Java Cryptography – Dealing with Practical Issues

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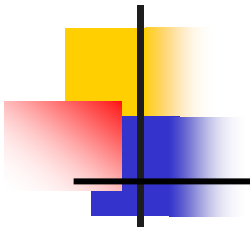
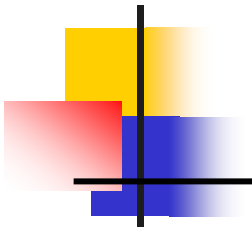


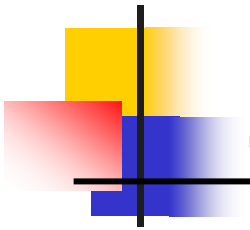
Sorting Out the Alphabet Soup

- Java Cryptography Architecture (JCA)
  - Framework for accessing and developing cryptographic functionality for the Java platform
    - Introduced in JDK 1.1
    - Enhanced and extended in subsequent releases
  - Encompasses the parts of the J2SDK Security API related to cryptography
  - Includes the provider architecture



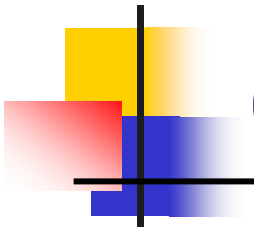
Sorting Out the Alphabet Soup(2)

- Java Cryptography Extension (JCE)
  - Extends the JCA API to include APIs for:
    - Encryption
    - Key exchange
    - Message authentication
  - An extension to versions 1.2 and 1.3
  - Integrated into JDK 1.4



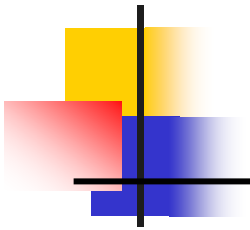
JCA Design Principles

- Implementation independence and interoperability
  - Achieved using a provider-based architecture
- Algorithm independence and extensibility
  - Achieved by defining classes that provide the functionality of well-defined "engines"
- Extensibility
  - New algorithms can be easily added



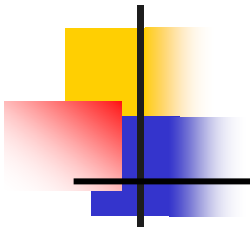
Cryptographic Service Provider

- A package (or set of packages) that supplies a concrete implementation of a subset of the cryptography aspects of the Security API
- Each SDK installation has one or more provider packages installed
- New providers may be added statically or dynamically



Practical Issue 1

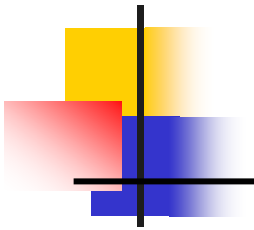
- Determining which providers are available and the services they offer
- The architecture was designed in such a manner that you can achieve this goal using code, so you do not have to rely on external documentation



Listing Providers

- The static method **`getProviders()`** of the **`Security`** class returns an array of **`Provider`** objects

- The **`Provider`** class defines the methods:
  - **`getName()`**
  - **`getVersion()`**
  - **`getInfo()`**
  - **`toString()`**

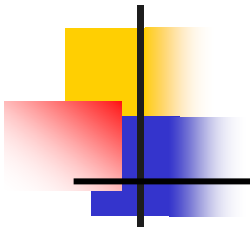


Listing Providers

```
import java.security.Provider;
import java.security.Security;
public class ListProviders {
  public static void main(String[] args) {
    Provider[] p = Security.getProviders();
    for (int i = 0; i < p.length; ++i) {
      System.out.println("-------------");
      System.out.println("PROVIDER # " + (i + 1));
      System.out.println(p[i]);
      System.out.println("info: " + p[i].getInfo());
      System.out.println("name: " + p[i].getName());
      System.out.println("version: " + p[i].getVersion());
      System.out.println("string: " + p[i].toString());
      System.out.println();
    }
    System.exit(0);

  }
}
```

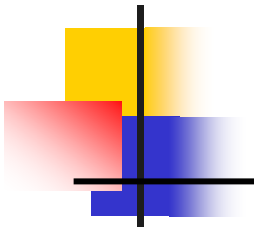
Partial List of Providers

```
------------
PROVIDER # 1
SUN version 1.2
info: SUN (DSA key/parameter generation; DSA signing; SHA-
1, MD5 digests; SecureRandom; X.509 certificates; JKS
keystore; PKIX CertPathValidator; PKIX CertPathBuilder;
LDAP, Collection CertStores)
name: SUN
version: 1.2
string: SUN version 1.2

------------
PROVIDER # 2
SunJSSE version 1.41
info: Sun JSSE provider(implements RSA Signatures, PKCS12,
SunX509 key/trust factories, SSLv3, TLSv1)
name: SunJSSE
version: 1.41
string: SunJSSE version 1.41
```



Determining Available Services

- Can be approached at two levels:
  - Use the **`keySet()`** method of **`Provider`**
    - Returns a **`Set`**
    - Use **`Iterator`** to retrieve elements
  - Use the **`getAlgorithms()`** method of **`Security`**
    - Takes as argument a **`String`** specifying one of:
      - ✓ "Signature", "MessageDigest", "Cipher", "Mac", "Keystore"
    - Returns a **`Set`**
    - Use **`Iterator`** to retrieve elements

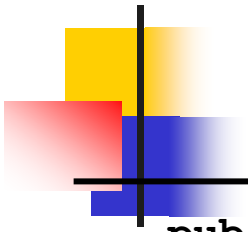


ListProviderProperties

```
import java.security.Provider;
import java.security.Security;
import java.util.Iterator;
import java.util.Set;
public class ListProviderProperties {
  public static void main(String[] args) {
    Provider[] providers = Security.getProviders();
    for (int i = 0; i < providers.length; ++i) {
      System.out.println("Provider " + providers[i]
        .getName() + " has the following properties:");
      System.out.println();
      Set keyset = providers[i].keySet();
      Iterator it = keyset.iterator();
      while (it.hasNext()) {
        System.out.println((String)it.next());
      }
    }
  }
}
```

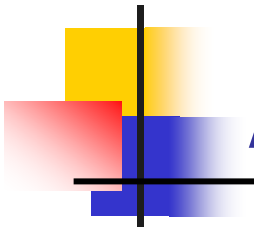
Partial List of Properties

```
Provider SunJCE has the following properties:

Cipher.DES
KeyStore.JCEKS
Alg.Alias.SecretKeyFactory.TripleDES
SecretKeyFactory.DES
KeyGenerator.HmacSHA1
Alg.Alias.KeyFactory.DH
KeyGenerator.DESede
Mac.HmacMD5
Cipher.Blowfish
Mac.HmacSHA1
Cipher.DESede
AlgorithmParameters.DESede
Alg.Alias.AlgorithmParameters.TripleDES
KeyPairGenerator.DiffieHellman
KeyFactory.DiffieHellman
Alg.Alias.AlgorithmParameters.PBEWithMD5AndDES
AlgorithmParameters.PBE
AlgorithmParameterGenerator.DiffieHellman
```



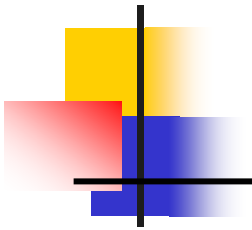
ListAlgorithms

```
public class ListAlgorithms {
  public static void main(String[] args) {
    String[] services = {"Signature", "MessageDigest",
      "Cipher", "Mac", "KeyStore”};
    for (int i = 0; i < services.length; ++i) {
      System.out.println("\n" + services[i] + ":");
      Set s = Security.getAlgorithms(services[i]);
      Iterator it = s.iterator();
      while (it.hasNext()) {
        System.out.println("\t" + (String)it.next());
      }
    }
  }
}
```



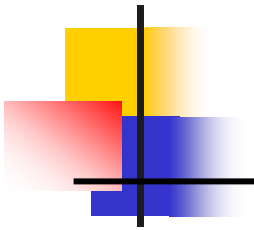
Available Algorithms

```
Signature:
   MD2WITHRSA
   SHA1WITHRSA
   SHA1WITHDSA
   MD5WITHRSA

MessageDigest:
   SHA
   MD5

Mac:
   HMACSHA1
   HMACMD5

Cipher:
PBEWITHMD5ANDTRIPLEDES
DESEDE
PBEWITHMD5ANDDES
BLOWFISH
DES

KeyStore:
   PKCS12
   JKS
   JCEKS
```



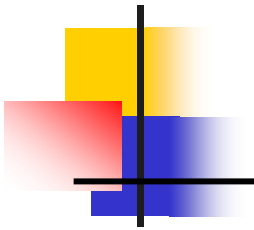
Standard Names

- JCE API requires and utilizes standard names for algorithms, algorithm modes and padding schemes
- Standard names defined in Appendix A of *Java Cryptography Architecture API Specification and Reference*
- Standard name list is supplemented in Appendix A of *Java Cryptography Extension (JCE) Reference Guide*



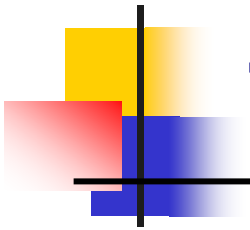
Examples of Standard Names

- Message digest:
  - MD2
  - MD5
  - SHA-1
- Cipher:
  - AES
  - Blowfish
  - DES



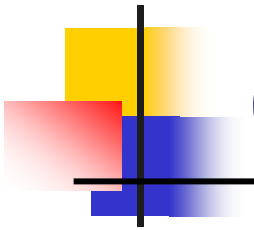
Practical Issue 2

- Obtaining sample code, or at least code snippets
- The *Java Cryptography Extension 1.2.2 API Specification & Reference* available from http://java.sun.com provides several useful examples
- The slides that follow offer additional snippets (full code will be available on the conference CD)



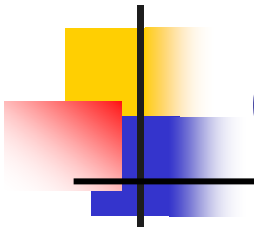
The Signature Class

- Based on algorithms whose mathematical properties are such that output produced by applying the algorithm using a public key is identical to output produced by applying the algorithm using the corresponding private key
- Used to authenticate and ensure integrity



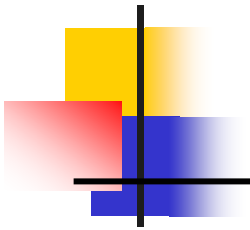
Generating a Digital Signature

- Generate a public/private key pair
- Obtain a **`Signature`** object
- Generate the signature
- Transmit the document, signature and public key to the recipient



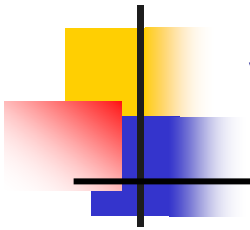
Generating a Key Pair

```
KeyPairGenerator keyGen = KeyPairGenerator.getInstance("DSA");
SecureRandom random = SecureRandom.getInstance("SHA1PRNG");

keyGen.initialize(1024, random);

KeyPair pair = keyGen.generateKeyPair();

PrivateKey priv = pair.getPrivate();
PublicKey pub = pair.getPublic();
```



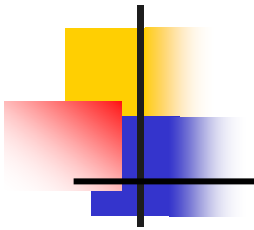
Signing a Document

```
Signature siginst = Signature.getInstance("SHA1withDSA");
siginst.initSign(priv);
FileInputStream fis = new FileInputStream(args[0]);
BufferedInputStream bufin = new BufferedInputStream(fis);
byte[] buffer = new byte[1024];
int len;
while (bufin.available() != 0) {
len = bufin.read(buffer);
siginst.update(buffer, 0, len);
};
bufin.close();
byte[] signature = siginst.sign();
```



Verifying a Signature

- Get the public key
- Get the signature bytes
- Obtain a **`Signature`** object
- Update **`Signature`** object with bytes from document that was originally signed
- Pass signature bytes to verify() method of **`Signature`** object
- Method returns **`true`** or **`false`**

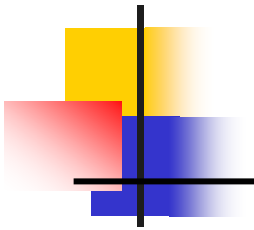


Retrieving a Public Key

```
FileInputStream keyfis = new FileInputStream(args[0]);
byte[] encKey = new byte[keyfis.available()];
keyfis.read(encKey);
keyfis.close();
X509EncodedKeySpec pubKeySpec = new X509EncodedKeySpec(encKey);
KeyFactory keyFactory = KeyFactory.getInstance("DSA");
PublicKey pubKey = keyFactory.generatePublic(pubKeySpec);
```

Obtaining and Initializing a Signature Object

```
Signature signature = Signature.getInstance("SHA1withDSA");
signature.initVerify(pubKey);
```

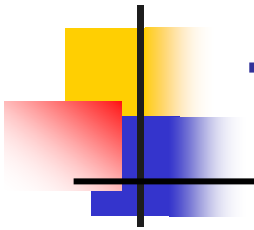


Updating the Signature Object

```
FileInputStream datafis = new FileInputStream(args[2]);
BufferedInputStream bufin = new BufferedInputStream(datafis);
byte[] buffer = new byte[1024];
int len;
while (bufin.available() != 0) {
  len = bufin.read(buffer);
  signature.update(buffer, 0, len);
};
bufin.close();
```

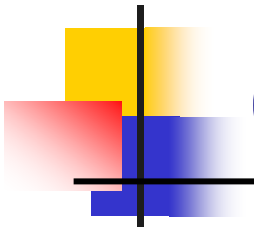
Performing Signature Verification

```
FileInputStream sigfis = new FileInputStream(args[1]);
byte[] candidateSignature = new byte[sigfis.available()];
sigfis.read(candidateSignature );
sigfis.close();
boolean verifies = signature.verify(candidateSignature);
System.out.println("signature is" +
  ((verifies) ? " " : " not ") + "valid");
```



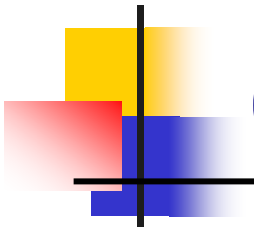
The Cipher Class

- Provides the functionality of a cryptographic cipher
- Two types:
  - Symmetric
    - Relies on a shared secret
    - Same key used for encryption and decryption
  - Asymmetric
    - Uses public/private key pair for encryption and decryption



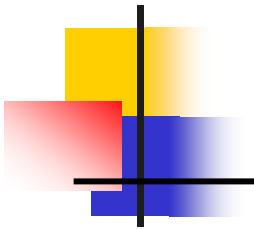
Creating a Cipher Object

```
Cipher c = Cipher.getInstance("DES");
```



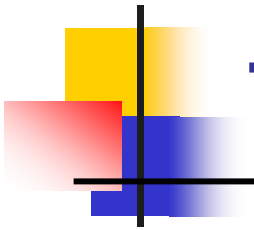
Creating a Secret Key

```
SecretKeyFactory desFactory = SecretKeyFactory.getInstance("DES");
DESKeySpec spec = new DESKeySpec(passPhrase.getBytes(),0);
key = desFactory.generateSecret(spec);
```



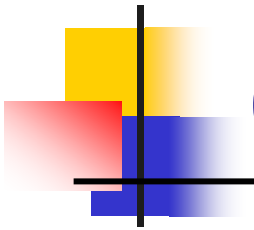
Using a Cipher

```
Cipher c = Cipher.getInstance("DES");

SecretKeyFactory desFactory = SecretKeyFactory.getInstance("DES");
DESKeySpec spec = new DESKeySpec(passPhrase.getBytes(),0);
key = desFactory.generateSecret(spec);

c.init(Cipher.ENCRYPT_MODE, key);
byte[] cipherText = c.doFinal(clearText.getBytes());

c.init(Cipher.DECRYPT_MODE, key);
byte[] recoveredTextFromArray = c.doFinal(cipherText);
```



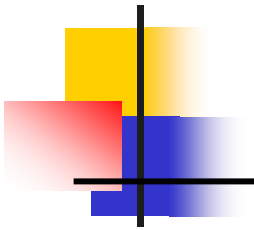
The Mac Class

- Provides the functionality of a "Message Authentication Code" (MAC)
- Used to check integrity of information
- If based on a hash algorithm, called HMAC



Generating a Message Digest

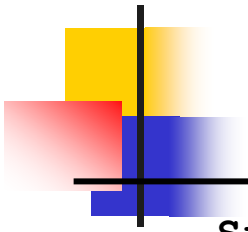
```
public byte[] generateMac(String message, SecretKey key)
      throws NoSuchAlgorithmException, InvalidKeyException {
  Mac mac = Mac.getInstance("HmacMD5");
  mac.init(key);
  return mac.doFinal(message.getBytes());
}
```



Detecting Tampering

```
String message = "The time has come the Walrus said";
String alteredMessage = "The time has come the Walrus said";
try {
  KeyGenerator kg = KeyGenerator.getInstance("HmacMD5");
  SecretKey sk = kg.generateKey();
  MacDemo demo = new MacDemo();
  byte[] result1 = demo.generateMac(message,sk);
  byte[] result2 = demo.generateMac(alteredMessage,sk);
  System.out.println("The string was " +
    (demo.isIdentical(result1,result2) ? "not " : " ") +
    " altered");
}
catch (InvalidKeyException e) {
}
catch (NoSuchAlgorithmException e) {
}
```

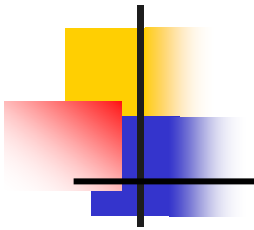
Program output: **`The string was not altered`**



An Eye Test

```
String message = "The time has come the Walrus said";
String alteredMessage = "The time has come the walrus said";
try {
  KeyGenerator kg = KeyGenerator.getInstance("HmacMD5");
  SecretKey sk = kg.generateKey();
  MacDemo demo = new MacDemo();
  byte[] result1 = demo.generateMac(message,sk);
  byte[] result2 = demo.generateMac(alteredMessage,sk);
  System.out.println("The string was " +
    (demo.isIdentical(result1,result2) ? "not " : " ") +
    " altered");
}
catch (InvalidKeyException e) {
}
catch (NoSuchAlgorithmException e) {
}
```

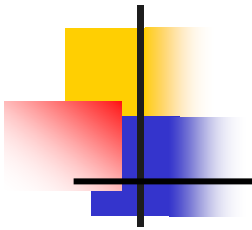
Program output: **`The string was altered`**



Practical Issue 3

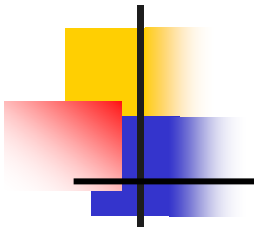
- The JCE jurisdiction policy files shipped with JDK 1.4 allow "strong" but limited cryptography to be used
- Residents of eligible countries can download and install an "unlimited strength" version
- Installation consists of unzipping download file and using contents to replace existing policy files*

* BACK UP ORIGINAL FILES



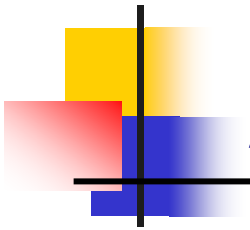
Practical Issue 4

- You might want to add a provider if:
  - Default provider(s) delivered with JDK do not provide all of the algorithms you need
  - Alternative providers offer algorithms that perform better



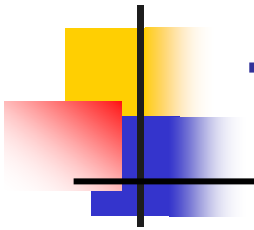
Finding Additional Providers

- Check out:
  - Legion of the Bouncy Castle
    - http://www.bouncycastle.org
  - Cryptix
    - http://www.cryptix.org
- Some others are listed at:
  - http://java.sun.com/products/jce/jce122_providers.html
- And remember, google.com is a developer's best friend



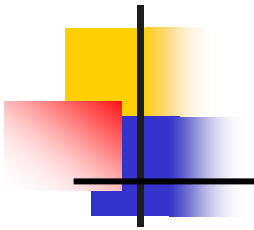
Adding a Provider

- A provider can be added in two ways:
  - Dynamically
    - Loaded by the program that requires it
    - Available only to the program for the life of the program
  - Statically
    - Loaded when the JVM starts up
    - Available to all programs
    - Persists



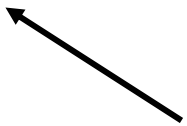
The java.security File

- The master security properties file
- Where static Cryptography Package Providers are registered
- One entry per provider
  - Format is:
    - security.provider.<n>=<className>
  - <className> is Provider subclass name
  - <n> is preference order

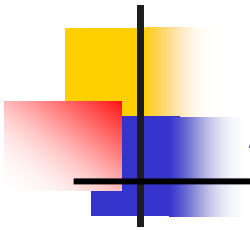


Entries in java.security

```
security.provider.1=sun.security.provider.Sun
security.provider.2=com.sun.net.ssl.internal.ssl.Provider
security.provider.3=com.sun.rsajca.Provider
security.provider.4=com.sun.crypto.provider.SunJCE
security.provider.5=sun.security.jgss.SunProvider
```



Note position of last provider



Adding a Provider Dynamically

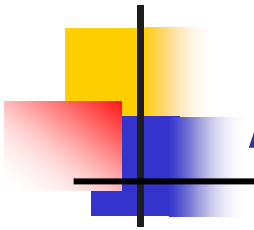
- Create an instance of the **`Provider`** subclass
- Pass the object to the static **`addProvider()`** method of the **`Security`** class
- Method returns the preference position at which the provider was added or -1 if the provider was already installed

Code to Load a Provider

```
import java.security.Security;
import java.security.Provider;
import org.bouncycastle.jce.provider.BouncyCastleProvider;

public class LoadProvider {

  public static void main(String args[]) {
    Provider provider = new BouncyCastleProvider();
    int position = Security.addProvider(provider);
    if (position >= 0) {
      System.out.println("Provider added at position " +
position);
    }
    else {
      System.err.println("Unable to add provider");
    }
  }
}
```

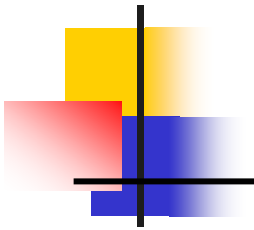
Program Output: `Provider added at Position 6`

(remember position of last provider two slides back)



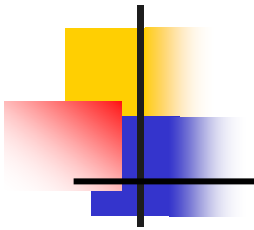
Adding a Provider Statically

- Place JAR file containing provider package where it can be located by JVM at startup (preferably, make it an installed extension)
- Create the appropriate entry in the java.security file



New Provider in java.security

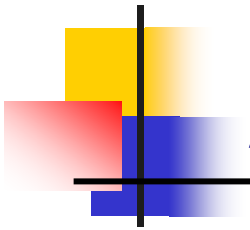
```
security.provider.1=sun.security.provider.Sun
security.provider.2=com.sun.net.ssl.internal.ssl.Provider
security.provider.3=com.sun.rsajca.Provider
security.provider.4=com.sun.crypto.provider.SunJCE
security.provider.5=sun.security.jgss.SunProvider
security.provider.6=org.bouncycastle.jce.provider.BouncyCastleProvider
```



Practical Issue 5

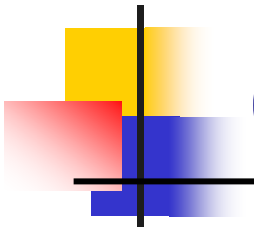
- If you want to add a new algorithm or provide your own implementation of an existing algorithm, you must write your own provider
- The ten steps required to implement a provider are documented at:

http://java.sun.com/products/jce/doc/guide/HowToImplAProvider.html



A Matter of Trust

- Authorized providers and users of authorized providers must mutually authenticate
- If you develop your own provider, it must be signed
- The two trusted Certification Authorities are:
  - Sun Microsystems JCE Code Signing CA
  - IBM JCE Code Signing CA



Conclusion

- Hopefully you will leave knowing:
  - How to determine what is in the default JCE and what is offered by installed providers
  - How to use the services provided by JCE
  - How to locate, obtain and install a provider
  - Where to obtain the blueprint for developing your own provider