

JCA/JCE



Java Crypto Architecture / Java Crypto Extensions

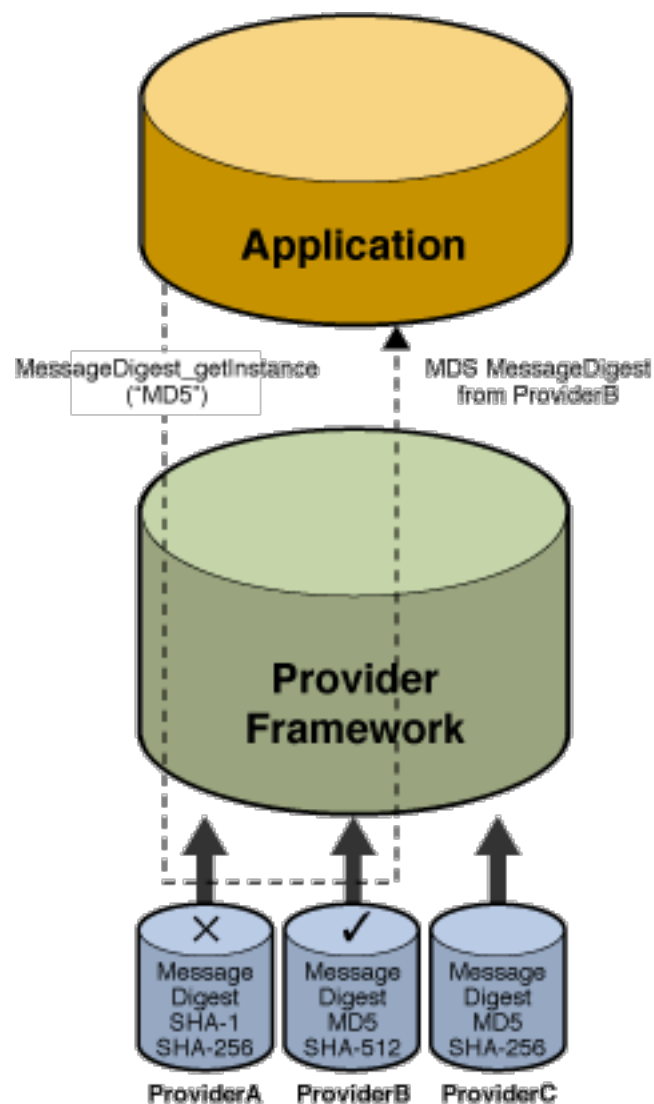
Dušan Klinec
deadcode.me

CRCS

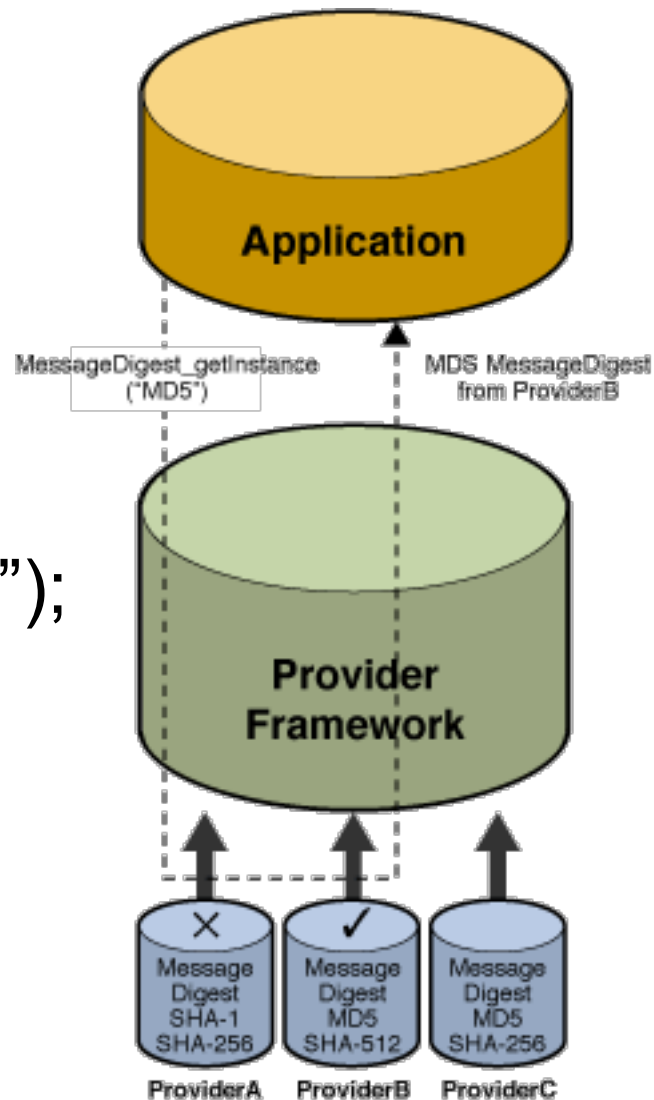
Centre for Research on
Cryptography and Security

www.fi.muni.cz/crocs

Provider architecture

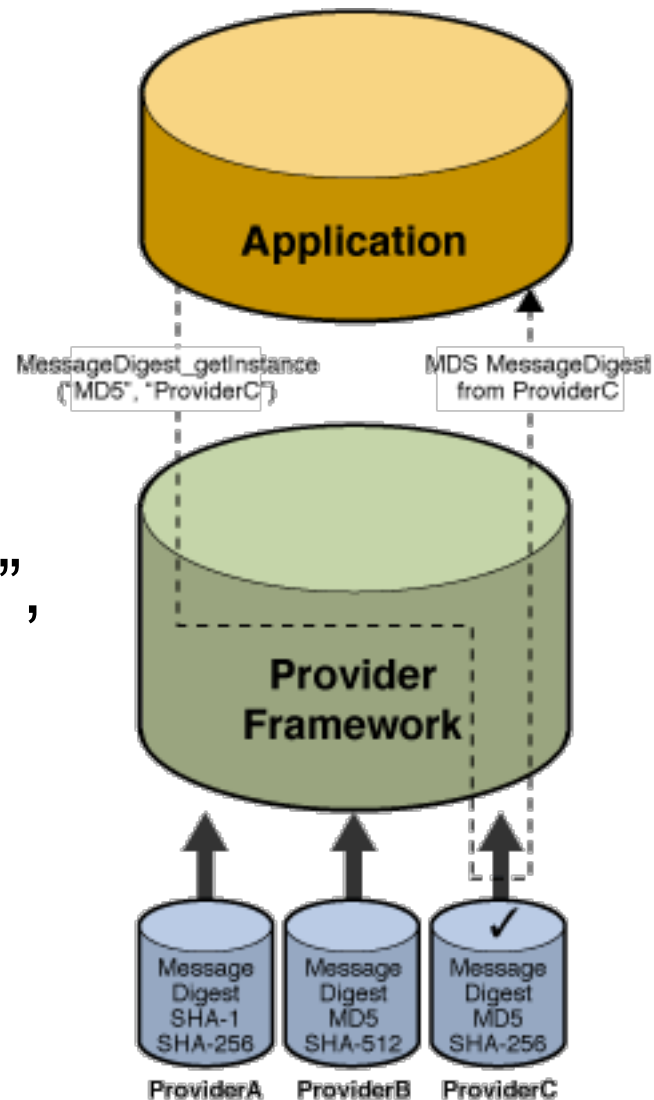


Provider architecture



```
MessageDigest.  
getInstance("MD5");
```

Provider architecture



```
MessageDigest.  
getInstance("MD5",  
"ProviderC");
```

JCA

- java.security.*
 - SecureRandom - PRNG
 - MessageDigest – SHA256, MD5, ...
 - Signature – RSA, DSA
 - KeyStore – PKCS12
 - KeyPairGenerator, KeyFactory, CertificateFactory,

JCE

- javax.crypto.*
 - Cipher – AES, RSA, ElGamal, RC4, Salsa20
 - Mac – HMACWithSHA256
 - KeyGenerator

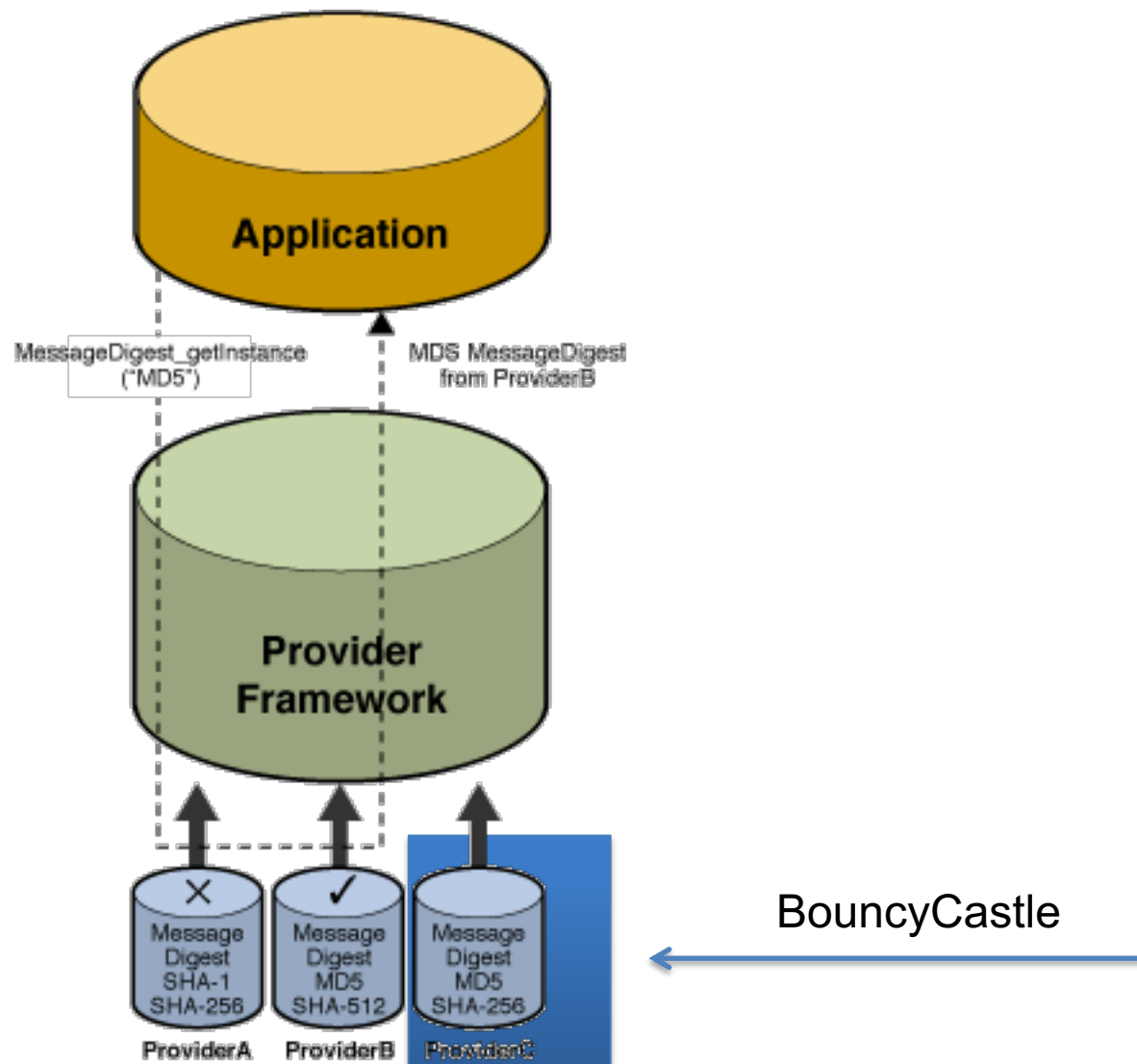
Provider architecture

- Implementation independence
- Implementation interoperability
- Algorithm extensibility

Bouncy Castle



Bouncy Castle



Bouncy Castle

- Implements a LOT OF ciphers, cipher suites, algorithms, modes, ASN.1, PEM, Certs, ...
- Origin: Australian, former advantage (crypto regulations)
- Android

Provider architecture – Engine classes

MessageDigest

Delegate

- MessageDigest(String)
- getInstance(String): MessageDigest
- getInstance(String, String): MessageDigest
- getInstance(String, Provider): MessageDigest
- getProvider(): Provider
- update(byte): void
- update(byte[], int, int): void
- update(byte[]): void
- update(ByteBuffer): void
- digest(): byte[]
- digest(byte[], int, int): int
- digest(byte[]): byte[]
- toString(): String ↑Object
- isEqual(byte[], byte[]): boolean
- reset(): void
- getAlgorithm(): String
- getDigestLength(): int

- getInstance()
- update()
- digest()
- reset()

Provider architecture – Engine classes

```
▼ C Cipher
  ◻ getInstance(String): Cipher
  ◻ getInstance(String, String): Cipher
  ◻ getInstance(String, Provider): Cipher
  ◻ getProvider(): Provider
  ◻ getAlgorithm(): String
  ◻ getBlockSize(): int
  ◻ getOutputSize(int): int
  ◻ getIV(): byte[]
  ◻ getParameters(): AlgorithmParameters
  ◻ getExemptionMechanism(): ExemptionMechanism
  ◻ init(int, Key): void
  ◻ init(int, Key, SecureRandom): void
  ◻ init(int, Key, AlgorithmParameterSpec): void
  ◻ init(int, Key, AlgorithmParameterSpec, SecureRandom): void
  ◻ init(int, Key, AlgorithmParameters): void
  ◻ init(int, Key, AlgorithmParameters, SecureRandom): void
  ◻ init(int, Certificate): void
  ◻ init(int, Certificate, SecureRandom): void
  ◻ update(byte[]): byte[]
  ◻ update(byte[], int, int): byte[]
  ◻ update(byte[], int, int, byte[]): int
  ◻ update(byte[], int, int, byte[], int): int
```

- `getInstance()`
- `init()`
- `update()`
- `doFinal()`

Provider architecture – Spi skeleton

```
public abstract class CipherSpi {  
    public CipherSpi() {  
    }  
  
    protected abstract void engineSetMode(String var1) throws NoSuchAlgorithmException;  
    protected abstract void engineSetPadding(String var1) throws NoSuchPaddingException;  
    protected abstract int engineGetBlockSize();  
    protected abstract int engineGetOutputSize(int var1);  
    protected abstract byte[] engineGetIV();  
    protected abstract AlgorithmParameters engineGetParameters();  
    protected abstract void engineInit(int var1, Key var2, SecureRandom var3) throws InvalidAlgorithmParametersException;  
    protected abstract void engineInit(int var1, Key var2, AlgorithmParameterSpec var3, SecureRandom var4) throws InvalidAlgorithmParametersException;  
    protected abstract void engineInit(int var1, Key var2, AlgorithmParameters var3, SecureRandom var4) throws InvalidAlgorithmParametersException;
```

Provider architecture – Spi skeleton

Choose Subclass of CipherSpi (207 classes found)

- AESEncipher (com.sun.crypto.provider)
- AESWrapCipher (com.sun.crypto.provider)
- ARCFOURCipher (com.sun.crypto.provider)
- AsymmetricBlockCipher (org.bouncycastle.pqc.jcajce.provider.util) NoSuchPaddingException;
- AsymmetricHybridCipher (org.bouncycastle.pqc.jcajce.provider.util)
- Base in ARC4 (org.bouncycastle.jcajce.provider.symmetric)
- Base in ChaCha (org.bouncycastle.jcajce.provider.symmetric)
- Base in Grain128 (org.bouncycastle.jcajce.provider.symmetric)
- Base in Grainv1 (org.bouncycastle.jcajce.provider.symmetric)
- Base in HC128 (org.bouncycastle.jcajce.provider.symmetric)
- Base in HC256 (org.bouncycastle.jcajce.provider.symmetric)
- Base in Salsa20 (org.bouncycastle.jcajce.provider.symmetric) SecureRandom var3) throws Invalid
- Base in VMPC (org.bouncycastle.jcajce.provider.symmetric)
- Base in VMPCKSA3 (org.bouncycastle.jcajce.provider.symmetric) AlgorithmParameterSpec var3, Sec
- Base in XSalsa20 (org.bouncycastle.jcajce.provider.symmetric) AlgorithmParameters var3, Secure
- BaseBlockCipher (com.enigmabridge.provider)

```

void encryptBlock(byte[] var1, int var2, byte[] var3, int var4) {
    byte var5 = 0;
    int var10000 = var1[var2++] << 24 | (var1[var2++] & 255) << 16 | (var1[var2++] & 255) << 8 | (var1[var2++] & 255);
    int var13 = var5 + 1;
    int var6 = var10000 ^ this.K[var5];
    int var7 = (var1[var2++] << 24 | (var1[var2++] & 255) << 16 | (var1[var2++] & 255) << 8 | (var1[var2++] & 255) << 0);
    int var8 = (var1[var2++] << 24 | (var1[var2++] & 255) << 16 | (var1[var2++] & 255) << 8 | (var1[var2++] & 255) << 0);

    int var9;
    int var10;
    int var12;
    for(var9 = (var1[var2++] << 24 | (var1[var2++] & 255) << 16 | (var1[var2++] & 255) << 8 | (var1[var2++] & 255) << 0);
        var10 = T1[var6 >>> 24] ^ T2[var7 >>> 16 & 255] ^ T3[var8 >>> 8 & 255] ^ T4[var9 >>> 0 & 255];
        int var11 = T1[var7 >>> 24] ^ T2[var8 >>> 16 & 255] ^ T3[var9 >>> 8 & 255] ^ T4[var10 >>> 0 & 255];
        var12 = T1[var8 >>> 24] ^ T2[var9 >>> 16 & 255] ^ T3[var6 >>> 8 & 255] ^ T4[var11 >>> 0 & 255];
        var9 = T1[var9 >>> 24] ^ T2[var6 >>> 16 & 255] ^ T3[var7 >>> 8 & 255] ^ T4[var12 >>> 0 & 255];
        var6 = var10;
        var7 = var11;
    }

    var10 = this.K[var13++];
    var3[var4++] = (byte)(S[var6 >>> 24] ^ var10 >>> 24);
    var3[var4++] = (byte)(S[var7 >>> 16 & 255] ^ var10 >>> 16);
    var3[var4++] = (byte)(S[var8 >>> 8 & 255] ^ var10 >>> 8);
    var3[var4++] = (byte)(S[var9 & 255] ^ var10);
    var10 = this.K[var13++];
    var3[var4++] = (byte)(S[var7 >>> 24] ^ var10 >>> 24);
    var3[var4++] = (byte)(S[var8 >>> 16 & 255] ^ var10 >>> 16);
    var3[var4++] = (byte)(S[var9 >>> 8 & 255] ^ var10 >>> 8);
    var3[var4++] = (byte)(S[var6 & 255] ^ var10);
}

```

Strong cryptography

- Limits the strength of your crypto
 - the size of the Key
- AES-256, RSA-2048 not available by default
- Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files

Overview

Downloads

Documentation

Community

Technologies

Training

Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 7 Download

Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 7

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Product / File Description	File Size	Download
Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files 7	7.3 K	UnlimitedJCEPolicyJDK7.zip

Java SE

Java EE

Java ME

Java SE Support

Java SE Advanced & Suite

Java Embedded

Java DB

Web Tier

Java Card

Java TV

New to Java

Community

Java Magazine

Strong cryptography

Algorithm	Key size
DES	64
DESEde	*
RC2	128
RC4	128
RC5	128
RSA	* (KeyPairGenerator 1024)
other	128

Download NetBeans project

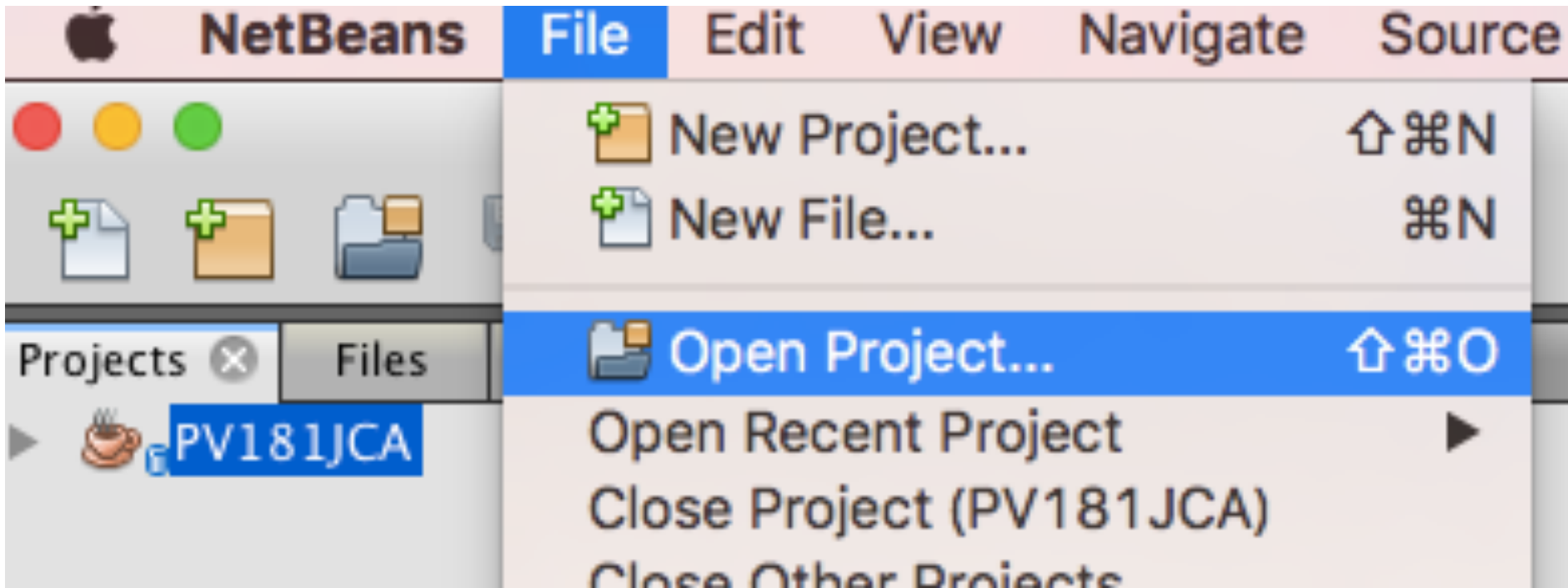
**Visit study
materials**

Pls open

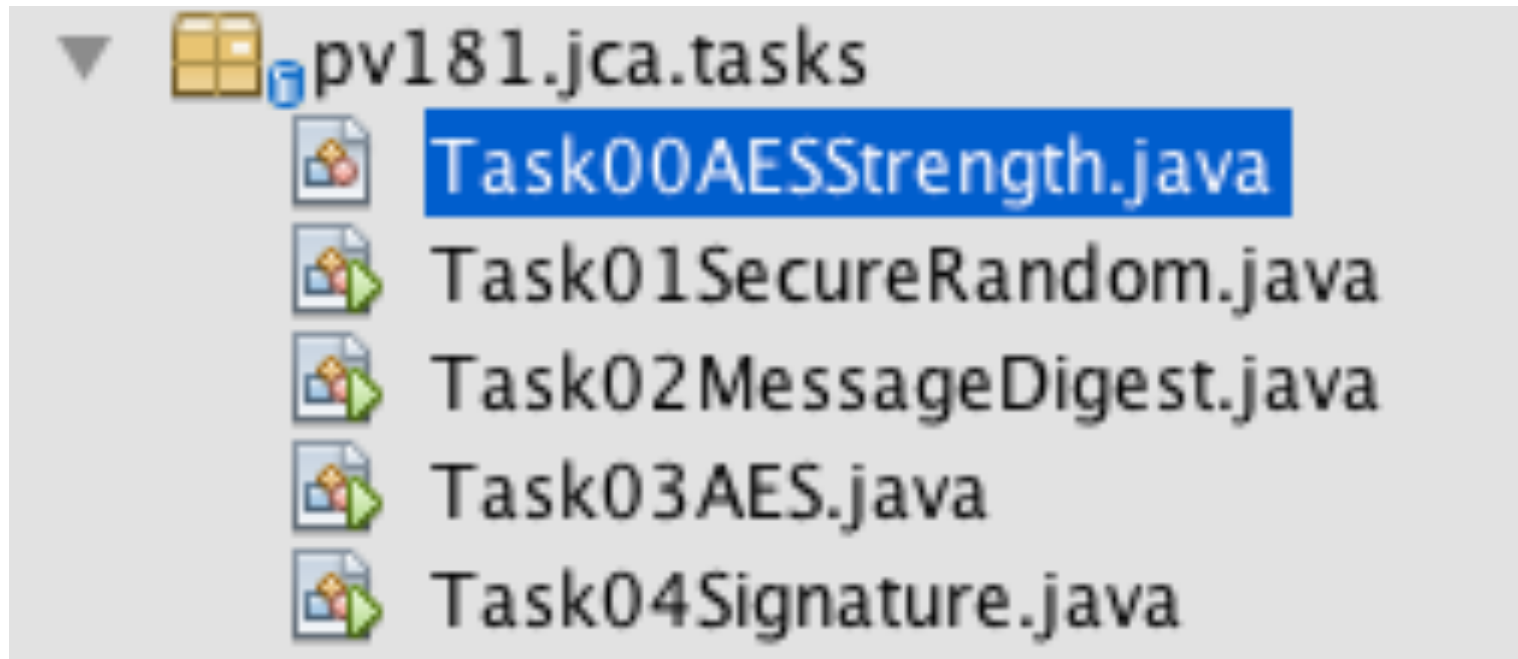


NetBeans

Pls open



Getting started



Cipher – import missing

```
20 |  
21 | System.out.println("Maximum allowed AES key size is " +  
22 |     Cipher.getMaxAllowedKeyLength("AES"));  
23 |
```

Cipher – import missing

```
20  
21 System.out.println("Maximum allowed AES key size is " +  
22     Cipher.getMaxAllowedKeyLength("AES"));
```



Lighbulb helps

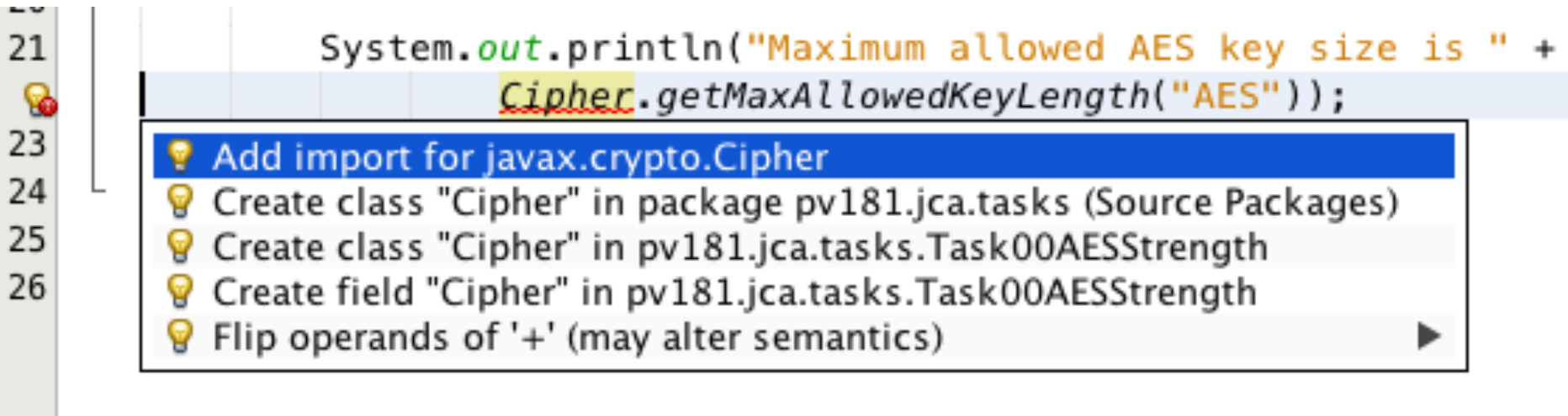
```
21 System.out.println("Maximum allowed AES key size is " +  
22 Cipher.getMaxAllowedKeyLength("AES"));
```

- 💡 Add import for javax.crypto.Cipher
- 💡 Create class "Cipher" in package pv181.jca.tasks (Source Packages)
- 💡 Create class "Cipher" in pv181.jca.tasks.Task00AESStrength
- 💡 Create field "Cipher" in pv181.jca.tasks.Task00AESStrength
- 💡 Flip operands of '+' (may alter semantics)

Getting started

CTRL+SHIFT+I

```
21 System.out.println("Maximum allowed AES key size is " +  
22     Cipher.getMaxAllowedKeyLength("AES"));  
23  
24  
25  
26
```



- 💡 Add import for javax.crypto.Cipher
- 💡 Create class "Cipher" in package pv181.jca.tasks (Source Packages)
- 💡 Create class "Cipher" in pv181.jca.tasks.Task00AESStrength
- 💡 Create field "Cipher" in pv181.jca.tasks.Task00AESStrength
- 💡 Flip operands of '+' (may alter semantics)

Problem again

23



25

```
System.out.println("Maximum allowed AES key size is " +  
Cipher.getMaxAllowedKeyLength("AES"));
```

Problem again

```
public class Task00AESStrength {  
    public static void main(String args[]) throws NoSuchAlgorithmException {  
        / click
```

The web



JCA & JCE

Pls open – the guide

goo.gl/4Ztqen

Case sensitive

Task01 - SecureRandom

- `SecureRandom rnd = new SecureRandom()`
- `rnd.nextDouble()`
- `rnd.nextByte()`
- `rnd.`

SecureRandom - solution

- `SecureRandom rnd = new SecureRandom();`
- `rnd.nextBytes(buffer);`
- `System.out.println(Globals.bytesToHex(buffer));`

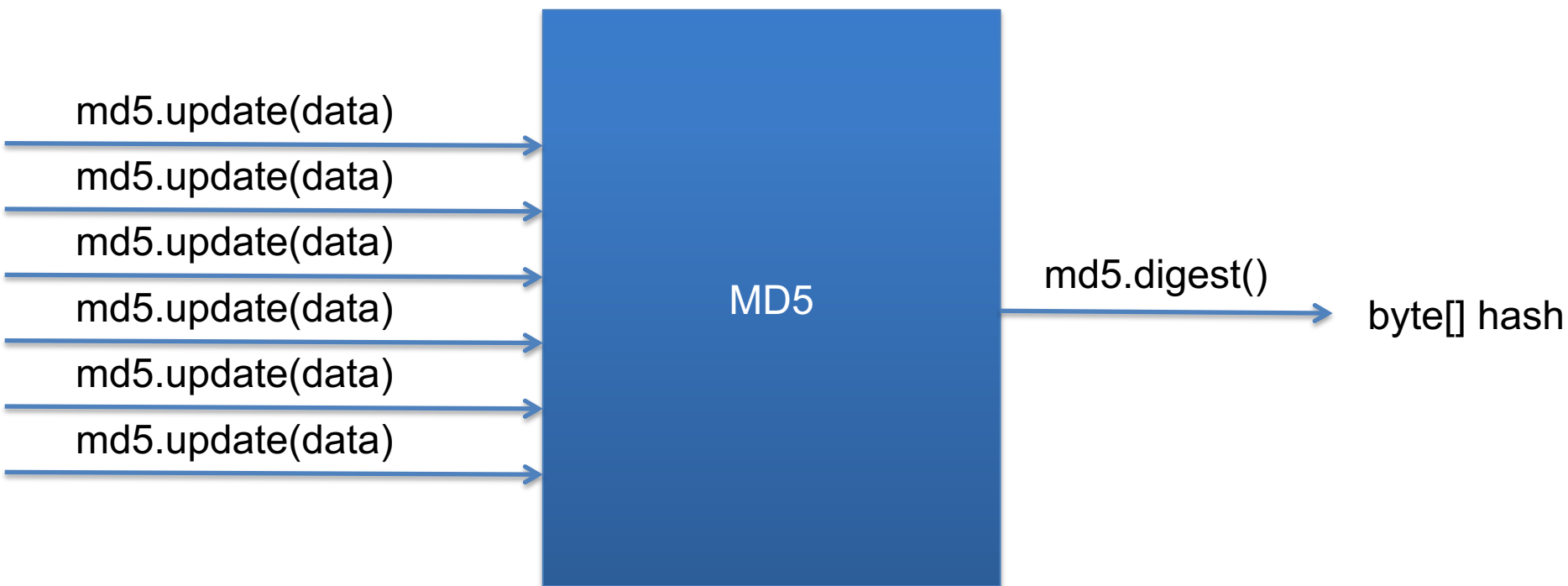
Task02 - MessageDigest

- MessageDigest md5 =
MessageDigest.getInstance("MD5");

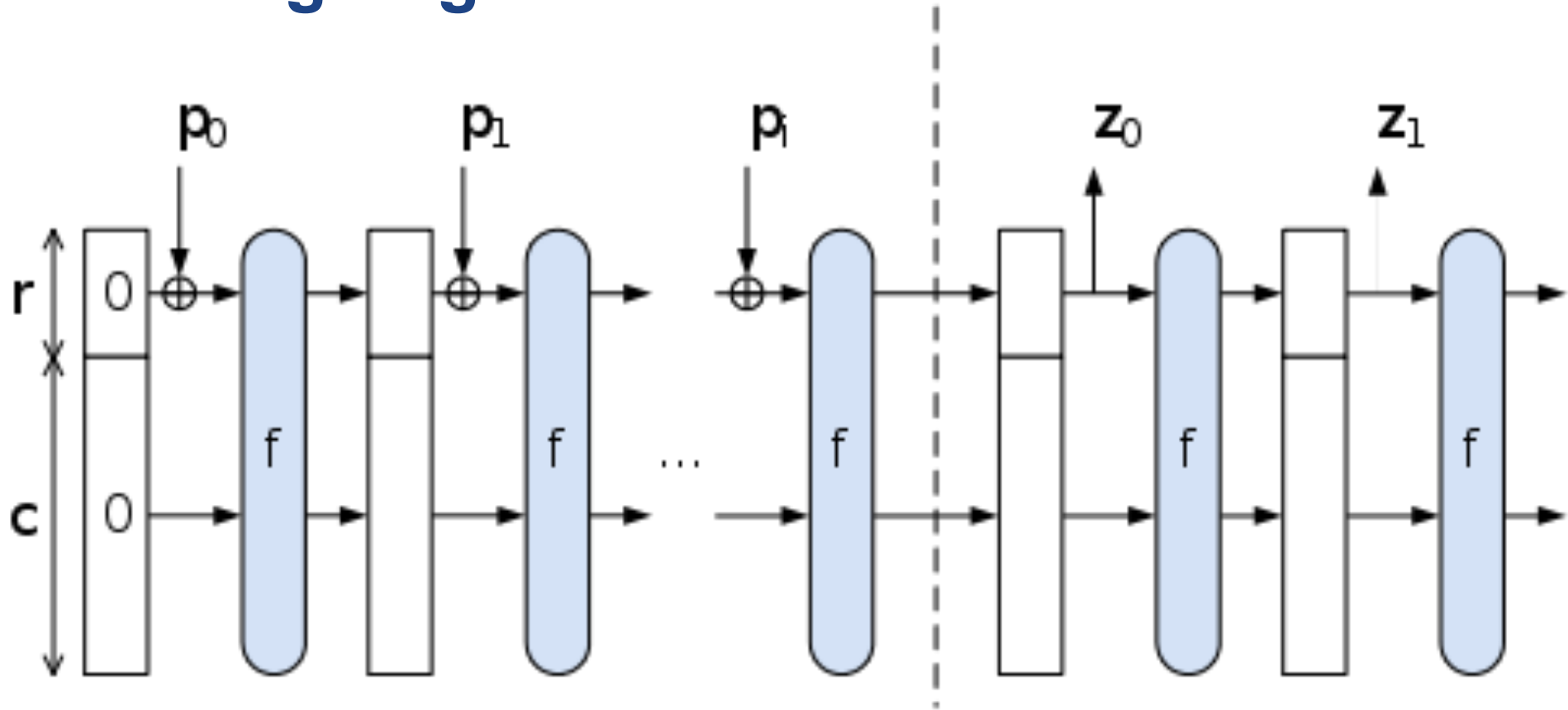
MessageDigest

- MessageDigest md5 =
MessageDigest.getInstance("MD5");
- md5.update(inputBuffer, 0, bytesRead);
- md5.update(inputBuffer, 0, bytesRead);
- md5.update(inputBuffer, 0, bytesRead);
- byte[] md5hash = md5.digest();

MessageDigest – incremental API



MessageDigest – incremental API



MessageDigest – solution

```
public static void main(String args[]) throws Exception {

    InputStream is01 = new URL("http://www.fi.muni.cz/~xklinec/java/file_a.bin")
    byte[] buffer = new byte[1024];

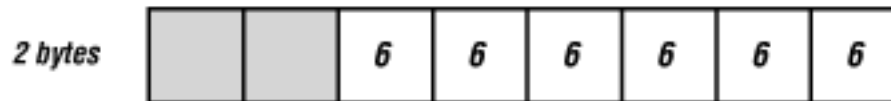
    MessageDigest md5 = MessageDigest.getInstance("MD5");
    MessageDigest sha = MessageDigest.getInstance("SHA-256");

    int bytesRead = -1;
    while ((bytesRead = is01.read(buffer)) >= 0){
        md5.update(buffer, 0, bytesRead);
        sha.update(buffer, 0, bytesRead);
    }

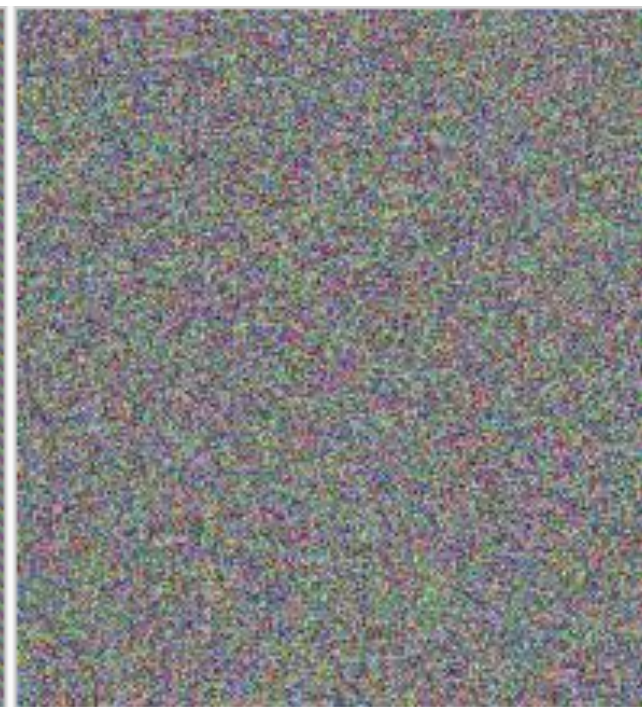
    System.out.println(Globals.bytesToHex(md5.digest(), false));
    System.out.println(Globals.bytesToHex(sha.digest(), false));
}
```

Task03 - Cipher

- `getInstance("algorithm/mode/padding");`
 - Default mode: ECB
 - Default padding: PKCS5



Cipher



Cipher

- `init(mode, key, algorithmParameterSpec)`
 - `Cipher.DECRYPT_MODE`
 - **`new SecretKeySpec(aesKey, "AES")`**
 - **`new IvParameterSpec(iv)`**

Cipher – Key vs KeySpec

- Key – opaque key, used in engine
 - `getAlgorithm()`, `getEncoded()`
- KeySpec – key specification, transport & storage
 - `getP()`, `getQ()`, `getN()`

Cipher – Key vs KeySpec

- SecretKeySpec = Spec & Key in the same time

Cipher – Key vs KeySpec

```
public class RSAPrivateCrtKeySpec extends RSAPrivateKeySpec {  
  
    private final BigInteger publicExponent;  
    private final BigInteger primeP;  
    private final BigInteger primeQ;  
    private final BigInteger primeExponentP;  
    private final BigInteger primeExponentQ;  
    private final BigInteger crtCoefficient;  
}
```

Cipher – Key vs KeySpec

- Why separated?

Cipher – Key vs KeySpec

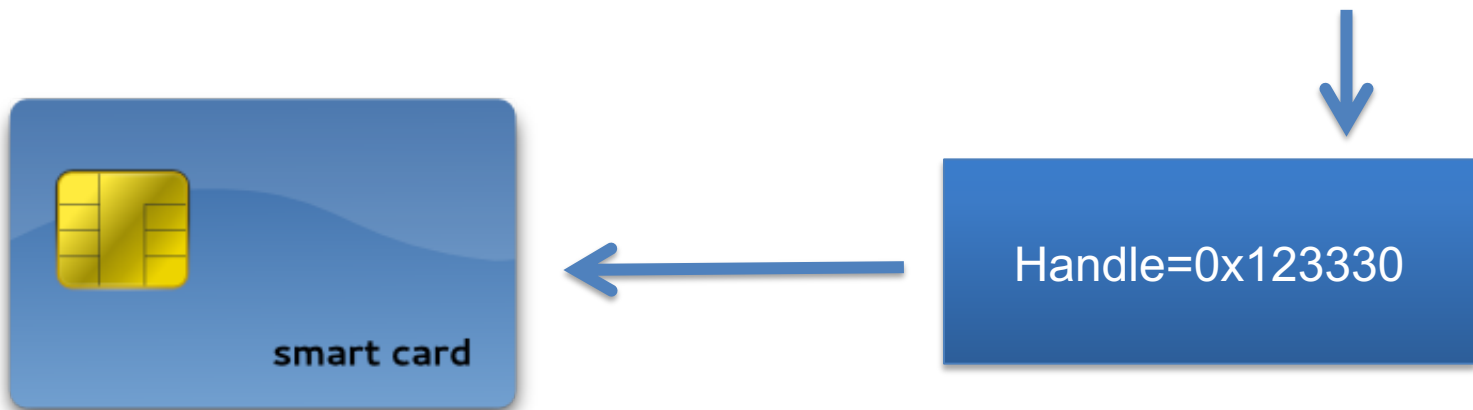
- Why separated?

```
Cipher.init(Cipher.DECRYPT_MODE, key)
```

Cipher – Key vs KeySpec

- Why separated?

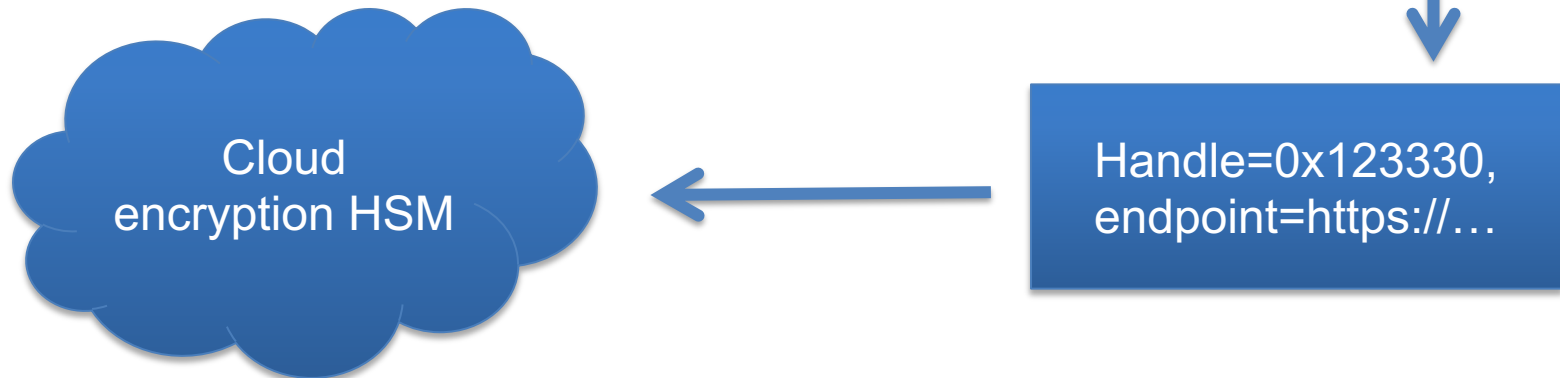
```
Cipher.init(Cipher.DECRYPT_MODE, key)
```



Cipher – Key vs KeySpec

- Why separated?

```
Cipher.init(Cipher.DECRYPT_MODE, key)
```



Cipher – Key materials

- String vs. char[]
 - String is immutable, cannot zero out
- Zero-out mutable byte[] after use to prevent key leakage to swap files (or Heartblead)

Cipher – Key materials

- GC deallocates but does not zero-out – key still there
- Modern GC can copy, reorder mem (heap defrag), unable to properly delete keys from memory nowadays (Java does not specify behaviour, can differ).

Cipher – Solution

```
byte[] key = DatatypeConverter.parseBase64Binary(
    "AAAAAAAAAAAAAAAAAAAAAAAAA==");
byte[] iv = DatatypeConverter.parseBase64Binary(
    "AAAAAAAAAAAAAAAAAAAAAAAAA==");
byte[] ciphertext = DatatypeConverter.parseBase64Binary(
    "6VMSY9xFduwNsiyn8mGZdLG6/NXb3ziw81MBSfaKozs=");

Cipher aes = Cipher.getInstance("AES/CBC/PKCS5Padding");

Key aesKey = new SecretKeySpec(key, "AES");
aes.init(Cipher.DECRYPT_MODE, aesKey, new IvParameterSpec(iv));

byte[] plaintext = aes.doFinal(ciphertext);
System.out.println(Globals.bytesToHex(plaintext, false));
System.out.println(new String(plaintext));
```

Key Factories

- KeySpec \rightarrow Key
- Key \rightarrow KeySpec

- KeyFactory – asymmetric keys
- SecretKeyFactory – symmetric keys

Key generators

- KeyGenerator – symmetric
 - generateSecret() → SecretKey
- KeyPairGenerator – asymmetric
 - generateKeyPair() → KeyPair

Certificate Builder

- X509V3CertificateGenerator
- goo.gl/I9WLUD

Diffie Hellman

- `KeyPairGenerator`
- `KeyAgreement`
- goo.gl/Lus40Y

Thank you for your attention!

Questions ?



References / resources

- TBD