Creating Code Obfuscation Virtual Machines

VM Creation 101

Craig Smith
Senior Security Consultant
Neohapsis

What is a VM?

Not VMWare, VirtualPC, etc.

Our own Custom Emulator

- Our own CPU
- Our own Language
- Our own Compiler (P-Code)

Why go through all this trouble?

- Code Obfuscation
- Hide Functionality and Intellectual Property
- Increases Analysis and Reversing Time
- Anti-Dumping Method

VM Benefits and Tricks

- The Virtual CPU is specialized for your tasks
- Built in Encryption
- Hidden Anti-Debugging Techniques
- VM Self-Modifying Code (SMC)
- Library or System Call obfuscation
- VM Junk Code

Who uses this?

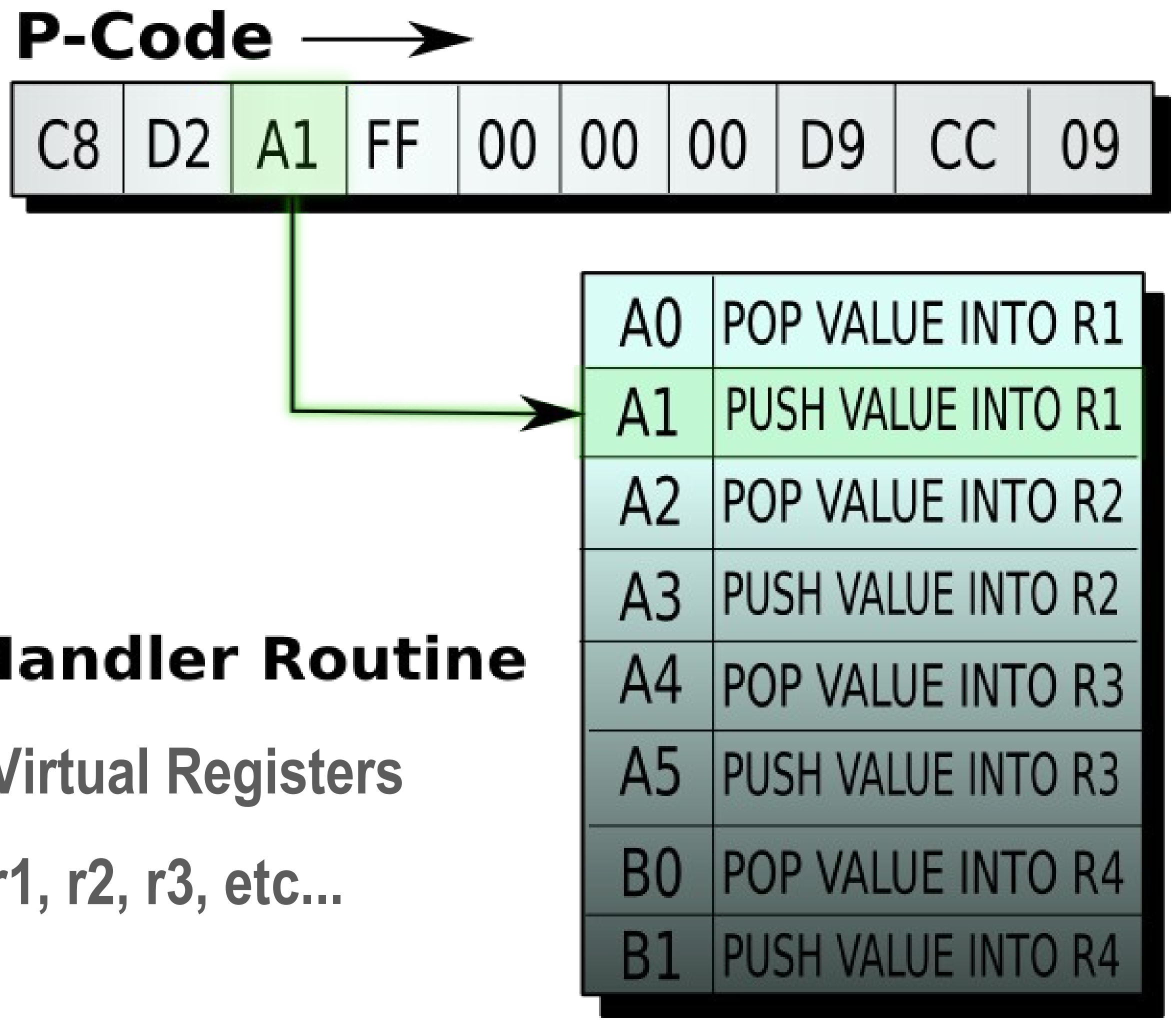
DRM Does

- Themedia
- VMProtect
- BD+ (Blue-Ray)

Virus, Spyware, Exploits can use this as well

- Made popular by Honeynet's SOTM32 (Nicolas Brulez)

Core Concepts



Handler Routine

Virtual Registers

r1, r2, r3, etc...

Our VM Crackme

Design for our VM Crackme:

- Core App runs and prompts user for password
- Pass password to our VM
- VM Does math on the password to make a "Key"
- "Key" is returned and used to Decrypt JMP to GoodBoy message
- Bonus Nugget: Null key is returned if password is wrong

What do we need to get started?

How many registers you want? **9**

How you want to control the program flow? **EIP**

How you going to handle memory? **ESP**

Macros or own custom language? **Custom**

What language will you write your compiler in? **Ruby**

Virtual CPU Register Layout

Four General Purpose Registers:

r1, r2, r3, r4

Instruction Registers

IP, baseip

Stack Registers

SP, basesp

Flag Registers

flags

Our Virtual CPU Instruction Set

- MOV r32, r32
- MOV [r1], r32
- MOV r1, [r1]
- MOV r32, value
- CMP r32, value
- INC/DEC r32
- AND/OR r1, value
- XOR r32,r32
- PUSH/POP r32
- JMP (Relative / Direct) JE, JL, JG
- CALL (r1 / value)
- EXITVM

Virtual CPU Initialization

```
miniVm proc
        pop ebx
        pop eax                 ; Stack Argument
        mov [stack],eax
        pop eax                 ; P-Code
        mov [ip],eax
        mov [baseip],eax
        pusha                   ; Save Registers
        mov [flags],0           ; Init some regs
        mov [stackp],0
        call _core              ; State Machine
        popa                    ; Restore
        push ebx                ; Jump back to code
        ret
```

Calling our CPU

- invoke SendMessage, PasswordHandle,WM_GETTEXT, 20, addr hPassword
- mov eax, offset mystack
- mov [eax], offset hPassword
- push offset vmcode
- push offset mystack
- call miniVm

Our Opcode Processor (State Machine)

```
_next_ip:
        mov ebx,[ip]
        xor eax,eax
        xor ecx,ecx
        xor edx,edx
        mov al,byte ptr [ebx]        ; al = instructional opcode
        mov dl,al
        and dl,0Fh                   ; Major opcode command
        and al,0F0h                  ; Minor opcode command
        cmp al,0C0h                  ; MOV r32
        je _call_mov
        ...
        call _inc_ip
        jmp _next_ip
```

Compiler Design

Can be as complex or as simple as you want. Don't forget if your VM is small you can always use Macros instead.

My First VM Compiler was in Perl (Back in 2004)

This one is in Ruby

- Object Oriented Core
- Simple method for adding Opcodes
- Easily expandable
- Portable

Very Simple VM Password Demo

```
; Sample MiniVM Code
        POP r1                  ; Get String off of stack
        MOV r1,[r1]             ; Get DWORD
        CMP r1,0x34333231       ; Cmp to "1234"
        JE  GoodPassword
        MOV r1,0                ; Set Stack to NULL
        PUSH r1
        JMP ExitCode
GoodPassword:
        MOV r1,1                ; Set Stack to 1 to show
                                ; password was valid
        PUSH r1
ExitCode:
        EXIT                    ; Quit VM
```

Ruby Compiler Object

```
MiniVMParser.rb:
class MiniVMParser < VMParser
...
  def define_opcodes
        ops = VMOpcodes.new
        ops.add("PUSH","r1",nil,"\x30")
        ops.add("PUSH","r2",nil,"\x31")
        ops.add("PUSH","r3",nil,"\x32")
        ops.add("CMP","r1","r2","\xd0")
        ops.add("CMP","r1",:value,"\xd8")
        ops.add("CMP","r2",:value,"\xd9")
        ops.add("MOV","eip",:value,"\xcc")
...etc...
```

Compiler Usage Output

miniVM Compiler

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Usage: minivmc [options]

Suggested Options:

-s, --source src	Source file to compile
-d, --destination dst	Destination file
-v, --verbose	Show opcodes per line
-o, --output style	Output style. [Bin, C, MASM]
-h, --help	Show this message

Compiler Directive XOR Example

```
; dbx directive example
        MOV r2, msg
        MOV r3, 76              ; r3 holds the xorkey
        JMP code
msg:
.dbx 76, '/etc/passwd',0
code:
        MOV r1, r2
        MOV r1, [r1]
        AND r1, 0x000000FFh
        XOR r1, r3
        CMP r1, 0
        JE done
...
```

Output of DBX directive

```
xxd -c 8 minivm.bin

0000000: c900 0000 0aca 0000  ........

0000008: 004c 6329 382f 633c  .Lc)8/c<

0000010: 2d3f 3f3b 284c b042  -??;(L.B

0000018: 4000 0000 0002 d800  @.......

0000020: 0000 0020 0000 0028  ... ...(
```

XOR KEY

String

How to add your own directives

3 Steps:

- @directives.add("mydirective")
- Def get_directive_size(tok) (optional)
- Def process_directive(tok, tokens)

tok.directive.cmd

tok.directive.line

Our Crackme

Valid: ReCon 08;
Goal: To find more valid passwords

Tips for Debugging your VM

Debugging Techniques:

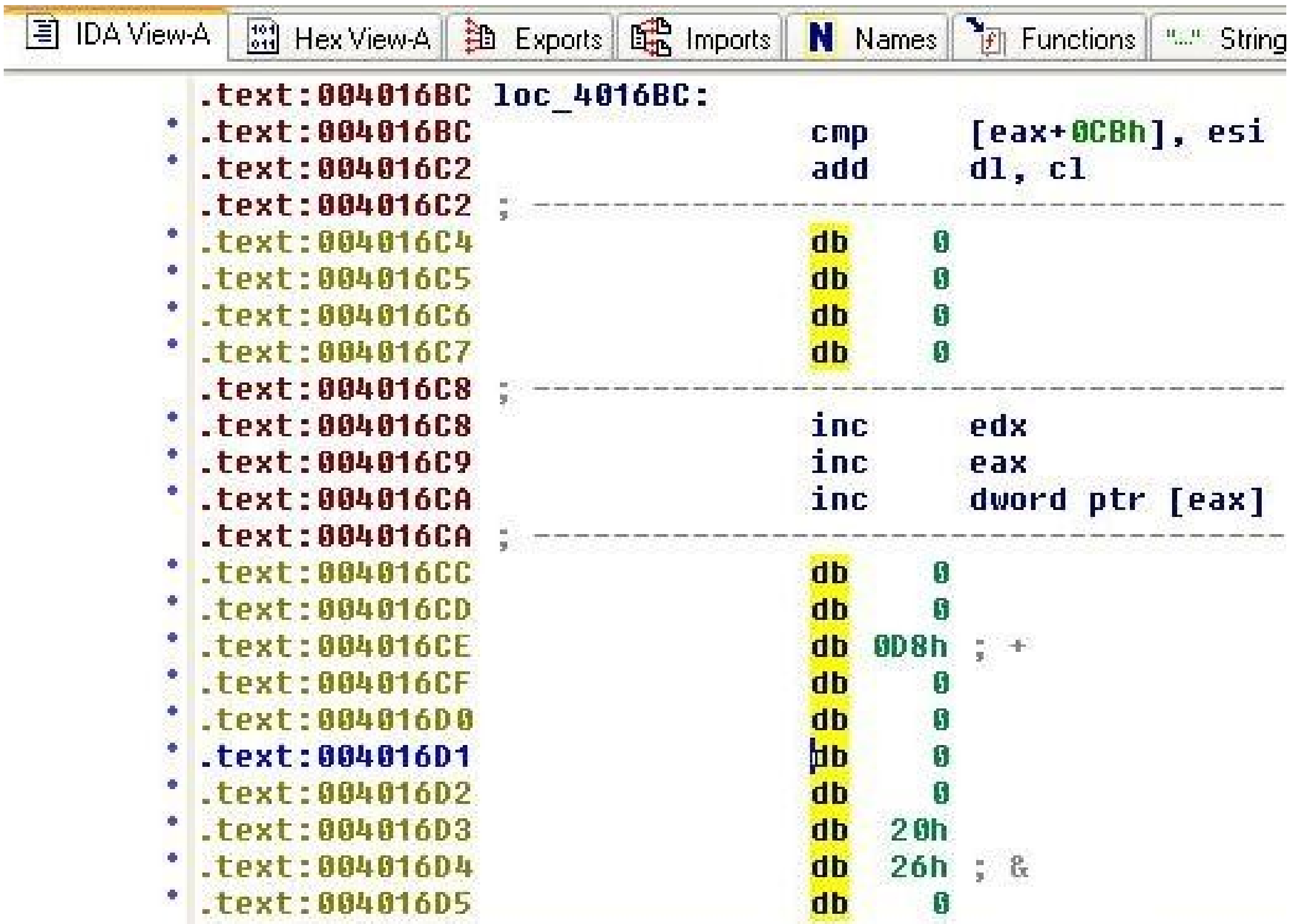
- Add INT 3 Breakpoints to your VM
- Break on the call handler table
- Minivmc -v
- View your Virtual Registers while you are debugging

Attacks against your VM

- Your VM Core must be decrypted in order to process your p-code
- It is very simply to use a signature to identify a VM processor
- Use traditional methods to try and protect your VM core.

Remember this is just obfuscation, not security. The goal is to quickly write code that takes a reverser much longer to analyze.

Example of our VM in IDA



Look Ma, I can mutate!

Self Modifying Code (SMC) example:

```
    MOV r1, mutate
    ADD r1, eip        ; Adjust for relative offset
    MOV [r1], 0x21000000h    ; 0x21h == JL opcode
    MOV r1, 6
    CMP r1, 5          ; 6 > 5
mutate:
    JG fakecode        ; Appears to always goto fakecode
                       ; After mutation becomes JL <some addr>
    JMP realcode
```

Advanced Extensions

XOR Register coupled with .xorkey directive

All Register Operations first pass through the XOR register

Example:

```
    MOV xorkey, 76      ; where xorkey is a register
    MOV r1, 1           ; 1 becomes 0x4Dh
    MOV xorkey, r1      ; xorkey becomes 1
.xorkey 1
    MOV r1, 1           ; 1 becomes 0
```

* Note included in this version

Shifting Operands

Shifting Operands

Similar to the xorkey register but used on the operand as follows:

•The CPU can be “seeded” on init with a value

•This value is used when parsing any operand byte (Example XOR)

•The compiler MUST know what the seed value is so it can write the appropriate opcode. Example: .seed 0x4c

•This seed value can change mid program

* Note included in this version

Where to get the Code

Neohapsis Labs (Blog)

VM, and Compiler

http://labs.neohapsis.com/

Crackme is here:

http://crackmes.de/

Email: craig.smith (\) neohapsis.com

Questions?