Automatically Generating Information-Flow Control Mechanisms: A First Step

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Abstract

Designing sound information-flow control mechanisms can be a challenging and error-prone task, particularly when dealing with complex programming languages. To make this task easier, we have developped a tool called Ott-IFC that can automatically generate information-flow control mechanisms from programming language specifications (i.e., syntax and semantics).

1 Introduction

Information-flow control mechanisms are...

Language-based security [1] is an active field of research in which techniques from programming languages, such as program analysis, monitoring, rewriting and type checking, are used to enforce security policies. One of the most studied security policy is called *non-interference*. It essentially states that private information may not interfere with the publicly observable behavior of a program. For example, Listings 1 and 2 both violate non-interference because someone observing the contents of `public` could learn something about `private`.

```
public := private
```

Listing 1. Insecure explicit flow

```
if (private > 0) then
  public := 0
else
  public := 1
end
```

Listing 2. Insecure implicit flow

Mechanisms that enforce non-interference are called *information-flow control mechanisms*, as they track and control where information may flow during the execution of a program.

In order to help language-based security researchers develop sound

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2 Approach and Uniqueness

We chose to use Ott [2] as our input language. Ott is a programming language specification tool which

```
arith_expr, a :: ae_ ::=
  | x
  | n
  | a1 + a2
  | a1 * a2

bool_expr, b :: be_ ::=
  | true
  | false
  | a1 < a2

commands, c :: cmd_ ::=
  | skip
  | x := a
  | c1 ; c2
  | if b then c1 else c2 end
  | while b do c end
```

Listing 3. Syntax of a simple imperative language

```
%%% Assignment %%%
<a, s> || <n, s>
--------------------------------
<x := a, s> || <skip, s[x |-> n]>
```

```
%%% If %%%
<b, s> || <true, s>
<c1, s> || <skip, s'>

  ------------------------------------------

<if b then c1 else c2 end, s> || <skip, s
  '>

<b, s> || <false, s>
<c2, s> || <skip, s'>

  ------------------------------------------

<if b then c1 else c2 end, s> || <skip, s
  '>
```

3 Current Status and Future Work

We have implemented a prototype of our algorithm and validated that it works on two simple imperative languages: one defined using small-step semantics and the other using large-step semantics. We have also begun to draft a soundness proof, that is, a proof showing that the generated mechanisms enforce non-interference.

Before our tool can be of real use to most researchers, much work remains to be done.

Language Support Ott-IFC currently makes two assumptions about the language: (1) that the syntax be composed of expressions, which may only read the memory, and commands, which may read or write the memory; and (2) that the program configurations be of the form $\langle command, memory \rangle$. While these assumptions helped simplify the implementation, it also restricts the types of languages that can be used in Ott-IFC. For example, most functional languages would not be supported because in those languages functions can be expressions. We are currently in the process of building a repository of formalized languages so that we can test our approach on additional languages.

Parametrization For the moment, Ott-IFC only generates one type of information-flow control mechanism: a type system which enforces termination-insensitive non-interference. We plan on parametrizing our tool so that users can choose the type of mechanism to generate (e.g., type system, monitor) and choose some of its features (e.g., flow-sensitivity, termination-sensitivity, progress-sensitivity).

Generating Formal Proofs We expect that some users will use the mechanisms generated by Ott-IFC as a foundation to build better and more precise mechanisms. One of the most grueling task when building an information-flow control mechanism is to prove its soundness. In order to help those users, we plan on generating a skeleton of the proof in Coq or Isabelle/HOL (both languages are supported by Ott).

Verifying Existing Mechanisms The same rules that Ott-IFC uses to generate sound mechanisms could be used to verify the soundness of existing mechanisms and identify potential errors.

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