Industrial Approach: Obfuscating Transformations

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Commercial Obfuscators:

- Semantic Designs: Thicket^{tm} obfuscators
  `http://www.semanticdesigns.com/Products/Obfuscators/`
- Zelix Klassmaster^{tm} obfuscator
  `http://www.zelix.com/klassmaster/`
- PreEmptive: DotObfuscator^{tm}
  `http://www.preemptive.com/products/dotfuscator/`
- Only for Java: at least 26 obfuscators
  `http://dmoz.org/Computers/Programming/Languages/Java/`
  `Development_Tools/Obfuscators/`

Outline

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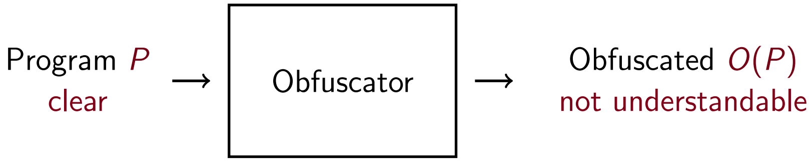
Objectives of Obfuscator



Objectives:

- Make automated analysis difficult

Objectives of Obfuscator

$$\begin{array}{c} \text{Program } P \\ \text{clear} \end{array} \longrightarrow \boxed{\text{Obfuscator}} \longrightarrow \begin{array}{c} \text{Obfuscated } O(P) \\ \text{not understandable} \end{array}$$

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- Make code not readable by human

Anatomy of Obfuscator (1)

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3. Repeats **step 2** until task completed or constraints exceeded

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    - Update internal representation

Quality of Obfuscation

How good is obfuscation? Measures:

- Potency
  $\frac{\text{Complexity}(\mathcal{O}(P))}{\text{Complexity}(P)}$
- Resilience (irreversibility)
  Weak, strong, one-way
- Cost
  Slowdown, increasing of code size and space requirements
- Stealth
  How similar are introduced obfuscated constructions to the rest of the code

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  Level of inheritance, coupling, number of methods triggered by another method, non-cohesiveness

Statistical Metrics

Measuring chaos:

- Distribution of opcodes (and any elements of program)
    - Rare elements contain iformation. Replace them by basic instructions
- Clustering (usage of variables, control flow commands)
    - Best of all: no clastering, uniform distribution
- Code patterns
    - Destroy long repeating patterns in program

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- Cost by not using efficiency enhancing mechanisms

  Caching is rarely possible; losing module structure

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Top Three Methods

- Renaming
  variables/procedures/classes/methods
- Deleting comments and spaces
  (destroying layout)
- Inserting dead code

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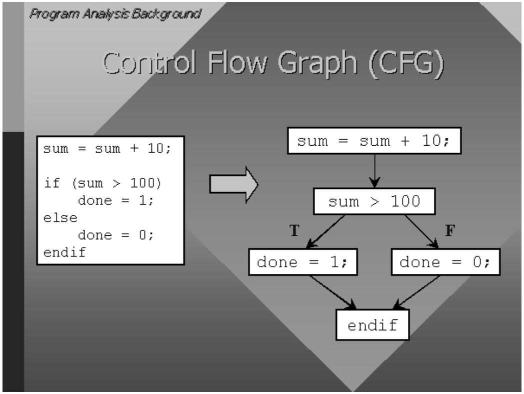
- Merge scalar variables

Control Flow (1)



Program Analysis Background

Control Flow Graph (CFG)

```
sum = sum + 10;

if (sum > 100)
     done = 1;
else
     done = 0;
endif
```

$$\begin{tikzcd}
 & \boxed{\texttt{sum = sum + 10;}} \arrow[d] & \\
 & \boxed{\texttt{sum > 100}} \arrow[dl, "T"'] \arrow[dr, "F"] & \\
\boxed{\texttt{done = 1;}} \arrow[dr] & & \boxed{\texttt{done = 0;}} \arrow[dl] \\
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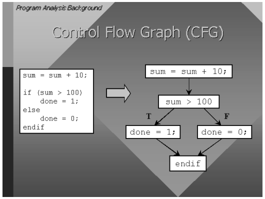
Control Flow (2)



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Compiler theory: program = control flow graph (CFG)

- Node = basic block = straight-line piece of code without any jumps or jump targets
- Directed edges = jumps in the control flow
- Every block: starts from jump target, ends by jump command

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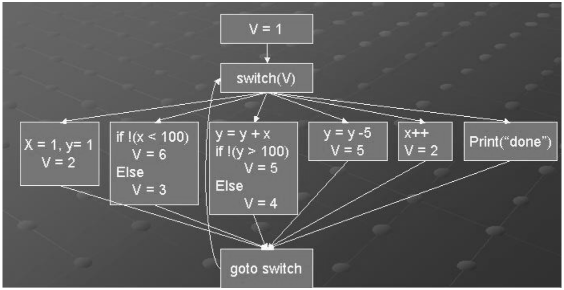
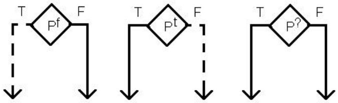
How to Destroy a Control Flow Graph?



1. Write down a list of all basic blocks
2. Split and merge some of them
3. Enumerate them
4. Replace all calls by indirect pointing
5. Write a single dispatcher to maintain all control flow

Opaque Predicates

How can we use IF operator for obfuscation?



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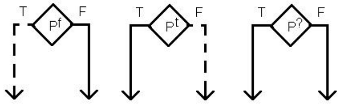

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Examples:

$$\boxed{((q+q^2)\ mod\ 2)\ =\ 0}$$

$$\boxed{((q^4)\ mod\ 16)\ =\ 0 \text{ OR } ((q^4)\ mod\ 16)\ =\ 1}$$

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Solution: unify signatures (in groups)

Even more transformations

Question: Can you invent more?

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- Reuse identifiers
- Introduce misleading comments :-)
- Modify inheritance relations
- Convert static data to procedural data
- Store part of the program as a text and interpret it only during runtime
- Remove library calls
- Protection aginst specific decompiling tools

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Disadvantages:

- ✘ No guaranteed security
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- ✘ Weak against dynamic attacks

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Main points:

- Obfuscator workflow: parse the program; apply transformations until the cost is exceeded

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- Obfuscator workflow: parse the program; apply transformations until the cost is exceeded
- Obfuscating transformations consist of layout, data and control tricks
- Hardness of deobfuscation is not proved

Course Conclusion

Why programming people like code obfuscation so much?

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Programming: CONSTRUCTIVE process

Obfuscation: DESTRUCTIVE process

Reading List

- C. Collberg, C. Thomborson, D. Low
  A taxonomy of obfuscating transformations, 1997.
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- M. Mambo, T. Murayama, E. Okamoto
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  Obfuscation of executable code to improve resistance to static disassembly, 2003.
  http://www.cs.arizona.edu/~linnc/research/CCS2003.pdf.

Thanks for attention. Questions?

Course Feedback

1. Comments/suggestions on contents:
   - Choice of topics? Ratio of theoretical/practical?
2. Comments/suggestions on presentation aspects:
   - Your opinion on slides? Black board explanation? Language mistakes?
3. Comments/suggestions on technical aspects:
   - Timetable of the course? Webpage? Room? Announcement?
4. Main advantage of the course (if any)?
   - Best lecture in your opinion?
5. Disatvantages. What and how can be improved?