UFR IM²AG
UNIVERSITÉ Grenoble Alpes

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Software Mining and Re-engineering

About Code Obfuscation

Master M2 MoSiG (AISSE)

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Code Obfuscation

→ Protecting a code against **reverse-engineering** techniques allowing to **inspect and/or tamper** a software (man at the end attacks !)

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Typical applications domains:

- intellectual property of some algorithms
- data confidentiality
- white-box cryptography
- digital rights managements (DRM)
- ...
- and malware implementation !

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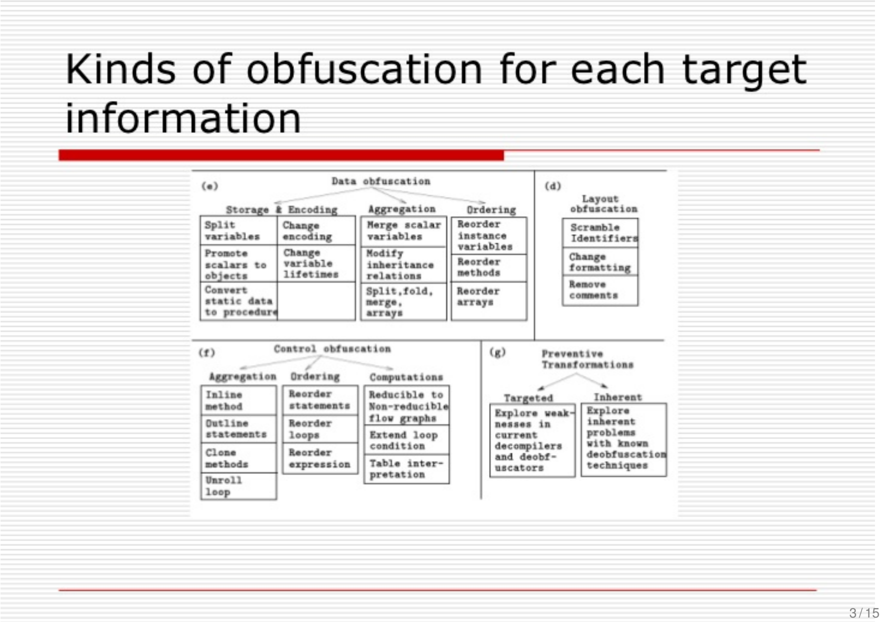
obfuscation may target various reverse-engineering approaches

- from source code vs from binary code
- manual vs tool-assisted
- static (i.e., code inspection) vs dymanic (i.e., code execution) techniques
- etc

⇒ a large spectrum of obfuscation techniques ...

Some examples of code obfuscation techniques



Outline

Basic transformations

Examples of Data Obfuscation

Examples of Code Obfuscation

Some other obfuscation techniques

Example: source-level obfuscation against manual RE (1/3)

Example:From Stunnix

- Actual code:
- function foo(arg1)
- {
- var myVar1 = "some string"; //first comment
- var intVar = 24 * 3600; //second comment
- /* here is
- a long
- multi-line comment blah */
- document. write("vars are:" + myVar1 + " " + intVar + " " + arg1) ;
- } ;

- Obfuscated code:
- function z001c775808(z3833986e2c) { var z0d8bd8ba25= "\x73\x6f\x6d\x65\x20\x73\x74\x72\x69\x6e\x67"; var z0ed9bcbcc2= (0x90b+785-0xc04)* (0x1136+6437-0x1c4b); document. write("\x76\x61\x72\x73\x20\x61\x72\x65\x3a"+ z0d8bd8ba25+ "\x20"+ z0ed9bcbcc2+ "\x20"+ z3833986e2c);};

Example: source-level obfuscation against manual RE (2/3)

Step by step examination

- The Stunnix obfuscator targets at obfuscating only the layout of the JavaScript code
- As the obfuscator parses the code, it removes spaces, comments and new line feeds
- While doing so, as it encounters user defined names, it replaces them with some random string
- It replaces print strings with their hexadecimal values
- It replaces integer values with complex equations

Example: source-level obfuscation against manual RE (3/3)

- In the sample code that was obfuscated, the following can be observed
- User defined variables:
  - foo replaced with z001c775808
  - arg1 replaced with z3833986e2c
  - myvar1 replaced with z0d8bd8ba25
  - intvar replaced with z0ed9bcbcc2
- Integers:
  - 20 replaced with (0x90b+785-0xc04)
  - 3600 replaced with (0x1136+6437-0x1c4b)
- Print strings:
  - "vars are" replaced with \x76\x61\x72\x73\x20\x61\x72\x65\x3a
  - Space replaced with \x20

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Data re-encoding

Replace variables by complex expressions, e.g.,

```
int a = arg1;
int b = arg2;
int x = a*b;
printf("x=%i\n",x);
```

replaced by

```
a = 1789355803 * arg1 + 1391591831;
b = 1789355803 * arg2 + 1391591831;
x = ((3537017619 * (a * b) - 3670706997 * a) -
                        3670706997 * b) + 3171898074;
printf("x=%i\n", -757949677 * x - 3670706997);
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Replace standart arithmetic operations by more complex ones,e.g.,

$$z = x + y + w$$

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⇒ obfuscate the data operations performed in the code

Data split, fold or merge

- Split some variables of type T_1 into sets of variables of type T_2, e.g.:

  ```
  int a
  ```

  split into

  ```
  struct {char a1; char a2; char a3 ; char a4} a
  ```

- Merge some variables of type T_1, T_2 into a variables of type T, e.g.:

  ```
  int a ; char b
  ```

  merged into

  ```
  long ab
  ```

- Fold or Flatten arrays into higer/lower dimensionnal arrays

- Convert static data into `procedural` data (“table look-up”, see next slide)

→ needs **alias computations** and **encoding/decoding** functions

Converting Static Data to Procedural Data

```
main() {
   String S1,S2,S3,S4;
   S1 = "AAA";
   S2 = "BAAA";
   S3 = "CCB";
   S4 = "CCB";
}
```

$\Downarrow \mathcal{T}$

```
main() {
   String S1,S2,S3,S4,S5;
   S1 = G(1);
   S2 = G(2);
   S3 = G(3);
   S4 = G(5);
   if (P^F) S5 = G(9);
}
```

$\overset{\mathcal{T}}{\Rightarrow}$

```
static String G (int n) {
   int i=0;
   int k;
   char[] S = new char[20];
   while (true) {
      L1:  if (n==1) {S[i++]='A'; k=0; goto L6};
      L2:  if (n==2) {S[i++]='B'; k=-2; goto L6};
      L3:  if (n==3) {S[i++]='C'; goto L9};
      L4:  if (n==4) {S[i++]='X'; goto L9};
      L5:  if (n==5) {S[i++]='C'; goto L11};
           if (n>12) goto L1;
      L6:  if (k++<=2) {S[i++]='A'; goto L6}
           else goto L8;
      L8:  return String.valueOf(S);
      L9:  S[i++]='C'; goto L10;
      L10: S[i++]='B'; goto L8;
      L11: S[i++]='C'; goto L12;
      L12: goto L10;
   }
}
```

Outline

Opaque predicates

Tramsform the control-flow graph (CFG) by inserting spurious conditions (evaluating always to **true**)
The condition is given as complex predicate, those value is hard to predict at compile-time, i.e.:

- not removed by the optimizer
- not detected by static code analyser

[1] `http://tigress.cs.arizona.edu/transformPage/docs/addOpaque/index.html`

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Some applications[1]

- if expr=false then
  call to random existing function
- if expr=false then
  call to non-existing function
- if expr=true then
  existing statement
  else
  buggified version of the statement

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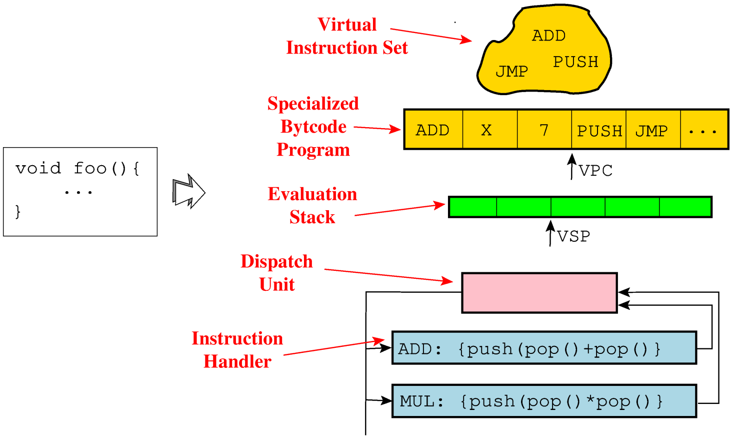
Virtualization

Turns a function into a interpreter by:

- generating a dedicated (bytecode) instruction set
- a bytecode array, a virtual program counter (VPC) and a virtual stack pointer (VSP)
- a dispatch unit, and the bytecode instruction handlers



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Anti-Disassembling

Code Obfuscation in Disassembly Phase

- Thwarting disassembly
- Junk Insertion
- Thwarting Linear Sweep
- Thwarting Recursive Traversal
  - Branch functions
  - Call conversion
  - Opaque predicates
  - Jump Table Spoofing

Anti-Dynamic analysis

Prevent a program to be analyzed under a debugger, an emulator, a virtual machine . . .

- use process control primitives to prevent debugging
  e.g., `ptrace` on Linux,
- try to access regular peripherals (network, printer, filesystem, etc.)
- monitor the execution time
- etc.

Rk: (highly) used by malwares . . . !

Conclusion

Many other transformations proposed so far . . .

Expected properties of an obfuscator

- correctness: should preserve the code semantics
- resilience: should prevent (basic/advanced ?) reverse-engineering
- cost: should not "explode" the code complexity (time, memory, etc.)

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However . . .

- no chance to build an universal obfuscator
  (i.e., able to obfuscate **any** input program)
- de-obfuscation tools are guided by existing obfuscation techniques . . .
  (keep your obfusactor **secret** !)

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Credits

- `https://fr.slideshare.net/bijondesai/code-obfuscation`
- `https://fr.slideshare.net/amolkamble16121/code-obfuscation-40283580`
- Christian Collberg web page: `http://tigress.cs.arizona.edu/index.html`