

Exploiting Software Vulnerabilities

Program Binary Analysis

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UNIVERSITY OF ZARAGOZA

Seminar A.25, Ada Byron building



Outline

- 1** Introduction to Program Binary Analysis
- 2** Static Analysis Techniques
- 3** Dynamic Analysis Techniques

Outline

- 1** Introduction to Program Binary Analysis
- 2 Static Analysis Techniques
- 3 Dynamic Analysis Techniques

Introduction

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

```
int main(int argc, char *argv[])  
{  
    printf("hello world!\n");  
    return 0;  
}
```

```
push    ebp  
mov     ebp, esp  
and     esp, -16  
sub     esp, 16  
call   ___main  
mov     DWORD PTR [esp], OFFSET FLAT:LC0  
call   _puts  
mov     eax, 0  
leave  
ret
```

■ Programs are written in text

- Both source code and assembly!
- **Character sequences (bytes)**
- Difficult to work with (for humans, not for machines)
- We need some **structured representation**

Introduction

Program Analysis

Automatically reason and derive properties about the behavior of computer programs

Approaches

■ Static Program Analysis

- Without running the program
- The abstract model of the program is obtained and (symbolically) executed
- Analysis performed through the abstract model
- **Examples:** CFA, DFA, concolic execution, ...

■ Dynamic Program Analysis

- Running the program on some chosen inputs
- Traces are collected and then analyzed
- Analysis performed through these concrete executions
- **Examples:** software testing, taint analysis, ...

Introduction

Input program formats for analysis

- **Abstract model:** all unnecessary information for analysis have been removed. Only the necessary information remains
- **Source code:** Keep track of high-level, human-readable information about the program (variables, types, functions, etc.)
- **Bytecode:** may vary depending on the bytecode considered, but keep a record of little high-level information about the program, such as types and functions. The programs are unstructured
- **Binary file:** just keep track of statements in an unstructured way (no for-loop, no clear argument passing in procedures, etc). No type, no names. The binary file can include meta-data that can be useful for analysis (symbols, debug, etc.)
- **Memory dump:** Pure assembler instructions with a full memory state of the current execution. We no longer have the meta-data of the executable file

Binary code is the closest format of what will be executed!

Introduction

Binary code vs. source code

What you code is not what you execute!

We want to analyze binary code. It can come as:

- an executable file,
- an object file,
- a dynamic library,
- a firmware,
- a memory dump,
- ...

We do not trust to obtain the corresponding high-level source code

Introduction

Motivations

Why should we analyze binary programs?

- Lack of high-level source code
- Low-level assembly code embedded in source code
- Legacy code
- Commercial Off-the-shelf software (COTS)
- App stores (for mobile phones and tablets)
- Malware (or other “hostile” programs)
- Technology forecast
- Mistrust in the compilation chain
- C compiler possibly buggy
- Checking for low-level bugs (e.g., exploiting a stack buffer overflow)
- Errors with strong hardware interconnection

Introduction

Understanding papers on Program Analysis

For those who keep track of such things, checkers in the research system typically traverse program paths (flow-sensitive) in a forward direction, going across function calls (inter-procedural) while keeping track of call-site-specific information (context-sensitive) and toward the end of the effort had some of the support needed to detect when a path was infeasible (path-sensitive).

Note these terms

- Flow-(in)sensitive
- Context-(in)sensitive
- Inter-(intro)procedural
- Path-(in)sensitive

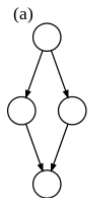
Further reading: *A few billion lines of code later: using static analysis to find bugs in the real world.* Al Bessey, Ken Block, Ben Chelf, Andy Chou, Bryan Fulton, Seth Hallett, Charles Henri-Gros, Asya Kamsky, Scott McPeak, Dawson Engler. *Communications of the ACM*, vol. 53, iss. 2, pp. 66-75 (February 2010). doi: 10.1145/1646353.1646374

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Static Analysis Techniques

Control-Flow Graphs

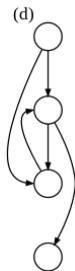
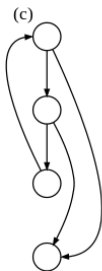


- **Control flow within a function**

- **Nodes: basic blocks**

- Sequence of consecutive program instructions that have an entry point (first executed instruction) and an exit point (last executed instruction)
- Entry and exit blocks

- **Edge:** control flows from A to B



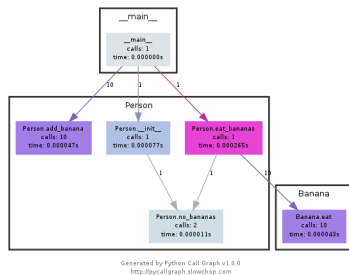
Applications

- Compiler optimizations
- Data-flow analysis (taint analysis)
- Behavioral-based monitors

Credits: https://en.wikipedia.org/wiki/Control_flow_graph

Static Analysis Techniques

Call Graphs



- **Interprocedural CFG. Information flow between functions**
- **Nodes: functions**
- **Edge: A could call B**
- Types: static, dynamic (record of program execution)
- Application: find never called procedures
- **Tools available for automatic generation of call graphs**

Credits: https://en.wikipedia.org/wiki/Call_graph

Static Analysis Techniques

Disassembling

0040166B	..0F85 24010000	JNZ xconv.00401795	
00401671	. 6A 0E	PUSH 0E	
00401673	. 68 2D544000	PUSH xconv.0040542D	Count = E (14.)
00401678	. 68 30000000	PUSH 30	Buffer = xconv.0040542D
0040167D	. FF75 08	PUSH DWORD PTR SS:[EBP+8]	ControlID = 88 (128.)
00401680	. E8 C1040000	CALL <JMP.&user32.GetDlgItemTextA>	hWnd
00401685	. 83F8 0C	CMP EAX,0C	GetDlgItemTextA
00401689	..7F 4B	JG SHORT xconv.004016D5	
0040168A	. 53F3 94	CMR EAX,4	
0040168D	..7C 46	JL SHORT xconv.004016D5	
0040168F	. 68 2D544000	PUSH xconv.0040542D	String2 = "DeAtH"
00401694	. 68 06334000	PUSH xconv.00403306	String1 = xconv.00403306
00401699	. E8 26050000	CALL <JMP.&kernel32.lstrcpyA>	lstrcpyA
0040169E	. 6A 1B	PUSH 1B	Count = 1B (27.)
004016A0	. 68 62544000	PUSH xconv.00405462	Buffer = xconv.00405462
004016A5	. 68 81000000	PUSH 81	ControlID = 81 (129.)
004016AA	. FF75 08	PUSH DWORD PTR SS:[EBP+8]	hWnd
004016AD	. E8 94040000	CALL <JMP.&user32.GetDlgItemTextA>	GetDlgItemTextA
004016B2	. E8 48020000	CALL xconv.00401501	
004016B7	. 83F8 01	CMP EAX,1	
004016BA	..74 32	JE SHORT xconv.004016EE	
004016BC	. 0005 B8534000	ADD BYTE PTR DS:[4053B8],1	
004016C3	. 805D B8534000	CMR BYTE PTR DS:[4053B8],3	
004016C9	..0F34 9C000000	JE xconv.00401795	
004016D0	..E9 81000000	JMP xconv.00401755	
004016D5	> 6A 10	PUSH 10	Style = MB_OK MB_ICONHAND MB_APPLMODAL
004016D7	. 68 79304000	PUSH xconv.00403079	Title = "Sorry"
004016DC	. 68 53324000	PUSH xconv.00403253	Text = "Sorry username must be at least 4 characters long and not n
004016E1	. 68 10000000	PUSH 10	hOwner
004016E4	. E8 69040000	CALL <JMP.&user32.MessageBoxA>	MessageBoxA
004016E9	..E9 D7000000	JMP xconv.004017C5	
004016EE	> E8 A0030000	CALL xconv.00401A98	
004016F3	. C605 72434000	MOV BYTE PTR DS:[404372],1	
004016F7	. 6A 40	PUSH 40	Style = MB_OK MB_ICONASTERISK MB_APPLMODAL
004016FC	. 68 33304000	PUSH xconv.00403033	Title = "Thank you!"
00401701	. 68 3E304000	PUSH xconv.0040303E	Text = "Registration done. Thank you for registering this program!"
00401706	. FF75 08	PUSH DWORD PTR SS:[EBP+8]	hOwner
00401709	. E8 44040000	CALL <JMP.&user32.MessageBoxA>	MessageBoxA
0040170E	. 6A 00	PUSH 0	Result = 0

- Roughly speaking, read PUSH EAX instead of 0x50
- **Many tools** see https://en.wikibooks.org/wiki/X86_Disassembly/Disassemblers_and_Decompilers
 - Win32Dasm
 - OllyDBG (it is also a debugger)
 - IDA Pro (it is also a debugger)
 - r2 (it is also a debugger)

Static Analysis Techniques

Disassembling

Main challenges

- **Variable-length instruction sets:** overlapping instructions
- **Mixed data and code:** misclassify data as instructions
- **Indirect jumps:** any location could be the beginning of an instruction!
- **Start of functions:** when calls are indirect
- **End of functions:** when there is no dedicated return instruction
 - Handwritten assembly code may not meet standard call conventions
- **Code compression:** the code of two functions overlaps
- **Self-modifying code**

Static Analysis Techniques

Decompilation – example

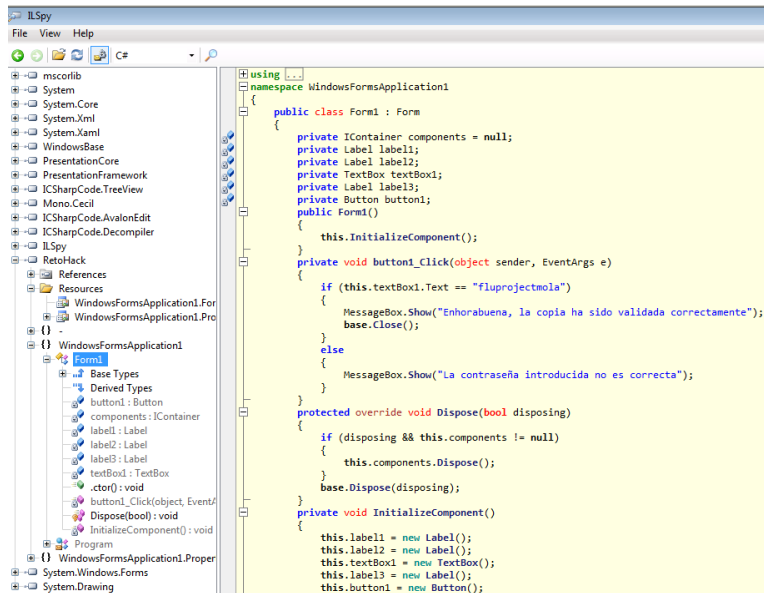
```
int __stdcall sub_40162C(HWND hDlg, int a2, int a3, int a4){
    HICON v4; // eax@2
    UINT v5; // eax@5

    switch ( a2 ) {
    case 272:
        v4 = LoadIconA(hInstance, (LPCSTR)0x64;
        SendMessageA(hDlg, 0x80u, 1u, (LPARAM)v4);
        break;
    case 273:
        if ( a3 == 126 ) {
            v5 = GetDlgItemTextA(hDlg, 128, dword_40542D, 14);
            if ( (signed int)v5 > 12 || (signed int)v5 < 4 ) {
                MessageBoxA(hDlg, "Sorry username must be at least 4
characters\r\nlong
and not more than 12 characters.", "Sorry", 0x10u);
            } else {
                lstrcpyA(dword_403306, dword_40542D);
                GetDlgItemTextA(hDlg, 129, byte_405462, 27);
                if ( sub_401901() == 1 ) {
                    sub_401A9B();
                    byte_404372 = 1;
                    MessageBoxA(hDlg, "Registration done. Thank you for registering
this
program!", "Thank you!", 0x40u);
                    EndDialog(hDlg, 0);
                    EnableWindow(dword_403363, 0);
                    SetWindowTextA(
                        dword_4054A7,
                            "X-Convertor v1.0 2005 by TDC and BoR0\r\n\r\n
Coded by\t: TDC and BoR0\r\n\r\nVersion\t\t: 1.0\r\n\r\nRelease
date\t: 18-08-2005\r\n\r\nX-Convertor converts up to 4KB
each convert.\r\n\r\n\r\nRegistered version. Thank you.\r\n\r\n");
                    lstrcatA(byte_403330, dword_403306);
                    SetWindowTextA(dword_4054AB, byte_403330);
                }
            }
        }
    }
}

else {
    ++byte_4053B8;
    if ( byte_4053B8 == 3 ) {
        MessageBoxA(hDlg, "Your serial is not correct",
            "Sorry", 0x10u);
        byte_4053B8 = 0;
        EndDialog(hDlg, 0);
    } else {
        MessageBoxA(hDlg, "Your serial is not correct",
            "Sorry", 0x10u);
    }
}
}
} else {
    if ( a3 == 127 ) {
        byte_4053B8 = 0;
        EndDialog(hDlg, 0);
    }
}
break;
case 16:
    byte_4053B8 = 0;
    EndDialog(hDlg, 0);
    break;
}
return 0;
}
```

Static Analysis Techniques

Decompilation



The screenshot shows the ILSpy decompiler interface. On the left, a tree view displays the project structure, including references to various .NET assemblies like System, System.Core, System.Xml, System.Xaml, WindowsBase, PresentationCore, PresentationFramework, ICSharpCode.TreeView, Mono.Cecil, ICSharpCode.AvalonEdit, ICSharpCode.Decompiler, ILSpy, and RetoHack. The 'Resources' folder is expanded, showing the decompiled code for 'WindowsFormsApplication1.Form1'. The main pane on the right displays the decompiled C# code for the 'Form1' class, which inherits from 'Form'. The code includes private fields for 'components', 'label1', 'label2', 'label3', 'textBox1', and 'button1', a constructor 'Form1()', a 'button1_Click' event handler, and an overridden 'Dispose' method. The code is as follows:

```
using ...
namespace WindowsFormsApplication1
{
    public class Form1 : Form
    {
        private IContainer components = null;
        private Label label1;
        private Label label2;
        private TextBox textBox1;
        private Label label3;
        private Button button1;
        public Form1()
        {
            this.InitializeComponent();
        }
        private void button1_Click(object sender, EventArgs e)
        {
            if (this.textBox1.Text == "fluprojectmola")
            {
                MessageBox.Show("Enhorabuena, la copia ha sido validada correctamente");
                base.Close();
            }
            else
            {
                MessageBox.Show("La contraseña introducida no es correcta");
            }
        }
        protected override void Dispose(bool disposing)
        {
            if (disposing && this.components != null)
            {
                this.components.Dispose();
            }
            base.Dispose(disposing);
        }
        private void InitializeComponent()
        {
            this.label1 = new Label();
            this.label2 = new Label();
            this.textBox1 = new TextBox();
            this.label3 = new Label();
            this.button1 = new Button();
        }
    }
}
```


Static Analysis Techniques

Decompilation

Main challenges

- **Disassembly:** **first step of any decompiler!**
- **Target language:** the assembly code may not correspond to any source code
- **Library functions**
- **Instruction compiler-dependent equivalents**
 - `int a = 0` → `mov eax, [a]; xor eax, eax`
- **Target architecture artifacts:** unnecessary jumps-to-jumps
- **Structured control-flow**
- **Compiler optimizations:** unrolling loops, shifts, adds, ...
- **Loads/stores:** operations on arrays, records, pointers, and objects
- **Self-modification code:** typically, the segment code should be unchanged, although there are programs that modify themselves!

Static Analysis Techniques

Data Flow Analysis

- Analyze the **effect of each basic block**
- Compose basic block effects to derive information at the limits of the basic blocks
- Framework for **providing facts about programs**. Based on all paths through the program (including infeasible paths as well)
- **Derive information about the dynamic behavior of a program by examining only the code statically**

Useful for...

- **Program debugging**: what definitions (of variables) can reach a program point?
- **Program optimizations**: constant folding, copy propagation, elimination of common subexpressions, etc.

Static Analysis Techniques

Data Flow Analysis

Consider the statement $a = b + c$

Statement effects

- **Uses variables** (b, c)
- **“Kills” a previous definition** (old value of a)
- **New definition** (a)

■ **Compose effect of statements** → **effect of a basic block**

- *Locally exposed usage*: usage of a data item that is not preceded in the basic block by a data item definition
- Any definition of a data item removes (*kills*) all definitions of the same data item that reach the basic block
- *Locally available definition*: last definition of the data item in the basic block

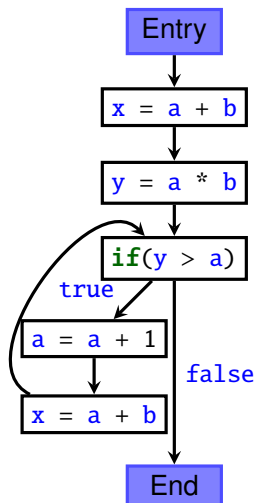
Static Analysis Techniques

Data Flow Analysis

■ Facts

- $a + b$ is available
- $a * b$ is available
- $a + 1$ is available

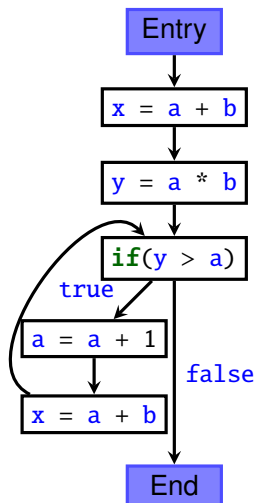
- Let's calculate the facts that hold for each program point!



Static Analysis Techniques

Data Flow Analysis

Statement	Gen	Kill
$x = a + b$	$a + b$	
$y = a * b$	$a * b$	
$y > a$		
$a = a + 1$		$a + b$ $a * b$
	$a + 1$	



Static Analysis Techniques

Data Flow Analysis

- *Forward versus backward*: data flow from the inside out (vs outside in)
- *Must versus may*: at joint points, just keep the facts that hold on all paths (vs. any path) that are joined

	Must	May
Forward	Available expressions	Reaching definitions
Backward	Very busy expressions	Live variables

Limitations

- **Data-Flow Analysis is good for analyzing local variables**
 - **What happens to values stored in the heap?**
 - Not modeled on traditional data flow
- Suppose $*x = p$
 - *Assume all data flow facts are killed*
 - Or assume writing via x can affect any variable whose address has been taken
- In general, **it is difficult to analyze pointers**

Static Analysis Techniques

Symbolic Execution

- **Allows us to scale and model all the possible executions of a program**
- Concrete versus symbolic execution
 - **Tests work, but each test only explores one possible execution path**
- **Symbolic execution generalizes testing**
 - Allows unknown symbolic variables in evaluation
 - **Checks the feasibility of the program paths**

Main challenges

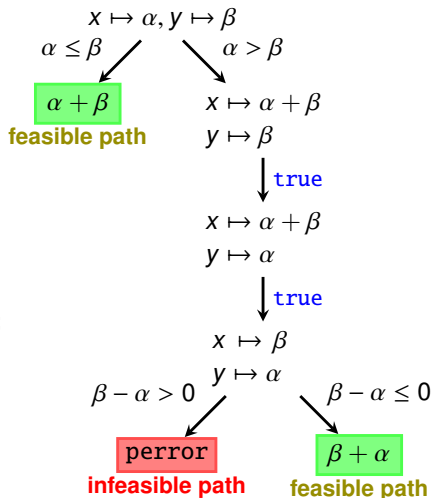
- **Path explosion**
- **Modeling statements and environments**
- **Constraint resolution**

Further reading: Roberto Baldoni, Emilio Coppa, Daniele Cono D'elia, Camil Demetrescu, and Irene Finocchi. *A Survey of Symbolic Execution Techniques*. ACM Comput. Surv. 51, 3, Article 50 (July 2018), 39 pages. doi: 10.1145/3182657

Static Analysis Techniques

Symbolic Execution

```
1  int f(int x, int y)
2  {
3      if(x > y)
4      {
5          x = x + y;
6          y = x - y;
7          x = x - y;
8          if(x - y > 0)
9              perror("Error!");
10     }
11
12     return x + y;
13 }
```



How to decide which branches are feasible?

Combine the path condition with the branch condition and ask an SMT solver!

Static Analysis Techniques

Symbolic Execution – example: bug finding

Catch the error! What value triggers it?

```
1  int bar(int i)
2  {
3      int j = 2*i;
4      i++;
5      i = i*j;
6      if (i < 1)
7          i = -i;
8
9      i = j/i;
10     return i;
11 }
```

False branch condition

$$i = (i_{in} + 1)2i_{in}$$

$$(i_{in} + 1)2i_{in} \geq 1$$

True branch condition

$$i = -(i_{in} + 1)2i_{in}$$

$$(i_{in} + 1)2i_{in} < 1$$

Static Analysis Techniques

Symbolic Execution – example: bug finding

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Division by zero creates problems...

Static Analysis Techniques

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Division by zero creates problems...

False branch is always safe

$$(i > 0, \forall i_{in} | (i_{in} + 1)2i_{in} \geq 1)$$

What about the true branch?

Static Analysis Techniques

Symbolic Execution – example: bug finding

Catch the error! What value triggers it?

```
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$$(i > 0, \forall i_{in} | (i_{in} + 1)2i_{in} \geq 1)$$

What about the true branch?

$$-(i_{in} + 1)2i_{in} = 0$$

Static Analysis Techniques

Symbolic Execution – example: bug finding

Catch the error! What value triggers it?

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1  int bar(int i)
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Division by zero creates problems...

False branch is always safe

$$(i > 0, \forall i_{in} | (i_{in} + 1)2i_{in} \geq 1)$$

What about the true branch?

$$-(i_{in} + 1)2i_{in} = 0 \rightarrow i_{in} = -1, i_{in} = 0$$

Static Analysis Techniques

Symbolic Execution – example: class exercise

Which values of **a** and **b** make the **assert** fail?

```
1 void foo(int a, int b)
2 {
3     int x = 1, y = 0;
4     if (a != 0){
5         y = 3 + x;
6         if (b == 0)
7             x = 2*(a + b);
8     }
9     assert(x - y != 0);
10 }
```

State 1

$\sigma = \{a \mapsto \alpha, b \mapsto \beta\}$
$\pi = true$
int x = 1, y = 0

Static Analysis Techniques

Symbolic Execution – example: class exercise

Which values of **a** and **b** make the **assert** fail?

```
1 void foo(int a, int b)
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```

State 1

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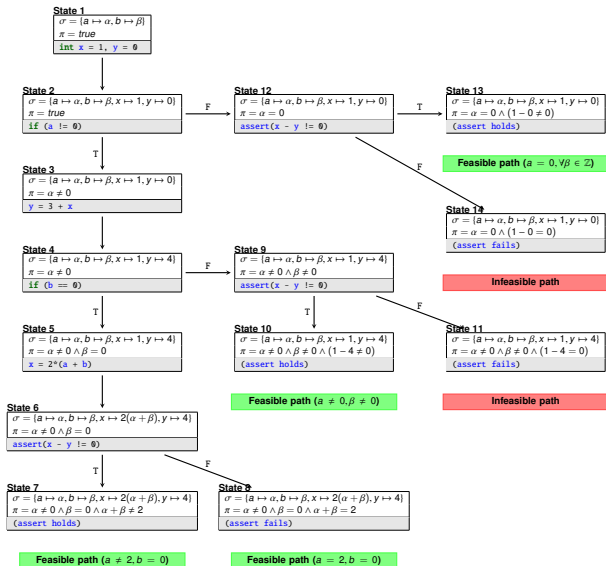
State 2

$\sigma = \{a \mapsto \alpha, b \mapsto \beta, x \mapsto 1, y \mapsto 0\}$ $\pi = true$
if (a != 0)

(you can continue it...)

Static Analysis Techniques

Symbolic Execution – solution to the class exercise above



Outline

- 1 Introduction to Program Binary Analysis
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- 3 Dynamic Analysis Techniques**

Dynamic Analysis Techniques

Debugging

- **Run the program instructions with special software:** *debuggers*
 - We can see the values of each CPU register, stack, memory, etc.
- Source code vs. binary debugging
- **Breakpoints:** stops execution when reached
 - Software (memory) breakpoints
 - Hardware breakpoints
 - In run, read, or write operations
- Step into / step onto

Dynamic Analysis Techniques

Debugging (example: OLLyDBG)

The screenshot displays the OLLyDbg interface for the process OLLYDBG.EXE. The main window shows assembly code for the function `JMP SHORT OLLYDBG.00401012`. The registers window on the right shows the state of various registers, including EAX, ECX, EDI, and EIP. The memory dump window at the bottom shows the hex dump and ASCII representation of the code at address 00401012.

Address	Hex dump	ASCII
00401012	00 00 60 43 4A 00 00 00	..*CJ..
00401013	F4 45 4A 00 00 05 F0 5C	MEJ..&-l
00401014	0A 03 00 04 03 53 00 00	..*J..
00401015	00 04 93 83 4A 00 00 0A	..*S..
00401016	AC 02 4D 00 00 0A 08 E1	*J..:ll
00401017	4A 00 00 0A F0 AC 4A 00	..J..0%J.
00401018	00 0A CC 56 4A 00 00 01	..*J..0
00401019	53 FF 4D 00 00 01 5C C2	*J..0*J..0*
0040101A	4A 00 00 03 53 C6 4A 00	..*J..*
0040101B	00 02 04 CB 4A 00 00 03	..*J..*
0040101C	9C CD 4A 00 00 00 FC D3	*J..*%E
0040101D	4A 00 00 00 88 28 4A 00	..*J..J.
0040101E	00 01 C3 3C 4A 00 00 00	..*J..
0040101F	0C 46 4A 00 00 00 5D FJ..*	..*J..*
00401020	4A 00 00 04 9C 83 4A 00	..*J..*
00401021	00 03 E0 C6 4A 00 00 02	..*J..*

Dynamic Analysis Techniques

Fuzzing

Roughly speaking, “fuzzing means. . .” (quoting Iñaki Rodríguez-Gastón)

Dynamic Analysis Techniques

Fuzzing

Roughly speaking, “fuzzing means. . .” (quoting Iñaki Rodríguez-Gastón)

- **Form of vulnerability analysis in application programs**
- **Black-box approach** (at the beginning): no prior knowledge of the internal aspects of the program
 - **Evolved to a white-box approach:** state-of-the-art fuzzers “learn” from program behavior
- **The application is given many anomalous (unexpected, invalid, or random data) inputs**
- **The application is monitored for any signs of error**
 - Unexpected behavior
 - Crashes
 - Buffer overflow
 - Integer overflow
 - Memory corruption errors
 - Format string bugs

Dynamic Analysis Techniques

Fuzzing

Charlie Miller's "five lines of Python" dumb fuzzer

■ Found vulnerabilities in PDF readers and MS Powerpoint

```
numwrites = random.randrange(math.ceil((float(len(buf)) / FuzzFactor))) + 1
for j in range(numwrites):
    rbyte = random.randrange(256)
    rn = random.randrange(len(buf))
    buf[rn] = "%c"%(rbyte);
```

Dynamic Analysis Techniques

Fuzz Testing

A simple example: HTTP GET requests

■ Standard HTTP GET request

- GET /index.html HTTP/1.1

■ Anomalous requests

- AAAAAA...AAAA /index.html HTTP/1.1
- GET /////index.html HTTP/1.1
- GET %n%n%n%n%n%n%n.html HTTP/1.1
- GET /AAAAAAAAAAAAA.html HTTP/1.1
- GET /index.html HTTTTTTTTTTTTTTTP/1.1
- GET /index.html HTTP/1.1.1.1.1.1.1.1
- etc.

Types of fuzzers

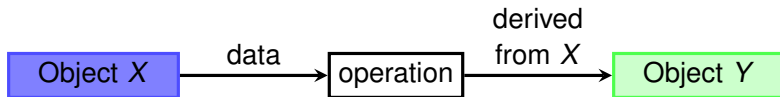
- Mutation-based fuzzing
- Generation-based fuzzing

Dynamic Analysis Techniques

Taint analysis

Can you measure the influence of the input data on the application?

- Data comes from tainted sources (any external input) and ends up in tainted sinks
- *Flow* from X to Y : an operation that uses X to derive a value Y
- **Tainted value**: if the source of the value X is untrustworthy (e.g., user-supplied string)



Taint Propagation

- Object X tainted the object Y
- **Taint operator** $t: X \mapsto t(Y)$
- The taint operator is transitive
 - $X \mapsto t(Y)$ and $Y \mapsto t(Z)$, then $X \mapsto t(Z)$

Dynamic Analysis Techniques

Taint analysis

Main challenges

■ Tainted addresses

- Distinguishing between memory addresses and cells is not always appropriate
- Taint granularity is important (bit, byte, word, etc.)

■ Undertainting

- Dynamic taint analysis does not adequately handle some types of information flow

■ Overtainting

- Deciding when to introduce a taint is often easier than deciding when to remove it

■ Detection time vs. attack time

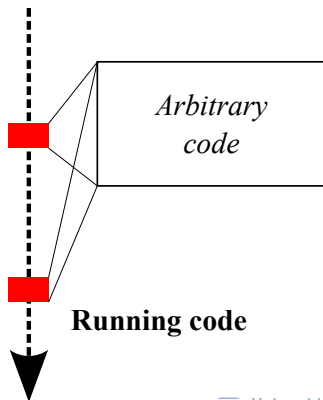
- When used for attack detection, dynamic taint analysis may generate an alert too late

Dynamic Analysis Techniques

Dynamic Binary Instrumentation

adding arbitrary code during the execution of a binary

- What insert? → **instrumentation function**
- Where? → **add places**



Dynamic Analysis Techniques

Dynamic Binary Instrumentation

adding arbitrary code during the execution of a binary

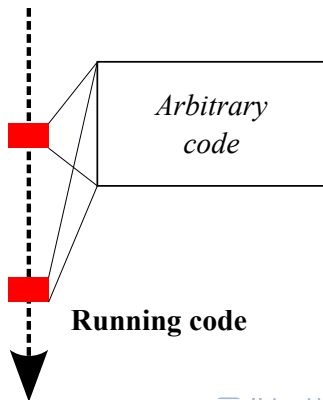
- What insert? → **instrumentation function**
- Where? → **add places**

Advantages

- **No need to recompile/relink every time**
- **Allow to find *on-the-fly* code**
- **Dynamically generated code**
- **Allow to instrument a process already running (*attach*)**

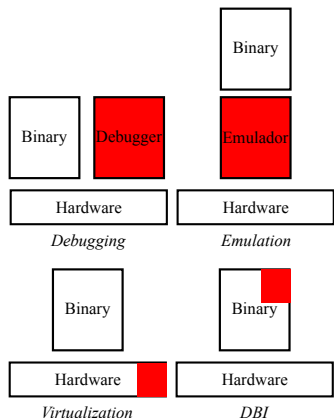
Main disadvantage

- **Overhead** ⇒⇓ **performance**



Dynamic Analysis Techniques

Placing DBI in the context of dynamic analysis



- Executable transformation
- Full control over execution
- No architectural support needed

Credits: J-Y. Marion, D. Reynaud *Dynamic Binary Instrumentation for Deobfuscation and Unpacking*. DeepSec, 2009

Exploiting Software Vulnerabilities

Program Binary Analysis

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Course 2021/2022

Master's Degree in Informatics Engineering

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Seminar A.25, Ada Byron building

