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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Web security: client-side threats

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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...
Web programming: application security

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- **Input validation**: to prevent SQL injection, command injection, other confidentiality attacks. Ajax: *beware client-side validation!* Understand metacharacters at every point. Use labels/indexes for hidden values, not values themselves.
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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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Java Secure Coding Guidelines

- **Using modifiers.** Reduce scope of methods and fields; beware non-final public static \((global)\) variables; avoid public fields, and add security checks to public accessors.
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See Oracle/CERT Secure Coding Guidelines.
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:

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.

```
Class       Domain        Permissions
A.class     domain X     permissions X
B.class     domain X     permissions X
C.class     domain Y     permissions Y
D.class     domain Y     permissions Y
E.class     domain Y     permissions Y
```
Java access control permissions

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

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<tr>
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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:

```plaintext
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`.  

Java security extensions

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- **Java Authentication and Authorization Service (JAAS).** Used for “reliable and secure” authentication of users, to determine who is currently executing Java code; and for authorization of users to ensure they have the permissions necessary for desired actions.
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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.
JCE cryptography services

- A cryptography service is associated with a particular algorithm or type, and manipulates or generates data, keys, algorithm parameters, keystores, or certificates.
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Engine classes include:

- MessageDigest: generate message digests (MDCs)
- Signature: sign data and verify digital signatures.
- KeyPairGenerator: generate public-private key-pair.
- CertificateFactory: create certificates and CRLs.
- KeyStore: create and manage key databases.
- AlgorithmParameters: manage parameters for an algorithm.
- SecureRandom: random or pseudo-random numbers.
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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`: server 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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- 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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Language futures for security
The Trusted Computing Base (TCB)

The set of all components (hardware, 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.
PCs now contain a **Trusted Platform Module** (TPM) security chip with embedded master keys.
Palladium/TCPA/NGSCB/Trustworthy Computing

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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.
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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.

Outline

Web security issues

Java Security: Coding and Models

Trusting code

Language futures for security
Language-based security

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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.  

Sverre H. Huseby.  
Innocent Code: a security wake-up call for web programmers.  
Wiley.

Gary McGraw.  
Securing Java.  

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