Program Analysis

Information Flow Analysis (Part 1)

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Outline

1. **Introduction**
2. **Information Flow Policy**
3. **Analyzing Information Flows**

Mostly based on these papers:

- *A Lattice Model of Secure Information Flow*, Denning, Comm ACM, 1976
- *Dytan: A Generic Dynamic Taint Analysis Framework*, Clause et al., ISSTA 2007

Secure Computing Systems

- **Overall goal: Secure the data manipulated by a computing system**
- **Enforce a security policy**
  - Confidentiality: Secret data does not leak to non-secret places
  - Integrity: High-integrity data is not influenced by low-integrity data

Information Flow

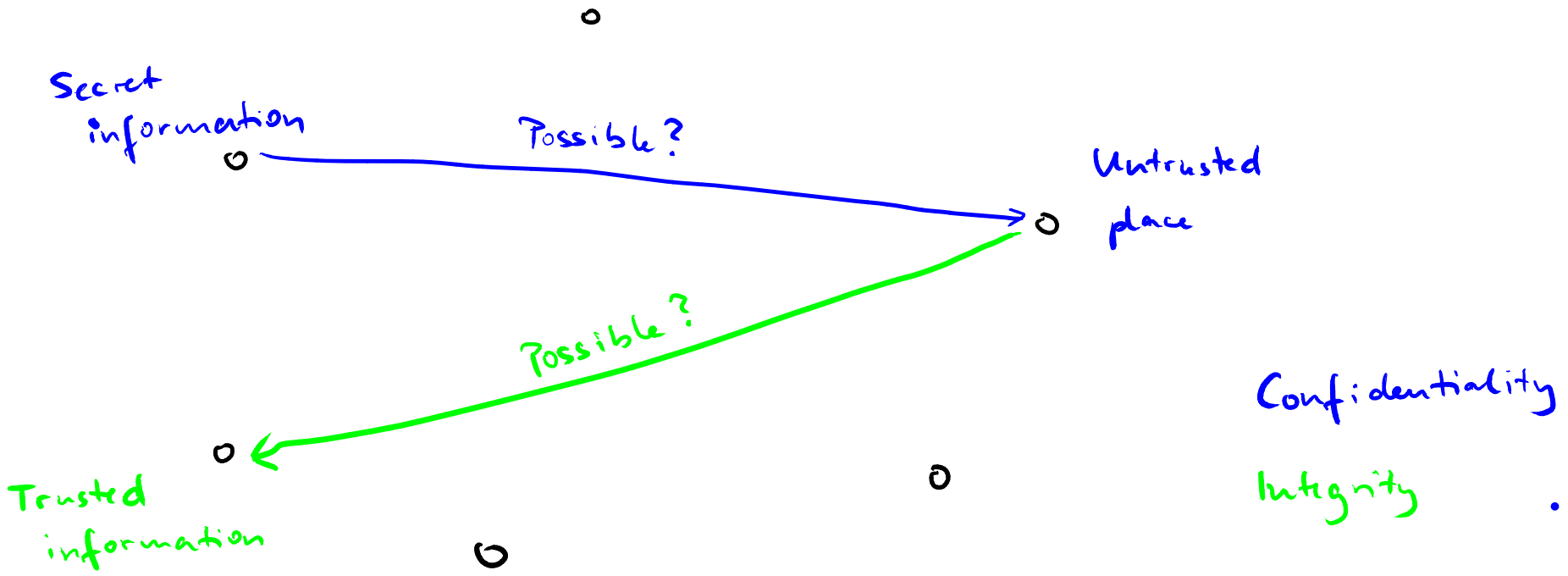
- **Goal of information flow analysis:**

  Check whether information from one ”place” propagates to another ”place”

  - For program analysis, ”place” means, e.g., code location or variable

- **Complements techniques that impose limits on releasing information**
  - Access control lists
  - Cryptography

o ... "Places" in program that hold data



Example: Confidentiality

Credit card number should not leak to `visible`

```
var creditCardNb = 1234;
var x = creditCardNb;
var visible = false;
if (x > 1000) {
  visible = true;
}
```

Example: Confidentiality

Credit card number should not leak to `visible`

```
var creditCardNb = 1234;
var x = creditCardNb;
var visible = false;
if (x > 1000) {
  visible = true;
}
```

Secret information propagates to `x`

Secret information (partly) propagates to `visible`

Example: Integrity

`userInput` should not influence who becomes president

```
var designatedPresident = "Michael";
var x = userInput();
var designatedPresident = x;
```

Example: Integrity

`userInput` should not influence who becomes president

```
var designatedPresident = "Michael";
var x = userInput();
var designatedPresident = x;
```

Low-integrity information propagates to high-integrity variable

Example: Integrity

`userInput` should not influence who becomes president

```
var designatedPresident = "Michael";
var x = userInput();
if (x.length === 5) {
  var designatedPresident = "Paul";
}
```

Example: Integrity

`userInput` should not influence who becomes president

```
var designatedPresident = "Michael";
var x = userInput();
if (x.length === 5) {
  var designatedPresident = "Paul";
}
```

Low-integrity information propagates to high-integrity variable

Confidentiality vs. Integrity

Confidentiality and integrity are dual problems for information flow analysis

(Focus of this lecture: Confidentiality)

Tracking Security Labels

How to analyze the flow of information?

- **Assign to each value some meta information that tracks the secrecy of the value**
- **Propagate meta information on program operations**

Example

secret

```
var creditCardNb = 1234;
var x = creditCardNb;
var visible = false;
if (x > 1000) {
  visible = true;
}
```

- - - .. contains a secret value

Non-Interference

Property that information flow analysis aims to ensure:

Confidential data does not interfere with public data

- Variation of confidential input does not cause a variation of public output
- Attacker cannot observe any difference between two executions that differ only in their confidential input