CIS 551 / TCOM 401

Computer and Network Security

Spring 2006

Lecture 6

Announcements

- Reminder:
  - Project 1 is due TODAY
  - Mail your .tar file to Karl by midnight tonight.

- Some of today's slides are adapted from slides by John Mitchell

Recap from last time

- We've been studying Acess Control Mechanisms
  - Access control lists
  - Capabilities
  - Unix/Windows OS access control
  - Stack inspection

- Today:
  - Discretionary access control (DAC)
  - Mandatory access control (MAC)
  - Information-flow security

Access Control

- *Discretionary*: The individual user may, at his own discretion, determine who is authorized to access the objects he creates.

- *Mandatory*: The creator of an object does not necessarily have the ability to determine who has authorized access to it.
  - Typically policy is governed by some central authority
  - The policy on an object in the system depends on what object/information was used to create the object.
  - Examples?

Multilevel Security

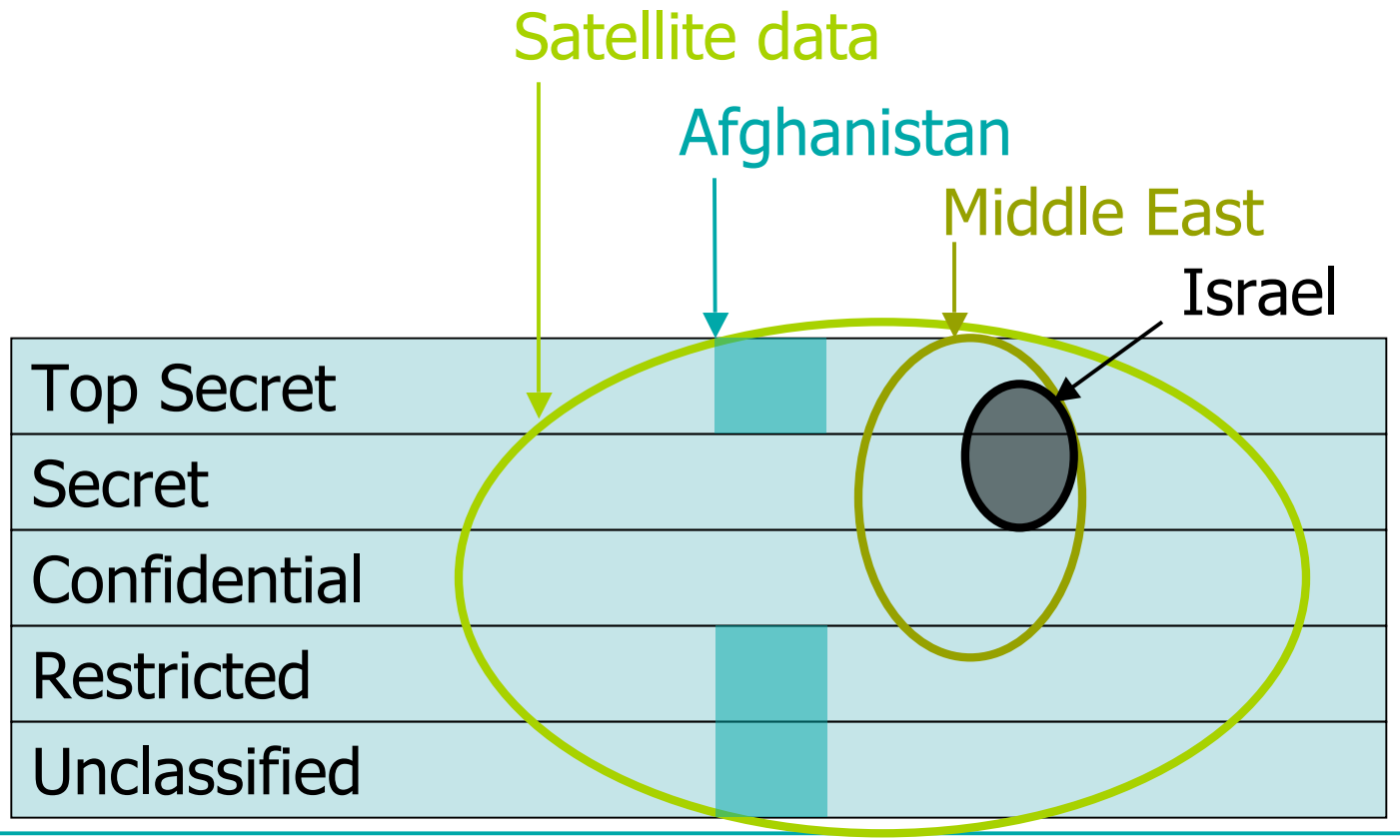
- Multiple levels of confidentiality ratings
- Military security policy
    - Classification involves sensitivity levels, compartments
    - Do not let classified information leak to unclassified files
- Group individuals and resources
  – Use some form of hierarchy to organize policy

- Trivial example: Public ≤ Secret

- *Information flow*
  – Regulate how information is used throughout entire system
  – A document generated from both Public and Secret information must be rated Secret.
  – Intuition: "Secret" information should not flow to "Public" locations.

Military security policy

- Sensitivity levels
- Compartments



Military security policy

- Classification of personnel and data
  - Class D = ⟨rank, compartment⟩
- Dominance relation
  - $D_1 \leq D_2$ iff $rank_1 \leq rank_2$ and $compartment_1 \subseteq compartment_2$
  - Example: ⟨Restricted, Israel⟩ ≤ ⟨Secret, Middle East⟩
- Applies to
  - Subjects – users or processes: C(S) = "clearance of S"
  - Objects – documents or resources: C(O) = "classification of O"

Bell-LaPadula Confidentiality Model

- "No read up, no write down."
  - Subjects are assigned clearance levels drawn from the lattice of security labels.

    C(S) = "clearance of the subject S"
  - A principal may read objects with lower (or equal) security label.
    - Read: $C(O) \leq C(S)$
  - A principal may write objects with higher (or equal) security label.
    - Write: $C(S) \leq C(O)$

- Example:
  A user with Secret clearance can:
  - Read objects with label Public and Secret
  - Write/create objects with label Secret

Multilevel Security Policies

- In general, security levels form a "join semi-lattice"
  - There is an ordering ≤ on security levels
  - For any pair of labels L1 and L2 there is an "join" operation:

    L1 ⊕ L2 is a label in the lattice such that:
    (1) L1 ≤ L1 ⊕ L2 and L2 ≤ L1 ⊕ L2 "upper bound"
    (2) If L1 ≤ L3 and L2 ≤ L3 then L1 ⊕ L2 ≤ L3 "least bound"

- For example: Public ⊕ Secret = Secret
- Labeling rules:
  - Classification is a function C : Object → Lattice
  - If some object O is "created from" objects $O_1,\ldots,O_n$ then $C(O) = C(O_1) \oplus \ldots \oplus C(O_n)$

Picture: Confidentiality

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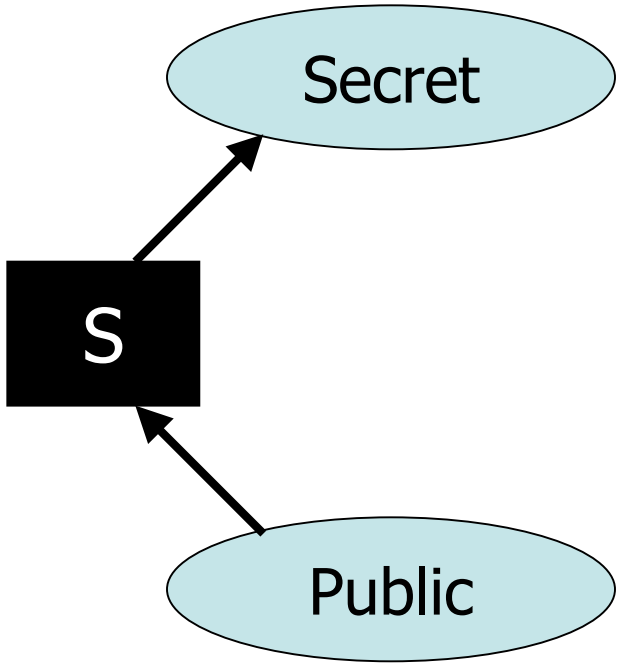

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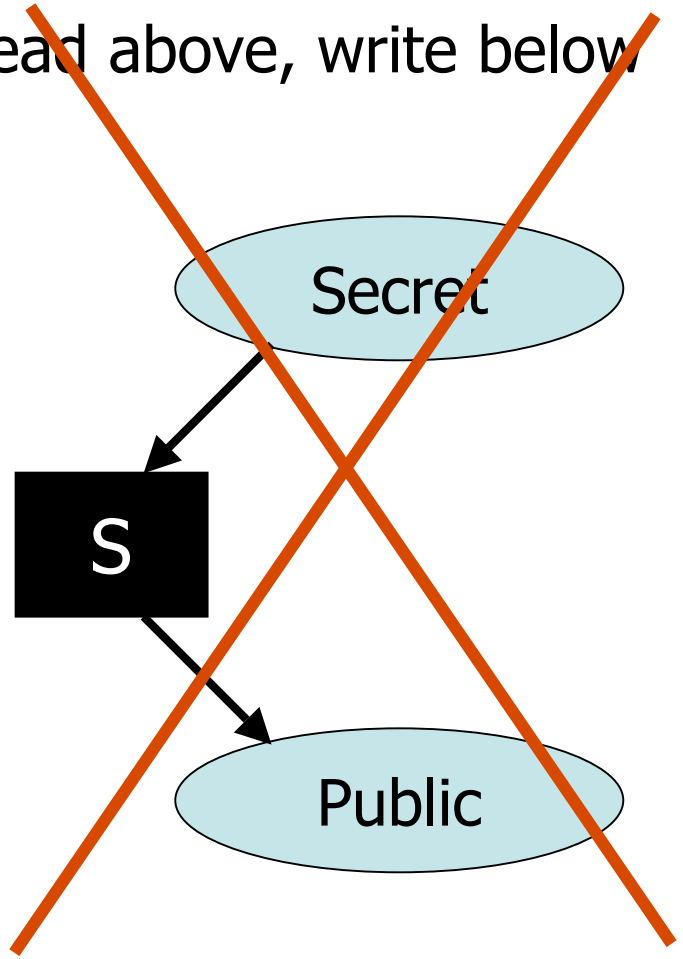

Picture: Integrity

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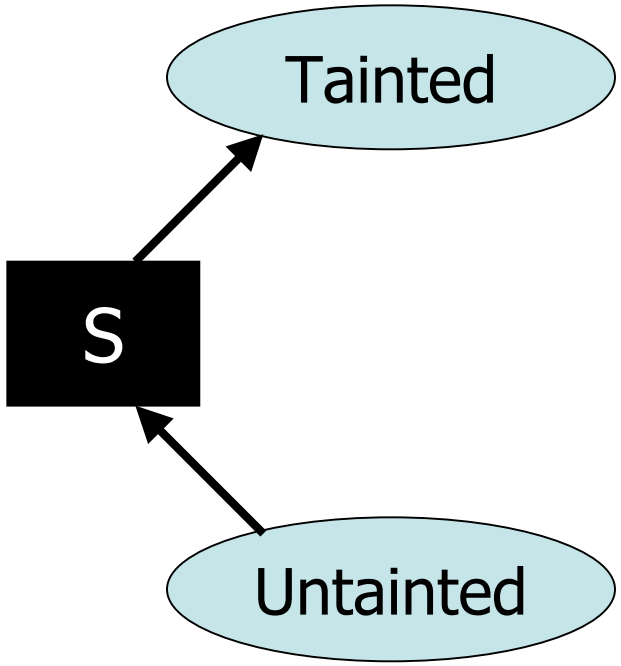

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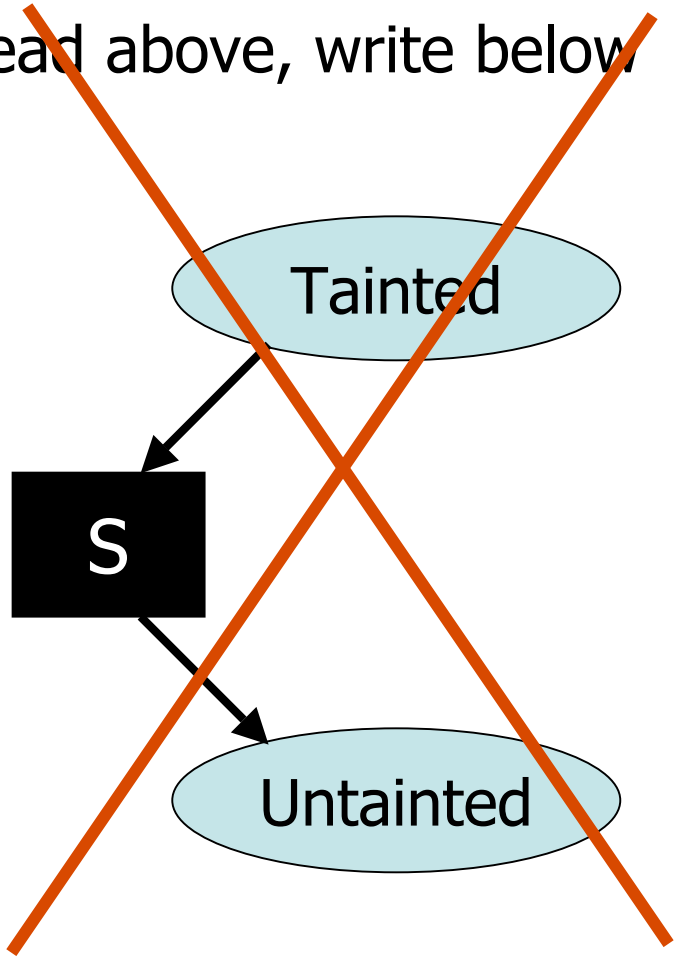

Problem with Stack Inspection

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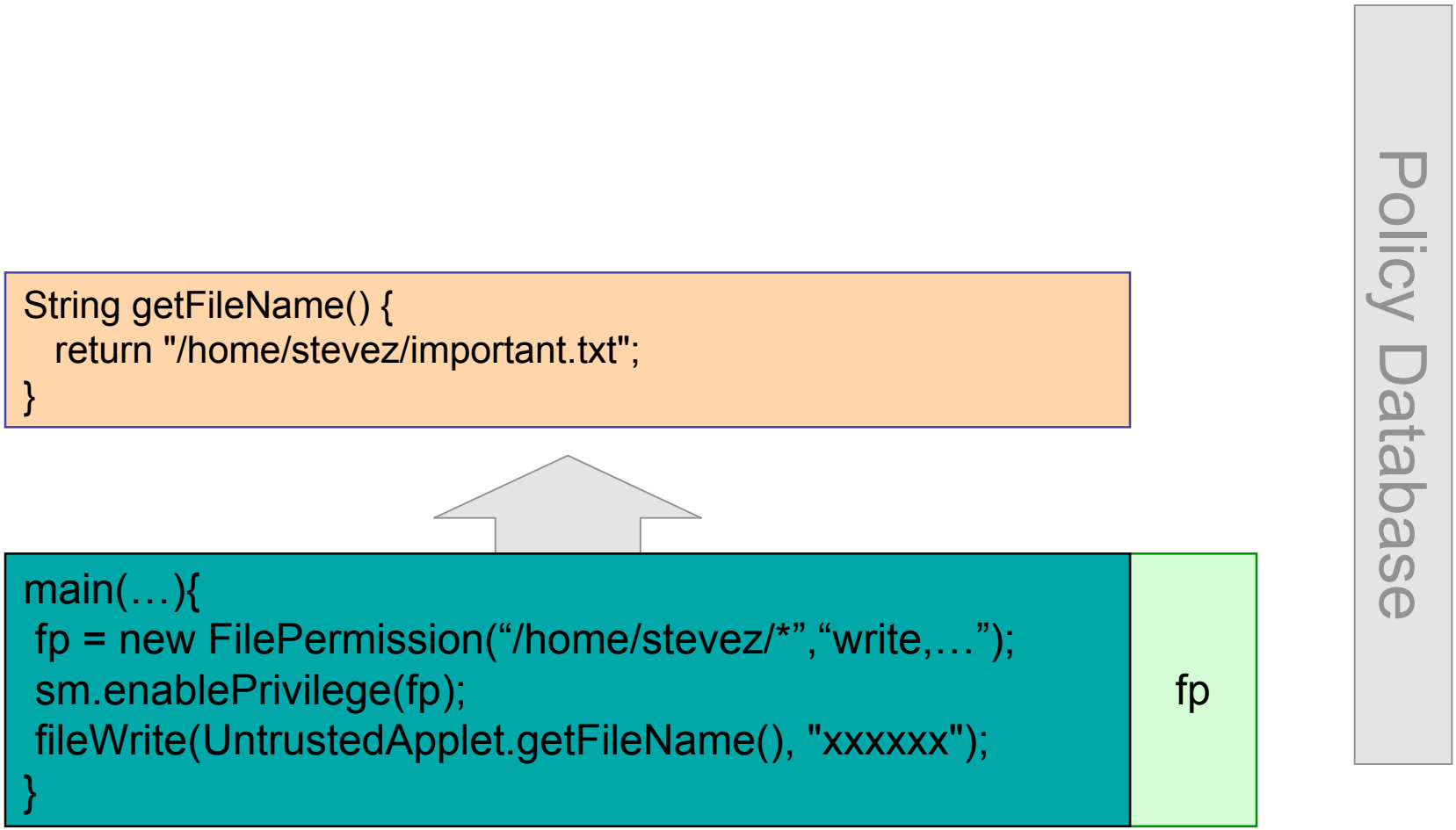

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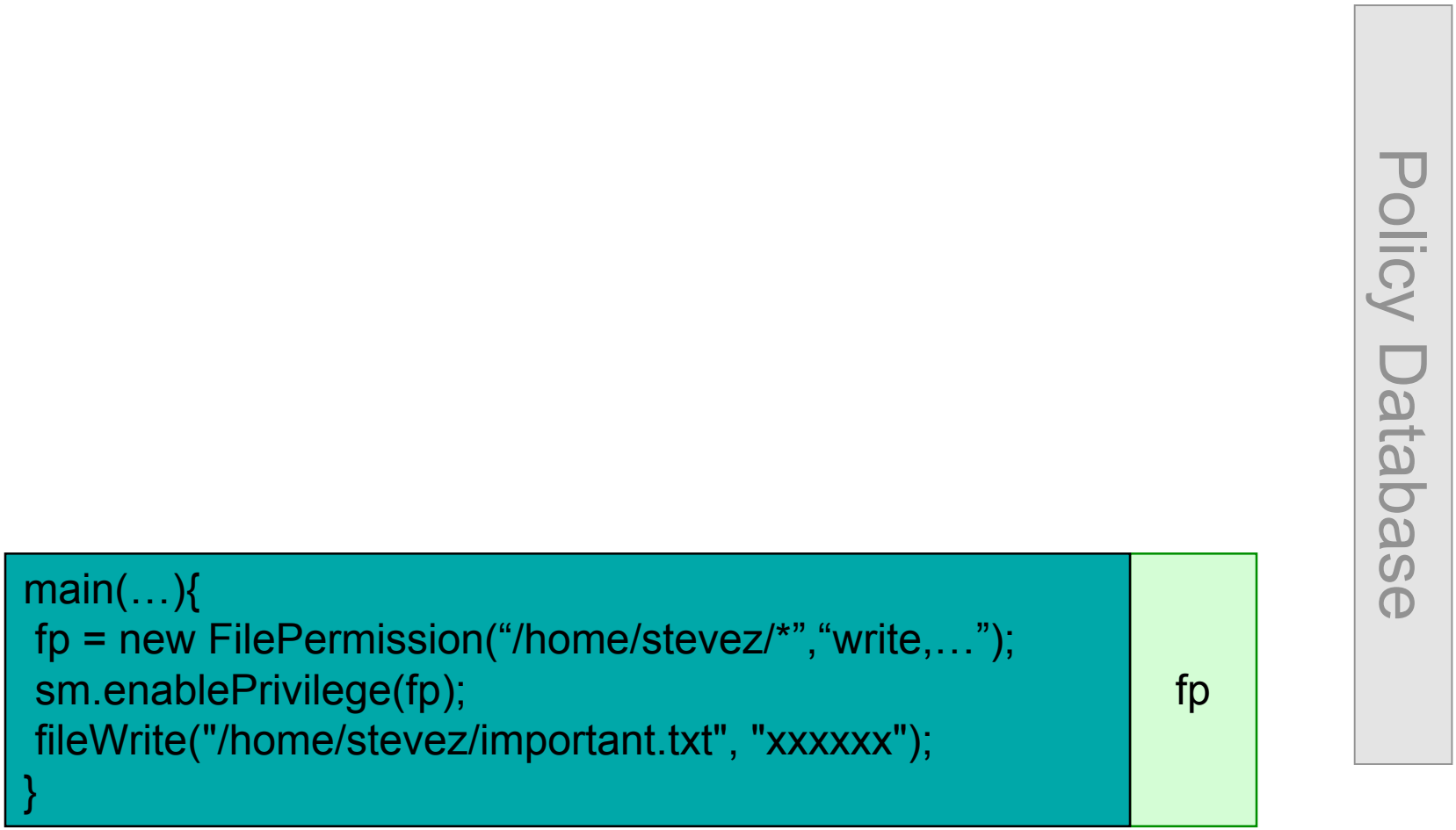

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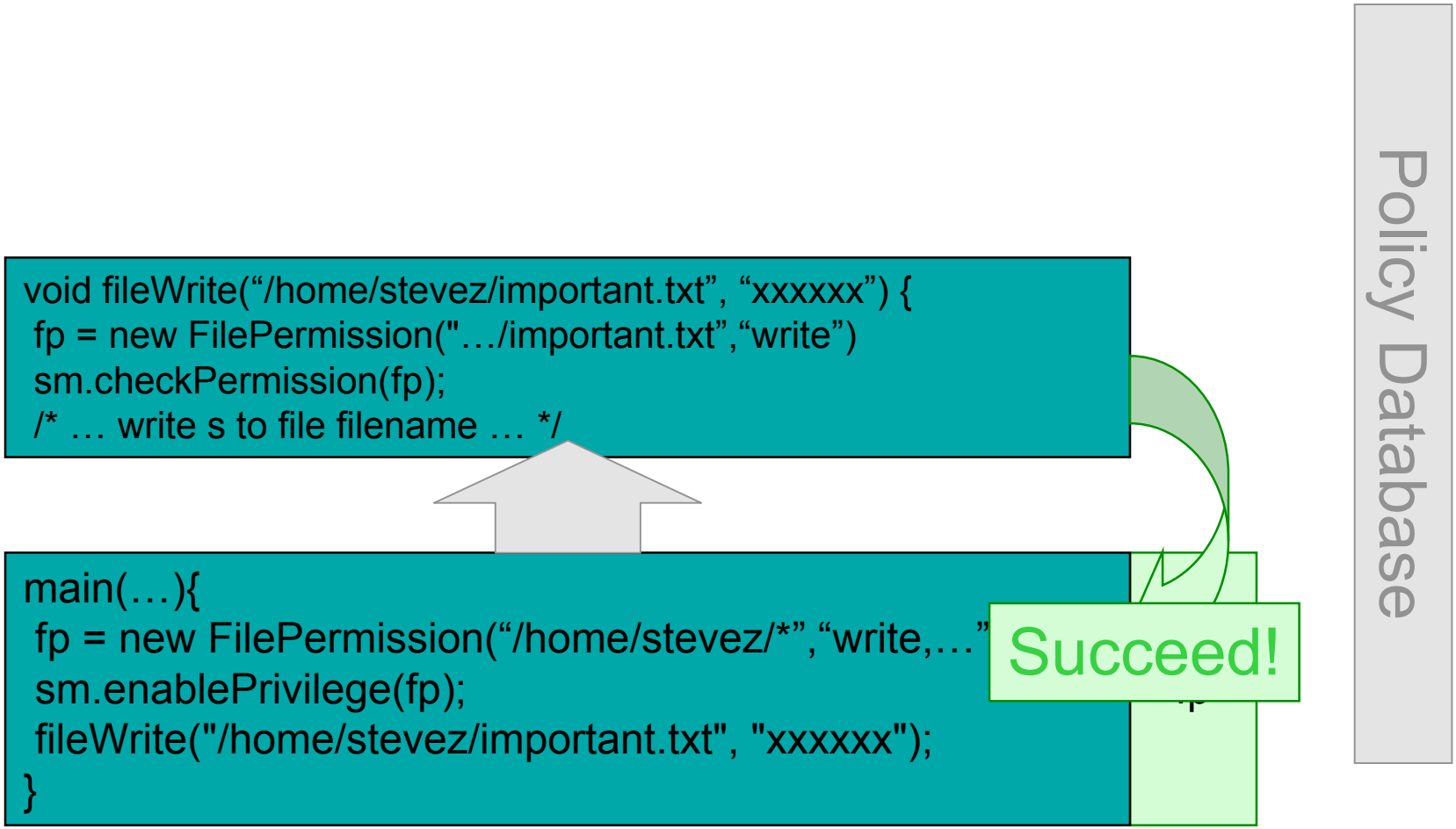

Implementing Multilevel Security

- Dynamic:
  - Tag all values in memory with their security level
  - Operations propagate security levels
  - Must be sure that tags can't be modified
  - Expensive, and approximate

- Classic result: Information-flow policies cannot be enforced purely by a reference monitor!
  - Problem arises from implicit flows

- Static:
  - Program analysis
  - May be more precise
  - May have less overhead

Information Flows through Software

Explicit Flows:

```
int{Secret} X = f();
int{Public} Y = 0;

Y = X;
```

Implicit Flows:

```
int{Secret} X = f();
int{Public} Y = 0;
int{Public} Z = 0;

if (X > 0) then {
  Y = 1;
} else {
  Z = 1;
}
```

Perl's Solution (for Integrity)

- The problem: need to track the source of data
- Examples: Format string, SQL injection, etc.

```
$arg = shift;
system ("echo $arg");
```

- Give this program the argument `"; rm *"`
- Perl offers a *taint checking* mode
  - Tracks the source of data (trusted vs. tainted)
  - Ensure that tainted data is not used in system calls
  - Tainted data can be converted to trusted data by pattern matching
  - Doesn't check implicit flows

SELinux

- Security-enhanced Linux system (NSA)
  - Enforce separation of information based on confidentiality and integrity requirements
  - Mandatory access control incorporated into the major subsystems of the kernel
    - Limit tampering and bypassing of application security mechanisms
    - Confine damage caused by malicious applications

http://www.nsa.gov/selinux/

SELinux Security Policy Abstractions

- Security-Encanced Linux
  - Built by NSA
- Type enforcement
  - Each process has an associated domain
  - Each object has an associated type (label)
  - Configuration files specify
    - How domains are allowed to access types
    - Allowable interactions and transitions between domains
- Role-based access control
  - Each process has an associated role
    - Separate system and user processes
  - configuration files specify
    - Set of domains that may be entered by each role

Two Other MAC Policies

- "Chinese Wall" policy: [Brewer & Nash '89]
  - Object labels are classified into "conflict classes"
  - If subject accesses one object with label L1 in a conflict class, all access to objects labeled with other labels in the conflict class are denied.
  - Policy changes dynamically

- "Separation of Duties":
  - Division of responsibilities among subjects
  - Example: Bank auditor cannot issue checks.