Getting fun with Frida

Turbo Talk – Ekoparty

Nahuel Riva

October 2016

Getting fun with Frida

CORE SECURITY

Agenda

Agenda

- Intro
  - What's DBI?
  - Why do we need DBI?
  - How do I perform DBI? (frameworks)
- Frida
  - What's Frida?
  - Why would I need Frida?
    - Differences with other frameworks
  - How do I use Frida
    - API
      - Interceptor
      - Stalker
    - Tools based on Frida
- Demos

CORE SECURITY

Intro

Intro – What's DBI?

- Definition taken from: http://uninformed.org/index.cgi?v=7&a=1&p=3

- "Dynamic Binary Instrumentation (DBI) is a method of analyzing the behavior of a binary application at runtime through the injection of instrumentation code. […] makes it possible to gain insight into the behavior and state of an application at various points in execution."

CORE SECURITY

Intro – What's DBI?

- Instrumentation code executes as part of the normal instruction stream after being injected
- Instrumentation code will be entirely transparent to the application that it's been injected to
- Instrumentation code executes at runtime

CORE SECURITY

Intro – Why do we need DBI?

- As an alternative
  - Debuggers
  - API hooking engines
- Evolution
  - More complex tasks to achieve (profiling, taint analysis, detection of possible bugs)

Intro – How do I perform DBI? (frameworks)

- Two main DBI frameworks:

- PIN: proprietary framework written in C/C++. Works on Windows/Linux/OSX/Android and i386/AMD64

- https://software.intel.com/en-us/articles/pin-a-dynamic-binary-instrumentation-tool

- DynamoRIO: originally a proprietary framework then open sourced (BSD). Created by HP (Dynamo optimization system) and MIT (RIO research group). Works on Windows/Linux and i386/AMD64.

- https://en.wikipedia.org/wiki/DynamoRIO

CORE SECURITY

Intro – How do I perform DBI? (frameworks)

- In both cases, you write a Pin/DynamoRIO tool using C/C++ language and inject C/C++ code
- Compile the Pin/Dynamo tool as a .dll/.so
- Inject the library into the target process using a command-line tool/GUI application

CORE SECURITY

Intro – How do I perform DBI? (frameworks)

Pintool example (**source/tools/ManualExamples/inscount0.cpp**):

```
int main(int argc, char * argv[])
{
    // Initialize pin
    if (PIN_Init(argc, argv)) return Usage();

    OutFile.open(KnobOutputFile.Value().c_str());

    // Register Instruction to be called to instrument instructions
    INS_AddInstrumentFunction(Instruction, 0);

    // Register Fini to be called when the application exits
    PIN_AddFiniFunction(Fini, 0);

    // Start the program, never returns
    PIN_StartProgram();

    return 0;
}
```

CORE SECURITY

Intro – How do I perform DBI? (frameworks)

```
ofstream OutFile;

// The running count of instructions is kept here
// make it static to help the compiler optimize docount
static UINT64 icount = 0;

// This function is called before every instruction is executed
VOID docount() { icount++; }

// Pin calls this function every time a new instruction is encountered
VOID Instruction(INS ins, VOID *v)
{
    // Insert a call to docount before every instruction, no arguments are passed
    INS_InsertCall(ins, IPOINT_BEFORE, (AFUNPTR)docount, IARG_END);
}

KNOB<string> KnobOutputFile(KNOB_MODE_WRITEONCE, "pintool",
    "o", "inscount.out", "specify output file name");
```

CORE SECURITY

Intro – How do I perform DBI? (frameworks)

```
// This function is called when the application exits
VOID Fini(INT32 code, VOID *v)
{
    // Write to a file since cout and cerr maybe closed by the application
    OutFile.setf(ios::showbase);
    OutFile << "Count " << icount << endl;
    OutFile.close();
}
```

CORE SECURITY

Intro – How do I perform DBI? (frameworks)

- For example, Pin can be executed as follow:

- pin.bat -t pintool.dll [pintoolargs] --program.exe [programargs]

- pin.bat -pid<programpid> -t pintool.dll [pintoolargs]

CORE SECURITY

Intro – How these frameworks work?

- JIT compiler
  - Input: binary code
  - Output: equivalent code with introspection code
  - The code is generated only when it is needed

- The only code that is executed is the code generated by the JIT compiler

- The original code remains in memory just as a reference but it is **never** executed

CORE SECURITY

Frida

Frida – What's Frida?

- Dynamic instrumentation toolkit
- Scriptable
  - Execute **Javascript** programs inside another process. It uses V8 and Duktape and JavaScriptCore (deprecated) engines.
- Multi-platform and multi-arch
  - Windows/Mac/Linux/Android/iOS/QNX – i386/AMD64/ARM/ARM64
- It has bindings for Python, .NET, C and Node.js
- Open-source (LGPL v2)

CORE SECURITY

Frida – Why would I need Frida?

- For reverse engineering in general
  - Dynamic binary instrumentation
  - Debugging

- To develop introspection tools very quickly to help you in the RE process

CORE SECURITY

Frida – Pros & Cons against other frameworks

- Pros
  - It has bindings for other languages like .NET, Python, C
  - No need to compile the tool
  - Rapid tool development
  - Continuous development (new features and bug fixing)
- Cons
  - Less mature than other DBI frameworks (contains bugs)
  - Lack of some functionality
  - Less granularity than other frameworks

CORE SECURITY

How do I use Frida?

Frida – How do I use Frida?

- First, you need to install it:

- Windows:
  - C:\Users\travesti>pip install frida

- Linux:
  - travesti@palermo:~$ sudo pip install frida

  - Then …

CORE SECURITY

Frida – How do I use Frida?

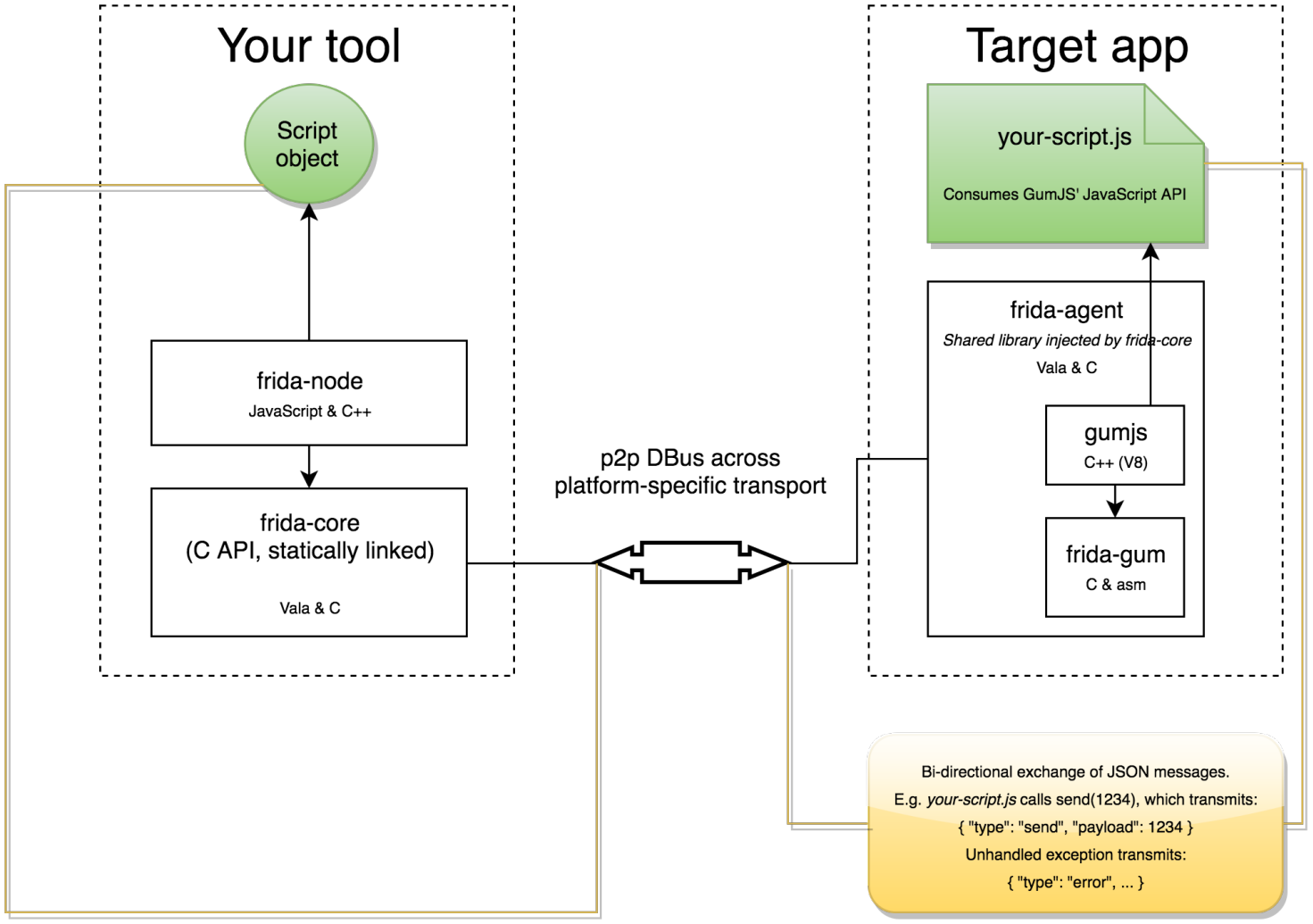
- As easy as this:

```
>> import frida
>> session = frida.attach("notepad.exe")
>> print([x.name for x in session.enumerate_modules()])
```

```
[u'notepad.exe', u'ntdll.dll', u'kernel32.dll', u'KERNELBASE.dll', u'ADVAPI32.dl
l', u'msvcrt.dll', u'sechost.dll', u'RPCRT4.dll', u'GDI32.dll', u'USER32.dll', u
'LPK.dll', u'USP10.dll', u'COMDLG32.dll', u'SHLWAPI.dll', u'COMCTL32.dll', u'SHE
LL32.dll', u'WINSPOOL.DRV', u'ole32.dll', u'OLEAUT32.dll', u'VERSION.dll', u'IMM
32.DLL', u'MSCTF.dll', u'actuser.dll', u'acdetoured.dll', u'msvcp60.dll', u'CRYP
TBASE.dll', u'uxtheme.dll', u'dwmapi.dll', u'CLBCatQ.DLL', u'frida-agent-64.dll'
, u'DNSAPI.dll', u'WS2_32.dll', u'NSI.dll', u'WINMM.dll', u'PSAPI.DLL', u'ntmart
a.dll', u'WLDAP32.dll']
```

CORE SECURITY

Frida – Architecture



CORE SECURITY

Frida – JavaScript API

- Its Javascript API has different components to interact with a process (http://www.frida.re/docs/javascript-api):

- console
- Process
- Module
- Memory
- Thread
- Socket
- File
- Instruction

CORE SECURITY

Frida – JavaScript API - Console

- **console**: used for output.

- console.log(line)
- console.warn(line)
- console.error(line)

CORE SECURITY

Frida – JavaScript API - Process

- **Process**: functions and properties used to interact with a process.

- Process.arch, Process.platform
- Process.isDebuggerAttached
- Process.enumerateThreads(callbacks)
- Process.findModuleByAddress(address)
- Process.findModuleByName(name)
- Process.enumerateModules(callbacks)

- […]

CORE SECURITY

Frida – JavaScript API - Module

- **Module**: used to interact with modules residing in the process.

- Module.enumerateImports(name, callbacks)
- Module.enumerateExports(name, callbacks)
- Module.enumerateRanges(name, protection, callbacks)
- Module.findBaseAddress(name)
- Module.findExportByName(moduleInull, exp)

- […]

CORE SECURITY

Frida – JavaScript API - Memory

- **Memory**: used to interact with memory pages residing in a given process.

- Memory.scan(address, size, pattern, callbacks)
- Memory.alloc(size)
- Memory.copy(dst, src, n)
- Memory.protect(address, size, protection)
- Memory.read*/write*
- MemoryAccessMonitor (monitor read/write/execute)

- […]

CORE SECURITY

Frida – JavaScript API - Thread

- **Thread**: used to interact with threads from a process.

- Thread.backtrace([context, backtracer])
- Thread.sleep(delay)

CORE SECURITY

Frida – JavaScript API - Socket

- **Socket**: used to handle sockets.

- Socket.type(handle)
- Socket.localAddress(handle)
- Socket.peerAddress(handle)

CORE SECURITY

Frida – JavaScript API - File

- **File**: used to handle file I/O.

- File(filePath, mode)
- write
- read
- flush
- close

CORE SECURITY

Frida – JavaScript API - Instruction

- **Instruction**: used to get information about a given instruction from process's code.

- Instruction.parse(target)

CORE SECURITY

Frida – Interceptor/Stalker

- Frida has two main components exposed trough its API:

- Interceptor
  - Normal operation mode (hooking)
  - No stealthiness

- Stalker
  - Instrumentation per-se
  - Stealth (kind of)
  - Lack of functionality (CALL/RET)
  - More details: https://medium.com/@oleavr/anatomy-of-a-code-tracer-b081aadb0df8

CORE SECURITY

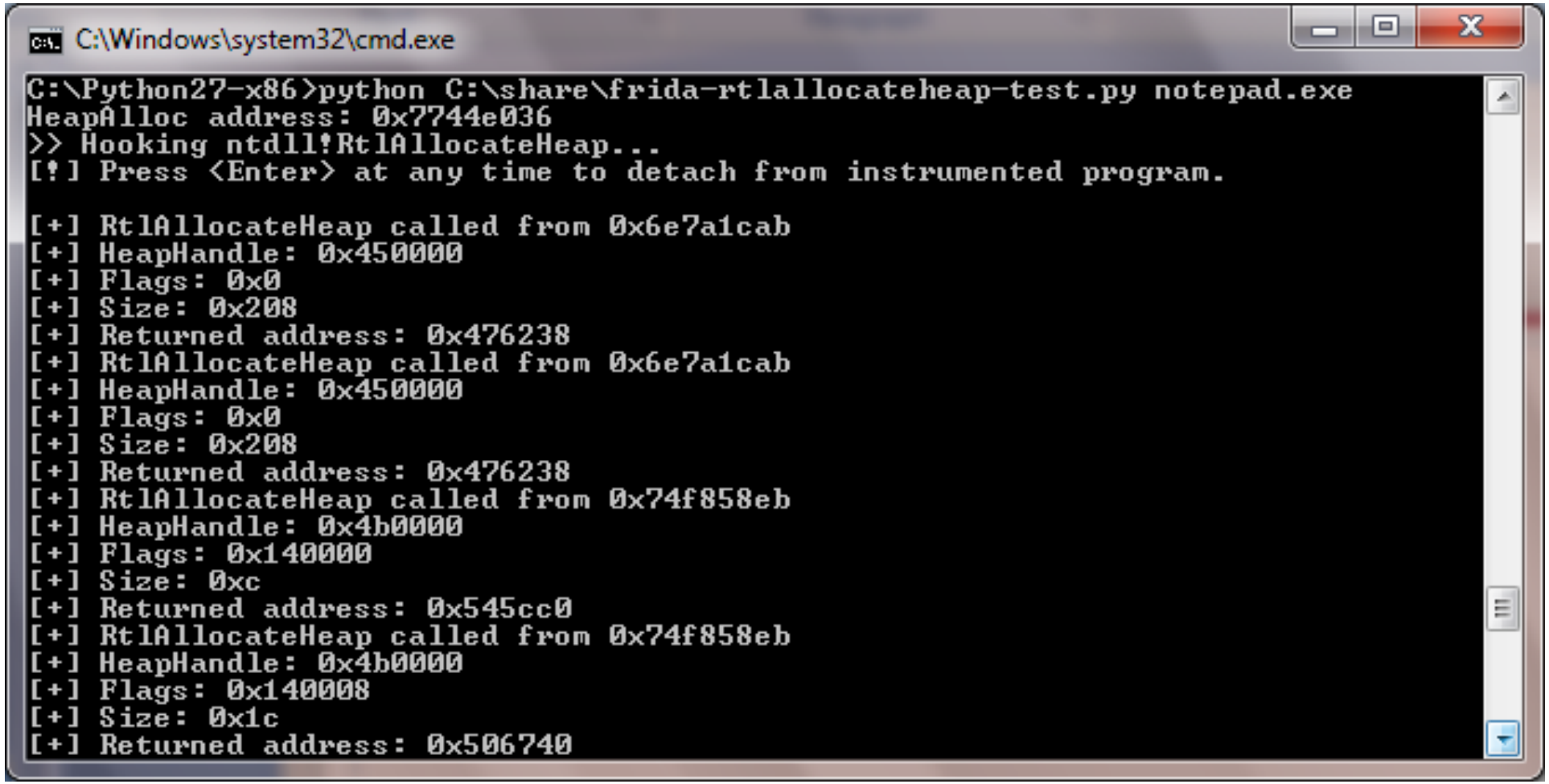
Frida – How do I use Interceptor?

- Interceptor example:

```
def main(target_process):
    heapalloc_rva = getExportedFunctionRva('RtlAllocateHeap', 'ntdll.dll')

    session = frida.attach(target_process)
    script = session.create_script("""
var RtlAllocateHeapAddr = Module.findBaseAddress('ntdll.dll').add(0x%x);
console.log('HeapAlloc address: ' + RtlAllocateHeapAddr.toString());

console.log('>> Hooking ntdll!RtlAllocateHeap...');

Interceptor.attach(RtlAllocateHeapAddr, {
    onEnter: function (args){
        console.log('[+] RtlAllocateHeap called from ' + this.returnAddress.sub(6).toString());
        console.log('[+] HeapHandle: ' + args[0].toString());
        console.log('[+] Flags: ' + args[1].toString());
        console.log('[+] Size: ' + args[2].toString());
        },
    onLeave: function (retval){
        console.log('[+] Returned address: ' + retval.toString());
        }
    });
""" % heapalloc_rva)

    script.on('message', on_message)
    script.load()
    raw_input('[!] Press <Enter> at any time to detach from instrumented program.\n\n')
    session.detach()
```

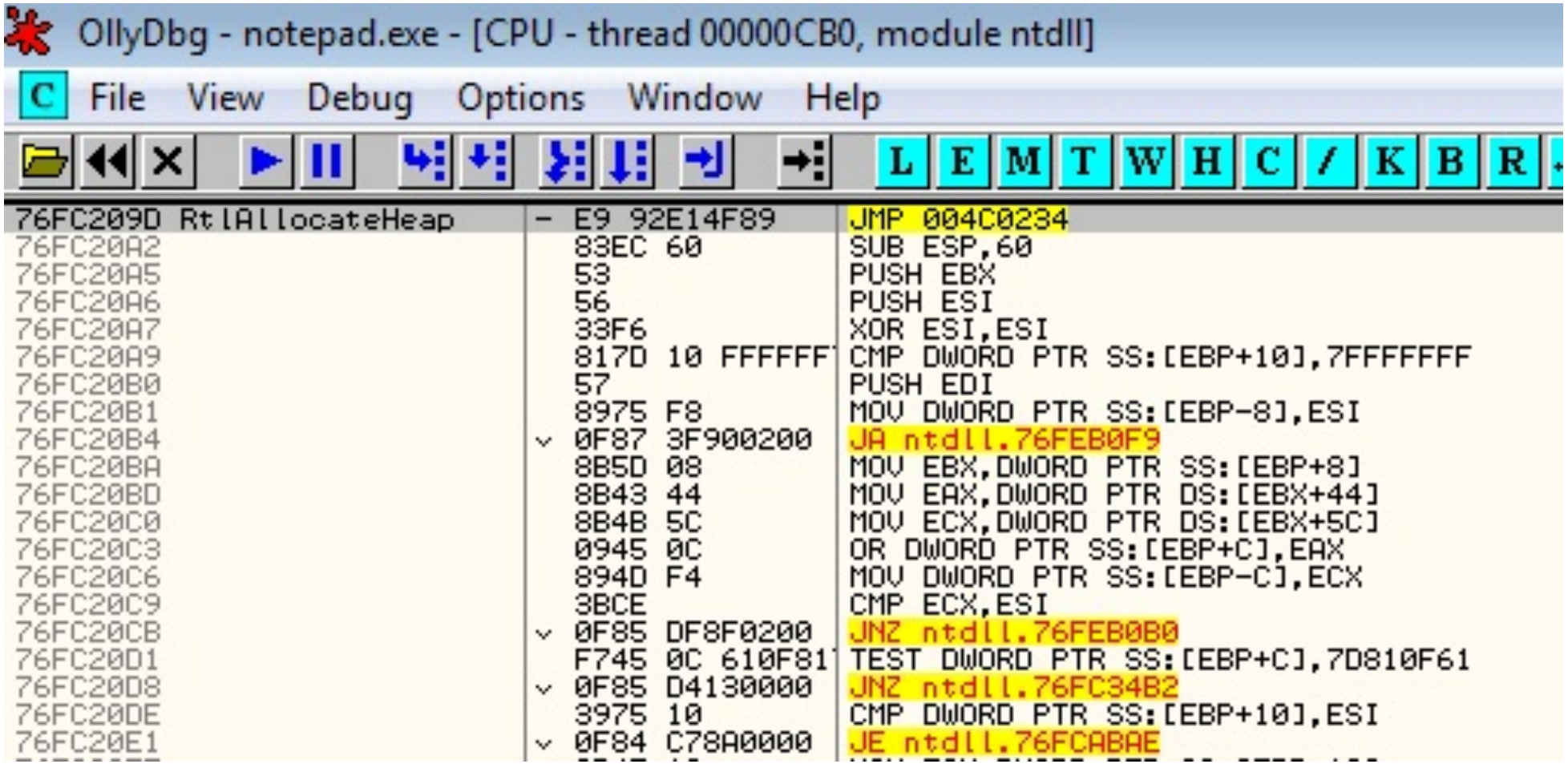
CORE SECURITY

Frida – Interceptor example output



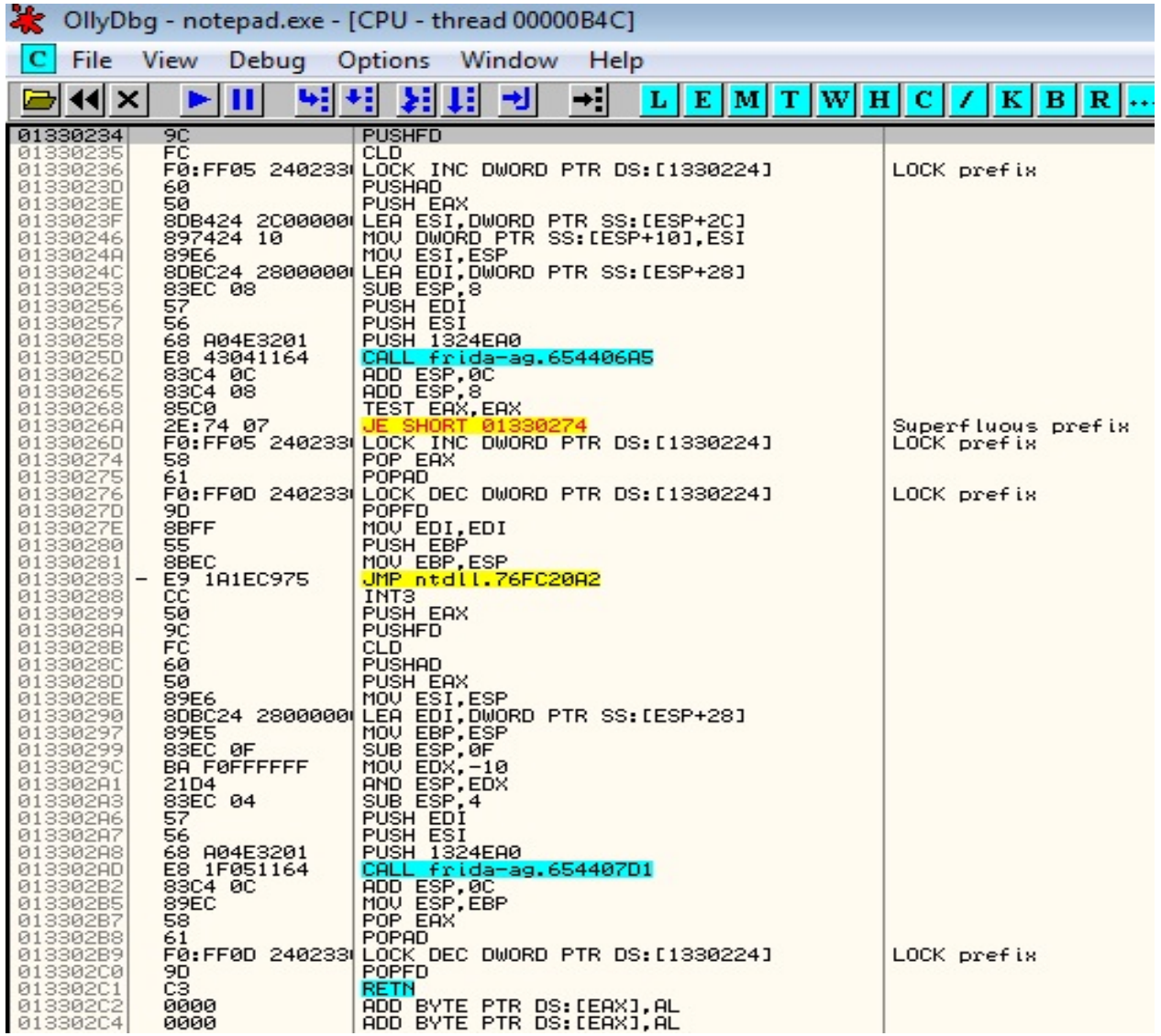
CORE SECURITY

Frida – Interceptor at low level (API hook)



CORE SECURITY

Frida – Interceptor stub



CORE SECURITY

Frida – Stalker

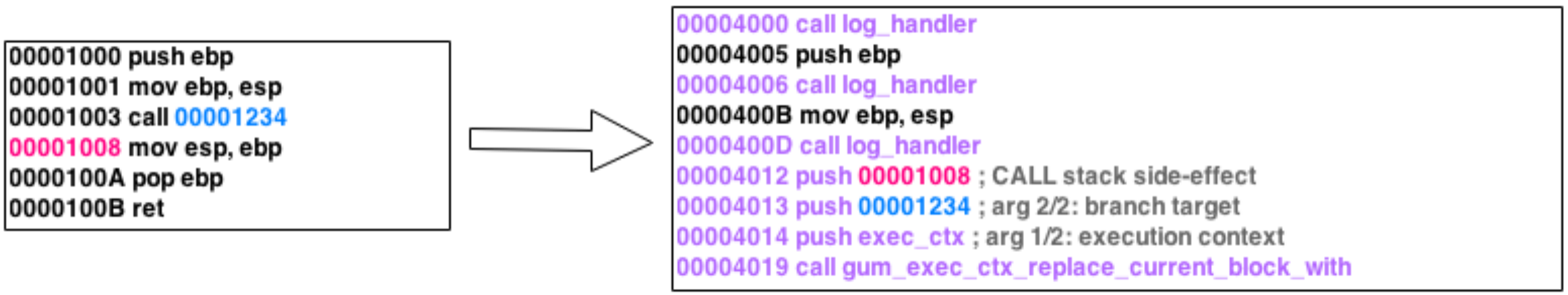
- Stalker example:

```
function StalkerExeample()
{
    threadIds = [];

    Process.enumerateThreads({
        onMatch: function (thread)
        {
            threadIds.push(thread.id);
            console.log("Thread ID: " + thread.id.toString());
        },

        onComplete: function ()
        {
            threadIds.forEach(function (threadId)
                {
                    Stalker.follow(threadId,
                    {
                        events: {call: true},

                    onReceive: function (events)
                    {
                        console.log("onReceive called.");
                    },
                    onCallSummary: function (summary)
                    {
                        console.log("onCallSummary called.");
                    }
                });
            });
        }
    });
}

StalkerExeample();
```

CORE SECURITY

Frida – How Stalker works?

- Stalker at low level:



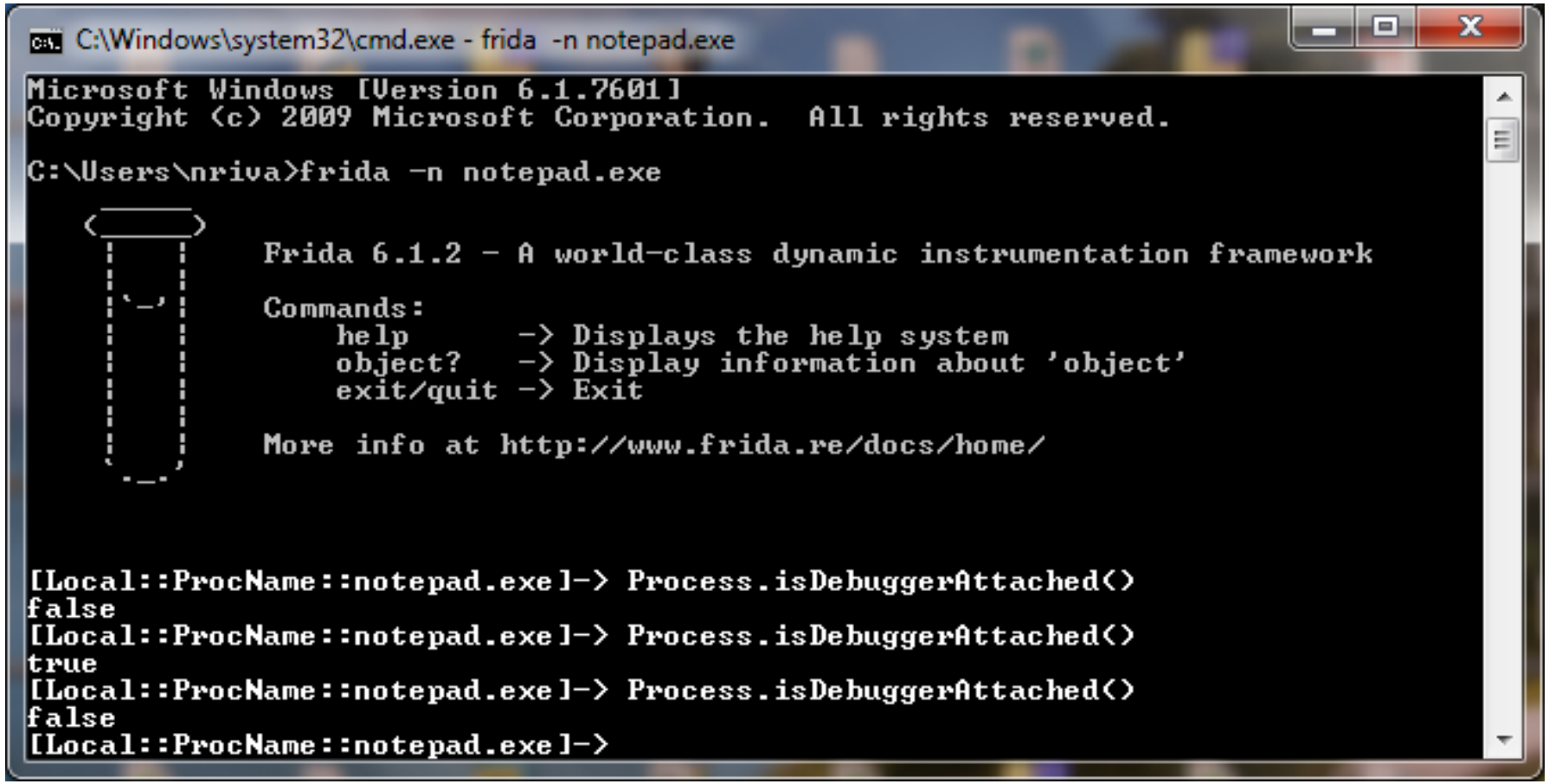
- Hint: See gum_exec_ctx_obtain_block_for in frida-gum/gum/backend-x86/gumstalker-x86.c

CORE SECURITY

Tools based on Frida

Tools based on Frida

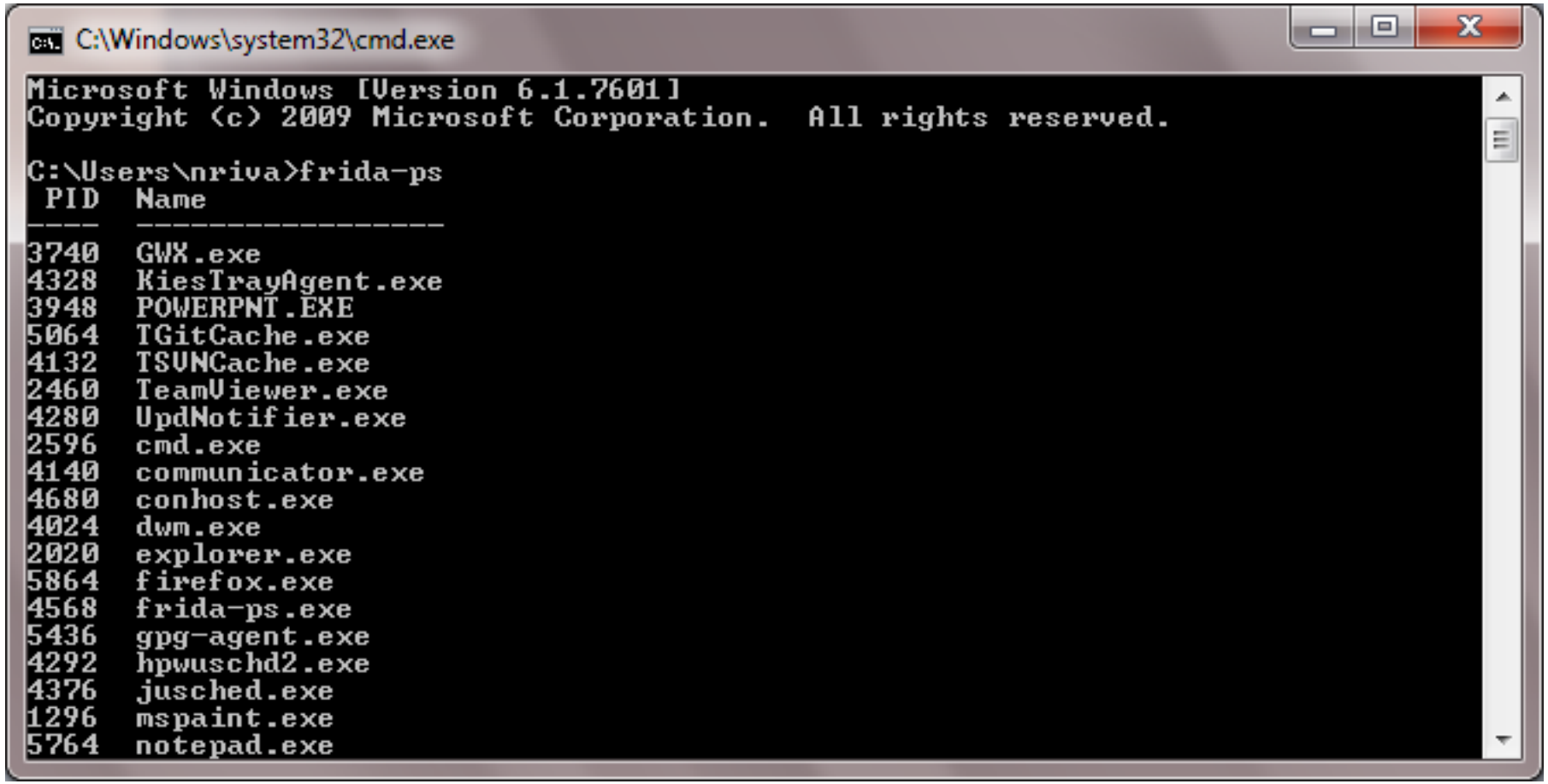
- **frida-cli**: command line interpreter which emulates an IPython console for rapid prototyping and easy debugging.



CORE SECURITY

Tools based on Frida

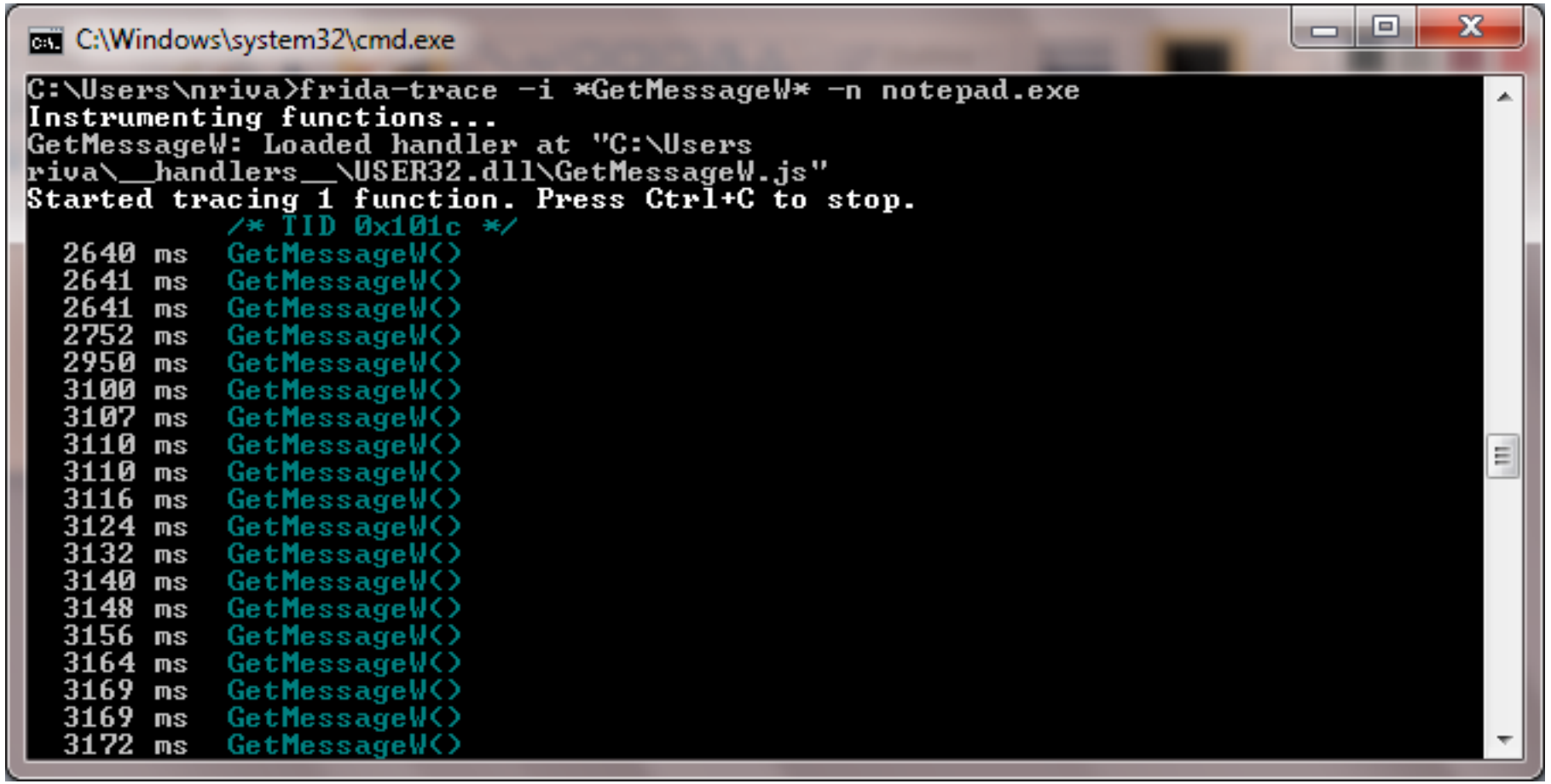
- **frida-ps**: command line tool for listing processes.



CORE SECURITY

Tools based on Frida

- **frida-trace**: command like tool to dynamically trace function calls.



CORE SECURITY

Tools based on Frida

- **frida-heap-trace**: trace RtlAllocateHeap, RtlFreeHeap and RtlReAllocateHeap function calls and arguments and log them to a file.

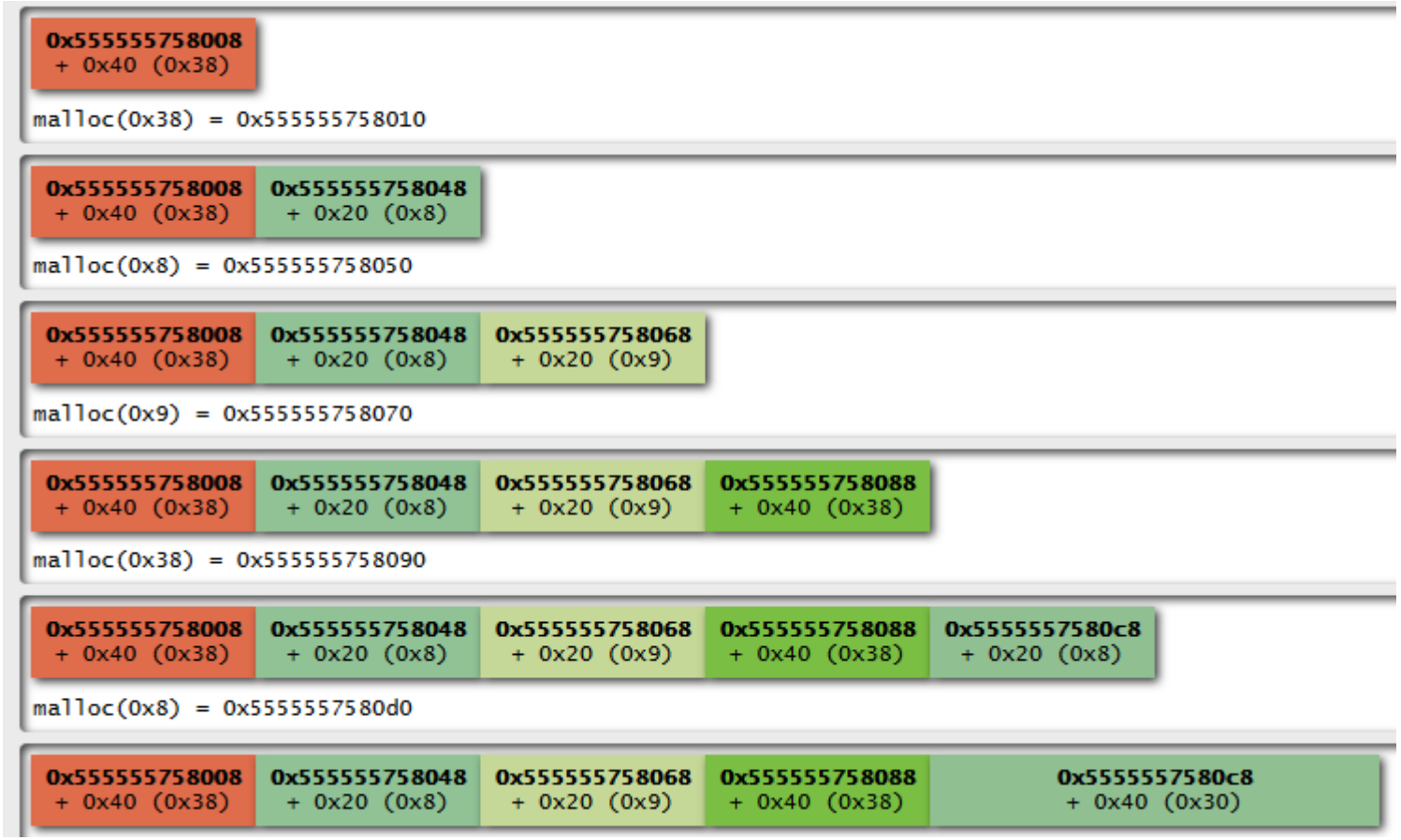
- Combine it with Villoc to create a map for all the heap movements

- https://github.com/poxyran/misc/blob/master/frida-heap-trace.py

CORE SECURITY

Tools based on Frida

- https://github.com/wapiflapi/villoc



CORE SECURITY

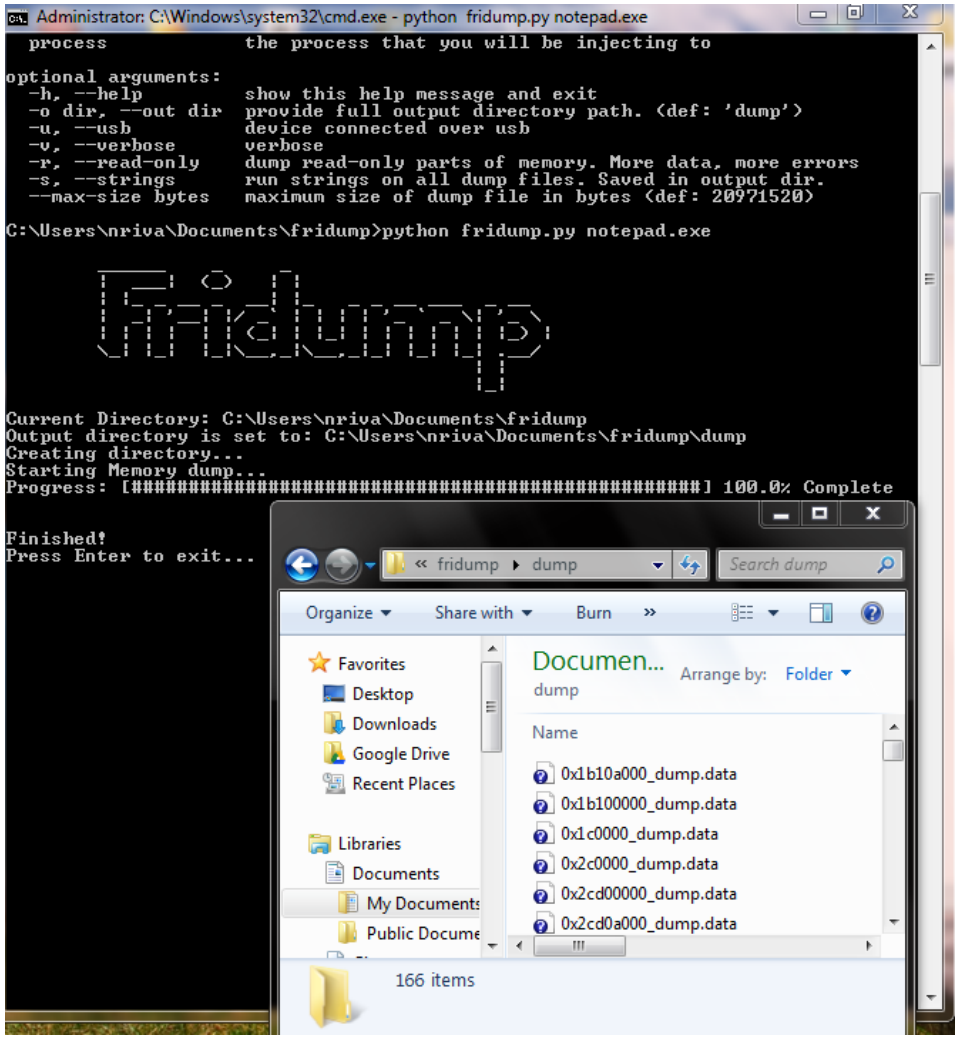
Tools based on Frida

- **fridump**: Universal memory dumper tool. Aimed to dump accessible memory regions from any platform supported by Frida.

https://github.com/Nightbringer21/fridump

CORE SECURITY

Tools based on Frida



CORE SECURITY

Tools based on Frida

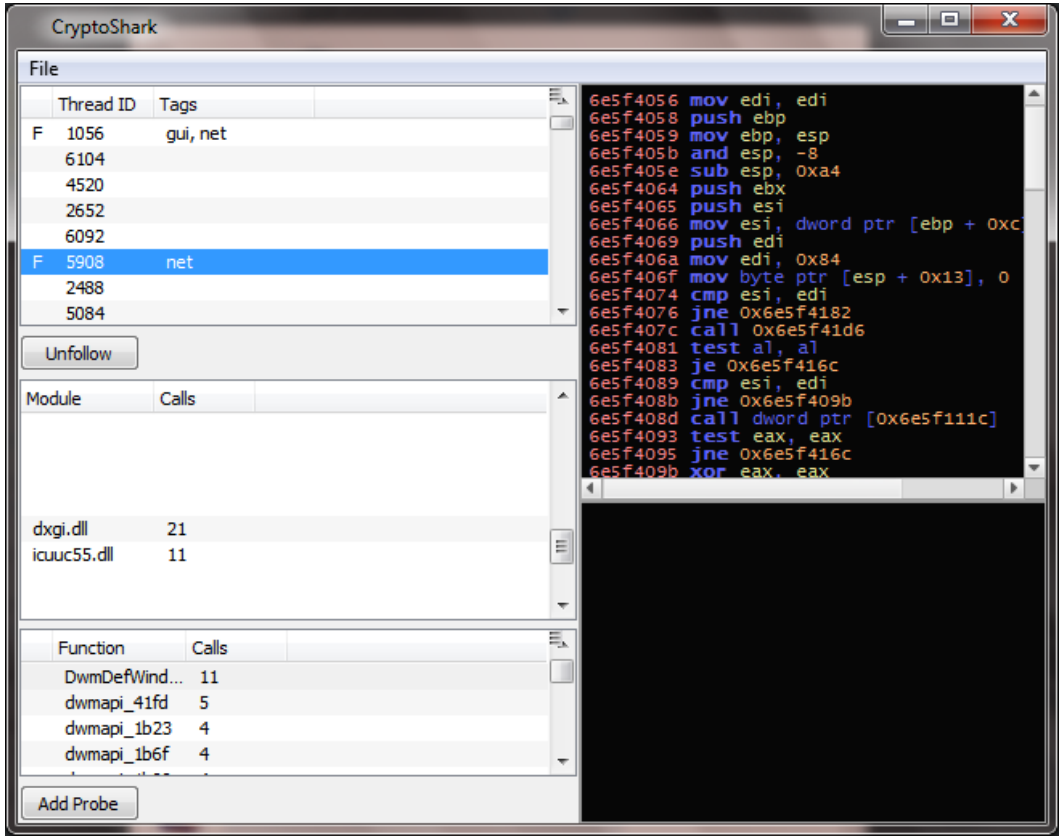
- **frida-extract**: FridaExtract is a Frida.re based RunPE extraction tool. Using FridaExtract you can automatically extract and reconstruct a PE file that has been injected using the RunPE method.

https://github.com/OALabs/frida-extract

CORE SECURITY

Tools based on Frida

- **frida-discover**: tool for discovering internal functions in a program. Eg: Cryptoshark: https://github.com/frida/cryptoshark



CORE SECURITY

Tools based on Frida

Cryptoshark and **frida-discover** are based on Frida's Stalker API.

They dynamically instrument every thread in a given process and stalk every called function during process execution trying to discover internal functions like statically linked functions.

CORE SECURITY

Conclusions

Conclusions

- When to use **Frida**? If you …

- Don’t want to download a compiler and compile every time you make a change
- Need to **quickly** write an introspection tool
- Need low granularity (this may change in the near future)
- Need multi-OS/Arch support

- Then …

CORE SECURITY

Conclusions

CORE SECURITY

Additional information

Additional information

- **Questions** to:
  - https://twitter.com/oleavr
- **Frida** news and docs:
  - http://www.frida.re/
- **Frida** source code:
  - https://github.com/frida
- Frida resources:
  - https://github.com/dweinstein/awesome-frida

CORE SECURITY

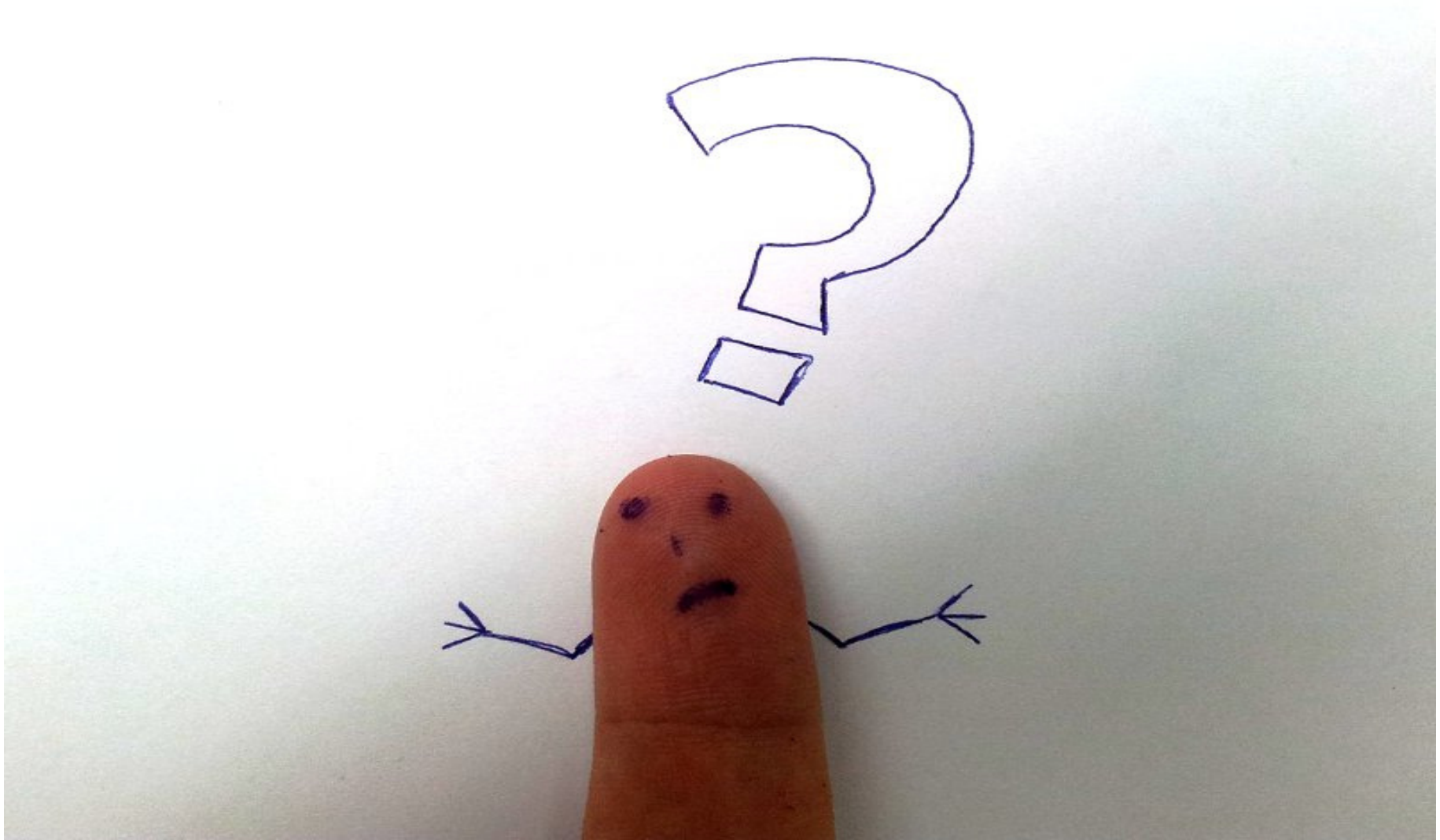
Acknowledgments & Greetings

Acknowledgments & Greetings

- Ole André V. Ravnås
  - For answering all my question about Frida
- Francisco Falcón
  - For the feedback about this presentation

CORE SECURITY

Questions?



CORE SECURITY

Thank you.