CIS 551 / TCOM 401

Computer and Network Security

Spring 2006

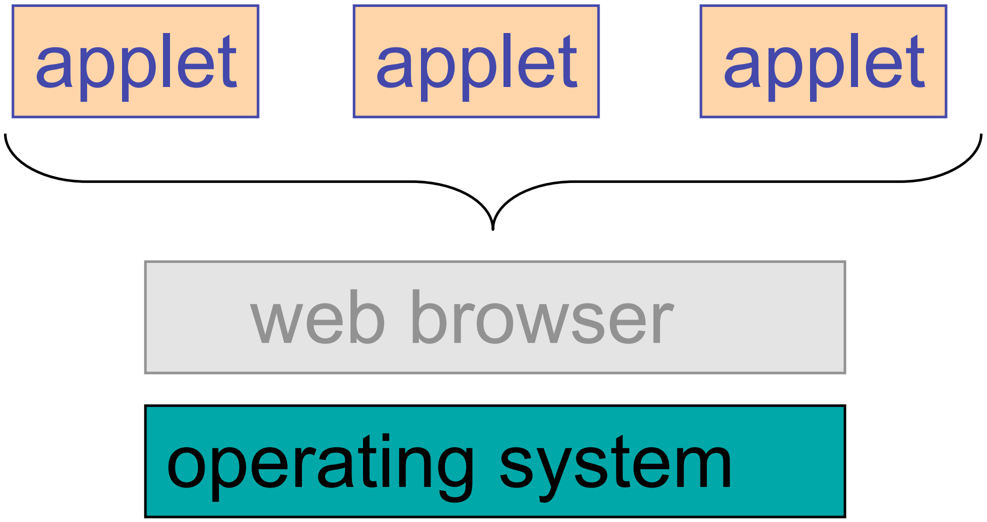
Lecture 5

Access Control

- Last time: Unix/Windows access control at the OS level.
- Today: Stack Inspection
- What are the security issues in mobile code?

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, …

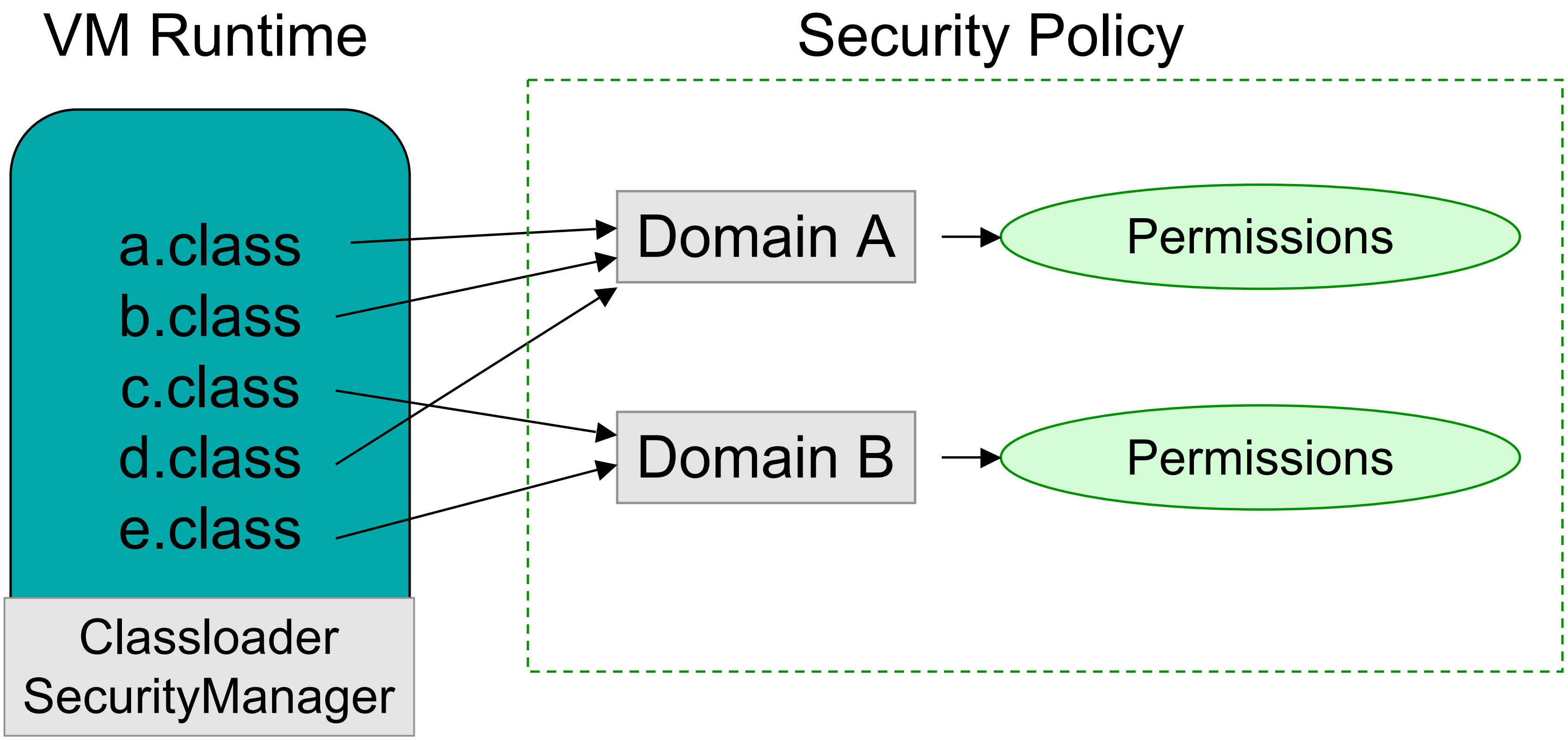
Applet Security Problems

- 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?

Java Security Model



http://java.sun.com/j2se/1.4.2/docs/guide/security/spec/security-specTOC.fm.html

Kinds of Permissions

- java.security.Permission Class

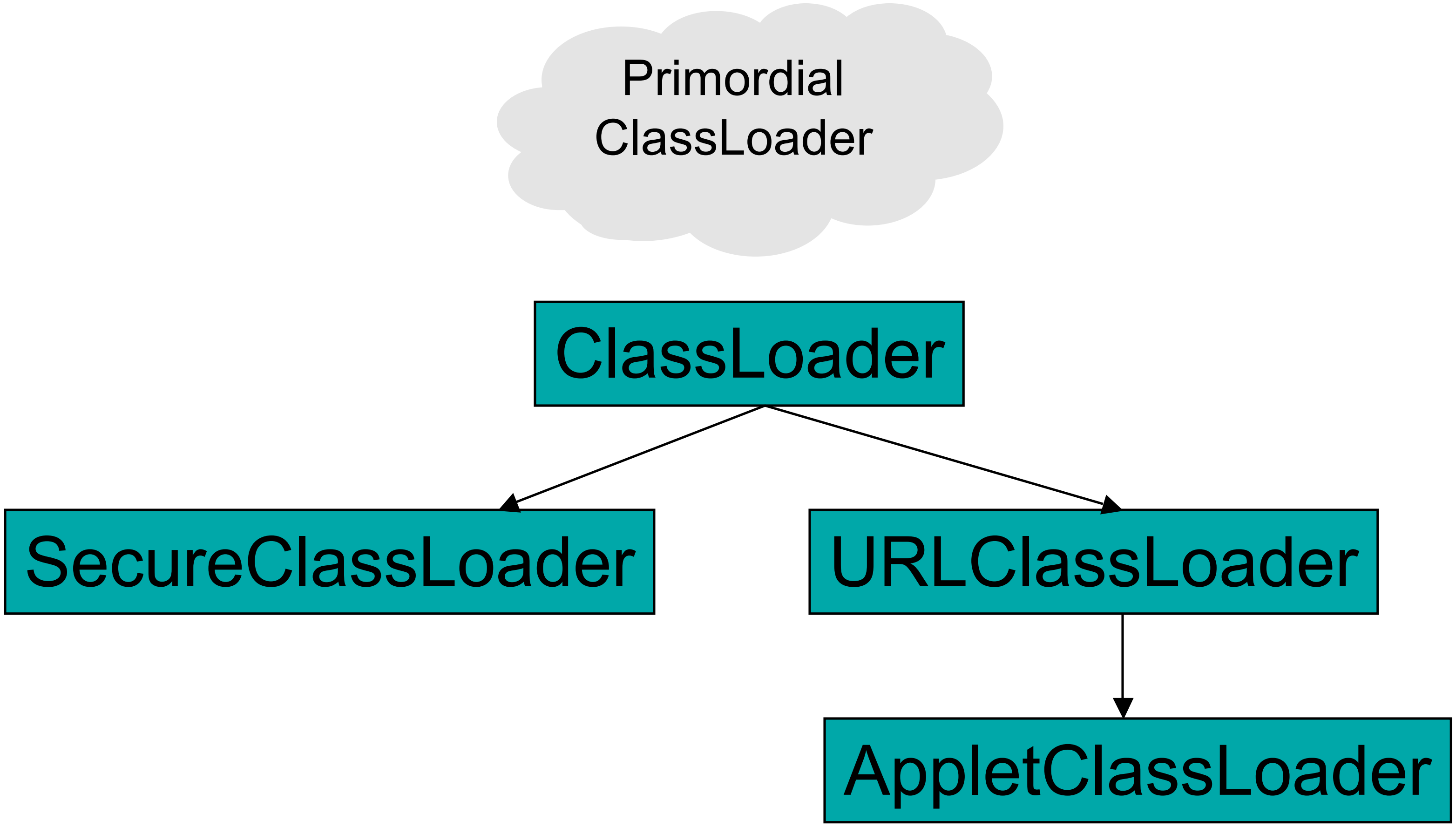
```
perm = new java.io.FilePermission("/tmp/abc","read");
```

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/

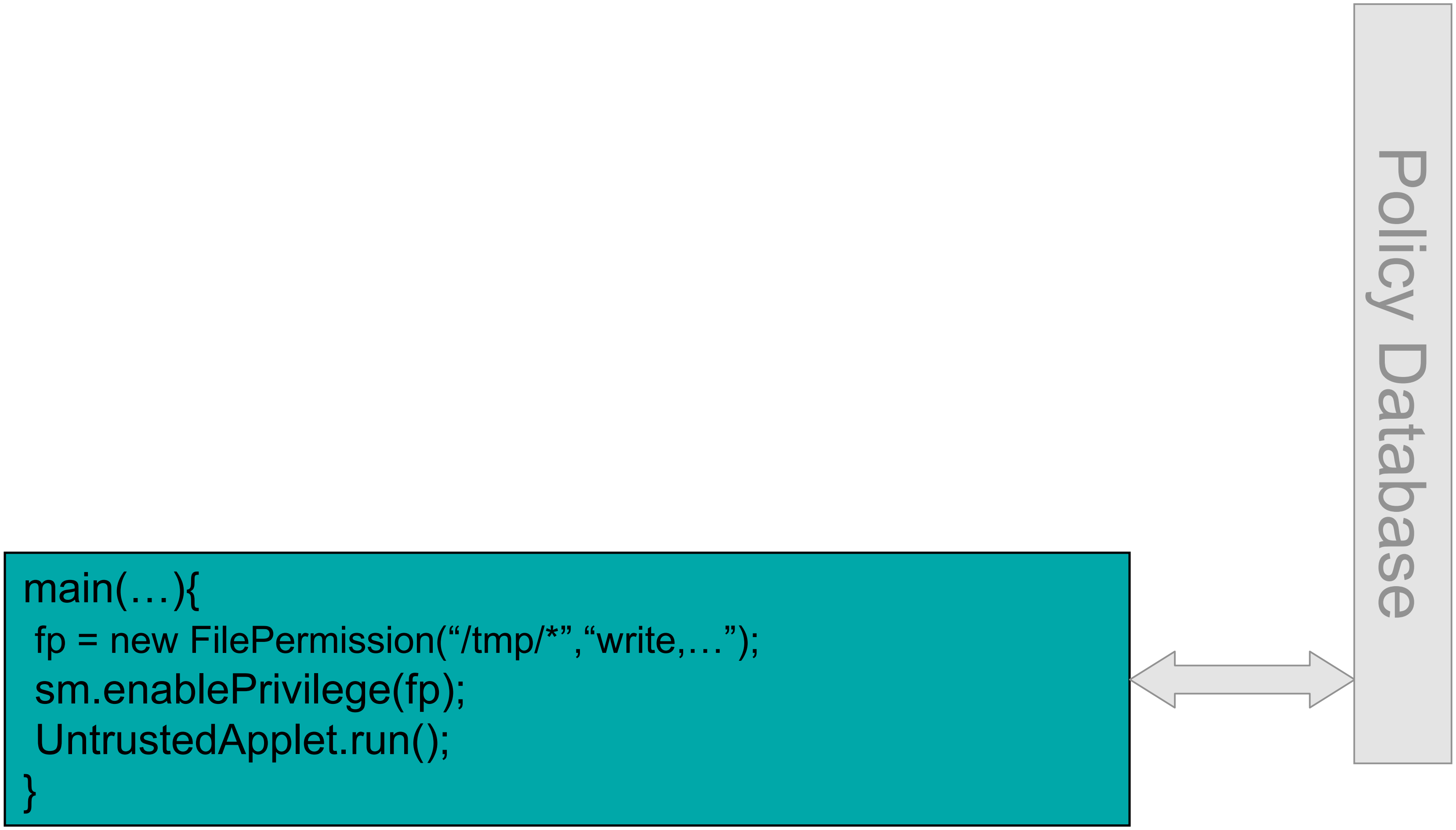
```
class UntrustedApplet {
  void run() {
    ...
    s.FileWrite(“/tmp/foo.txt”, “Hello!”);
    ...
    s.FileWrite(“/home/stevez/important.tex”, “kwijibo”);
    ...
  }
}
```

Stack Inspection

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

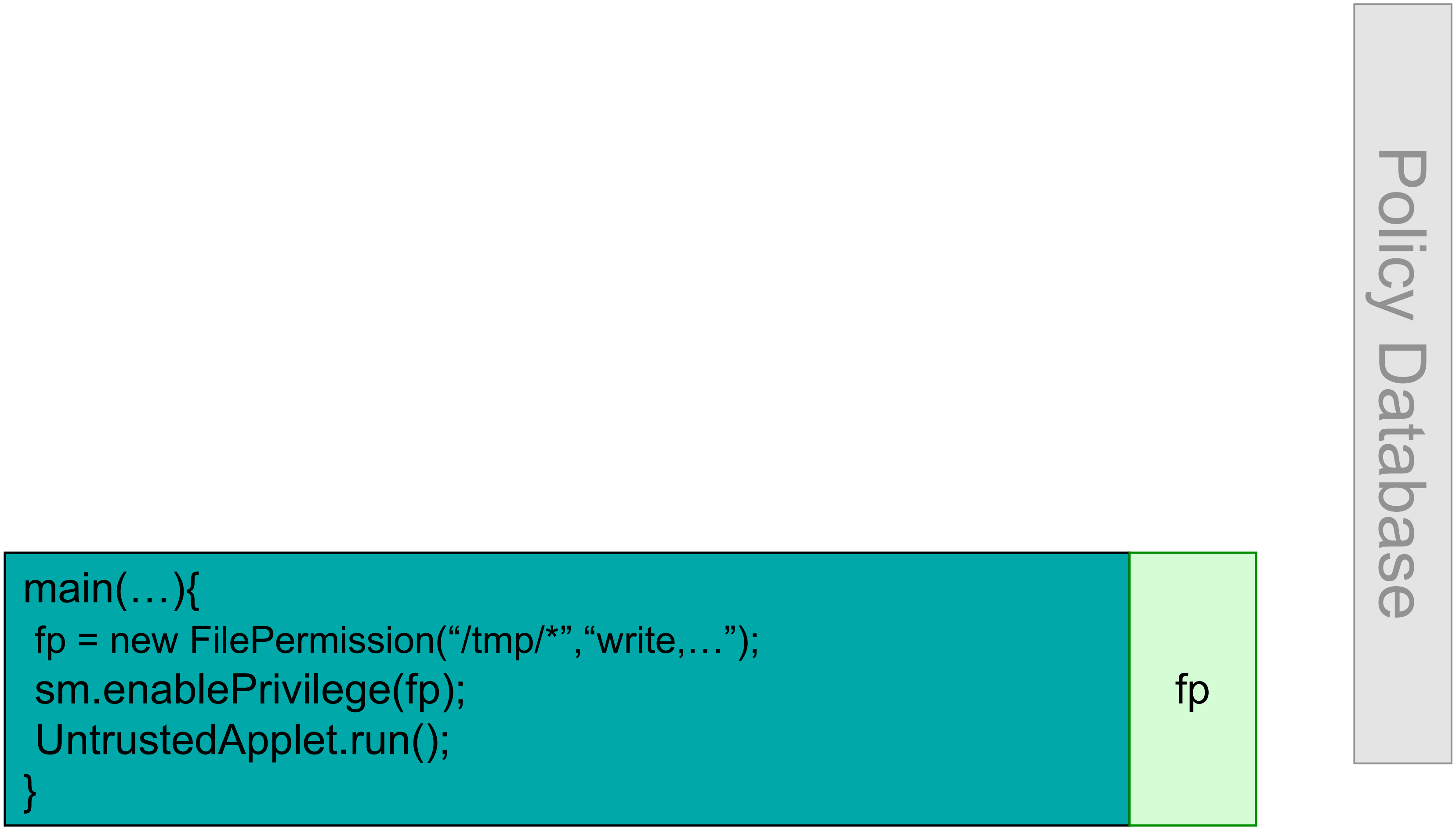
- During inspection, stack frames are searched from most to least recent:
  - fail if a frame belonging to someone not authorized for privilege is encountered
  - succeed if activated privilege is found in frame

Stack Inspection Example



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

Stack Inspection Example

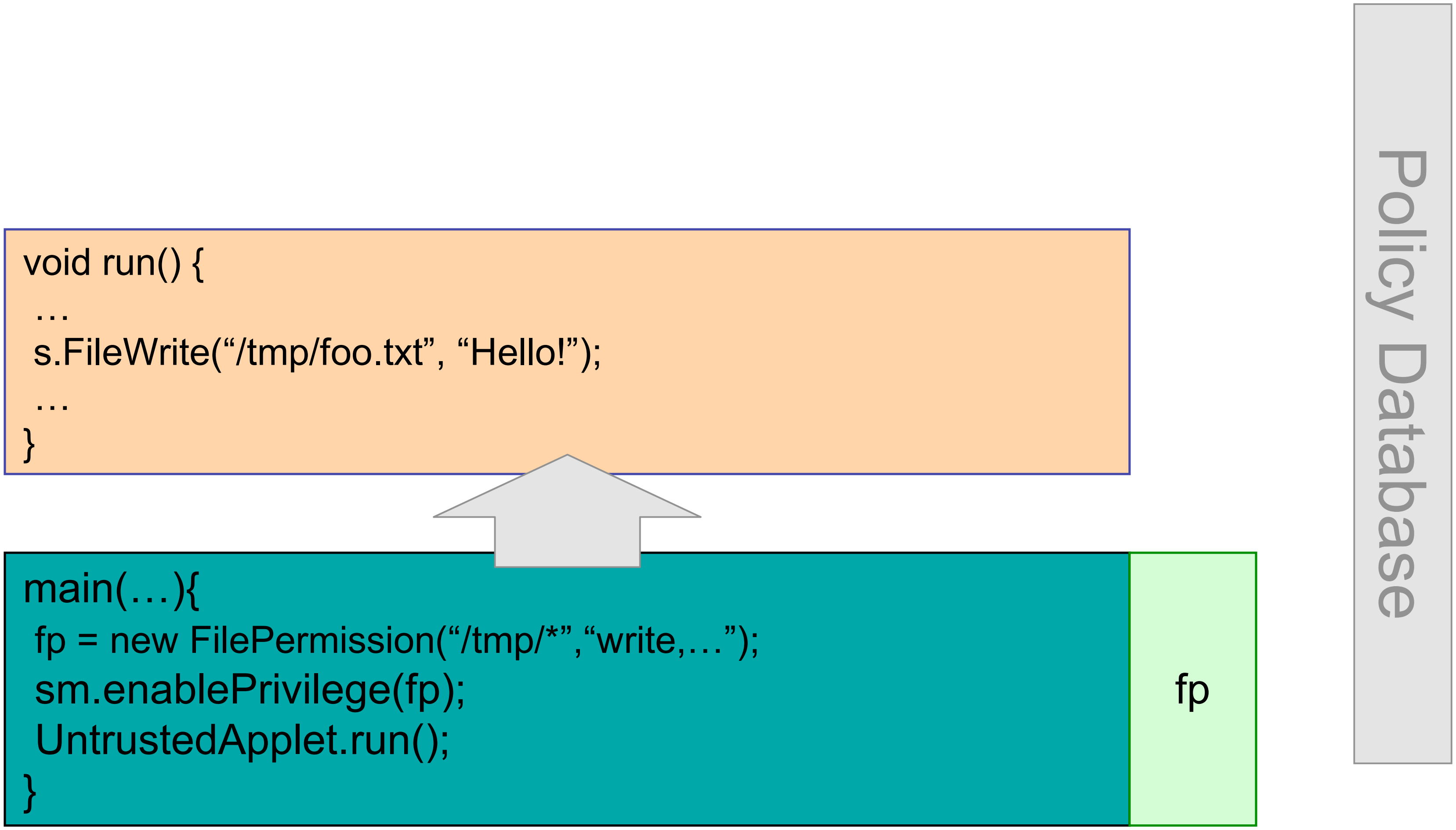


```
main(…){
 fp = new FilePermission(“/tmp/*”,“write,…”);
 sm.enablePrivilege(fp);
 UntrustedApplet.run();
}
```

fp

Policy Database

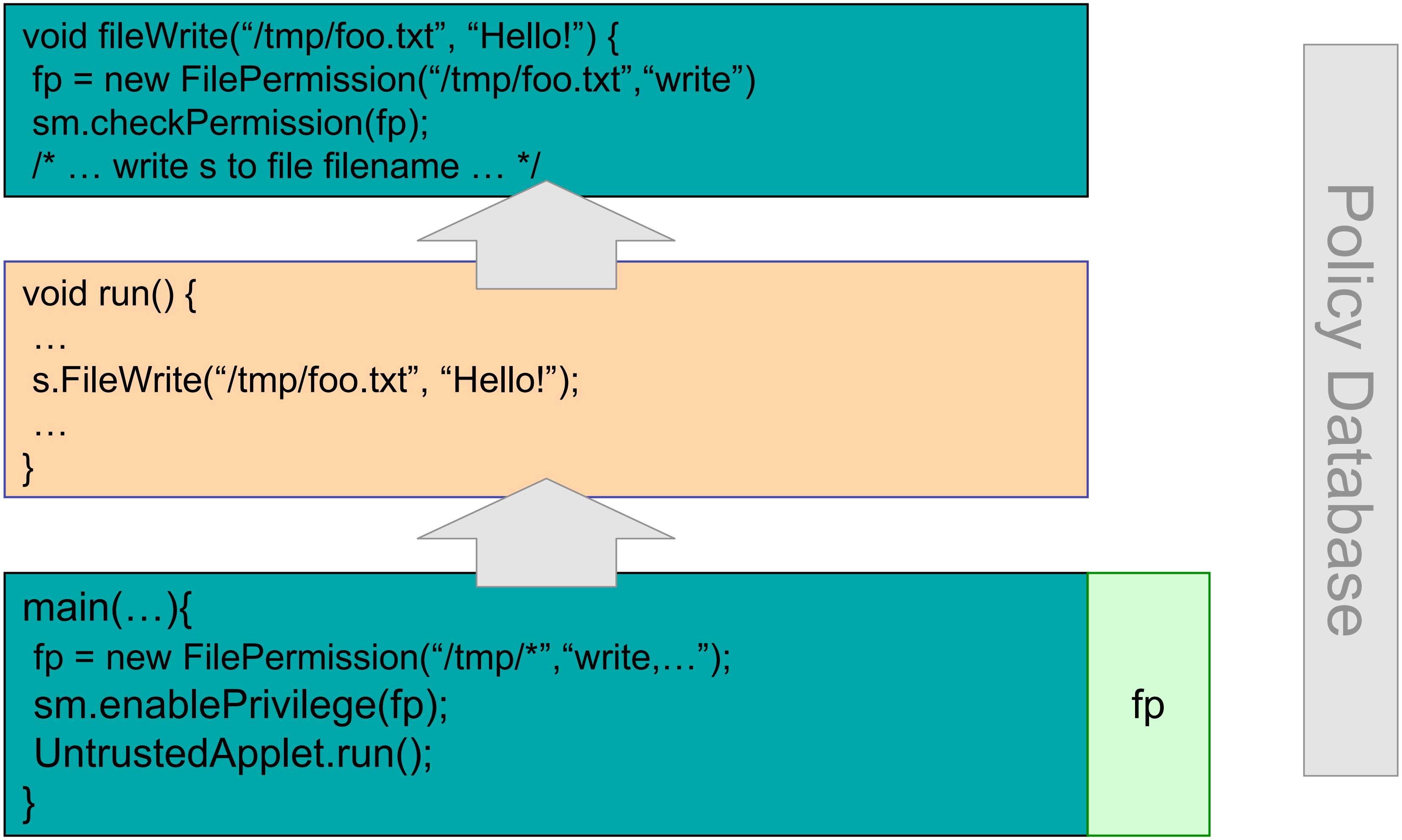
Stack Inspection Example



```
void run() {
 …
 s.FileWrite("/tmp/foo.txt", "Hello!");
 …
}
```

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

Stack Inspection Example



```
void fileWrite(“/tmp/foo.txt”, “Hello!”) {
 fp = new FilePermission(“/tmp/foo.txt”,“write”)
 sm.checkPermission(fp);
 /* … write s to file filename … */
```

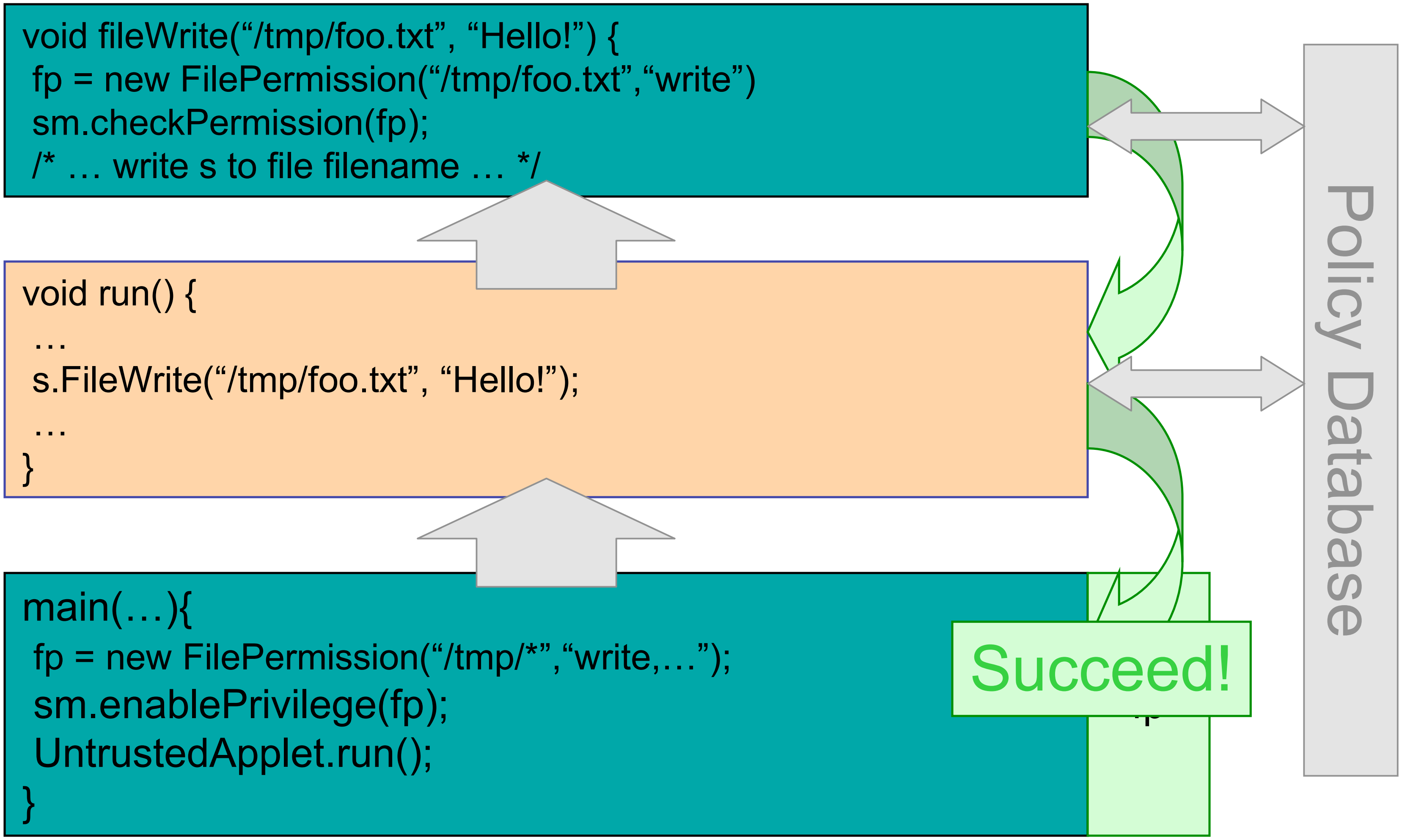
```
void run() {
 …
 s.FileWrite(“/tmp/foo.txt”, “Hello!”);
 …
}
```

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

fp

Policy Database

Stack Inspection Example



```
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 fp = new FilePermission(“/tmp/foo.txt”,“write”)
 sm.checkPermission(fp);
 /* … write s to file filename … */
```

```
void run() {
 …
 s.FileWrite(“/tmp/foo.txt”, “Hello!”);
 …
}
```

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main(…){
 fp = new FilePermission(“/tmp/*”,“write,…”);
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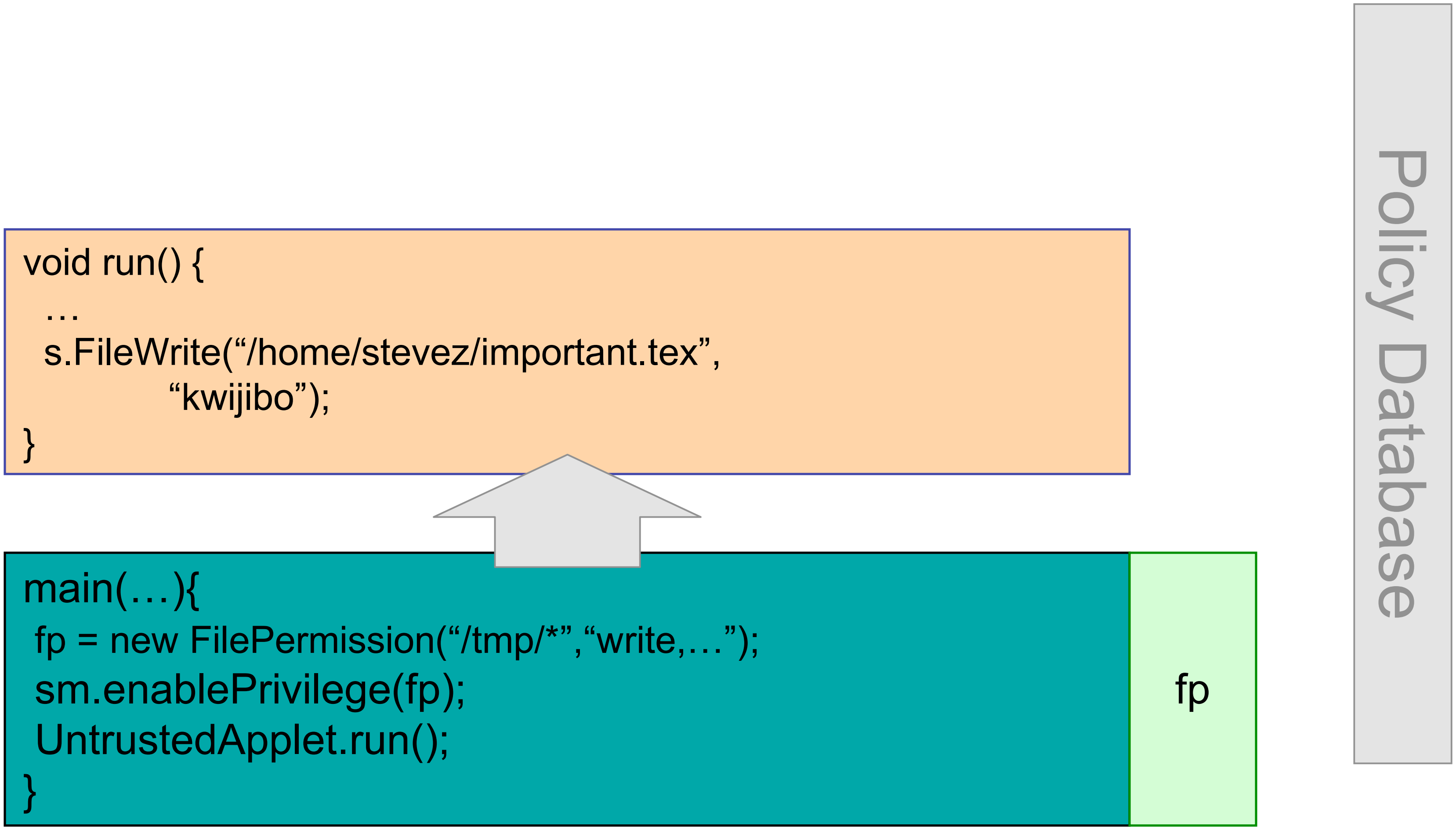
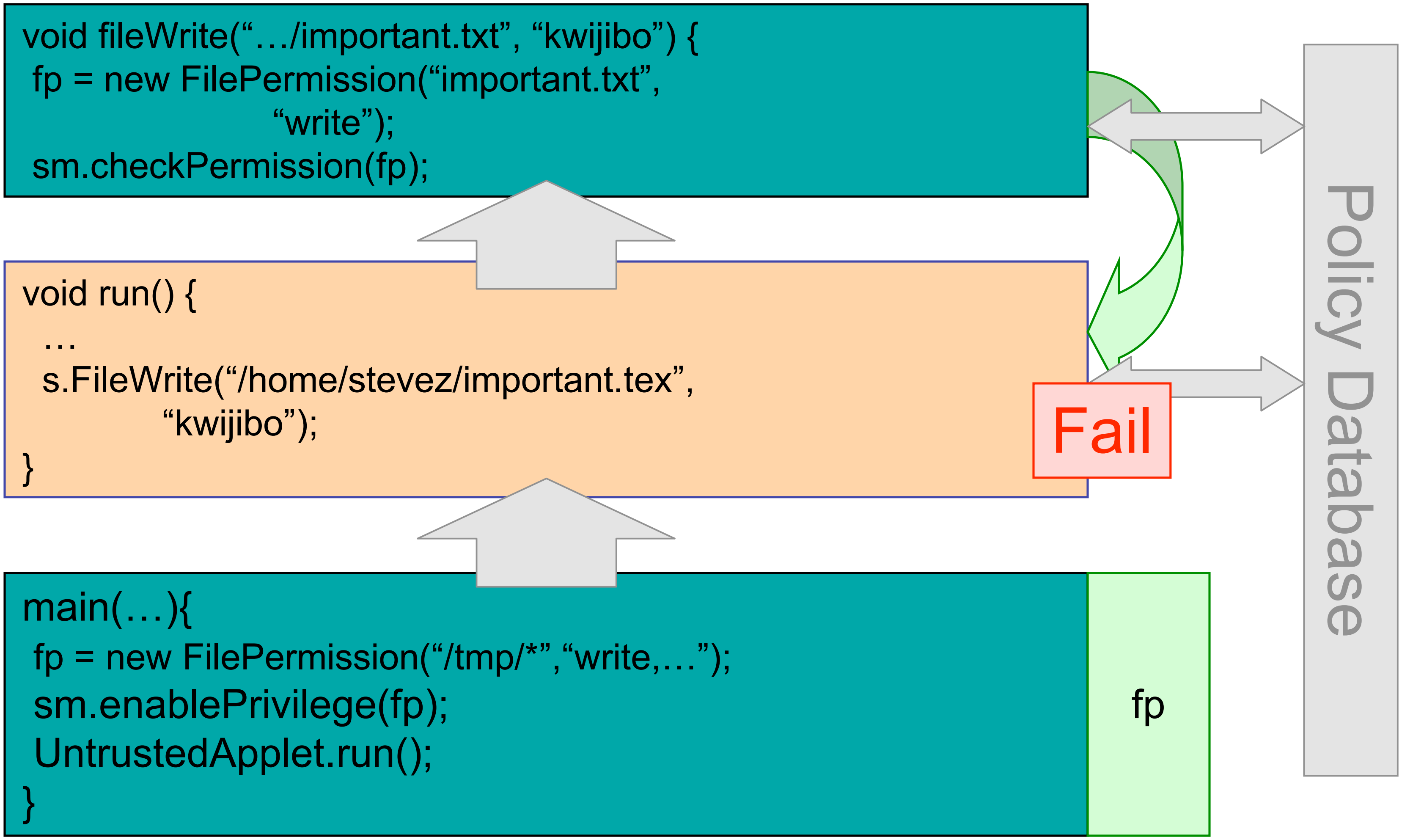
Stack Inspection Example



```
void run() {
  …
  s.FileWrite("/home/stevez/important.tex",
              "kwijibo");
}
```

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

Stack Inspection Example



```
void fileWrite("…/important.txt", "kwijibo") {
 fp = new FilePermission("important.txt",
                         "write");
 sm.checkPermission(fp);
```

```
void run() {
  …
  s.FileWrite("/home/stevez/important.tex",
             "kwijibo");
}
```

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

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 (Netscape || …) throw ForbiddenException;
  if (MS IE4.0 || 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?

Stack Inspection Research

- 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
  - Formalize Java Stack Inspection using ABLP logic