CIS 551 / TCOM 401

Computer and Network Security

Spring 2008
Lecture 7

Announcements

- Project 1 is due *this Friday* at 11:59
- Today: access control continued
  - Mandatory access control
  - Java / C# stack inspection model

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.

Covert Channels & Information Hiding

- A covert channel is a means by which two components of a system that are not permitted to communicate do so anyway by affecting a shared resource.

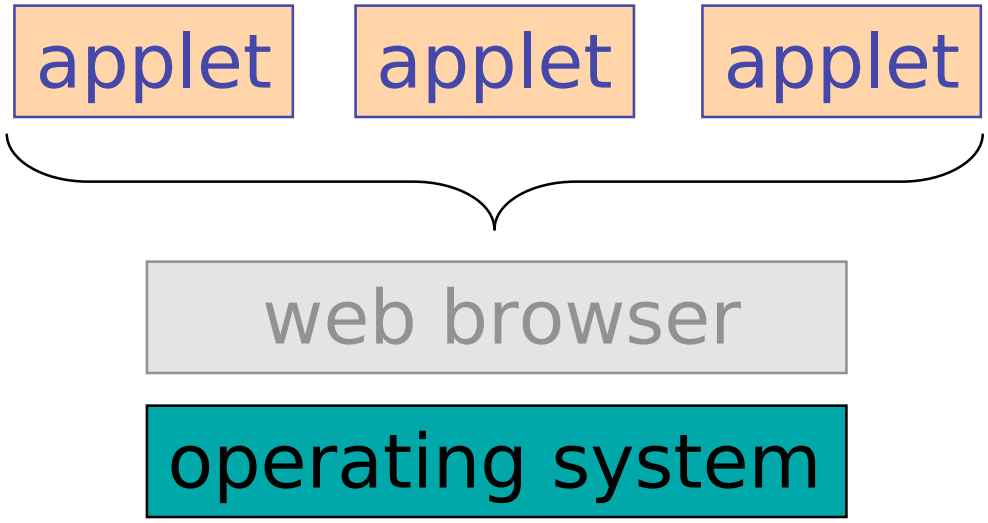
- Information hiding: Two components of the system that are permitted to communicate about one set of things, exchange information about disallowed topics by encoding contraband information in the legitimate traffic.

- Not that hard to leak a small amount of data
  - A 64 bit encryption key is not that hard to transmit
  - Even possible to encode relatively large amounts of data!

- Example channels / information hiding strategies
  - Program behavior
  - Adjust the formatting of output:
    use the “\t” character for “1” and 8 spaces for “0”
  - Vary timing behavior based on key
  - Use "low order" bits to send signals
  - Power consumption
  - Grabbing/releasing a lock on a shared resource

Mobile Code

- Modern languages like Java and C# have been designed for Internet applications and extensible systems



- PDAs, Cell Phones, Smart Cards, …

Java and C# Security

- Static Type Systems
  - Memory safety and jump safety
- Run-time checks for
  - Array index bounds
  - Downcasts
  - Access controls
- Virtual Machine / JIT compilation
  - Bytecode verification
  - Enforces encapsulation boundaries (e.g. private field)
- Garbage Collected
  - Eliminates memory management errors
- Library support
  - Cryptography, authentication, …

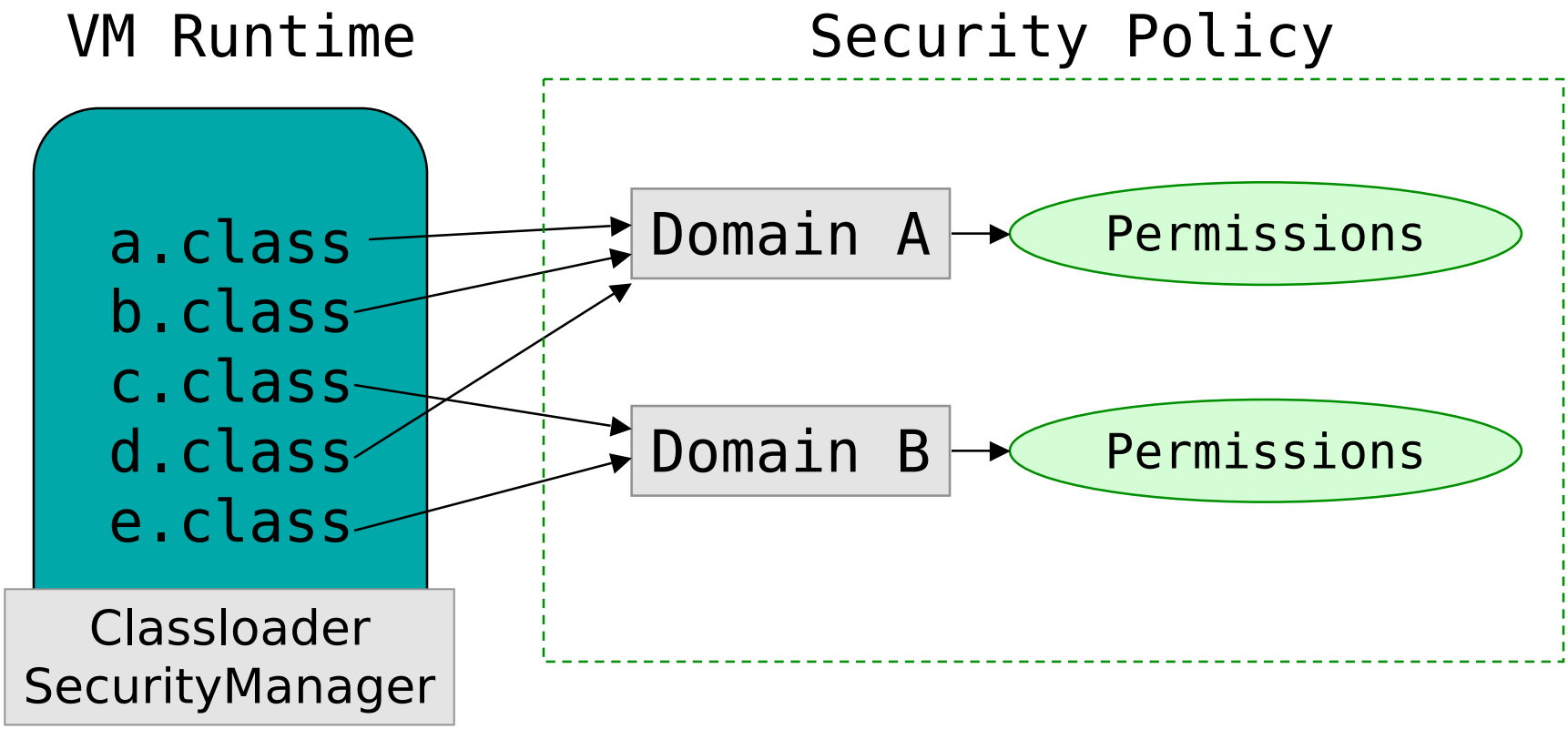
Applet Security Problems

- Protect OS & other valuable resources.
- Applets should not:
  - crash browser or OS
  - execute “rm –rf /”
  - be able to exhaust resources
- Applets should:
  - be able to access *some* system resources (e.g. to display a picture)
  - be isolated from each other
- Principles of least privileges and complete mediation apply

Access Control for Applets

- What level of granularity?
  - Applets can touch some parts of the file system but not others
  - Applets can make network connections to some locations but not others
- Different code has different levels of trustworthiness
  - www.l33t-hax0rs.com vs. www.java.sun.com
- Trusted code can call untrusted code
  - e.g. to ask an applet to repaint its window
- Untrusted code can call trusted code
  - e.g. the paint routine may load a font
- How is the access control policy specified?
- How is it enforced?

Java Security Model



Kinds of Permissions

- java.security.Permission Class

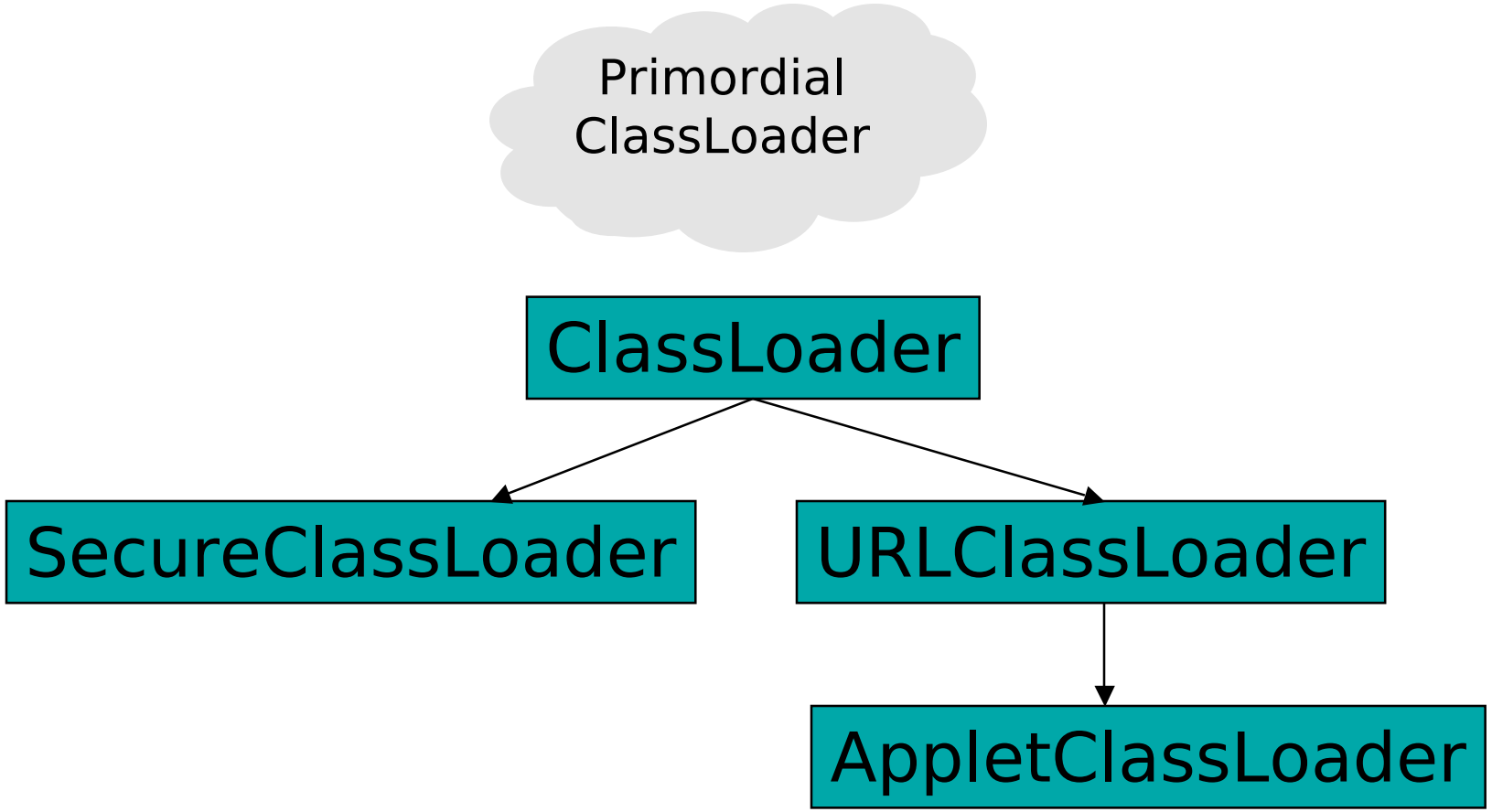
```
perm = new java.io.FilePermission("/tmp/abc","read");

java.security.AllPermission
java.security.SecurityPermission
java.security.UnresolvedPermission
java.awt.AWTPermission
java.io.FilePermission
java.io.SerializablePermission
java.lang.reflect.ReflectPermission
java.lang.RuntimePermission
java.net.NetPermission
java.net.SocketPermission
…
```

Code Trustworthiness

- How does one decide what protection domain the code is in?
  - Source (e.g. local or applet)
  - Digital signatures
    - C# calls this “evidence based”
- How does one decide what permissions a protection domain has?
  - Configurable – administrator file or command line
- Enforced by the classloader

Classloader Hierarchy



Classloader Resolution

- When loading the first class of an application, a new instance of the URLClassLoader is used.
- When loading the first class of an applet, a new instance of the AppletClassLoader is used.
- When java.lang.Class.ForName is directly called, the primordial class loader is used.
- If the request to load a class is triggered by a reference to it from an existing class, the class loader for the existing class is asked to load the class.

- Exceptions and special cases… (e.g. web browser may reuse applet loader)

Example Java Policy

```
grant codeBase “http://www.l33t-hax0rz.com/*” {
  permission java.io.FilePermission(“/tmp/*”, “read,write”);
}

grant codeBase “file://$JAVA_HOME/lib/ext/*” {
  permission java.security.AllPermission;
}

grant signedBy “trusted-company.com” {
  permission java.net.SocketPermission(…);
  permission java.io.FilePermission(“/tmp/*”, “read,write”);
  …
}
```

Policy information stored in:

`$JAVA_HOME/lib/security/java.policy`
`$USER_HOME/.java.policy`
(or passed on command line)

Example Trusted Code

Code in the System protection domain

```
void fileWrite(String filename, String s) {
  SecurityManager sm = System.getSecurityManager();
  if (sm != null) {
    FilePermission fp = new FilePermission(filename,“write”);
    sm.checkPermission(fp);
    /* … write s to file filename (native code) … */
  } else {
    throw new SecurityException();
  }
}
```

```
public static void main(…) {
  SecurityManager sm = System.getSecurityManager();
  FilePermission fp = new FilePermission(“/tmp/*”,“write,…”);
  sm.enablePrivilege(fp);
  UntrustedApplet.run();
}
```

Example Client

Applet code obtained from
http://www.l33t-hax0rz.com/

```
class UntrustedApplet {
  void run() {
    ...
    s.FileWrite(“/tmp/foo.txt”, “Hello!”);
    ...
    s.FileWrite(“/home/stevez/important.tex”, “kwijibo”);
    ...
  }
}
```

Stack Inspection

- Stack frames are annotated with their protection domains and any enabled privileges.

- During inspection, stack frames are searched from most to least recent:
  - fail if a frame belonging to someone not authorized for privilege is encountered
  - succeed if activated privilege is found in frame

Stack Inspection Example

```
main(…){
 fp = new FilePermission(“/tmp/*”,“write,…”);
 sm.enablePrivilege(fp);
 UntrustedApplet.run();
}
```

Policy Database

Stack Inspection Example

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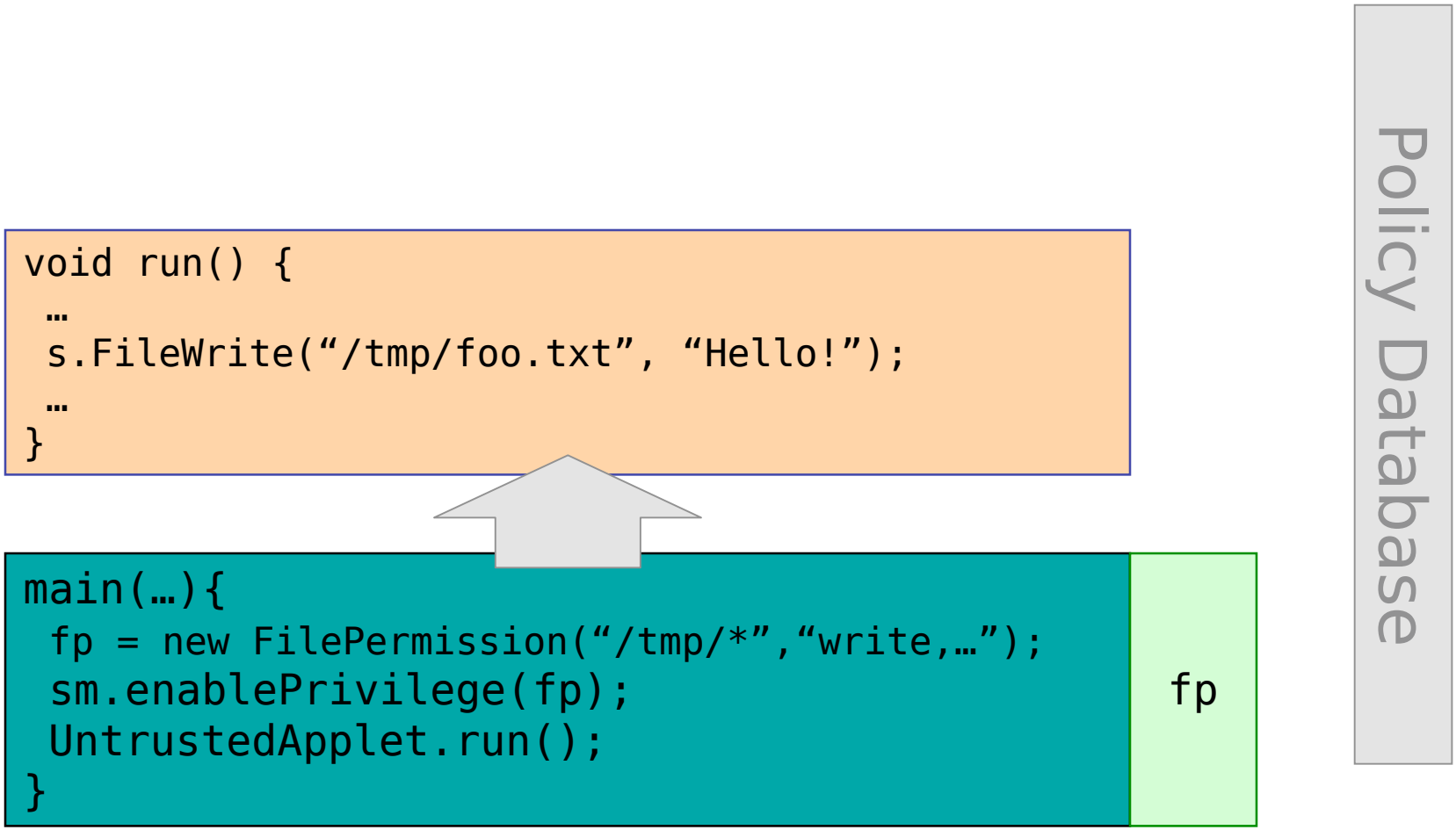

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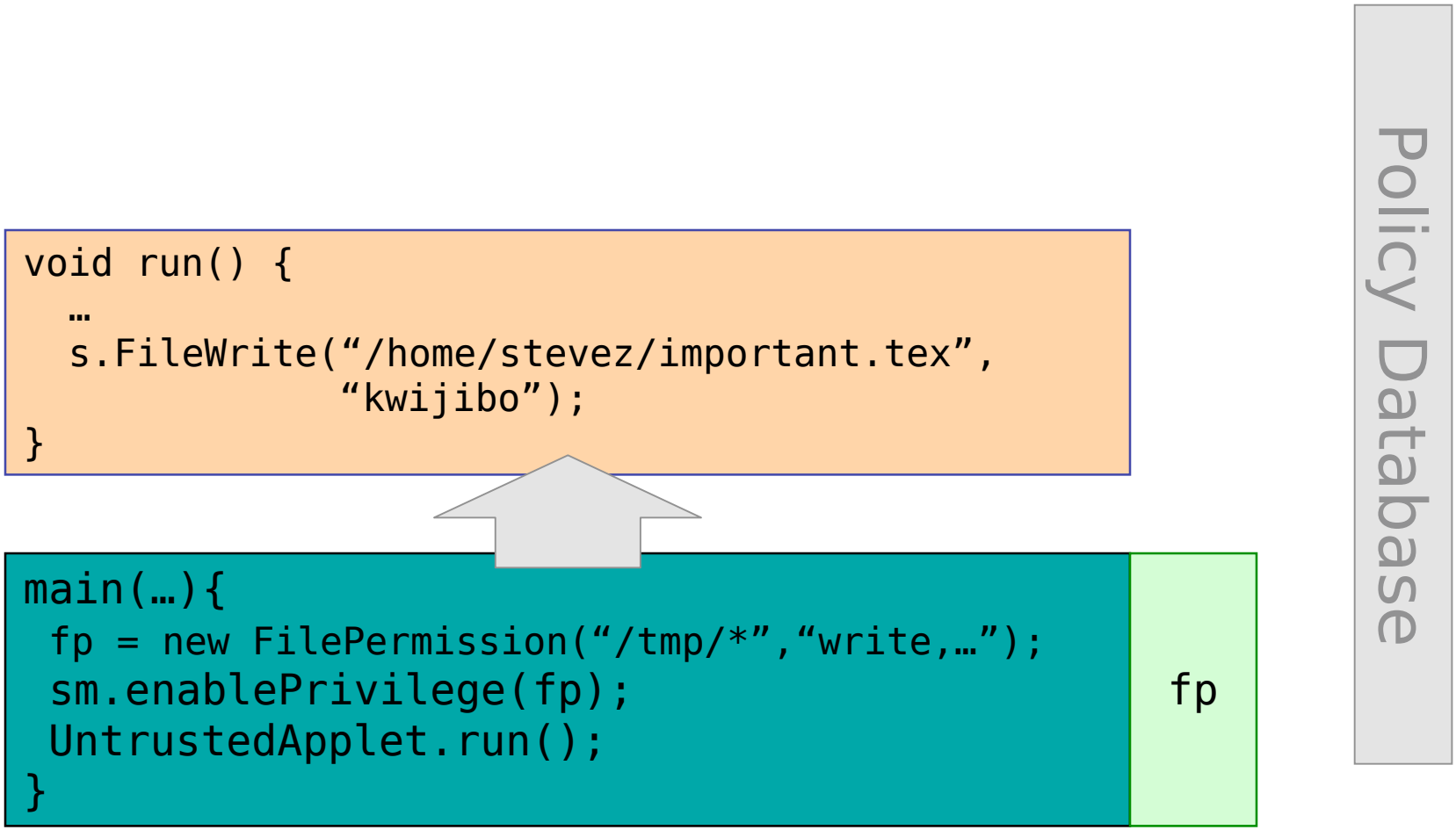
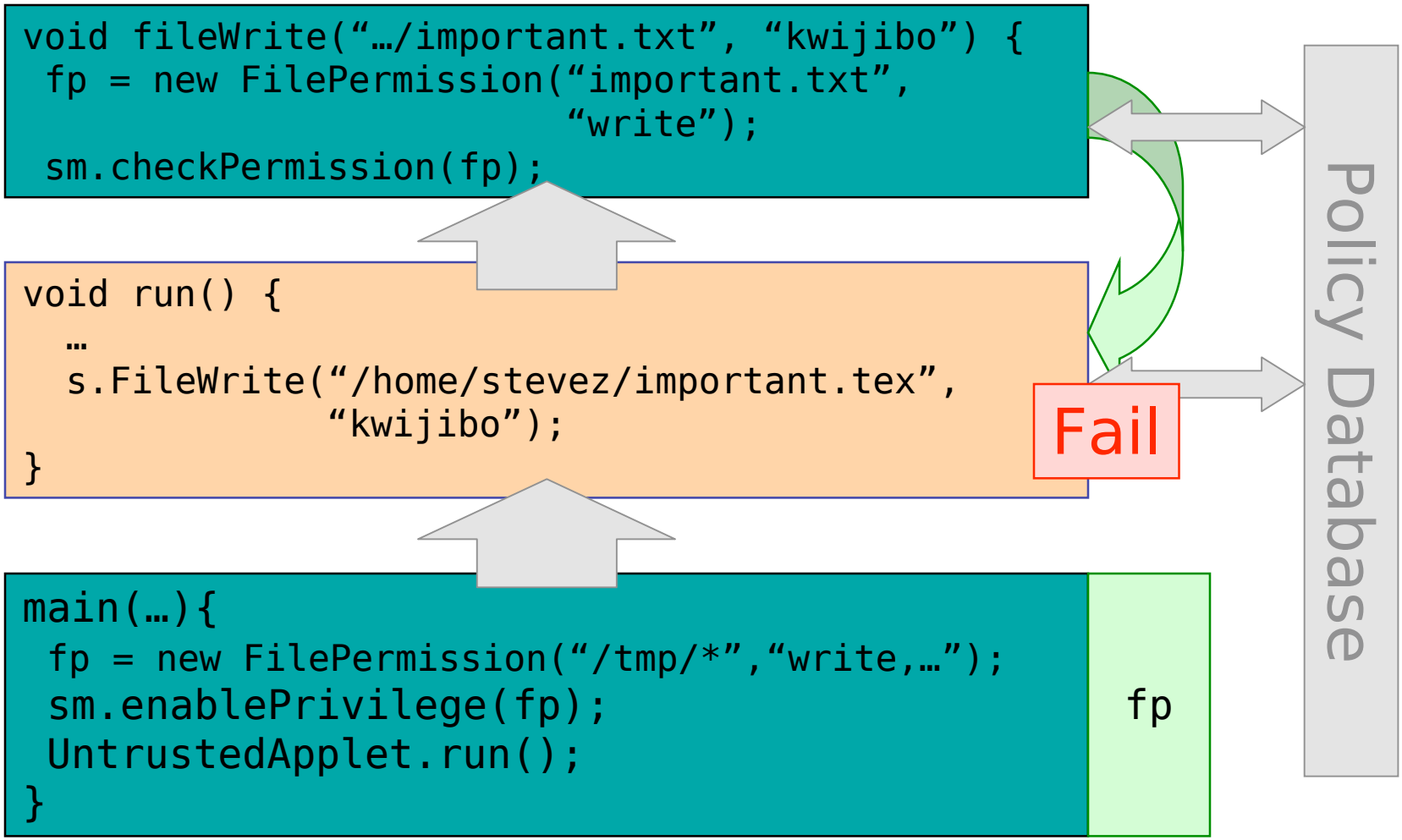


Stack Inspection Example



Other Possibilities

- The `fileWrite` method could enable the write permission itself
  - Potentially dangerous, should not base which file to write on data provided by the applet
  - … but no enforcement in Java (information flow would help here)

- A trusted piece of code could *disable* a previously granted permission
  - Terminate the stack inspection early

Stack Inspection Algorithm

```
checkPermission(T) {
  // loop newest to oldest stack frame
  foreach stackFrame {
    if (local policy forbids access to T by class executing in
        stack frame) throw ForbiddenException;

    if (stackFrame has enabled privilege for T)
      return;  // allow access

    if (stackFrame has disabled privilege for T)
      throw ForbiddenException;
  }

  // end of stack
  if (Thunderbird || ...) throw ForbiddenException;
  if (MS IE || JDK || ...) return;
}
```

Two Implementations

- On demand –
  - On a checkPermission invocation, actually crawl down the stack, checking on the way
  - Used in practice
- Eagerly –
  - Keep track of the current set of available permissions during execution (security-passing style Wallach & Felten)

  + more apparent (could print current perms.)

  - more expensive (checkPermission occurs infrequently)

Stack Inspection

- Stack inspection seems appealing:
  - Fine grained, flexible, configurable policies
  - Distinguishes between code of varying degrees of trust
- But…
  - How do we understand what the policy is?
  - Semantics tied to the operational behavior of the program (defined in terms of stacks!)
  - Changing the program (e.g. optimizing it) may change the security policy
  - Policy is distributed throughout the software, and is not apparent from the program interfaces.
  - Is it any good?
  - It's not complete!

Problem with Stack Inspection

```
main(…){
 fp = new FilePermission(“/home/stevez/*”,“write,…”);
 sm.enablePrivilege(fp);
 fileWrite(UntrustedApplet.getFileName(), "xxxxxx");
}
```

Policy Database

Problem with Stack Inspection

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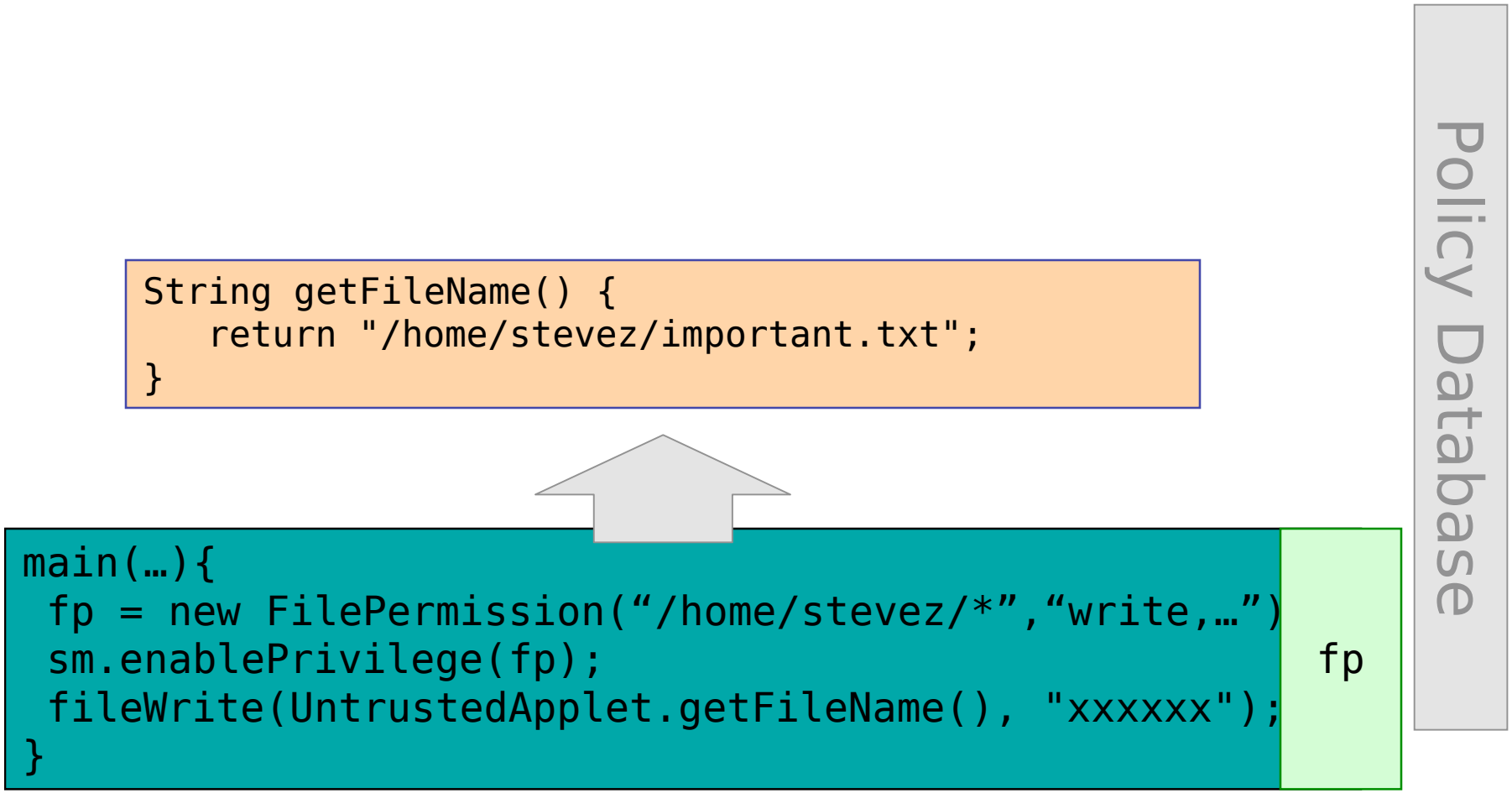

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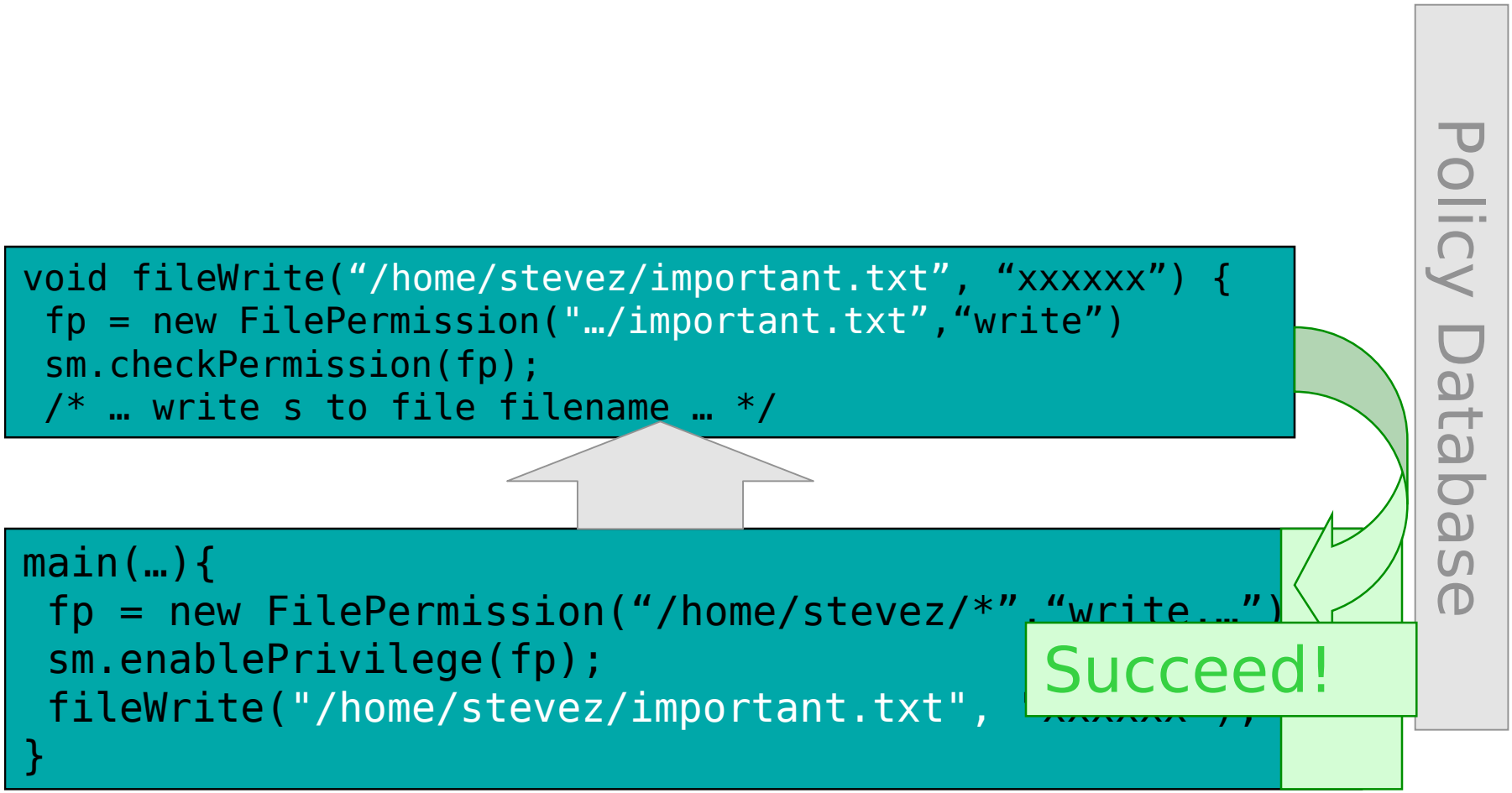

Stack Inspection: Final thoughts

- Question: How does taint tracking relate to this problem with stack inspection?

- Related Papers (not required reading):
  - A Systematic Approach to Static Access Control
    François Pottier, Christian Skalka, Scott Smith
  - Stack Inspection: Theory and Variants
    Cédric Fournet and Andrew D. Gordon
  - Understanding Java Stack Inspection
    Dan S. Wallach and Edward W. Felten