Programming Securely II

Computer Security Lecture 14

David Aspinall

School of Informatics
University of Edinburgh

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Outline

Web security issues

Java Security: Coding and Models

Trusting code

Language futures for security

Programming and Security

Programming Securely
: To develop code in a secure manner so that the code itself is not a vulnerability that can be exploited by an attacker.

Programming Security
: To develop code for security-specific functions such as encryption, digital signatures, firewalls, etc.

In this lecture, we look at both sides:

- continuing programming securely: some **web application** security issues and some **Java** guidelines.
- programming security: overview of **Java security APIs** and **current and future trust models**.

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Web security: client-side threats

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- Browsers store **cookies** which have confidentiality implications. Even without cookies, web browsing is less anonymous than it feels: information is stored in browser's history and document cache, firewall and proxy logs, and the remote sites visited, even before any spyware is present. (All great for market researchers).

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- Buggy browsers: buffer overflows, crypto bugs, etc.

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- Server-side **scripting languages**: C or shell CGI, PHP, ASP, JSP, Python, Ruby, all have serious security implications in configuration and execution. File systems and permissions have to be carefully designed. That's before any implemented *web application* is even considered. . .

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- **Output filtering**: cross-site scripting (XSS), when attacker-generated HTML appears on site: used for session hijacking, phishing attacks. Beware passing informative error messages.
- **Careful cryptography**: encryption/hashing to *protect server state in client*, use of *appropriate authentication* mechanisms for web accounts (never Referer header).

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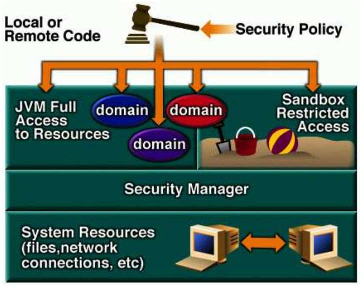
Access Control in Java

Java 1.0 had a **sandbox** security model, where downloaded Java applets ran in a restricted environment with no access to local files, etc: often too restrictive. Java 2 has a more flexible, fine-grained level of control:



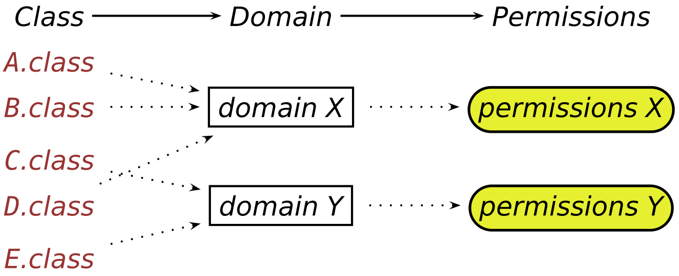
Local or Remote Code
Security Policy
JVM Full Access to Resources
domain
domain
domain
Sandbox Restricted Access
Security Manager
System Resources (files,network connections, etc)

Applications and applets are subject to a **security policy** which specifies **protection domains** based on **location** of code, whether it is **signed** by a trusted entity, and the user **identity**. Each domain specifies a set of **permissions** for accessing resources.

This picture is reproduced from the Java Security Tutorial (c) Sun

Java security architecture

- A `SecurityManager` is installed by web browsers for Java applets; an application must either itself install the security manager, or be invoked with the option `-Djava.security.manager`. If the security manager's checks fail, a `java.lang.SecurityException` is raised.
- Access control in Java is based on **protection domains** which group together the set of objects which are currently accessible by a principal.



Java access control permissions

- Domains are associated with sets of **permissions**

java.security.AllPermission	every resource
java.io.FilePermission	file system access
java.net.SocketPermission	accept/connect based on host/IP & p
java.awt.AWTPermission	window-system permissions
java.lang.RuntimePermission	JVM config; threads; printing
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Permissions implement an **implies** method for access control decisions. Here `p2.implies(p1)`.

Java security policies

- The system security policy for a Java application environment specifies permissions available for code from various sources, represented by a `Policy` object. Only one in effect at a time.
- A `Policy` object evaluates the global policy using the `ProtectionDomain` for a class, and returns an appropriate `Permissions` object.
- Java supplies a GUI **policytool** utility for editing ASCII format policy files, with entries like this, specifying a key store and zero or more “grant” entries:

  ```
  keystore ".keystore", "JKS";
  grant principal com.sun.security.auth.UnixPrincipal "da" {
    permission java.util.PropertyPermission "java.home", "read";
    permission java.io.FilePermission "/tmp/foo", "read,write";
  };
  ```

  Default, system policy is in *javahome*/lib/security/java.policy. User policy is in *userhome*.java.policy.

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- **Java GSS-API**. Bindings for Generic Security Service API (RFC2853). Used for securely exchanging messages between communicating applications, using various underlying mechanisms (e.g., Kerberos).

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- See: `javax.crypto`, `javax.crypto.interfaces`, `javax.crypto.spec`.

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Signature	sign data and verify digital signatures.
KeyPairGenerator	generate public-private key-pair.
CertificateFactory	create certificates and CRLs.
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- Factory methods in engine classes are used to return instances of the class, e.g. `Signature.getInstance("SHA1withDSA")`.

Java Secure Socket Extension (JSSE)

- The JSSE is also based on a provider plug-in architecture.
- Has a simple structure. Main use is with SSL client sockets, SSL server sockets, and SSL session handles. Sample classes:

SSLSocket	socket for SSL/TLS/WTLS protocols
SSLSocketFactory	factory for SSLSocket objects
SSLServerSocket	sever socket for SSL/TLS/WTLS
··· Factory	factory for SSLServerSockets
SSLSession	encapsulation of SSL session

- Creating SSL client or server sockets is as easy as creating ordinary Java TCP/IP sockets: each SSL class extends the corresponding ordinary TCP socket class, and provides a few extra hooks for setting security parameters.
- See `javax.net.ssl`, also `javax.net` and `javax.security.cert`.

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- **Authorization** happens when a subject is associated with a thread's `AccessControlContext` using the **doAs** methods for performing actions (`java.security.PrivilegedAction.run`). Then principal-based entries in the current security policy are used.

Flaws in the Java infrastructure

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  Type safety relies on byte code verification being correct. Unfortunately getting this right is complicated. . .

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  - 8th Feb 2006, CVE-2006-0614,0615,0617: Sun fixes seven vulnerabilities in current JREs which allowed remote code to bypass sandbox using reflection.
- Shows *defence in depth* is important; even with a careful Java security policy restricting what downloaded code can do, you should still beware *untrusted* code.

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The Trusted Computing Base

Trusted Computing Base (TCB)

The set of all components (harware, software, human, . . .) whose correct functioning is sufficient to ensure that the security policy is enforced.

- Equivalently: failure of the TCB causes failure of security.
  Misplaced trust can hurt you!
- This motivates design principles for the TCB:
  - make it as small as possible
  - do not change it often
  - verify it carefully: so it is as secure as possible
- In access control systems, the TCB is the **Reference Monitor** implementation.

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- Allows certificates, e.g. "this document created with v 1751 of MS Word, on Windows Vista Trusted, 27th August 2008, on Dell Megaplex ZZ5 S/N 5091237896". Files stored encrypted, cannot be decrypted on other machines.

Palladium/TCPA/NGSCB/Trustworthy Computing

- PCs now contain a **Trusted Platform Module** (TPM) security chip with embedded master keys.
- Security model idea: PC boots, hashing BIOS, OS and application code. Builds a chain of trust.
- Protection domains in OS extended into hardware (secure keyboard reading, sound channels). Desire: close down an open system (cf XBox).
- Allows certificates, e.g. “this document created with v 1751 of MS Word, on Windows Vista Trusted, 27th August 2008, on Dell Megaplex ZZ5 S/N 5091237896”. Files stored encrypted, cannot be decrypted on other machines.
- Many uses. Strong anti-privacy measures. Business clients: financial services, government, and healthcare. Home PC users: reduction in spyware, digital rights management (DRM). New uses: renting, lending, time-limited, etc. Considerable controversy (Stallman: “Treacherous Computing”).

Outline

Web security issues

Java Security: Coding and Models

Trusting code

Language futures for security

Language-based security

An active research area: applying programming language theory, designing new constructs and mechanisms.
Most work applies verification technology including static analysis, extended type systems and theorem proving.

- Proof-carrying code (PCC), which equips code with independently checkable safety certificates.

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  - **ensuring authentication** before authorisation
  - fixing patterns of **access control**, e.g. close file after opening.

References

- Mark G. Graff and Kenneth R. van Wyk.
  Secure Coding: Principles & Practices.
  O'Reilly, 2003.
- Sverre H. Huseby.
  Innocent Code: a security wake-up call for web programmers.
  Wiley.
- Gary McGraw.
  Securing Java.
  John Wiley & Sons, 1999.

Recommended Reading

For web programming: Huseby's book, or the more recent information at OWASP, `https://www.owasp.org`.
For Java security: the Oracle/CERT guidelines at
`https://www.securecoding.cert.org`