Different Concepts for Program Obfuscation

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Outline

Applications for Obfuscation

Today: only short overview of applications

In details: Lecture 4 - “Applications for Obfuscation”

Classical Cryptography

What applications in cryptography can we imagine?

- ⇨ Private key cryptosystem → Public key cryptosystem
  It was mentioned even in famous Diffie-Hellman paper.
- ⇨ Homomorphic encoding
- ⇨ Random oracles removing

Software Protection

Situation: we distribute (sell) software products.

Question: Threats and applications you see?

- Competitors threat (reusing your code)
- Intelligent tampering (changing parameters)
- Threat of functionality changes (protection demo-versions)
- Watermarks protection

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Classical Cryptography
Software Protection
Mobile Agents Technology
Other
Main Approaches
Obfuscating Transformations
Blackbox Security
Mobile Cryptography
Aspects of Model
Program Representation
Attacks and Environment
Summary

Mobile Agents Technology

Situation: we distribute programs for our needs.

Question: Threats and applications you see?

- Privacy: e.g. internet-distributed computation
- Keys protection: buying agents.
- Intelligent tampering

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Other applications

Question: More applications?

Yes!

- Virus development
- Watermark attacks

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An Obfuscator

In details: Lecture 2 - “Obfuscating transformations”

- Functionality preserving
- Increase of code size, time & space requirements are restricted (usually by constant factor)
- Obfuscated program is not readable (not understandable)

Classification of obfuscating transformations

What can we obfuscate in the program?

- Layout transformations
  Change formatting information
- Control flow transformations
  Alter control program and computation
- Aggregation transformation
  Refactor program using aggregation methods
- Data transformations
  Use information encoding

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Quality of Obfuscation

How good our obfuscation is?

Strength can be measured by:

- Potency
  $\frac{E(P')}{E(P)} - 1$
- Resilience
  Trivial, weak, strong, full, one-way
- Cost
  Free, cheap, costly, expensive
- Stealthy

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Ideal case

What do we want to get?

Very limited information:

- input-output behavior
- running time

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Ana and BAna

We are interested in 2 types of polynomial-time analyzers:

- Ana is a source-code analyzer that can read the program.
  $$Ana(P)$$
- BAna is a black-box analyzer that only queries the program as an oracle.
  $$BAna^P(time(P))$$

Black-Box security

Ana can't get more information than BAna could

Property Hiding

How to formalize property hiding?

Instance: two families of programs Π_1 and Π_2 Adversary task: given a program $P \in \Pi_1 \cup \Pi_2$ to decide whether $P \in \Pi_1$ or $P \in \Pi_2$.

Desirable protection: make adversary task as difficult as well-known computationally hard problem is.

Constant Hiding

How to formalize constant hiding?

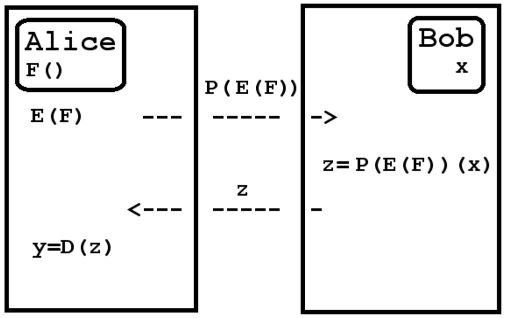
Instance: family of programs $\Pi = \{P \mid P \text{ computes } f(s,x);\ s \in S\}$ Adversary task: given a program $P \in \Pi$ to compute parameter s.

Desirable protection: make adversary task as difficult as well-known computationally hard problem is.

Encrypted Computation

More details: Lecture 5 - “Basic Complexity Results”

What is encrypted computation?



Basic task: keep F unknown to Bob.

Extendings of Encrypted Computation

Additional tasks of encrypted computation model:

- Move difficult computations to Bob
  D is easier than F
- Reduce communication complexity
  In the case $\mathit{sizeof}((F(x)) \ll \mathit{sizeof}(x)$. Example: x is database
- Keep x secret from Alice

Currently studied representations

Obfuscating techniques development depends on used program representation

So what sort of programs are we going to protect?

- Turing Machines / Circuits (function computing)
- C++/Java code
- Assembler code
- Rational function / Matrix representation

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Search for other representations

Is it enough?

Not! New models should contain:

- Current state of the program.
- Self-modifiable code
- Notion of computation trace.
- Other formalizations for functionality preserving.

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Adversary

What should we specify about adversary?

- Adversary knowledge about protected program
  - Member of family
  - Known function – unknown parameters (data) and state.
- Adversary task (attack)
  - Classification follows in Lecture 4.

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Potential for Obfuscation

Is it possible to protect every program?

- How to measure potential of obfuscation?
  - Learnability: black-box learnable functions are impossible to obfuscate.
- What couldn't be protected?
  - Input-Outbut behaviour
  - Traces

Network model

What are interesting network extentions of the model?

- Many programs cooperate
- Programs are migrating
- Programs can be recharged
- Different sources for inputs (outside connections)

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Summary

- Rough idea of applications: cryptosystem design, mobile agents technology, software protection.
- Basic approaches: obfuscating transformations, black-box security, encrypted computation.
- Further aspects of the model: program representation, state protection, adversary description, functionality preserving.

Question Time!

Not covered by the talk

Gray & white security
Approximate obfuscators
Operations on obfuscated code
Adversary success
Nondeterministic nature
Modifying algorithm vs. modifying code
Complexity of deobfuscation: NP, NP-hard, undecidable, one-way...
Obfuscation on specification level
Wroblewsky model

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Back Up Slides
Not covered by the talk
References

For Further Reading

Yury Lifshits
Program Obfuscation. A Survey [in Russian]
http://logic.pdmi.ras.ru/~yura/of/survey1.pdf

Luis F.G. Sarmenta
Protecting Programs from Hostile Environments
http://bayanihancomputing.net/papers/ae/ae.ps