Computer, Network, and Java Security

Introduction

- Need for Computer/Internet security
  - Consumers buying products, trading stocks, and banking online
  - Credit-card, social security, and confidential business information exchanged
  - Security attacks
    - Data theft and hacker attacks
    - Wireless transmissions easier to intercept
- Security fundamentals
  - *Privacy*: no third party
  - *Integrity*: information unaltered
  - *Authentication*: proving identities
  - *Non-repudiation*: legal proof of message received
  - Availability: Network stays in operation continuously

Computer Security: General Rules

- Limits of computer security
  - Absolute computer security is not feasible
  - Given unlimited resources any form of security can be broken
  - Objective: cost for breaking a system must far outweigh rewards
- End-to-end security
  - In multitier systems, each tier must have its own security
  - Security is as strong as the weakest link
- Complex vs. Simple systems
  - Complex systems: high cost of design and implementation
  - Simple systems: Easier understood, better analyzed
- Always required
  - Security must be an integral part of a system design

Types of Threats

- Secrecy Attacks
  - Attempts to steal confidential information
- Integrity Attacks
  - Attempts to alter information with malicious intent
- Availability Attacks
  - Attempts to disrupt a system’s normal operation

Example of Attacks

- Brute force
  - Involves searching every key until the right one unlocks the system
- Trojan Horse
  - Involves planting an enemy program as an insider in such a way that it is not apparently noticeable
- Person-in-the middle attack
  - Attacker intercepts the communication between two parties without their knowledge

Protections

- Network related:
  - Firewalls
  - Virtual Private Networks
- Cryptography
  - Design of algorithms for encrypting and decrypting information
    - *Plaintext*: unencrypted data
    - *Ciphertext*: encrypted data
    - *Key*: used by sender and receiver to encrypt and decrypt message
  - Provides confidentiality (only the intended recipient can make sense of the message)

Protections (cont’d)

- Authentication
  - Confirms user’s identity (e.g. passwords, smart cards, biometrics, etc.)
- Authorization
  - After authentication, access to the user is governed by an access control policy
- Auditing and logs
  - Keeping a record of resource access that were granted or denied can serve in preventing or analyzing a break-in

Security Layered Architecture

Java	Encryption, Authentication, Authorization, JVM security
Application	Encryption, Authentication, Authorization
Transport	SSL/TLS
Network	IPSEC, firewalls, VPN
Link Layer	WEP, PPP LCP
PHY	Securing cabling, avoiding Interference, Spread Spectrum

Cryptanalysis

- Even if keys are secret, it is possible to compromise the security of a system
- *Cryptanalysis*: trying to decrypt ciphertext without knowledge of the decryption key
  - Cryptanalytic attacks
- Attacks can be reduced if proper key management structures are in place and keys use expiration dates

General Security Considerations

- Know your enemy
- Identify assumptions and weaknesses
- Control secrets
- Remember human factors
- Limit the scope of access
- Understand your environment
- Remember physical security
- Make security pervasive

Java Security Extensions

- If you are using JDK 1.3.x, download
  - JCE 1.2.2
  - JAAS 1.0 class libraries
  - JSSE 1.0.3
- Copy *.jar to C:\jdk1.3.1\jre\lib\ext
- Insert the follow two lines to C:\jdk1.3.1\jre\lib\security\java.security after the line **`security.provider.2=…`**

```
security.provider.3=com.sun.crypto.provider.SunJCE
security.provider.4=com.sun.net.ssl.internal.ssl.Provider
```

Cryptography Algorithms

- Based on the secrecy of the algorithm (Ancient Ciphers mostly):
  - *Substitution ciphers*: given letter replaced by different letter. Example: Rot13, rotates a character in the message by 13 positions
  - *Transposition ciphers*: letter ordering shifted
- Based on the secrecy of the key (Modern Algorithms):
  - One-way hash functions
  - Symmetric ciphers
  - Asymmetric ciphers

1. One-way hash functions

- Given input message M of any length, compute h = H(M) to produce a hash value h of length m
- Properties:
  - Given M, it is easy to compute h
  - Given h, it is hard to compute M such that H(M)=h
  - Given M, it is hard to find a message M’, such that H(M)=H(M’)
- Useful to produce fingerprints
  - RSA’s MD4, MD5 (RFC 1321, 1992)
    - MD=Message Digest
    - RSA=Ron Rivest, Adi Shamir, and Leonard Adlemaen
    - Produce a 128-bit hash
  - NIST and NSA’s SHA, SHA-1 (1994)
    - SHA=Secure hashing algorithm
    - Produces a 160-bit hash used in the Digital Signature Algorithm (DSA)

Example: MD5

Original Message	Hash value (in hexadecimal)
a quick brown fox jumped over a lazy dog	13b5eeb338c2318b790f2ebccb91756f
a quick blue fox jumped over a lazy dog	32c63351ac1c7070ab0f7d5e017dbcea
a quick brown dog jumped over a lazy fox	a4c3b4cd38ade6b5e2e101d879a966f5

MD5/SHA in Java

```
import java.security.*;
import java.io.*;

public class md5 {

   public static void main(String args[]) {

        if (args.length != 1) {
              System.out.println("Usage: java md5 <your text>");
              System.exit(1);
        }
        try {

          // Create an output file "digest"
          FileOutputStream digestStream = new FileOutputStream("digest");
          // Use the MD5 algorithm. SHA will work as well
          MessageDigest md=MessageDigest.getInstance("MD5");
          byte buf[] = args[0].getBytes();
          // Update the data and digest it
          md.update(buf);
          digestStream.write(md.digest());

        } catch (Exception e) {
              System.out.println(e);
        }
   }
}
```

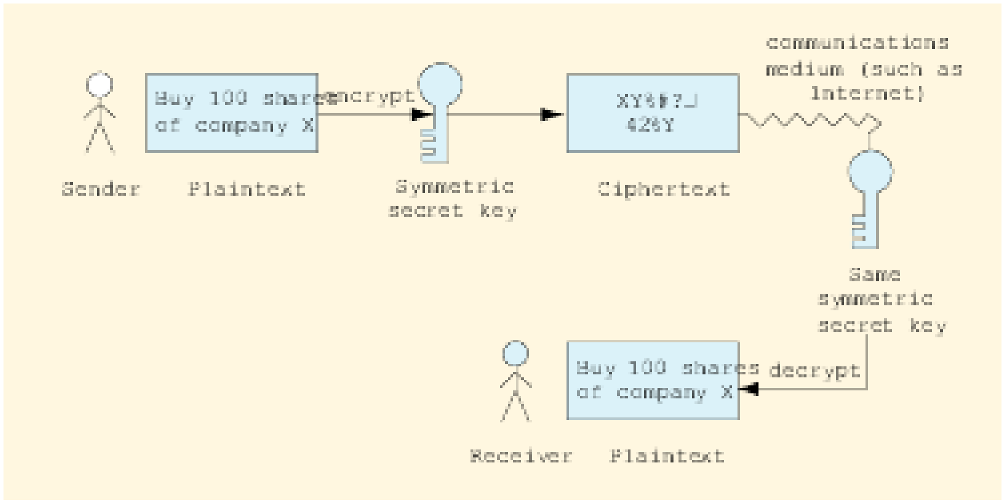
2. Symmetric Ciphers

- A *symmetric cipher* in conjunction with a secret key translates *plaintext* to *ciphertext* (Secret-key cryptography)
- Cipher can also recover plaintext from ciphertext using the *same* key
- Both encryption and decryption use the same key
- Formally
  - $E_k(M) = C$, where *M* is the *plaintext*, *C* is the *ciphertext* and *k* is the key
  - $D_k(C) = M$, where *C, M* and *k* have the same meaning
- The essential property: $D_k(E_k(M)) = M$

Symmetric Ciphers (cont’d)

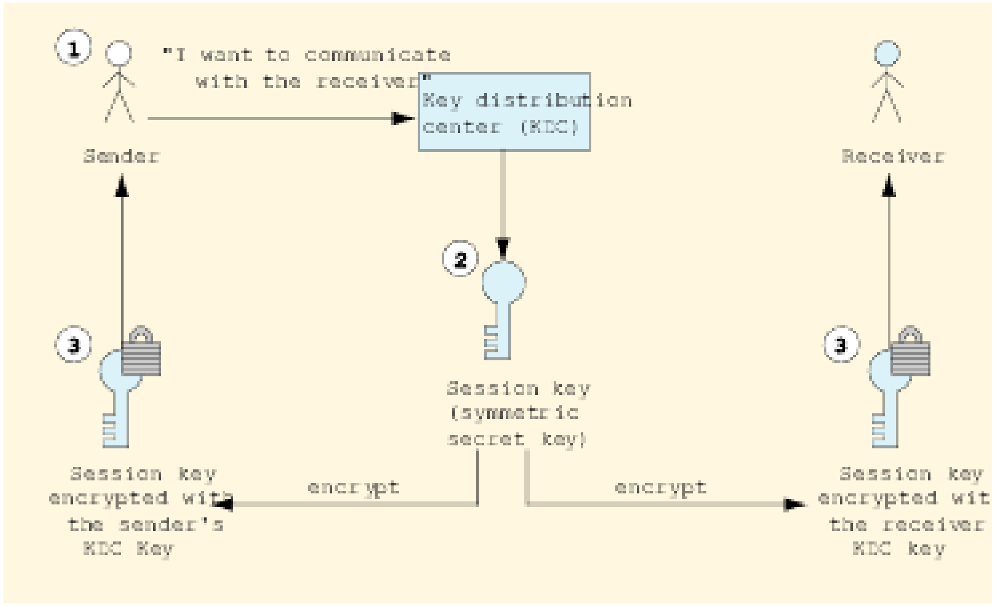
- Disadvantages
  - Need secure method to transfer key
  - No authentication because same key used on both ends
  - Sender needs separate secret key for each receiver
- *Key distribution center (KDC)*
  - Shares secret key with users in network
  - Encrypts *session key* with secret keys to sender and receiver
  - Session key used for transaction
  - New keys and less couriers for transactions, but security depends on security on KDC

Symmetric Ciphers (cont'd)


communications medium (such as Internet)
Buy 100 shares of company X
encrypt
XY%#?_ 42%Y
Sender
Plaintext
Symmetric secret key
Ciphertext
Same symmetric secret key
Buy 100 shares of company X
decrypt
Receiver
Plaintext

Encrypting and decrypting a message using a symmetric secret key

Symmetric Ciphers and KDC



1
"I want to communicate with the receiver"
Key distribution center (KDC)
Sender
Receiver
2
Session key (symmetric secret key)
3
Session key encrypted with the sender's KDC Key
encrypt
encrypt
3
Session key encrypted wit the receiver KDC key

Distributing a session key with a key distribution center

Symmetric Ciphers (cont'd)

- Types of symmetric ciphers:
  - *Block ciphers* operate on a group of bits. The same plaintext block will encrypt to the same ciphertext block when using the same key.
  - *Stream ciphers* operate on the stream of bits or bytes. They produce always different ciphertext.
- Most block algorithms obey the Feistel Network property (algorithms for encryption/decryption are the same)

Implementations

- *Data Encryption Standard (DES)*
  - Uses *block cipher*: Creates bit groups from message and applies algorithm to whole block
  - DES standard set by *American National Standards Institute (ANSI)* for years, no loner considered secure
- Triple DES (3DES) replaced DES
  - Three DES systems in row with unique secret key
- *Advanced Encryption Standard (AES)* is new standard
  - *Nation Institute of Standards and Technology (NIST)* currently evaluating *Rijndael* for AES

3. Asymmetric Ciphers

- Uses *public-key* (distributed) and *private-key* (kept secret)
- Public-key decrypts private-key and vice-versa
- Computationally infeasible to deduce private-key from public-key
- Authentication
  - If receiver's public-key and sender's private key are both used, both parties are authenticated
- *RSA*: most common public-key algorithm
  - Used by most Fortune 1000 and e-commerce businesses

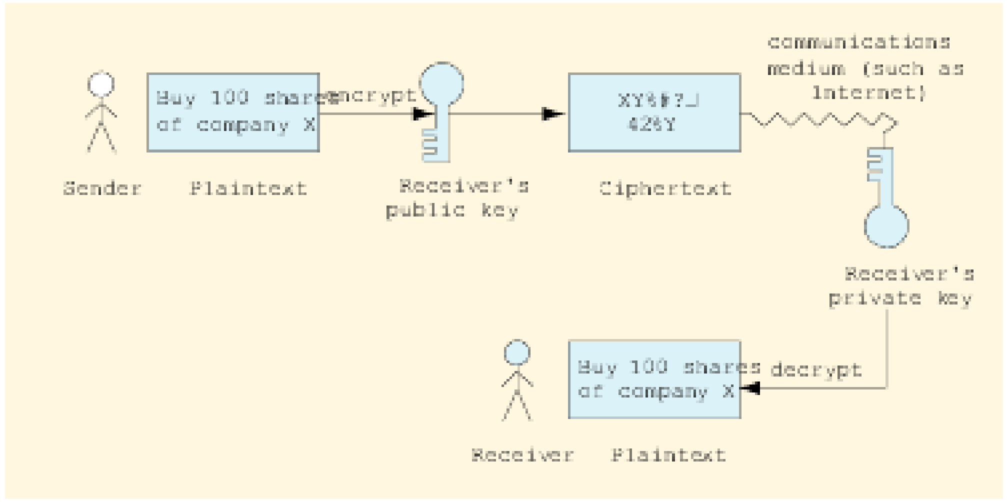
Asymmetric Ciphers

- asymmetric ciphers involve the use of different keys for encryption/decryption:
  - $E_{k1}(M) = C$, where *k1* is the encryption key
  - $D_{k2}(C) = M$, where *k2* is the decryption key
- Essential property: $D_{k1}(E_{k2}(M)) = M$
- k1 and k2 are mathematically related and they are referred as the *public and private keys*

Asymmetric Ciphers

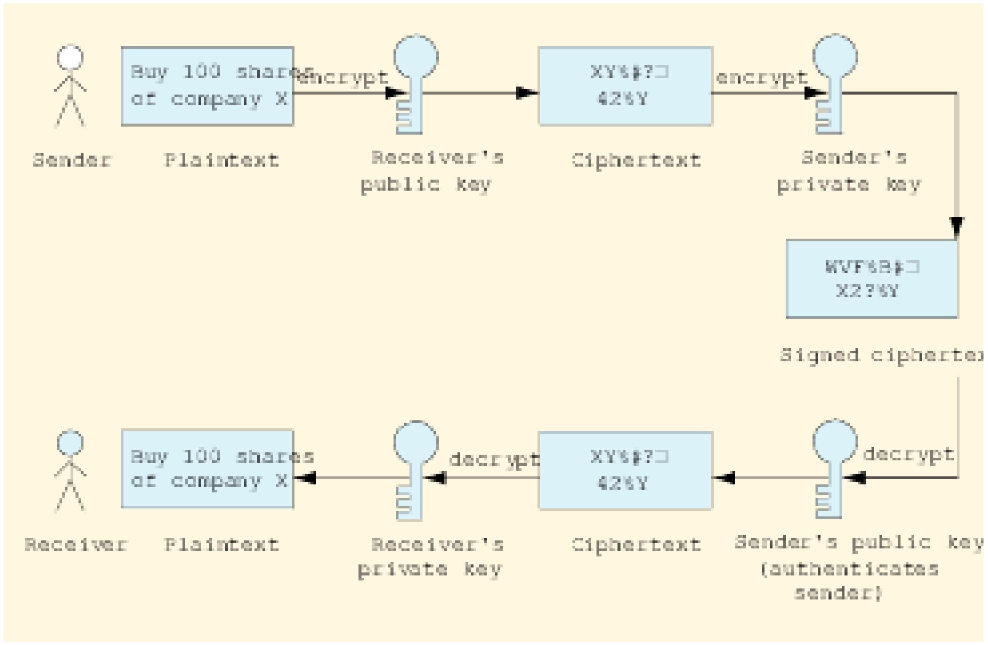
- Security is determined by the strength of the algorithm and the key's length
  - Assume there is a computer capable of trying a billion keys per second
    - Key of 16 bits, 2^16 possibilities, easy to break
    - Key of 128 bits, 10^22 years to try all possibilities
- Use:
  - Public-key crypthography
    - E.g. SSL
  - Digital signatures
  - Certificates
  - *Pretty Good Privacy (PGP),* encrypts e-mails and files using "web of trust"

Public-key Cryptography (cont'd)



Encrypting and decrypting a message using public-key cryptography.

Public-key Cryptography (cont'd)



Authentication with a public-key algorithm

Key Management

Secrecy of private keys crucial to system security

- *Poor key management*: mishandling of private keys
- *Key generation*: process by which keys created
  - Should be as random as possible
- *Brute-force cracking*: decrypting message using every possible decryption key

Java Cryptography Extension (JCE)

- provides Java applications with various security facilities
- supports
  - secret-key encryption
    - 3DES
  - public-key algorithms
    - Diffie-Hellman
    - RSA
- customizable levels of encryption through
  - multiple encryption algorithms
  - various key sizes
- architecture is provider-based
  - developers add algorithms by adding providers' algorithms

Encipher (1/2)

```
import java.awt.*;
import java.awt.event.*;
import java.io.*;
import java.util.*;
import java.security.*;
import java.security.spec.*;
import com.sun.crypto.provider.SunJCE;
import javax.swing.*;
import javax.crypto.*;
import javax.crypto.spec.*;

public class Encipher {

   private static final byte[] salt = {
      ( byte )0xf5, ( byte )0x33, ( byte )0x01, ( byte )0x2a,
      ( byte )0xb2, ( byte )0xcc, ( byte )0xe4, ( byte )0x7f
   };
   private int iterationCount = 100;   // iteration count
   String password = "abc123";

   public Encipher() {

      Security.addProvider( new SunJCE() );

      String line=null;
      StringBuffer buffer= new StringBuffer();
      BufferedReader in = new BufferedReader(new InputStreamReader(System.in));
      while(true) {
            try {        line = in.readLine();  }
            catch(Exception e){}
            if(line.equals("")) break;
            buffer.append(line + "\n");
      }
      String originalText = buffer.toString();
```

Encipher (2/2)

```
 Cipher cipher = null;
      try {
         PBEKeySpec keySpec = new PBEKeySpec( password.toCharArray() );
         SecretKeyFactory keyFactory = SecretKeyFactory.getInstance( "PBEWithMD5AndDES" );
         SecretKey secretKey = keyFactory.generateSecret( keySpec );
         PBEParameterSpec parameterSpec = new PBEParameterSpec( salt, iterationCount );
         cipher = Cipher.getInstance( "PBEWithMD5AndDES" );
         cipher.init( Cipher.ENCRYPT_MODE, secretKey, parameterSpec );
      }
      catch ( Exception e) {}

      byte[] outputArray = null;
      try {
         outputArray = originalText.getBytes( "ISO-8859-1" );
      }
      catch ( Exception e ) {}

      CipherOutputStream out = new CipherOutputStream( System.out, cipher );
      try {
         out.write( outputArray );
         out.flush();
         out.close();
      }
      catch ( Exception e ) {}
   }

   public static void main( String[] args )
   {
      Encipher crypto = new Encipher();
   }
}
```

Decipher (1/2)

```
import java.awt.*;
import java.awt.event.*;
import java.io.*;
import java.util.*;
import java.security.*;
import java.security.spec.*;
import com.sun.crypto.provider.SunJCE;
import javax.swing.*;
import javax.crypto.*;
import javax.crypto.spec.*;

public class Decipher {

   private static final byte[] salt = {
      ( byte )0xf5, ( byte )0x33, ( byte )0x01, ( byte )0x2a,
      ( byte )0xb2, ( byte )0xcc, ( byte )0xe4, ( byte )0x7f
   };
   private int iterationCount = 100;   // iteration count
   String password = "abc123";

   public Decipher() {

      Security.addProvider( new SunJCE() );
      Vector fileBytes = new Vector();
      Cipher cipher = null;
      try {
         PBEKeySpec keySpec = new PBEKeySpec( password.toCharArray() );
         SecretKeyFactory keyFactory = SecretKeyFactory.getInstance( "PBEWithMD5AndDES" );
         SecretKey secretKey = keyFactory.generateSecret( keySpec );
         PBEParameterSpec parameterSpec = new PBEParameterSpec( salt, iterationCount );
         cipher = Cipher.getInstance( "PBEWithMD5AndDES" );
         cipher.init( Cipher.DECRYPT_MODE, secretKey,
            parameterSpec );
      }
      catch ( Exception e) {}
```

Decipher (2/2)

```
      try{
            CipherInputStream in =  new CipherInputStream( System.in, cipher );
            byte contents = ( byte ) in.read();
            while ( contents != -1 ) {
                        fileBytes.add( new Byte( contents ) );
                        contents = ( byte ) in.read();
            }
            in.close();
      }
      catch ( Exception e) {}

      byte[] decryptedText = new byte[ fileBytes.size() ];

      for ( int i = 0; i < fileBytes.size(); i++ )
         decryptedText[ i ] = ( ( Byte )fileBytes.elementAt( i ) ).byteValue();

      System.out.println( new String( decryptedText ) );
   }

   public static void main( String[] args )
   {
      Decipher crypto = new Decipher();
   }
}
```

Run the example

- The secret key was predefined in Encipher.java and Decipher.java
- Create a plain text file “plaintext.txt” with the source data
- To encode:

```
cat plaintext.txt | java Encipher > ciphertext.txt
```

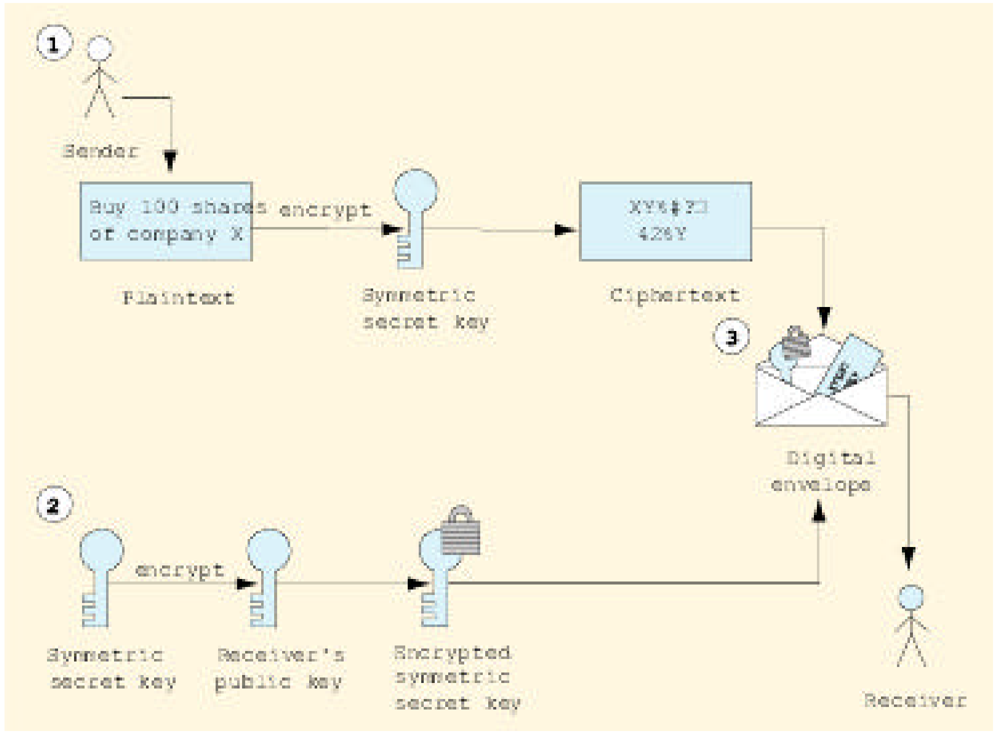
- ciphertxt.txt now contains the encoded text
- To decode:

```
cat ciphertext.txt | java Encipher
```

Key Agreement Protocols

- Public-key algorithms not efficient for large amounts of data
  - Large computing power requirements slow communication
- *Key Agreement Protocol*
  - Two parties exchange keys over unsecure medium
  - *Digital envelope*: symmetric secret key encrypted using public-key encryption

Digital Envelope

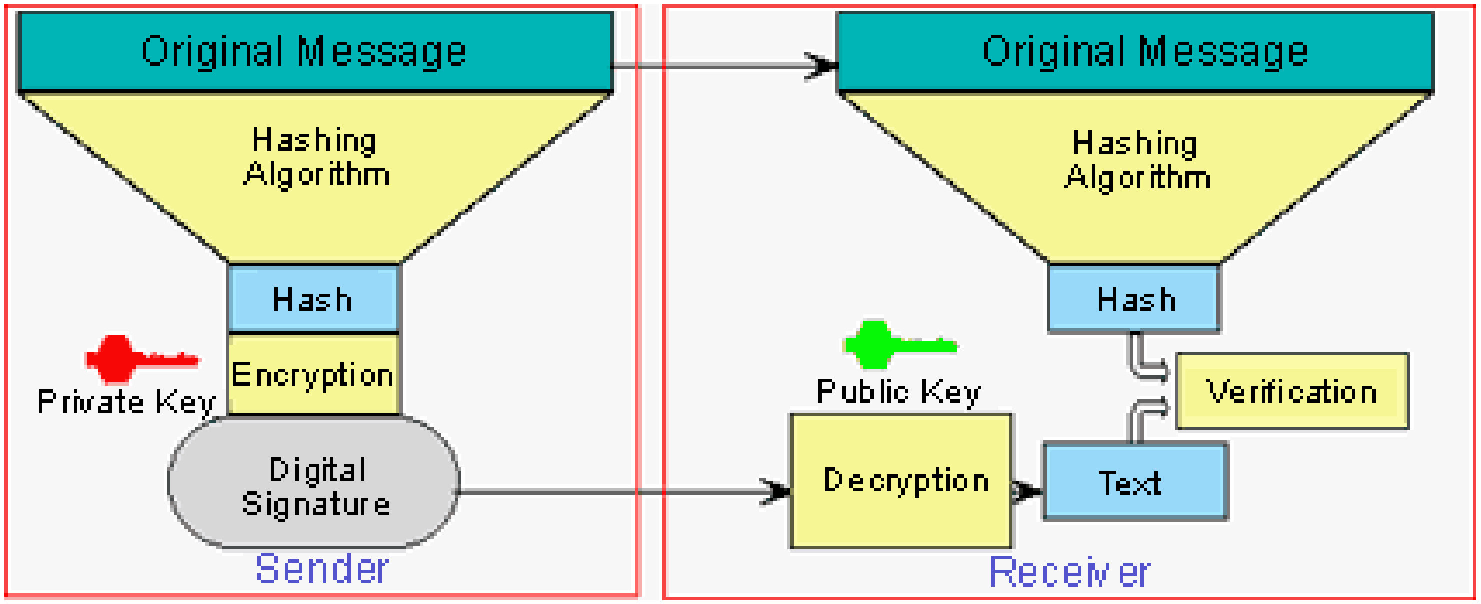


Digital Signatures

- Provide proof of authenticity of the sender and integrity of the message
- The sender cannot deny that he/she signed a document (non-repudiation)
- Rely on public-key cryptography
- The basic digital signature protocol is:
  - The sender encrypts the document with his/her private key, implicitly signing the document
  - The message is sent
  - The receiver decrypts the document with the sender's public key, thereby verifying the signature

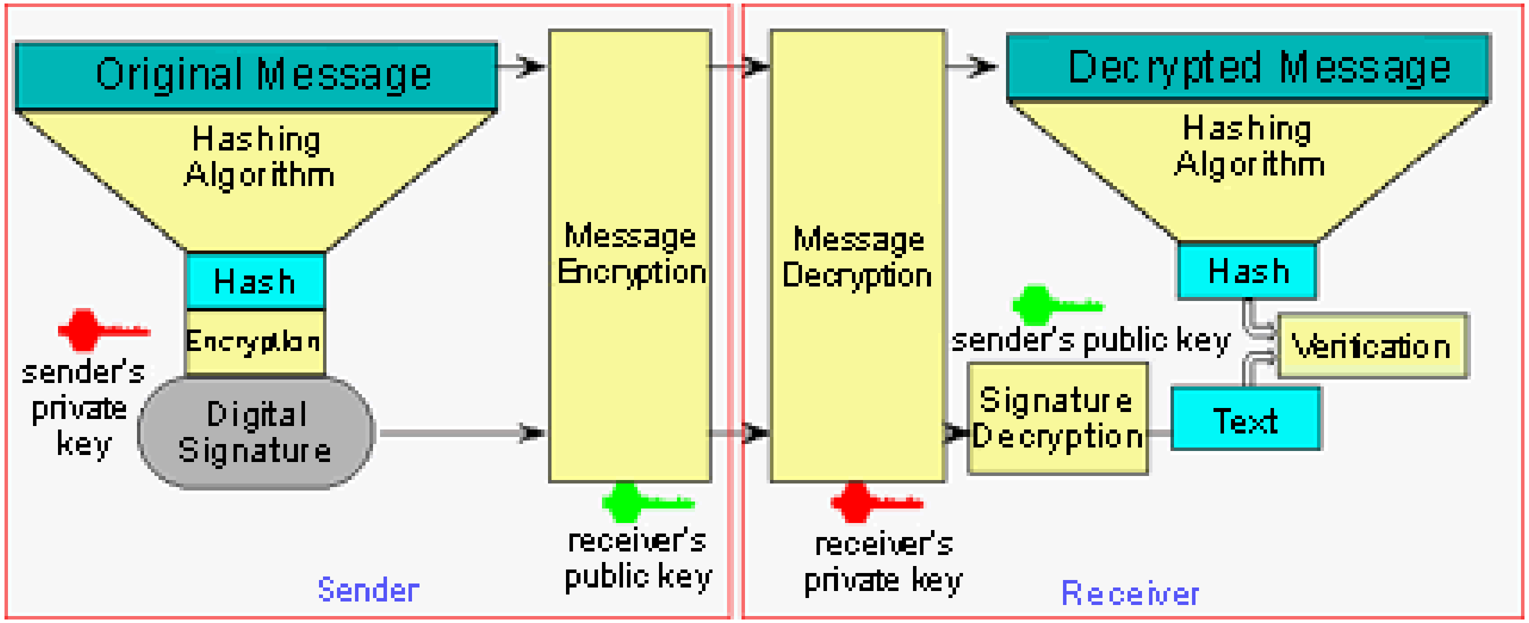
Digital Signatures (cont’d)

- To reduce processing time, often only a hash of the message is signed:



Digital Signatures (cont’d)

- Encryption can be included to guarantee confidentiality:



Public Key Infrastructure (PKI)

- Integrates public-key cryptography with *digital certificates* and *certification authorities (CA’s)*
  - Digital certificate: identifies user, issued by certification authority (such as VeriSign)
  - Digital certificates stored in *certificate repositories*
- *Certificate authority hierarchy*
  - *Root certification authority*, the Internet Policy Registration Authority (IPRA), signs certificates for *policy creation authorities* who set policies for obtaining digital certificates
  - Policy creation authorities sign for CA’s who sign for individuals and organizations
  - Signings use public-key cryptography

PKI, Certificates and CA (cont'd)

- Changing keys necessary for maintaining security
  - Digital certificates have expiration dates
  - Canceled and revoked certificates placed on *certificate revocation list (CRL)*
- Ensuring authenticity
  - Check certificate with CRL (inconvenient)
  - *Online Certificate Status Protocol (OCSP)* validates certificates in real-time
- PKI and digital certificate transactions are more secure than phone line, mail or even credit-card transactions

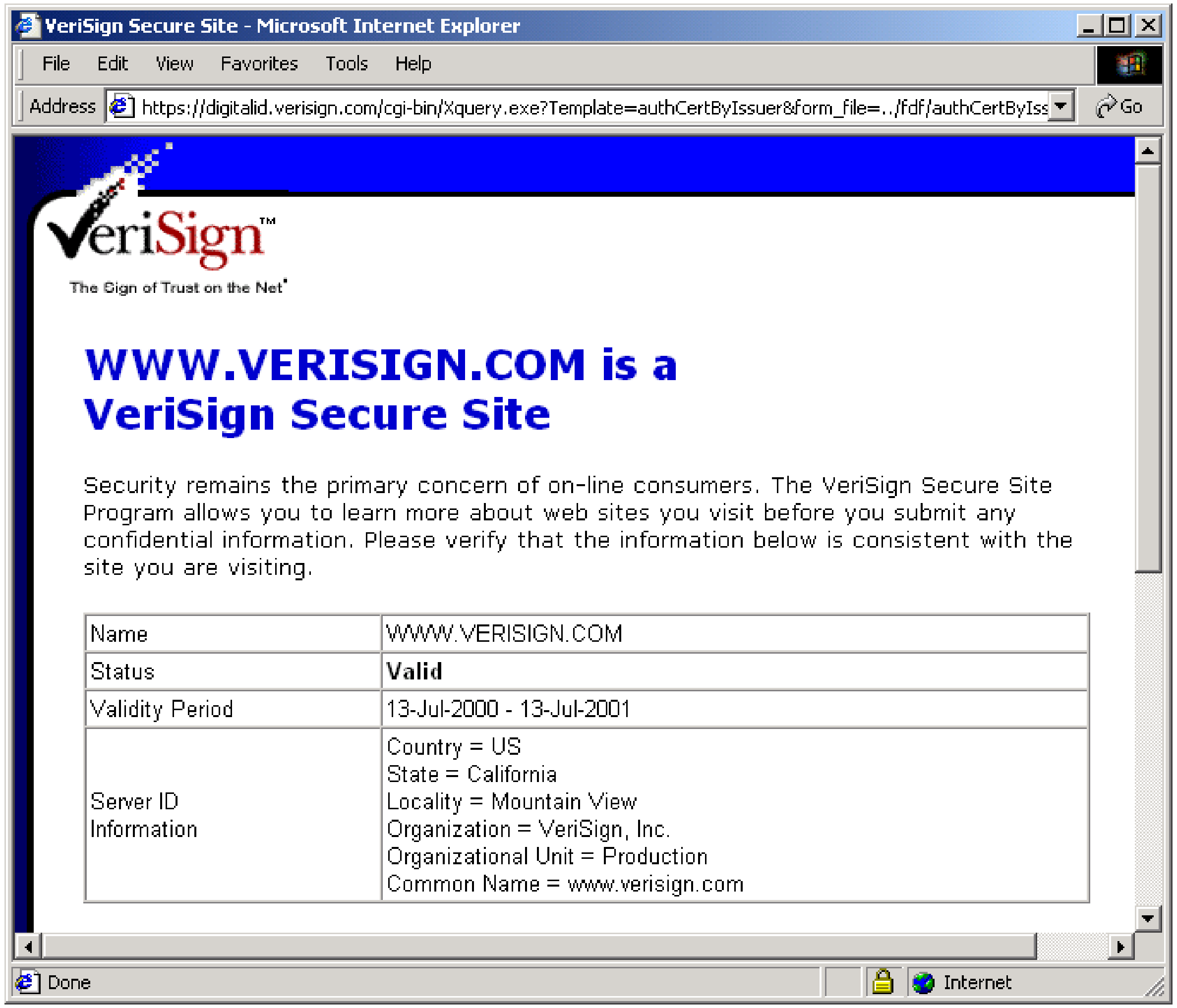
Certificates

- Issued by a CA
- Digitally signed by the CA
- Implicit assumption: CA’s signature is widely available and trusted
- Use X.509 format

X.509 Format

- Version and Serial Number
- Subject Name and afiliation
- Issuer Name
- Signature Algorithm
- Period of Validity

A Certificate Authority



VeriSign Secure Site - Microsoft Internet Explorer

File Edit View Favorites Tools Help
Address https://digitalid.verisign.com/cgi-bin/Xquery.exe?Template=authCertByIssuer&form_file=../fdf/authCertByIss
Go
VeriSign™
The Sign of Trust on the Net
Done
Internet

WWW.VERISIGN.COM is a VeriSign Secure Site

Security remains the primary concern of on-line consumers. The VeriSign Secure Site Program allows you to learn more about web sites you visit before you submit any confidential information. Please verify that the information below is consistent with the site you are visiting.

Name	WWW.VERISIGN.COM
Status	**Valid**
Validity Period	13-Jul-2000 - 13-Jul-2001

Server ID Information	Country = US
	State = California
	Locality = Mountain View
	Organization = VeriSign, Inc.
	Organizational Unit = Production
	Common Name = www.verisign.com

A portion of the VeriSign digital certificate. (Courtesy of VeriSign, Inc.)

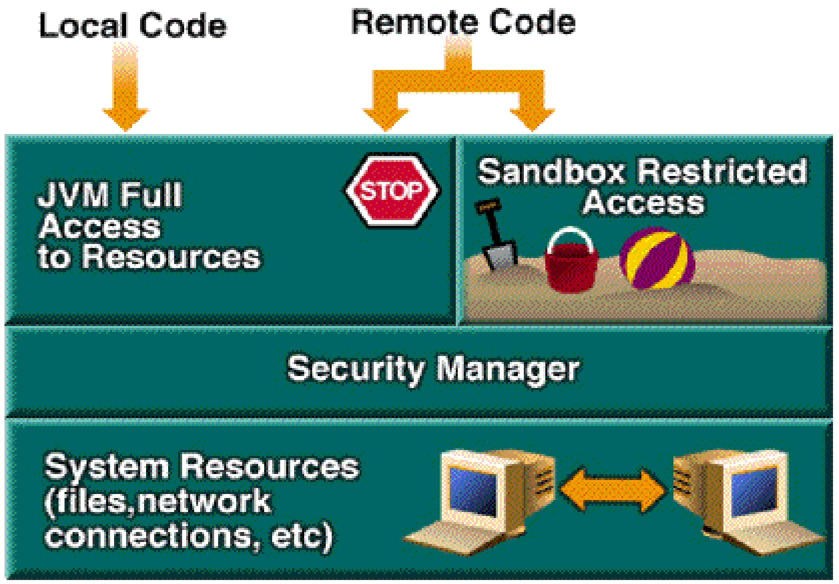
Java Security Architecture

Java Security

- Java code can originate and run anywhere in the network
- Java has been designed to run code securely via enforcement of security policies during execution

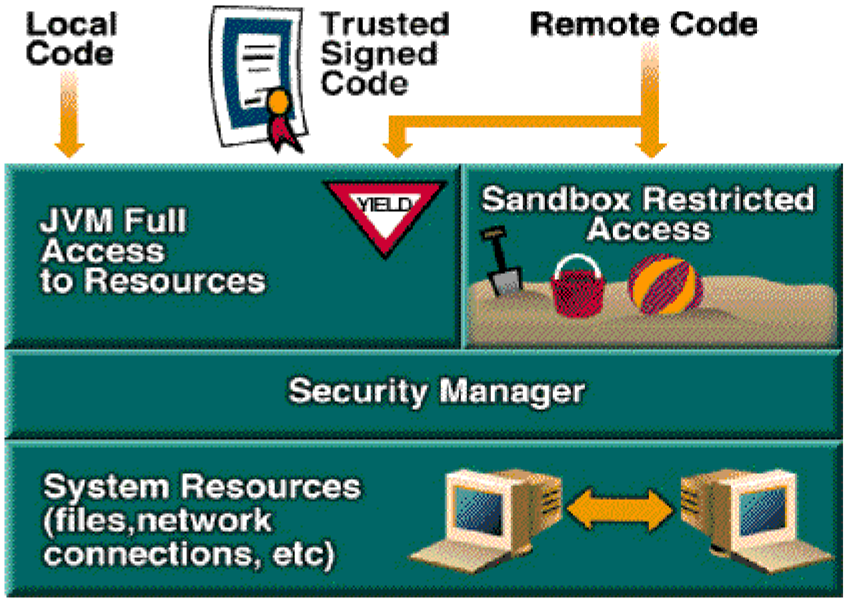
Evolution of Java Security

- JDK 1.0: The sandbox
  - The sandbox model confines Java applets to a defined arena where they cannot affect system resources
  - Applications enjoy unlimited access to all resources


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

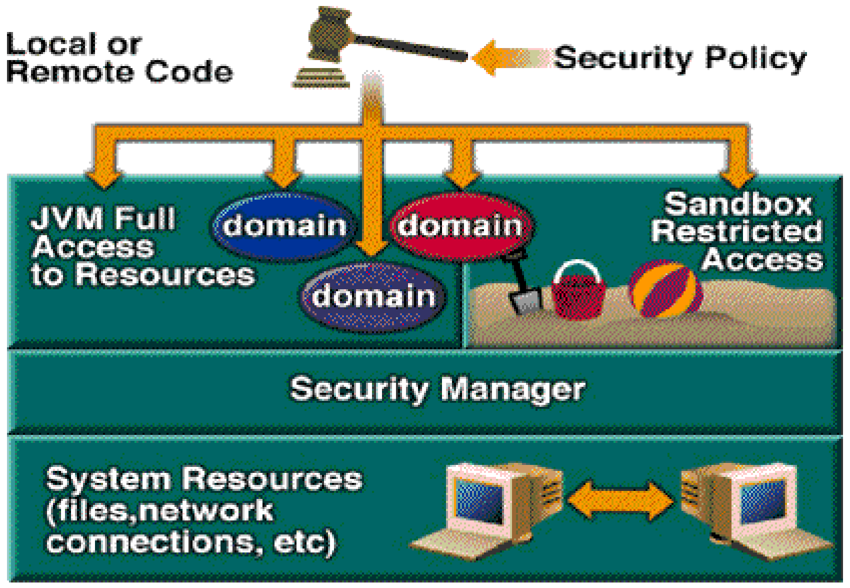
Evolution of Java Security

- JDK 1.1: all or nothing
  - Introduced signed applets which enjoyed unlimited access to all resources just like local applications
  - No selective access

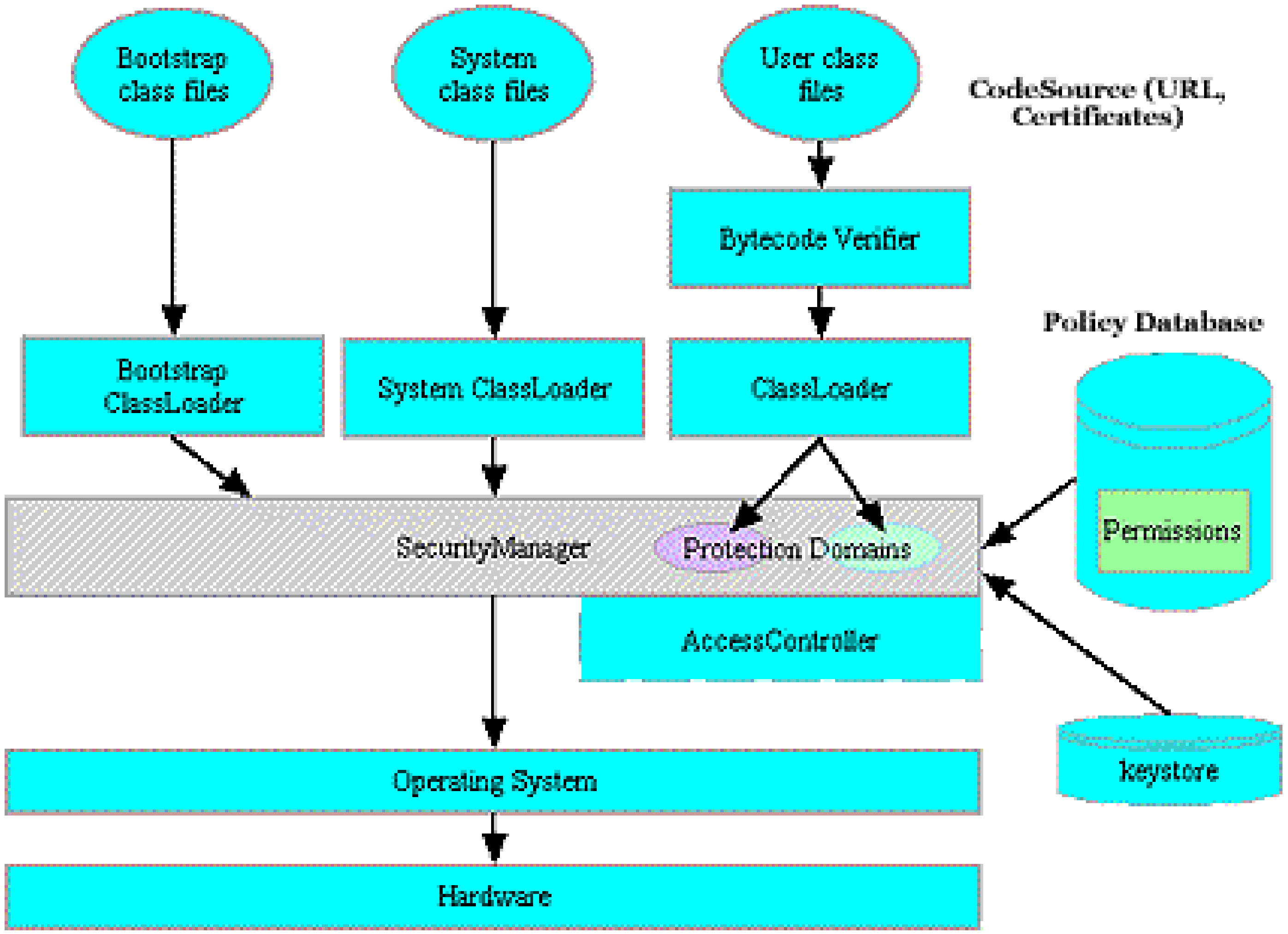

Local Code
Trusted Signed Code
Remote Code
JVM Full Access to Resources
YIELD
Sandbox Restricted Access
Security Manager
System Resources (files,network connections, etc)

Evolution of Java Security

- JDK 2: fine-grained security
  - Flexible policy for applets and applications
  - Introduces the concept of ProtectionDomain


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)

Java 2 Security Architecture



1. Byte-code verifier

- It screens the code to be sure that it was produced by a trustworthy compiler:
  - the format of the class file, the right length, the correct magic numbers, no operand stack overflows and underflows, and so on.
  - confirms or denies that the class file is consistent with the specifications
- Its behavior may be altered with command line options on the interpreter, when applicable.

2. ClassLoader

- The ClassLoader loads Java byte codes into the JVM
- Works in conjunction with the SecurityManager and the access controller to enforce security rules
- Information about the URL from which the code originated and the code's signers is initially available to the ClassLoader

3. CodeSource

- The object java.security.CodeSource fully describes a piece of code:
  - code's origin (URL)
  - digital certificates containing public keys corresponding to private keys used to sign the code.
- Many access-control decisions are based in part on this property

4. Protection domains

- It is more flexible to group classes into protection domains and associate permissions with those domains (Rather than to associate permissions to individual classes)
- This relationship between the class and the permissions via the protection domain provides for flexible implementation mechanisms.

5. Policy

- The numerous mappings of permissions to classes are collectively referred to as *policy*
- A policy file is used to configure the policy for a particular implementation
- It can be composed by a simple text editor or using policytool (GUI)

6. Permissions

- Permission classes represent access to various system resources such as files, sockets, and so on
- For example, permission may be given to read and write files in the /tmp directory
- Permission classes are additive. They represent approvals, but not denials
- A number of permission classes are subclasses of the abstract java.security.Permission class, examples of which include FilePermission, AWTPermission, and even customized protections like SendMailPermission

7. SecurityManager

- The class java.lang.SecurityManager is at the focal point of authorization
- SecurityManager consists of a number of *check* methods. For example:
  - checkRead (String file) can determine read access to a file.
  - checkPermission(Permission perm, Object context) method can check to see if the requested access has the given permission based on the policy.
- The access controller will raise an exception if the requested permission cannot be granted.

8. AccessController

- The java.security.AccessController class is used for three purposes:
  - To decide whether access to a critical system resource should be allowed or denied, based on the security policy currently in effect
  - To mark code as privileged, thus affecting subsequent access determinations
  - To obtain a snapshot of the current calling context, so access-control decisions from a different context can be made with respect to the saved context
- While the SecurityManager can be overridden, the static methods in AccessController are always available

9. keystore

- The keystore is a password-protected database that holds private keys and certificates.
- A password is selected at the time of creation
- Each database entry can be guarded by its own password for extra security
- Certificates accepted into the keystore are considered to be trusted. Keystore information can be used and updated by the security tools provided with the SDK

Example: Application Security

```
import java.io.*;
import java.util.*;

public class writeFile {
 public writeFile() {

   String filename="thisisthefile.txt";
   File file = new File(filename);
   try {
      BufferedWriter output = new BufferedWriter(new FileWriter(file));
      output.write("Hello there");
      output.close();
   }
   catch (SecurityException e) {
        System.err.println("writeFile: caught security exception"); }
   catch (IOException e) {
        System.err.println("writeFile: caught IO exception");       }
 }

 public static void main(String[] args) {
   writeFile wf = new writeFile();
 }
}
```

Running the Example

- This succeeds:

```
java writeFile
```

- This produces a security exception:

```
java –Djava.security.manager writeFile
```

Defining the policy

- Create the file my.policy:

```
grant {

  permission java.io.FilePermission
  "<<ALL FILES>>", "write";
};
```

- Now run the program:

```
java –Djava.security.manager –
  Djava.security.policy=my.policy writeFile
```

Example: Applet Security

```
import java.io.*; import java.util.*; import java.awt.*; import
   java.applet.*;

public class writeFile extends Applet {
   public void paint(Graphics g) {
   String filename="thisisthefile.txt";
   File file = new File(filename);
   try {
      BufferedWriter output = new BufferedWriter(new FileWriter(file));
      output.write("Hello there");
      output.close();
      g.drawString("File " + filename + " written", 10, 10);
   }
   catch (SecurityException e) {
      g.drawString("writeFile: caught security exception", 10, 10);  }
   catch (IOException e) {
      g.drawString("writeFile: caught IO exception", 10, 10);       }
   }

   public static void main(String[] args) {
   Frame f = new Frame("writeFile");
   writeFile wf = new writeFile();
   wf.start();
   f.add("Center", wf);   f.setSize(300,300);       f.show();
   }
}
```

HTML

```
<html>
<title> Java Security Example: Writing Files</title>
<h1> Java Security Example: Writing Files </h1>
<hr>
<APPLET  CODE = writeFile.class  WIDTH = 500 HEIGHT
  = 50 >
</APPLET>
<hr>
</html>
```

Running the Example

- This produces a security exception:

  appletviewer index.html

- This succeeds:

  appletviewer –J”-Djava.security.manager=my.policy” index.html

Browsers and Security

- Default lack of trust in downloaded code
  - Addressed by the sandbox model
- Limited access to command-line options within the browser
  - No simple way to deploy and use customized policy files
- Inadequate support for some security features in the JVMs bundled with browsers
  - Solved by using a java plug-in

SDK Security Tools

- Keytool
  - Manages keystores and certificates
- Jarsigner
  - Generates and verifies JAR signatures
- Policytool
  - Manages policy files via a GUI-based tool

keytool

- Create/Manage public/private key pairs
- Issue certificate requests (sent to the appropriate Certification Authority)
- Import certificate replies (obtained from the Certification Authority you contacted)
- Designate public keys belonging to other parties as trusted

keytool

- *Keystore*
  - repository for storing public and private keys
  - modifying stored keys requires use of password
  - default keystore located in **`home/user/.keystore`**
- command line arguments

`-genkey`

produces private and public key pair

`-export`

export a certificate

`-import`

import certificate from trusted source

`-list`

list all contents of keystore

`-alias` <*alias_name*>

identify public and private pair for later use

keytool

- **`keytool`**-generated certificates identified through
  - *commonName (CN)*
  - *organizationUnit (OU)*
  - *organizationName (O)*
  - *localityName (L)*
  - *stateName (S)*
  - *country (C)*

keytool

- To generate a public and private key pair

```
keytool –genkey –alias MyCertificate
```

- Obtain digital certificate from certificate authority

```
keytool –certreq –alias MyCertificate –file
myRequest.cer
```

- Submit certificate file to authority
  - follow authority’s steps on Web site
- To generate certificate other users may use

```
keytool –export –alias MyCertificate –file
myCertificate.cer
```

Digital Signatures for Java Code

- Java Plug-in supports RSA-signed applets
- Steps
  - generate RSA keypair

    ```
    keytool –genkey –keyalg RSA –alias MyCertificate
    ```
  - export digital signature to file

    ```
    keytool –export –alias MyCertificate –file myCertificate.cer
    ```
  - add to keystore

    ```
    keytool –import –alias MyTrustedCertificate –keystore cacerts
       –file myCertificate.cer
    ```
    - `cacerts` is complete path to keystore
  - sign applet’s JAR file with digital signature

    ```
    jarsigner FileTreeApplet.jar MyCertificate
    ```
  - enable Java Plug-in instead of Web browser’s JVM

    ```
    htmlconverter signedApplet.html
    ```

Example

- See LectureSet6/applet_signature
- Server side:
  - **`keytool -genkey -alias alias    -keystore server.ks -storepass storepass -keypass keypass`**
  - **`keytool -selfcert -alias alias    -keystore server.ks -storepass storepass -keypass keypass`**
  - **`keytool -export -file client.cer -alias alias -keystore server.ks -storepass storepass -keypass keypass`**
  - **`keytool -list     -keystore server.ks -storepass storepass -keypass keypass`**
  - **`jarsigner -keystore server.ks -storepass storepass -keypass keypass WriteFile.jar rlent`**

Example: Client side

- Using appletviewer:
  - `keytool -printcert -file client.cer`
  - `keytool -import -file client.cer -keystore client.ks -storepass storepass -keypass keypass`
  - `appletviewer -J-Djava.security.policy=client.policy index.html`
- Using a browser
  - Install Java plug-in !

Authentication

- Current authentication models
  - restrict access to certain aspects of a program
  - allow users to connect to a network
  - regulate resources available to users on network
- *Java Authentication and Authorization Service (JAAS)*
  - based on plug-in framework
  - allows *Kerberos* and *single sign-on* implementations

Kerberos

- Employs secret key cryptography
- Authentication handled by
  - Kerberos system
    - authenticates client's identity
  - secondary *Ticket Granting Service* (TGS)
    - similar to key distribution centers
    - authenticates client's rights to access services
- Authentication cycle
  1. client submits user name and password to Kerberos server
  2. server returns Ticket-Granting Ticket (TGT)
     - encrypted with client's key
  3. client decrypts TGT
  4. client requests *service ticket* by sending decrypted TGT to TGS
  5. server authorizes client with renewable service ticket

Single Sign-On

- Single sign-on allows users to log into different servers once with single password.
- three types:
  1. workstation login scripts
     - login script sends password to each application
       - stores password on workstation
  2. authentication server scripts
     - authenticate users with central server
  3. tokens
     - once authenticated, non-reusable token identifies user

Java Authentication and Authorization Service (JAAS)

- Protects applications from unauthorized users.
- Based on *Pluggable Authentication Module (PAM)*
    - supports multiple authentication systems
    - different authentication systems may be combined
- Can control access by
    - user
        - governs access to resources on user policies
    - group
        - associates user to group, bases policies on group privileges
    - role-based security policies
        - similar to group policies
        - unlike group policies, no default policies exist
            - users obtain privileges to needed applications based on intended task

JAAS (cont’d)

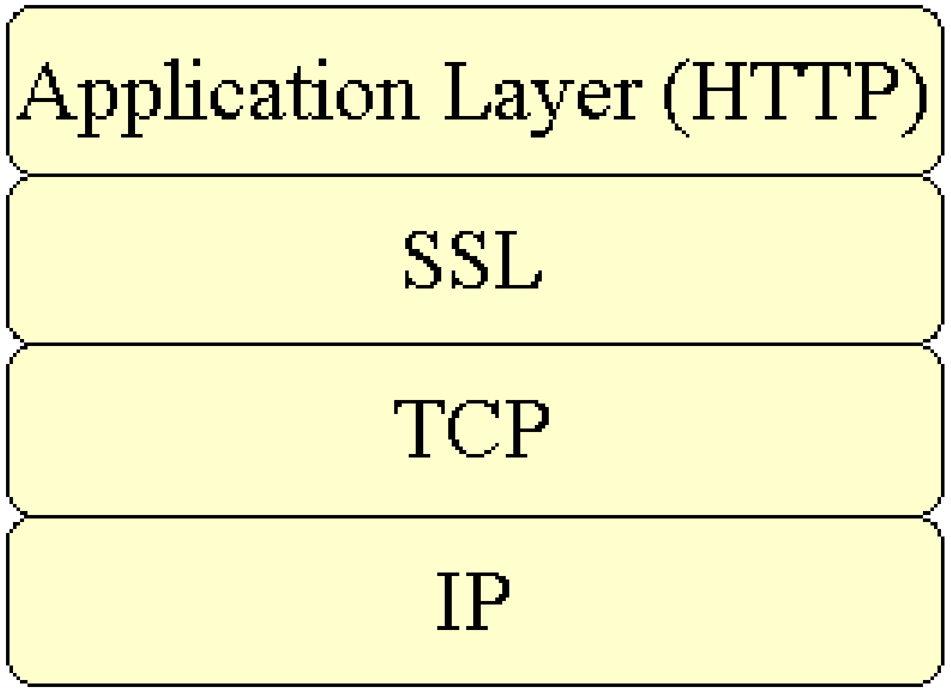
- Example **`AuthenticateNT`**
- To execute:

```
java –Djava.security.policy=java.policy
  -Djava.security.auth.policy=jaas.policy
  -Djava.security.auth.login.config=jaas.config
  AuthenticateNT
```

Secure Sockets Layer (SSL)

- Nonproprietary protocol
- Used to secure communications between computers
- Implements
  - public-key technology using RSA algorithm
  - digital certificates
    - to authenticate server
    - to protect private information
- Does not require user authentication

TCP/IP and SSL Protocol Stack



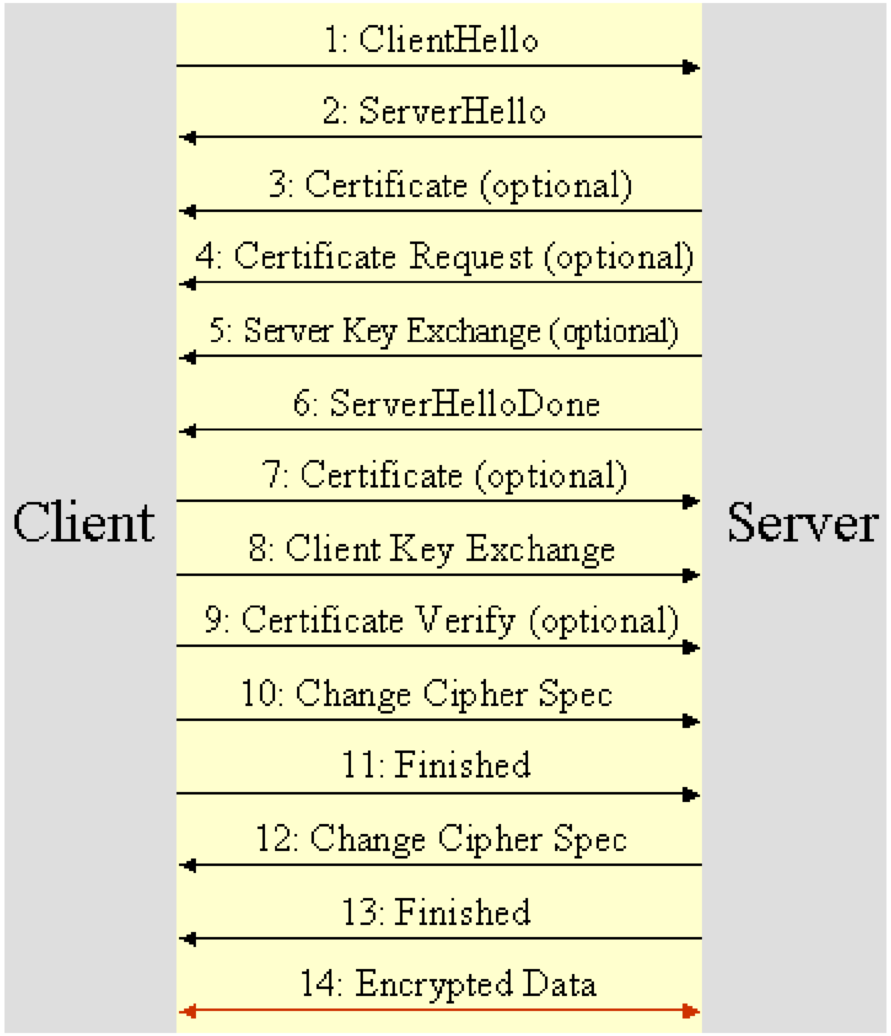
SSL (cont'd)

- Process:
  1. client sends message to server
  2. server responds with digital certificate
  3. client and server negotiate session keys
     - use public key cryptography for negotiation
  4. once keys established, communication proceeds
     - information encrypted
     - information transmitted
     - information decrypted at receiving end
- Primarily secure *point-to-point* connections

Java Secure Socket Extension (JSSE)

- SSL encryption integrated into Java through *Java Secure Socket Extension (JSEE)*
- Secures passage of information between two clients
- Use of SSL connections transparent to user

SSL Handshake Protocol



Example SSL Client/Server

~/LectureSet6/ssl, files:

- client/client.java
- server/server.java

Run the example: Server side

- Create keystore and certificate:

```
keytool –genkey –keystore SSLStore –alias
  SSLCertificate –keypass keypass –storepass storepass
```

  If SSLStore does not exist, this will create keystore with storepass as password

- To check stored entries:

```
keytool –list –keystore SSLStore
```

- Execute **sslServer**

```
java –Djavax.net.ssl.keyStore=SSLStore
  -Djavax.net.ssl.keyStorePassword=password sslServer
```

- Export Certificate

```
keytool –export –alias SSLCertificate –keystore
  SSLStore –file mycertificate.cer
```

Now make file mycertificate.cer available to client

Run the example: Client side

- Get file mycertificate.cer from server
- Import Certificate

```
keytool –import –alias SSLCertificate –keystore
  SSLStore –file mycertificate.cer
```

- To check the entry:

```
keytool –list –keystore SSLStore
```

- Execute **sslClient**

```
java –Djavax.net.ssl.trustStore=SSLStore
  -Djavax.net.ssl.trustStorePassword=password sslClient
```

Example HTTPS

~/LectureSet6/https, files:

- sslWebClient.java
- Two versions of the server:
  - sslWebServer.java (security parameters externally defined)
  - sslWebServer2.java(security parameters internally defined)
- cert-s.sh and cert-c.sh create certificates for server and client
- runs.sh and runc.sh execute server and client with external parameters