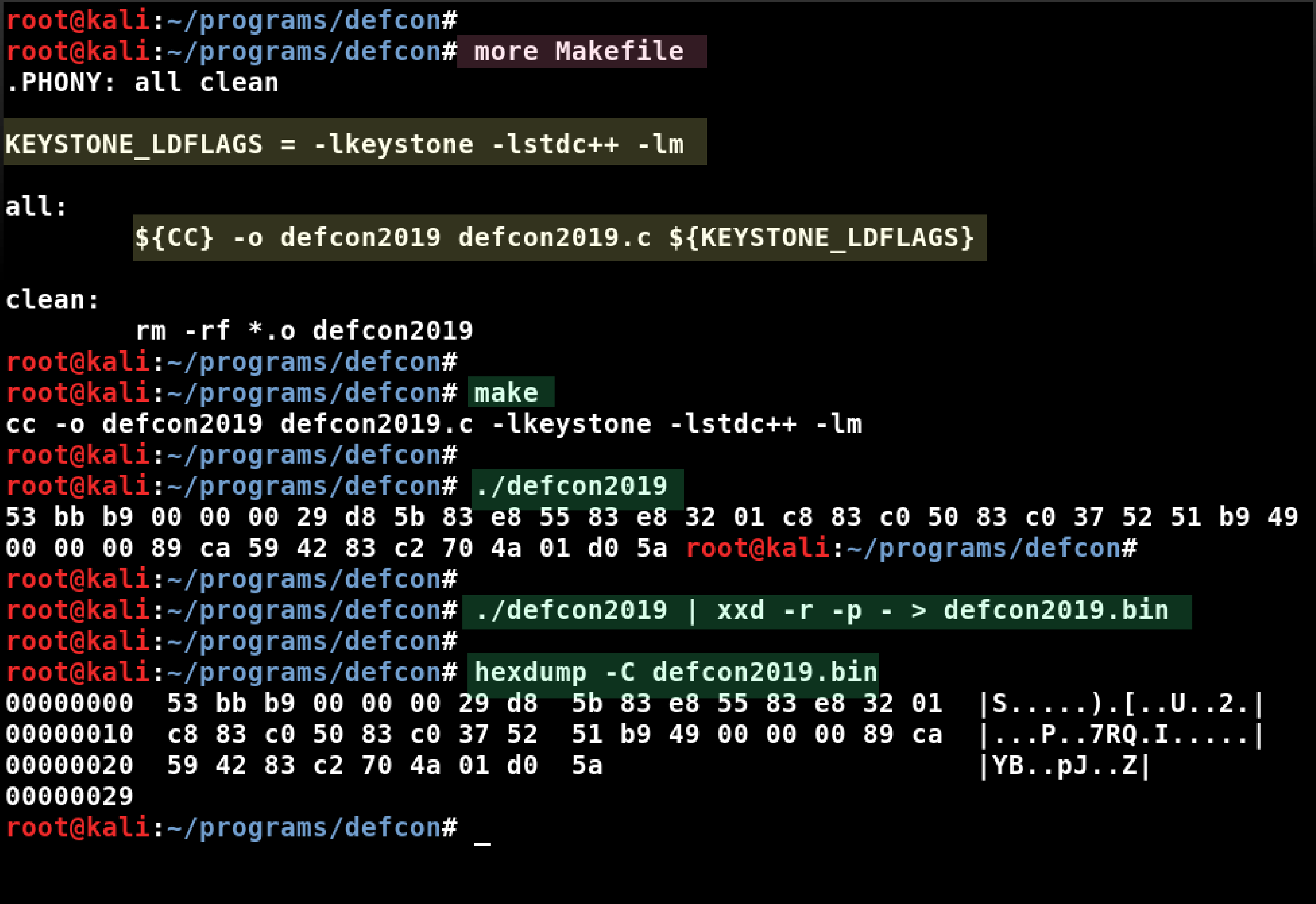
```
#include <stdio.h>
#include <keystone/keystone.h>

#define DEFCON "push ebx; mov ebx, 0xb9; sub eax, ebx; pop ebx; sub eax, 0x55; sub eax,
 0x32; add eax, ecx; add eax, 0x50; add eax, 0x37; push edx; push ecx; mov ecx, 0x49; m
ov edx, ecx; pop ecx; inc edx; add edx, 0x70; dec edx; add eax, edx; pop edx"

int main(int argc, char **argv)
{
    ks_engine *keyeng;
    ks_err keyerr = KS_ERR_ARCH;
    size_t count;
    unsigned char *encode;
    size_t size;

    keyerr = ks_open(KS_ARCH_X86, KS_MODE_32, &keyeng);
    if (keyerr != KS_ERR_OK) {
        printf("ERROR: A fail occurred while calling ks_open(), quit\n");
        return -1;
    }

    if (ks_asm(keyeng, DEFCON, 0, &encode, &size, &count)) {
        printf("ERROR: A fail has occured while calling ks_asm() with count = %lu, erro
r code = %u\n", count, ks_errno(keyeng));
    } else {
        size_t i;

        for (i = 0; i < size; i++) {
            printf("%02x ", encode[i]);
        }

    }

    ks_free(encode);
    ks_close(keyeng);

    return 0;
}
```

instructions from the original obsfuscated code

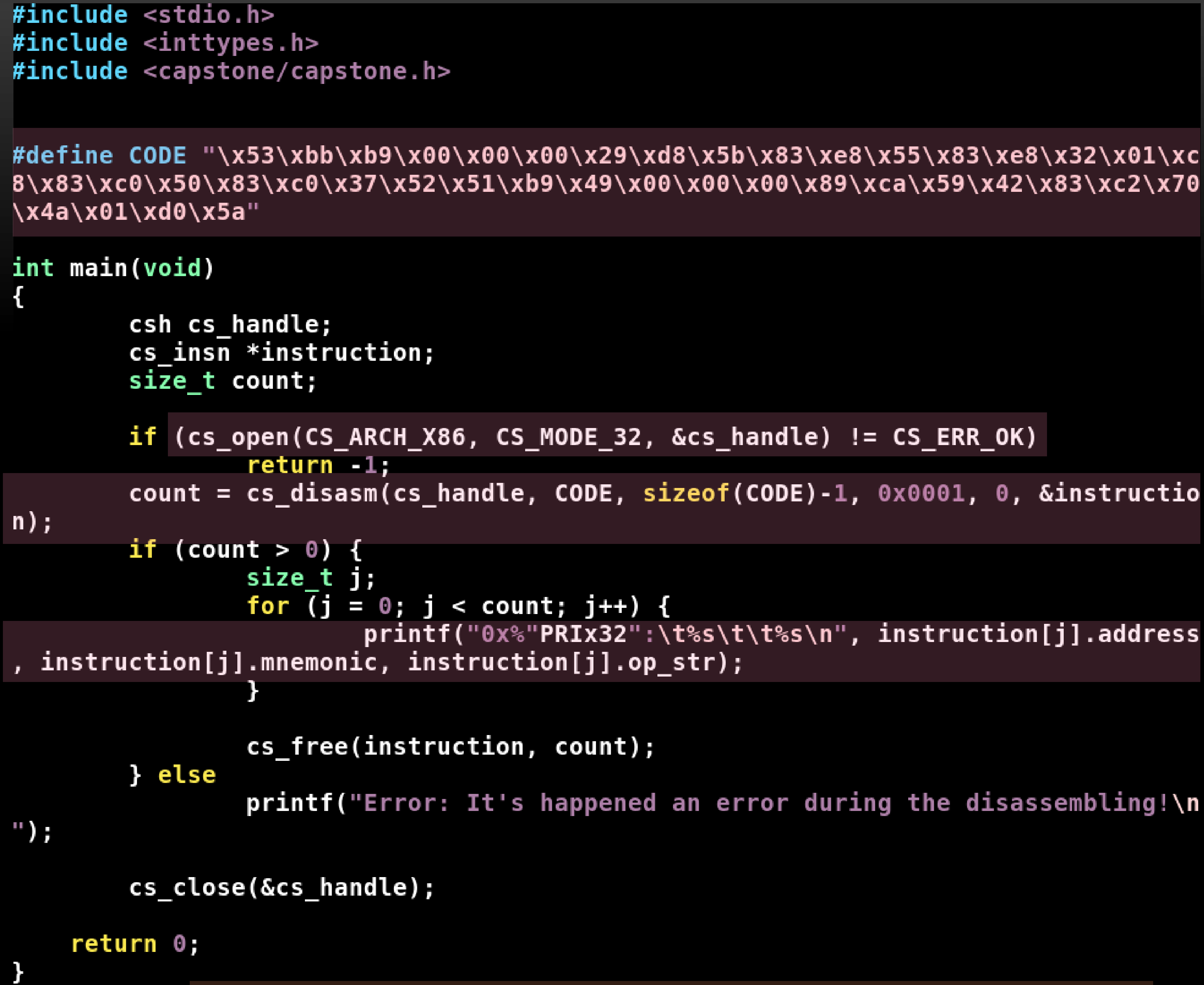
Creating a keystone engine

Assembling our instructions using keystone engine.

Freeing memory and closing engine.

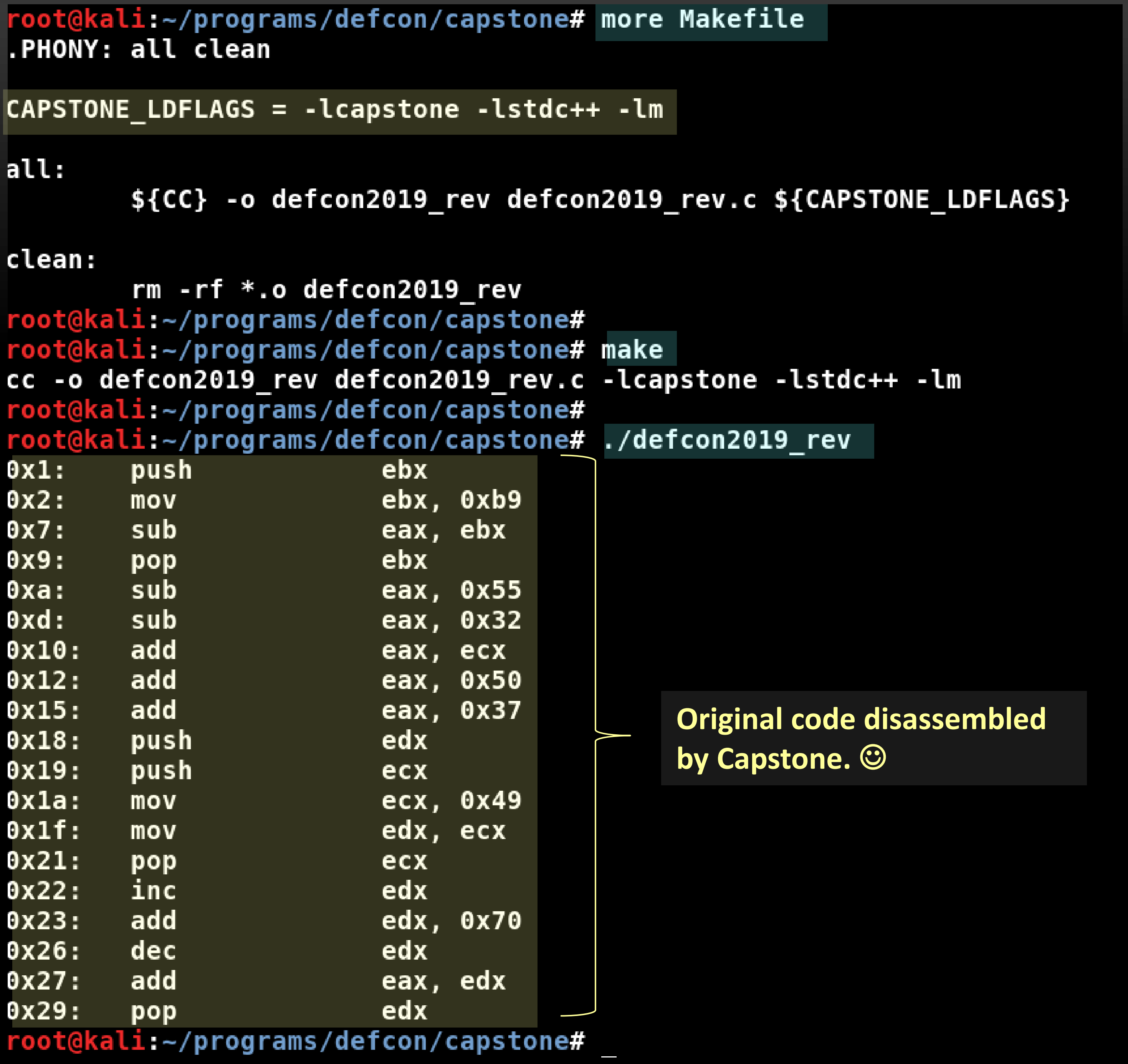


```
root@kali:~/programs/defcon#
root@kali:~/programs/defcon# more Makefile
.PHONY: all clean

KEYSTONE_LDFLAGS = -lkeystone -lstdc++ -lm

all:
        ${CC} -o defcon2019 defcon2019.c ${KEYSTONE_LDFLAGS}

clean:
        rm -rf *.o defcon2019
root@kali:~/programs/defcon#
root@kali:~/programs/defcon# make
cc -o defcon2019 defcon2019.c -lkeystone -lstdc++ -lm
root@kali:~/programs/defcon#
root@kali:~/programs/defcon# ./defcon2019
53 bb b9 00 00 00 29 d8 5b 83 e8 55 83 e8 32 01 c8 83 c0 50 83 c0 37 52 51 b9 49
00 00 00 89 ca 59 42 83 c2 70 4a 01 d0 5a root@kali:~/programs/defcon#
root@kali:~/programs/defcon#
root@kali:~/programs/defcon# ./defcon2019 | xxd -r -p - > defcon2019.bin
root@kali:~/programs/defcon#
root@kali:~/programs/defcon# hexdump -C defcon2019.bin
00000000  53 bb b9 00 00 00 29 d8  5b 83 e8 55 83 e8 32 01  |S.....).[..U..2.|
00000010  c8 83 c0 50 83 c0 37 52  51 b9 49 00 00 00 89 ca  |...P..7RQ.I.....|
00000020  59 42 83 c2 70 4a 01 d0  5a                       |YB..pJ..Z|
00000029
root@kali:~/programs/defcon# _
```



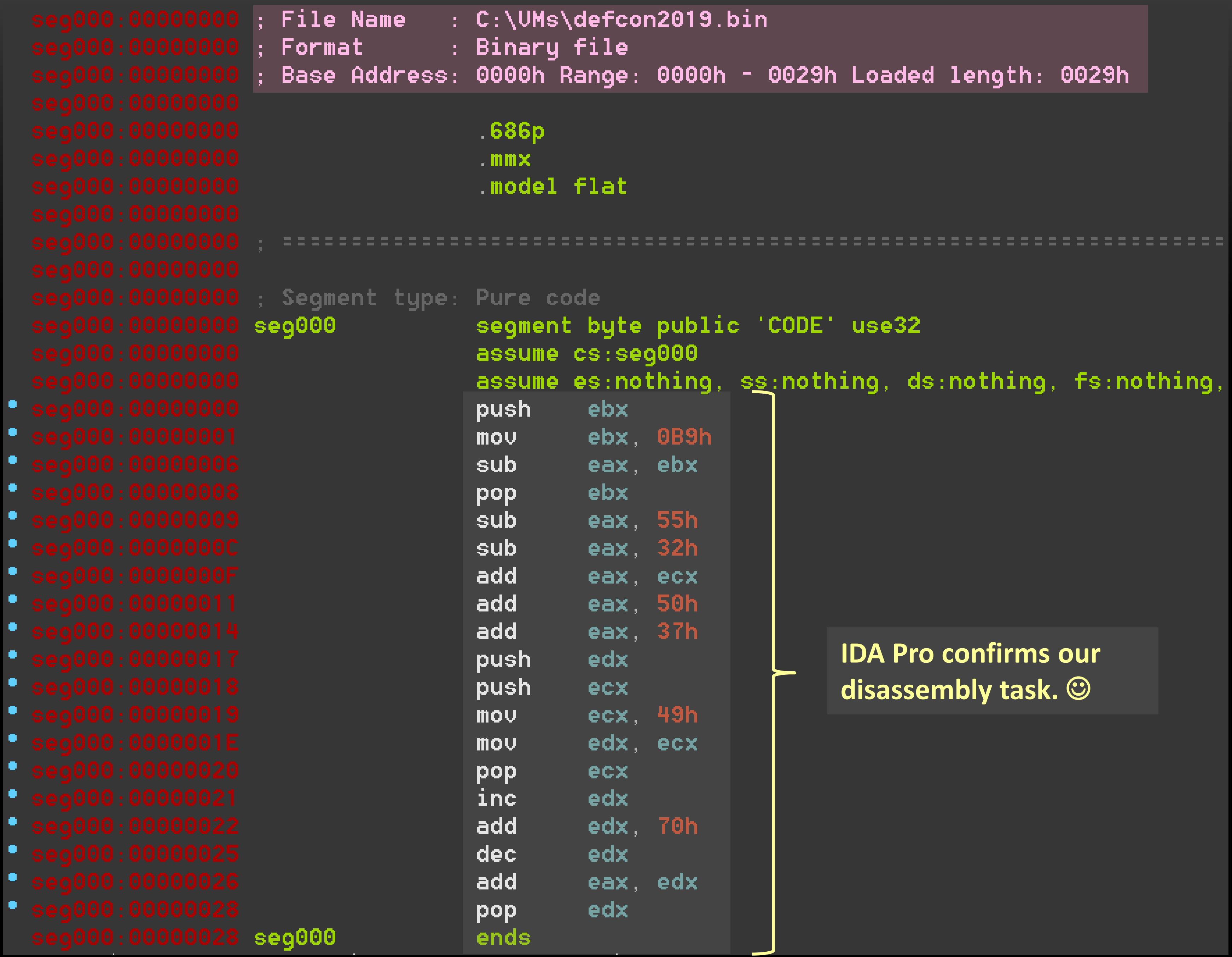
```
#include <stdio.h>
#include <inttypes.h>
#include <capstone/capstone.h>


#define CODE "\x53\xbb\xb9\x00\x00\x00\x29\xd8\x5b\x83\xe8\x55\x83\xe8\x32\x01\xc
8\x83\xc0\x50\x83\xc0\x37\x52\x51\xb9\x49\x00\x00\x00\x89\xca\x59\x42\x83\xc2\x70
\x4a\x01\xd0\x5a"

int main(void)
{
        csh cs_handle;
        cs_insn *instruction;
        size_t count;

        if (cs_open(CS_ARCH_X86, CS_MODE_32, &cs_handle) != CS_ERR_OK)
                return -1;
        count = cs_disasm(cs_handle, CODE, sizeof(CODE)-1, 0x0001, 0, &instructio
n);
        if (count > 0) {
                size_t j;
                for (j = 0; j < count; j++) {
                        printf("0x%"PRIx32":\t%s\t\t%s\n", instruction[j].address
, instruction[j].mnemonic, instruction[j].op_str);
                }

                cs_free(instruction, count);
        } else
                printf("Error: It's happened an error during the disassembling!\n
");

        cs_close(&cs_handle);

    return 0;
}
```

To install Capstone: apt-get install libcapstone3 libcapstone-dev ☺



```
root@kali:~/programs/defcon/capstone# more Makefile
.PHONY: all clean

CAPSTONE_LDFLAGS = -lcapstone -lstdc++ -lm

all:
        ${CC} -o defcon2019_rev defcon2019_rev.c ${CAPSTONE_LDFLAGS}

clean:
        rm -rf *.o defcon2019_rev
root@kali:~/programs/defcon/capstone#
root@kali:~/programs/defcon/capstone# make
cc -o defcon2019_rev defcon2019_rev.c -lcapstone -lstdc++ -lm
root@kali:~/programs/defcon/capstone#
root@kali:~/programs/defcon/capstone# ./defcon2019_rev
0x1:    push            ebx
0x2:    mov             ebx, 0xb9
0x7:    sub             eax, ebx
0x9:    pop             ebx
0xa:    sub             eax, 0x55
0xd:    sub             eax, 0x32
0x10:   add             eax, ecx
0x12:   add             eax, 0x50
0x15:   add             eax, 0x37
0x18:   push            edx
0x19:   push            ecx
0x1a:   mov             ecx, 0x49
0x1f:   mov             edx, ecx
0x21:   pop             ecx
0x22:   inc             edx
0x23:   add             edx, 0x70
0x26:   dec             edx
0x27:   add             eax, edx
0x29:   pop             edx
root@kali:~/programs/defcon/capstone# _
```

Original code disassembled by Capstone. ☺

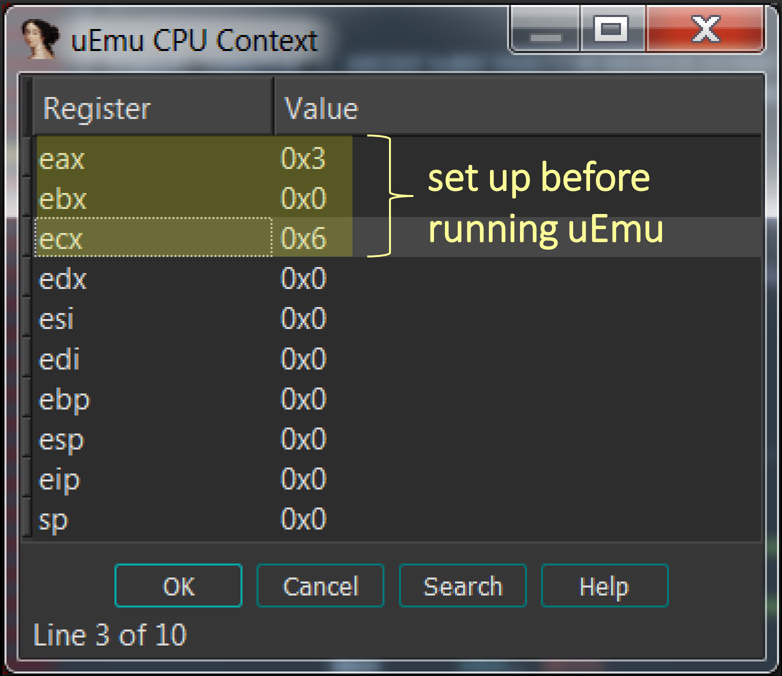


```
seg000:00000000 ; File Name    : C:\VMs\defcon2019.bin
seg000:00000000 ; Format       : Binary file
seg000:00000000 ; Base Address: 0000h Range: 0000h - 0029h Loaded length: 0029h
seg000:00000000
seg000:00000000                 .686p
seg000:00000000                 .mmx
seg000:00000000                 .model flat
seg000:00000000
seg000:00000000 ; ===================================================================
seg000:00000000
seg000:00000000 ; Segment type: Pure code
seg000:00000000 seg000          segment byte public 'CODE' use32
seg000:00000000                 assume cs:seg000
seg000:00000000                 assume es:nothing, ss:nothing, ds:nothing, fs:nothing,
seg000:00000000                 push    ebx
seg000:00000001                 mov     ebx, 0B9h
seg000:00000006                 sub     eax, ebx
seg000:00000008                 pop     ebx
seg000:00000009                 sub     eax, 55h
seg000:0000000C                 sub     eax, 32h
seg000:0000000F                 add     eax, ecx
seg000:00000011                 add     eax, 50h
seg000:00000014                 add     eax, 37h
seg000:00000017                 push    edx
seg000:00000018                 push    ecx
seg000:00000019                 mov     ecx, 49h
seg000:0000001E                 mov     edx, ecx
seg000:00000020                 pop     ecx
seg000:00000021                 inc     edx
seg000:00000022                 add     edx, 70h
seg000:00000025                 dec     edx
seg000:00000026                 add     eax, edx
seg000:00000028                 pop     edx
seg000:00000028 seg000          ends
```

IDA Pro confirms our disassembly task. ☺

ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER

- ✓ Download uEmu from https://github.com/alexhude/uEmu
- ✓ Install Unicorn: pip install unicorn.
- ✓ Load uEmu in IDA using ALT+F7 hot key.
- ✓ Right click the code and choose the uEmu sub-menu.

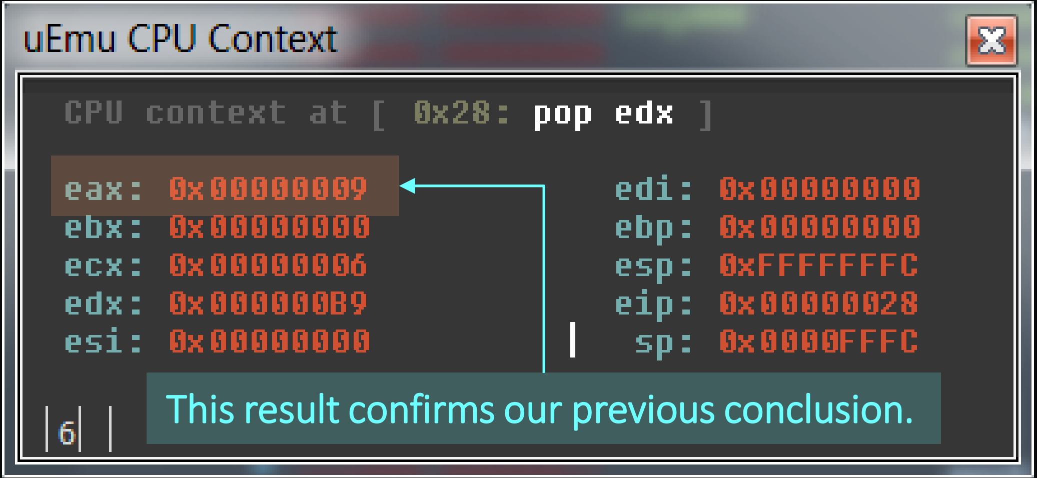


uEmu CPU Context

Register	Value
eax	0x3
ebx	0x0
ecx	0x6
edx	0x0
esi	0x0
edi	0x0
ebp	0x0
esp	0x0
eip	0x0
sp	0x0

set up before running uEmu

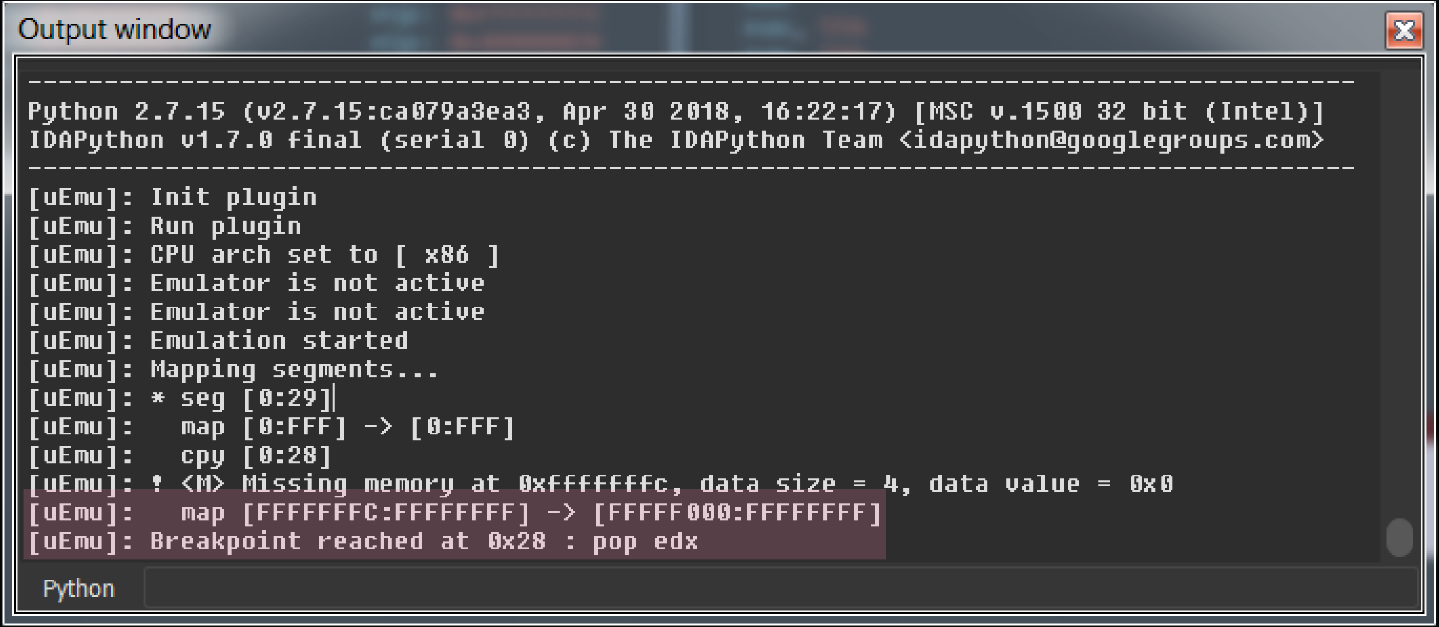
Line 3 of 10



uEmu CPU Context

```
CPU context at [ 0x28: pop edx ]

eax: 0x00000009                  edi: 0x00000000
ebx: 0x00000000                  ebp: 0x00000000
ecx: 0x00000006                  esp: 0xFFFFFFFC
edx: 0x000000B9                  eip: 0x00000028
esi: 0x00000000                   sp: 0x0000FFFC
```

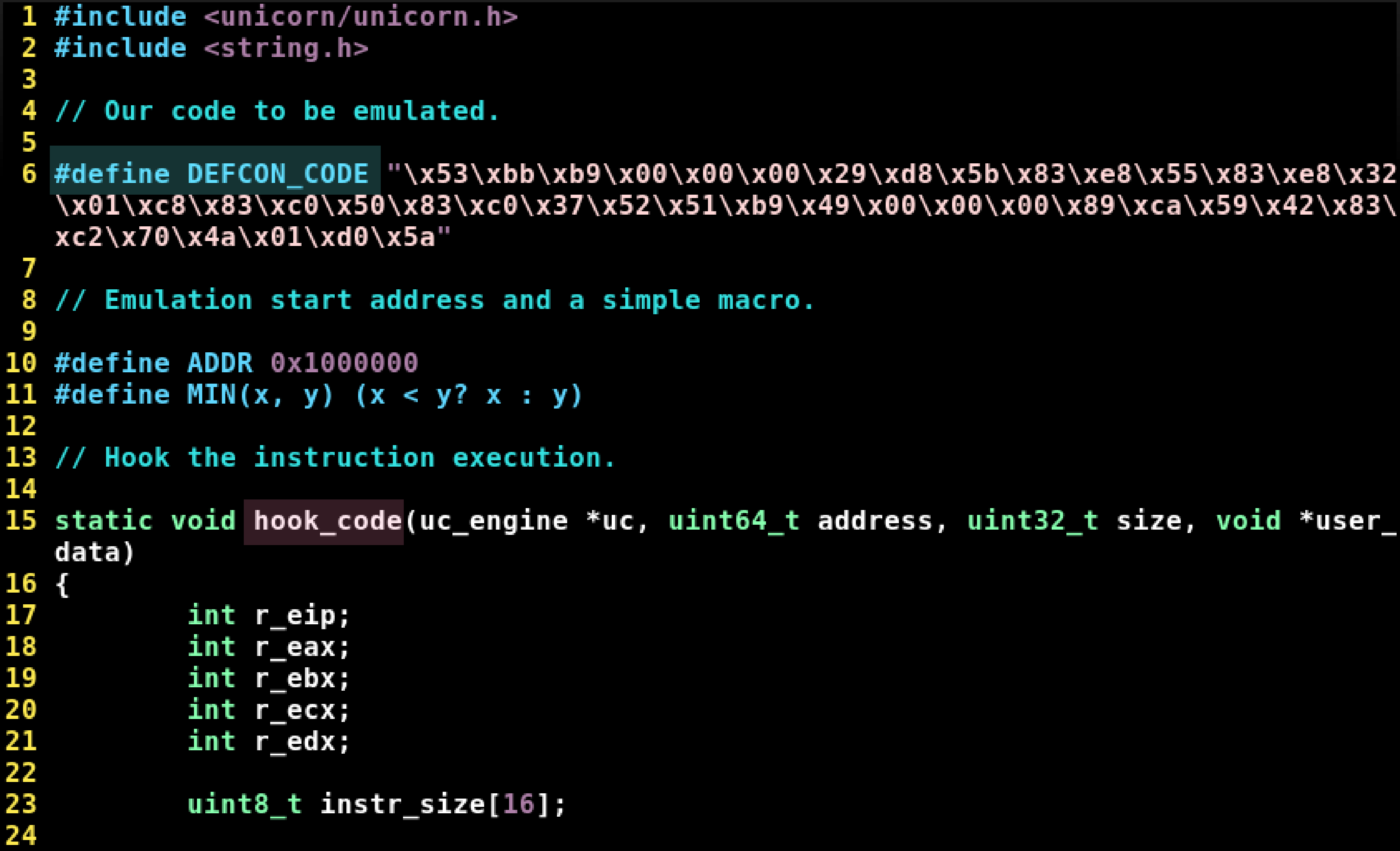
This result confirms our previous conclusion.



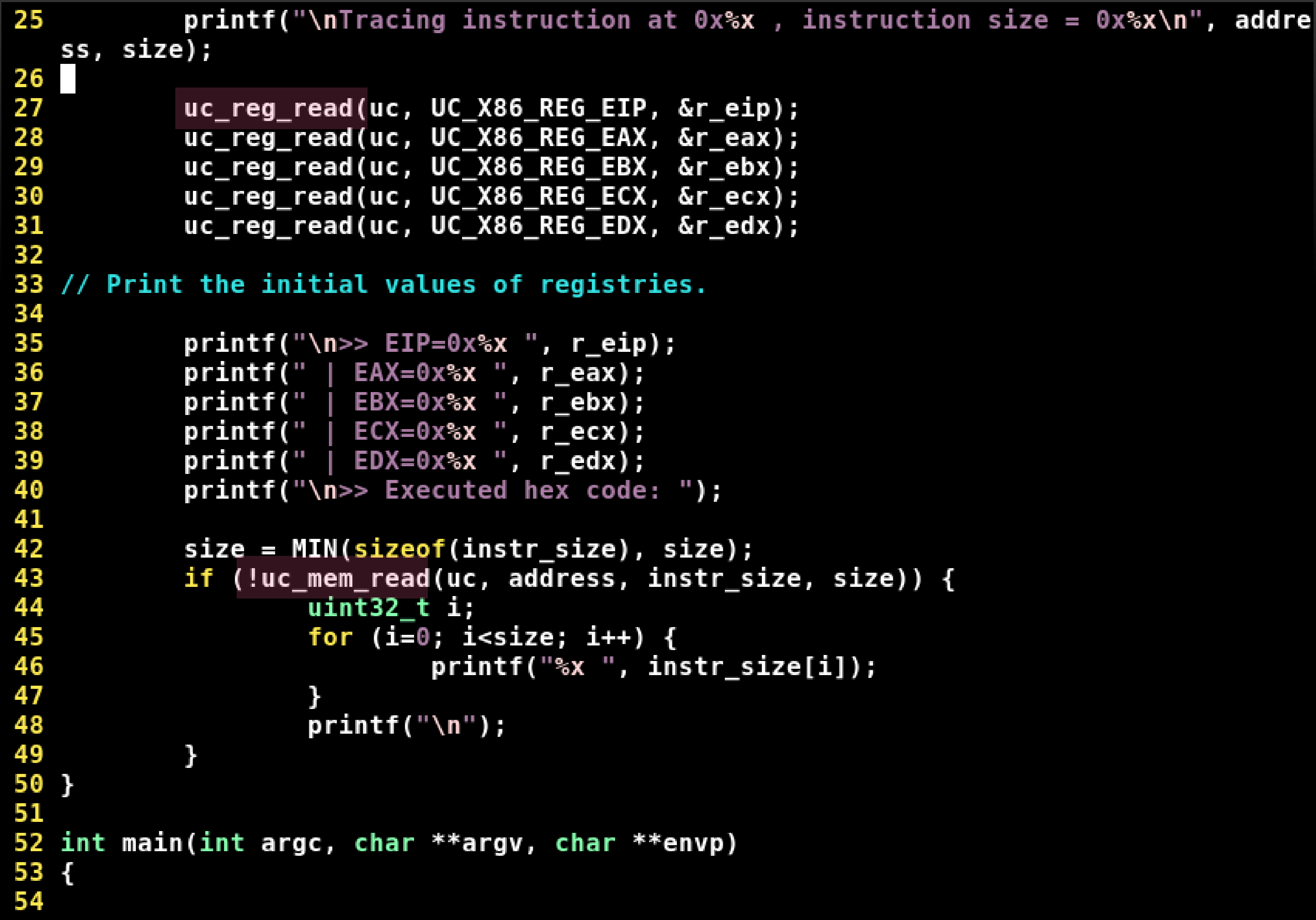
Output window

```
---------------------------------------------------------------------------------------
Python 2.7.15 (v2.7.15:ca079a3ea3, Apr 30 2018, 16:22:17) [MSC v.1500 32 bit (Intel)]
IDAPython v1.7.0 final (serial 0) (c) The IDAPython Team <idapython@googlegroups.com>
---------------------------------------------------------------------------------------
[uEmu]: Init plugin
[uEmu]: Run plugin
[uEmu]: CPU arch set to [ x86 ]
[uEmu]: Emulator is not active
[uEmu]: Emulator is not active
[uEmu]: Emulation started
[uEmu]: Mapping segments...
[uEmu]: * seg [0:29]
[uEmu]:   map [0:FFF] -> [0:FFF]
[uEmu]:   cpy [0:28]
[uEmu]: ! <M> Missing memory at 0xfffffffc, data size = 4, data value = 0x0
[uEmu]:   map [FFFFFFFC:FFFFFFFF] -> [FFFFF000:FFFFFFFF]
[uEmu]: Breakpoint reached at 0x28 : pop edx
```

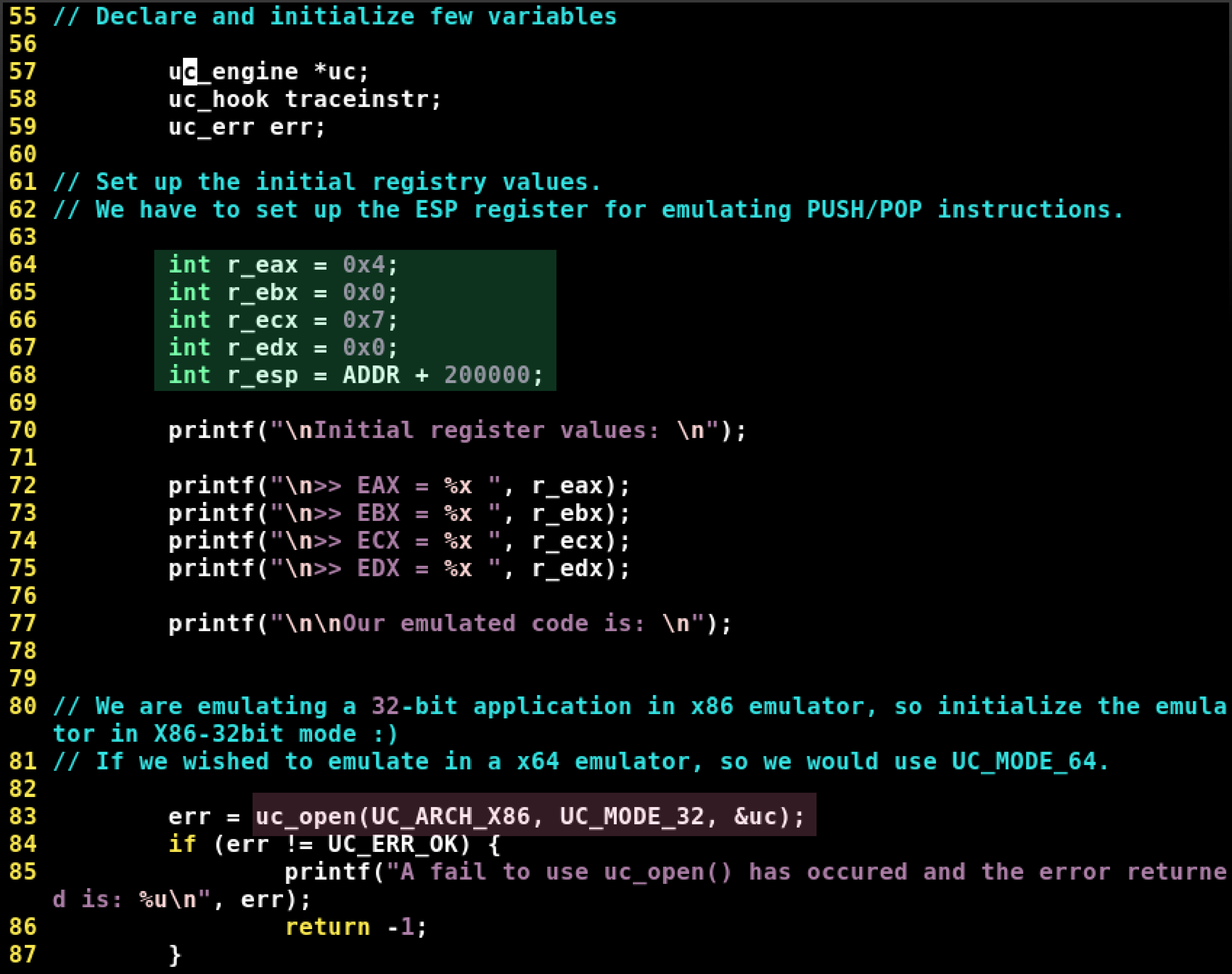
- ✓ # git clone https://github.com/unicorn-engine/unicorn.git
- ✓ # cd unicorn ; ./make.sh
- ✓ # ./make.sh install



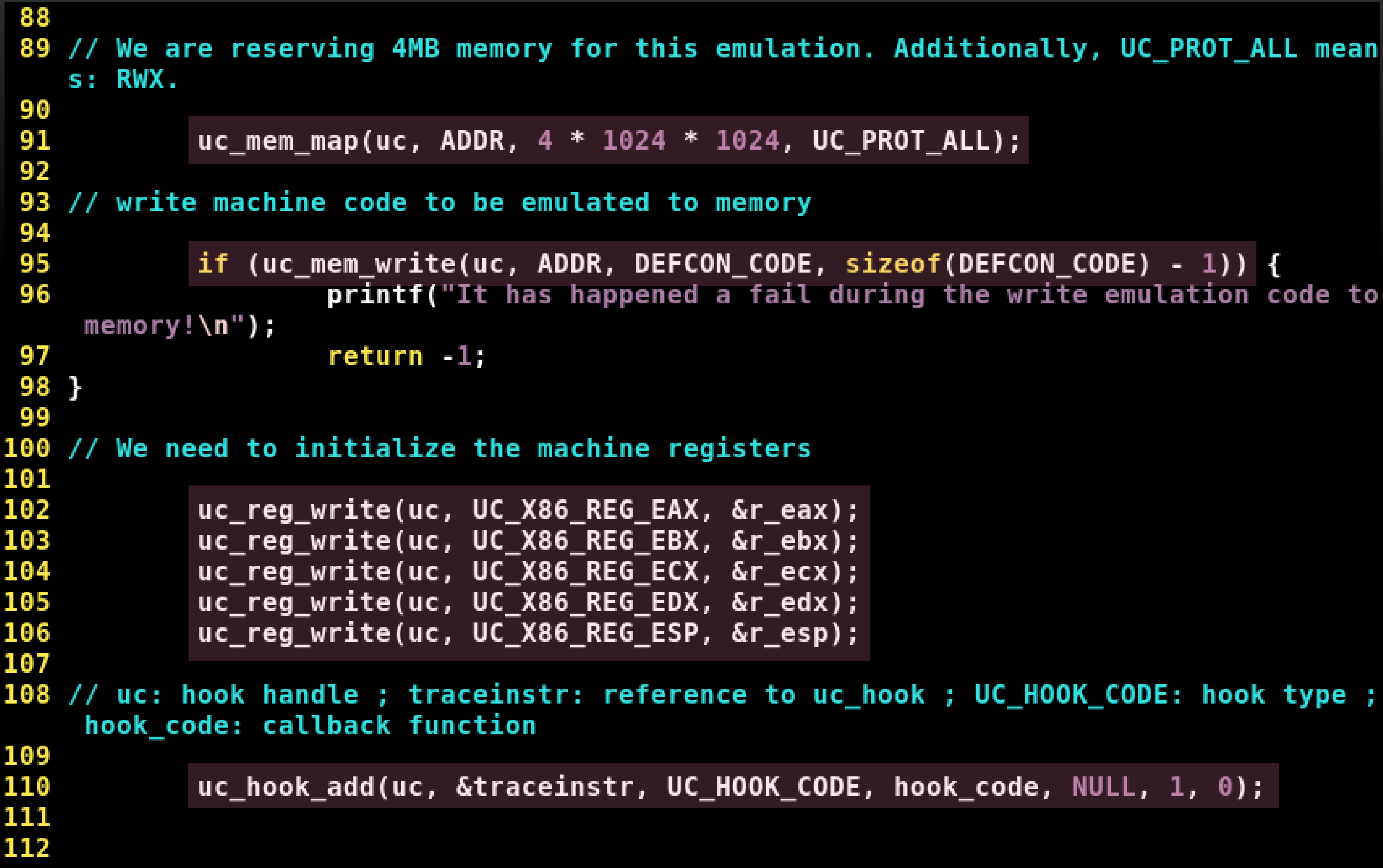
```c
#include <unicorn/unicorn.h>
#include <string.h>

// Our code to be emulated.

#define DEFCON_CODE "\x53\xbb\xb9\x00\x00\x00\x29\xd8\x5b\x83\xe8\x55\x83\xe8\x32\x01\xc8\x83\xc0\x50\x83\xc0\x37\x52\x51\xb9\x49\x00\x00\x00\x89\xca\x59\x42\x83\xc2\x70\x4a\x01\xd0\x5a"

// Emulation start address and a simple macro.

#define ADDR 0x1000000
#define MIN(x, y) (x < y? x : y)

// Hook the instruction execution.

static void hook_code(uc_engine *uc, uint64_t address, uint32_t size, void *user_data)
{
		int r_eip;
		int r_eax;
		int r_ebx;
		int r_ecx;
		int r_edx;

		uint8_t instr_size[16];

```



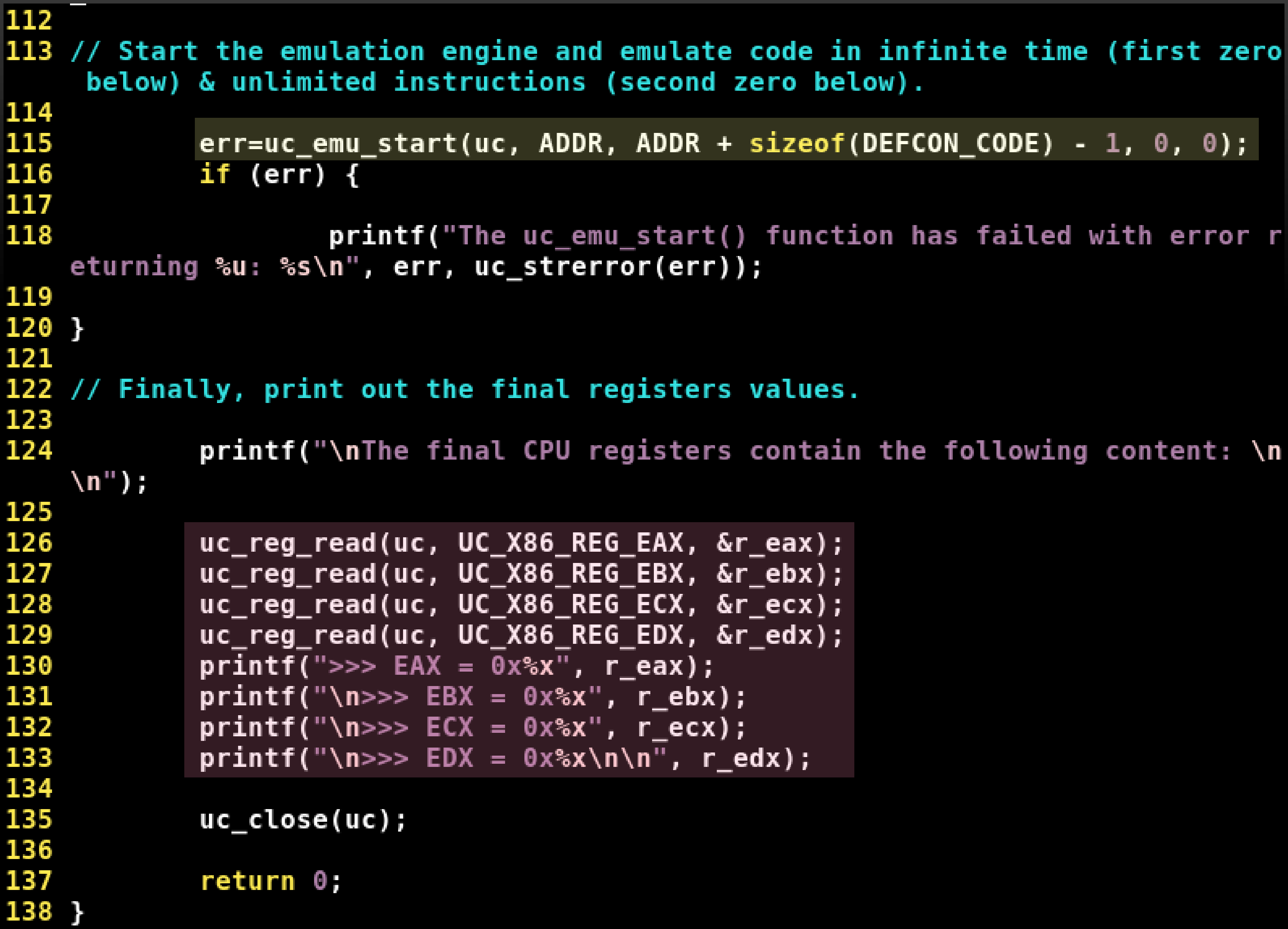
```c
        printf("\nTracing instruction at 0x%x , instruction size = 0x%x\n", address, size);

        uc_reg_read(uc, UC_X86_REG_EIP, &r_eip);
        uc_reg_read(uc, UC_X86_REG_EAX, &r_eax);
        uc_reg_read(uc, UC_X86_REG_EBX, &r_ebx);
        uc_reg_read(uc, UC_X86_REG_ECX, &r_ecx);
        uc_reg_read(uc, UC_X86_REG_EDX, &r_edx);

// Print the initial values of registries.

        printf("\n>> EIP=0x%x ", r_eip);
        printf(" | EAX=0x%x ", r_eax);
        printf(" | EBX=0x%x ", r_ebx);
        printf(" | ECX=0x%x ", r_ecx);
        printf(" | EDX=0x%x ", r_edx);
        printf("\n>> Executed hex code: ");

        size = MIN(sizeof(instr_size), size);
        if (!uc_mem_read(uc, address, instr_size, size)) {
                uint32_t i;
                for (i=0; i<size; i++) {
                        printf("%x ", instr_size[i]);
                }
                printf("\n");
        }
}

int main(int argc, char **argv, char **envp)
{

```



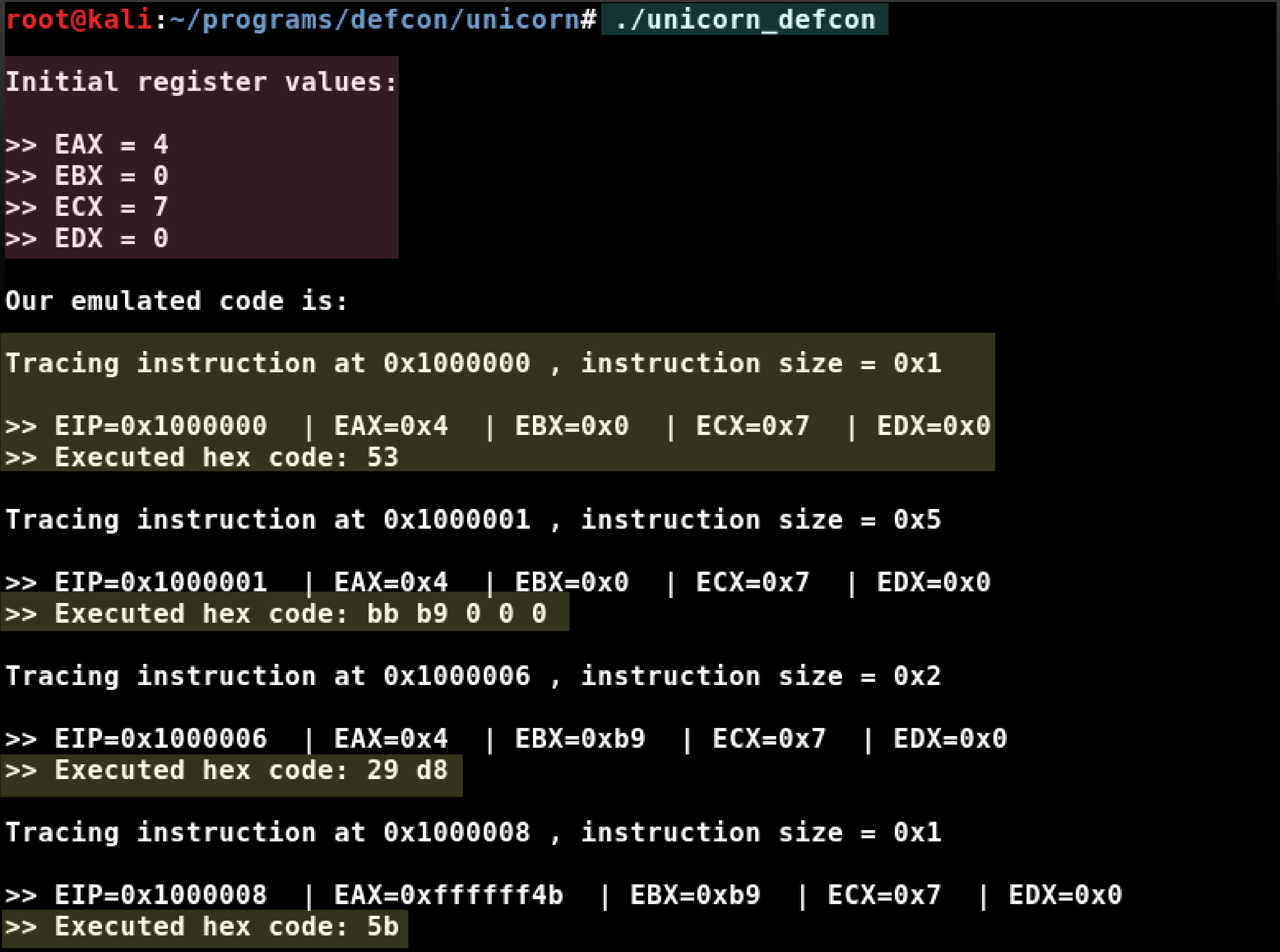
```c
// Declare and initialize few variables

        uc_engine *uc;
        uc_hook traceinstr;
        uc_err err;

// Set up the initial registry values.
// We have to set up the ESP register for emulating PUSH/POP instructions.

        int r_eax = 0x4;
        int r_ebx = 0x0;
        int r_ecx = 0x7;
        int r_edx = 0x0;
        int r_esp = ADDR + 200000;

        printf("\nInitial register values: \n");

        printf("\n>> EAX = %x ", r_eax);
        printf("\n>> EBX = %x ", r_ebx);
        printf("\n>> ECX = %x ", r_ecx);
        printf("\n>> EDX = %x ", r_edx);

        printf("\n\nOur emulated code is: \n");


// We are emulating a 32-bit application in x86 emulator, so initialize the emulator in X86-32bit mode :)
// If we wished to emulate in a x64 emulator, so we would use UC_MODE_64.

        err = uc_open(UC_ARCH_X86, UC_MODE_32, &uc);
        if (err != UC_ERR_OK) {
                printf("A fail to use uc_open() has occured and the error returned is: %u\n", err);
                return -1;
        }
```



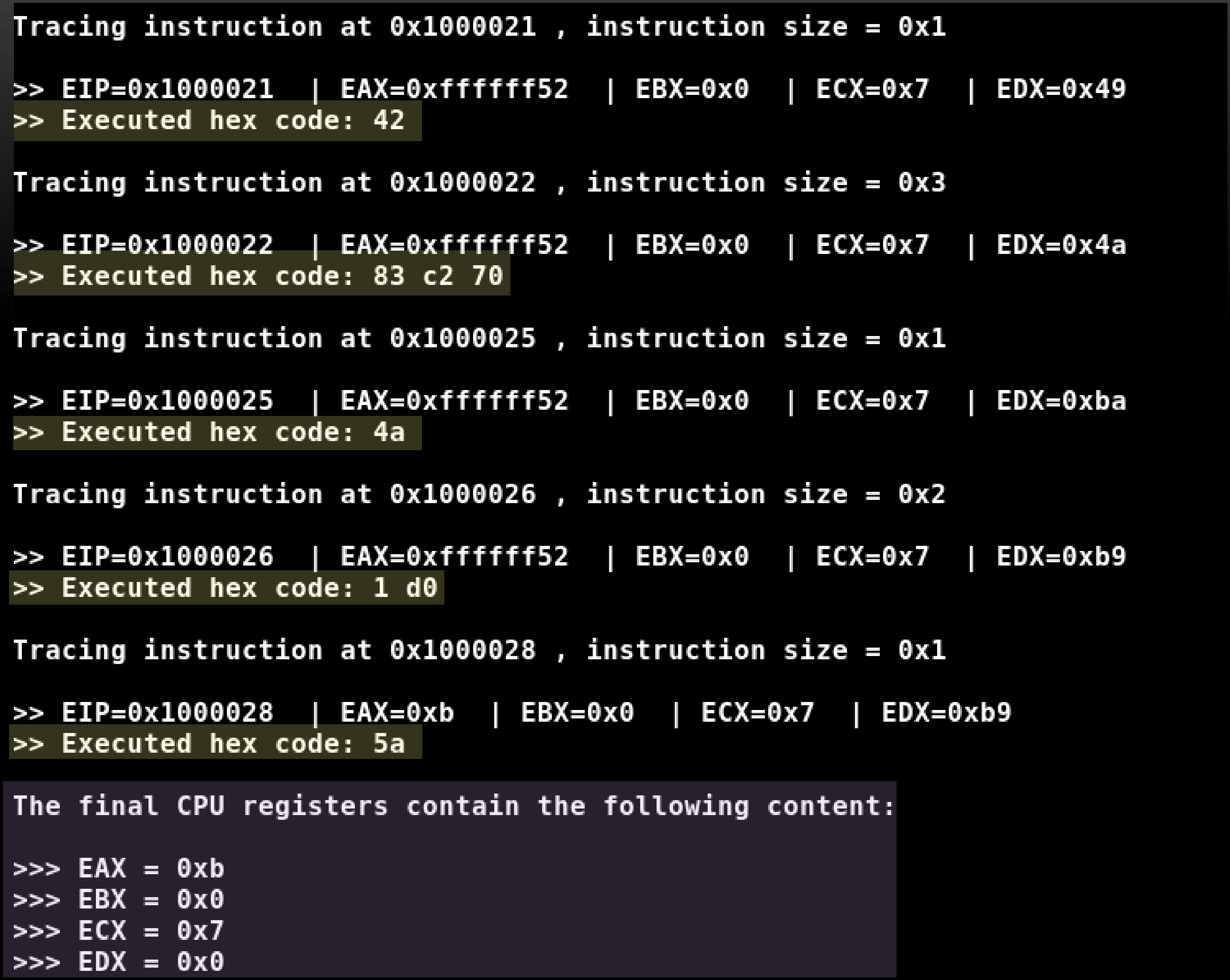
```

// We are reserving 4MB memory for this emulation. Additionally, UC_PROT_ALL means: RWX.

        uc_mem_map(uc, ADDR, 4 * 1024 * 1024, UC_PROT_ALL);

// write machine code to be emulated to memory

        if (uc_mem_write(uc, ADDR, DEFCON_CODE, sizeof(DEFCON_CODE) - 1)) {
                printf("It has happened a fail during the write emulation code to memory!\n");
                return -1;
}

// We need to initialize the machine registers

        uc_reg_write(uc, UC_X86_REG_EAX, &r_eax);
        uc_reg_write(uc, UC_X86_REG_EBX, &r_ebx);
        uc_reg_write(uc, UC_X86_REG_ECX, &r_ecx);
        uc_reg_write(uc, UC_X86_REG_EDX, &r_edx);
        uc_reg_write(uc, UC_X86_REG_ESP, &r_esp);

// uc: hook handle ; traceinstr: reference to uc_hook ; UC_HOOK_CODE: hook type ; hook_code: callback function

        uc_hook_add(uc, &traceinstr, UC_HOOK_CODE, hook_code, NULL, 1, 0);


```



```
// Start the emulation engine and emulate code in infinite time (first zero below) & unlimited instructions (second zero below).

        err=uc_emu_start(uc, ADDR, ADDR + sizeof(DEFCON_CODE) - 1, 0, 0);
        if (err) {

                printf("The uc_emu_start() function has failed with error returning %u: %s\n", err, uc_strerror(err));

}

// Finally, print out the final registers values.

        printf("\nThe final CPU registers contain the following content: \n\n");

        uc_reg_read(uc, UC_X86_REG_EAX, &r_eax);
        uc_reg_read(uc, UC_X86_REG_EBX, &r_ebx);
        uc_reg_read(uc, UC_X86_REG_ECX, &r_ecx);
        uc_reg_read(uc, UC_X86_REG_EDX, &r_edx);
        printf(">>> EAX = 0x%x", r_eax);
        printf("\n>>> EBX = 0x%x", r_ebx);
        printf("\n>>> ECX = 0x%x", r_ecx);
        printf("\n>>> EDX = 0x%x\n\n", r_edx);

        uc_close(uc);

        return 0;
}
```



```
root@kali:~/programs/defcon/unicorn# ./unicorn_defcon

Initial register values:

>> EAX = 4
>> EBX = 0
>> ECX = 7
>> EDX = 0

Our emulated code is:

Tracing instruction at 0x1000000 , instruction size = 0x1

>> EIP=0x1000000  | EAX=0x4  | EBX=0x0  | ECX=0x7  | EDX=0x0
>> Executed hex code: 53

Tracing instruction at 0x1000001 , instruction size = 0x5

>> EIP=0x1000001  | EAX=0x4  | EBX=0x0  | ECX=0x7  | EDX=0x0
>> Executed hex code: bb b9 0 0 0

Tracing instruction at 0x1000006 , instruction size = 0x2

>> EIP=0x1000006  | EAX=0x4  | EBX=0xb9  | ECX=0x7  | EDX=0x0
>> Executed hex code: 29 d8

Tracing instruction at 0x1000008 , instruction size = 0x1

>> EIP=0x1000008  | EAX=0xffffff4b  | EBX=0xb9  | ECX=0x7  | EDX=0x0
>> Executed hex code: 5b
```



```
Tracing instruction at 0x1000021 , instruction size = 0x1

>> EIP=0x1000021  | EAX=0xffffff52  | EBX=0x0  | ECX=0x7  | EDX=0x49
>> Executed hex code: 42

Tracing instruction at 0x1000022 , instruction size = 0x3

>> EIP=0x1000022  | EAX=0xffffff52  | EBX=0x0  | ECX=0x7  | EDX=0x4a
>> Executed hex code: 83 c2 70

Tracing instruction at 0x1000025 , instruction size = 0x1

>> EIP=0x1000025  | EAX=0xffffff52  | EBX=0x0  | ECX=0x7  | EDX=0xba
>> Executed hex code: 4a

Tracing instruction at 0x1000026 , instruction size = 0x2

>> EIP=0x1000026  | EAX=0xffffff52  | EBX=0x0  | ECX=0x7  | EDX=0xb9
>> Executed hex code: 1 d0

Tracing instruction at 0x1000028 , instruction size = 0x1

>> EIP=0x1000028  | EAX=0xb  | EBX=0x0  | ECX=0x7  | EDX=0xb9
>> Executed hex code: 5a

The final CPU registers contain the following content:

>>> EAX = 0xb
>>> EBX = 0x0
>>> ECX = 0x7
>>> EDX = 0x0
```

MIASM

- MIASM is one of most impressive framework for reverse engineering, which is able to analyze, generate and modify several different types of programs.

- MIASM supports assembling and disassembling programs from different platforms such as ARM, x86, MIPS and so on, and it also is able to emulate by using JIT.

- Therefore, MIASM is excellent to de-obfuscation.

- Installing MIASM:

    - git clone https://github.com/serpilliere/elfesteem.git elfesteem
    - cd elfesteem/
    - python setup.py build
    - python setup.py install
    - apt-get install clang texinfo texi2html
    - apt-get remove libtcc-dev
    - apt-get install llvm
    - cd ..
    - git clone http://repo.or.cz/tinycc.git
    - cd tinycc/
    - git checkout release_0_9_26
    - ./configure --disable-static
    - make
    - make install

✓ pip install llvmlite

✓ apt-get install z3

✓ apt-get install python-pycparser

✓ git clone https://github.com/cea-sec/miasm.git

✓ root@kali:~/programs/miasm# python setup.py build

✓ root@kali:~/programs/miasm# python setup.py install

✓ root@kali:~/programs/miasm/test# python test_all.py

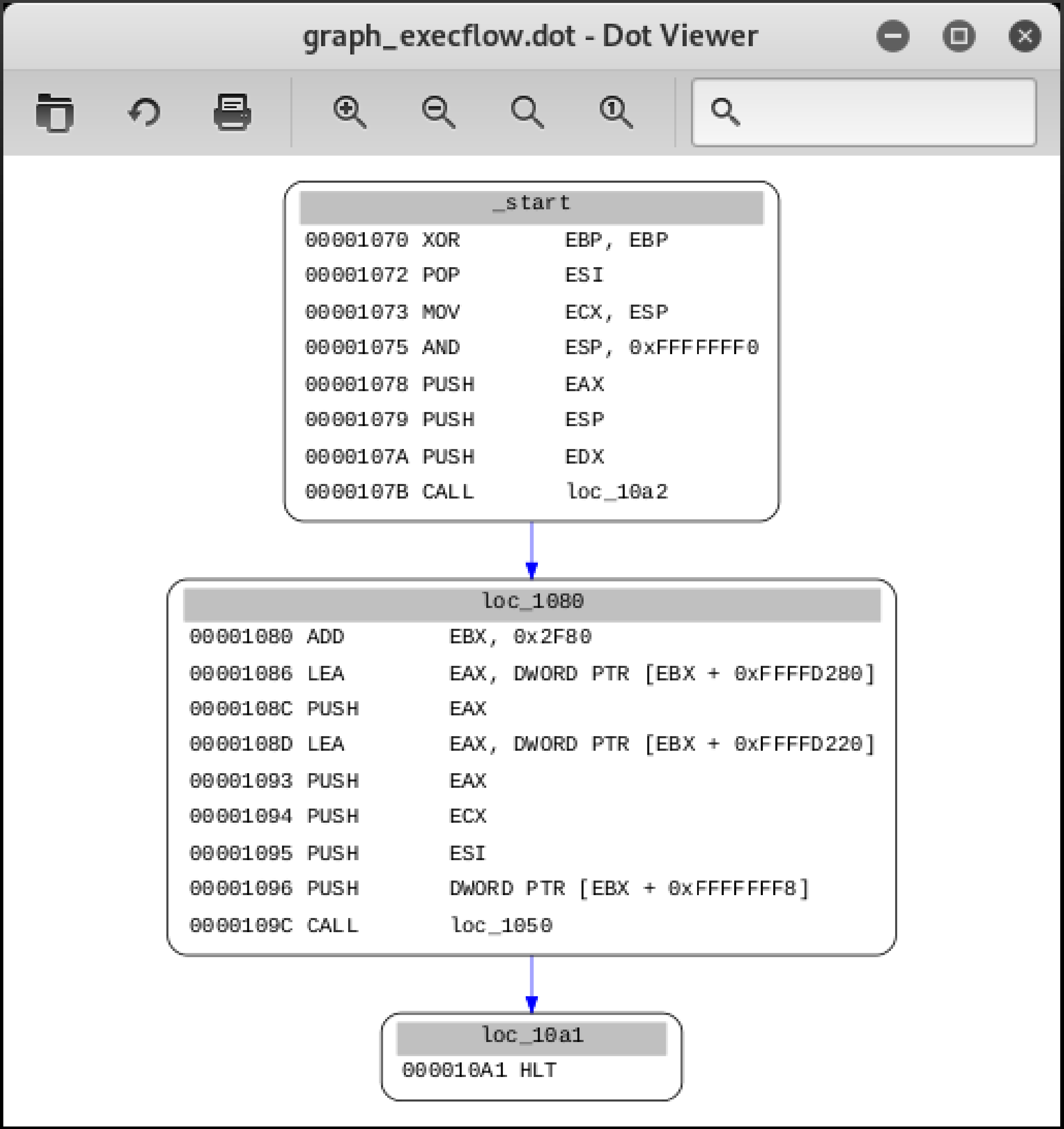
✓ apt-get install graphviz

✓ apt-get install xdot

✓ (testing MIASM) root@kali:~/programs# python /root/programs/miasm/example/disasm/full.py -m x86_32 /root/programs/shellcode

```
INFO : Load binary
INFO : ok
INFO : import machine...
INFO : ok
INFO : func ok 0000000000001070 (0)
INFO : generate graph file
INFO : generate intervals
[0x1070 0x10A2]
INFO : total lines 0
```

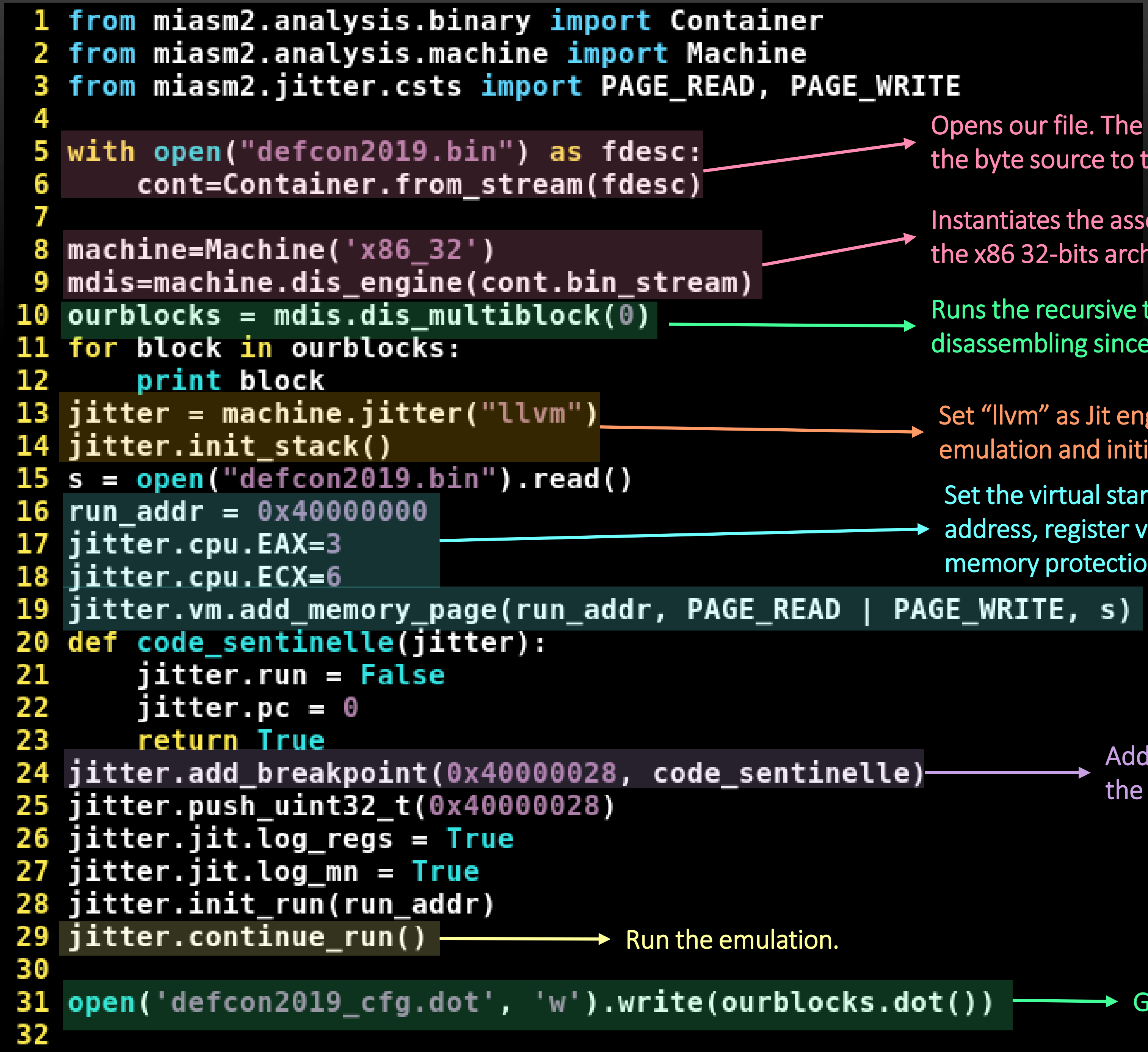
✓ (testing MIASM) xdot graph_execflow.dot



```
_start
00001070 XOR        EBP, EBP
00001072 POP        ESI
00001073 MOV        ECX, ESP
00001075 AND        ESP, 0xFFFFFFF0
00001078 PUSH       EAX
00001079 PUSH       ESP
0000107A PUSH       EDX
0000107B CALL       loc_10a2
```

```
loc_1080
00001080 ADD        EBX, 0x2F80
00001086 LEA        EAX, DWORD PTR [EBX + 0xFFFFD280]
0000108C PUSH       EAX
0000108D LEA        EAX, DWORD PTR [EBX + 0xFFFFD220]
00001093 PUSH       EAX
00001094 PUSH       ECX
00001095 PUSH       ESI
00001096 PUSH       DWORD PTR [EBX + 0xFFFFFFF8]
0000109C CALL       loc_1050
```

```
loc_10a1
000010A1 HLT
```



```
from miasm2.analysis.binary import Container
from miasm2.analysis.machine import Machine
from miasm2.jitter.csts import PAGE_READ, PAGE_WRITE

with open("defcon2019.bin") as fdesc:
    cont=Container.from_stream(fdesc)

machine=Machine('x86_32')
mdis=machine.dis_engine(cont.bin_stream)
ourblocks = mdis.dis_multiblock(0)
for block in ourblocks:
    print block
jitter = machine.jitter("llvm")
jitter.init_stack()
s = open("defcon2019.bin").read()
run_addr = 0x40000000
jitter.cpu.EAX=3
jitter.cpu.ECX=6
jitter.vm.add_memory_page(run_addr, PAGE_READ | PAGE_WRITE, s)
def code_sentinelle(jitter):
    jitter.run = False
    jitter.pc = 0
    return True
jitter.add_breakpoint(0x40000028, code_sentinelle)
jitter.push_uint32_t(0x40000028)
jitter.jit.log_regs = True
jitter.jit.log_mn = True
jitter.init_run(run_addr)
jitter.continue_run()

open('defcon2019_cfg.dot', 'w').write(ourblocks.dot())

```

Opens our file. The Container provides the byte source to the disasm engine.

Instantiates the assemble engine using the x86 32-bits architecture.

Runs the recursive transversal disassembling since beginning.

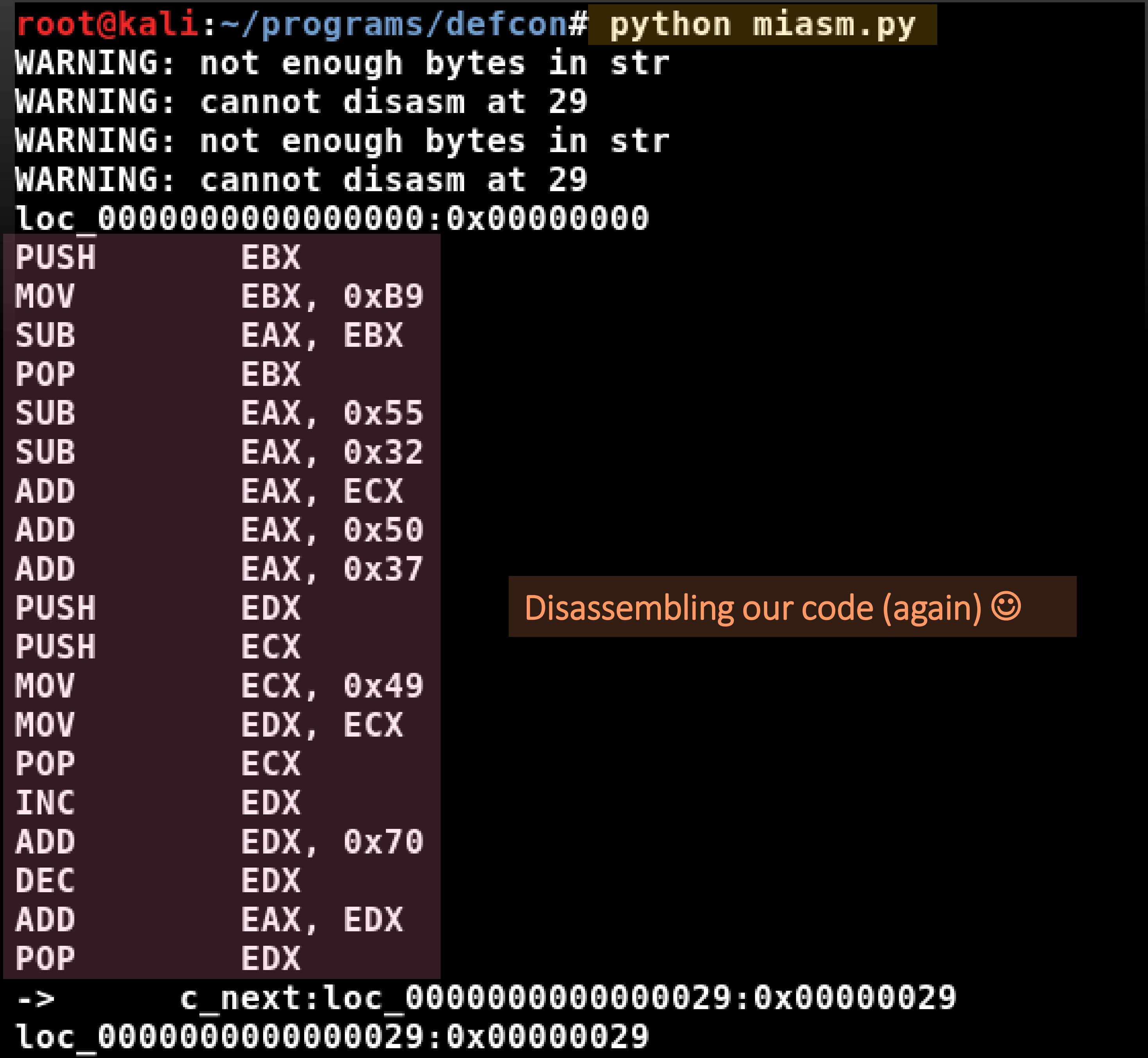
Set "llvm" as Jit engine to emulation and initialize the stack.

Set the virtual start address, register values and memory protection.

Adds a breakpoint at the last line of code.

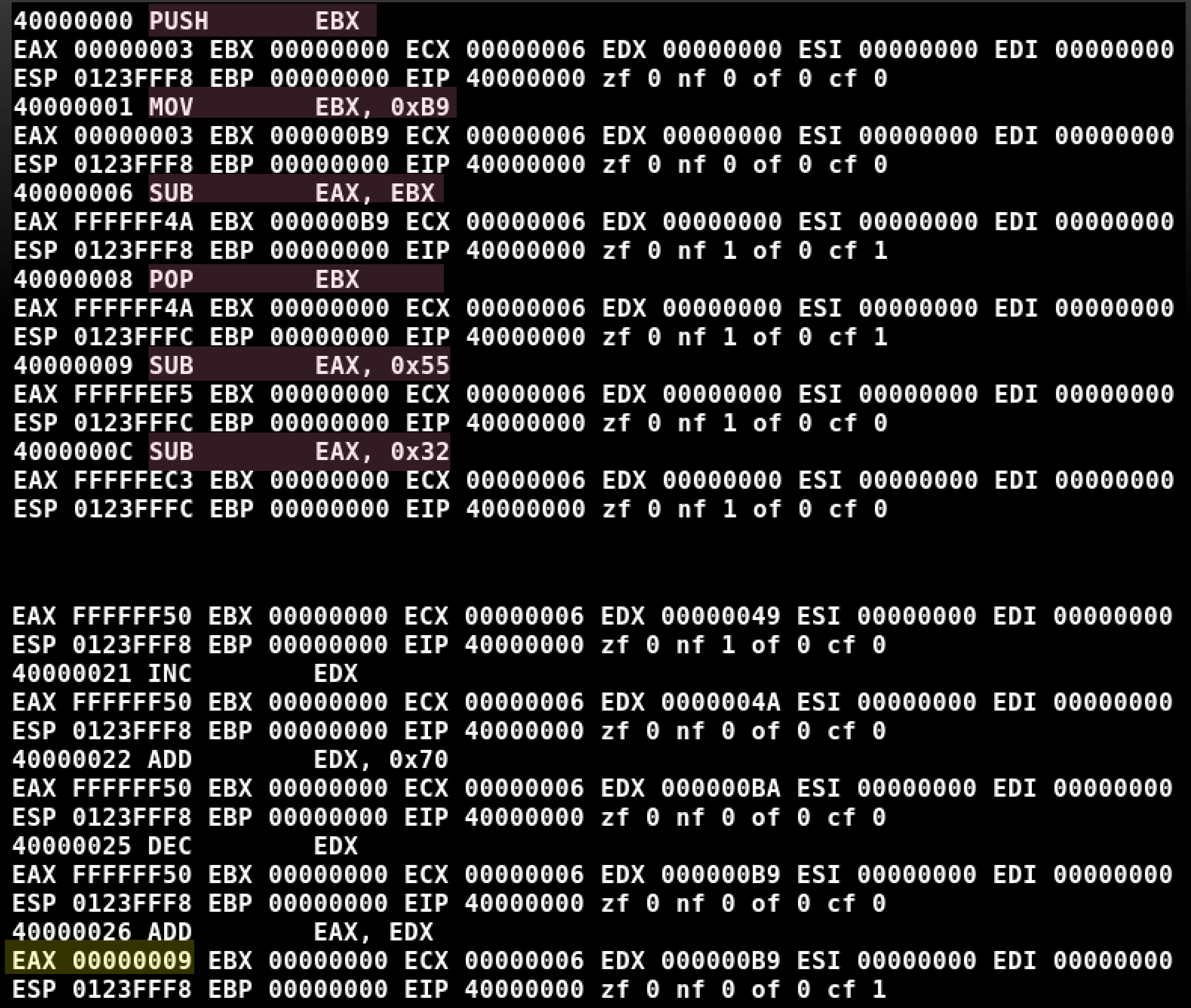
Run the emulation.

Generates a dot graph.



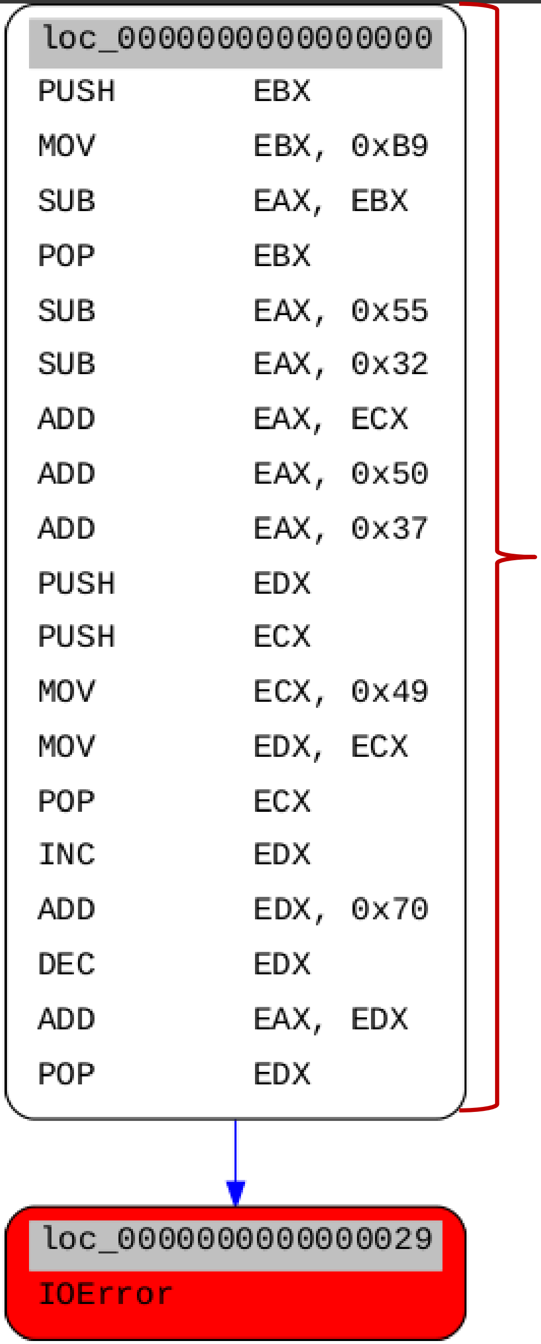
```
root@kali:~/programs/defcon# python miasm.py
WARNING: not enough bytes in str
WARNING: cannot disasm at 29
WARNING: not enough bytes in str
WARNING: cannot disasm at 29
loc_0000000000000000:0x00000000
PUSH       EBX
MOV        EBX, 0xB9
SUB        EAX, EBX
POP        EBX
SUB        EAX, 0x55
SUB        EAX, 0x32
ADD        EAX, ECX
ADD        EAX, 0x50
ADD        EAX, 0x37
PUSH       EDX
PUSH       ECX
MOV        ECX, 0x49
MOV        EDX, ECX
POP        ECX
INC        EDX
ADD        EDX, 0x70
DEC        EDX
ADD        EAX, EDX
POP        EDX
->       c_next:loc_0000000000000029:0x00000029
loc_0000000000000029:0x00000029
```

Disassembling our code (again) ☺



```
40000000 PUSH       EBX
EAX 00000003 EBX 00000000 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 0
40000001 MOV        EBX, 0xB9
EAX 00000003 EBX 000000B9 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 0
40000006 SUB        EAX, EBX
EAX FFFFFF4A EBX 000000B9 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 1 of 0 cf 1
40000008 POP        EBX
EAX FFFFFF4A EBX 00000000 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFFC EBP 00000000 EIP 40000000 zf 0 nf 1 of 0 cf 1
40000009 SUB        EAX, 0x55
EAX FFFFFEF5 EBX 00000000 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFFC EBP 00000000 EIP 40000000 zf 0 nf 1 of 0 cf 0
4000000C SUB        EAX, 0x32
EAX FFFFFEC3 EBX 00000000 ECX 00000006 EDX 00000000 ESI 00000000 EDI 00000000
ESP 0123FFFC EBP 00000000 EIP 40000000 zf 0 nf 1 of 0 cf 0
```

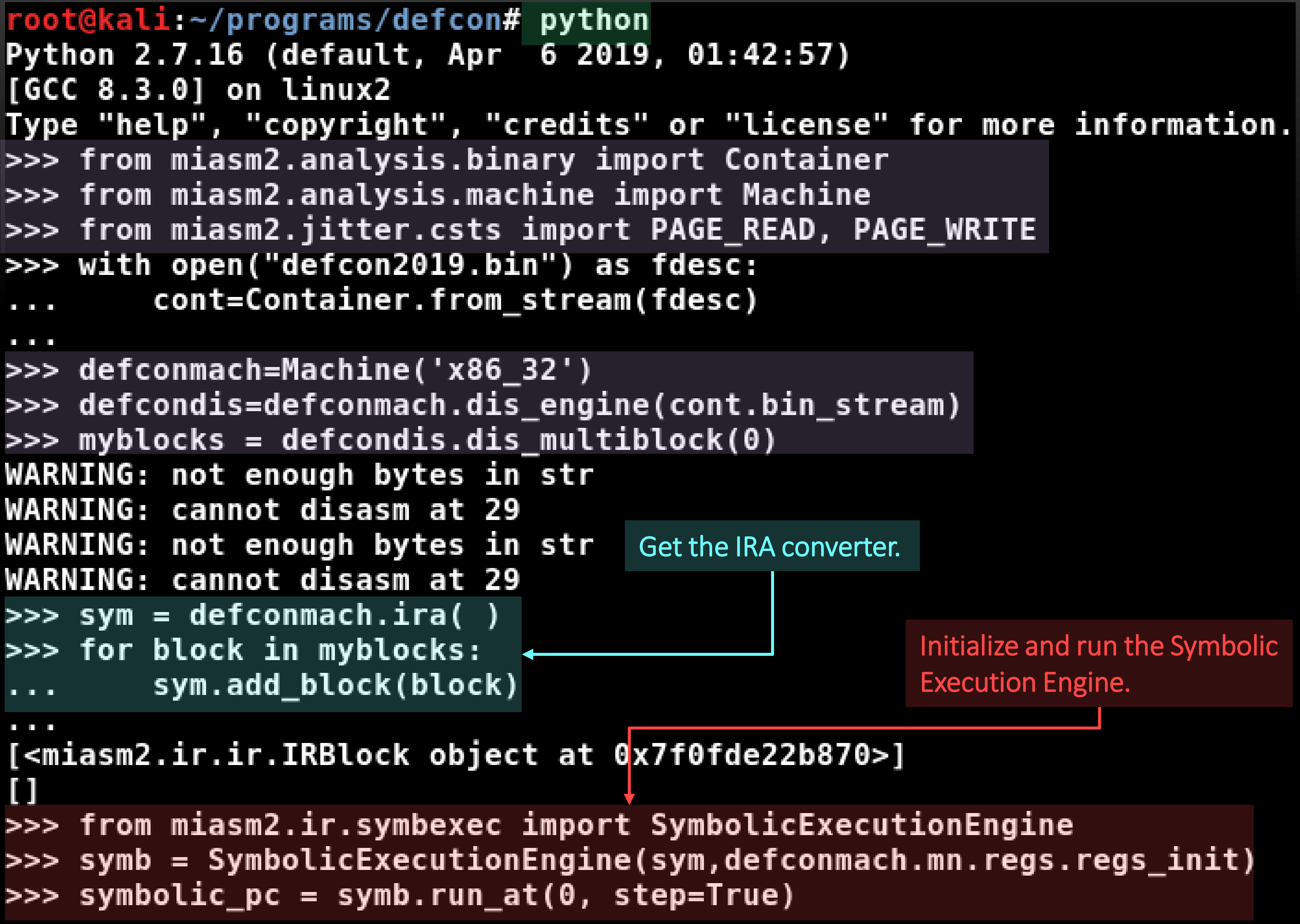
```
EAX FFFFFF50 EBX 00000000 ECX 00000006 EDX 00000049 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 1 of 0 cf 0
40000021 INC        EDX
EAX FFFFFF50 EBX 00000000 ECX 00000006 EDX 0000004A ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 0
40000022 ADD        EDX, 0x70
EAX FFFFFF50 EBX 00000000 ECX 00000006 EDX 000000BA ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 0
40000025 DEC        EDX
EAX FFFFFF50 EBX 00000000 ECX 00000006 EDX 000000B9 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 0
40000026 ADD        EAX, EDX
EAX 00000009 EBX 00000000 ECX 00000006 EDX 000000B9 ESI 00000000 EDI 00000000
ESP 0123FFF8 EBP 00000000 EIP 40000000 zf 0 nf 0 of 0 cf 1
```



```
loc_0000000000000000
PUSH          EBX
MOV           EBX, 0xB9
SUB           EAX, EBX
POP           EBX
SUB           EAX, 0x55
SUB           EAX, 0x32
ADD           EAX, ECX
ADD           EAX, 0x50
ADD           EAX, 0x37
PUSH          EDX
PUSH          ECX
MOV           ECX, 0x49
MOV           EDX, ECX
POP           ECX
INC           EDX
ADD           EDX, 0x70
DEC           EDX
ADD           EAX, EDX
POP           EDX
```

```
loc_0000000000000029
IOError
```

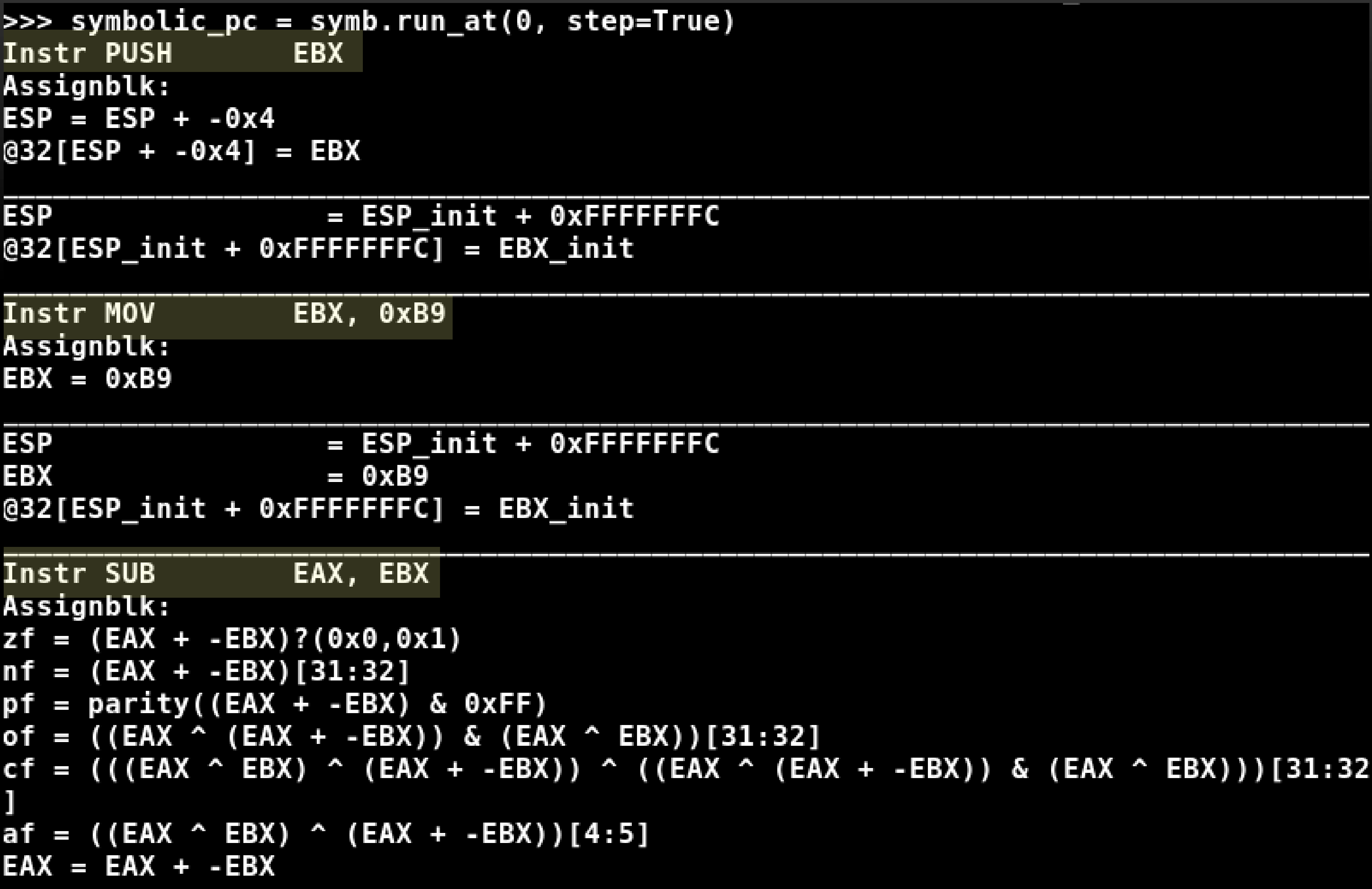
Our proposed code. ☺



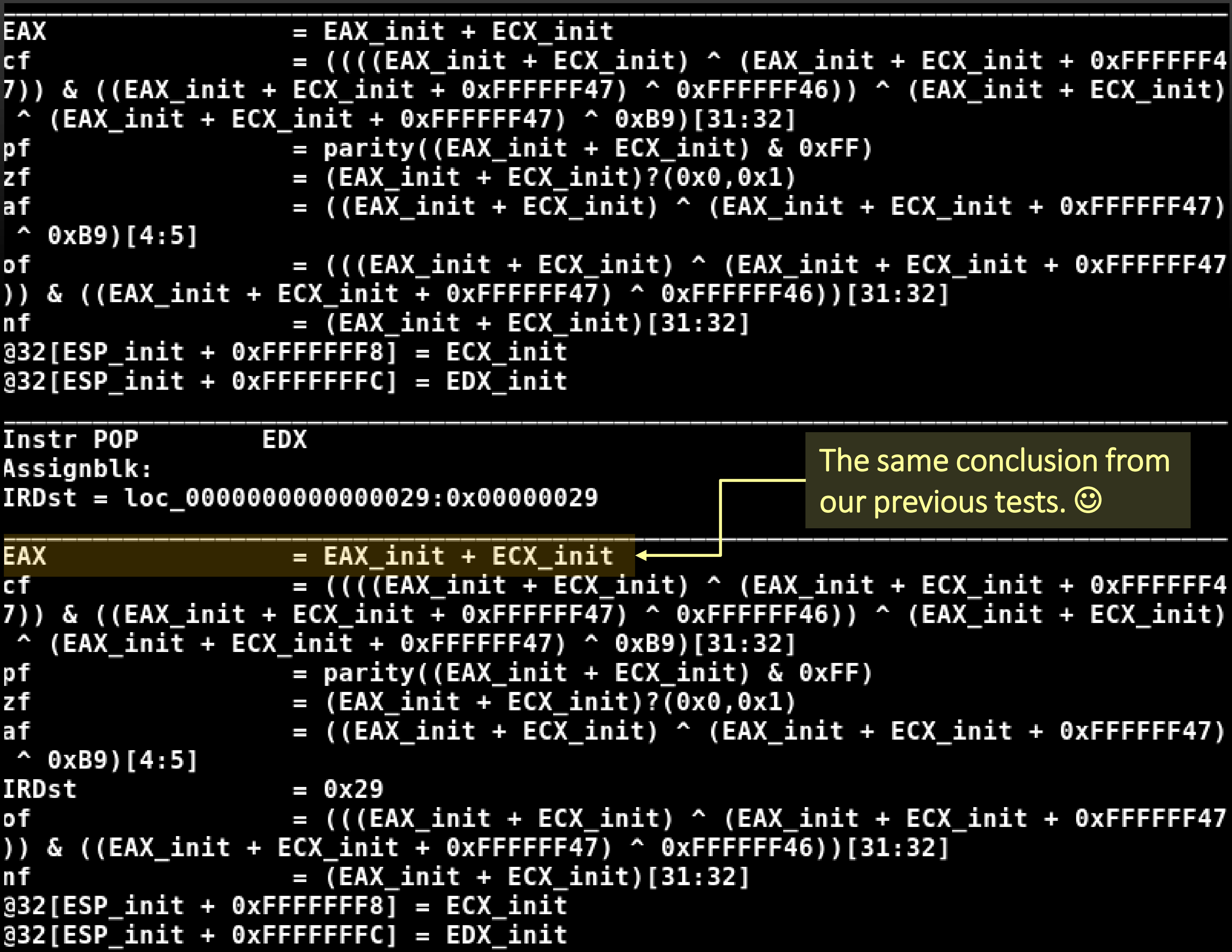
```
root@kali:~/programs/defcon# python
Python 2.7.16 (default, Apr  6 2019, 01:42:57)
[GCC 8.3.0] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> from miasm2.analysis.binary import Container
>>> from miasm2.analysis.machine import Machine
>>> from miasm2.jitter.csts import PAGE_READ, PAGE_WRITE
>>> with open("defcon2019.bin") as fdesc:
...     cont=Container.from_stream(fdesc)
...
>>> defconmach=Machine('x86_32')
>>> defcondis=defconmach.dis_engine(cont.bin_stream)
>>> myblocks = defcondis.dis_multiblock(0)
WARNING: not enough bytes in str
WARNING: cannot disasm at 29
WARNING: not enough bytes in str
WARNING: cannot disasm at 29
>>> sym = defconmach.ira( )
>>> for block in myblocks:
...     sym.add_block(block)
...
[<miasm2.ir.ir.IRBlock object at 0x7f0fde22b870>]
[]
>>> from miasm2.ir.symbexec import SymbolicExecutionEngine
>>> symb = SymbolicExecutionEngine(sym,defconmach.mn.regs.regs_init)
>>> symbolic_pc = symb.run_at(0, step=True)
```

Get the IRA converter.

Initialize and run the Symbolic Execution Engine.



```
>>> symbolic_pc = symb.run_at(0, step=True)
Instr PUSH        EBX
Assignblk:
ESP = ESP + -0x4
@32[ESP + -0x4] = EBX

________________________________________________________________________________
ESP                 = ESP_init + 0xFFFFFFFC
@32[ESP_init + 0xFFFFFFFC] = EBX_init

________________________________________________________________________________
Instr MOV         EBX, 0xB9
Assignblk:
EBX = 0xB9

________________________________________________________________________________
ESP                 = ESP_init + 0xFFFFFFFC
EBX                 = 0xB9
@32[ESP_init + 0xFFFFFFFC] = EBX_init

________________________________________________________________________________
Instr SUB         EAX, EBX
Assignblk:
zf = (EAX + -EBX)?(0x0,0x1)
nf = (EAX + -EBX)[31:32]
pf = parity((EAX + -EBX) & 0xFF)
of = ((EAX ^ (EAX + -EBX)) & (EAX ^ EBX))[31:32]
cf = (((EAX ^ EBX) ^ (EAX + -EBX)) ^ ((EAX ^ (EAX + -EBX)) & (EAX ^ EBX)))[31:32
]
af = ((EAX ^ EBX) ^ (EAX + -EBX))[4:5]
EAX = EAX + -EBX
```



```
--------------------------------------------------------------------------------
EAX                = EAX_init + ECX_init
cf                 = ((((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF4
7)) & ((EAX_init + ECX_init + 0xFFFFFF47) ^ 0xFFFFFF46)) ^ (EAX_init + ECX_init)
 ^ (EAX_init + ECX_init + 0xFFFFFF47) ^ 0xB9)[31:32]
pf                 = parity((EAX_init + ECX_init) & 0xFF)
zf                 = (EAX_init + ECX_init)?(0x0,0x1)
af                 = ((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF47)
 ^ 0xB9)[4:5]
of                 = (((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF47
)) & ((EAX_init + ECX_init + 0xFFFFFF47) ^ 0xFFFFFF46))[31:32]
nf                 = (EAX_init + ECX_init)[31:32]
@32[ESP_init + 0xFFFFFFF8] = ECX_init
@32[ESP_init + 0xFFFFFFFC] = EDX_init

--------------------------------------------------------------------------------
Instr POP        EDX
Assignblk:
IRDst = loc_0000000000000029:0x00000029

--------------------------------------------------------------------------------
EAX                = EAX_init + ECX_init
cf                 = ((((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF4
7)) & ((EAX_init + ECX_init + 0xFFFFFF47) ^ 0xFFFFFF46)) ^ (EAX_init + ECX_init)
 ^ (EAX_init + ECX_init + 0xFFFFFF47) ^ 0xB9)[31:32]
pf                 = parity((EAX_init + ECX_init) & 0xFF)
zf                 = (EAX_init + ECX_init)?(0x0,0x1)
af                 = ((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF47)
 ^ 0xB9)[4:5]
IRDst              = 0x29
of                 = (((EAX_init + ECX_init) ^ (EAX_init + ECX_init + 0xFFFFFF47
)) & ((EAX_init + ECX_init + 0xFFFFFF47) ^ 0xFFFFFF46))[31:32]
nf                 = (EAX_init + ECX_init)[31:32]
@32[ESP_init + 0xFFFFFFF8] = ECX_init
@32[ESP_init + 0xFFFFFFFC] = EDX_init
```

The same conclusion from our previous tests. ☺

TRITON

❑ TRITON

- ✓ It can be downloaded from https://triton.quarkslab.com/
- ✓ Based on Intel Pin instrumentation tool: https://software.intel.com/en-us/articles/pin-a-dynamic-binary-instrumentation-tool

- ✓ Triton offers a C/C++/Python interface provides:

  - ✓ dynamic symbolic execution
  - ✓ run time registry information and memory modification
  - ✓ taint engine
  - ✓ Z3 interface to handle contraints
  - ✓ snapshot engine (it is not necessary to restart the program every time, but only restores memory and register states)
  - ✓ access to Pin funtions
  - ✓ symbolic fuzzing
  - ✓ gather code coverage

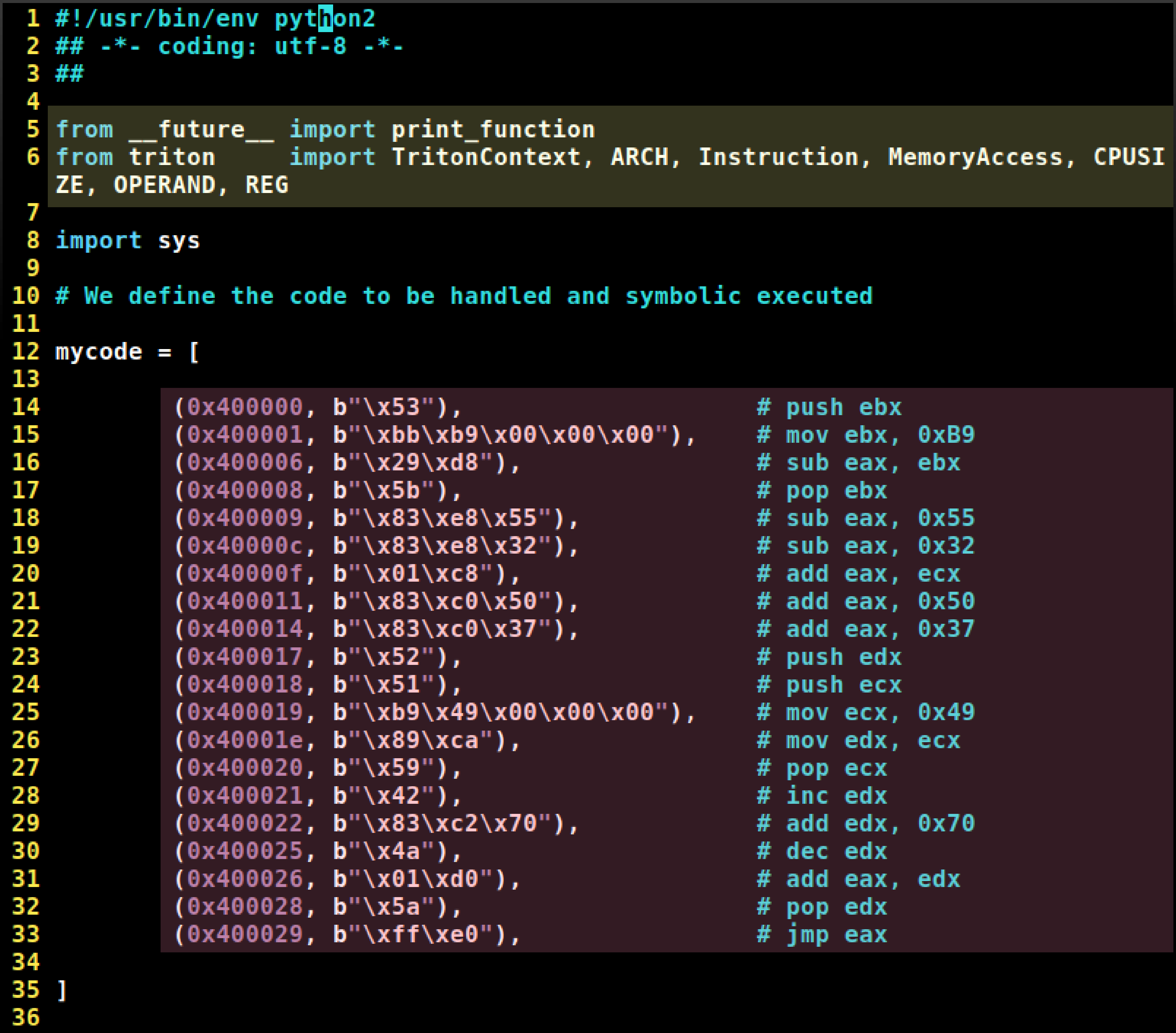
- ✓ Supports x86 and x64 architecture.

- ✓ Triton supports:
  - ✓ symbolic execution mode:
    - ✓ emulates instruction effects.
    - ✓ allows us to emulate only part of the program (excellent for analyzing branches).
  - ✓ concolic execution mode:
    - ✓ allows us to analyze the program only from start.
- ✓ Taint analysis is amazing because we are able to using in fuzzing tasks to know what registers and memory address are "affected" by the user data input. ☺
- ✓ During Virtual Machine's decoding, it is interesting to distinguish which instructions are related to user input and which are not. ☺

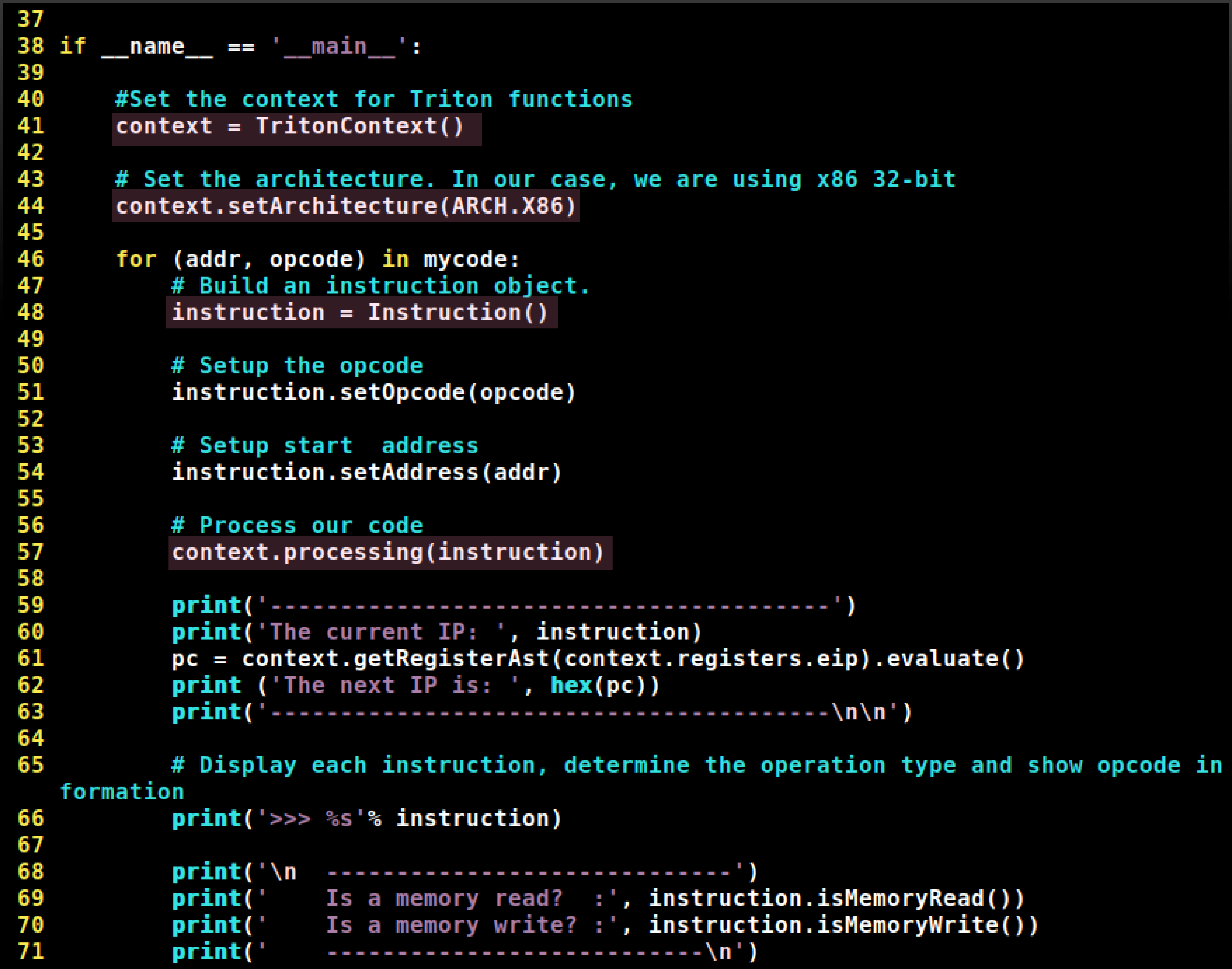
❖ Installing Triton without Pin (Ubuntu 19):

- ✓ apt-get install libboost-all-dev
- ✓ apt-get install libpython-dev
- ✓ apt-get install libcapstone-dev
- ✓ Take care: DO NOT install libz3-dev. If this package is already installed, so remove it.
- ✓ git clone https://github.com/Z3Prover/z3
- ✓ cd z3/
- ✓ python scripts/mk_make.py
- ✓ cd build/
- ✓ make
- ✓ make install
- ✓ git clone https://github.com/JonathanSalwan/Triton.git
- ✓ cd Triton/
- ✓ mkdir build
- ✓ cd build/
- ✓ cmake ..
- ✓ make -j install (my recommendation: 8 GB RAM + 8 GB swapfile)

- ✓ Installing Triton with Pin (Ubuntu 19):
  - ✓ Install the same packages from last slide.
  - ✓ Install Z3 as shown in the last slide.
  - ✓ wget https://software.intel.com/sites/landingpage/pintool/downloads/pin-2.14-71313-gcc.4.4.7-linux.tar.gz
  - ✓ tar zxvf pin-2.14-71313-gcc.4.4.7-linux.tar.gz
  - ✓ cd pin-2.14-71313-gcc.4.4.7-linux/source/tools
  - ✓ git clone https://github.com/JonathanSalwan/Triton.git
  - ✓ cd Triton/
  - ✓ mkdir build
  - ✓ cd build
  - ✓ cmake -DPINTOOL=on -DKERNEL4=on ..
  - ✓ make
  - ✓ cd ..
  - ✓ ./build/triton ./src/examples/pin/ir.py /usr/bin/host (only to test the installation).

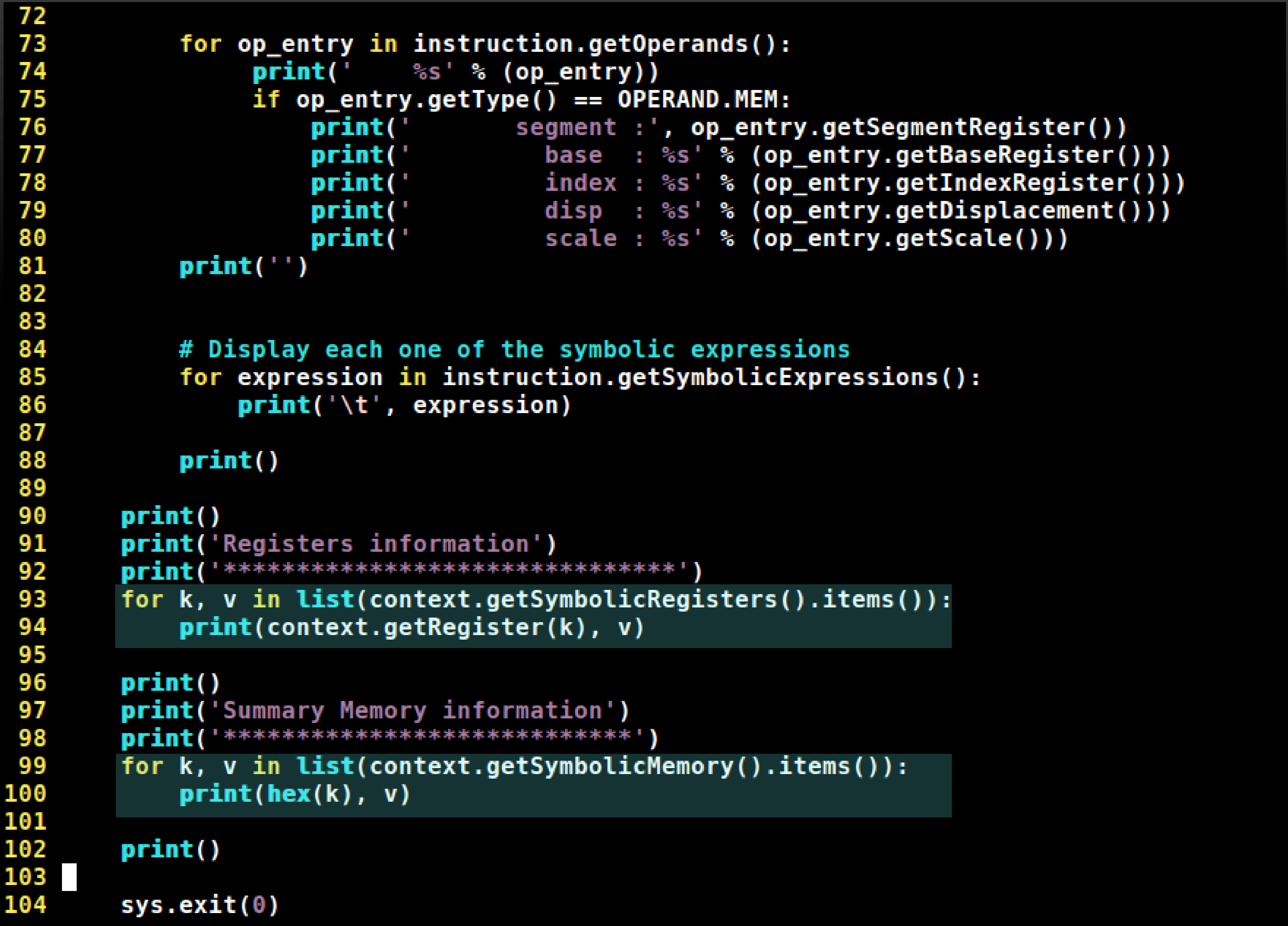


```
#!/usr/bin/env python2
## -*- coding: utf-8 -*-
##

from __future__ import print_function
from triton     import TritonContext, ARCH, Instruction, MemoryAccess, CPUSIZE, OPERAND, REG

import sys

# We define the code to be handled and symbolic executed

mycode = [

        (0x400000, b"\x53"),                    # push ebx
        (0x400001, b"\xbb\xb9\x00\x00\x00"),    # mov ebx, 0xB9
        (0x400006, b"\x29\xd8"),                # sub eax, ebx
        (0x400008, b"\x5b"),                    # pop ebx
        (0x400009, b"\x83\xe8\x55"),            # sub eax, 0x55
        (0x40000c, b"\x83\xe8\x32"),            # sub eax, 0x32
        (0x40000f, b"\x01\xc8"),                # add eax, ecx
        (0x400011, b"\x83\xc0\x50"),            # add eax, 0x50
        (0x400014, b"\x83\xc0\x37"),            # add eax, 0x37
        (0x400017, b"\x52"),                    # push edx
        (0x400018, b"\x51"),                    # push ecx
        (0x400019, b"\xb9\x49\x00\x00\x00"),    # mov ecx, 0x49
        (0x40001e, b"\x89\xca"),                # mov edx, ecx
        (0x400020, b"\x59"),                    # pop ecx
        (0x400021, b"\x42"),                    # inc edx
        (0x400022, b"\x83\xc2\x70"),            # add edx, 0x70
        (0x400025, b"\x4a"),                    # dec edx
        (0x400026, b"\x01\xd0"),                # add eax, edx
        (0x400028, b"\x5a"),                    # pop edx
        (0x400029, b"\xff\xe0"),                # jmp eax

]

```

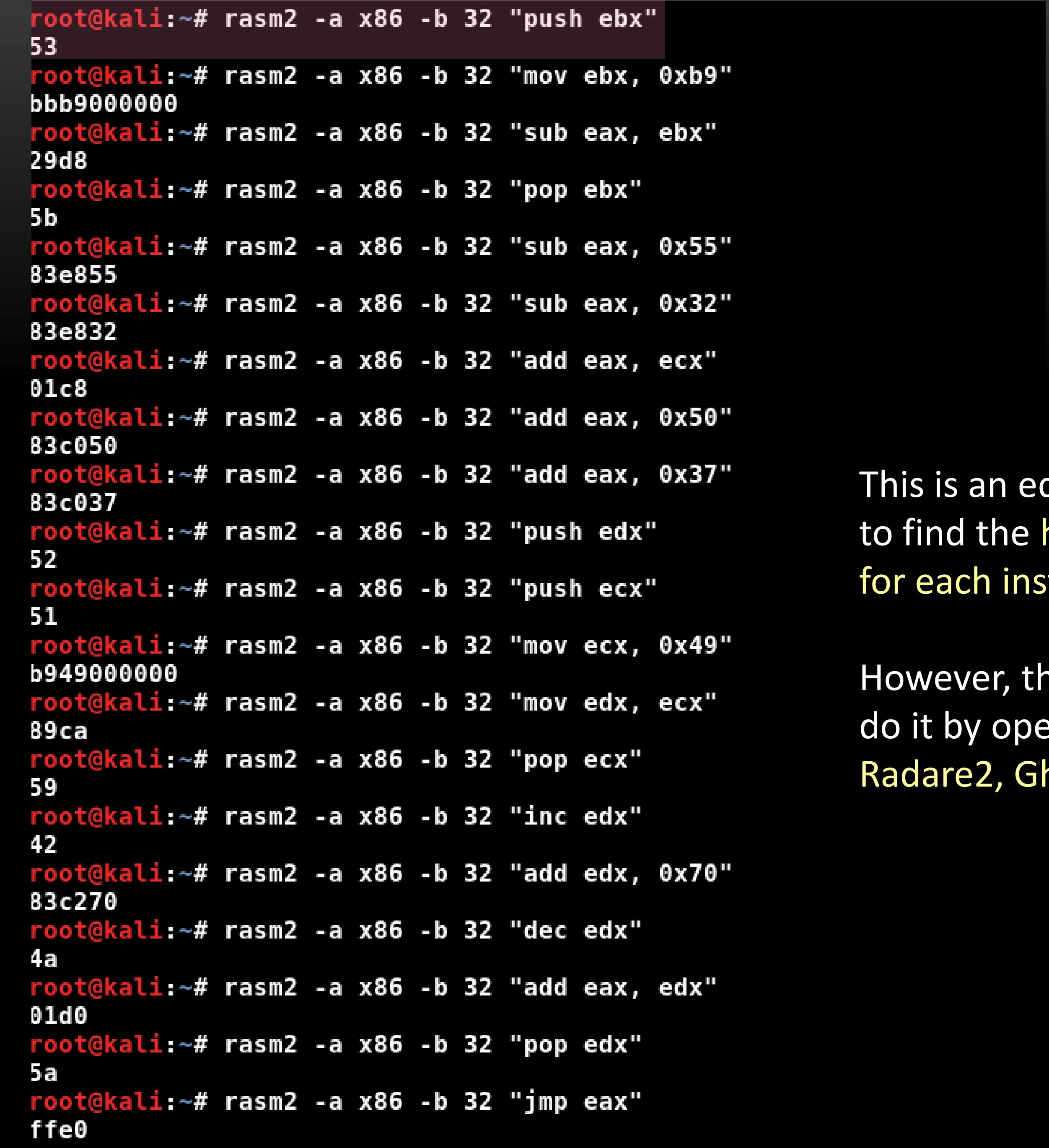


```
if __name__ == '__main__':

    #Set the context for Triton functions
    context = TritonContext()

    # Set the architecture. In our case, we are using x86 32-bit
    context.setArchitecture(ARCH.X86)

    for (addr, opcode) in mycode:
        # Build an instruction object.
        instruction = Instruction()

        # Setup the opcode
        instruction.setOpcode(opcode)

        # Setup start  address
        instruction.setAddress(addr)

        # Process our code
        context.processing(instruction)

        print('-----------------------------------------')
        print('The current IP: ', instruction)
        pc = context.getRegisterAst(context.registers.eip).evaluate()
        print ('The next IP is: ', hex(pc))
        print('-----------------------------------------\n\n')

        # Display each instruction, determine the operation type and show opcode information
        print('>>> %s'% instruction)

        print('\n  -----------------------------')
        print('    Is a memory read?  :', instruction.isMemoryRead())
        print('    Is a memory write? :', instruction.isMemoryWrite())
        print('    ---------------------------\n')
```

ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER



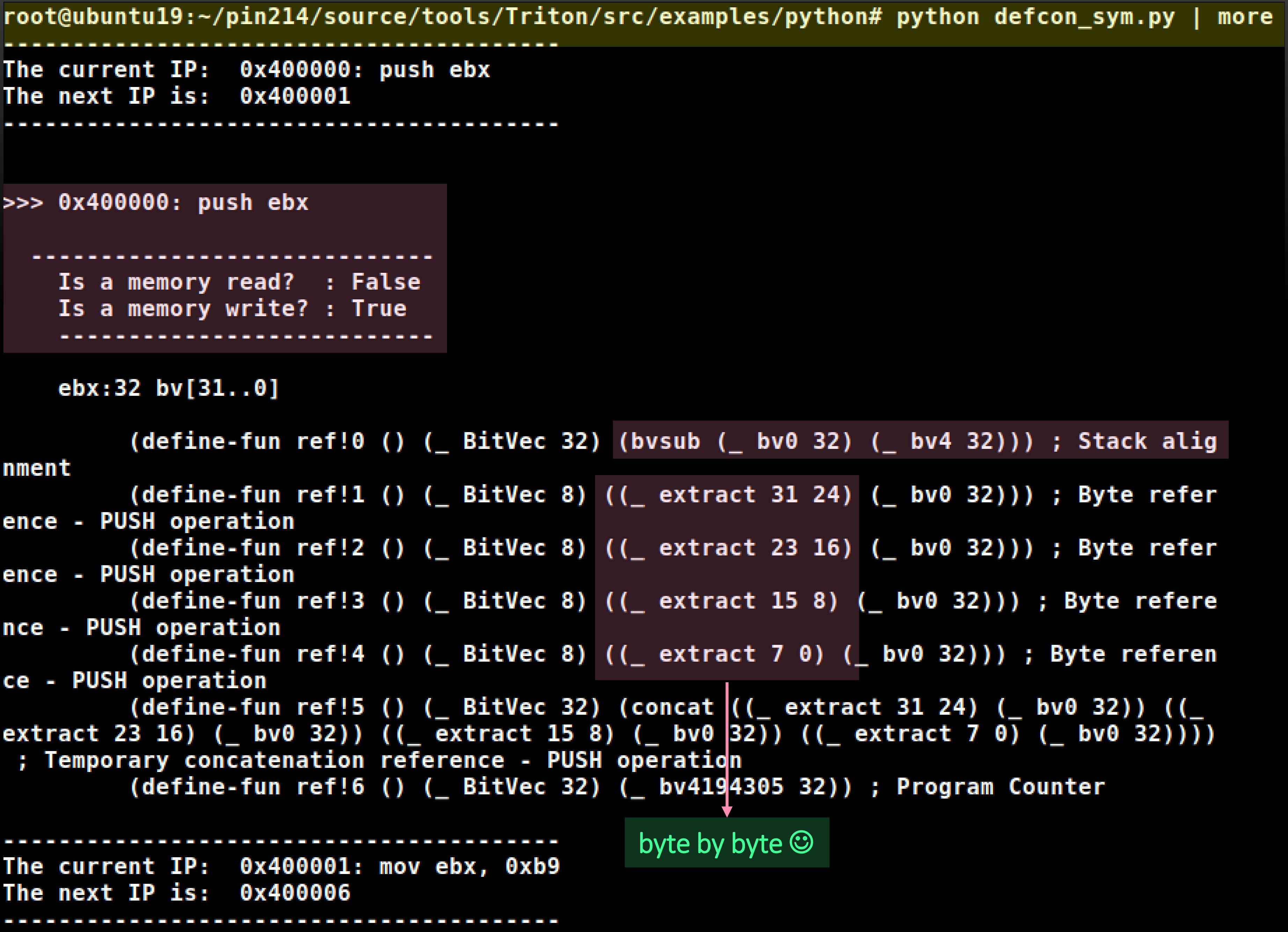
```
        for op_entry in instruction.getOperands():
             print('    %s' % (op_entry))
             if op_entry.getType() == OPERAND.MEM:
                 print('       segment :', op_entry.getSegmentRegister())
                 print('         base  : %s' % (op_entry.getBaseRegister()))
                 print('         index : %s' % (op_entry.getIndexRegister()))
                 print('         disp  : %s' % (op_entry.getDisplacement()))
                 print('         scale : %s' % (op_entry.getScale()))
        print('')


        # Display each one of the symbolic expressions
        for expression in instruction.getSymbolicExpressions():
            print('\t', expression)

        print()

    print()
    print('Registers information')
    print('*******************************')
    for k, v in list(context.getSymbolicRegisters().items()):
        print(context.getRegister(k), v)

    print()
    print('Summary Memory information')
    print('****************************')
    for k, v in list(context.getSymbolicMemory().items()):
        print(hex(k), v)

    print()

    sys.exit(0)
```



```
root@kali:~# rasm2 -a x86 -b 32 "push ebx"
53
root@kali:~# rasm2 -a x86 -b 32 "mov ebx, 0xb9"
bbb9000000
root@kali:~# rasm2 -a x86 -b 32 "sub eax, ebx"
29d8
root@kali:~# rasm2 -a x86 -b 32 "pop ebx"
5b
root@kali:~# rasm2 -a x86 -b 32 "sub eax, 0x55"
83e855
root@kali:~# rasm2 -a x86 -b 32 "sub eax, 0x32"
83e832
root@kali:~# rasm2 -a x86 -b 32 "add eax, ecx"
01c8
root@kali:~# rasm2 -a x86 -b 32 "add eax, 0x50"
83c050
root@kali:~# rasm2 -a x86 -b 32 "add eax, 0x37"
83c037
root@kali:~# rasm2 -a x86 -b 32 "push edx"
52
root@kali:~# rasm2 -a x86 -b 32 "push ecx"
51
root@kali:~# rasm2 -a x86 -b 32 "mov ecx, 0x49"
b949000000
root@kali:~# rasm2 -a x86 -b 32 "mov edx, ecx"
89ca
root@kali:~# rasm2 -a x86 -b 32 "pop ecx"
59
root@kali:~# rasm2 -a x86 -b 32 "inc edx"
42
root@kali:~# rasm2 -a x86 -b 32 "add edx, 0x70"
83c270
root@kali:~# rasm2 -a x86 -b 32 "dec edx"
4a
root@kali:~# rasm2 -a x86 -b 32 "add eax, edx"
01d0
root@kali:~# rasm2 -a x86 -b 32 "pop edx"
5a
root@kali:~# rasm2 -a x86 -b 32 "jmp eax"
ffe0
```

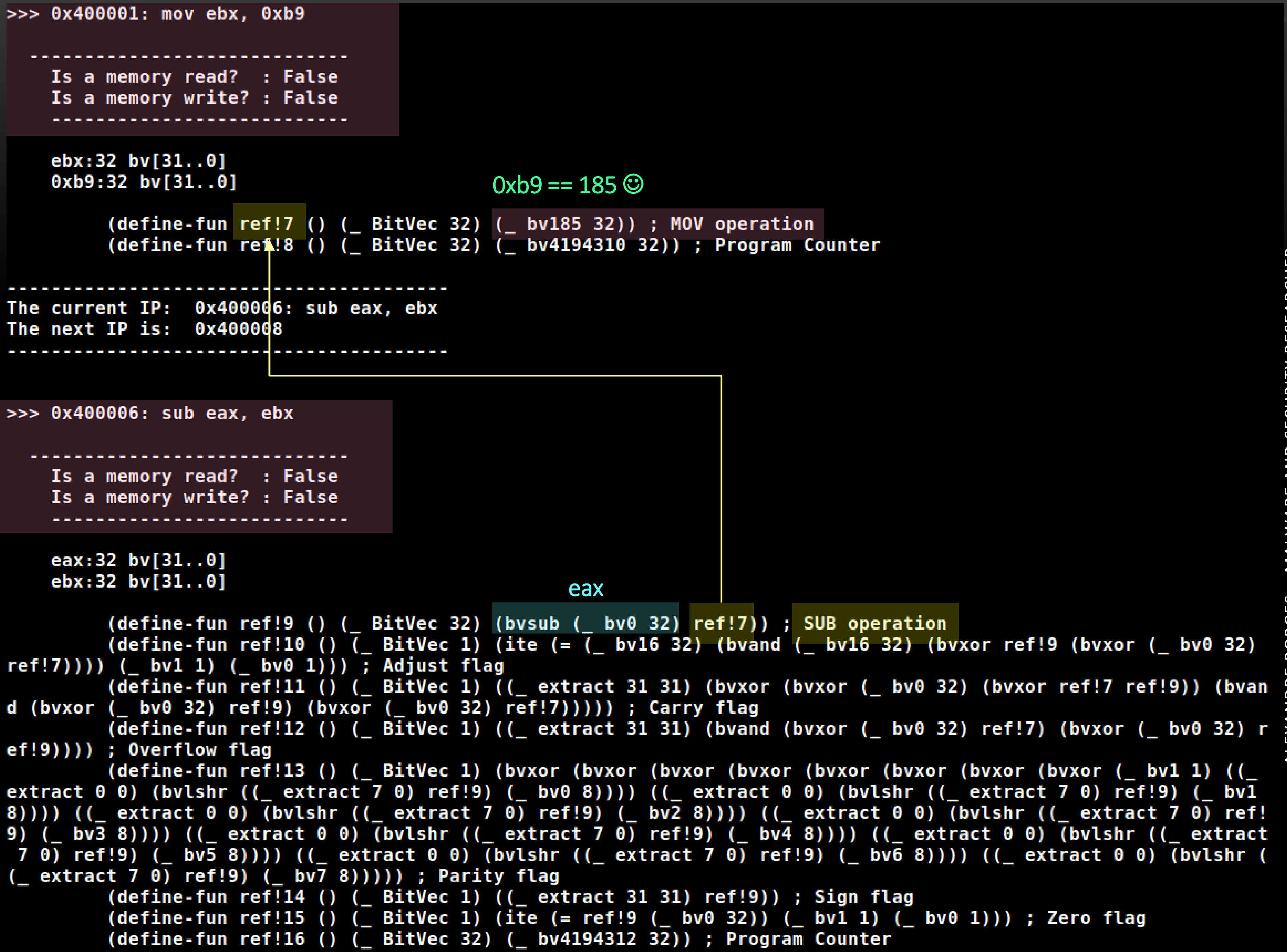
This is an educational way to show how to find the hexadecimal representation for each instruction.

However, there are much better ways to do it by opening the binary on IDA Pro, Radare2, Ghidra or even using distorm3.



```
root@ubuntu19:~/pin214/source/tools/Triton/src/examples/python# python defcon_sym.py | more
----------------------------------------
The current IP:  0x400000: push ebx
The next IP is:  0x400001
----------------------------------------


>>> 0x400000: push ebx

  ----------------------------
    Is a memory read?  : False
    Is a memory write? : True
    ---------------------------

    ebx:32 bv[31..0]

         (define-fun ref!0 () (_ BitVec 32) (bvsub (_ bv0 32) (_ bv4 32))) ; Stack alig
nment
         (define-fun ref!1 () (_ BitVec 8) ((_ extract 31 24) (_ bv0 32))) ; Byte refer
ence - PUSH operation
         (define-fun ref!2 () (_ BitVec 8) ((_ extract 23 16) (_ bv0 32))) ; Byte refer
ence - PUSH operation
         (define-fun ref!3 () (_ BitVec 8) ((_ extract 15 8) (_ bv0 32))) ; Byte refere
nce - PUSH operation
         (define-fun ref!4 () (_ BitVec 8) ((_ extract 7 0) (_ bv0 32))) ; Byte referen
ce - PUSH operation
         (define-fun ref!5 () (_ BitVec 32) (concat ((_ extract 31 24) (_ bv0 32)) ((_
extract 23 16) (_ bv0 32)) ((_ extract 15 8) (_ bv0 32)) ((_ extract 7 0) (_ bv0 32))))
 ; Temporary concatenation reference - PUSH operation
         (define-fun ref!6 () (_ BitVec 32) (_ bv4194305 32)) ; Program Counter

----------------------------------------
The current IP:  0x400001: mov ebx, 0xb9
The next IP is:  0x400006
----------------------------------------
```

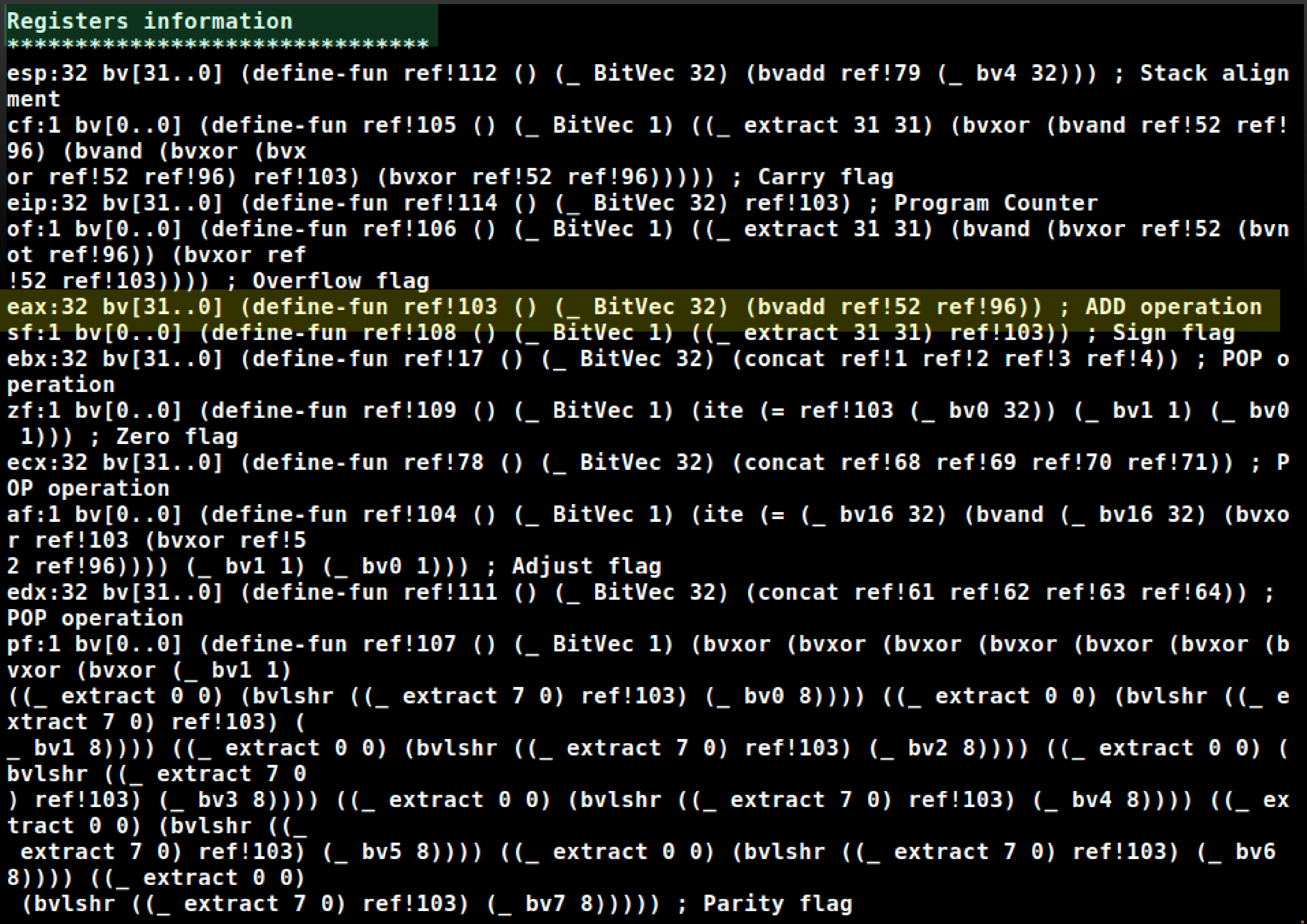
byte by byte ☺



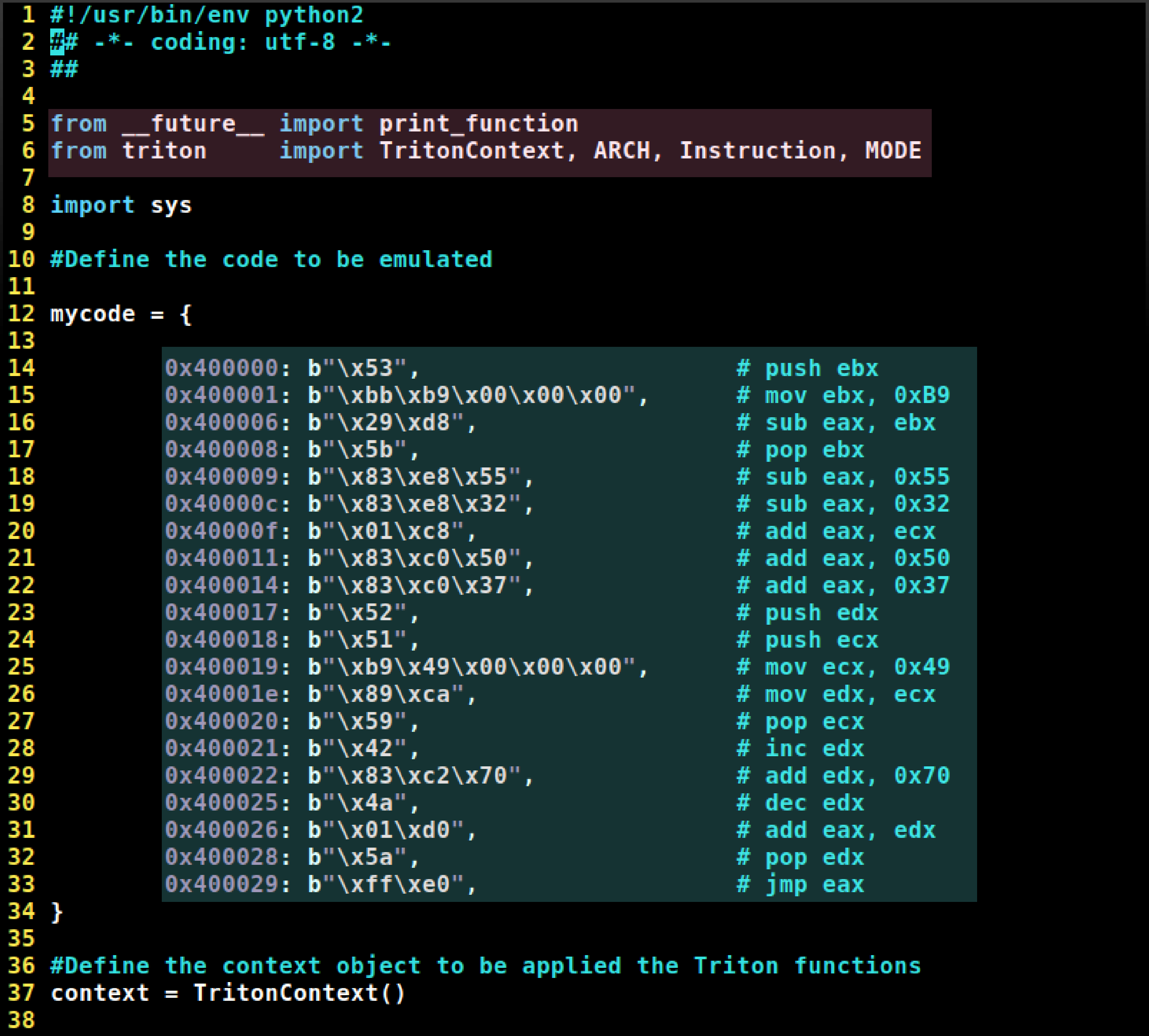
0xb9 == 185 ☺

eax

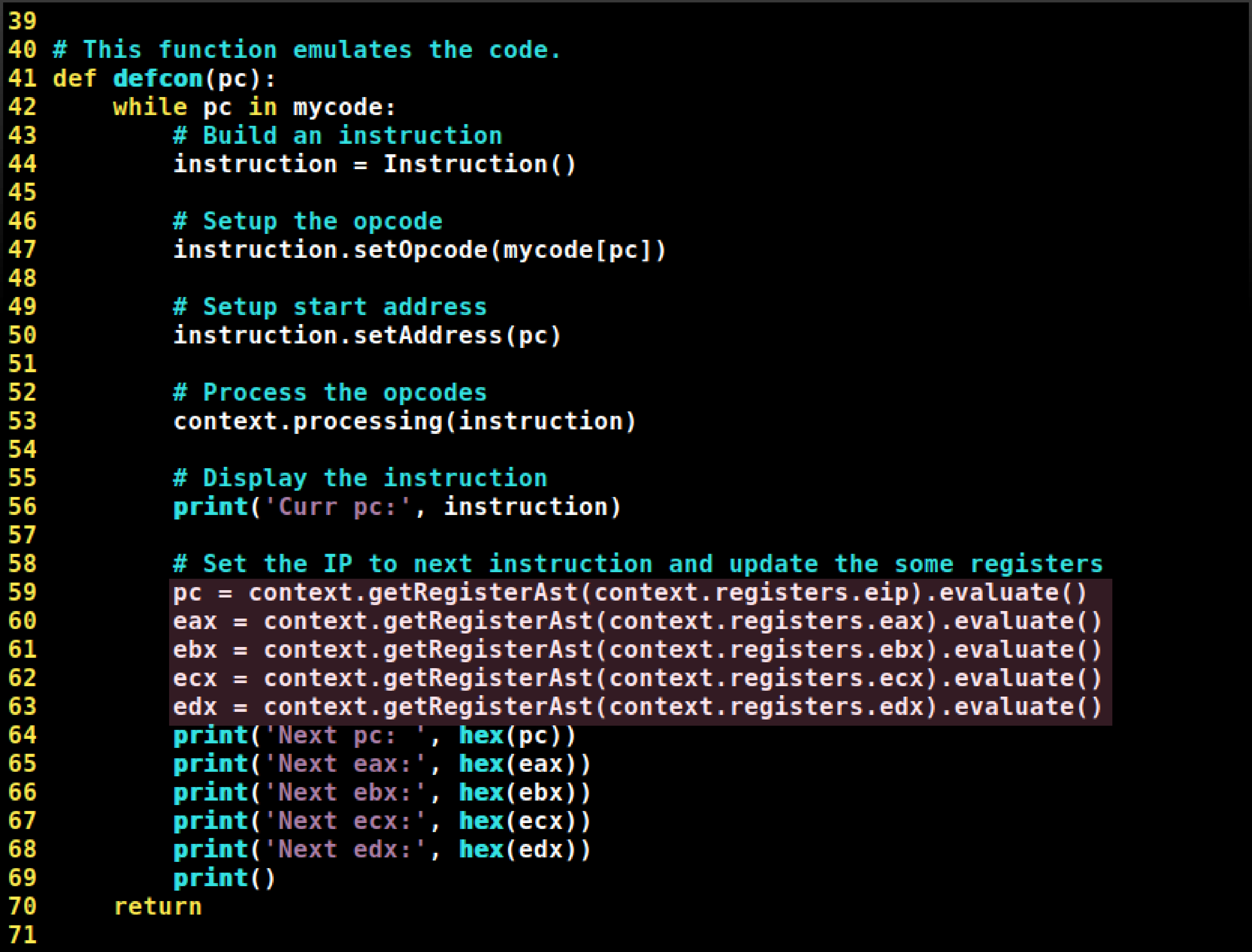
```
>>> 0x400001: mov ebx, 0xb9

    ---------------------------
      Is a memory read?  : False
      Is a memory write? : False
      ---------------------------

    ebx:32 bv[31..0]
    0xb9:32 bv[31..0]

         (define-fun ref!7 () (_ BitVec 32) (_ bv185 32)) ; MOV operation
         (define-fun ref!8 () (_ BitVec 32) (_ bv4194310 32)) ; Program Counter

----------------------------------------
The current IP:  0x400006: sub eax, ebx
The next IP is:  0x400008
----------------------------------------


>>> 0x400006: sub eax, ebx

    ---------------------------
      Is a memory read?  : False
      Is a memory write? : False
      ---------------------------

    eax:32 bv[31..0]
    ebx:32 bv[31..0]

         (define-fun ref!9 () (_ BitVec 32) (bvsub (_ bv0 32) ref!7)) ; SUB operation
         (define-fun ref!10 () (_ BitVec 1) (ite (= (_ bv16 32) (bvand (_ bv16 32) (bvxor ref!9 (bvxor (_ bv0 32)
ref!7)))) (_ bv1 1) (_ bv0 1))) ; Adjust flag
         (define-fun ref!11 () (_ BitVec 1) ((_ extract 31 31) (bvxor (bvxor (_ bv0 32) (bvxor ref!7 ref!9)) (bvan
d (bvxor (_ bv0 32) ref!9) (bvxor (_ bv0 32) ref!7))))) ; Carry flag
         (define-fun ref!12 () (_ BitVec 1) ((_ extract 31 31) (bvand (bvxor (_ bv0 32) ref!7) (bvxor (_ bv0 32) r
ef!9)))) ; Overflow flag
         (define-fun ref!13 () (_ BitVec 1) (bvxor (bvxor (bvxor (bvxor (bvxor (bvxor (bvxor (bvxor (_ bv1 1) ((_
extract 0 0) (bvlshr ((_ extract 7 0) ref!9) (_ bv0 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!9) (_ bv1
8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!9) (_ bv2 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!
9) (_ bv3 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!9) (_ bv4 8)))) ((_ extract 0 0) (bvlshr ((_ extract
 7 0) ref!9) (_ bv5 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!9) (_ bv6 8)))) ((_ extract 0 0) (bvlshr (
(_ extract 7 0) ref!9) (_ bv7 8))))) ; Parity flag
         (define-fun ref!14 () (_ BitVec 1) ((_ extract 31 31) ref!9)) ; Sign flag
         (define-fun ref!15 () (_ BitVec 1) (ite (= ref!9 (_ bv0 32)) (_ bv1 1) (_ bv0 1))) ; Zero flag
         (define-fun ref!16 () (_ BitVec 32) (_ bv4194312 32)) ; Program Counter
```



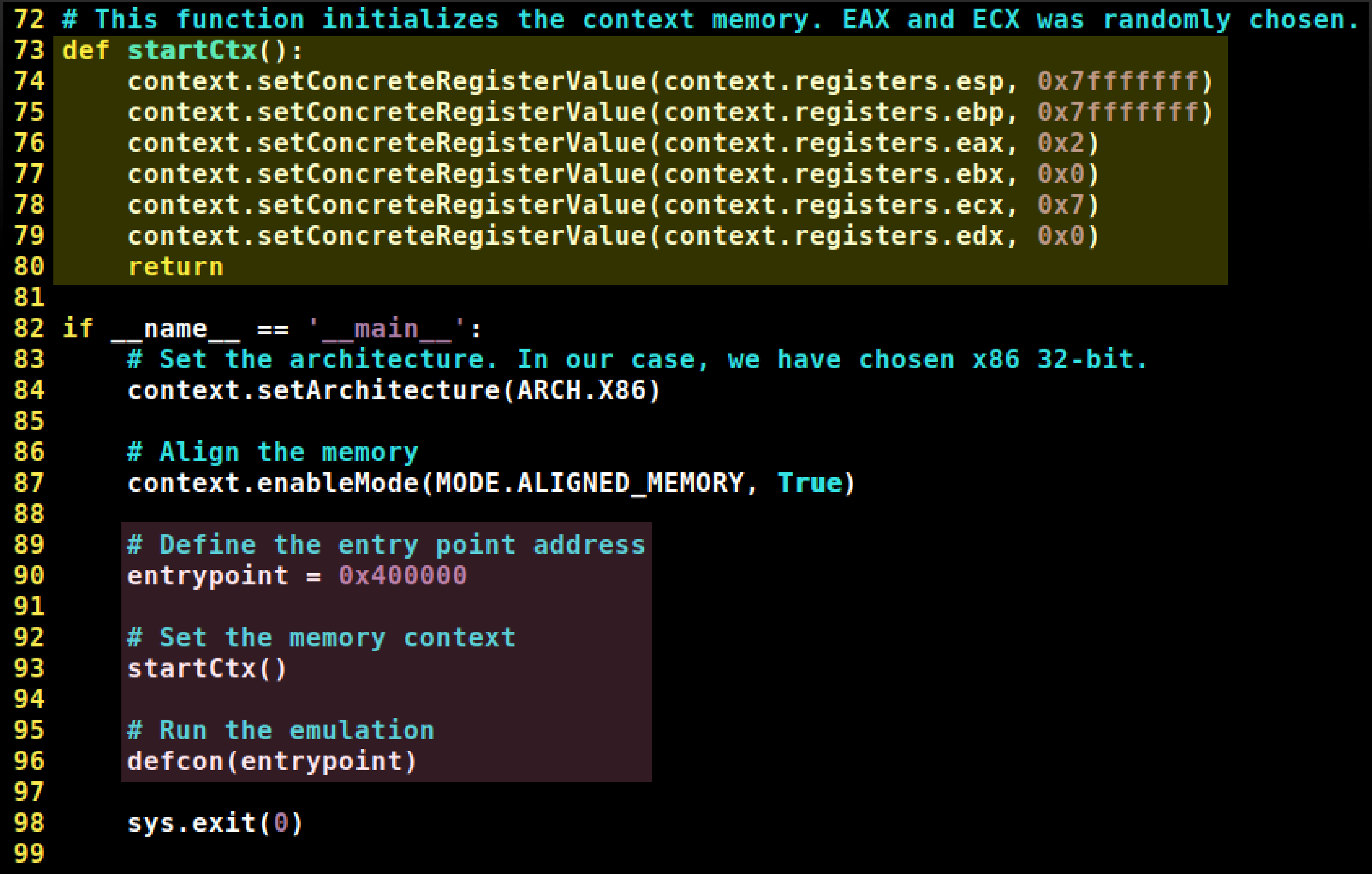
```
Registers information
*******************************
esp:32 bv[31..0] (define-fun ref!112 () (_ BitVec 32) (bvadd ref!79 (_ bv4 32))) ; Stack align
ment
cf:1 bv[0..0] (define-fun ref!105 () (_ BitVec 1) ((_ extract 31 31) (bvxor (bvand ref!52 ref!
96) (bvand (bvxor (bvx
or ref!52 ref!96) ref!103) (bvxor ref!52 ref!96))))) ; Carry flag
eip:32 bv[31..0] (define-fun ref!114 () (_ BitVec 32) ref!103) ; Program Counter
of:1 bv[0..0] (define-fun ref!106 () (_ BitVec 1) ((_ extract 31 31) (bvand (bvxor ref!52 (bvn
ot ref!96)) (bvxor ref
!52 ref!103)))) ; Overflow flag
eax:32 bv[31..0] (define-fun ref!103 () (_ BitVec 32) (bvadd ref!52 ref!96)) ; ADD operation
sf:1 bv[0..0] (define-fun ref!108 () (_ BitVec 1) ((_ extract 31 31) ref!103)) ; Sign flag
ebx:32 bv[31..0] (define-fun ref!17 () (_ BitVec 32) (concat ref!1 ref!2 ref!3 ref!4)) ; POP o
peration
zf:1 bv[0..0] (define-fun ref!109 () (_ BitVec 1) (ite (= ref!103 (_ bv0 32)) (_ bv1 1) (_ bv0
 1))) ; Zero flag
ecx:32 bv[31..0] (define-fun ref!78 () (_ BitVec 32) (concat ref!68 ref!69 ref!70 ref!71)) ; P
OP operation
af:1 bv[0..0] (define-fun ref!104 () (_ BitVec 1) (ite (= (_ bv16 32) (bvand (_ bv16 32) (bvxo
r ref!103 (bvxor ref!5
2 ref!96)))) (_ bv1 1) (_ bv0 1))) ; Adjust flag
edx:32 bv[31..0] (define-fun ref!111 () (_ BitVec 32) (concat ref!61 ref!62 ref!63 ref!64)) ;
POP operation
pf:1 bv[0..0] (define-fun ref!107 () (_ BitVec 1) (bvxor (bvxor (bvxor (bvxor (bvxor (bvxor (b
vxor (bvxor (_ bv1 1)
((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!103) (_ bv0 8)))) ((_ extract 0 0) (bvlshr ((_ e
xtract 7 0) ref!103) (
_ bv1 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!103) (_ bv2 8)))) ((_ extract 0 0) (
bvlshr ((_ extract 7 0
) ref!103) (_ bv3 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!103) (_ bv4 8)))) ((_ ex
tract 0 0) (bvlshr ((_
 extract 7 0) ref!103) (_ bv5 8)))) ((_ extract 0 0) (bvlshr ((_ extract 7 0) ref!103) (_ bv6
8)))) ((_ extract 0 0)
 (bvlshr ((_ extract 7 0) ref!103) (_ bv7 8))))) ; Parity flag
```



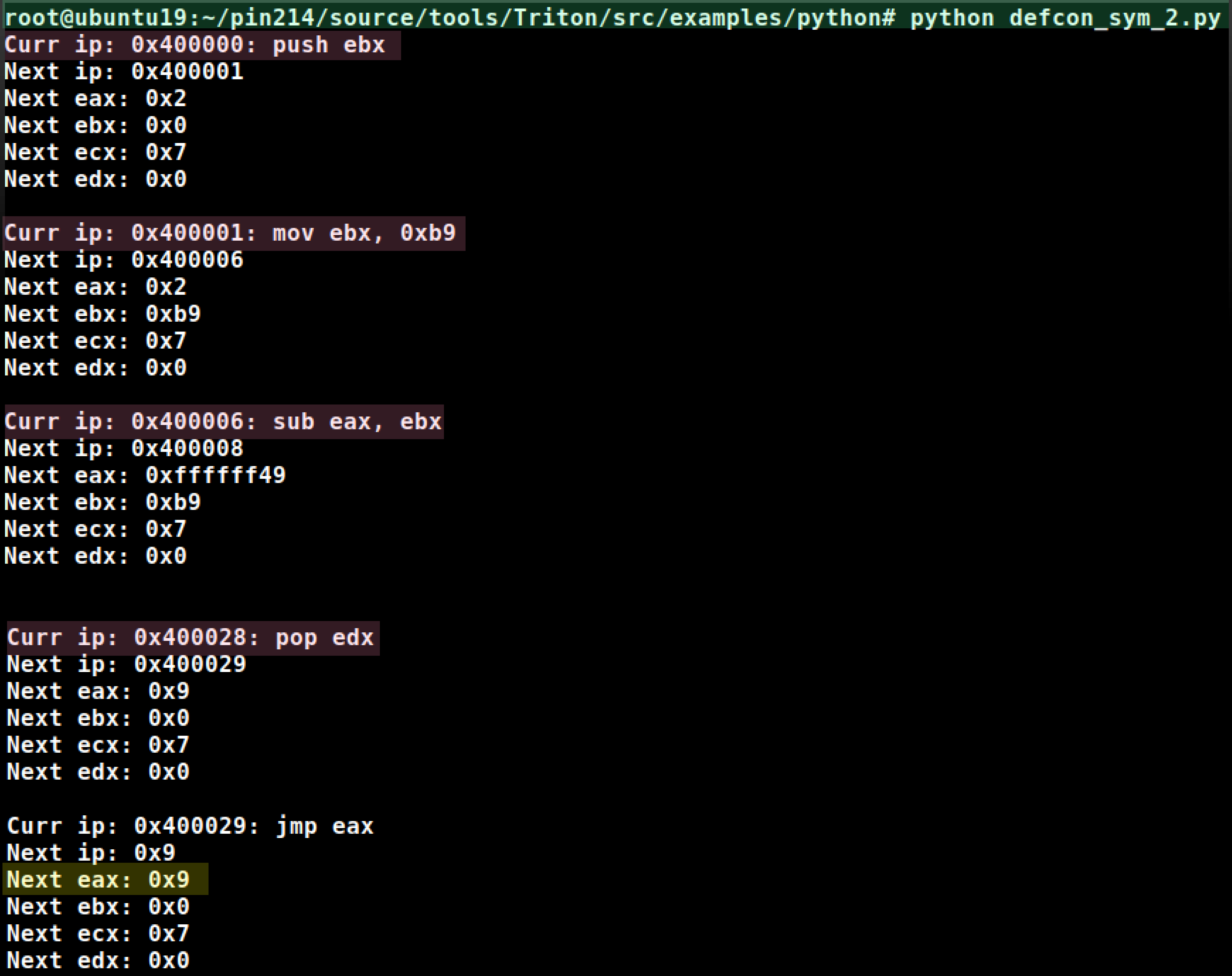
```
#!/usr/bin/env python2
## -*- coding: utf-8 -*-
##

from __future__ import print_function
from triton     import TritonContext, ARCH, Instruction, MODE

import sys

#Define the code to be emulated

mycode = {

        0x400000: b"\x53",                      # push ebx
        0x400001: b"\xbb\xb9\x00\x00\x00",      # mov ebx, 0xB9
        0x400006: b"\x29\xd8",                  # sub eax, ebx
        0x400008: b"\x5b",                      # pop ebx
        0x400009: b"\x83\xe8\x55",              # sub eax, 0x55
        0x40000c: b"\x83\xe8\x32",              # sub eax, 0x32
        0x40000f: b"\x01\xc8",                  # add eax, ecx
        0x400011: b"\x83\xc0\x50",              # add eax, 0x50
        0x400014: b"\x83\xc0\x37",              # add eax, 0x37
        0x400017: b"\x52",                      # push edx
        0x400018: b"\x51",                      # push ecx
        0x400019: b"\xb9\x49\x00\x00\x00",      # mov ecx, 0x49
        0x40001e: b"\x89\xca",                  # mov edx, ecx
        0x400020: b"\x59",                      # pop ecx
        0x400021: b"\x42",                      # inc edx
        0x400022: b"\x83\xc2\x70",              # add edx, 0x70
        0x400025: b"\x4a",                      # dec edx
        0x400026: b"\x01\xd0",                  # add eax, edx
        0x400028: b"\x5a",                      # pop edx
        0x400029: b"\xff\xe0",                  # jmp eax
}

#Define the context object to be applied the Triton functions
context = TritonContext()

```



```
# This function emulates the code.
def defcon(pc):
    while pc in mycode:
        # Build an instruction
        instruction = Instruction()

        # Setup the opcode
        instruction.setOpcode(mycode[pc])

        # Setup start address
        instruction.setAddress(pc)

        # Process the opcodes
        context.processing(instruction)

        # Display the instruction
        print('Curr pc:', instruction)

        # Set the IP to next instruction and update the some registers
        pc = context.getRegisterAst(context.registers.eip).evaluate()
        eax = context.getRegisterAst(context.registers.eax).evaluate()
        ebx = context.getRegisterAst(context.registers.ebx).evaluate()
        ecx = context.getRegisterAst(context.registers.ecx).evaluate()
        edx = context.getRegisterAst(context.registers.edx).evaluate()
        print('Next pc:  ', hex(pc))
        print('Next eax:', hex(eax))
        print('Next ebx:', hex(ebx))
        print('Next ecx:', hex(ecx))
        print('Next edx:', hex(edx))
        print()
    return
```

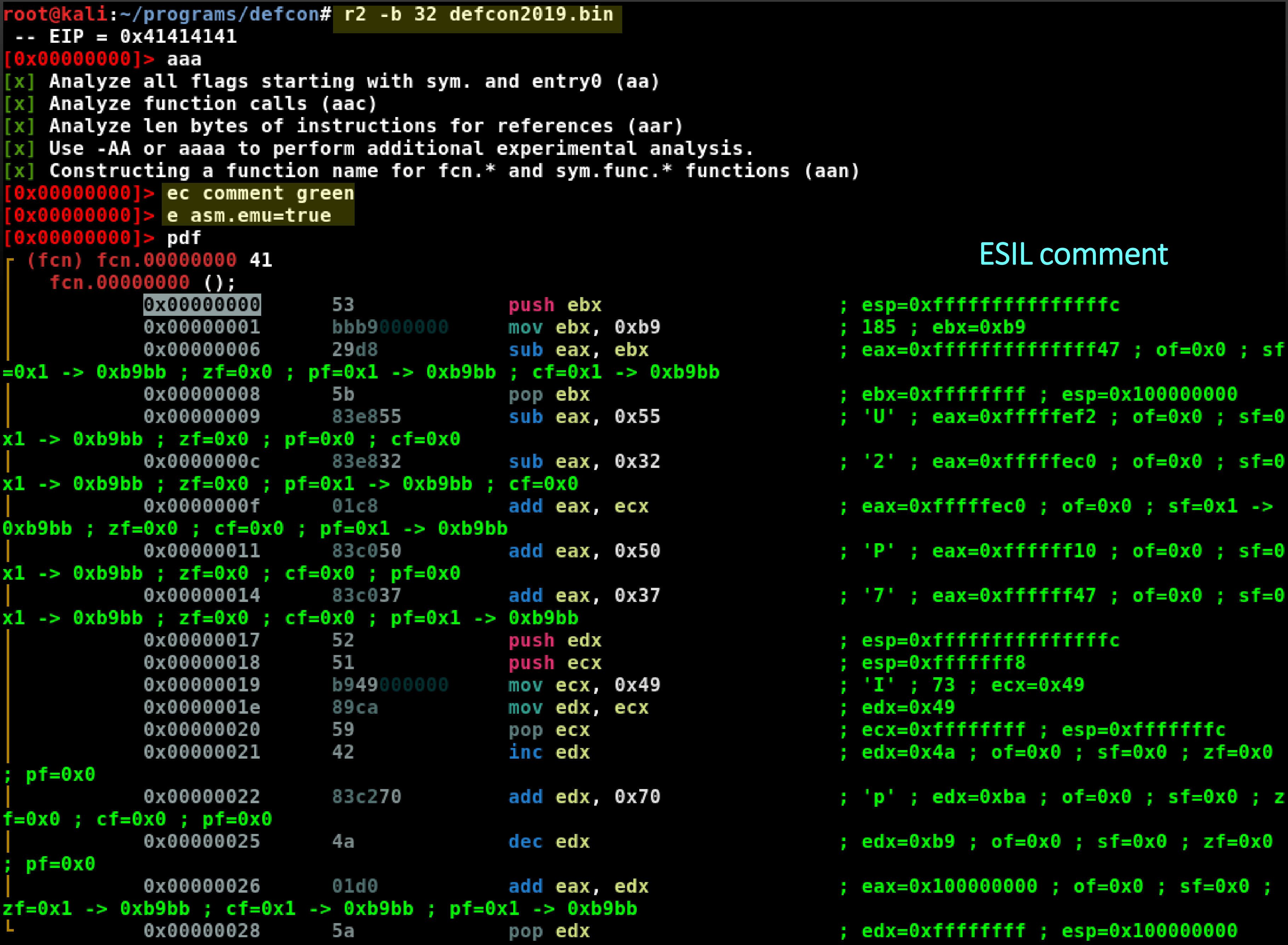


```
# This function initializes the context memory. EAX and ECX was randomly chosen.
def startCtx():
    context.setConcreteRegisterValue(context.registers.esp, 0x7fffffff)
    context.setConcreteRegisterValue(context.registers.ebp, 0x7fffffff)
    context.setConcreteRegisterValue(context.registers.eax, 0x2)
    context.setConcreteRegisterValue(context.registers.ebx, 0x0)
    context.setConcreteRegisterValue(context.registers.ecx, 0x7)
    context.setConcreteRegisterValue(context.registers.edx, 0x0)
    return

if __name__ == '__main__':
    # Set the architecture. In our case, we have chosen x86 32-bit.
    context.setArchitecture(ARCH.X86)

    # Align the memory
    context.enableMode(MODE.ALIGNED_MEMORY, True)

    # Define the entry point address
    entrypoint = 0x400000

    # Set the memory context
    startCtx()

    # Run the emulation
    defcon(entrypoint)

    sys.exit(0)

```



```
root@ubuntu19:~/pin214/source/tools/Triton/src/examples/python# python defcon_sym_2.py
Curr ip: 0x400000: push ebx
Next ip: 0x400001
Next eax: 0x2
Next ebx: 0x0
Next ecx: 0x7
Next edx: 0x0

Curr ip: 0x400001: mov ebx, 0xb9
Next ip: 0x400006
Next eax: 0x2
Next ebx: 0xb9
Next ecx: 0x7
Next edx: 0x0

Curr ip: 0x400006: sub eax, ebx
Next ip: 0x400008
Next eax: 0xffffff49
Next ebx: 0xb9
Next ecx: 0x7
Next edx: 0x0


Curr ip: 0x400028: pop edx
Next ip: 0x400029
Next eax: 0x9
Next ebx: 0x0
Next ecx: 0x7
Next edx: 0x0

Curr ip: 0x400029: jmp eax
Next ip: 0x9
Next eax: 0x9
Next ebx: 0x0
Next ecx: 0x7
Next edx: 0x0
```

RADARE2 + MIASM



```
root@kali:~/programs/defcon# r2 -b 32 defcon2019.bin
 -- EIP = 0x41414141
[0x00000000]> aaa
[x] Analyze all flags starting with sym. and entry0 (aa)
[x] Analyze function calls (aac)
[x] Analyze len bytes of instructions for references (aar)
[x] Use -AA or aaaa to perform additional experimental analysis.
[x] Constructing a function name for fcn.* and sym.func.* functions (aan)
[0x00000000]> ec comment green
[0x00000000]> e asm.emu=true
[0x00000000]> pdf
┌ (fcn) fcn.00000000 41
│   fcn.00000000 ();
│           0x00000000      53             push ebx                     ; esp=0xfffffffffffffffc
│           0x00000001      bbb900000000   mov ebx, 0xb9                ; 185 ; ebx=0xb9
│           0x00000006      29d8           sub eax, ebx                 ; eax=0xffffffffffffff47 ; of=0x0 ; sf
=0x1 -> 0xb9bb ; zf=0x0 ; pf=0x1 -> 0xb9bb ; cf=0x1 -> 0xb9bb
│           0x00000008      5b             pop ebx                      ; ebx=0xffffffff ; esp=0x100000000
│           0x00000009      83e855         sub eax, 0x55                ; 'U' ; eax=0xfffffef2 ; of=0x0 ; sf=0
x1 -> 0xb9bb ; zf=0x0 ; pf=0x0 ; cf=0x0
│           0x0000000c      83e832         sub eax, 0x32                ; '2' ; eax=0xfffffec0 ; of=0x0 ; sf=0
x1 -> 0xb9bb ; zf=0x0 ; pf=0x1 -> 0xb9bb ; cf=0x0
│           0x0000000f      01c8           add eax, ecx                 ; eax=0xfffffec0 ; of=0x0 ; sf=0x1 ->
0xb9bb ; zf=0x0 ; cf=0x0 ; pf=0x1 -> 0xb9bb
│           0x00000011      83c050         add eax, 0x50                ; 'P' ; eax=0xffffff10 ; of=0x0 ; sf=0
x1 -> 0xb9bb ; zf=0x0 ; cf=0x0 ; pf=0x0
│           0x00000014      83c037         add eax, 0x37                ; '7' ; eax=0xffffff47 ; of=0x0 ; sf=0
x1 -> 0xb9bb ; zf=0x0 ; cf=0x0 ; pf=0x1 -> 0xb9bb
│           0x00000017      52             push edx                     ; esp=0xfffffffffffffffc
│           0x00000018      51             push ecx                     ; esp=0xfffffff8
│           0x00000019      b949000000     mov ecx, 0x49                ; 'I' ; 73 ; ecx=0x49
│           0x0000001e      89ca           mov edx, ecx                 ; edx=0x49
│           0x00000020      59             pop ecx                      ; ecx=0xffffffff ; esp=0xfffffffc
│           0x00000021      42             inc edx                      ; edx=0x4a ; of=0x0 ; sf=0x0 ; zf=0x0
; pf=0x0
│           0x00000022      83c270         add edx, 0x70                ; 'p' ; edx=0xba ; of=0x0 ; sf=0x0 ; z
f=0x0 ; cf=0x0 ; pf=0x0
│           0x00000025      4a             dec edx                      ; edx=0xb9 ; of=0x0 ; sf=0x0 ; zf=0x0
; pf=0x0
│           0x00000026      01d0           add eax, edx                 ; eax=0x100000000 ; of=0x0 ; sf=0x0 ;
zf=0x1 -> 0xb9bb ; cf=0x1 -> 0xb9bb ; pf=0x1 -> 0xb9bb
└           0x00000028      5a             pop edx                      ; edx=0xffffffff ; esp=0x100000000
```

ESIL comment

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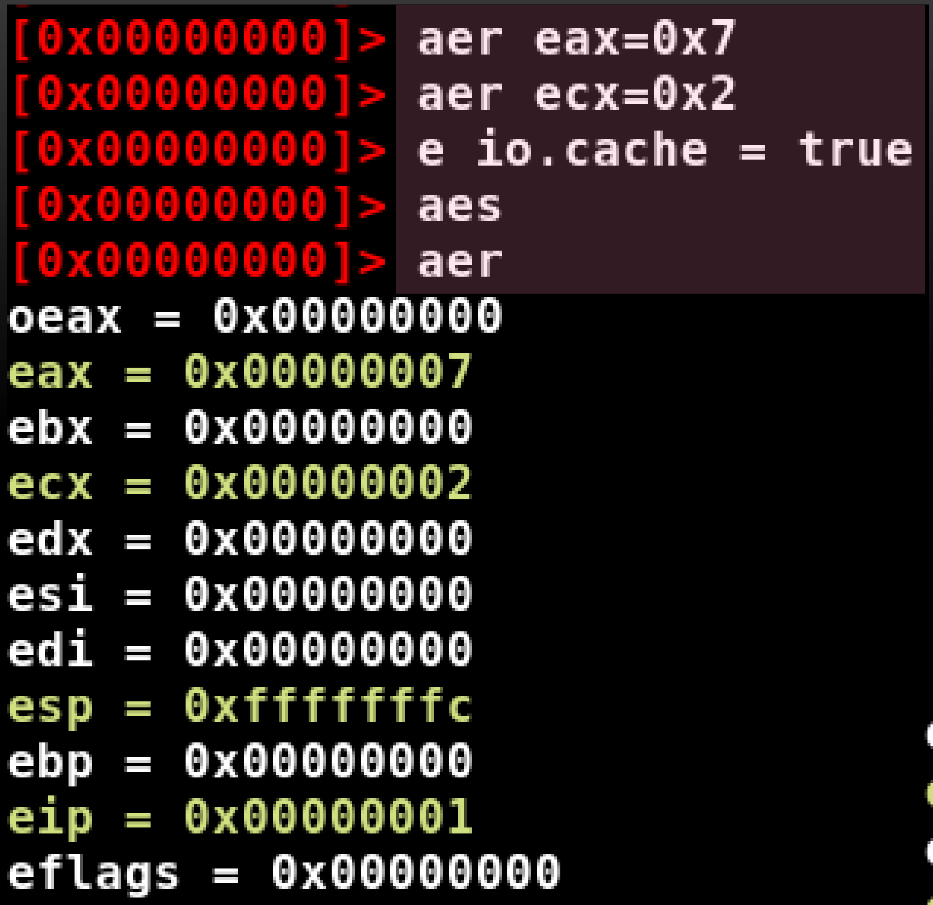
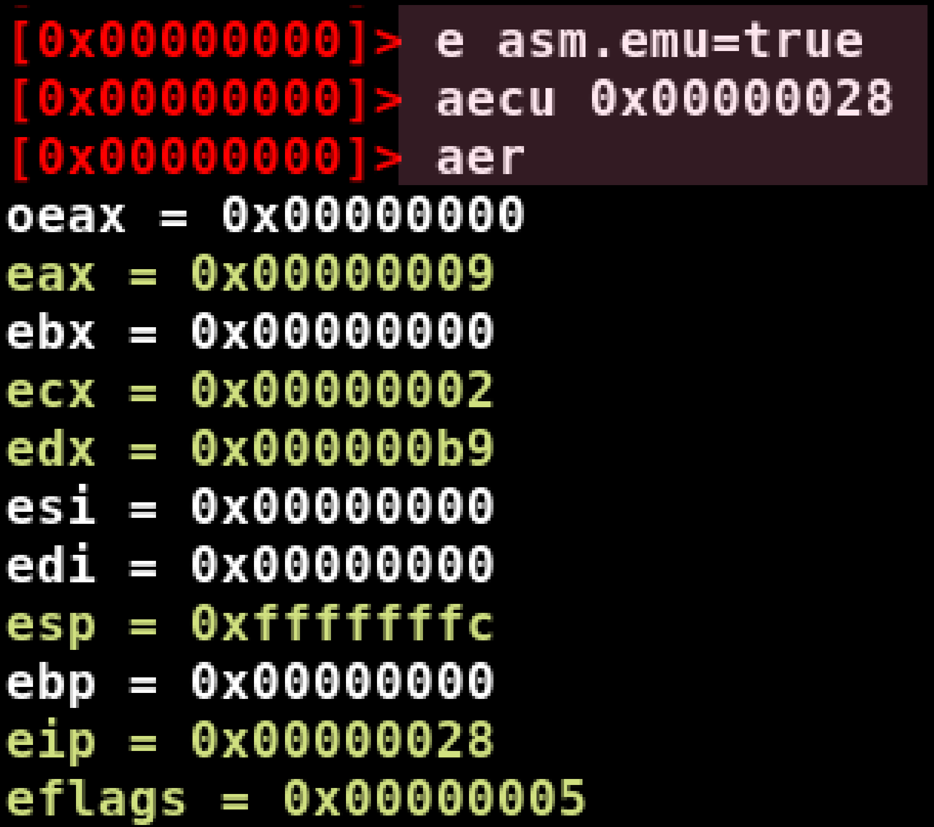


```
[0x00000000]> aer eax=0x7
[0x00000000]> aer ecx=0x2
[0x00000000]> e io.cache = true
[0x00000000]> aes
[0x00000000]> aer
oeax = 0x00000000
eax = 0x00000007
ebx = 0x00000000
ecx = 0x00000002
edx = 0x00000000
esi = 0x00000000
edi = 0x00000000
esp = 0xfffffffc
ebp = 0x00000000
eip = 0x00000001
eflags = 0x00000000
```

- ✓ aer: handle ESIL registers (set and show)
- ✓ aes: perform emulated debugger step
- ✓ aecu: continue until address



```
[0x00000000]> e asm.emu=true
[0x00000000]> aecu 0x00000028
[0x00000000]> aer
oeax = 0x00000000
eax = 0x00000009
ebx = 0x00000000
ecx = 0x00000002
edx = 0x000000b9
esi = 0x00000000
edi = 0x00000000
esp = 0xfffffffc
ebp = 0x00000000
eip = 0x00000028
eflags = 0x00000005
```

R2M2 bridges the radare2 and miasm2 communities: radare2 being the graphical interface of miasm2, and miasm2 simplifying the implementation of new architectures.

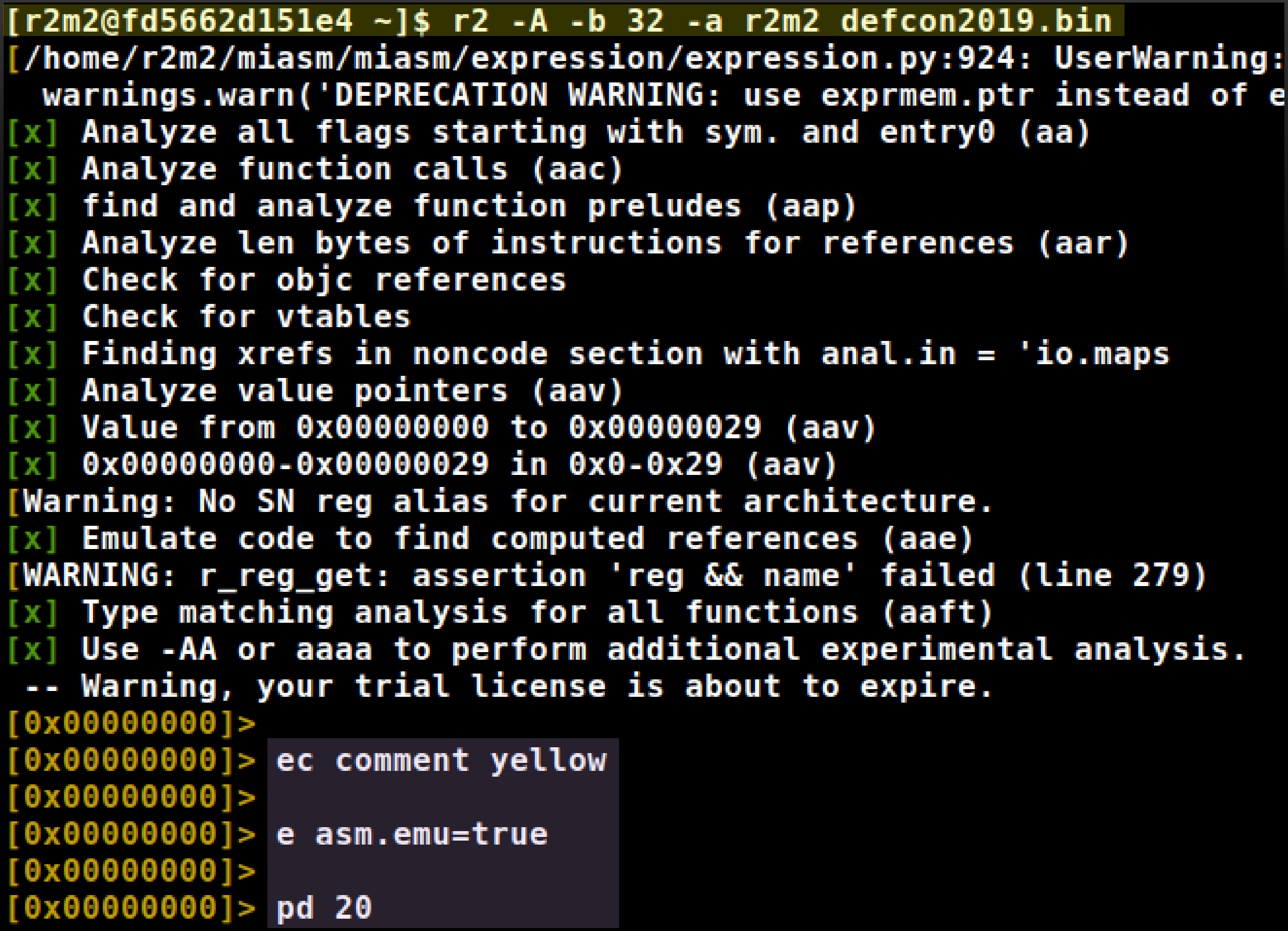
How to install it?

- ✓ apt-get install docker
- ✓ git clone https://github.com/radare/radare2.git
- ✓ cd radare2/
- ✓ sys/install.sh
- ✓ Install MIASM
- ✓ pip install cffi
- ✓ pip install jinja2
- ✓ docker pull guedou/r2m2
- ✓ docker run --rm -it -e 'R2M2_ARCH=x86_32' guedou/r2m2 bash

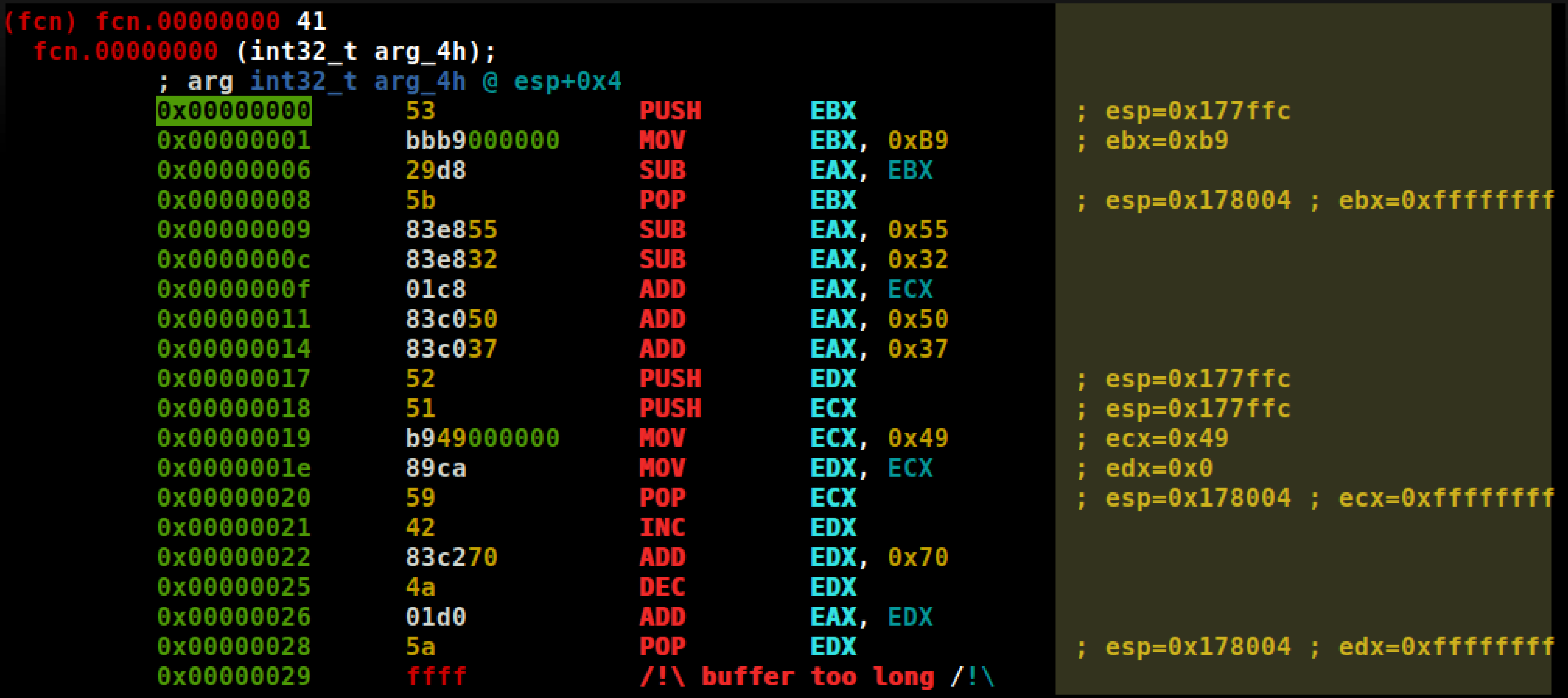
- ✓ [r2m2@fd5662d151e4 ~]$ pwd

- ✓ (another terminal) docker ps -a
- ✓ (another terminal) docker cp /root/defcon2019.bin fd5662d151e4:/home/r2m2/defcon2019.bin

- ✓ [r2m2@fd5662d151e4 ~]$ export R2M2_ARCH=x86_32
- ✓ [r2m2@fd5662d151e4 ~]$ r2 -A -b 32 -a r2m2 defcon2019.bin



```
[r2m2@fd5662d151e4 ~]$ r2 -A -b 32 -a r2m2 defcon2019.bin
[/home/r2m2/miasm/miasm/expression/expression.py:924: UserWarning:
  warnings.warn('DEPRECATION WARNING: use exprmem.ptr instead of e
[x] Analyze all flags starting with sym. and entry0 (aa)
[x] Analyze function calls (aac)
[x] find and analyze function preludes (aap)
[x] Analyze len bytes of instructions for references (aar)
[x] Check for objc references
[x] Check for vtables
[x] Finding xrefs in noncode section with anal.in = 'io.maps
[x] Analyze value pointers (aav)
[x] Value from 0x00000000 to 0x00000029 (aav)
[x] 0x00000000-0x00000029 in 0x0-0x29 (aav)
[Warning: No SN reg alias for current architecture.
[x] Emulate code to find computed references (aae)
[WARNING: r_reg_get: assertion 'reg && name' failed (line 279)
[x] Type matching analysis for all functions (aaft)
[x] Use -AA or aaaa to perform additional experimental analysis.
 -- Warning, your trial license is about to expire.
[0x00000000]>
[0x00000000]> ec comment yellow
[0x00000000]>
[0x00000000]> e asm.emu=true
[0x00000000]>
[0x00000000]> pd 20
```



```
(fcn) fcn.00000000 41
  fcn.00000000 (int32_t arg_4h);
          ; arg int32_t arg_4h @ esp+0x4
          0x00000000      53              PUSH       EBX           ; esp=0x177ffc
          0x00000001      bbb9000000      MOV        EBX, 0xB9     ; ebx=0xb9
          0x00000006      29d8            SUB        EAX, EBX
          0x00000008      5b              POP        EBX           ; esp=0x178004 ; ebx=0xffffffff
          0x00000009      83e855          SUB        EAX, 0x55
          0x0000000c      83e832          SUB        EAX, 0x32
          0x0000000f      01c8            ADD        EAX, ECX
          0x00000011      83c050          ADD        EAX, 0x50
          0x00000014      83c037          ADD        EAX, 0x37
          0x00000017      52              PUSH       EDX           ; esp=0x177ffc
          0x00000018      51              PUSH       ECX           ; esp=0x177ffc
          0x00000019      b949000000      MOV        ECX, 0x49     ; ecx=0x49
          0x0000001e      89ca            MOV        EDX, ECX      ; edx=0x0
          0x00000020      59              POP        ECX           ; esp=0x178004 ; ecx=0xffffffff
          0x00000021      42              INC        EDX
          0x00000022      83c270          ADD        EDX, 0x70
          0x00000025      4a              DEC        EDX
          0x00000026      01d0            ADD        EAX, EDX
          0x00000028      5a              POP        EDX           ; esp=0x178004 ; edx=0xffffffff
          0x00000029      ffff            /!\ buffer too long /!\
```

DTRACE on WINDOWS

- ✓ DTrace is a dynamic tracing framework, which is very efficient and famous on Solaris operating system.

- ✓ Dtrace was initially written by Mike Shapiro, Adam Leventhal and Brian Cantrill at Sun Microsystems. Although they were developing DTrace since 2003, it was only introduced in Solaris 10 03/05.

- ✓ It is used to get a real time overview of a system in user and kernel mode. Furthermore, it can be used to understand how application and systems are behaving.

- ✓ Few months ago, DTrace was ported to Windows: https://github.com/opendtrace/opendtrace/tree/windows

- ✓ DTrace is could be summarized as a set of probes (sensors) scattered over the key point in the kernel. Thus, every time that a probe is "activated", it is possible to register and understand the application behavior.

- ✓ Using DTrace makes easier to trace the profile of a process and the system, find which system calls are "called", how many bytes are written/read by a process, file opened by a process, tracing the sequence of called system calls and so on.

✓ DTrace scripts are written in D language (similar to awk).

✓ Probe names are described by the following syntaxe:

```
provider:module:function:name
```

where:

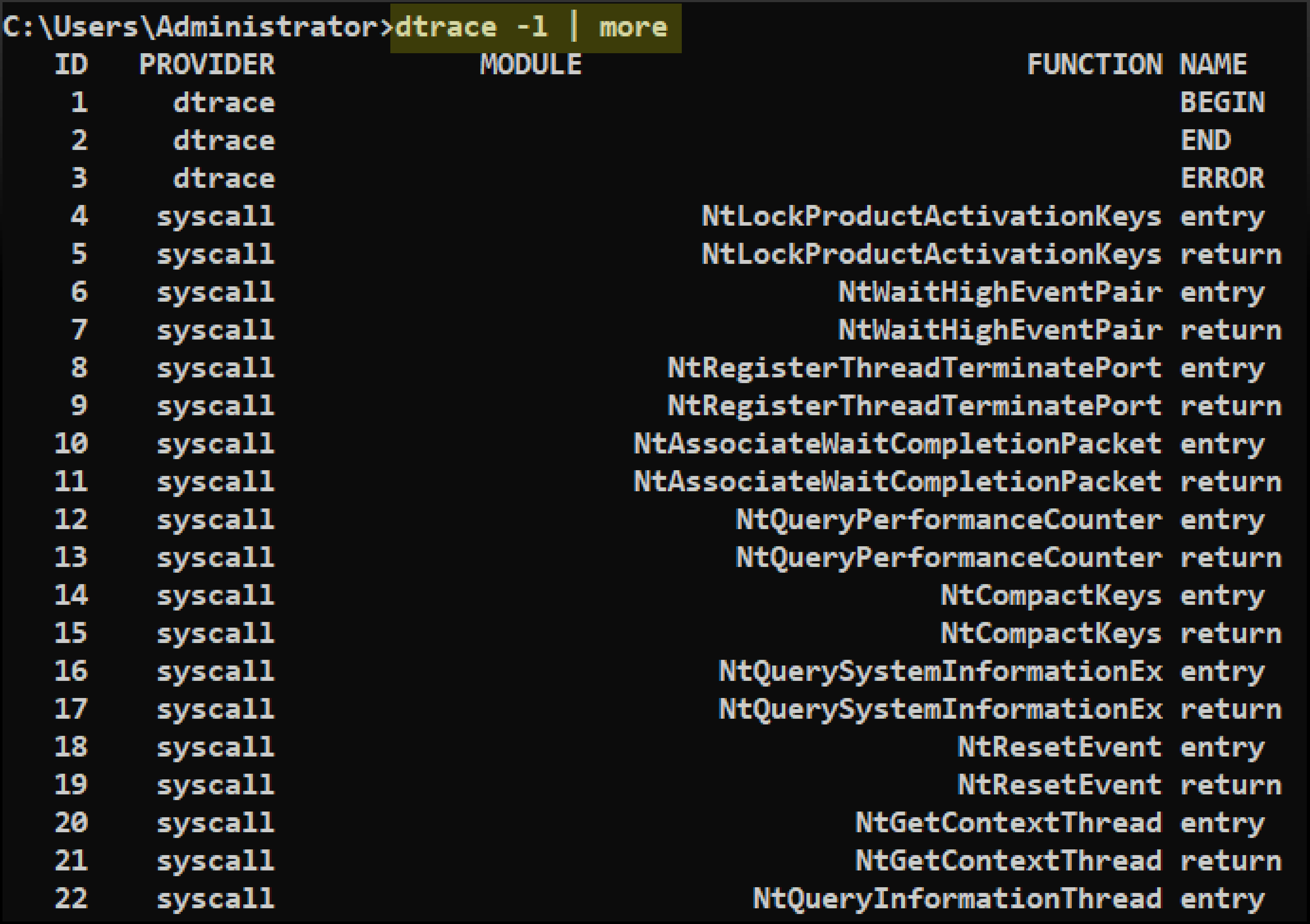
- ✓ provider: library of probes used to instrument an area of the system. On Windows, the existing providers are syscall, etw, profile, pid and dtrace.

- ✓ module: kernel module where we find the probe.
- ✓ function: function contaning the probe.
- ✓ name: specific name or description of the target probe.

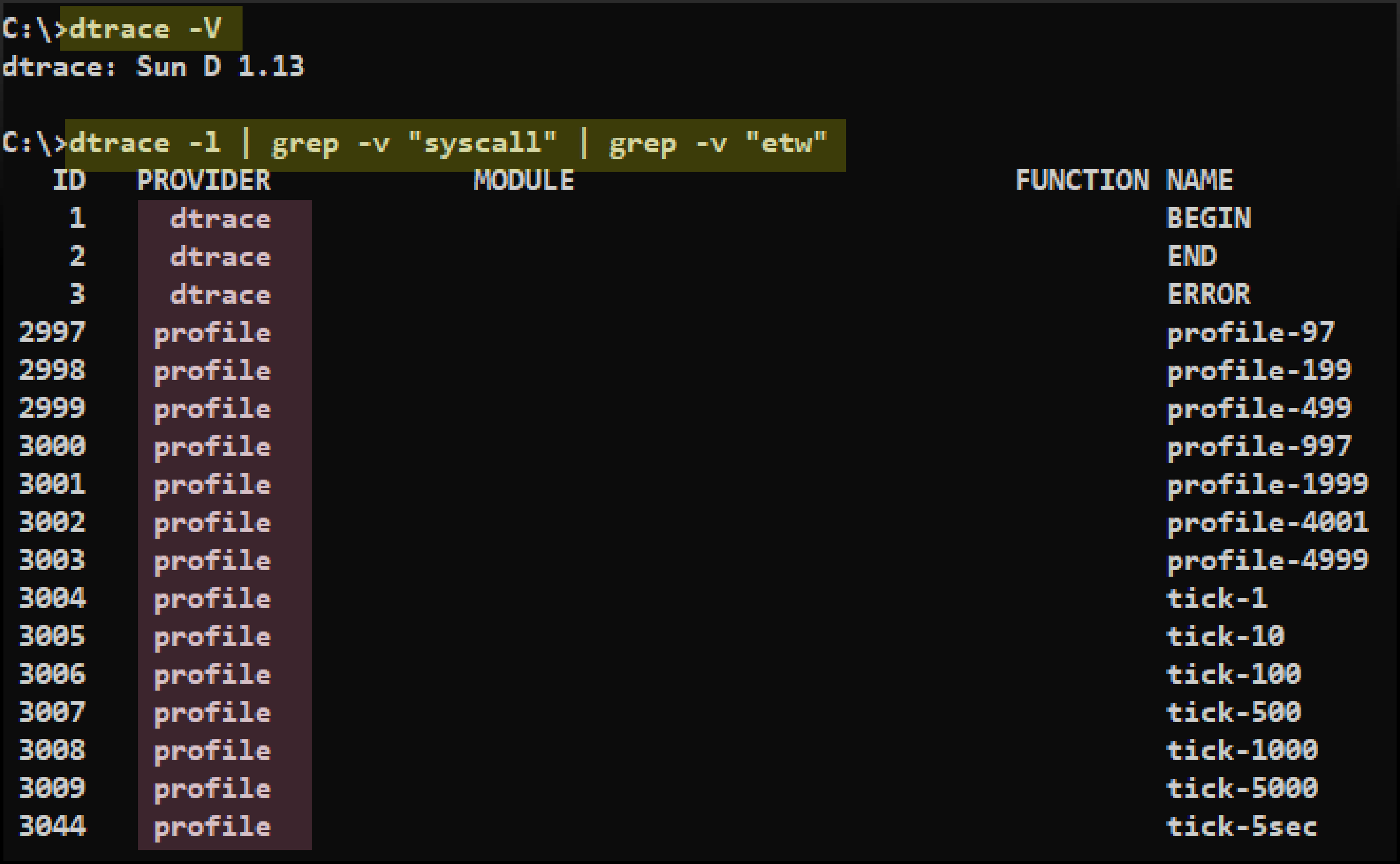
✓ Key concepts:

- ✓ predicates: user defined conditions.
- ✓ actions: tasks that are run when a probe fires.
- ✓ aggregations: coalesce data using aggregation functions.

- ✓ To install DTrace:
  - ✓ Windows 10 x64 (build 18342 or later) from Windows Insider Program.
  - ✓ bcdedit.exe /set dtrace on
  - ✓ Download DTrace package: http://download.microsoft.com/download/B/D/4/BD4B95A5-0B61-4D8F-837C-F889AAD8DAA2/DTrace.amd64.msi
  - ✓ _NT_SYMBOL_PATH=srv*C:\symbols*https://msdl.microsoft.com/download/symbols
  - ✓ Reboot the system.
  - ✓ Open a command prompt as administrator.
  - ✓ If you are using fbt (function boundary tracing), so it is necessary to attach the WinDbg and boot the Windows in debug mode. ☺



```
C:\Users\Administrator>dtrace -l | more
   ID   PROVIDER            MODULE                          FUNCTION NAME
    1     dtrace                                                     BEGIN
    2     dtrace                                                     END
    3     dtrace                                                     ERROR
    4    syscall                       NtLockProductActivationKeys entry
    5    syscall                       NtLockProductActivationKeys return
    6    syscall                               NtWaitHighEventPair entry
    7    syscall                               NtWaitHighEventPair return
    8    syscall                     NtRegisterThreadTerminatePort entry
    9    syscall                     NtRegisterThreadTerminatePort return
   10    syscall                   NtAssociateWaitCompletionPacket entry
   11    syscall                   NtAssociateWaitCompletionPacket return
   12    syscall                         NtQueryPerformanceCounter entry
   13    syscall                         NtQueryPerformanceCounter return
   14    syscall                                     NtCompactKeys entry
   15    syscall                                     NtCompactKeys return
   16    syscall                        NtQuerySystemInformationEx entry
   17    syscall                        NtQuerySystemInformationEx return
   18    syscall                                      NtResetEvent entry
   19    syscall                                      NtResetEvent return
   20    syscall                                NtGetContextThread entry
   21    syscall                                NtGetContextThread return
   22    syscall                          NtQueryInformationThread entry
```



```
C:\>dtrace -V
dtrace: Sun D 1.13

C:\>dtrace -l | grep -v "syscall" | grep -v "etw"
   ID   PROVIDER            MODULE                          FUNCTION NAME
    1     dtrace                                                     BEGIN
    2     dtrace                                                     END
    3     dtrace                                                     ERROR
 2997    profile                                                     profile-97
 2998    profile                                                     profile-199
 2999    profile                                                     profile-499
 3000    profile                                                     profile-997
 3001    profile                                                     profile-1999
 3002    profile                                                     profile-4001
 3003    profile                                                     profile-4999
 3004    profile                                                     tick-1
 3005    profile                                                     tick-10
 3006    profile                                                     tick-100
 3007    profile                                                     tick-500
 3008    profile                                                     tick-1000
 3009    profile                                                     tick-5000
 3044    profile                                                     tick-5sec
```

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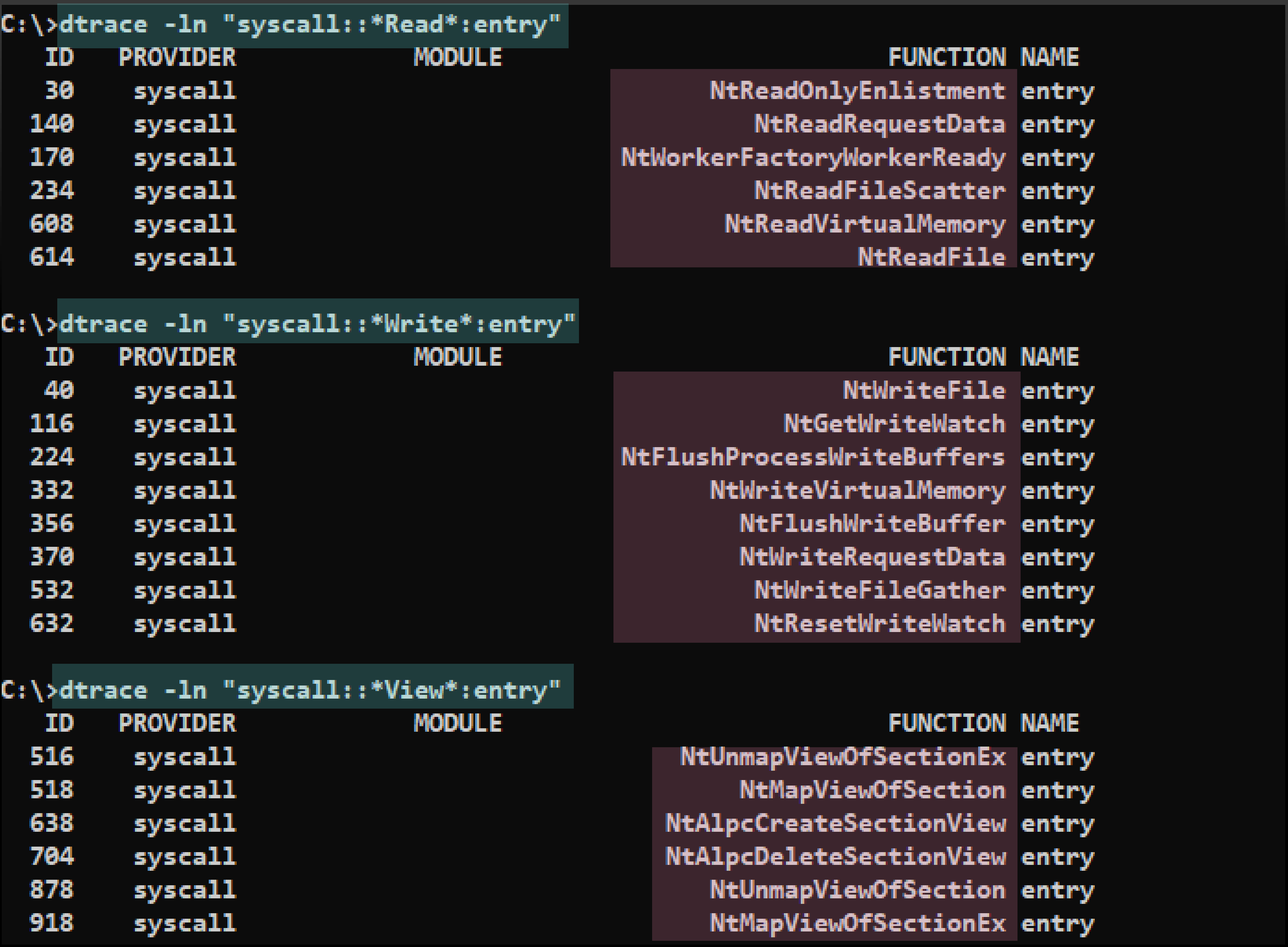
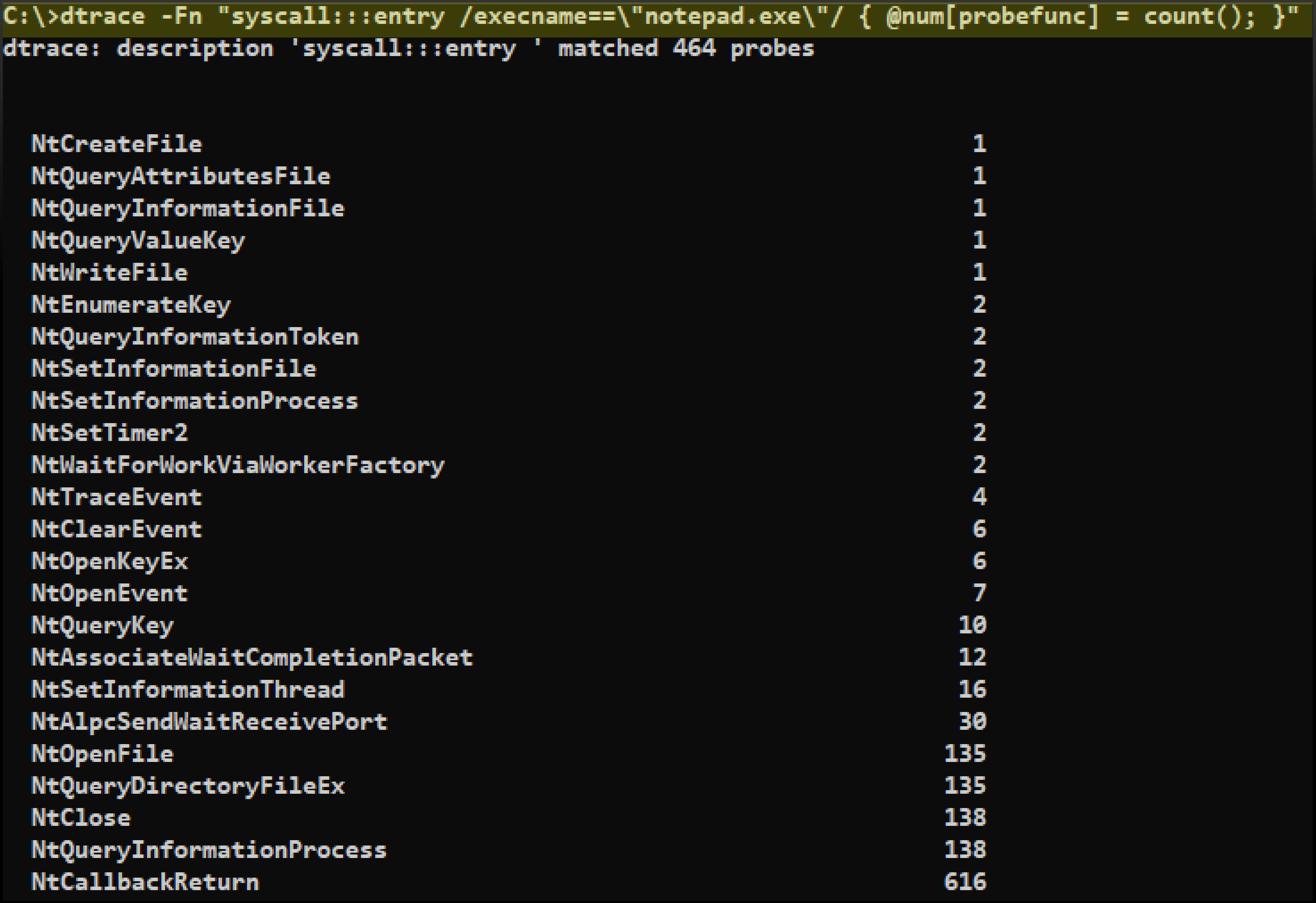
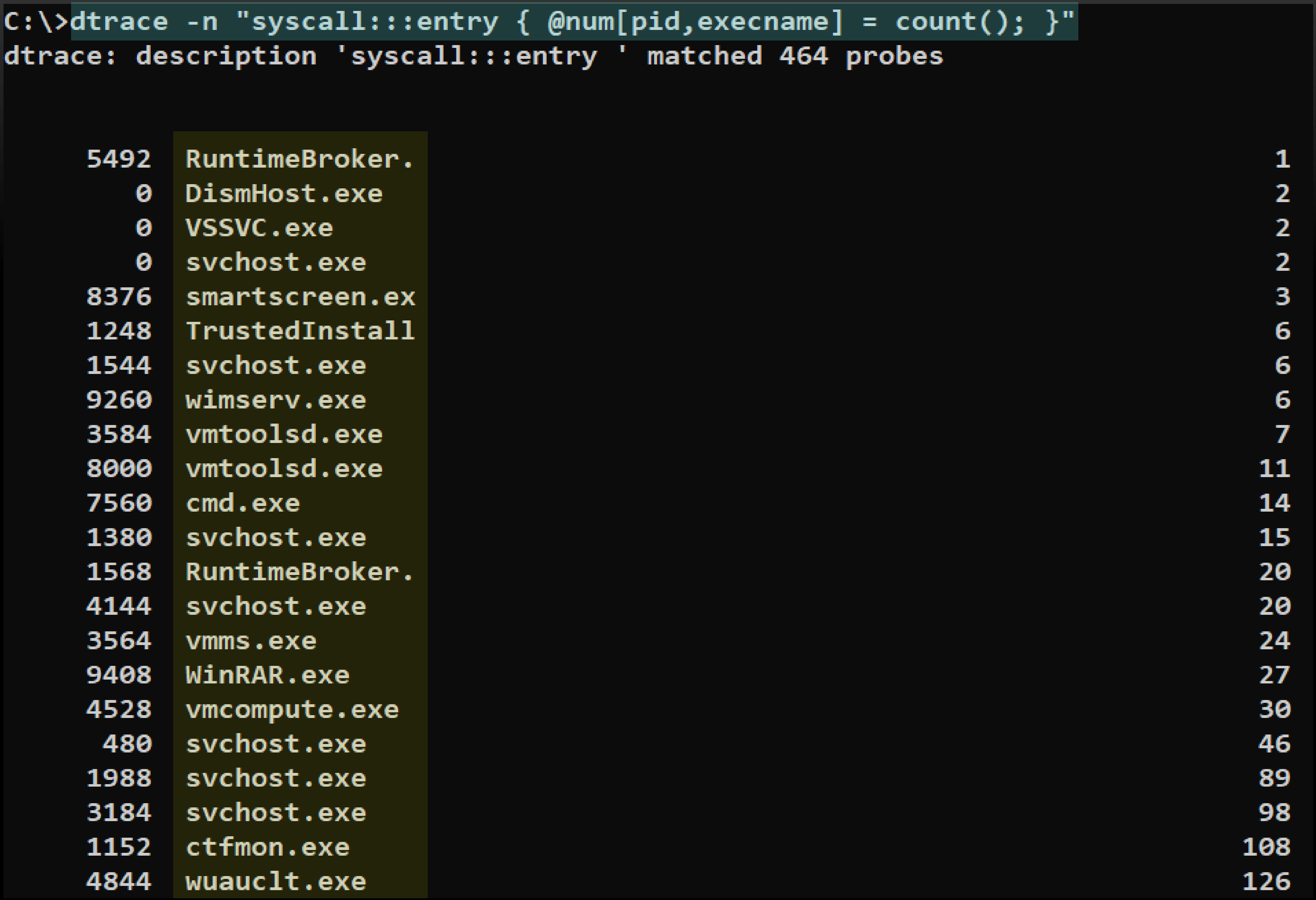


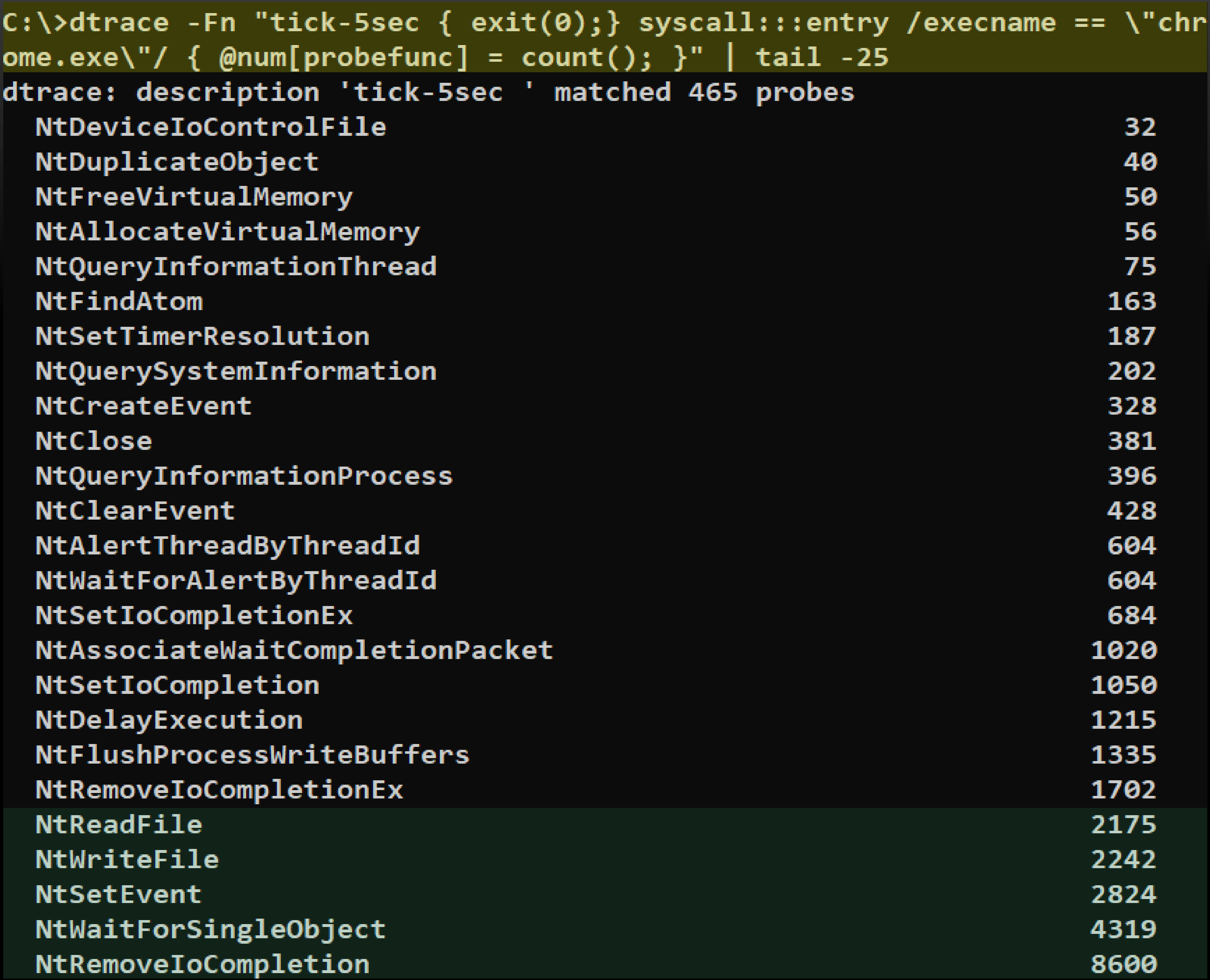
```
C:\>dtrace -ln "syscall::*Read*:entry"
   ID   PROVIDER            MODULE                          FUNCTION NAME
   30    syscall                               NtReadOnlyEnlistment entry
  140    syscall                                 NtReadRequestData entry
  170    syscall                         NtWorkerFactoryWorkerReady entry
  234    syscall                                 NtReadFileScatter entry
  608    syscall                               NtReadVirtualMemory entry
  614    syscall                                        NtReadFile entry

C:\>dtrace -ln "syscall::*Write*:entry"
   ID   PROVIDER            MODULE                          FUNCTION NAME
   40    syscall                                       NtWriteFile entry
  116    syscall                                   NtGetWriteWatch entry
  224    syscall                         NtFlushProcessWriteBuffers entry
  332    syscall                              NtWriteVirtualMemory entry
  356    syscall                                NtFlushWriteBuffer entry
  370    syscall                                NtWriteRequestData entry
  532    syscall                                 NtWriteFileGather entry
  632    syscall                                 NtResetWriteWatch entry

C:\>dtrace -ln "syscall::*View*:entry"
   ID   PROVIDER            MODULE                          FUNCTION NAME
  516    syscall                            NtUnmapViewOfSectionEx entry
  518    syscall                                NtMapViewOfSection entry
  638    syscall                             NtAlpcCreateSectionView entry
  704    syscall                             NtAlpcDeleteSectionView entry
  878    syscall                              NtUnmapViewOfSection entry
  918    syscall                              NtMapViewOfSectionEx entry
```



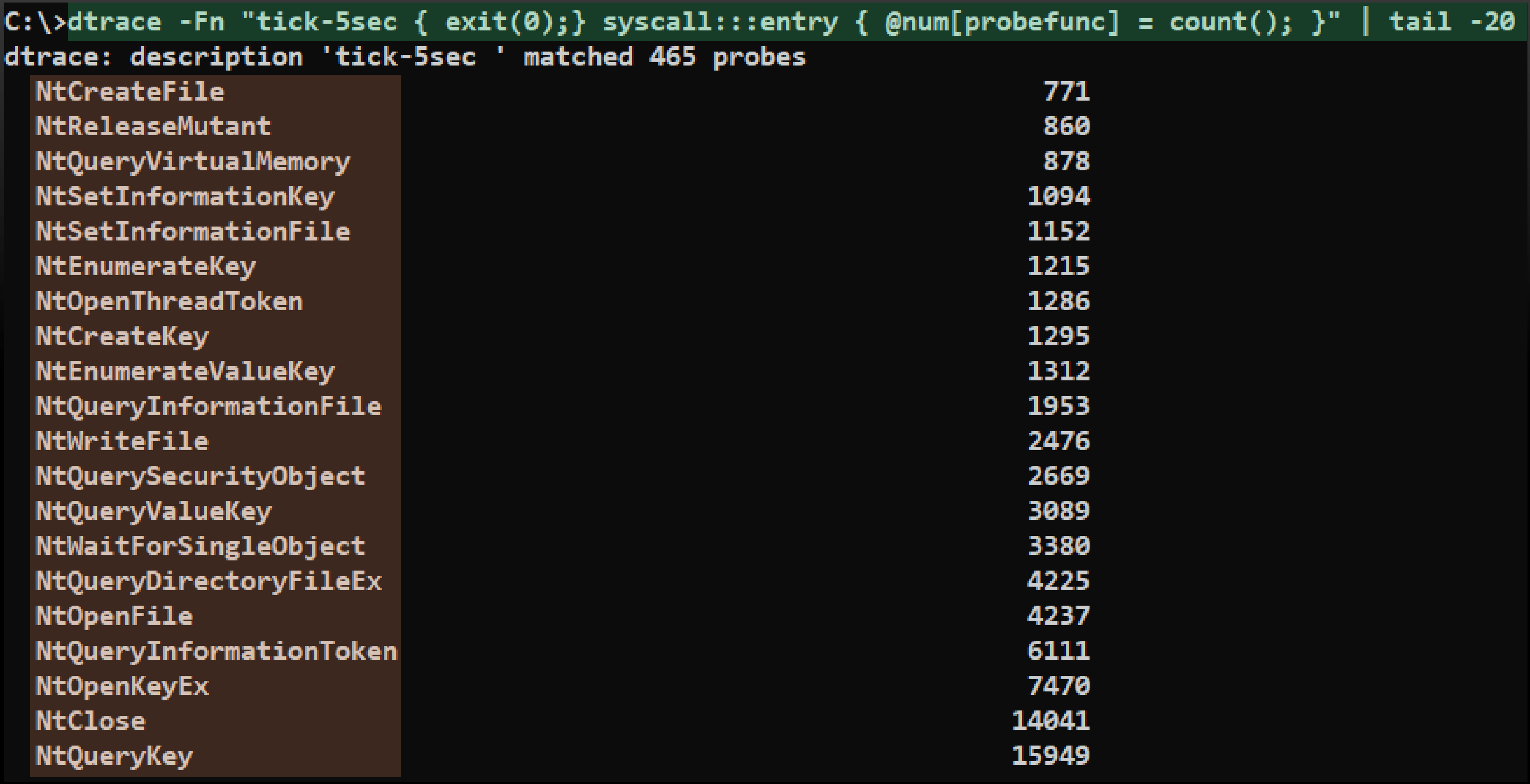
```
C:\>dtrace -Fn "syscall:::entry /execname==\"notepad.exe\"/ { @num[probefunc] = count(); }"
dtrace: description 'syscall:::entry ' matched 464 probes


  NtCreateFile                                                      1
  NtQueryAttributesFile                                             1
  NtQueryInformationFile                                            1
  NtQueryValueKey                                                   1
  NtWriteFile                                                       1
  NtEnumerateKey                                                    2
  NtQueryInformationToken                                           2
  NtSetInformationFile                                              2
  NtSetInformationProcess                                           2
  NtSetTimer2                                                       2
  NtWaitForWorkViaWorkerFactory                                     2
  NtTraceEvent                                                      4
  NtClearEvent                                                      6
  NtOpenKeyEx                                                       6
  NtOpenEvent                                                       7
  NtQueryKey                                                       10
  NtAssociateWaitCompletionPacket                                  12
  NtSetInformationThread                                           16
  NtAlpcSendWaitReceivePort                                        30
  NtOpenFile                                                      135
  NtQueryDirectoryFileEx                                          135
  NtClose                                                         138
  NtQueryInformationProcess                                       138
  NtCallbackReturn                                                616
```



```
C:\>dtrace -n "syscall:::entry { @num[pid,execname] = count(); }"
dtrace: description 'syscall:::entry ' matched 464 probes


     5492  RuntimeBroker.                                                        1
        0  DismHost.exe                                                          2
        0  VSSVC.exe                                                             2
        0  svchost.exe                                                           2
     8376  smartscreen.ex                                                        3
     1248  TrustedInstall                                                        6
     1544  svchost.exe                                                           6
     9260  wimserv.exe                                                           6
     3584  vmtoolsd.exe                                                          7
     8000  vmtoolsd.exe                                                         11
     7560  cmd.exe                                                              14
     1380  svchost.exe                                                          15
     1568  RuntimeBroker.                                                       20
     4144  svchost.exe                                                          20
     3564  vmms.exe                                                             24
     9408  WinRAR.exe                                                           27
     4528  vmcompute.exe                                                        30
      480  svchost.exe                                                          46
     1988  svchost.exe                                                          89
     3184  svchost.exe                                                          98
     1152  ctfmon.exe                                                          108
     4844  wuauclt.exe                                                         126
```



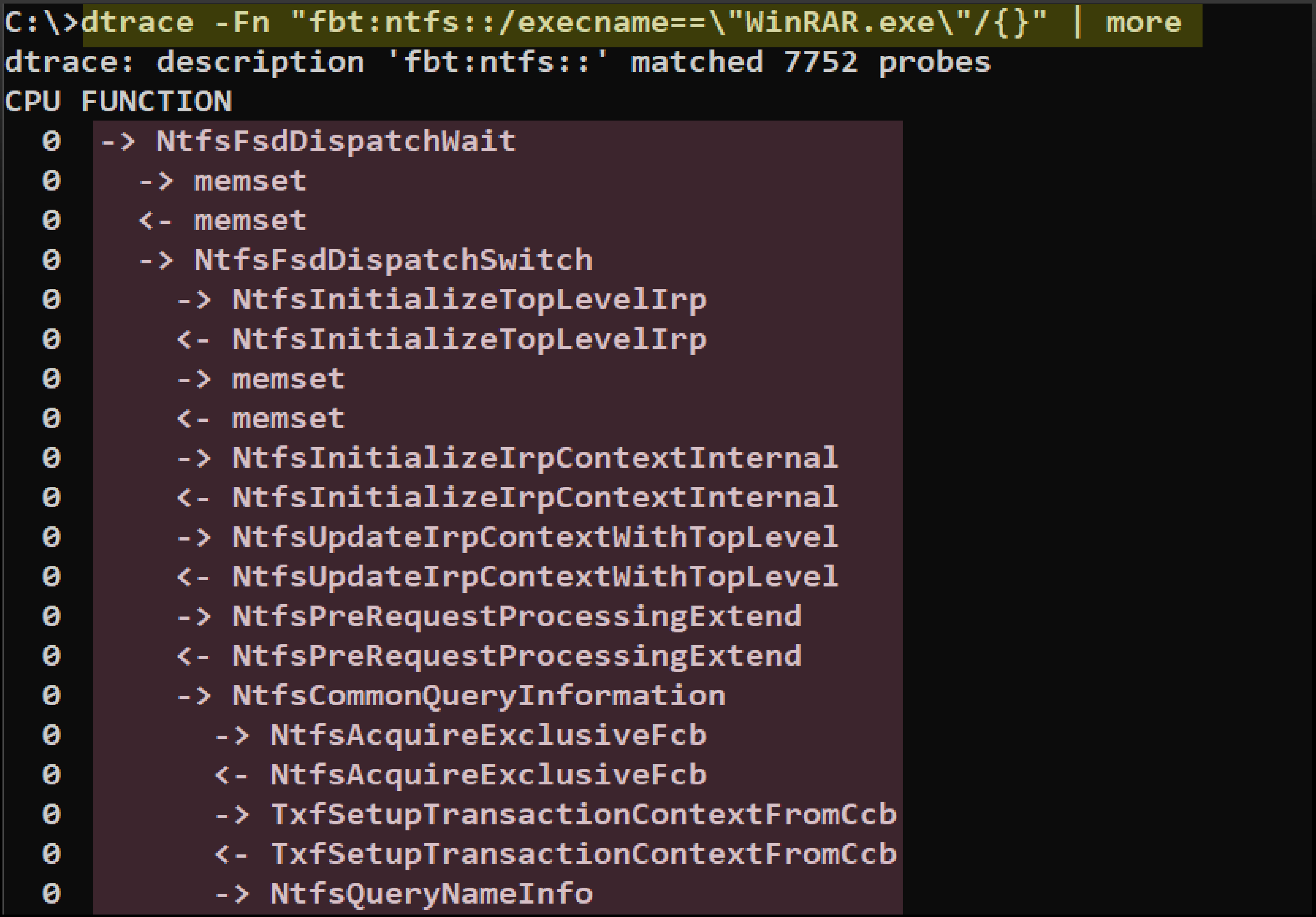
```
C:\>dtrace -Fn "tick-5sec { exit(0);} syscall:::entry /execname == \"chr
ome.exe\"/ { @num[probefunc] = count(); }" | tail -25
dtrace: description 'tick-5sec ' matched 465 probes
  NtDeviceIoControlFile                                            32
  NtDuplicateObject                                                40
  NtFreeVirtualMemory                                              50
  NtAllocateVirtualMemory                                          56
  NtQueryInformationThread                                         75
  NtFindAtom                                                      163
  NtSetTimerResolution                                            187
  NtQuerySystemInformation                                        202
  NtCreateEvent                                                   328
  NtClose                                                         381
  NtQueryInformationProcess                                       396
  NtClearEvent                                                    428
  NtAlertThreadByThreadId                                         604
  NtWaitForAlertByThreadId                                        604
  NtSetIoCompletionEx                                             684
  NtAssociateWaitCompletionPacket                                1020
  NtSetIoCompletion                                              1050
  NtDelayExecution                                               1215
  NtFlushProcessWriteBuffers                                     1335
  NtRemoveIoCompletionEx                                         1702
  NtReadFile                                                     2175
  NtWriteFile                                                    2242
  NtSetEvent                                                     2824
  NtWaitForSingleObject                                          4319
  NtRemoveIoCompletion                                           8600
```



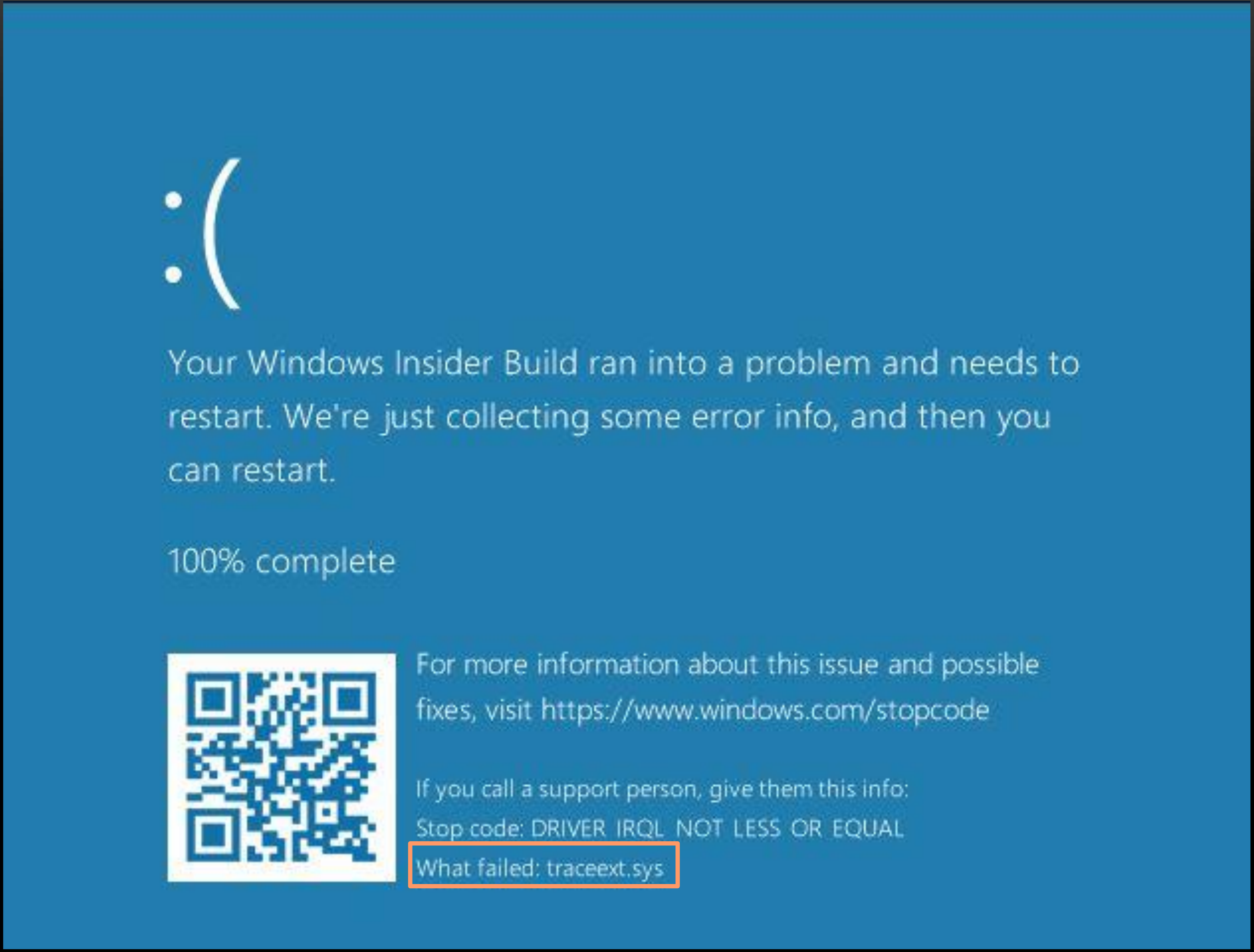
```
C:\>dtrace -Fn "tick-5sec { exit(0);} syscall::entry { @num[probefunc] = count(); }" | tail -20
dtrace: description 'tick-5sec ' matched 465 probes
  NtCreateFile                                                        771
  NtReleaseMutant                                                     860
  NtQueryVirtualMemory                                                878
  NtSetInformationKey                                                1094
  NtSetInformationFile                                               1152
  NtEnumerateKey                                                     1215
  NtOpenThreadToken                                                  1286
  NtCreateKey                                                        1295
  NtEnumerateValueKey                                                1312
  NtQueryInformationFile                                             1953
  NtWriteFile                                                        2476
  NtQuerySecurityObject                                              2669
  NtQueryValueKey                                                    3089
  NtWaitForSingleObject                                              3380
  NtQueryDirectoryFileEx                                             4225
  NtOpenFile                                                         4237
  NtQueryInformationToken                                            6111
  NtOpenKeyEx                                                        7470
  NtClose                                                           14041
  NtQueryKey                                                        15949
```

- ✓ It is possible to use a different type of provider named "fbt" (function boundary tracing), which tracks the sequence of system calls being executed through the NTFS in the kernel.

- ✓ The "fbt" provider only it is available when there is kernel debugger attached to the Windows 10.



```
C:\>dtrace -Fn "fbt:ntfs::/execname==\"WinRAR.exe\"/{}" | more
dtrace: description 'fbt:ntfs::' matched 7752 probes
CPU FUNCTION
  0  -> NtfsFsdDispatchWait
  0    -> memset
  0    <- memset
  0    -> NtfsFsdDispatchSwitch
  0      -> NtfsInitializeTopLevelIrp
  0      <- NtfsInitializeTopLevelIrp
  0      -> memset
  0      <- memset
  0      -> NtfsInitializeIrpContextInternal
  0      <- NtfsInitializeIrpContextInternal
  0      -> NtfsUpdateIrpContextWithTopLevel
  0      <- NtfsUpdateIrpContextWithTopLevel
  0      -> NtfsPreRequestProcessingExtend
  0      <- NtfsPreRequestProcessingExtend
  0      -> NtfsCommonQueryInformation
  0        -> NtfsAcquireExclusiveFcb
  0        <- NtfsAcquireExclusiveFcb
  0        -> TxfSetupTransactionContextFromCcb
  0        <- TxfSetupTransactionContextFromCcb
  0        -> NtfsQueryNameInfo
```



:(

Your Windows Insider Build ran into a problem and needs to restart. We're just collecting some error info, and then you can restart.

100% complete

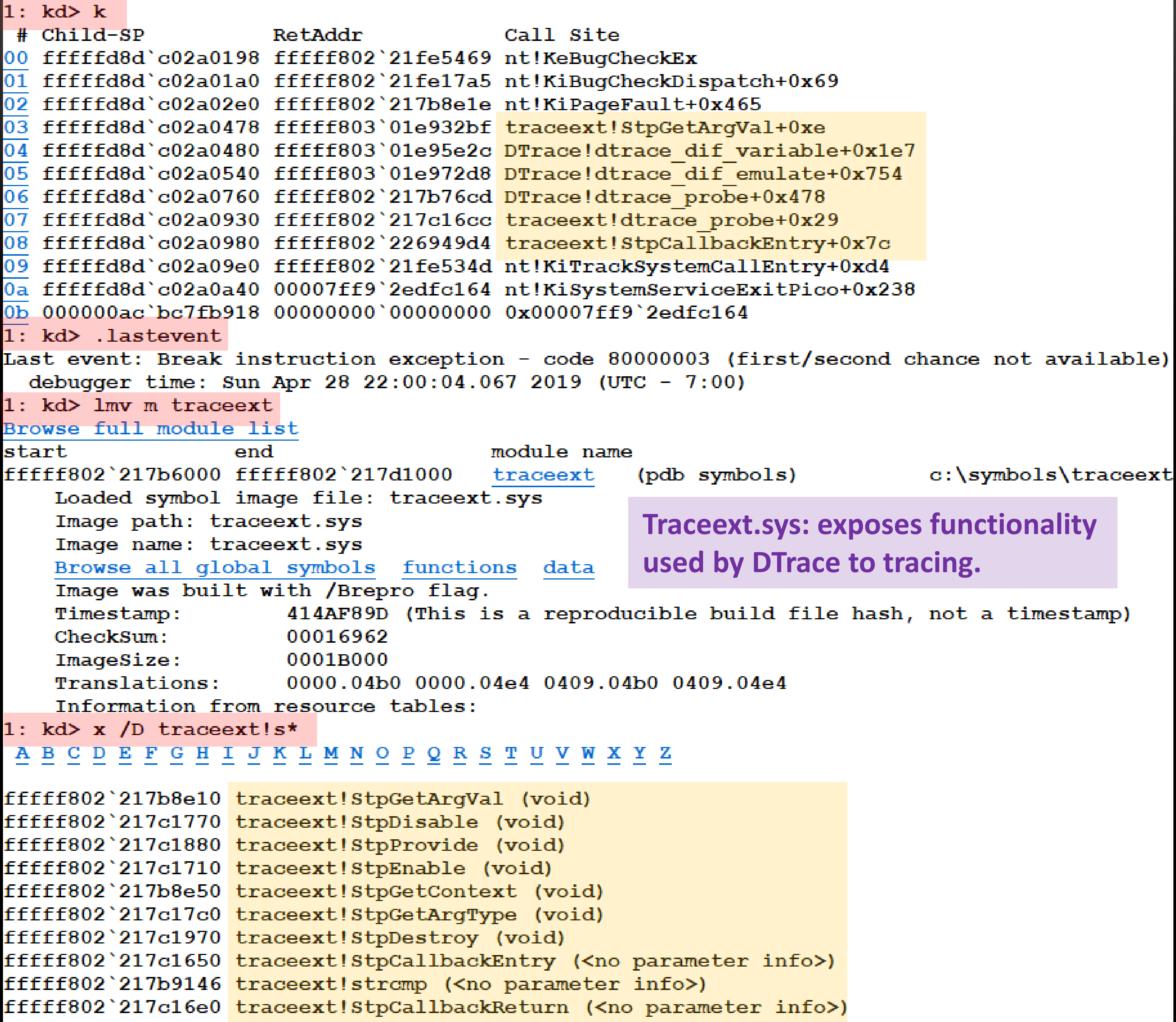
For more information about this issue and possible fixes, visit https://www.windows.com/stopcode

If you call a support person, give them this info:

Stop code: DRIVER IRQL NOT LESS OR EQUAL

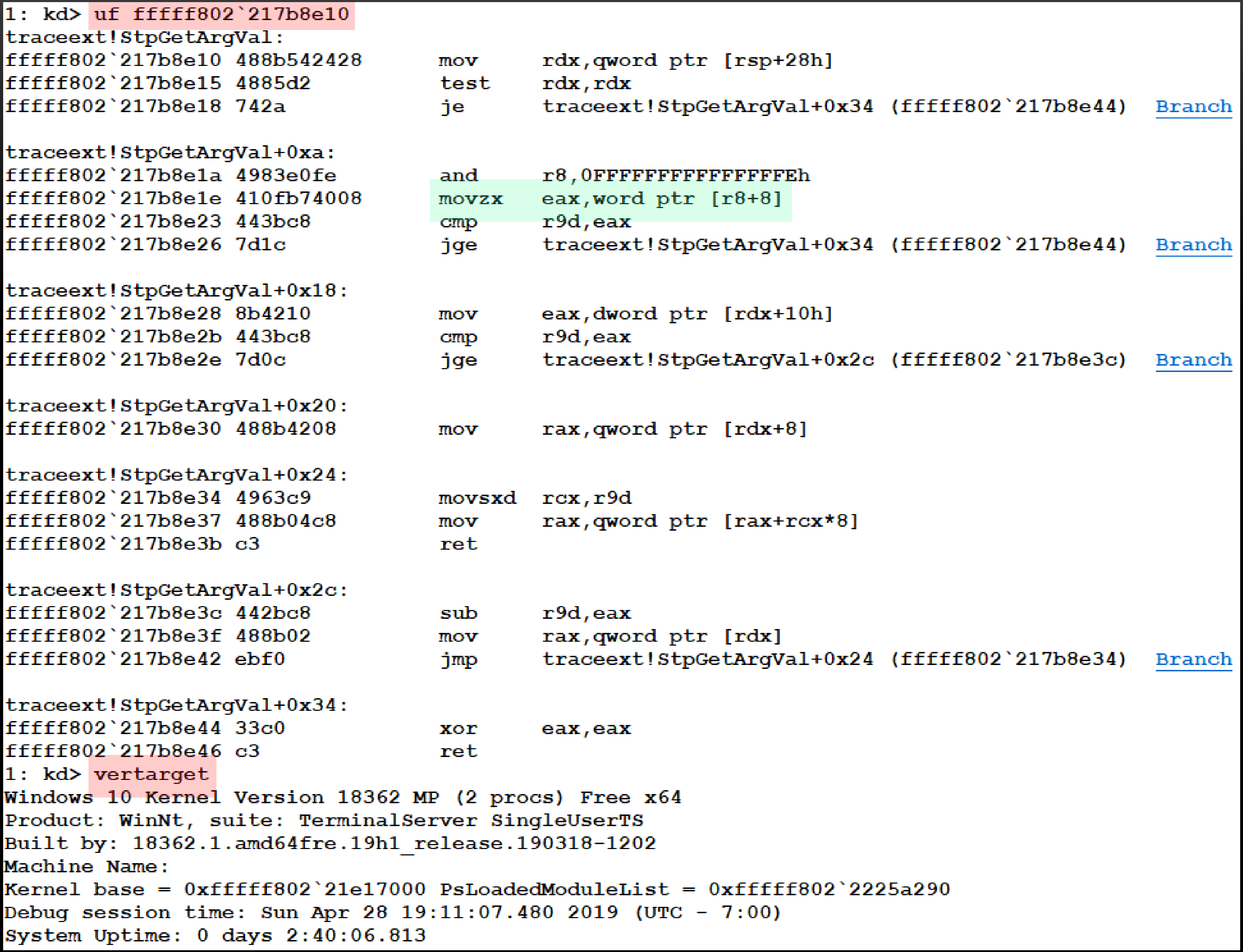
What failed: traceext.sys

ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER



```
1: kd> k
 # Child-SP          RetAddr           Call Site
00 ffffd8d`c02a0198 fffff802`21fe5469 nt!KeBugCheckEx
01 ffffd8d`c02a01a0 fffff802`21fe17a5 nt!KiBugCheckDispatch+0x69
02 ffffd8d`c02a02e0 fffff802`217b8e1e nt!KiPageFault+0x465
03 ffffd8d`c02a0478 fffff803`01e932bf traceext!StpGetArgVal+0xe
04 ffffd8d`c02a0480 fffff803`01e95e2c DTrace!dtrace_dif_variable+0x1e7
05 ffffd8d`c02a0540 fffff803`01e972d8 DTrace!dtrace_dif_emulate+0x754
06 ffffd8d`c02a0760 fffff802`217b76cd DTrace!dtrace_probe+0x478
07 ffffd8d`c02a0930 fffff802`217c16cc traceext!dtrace_probe+0x29
08 ffffd8d`c02a0980 fffff802`226949d4 traceext!StpCallbackEntry+0x7c
09 ffffd8d`c02a09e0 fffff802`21fe534d nt!KiTrackSystemCallEntry+0xd4
0a ffffd8d`c02a0a40 00007ff9`2edfc164 nt!KiSystemServiceExitPico+0x238
0b 000000ac`bc7fb918 00000000`00000000 0x00007ff9`2edfc164
1: kd> .lastevent
Last event: Break instruction exception - code 80000003 (first/second chance not available)
  debugger time: Sun Apr 28 22:00:04.067 2019 (UTC - 7:00)
1: kd> lmv m traceext
Browse full module list
start             end                 module name
fffff802`217b6000 fffff802`217d1000   traceext   (pdb symbols)          c:\symbols\traceext
    Loaded symbol image file: traceext.sys
    Image path: traceext.sys
    Image name: traceext.sys
    Browse all global symbols  functions  data
    Image was built with /Brepro flag.
    Timestamp:        414AF89D (This is a reproducible build file hash, not a timestamp)
    CheckSum:         00016962
    ImageSize:        0001B000
    Translations:     0000.04b0 0000.04e4 0409.04b0 0409.04e4
    Information from resource tables:
1: kd> x /D traceext!s*
 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

fffff802`217b8e10 traceext!StpGetArgVal (void)
fffff802`217c1770 traceext!StpDisable (void)
fffff802`217c1880 traceext!StpProvide (void)
fffff802`217c1710 traceext!StpEnable (void)
fffff802`217b8e50 traceext!StpGetContext (void)
fffff802`217c17c0 traceext!StpGetArgType (void)
fffff802`217c1970 traceext!StpDestroy (void)
fffff802`217c1650 traceext!StpCallbackEntry (<no parameter info>)
fffff802`217b9146 traceext!strcmp (<no parameter info>)
fffff802`217c16e0 traceext!StpCallbackReturn (<no parameter info>)
```

Traceext.sys: exposes functionality used by DTrace to tracing.



```
1: kd> uf fffff802`217b8e10
traceext!StpGetArgVal:
fffff802`217b8e10 488b542428      mov     rdx,qword ptr [rsp+28h]
fffff802`217b8e15 4885d2          test    rdx,rdx
fffff802`217b8e18 742a            je      traceext!StpGetArgVal+0x34 (fffff802`217b8e44)  Branch

traceext!StpGetArgVal+0xa:
fffff802`217b8e1a 4983e0fe        and     r8,0FFFFFFFFFFFFFFFEh
fffff802`217b8e1e 410fb74008      movzx   eax,word ptr [r8+8]
fffff802`217b8e23 443bc8          cmp     r9d,eax
fffff802`217b8e26 7d1c            jge     traceext!StpGetArgVal+0x34 (fffff802`217b8e44)  Branch

traceext!StpGetArgVal+0x18:
fffff802`217b8e28 8b4210          mov     eax,dword ptr [rdx+10h]
fffff802`217b8e2b 443bc8          cmp     r9d,eax
fffff802`217b8e2e 7d0c            jge     traceext!StpGetArgVal+0x2c (fffff802`217b8e3c)  Branch

traceext!StpGetArgVal+0x20:
fffff802`217b8e30 488b4208        mov     rax,qword ptr [rdx+8]

traceext!StpGetArgVal+0x24:
fffff802`217b8e34 4963c9          movsxd  rcx,r9d
fffff802`217b8e37 488b04c8        mov     rax,qword ptr [rax+rcx*8]
fffff802`217b8e3b c3              ret

traceext!StpGetArgVal+0x2c:
fffff802`217b8e3c 442bc8          sub     r9d,eax
fffff802`217b8e3f 488b02          mov     rax,qword ptr [rdx]
fffff802`217b8e42 ebf0            jmp     traceext!StpGetArgVal+0x24 (fffff802`217b8e34)  Branch

traceext!StpGetArgVal+0x34:
fffff802`217b8e44 33c0            xor     eax,eax
fffff802`217b8e46 c3              ret
1: kd> vertarget
Windows 10 Kernel Version 18362 MP (2 procs) Free x64
Product: WinNt, suite: TerminalServer SingleUserTS
Built by: 18362.1.amd64fre.19h1_release.190318-1202
Machine Name:
Kernel base = 0xfffff802`21e17000 PsLoadedModuleList = 0xfffff802`2225a290
Debug session time: Sun Apr 28 19:11:07.480 2019 (UTC - 7:00)
System Uptime: 0 days 2:40:06.813
```

ANTI-VM

- ✓ It is extremely easy writing malware samples using anti-VM techniques designed to detect VMWare (checking I/O port communication), VirtualBox, Parallels, SeaBIOS emulator, QEMU emulator, Bochs emulator, QEMU emulator, Hyper-V, Innotek VirtualBox, sandboxes (Cuckoo).

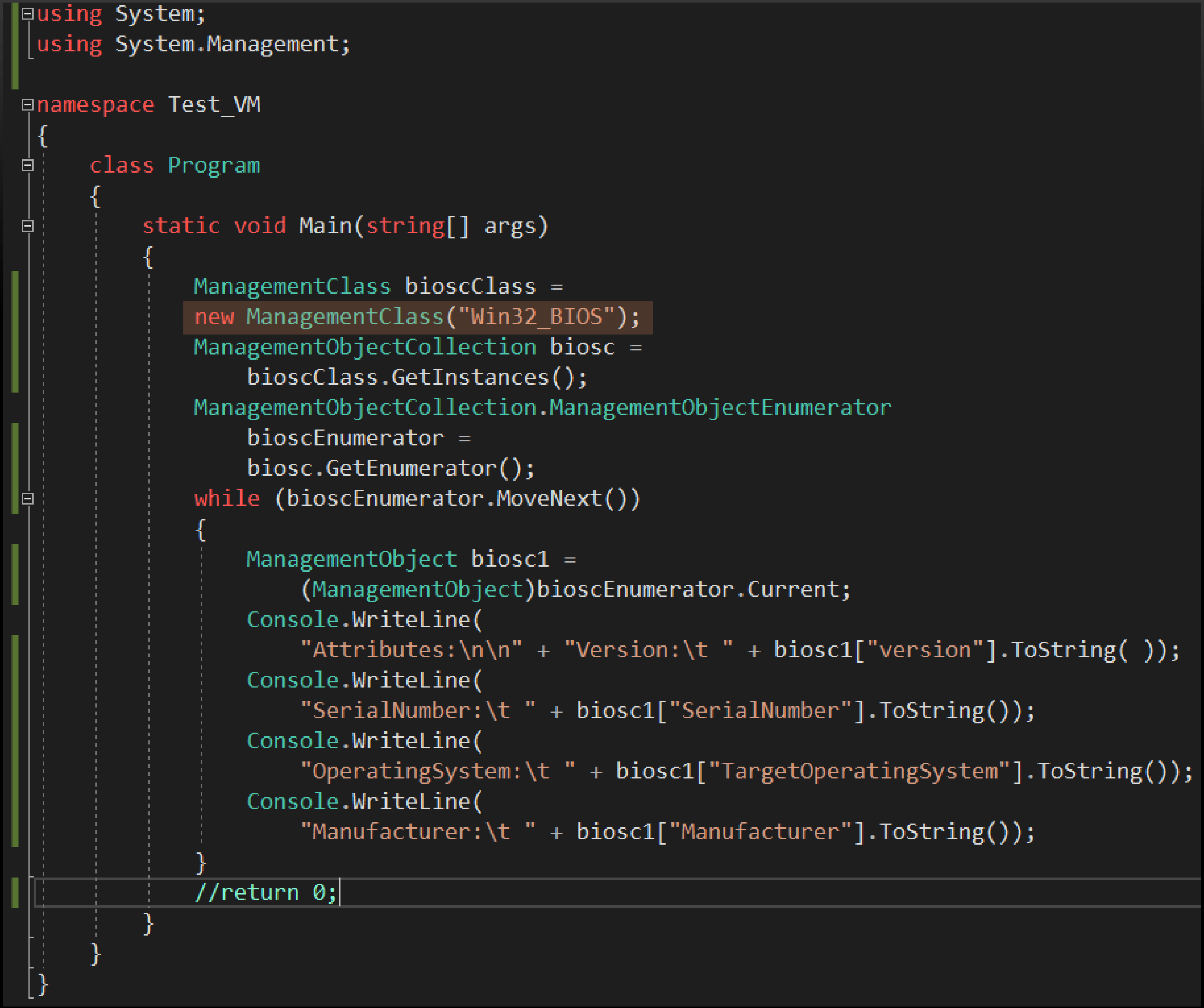
- ✓ Furthermore, there are dozens of techniques that could be used for detection Vmware sandboxes:

  - ✓ Examing the registry (OpenSubKey( ) function) to try to find entries related to tools installed in the guest (HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\VirtualMachine\Guest\Parameters).

  - ✓ Using WMI to query the Win32_BIOS management class to interact with attributes from the physical machine.

- ✓ We have already know every single anti-VM technique around the world and all of them are documented.

- ✓ Most current techniques use WMI and it is quick to write a C# program using them.



```
using System;
using System.Management;

namespace Test_VM
{
    class Program
    {
        static void Main(string[] args)
        {
            ManagementClass bioscClass =
            new ManagementClass("Win32_BIOS");
            ManagementObjectCollection biosc =
                bioscClass.GetInstances();
            ManagementObjectCollection.ManagementObjectEnumerator
                bioscEnumerator =
                biosc.GetEnumerator();
            while (bioscEnumerator.MoveNext())
            {
                ManagementObject biosc1 =
                    (ManagementObject)bioscEnumerator.Current;
                Console.WriteLine(
                    "Attributes:\n\n" + "Version:\t " + biosc1["version"].ToString( ));
                Console.WriteLine(
                    "SerialNumber:\t " + biosc1["SerialNumber"].ToString());
                Console.WriteLine(
                    "OperatingSystem:\t " + biosc1["TargetOperatingSystem"].ToString());
                Console.WriteLine(
                    "Manufacturer:\t " + biosc1["Manufacturer"].ToString());
            }
            //return 0;
        }
    }
}
```

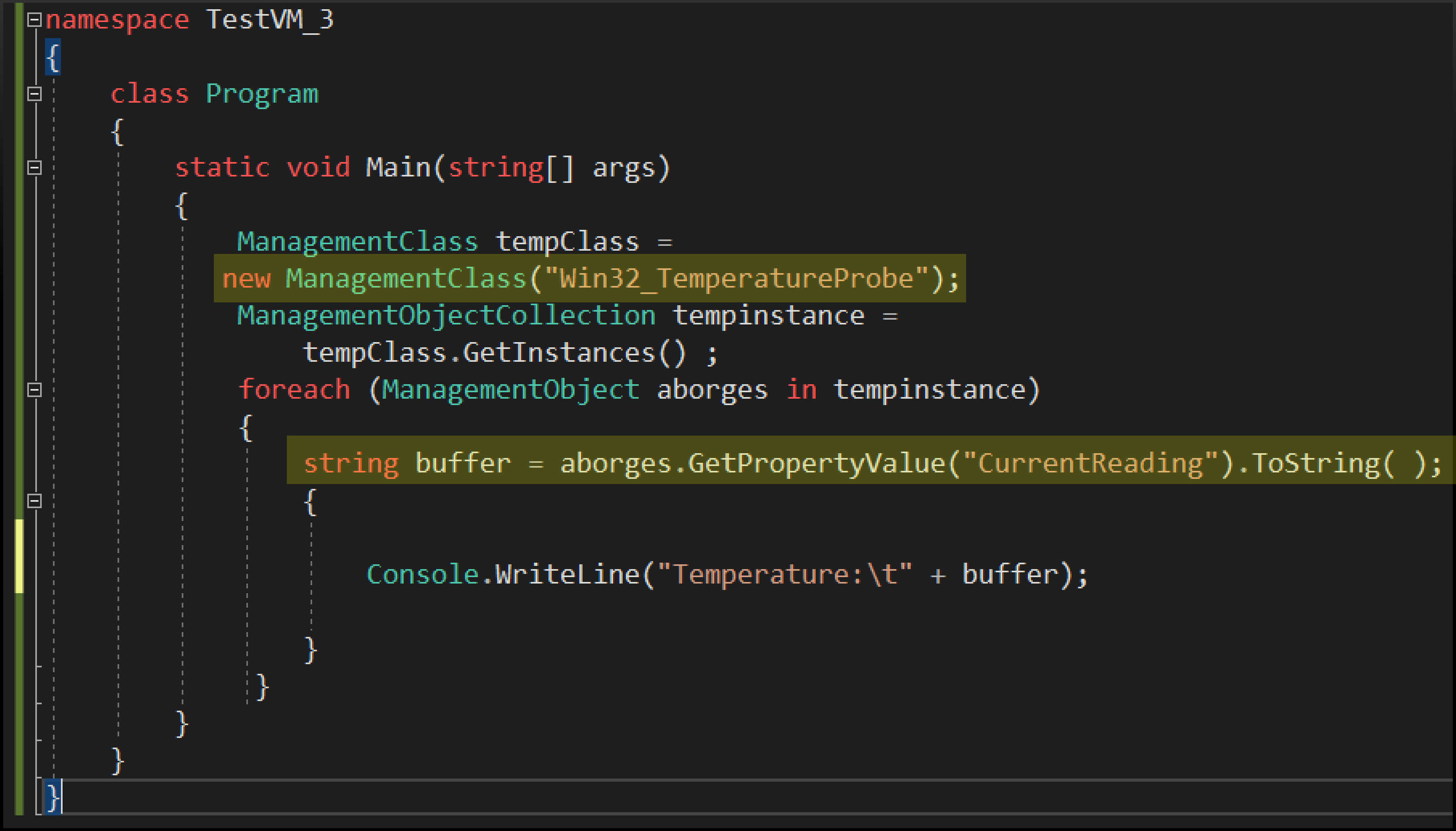
- ✓ The code from last slide does not have any news:
  - ✓ The ManagementClass class represents a Common Information Model (CIM) management class.
  - ✓ Win32_BIOS WMI class represents the attributes of BIOS and members of this class enable you to access WMI data using a specific WMI class path.
  - ✓ GetInstances( ) acquires a collection of all instances of the class.
  - ✓ GetEnumerator( ) returns the enumerator (IEnumerator) for the collection.
  - ✓ IEnumerator.Current( ) returns the same object.
  - ✓ IEnumerator.MoveNext( ) advances the enumerator to the next element of the collection.

❑ Physical host:

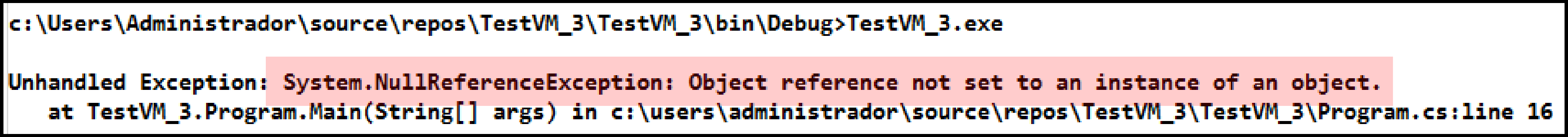
```
C:\> Test_VM.exe
Attributes:
Version:        DELL   - 6222004
SerialNumber:    D5965S1
OperatingSystem:        0
Manufacturer:    Dell Inc.
```

❑ Guest virtual machine:

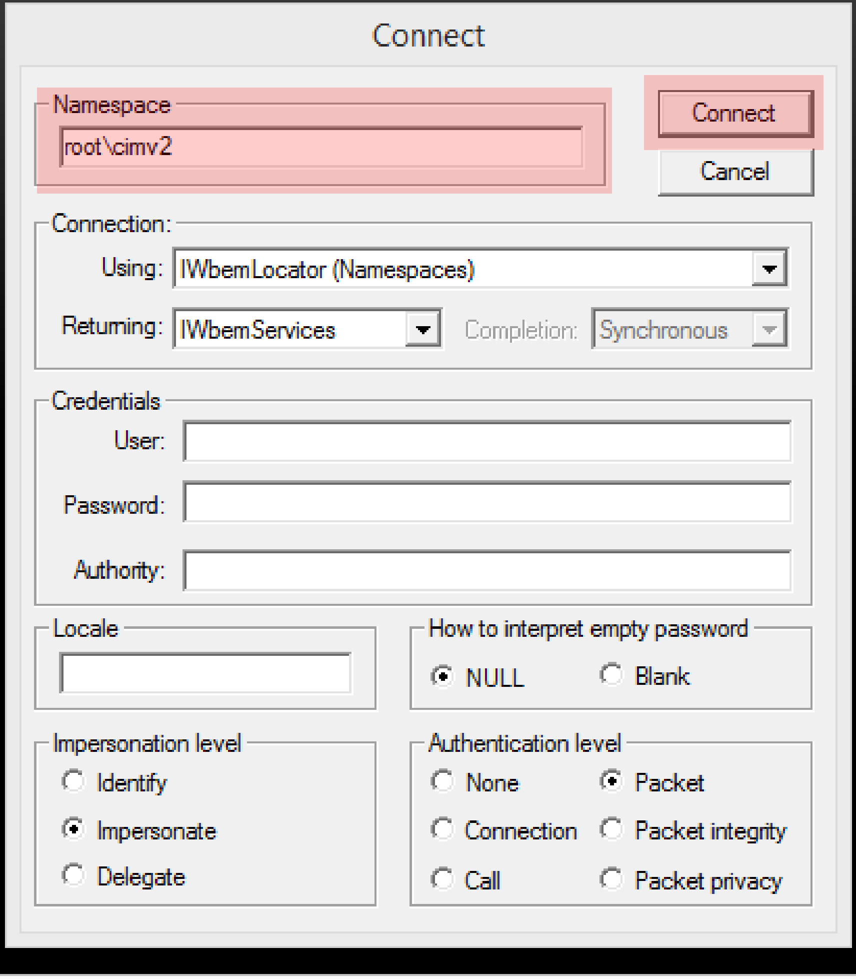
```
E:\> Test_VM.exe
Attributes:
Version:        LENOVO - 6040000
SerialNumber:    VMware-56 4d 8d c3 a7 c7 e5 2b-39 d6 cc 93 bf 90 28 2d
OperatingSystem:        0
Manufacturer:    Phoenix Technologies LTD
```



```
namespace TestVM_3
{
    class Program
    {
        static void Main(string[] args)
        {
            ManagementClass tempClass =
           new ManagementClass("Win32_TemperatureProbe");
            ManagementObjectCollection tempinstance =
                tempClass.GetInstances() ;
            foreach (ManagementObject aborges in tempinstance)
            {
                string buffer = aborges.GetPropertyValue("CurrentReading").ToString( );
                {

                    Console.WriteLine("Temperature:\t" + buffer);

                }
            }
        }
    }
}
```



```
c:\Users\Administrador\source\repos\TestVM_3\TestVM_3\bin\Debug>TestVM_3.exe

Unhandled Exception: System.NullReferenceException: Object reference not set to an instance of an object.
   at TestVM_3.Program.Main(String[] args) in c:\users\administrador\source\repos\TestVM_3\TestVM_3\Program.cs:line 16
```



Connect

Namespace: root\cimv2

Connection:
Using: IWbemLocator (Namespaces)
Returning: IWbemServices
Completion: Synchronous

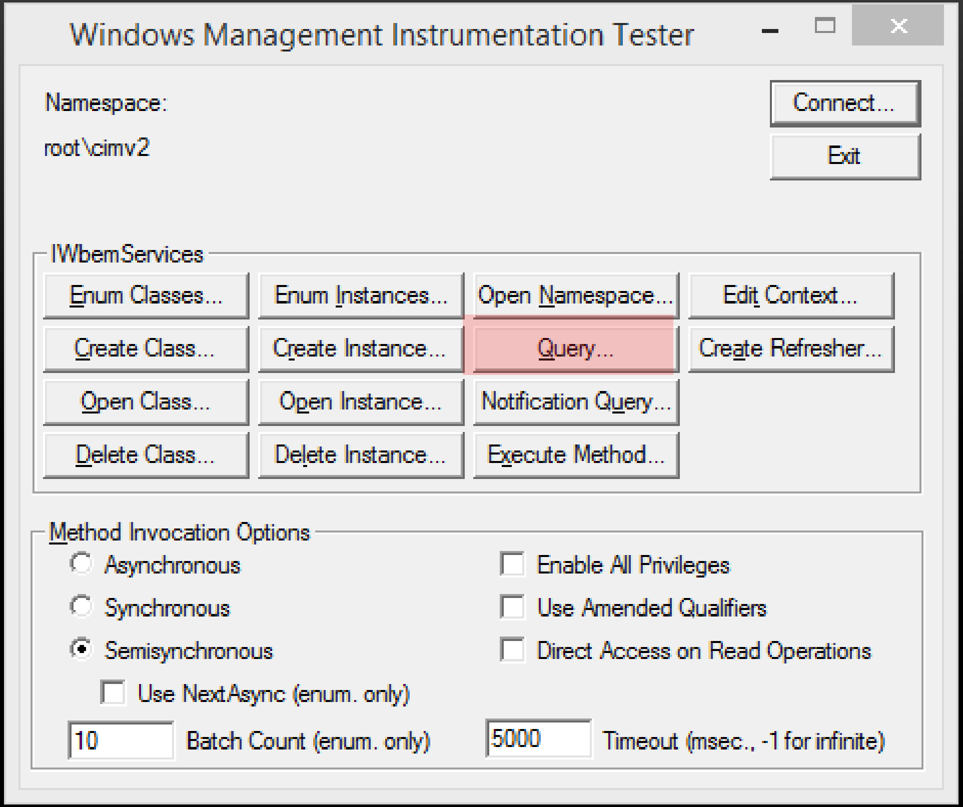
Credentials
User:
Password:
Authority:

Locale

How to interpret empty password
● NULL ○ Blank

Impersonation level
○ Identify
● Impersonate
○ Delegate

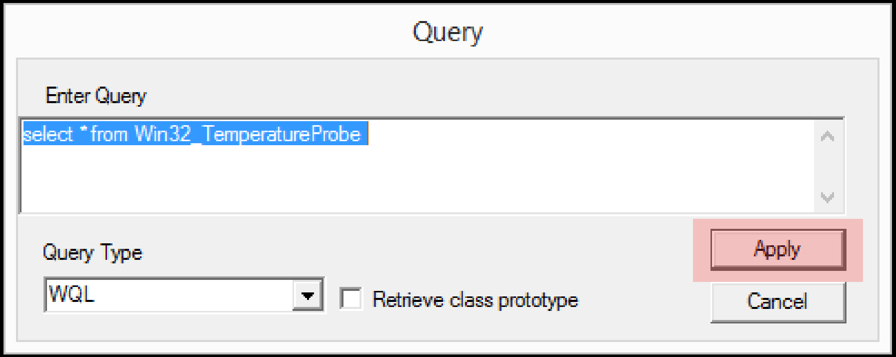
Authentication level
○ None ● Packet
○ Connection ○ Packet integrity
○ Call ○ Packet privacy



Windows Management Instrumentation Tester

Namespace:
root\cimv2

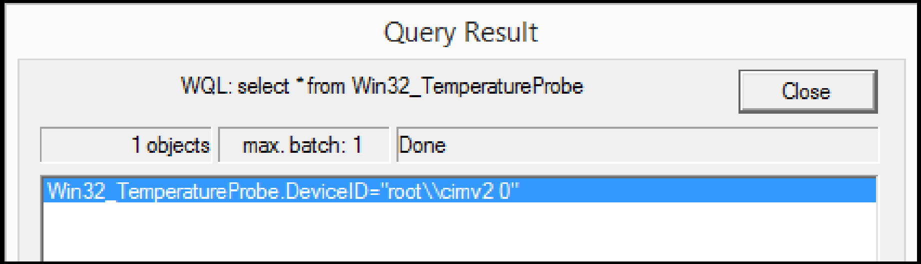
Method Invocation Options
○ Asynchronous
○ Synchronous
● Semisynchronous
□ Use NextAsync (enum. only)
□ Enable All Privileges
□ Use Amended Qualifiers
□ Direct Access on Read Operations
10 Batch Count (enum. only)
5000 Timeout (msec., -1 for infinite)



Query

Enter Query
select * from Win32_TemperatureProbe

Query Type
WQL
□ Retrieve class prototype



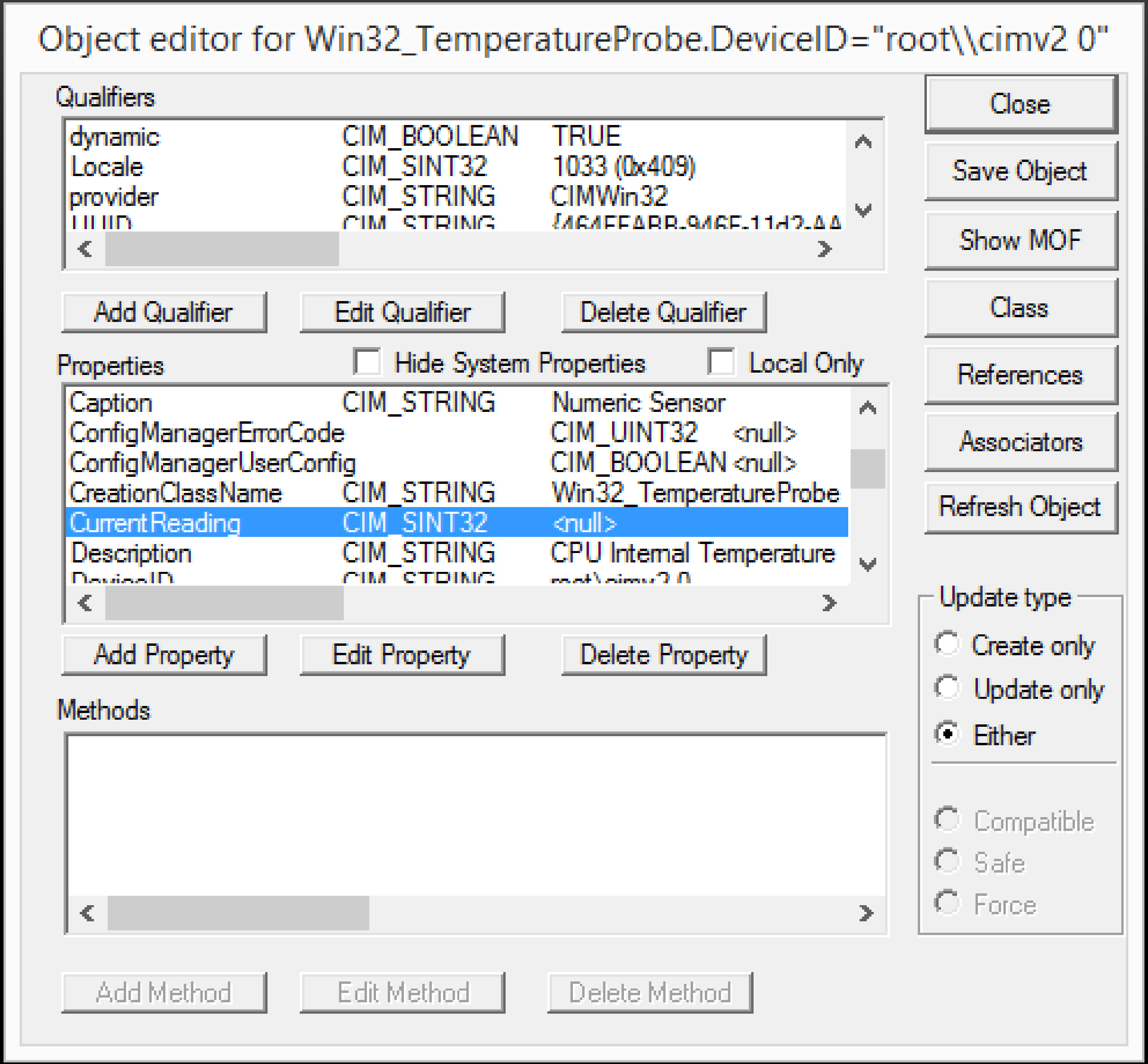
Query Result

WQL: select * from Win32_TemperatureProbe

1 objects | max. batch: 1 | Done

Win32_TemperatureProbe.DeviceID="root\\cimv2 0"

Double-click the result....



Object editor for Win32_TemperatureProbe.DeviceID="root\\cimv2 0"

Qualifiers

dynamic	CIM_BOOLEAN	TRUE
Locale	CIM_SINT32	1033 (0x409)
provider	CIM_STRING	CIMWin32
UUID	CIM_STRING	{464FFABB-946F-11d2-AA

Properties

☐ Hide System Properties ☐ Local Only

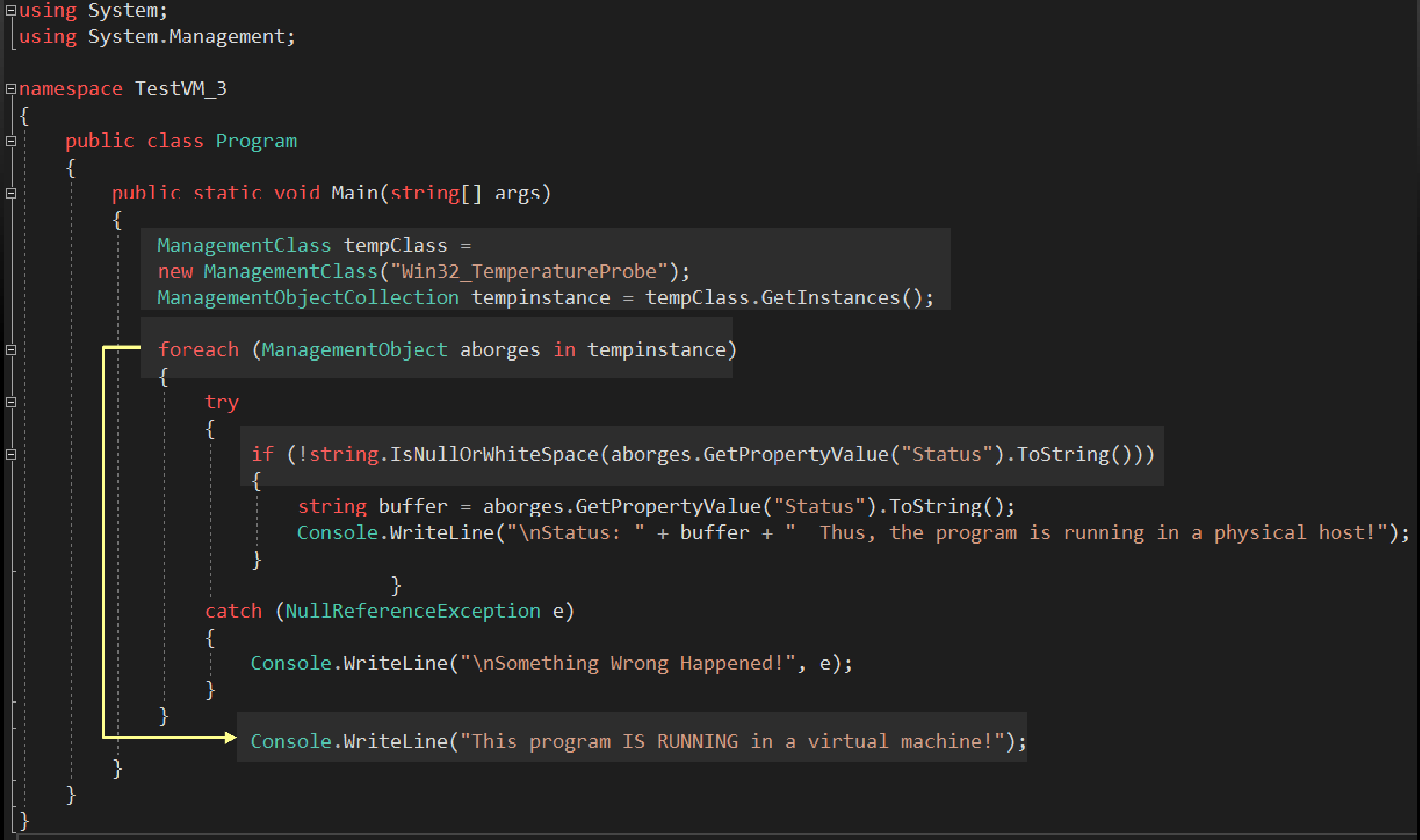
Caption	CIM_STRING	Numeric Sensor
ConfigManagerErrorCode	CIM_UINT32	<null>
ConfigManagerUserConfig	CIM_BOOLEAN	<null>
CreationClassName	CIM_STRING	Win32_TemperatureProbe
CurrentReading	CIM_SINT32	<null>
Description	CIM_STRING	CPU Internal Temperature
DeviceID	CIM_STRING	root\cimv2 0

Methods

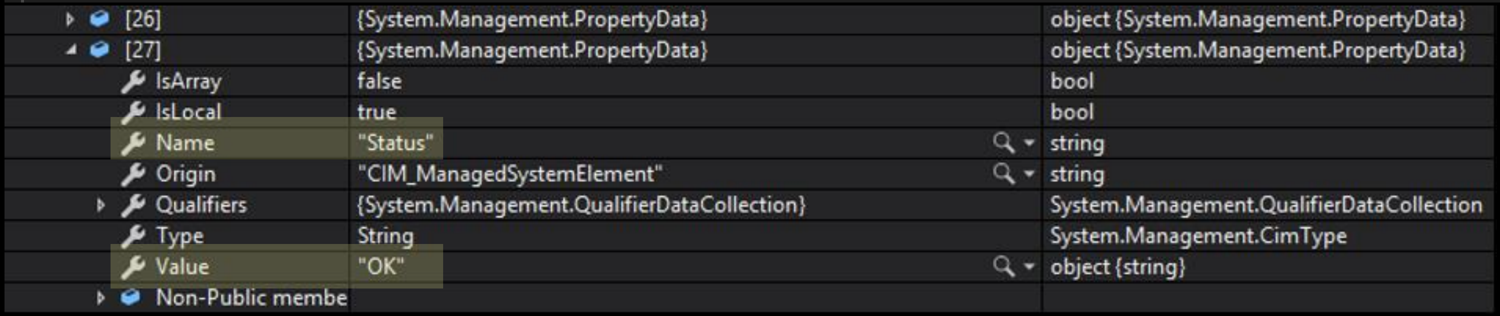
Update type

○ Create only
○ Update only
● Either

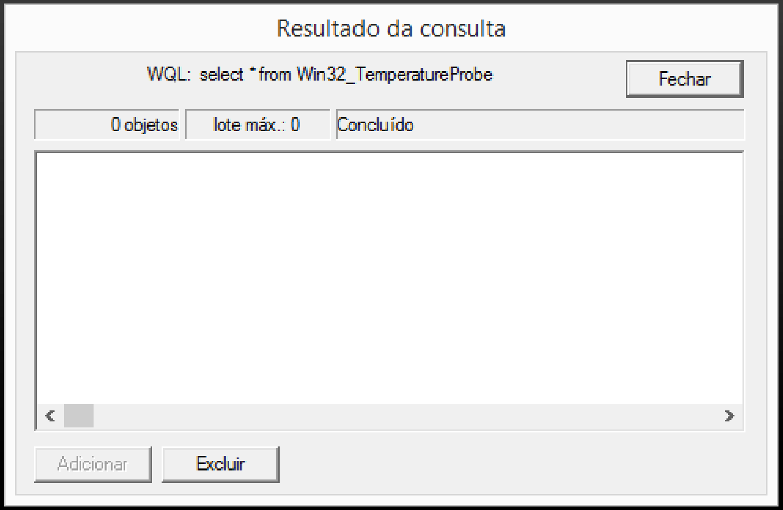
○ Compatible
○ Safe
○ Force



```
using System;
using System.Management;

namespace TestVM_3
{
    public class Program
    {
        public static void Main(string[] args)
        {
            ManagementClass tempClass =
            new ManagementClass("Win32_TemperatureProbe");
            ManagementObjectCollection tempinstance = tempClass.GetInstances();

            foreach (ManagementObject aborges in tempinstance)
            {
                try
                {
                    if (!string.IsNullOrWhiteSpace(aborges.GetPropertyValue("Status").ToString()))
                    {
                        string buffer = aborges.GetPropertyValue("Status").ToString();
                        Console.WriteLine("\nStatus: " + buffer + "  Thus, the program is running in a physical host!");
                    }
                                }
                catch (NullReferenceException e)
                {
                    Console.WriteLine("\nSomething Wrong Happened!", e);
                }
            }
                    Console.WriteLine("This program IS RUNNING in a virtual machine!");
        }
    }
}
```



[26]	{System.Management.PropertyData}	object {System.Management.PropertyData}
[27]	{System.Management.PropertyData}	object {System.Management.PropertyData}
IsArray	false	bool
IsLocal	true	bool
Name	"Status"	string
Origin	"CIM_ManagedSystemElement"	string
Qualifiers	{System.Management.QualifierDataCollection}	System.Management.QualifierDataCollection
Type	String	System.Management.CimType
Value	"OK"	object {string}
Non-Public membe		

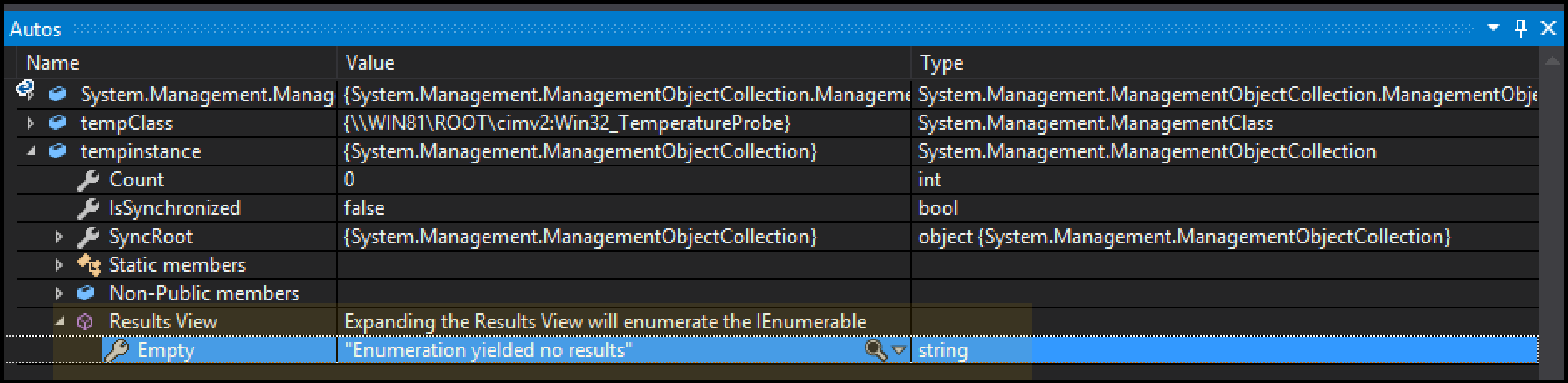


Resultado da consulta

WQL: select * from Win32_TemperatureProbe

0 objetos | lote máx.: 0 | Concluído

- ✓ There is not support for acquiring temperature data in virtual machines.
- ✓ Therefore, malwares are able to know whether they are running on virtual machines or not. ☺



Autos

Name	Value	Type
System.Management.Manag	{System.Management.ManagementObjectCollection.Manageme	System.Management.ManagementObjectCollection.ManagementObje
tempClass	{\\WIN81\ROOT\cimv2:Win32_TemperatureProbe}	System.Management.ManagementClass
tempinstance	{System.Management.ManagementObjectCollection}	System.Management.ManagementObjectCollection
Count	0	int
IsSynchronized	false	bool
SyncRoot	{System.Management.ManagementObjectCollection}	object {System.Management.ManagementObjectCollection}
Static members		
Non-Public members		
Results View	Expanding the Results View will enumerate the IEnumerable	
Empty	"Enumeration yielded no results"	string

✓ Physical Host:

C:\> VM_Test2.exe

Status: OK Thus, the program is running in a physical host!

✓ Virtual Machine:

C:\> VM_Test2.exe

This program IS RUNNING in a virtual machine!

ALEXANDRE BORGES – MALWARE AND SECURITY RESEARCHER

❑ FEW CONCLUSIONS:

- ✓ Before trying to unpack modern protectors, it is really necessary to understand the common anti-reversing techniques.

- ✓ MIASM, METASM and TRITON are amazing tools to handle and deobfuscate complex codes.

- ✓ Emulation is an possible alternative to understand small and complicated piece of codes.

- ✓ DTrace has done an excellent job on Solaris and it may be an excellent tool on Windows operating system. Stay tuned. ☺

- ✓ Although excellent researches have found sophisticated anti-vm techniques, many other simples and smart ones exist. Take care.

❖ Acknowledgments to:

✓ DEF CON's staff, who have been always very kind with me.

✓ You, who reserved some time to attend my talk.

✓ Remember: the best of this life are people. ☺

THANK YOU FOR ATTENDING MY TALK. ☺ 謝謝

- ✓ Malware and Security Researcher.
- ✓ Speaker at DEFCON USA 2018
- ✓ Speaker at HITB2019 Amsterdam
- ✓ Speaker at CONFidence Conf. 2019
- ✓ Speaker at BSIDES 2018/2017/2016
- ✓ Speaker at H2HC 2016/2015
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