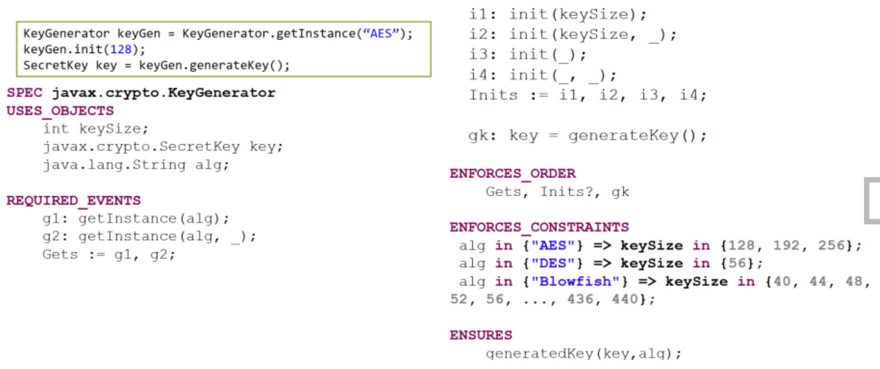
Mastering Variability in Crypto APIs

Speaker: Stefan Krüger

Crypto APIs

- Studies show: Hard to use
- Solution:



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ENFORCES_ORDER
    Gets, Inits?, gk

ENFORCES_CONSTRAINTS
 alg in {"AES"} => keySize in {128, 192, 256};
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ENSURES
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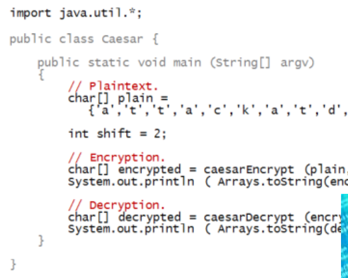

```
import java.util.*;

public class Caesar {

    public static void main (String[] argv)
    {
        // Plaintext.
        char[] plain =
           {'a','t','t','a','c','k','a','t','d','a','w','n'};

        int shift = 2;

        // Encryption.
        char[] encrypted = caesarEncrypt (plain, shift);
        System.out.println ( Arrays.toString(encrypted) );

        // Decryption.
        char[] decrypted = caesarDecrypt (encr
        System.out.println ( Arrays.toString(de
    }

}
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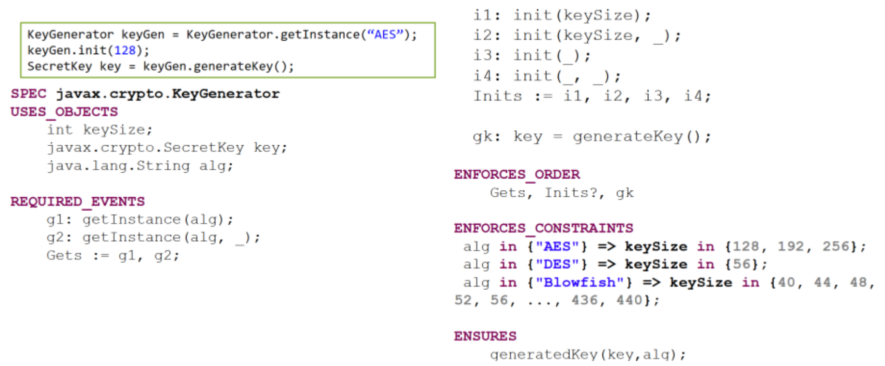

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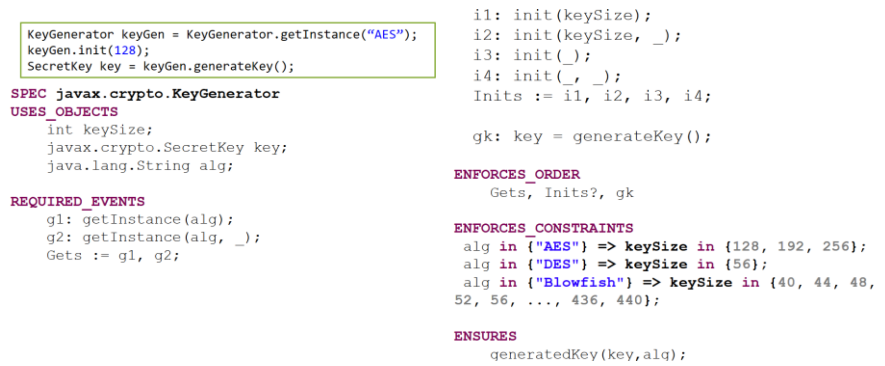

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Crypto APIs & Variability

Methods & Overloads

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KeyGenerator keyGen = KeyGenerator.getInstance(“AES”);
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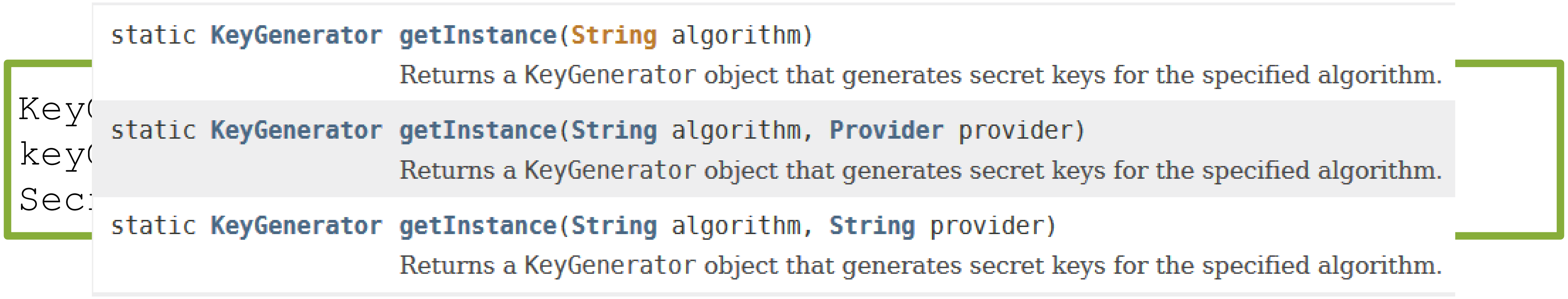
Crypto APIs & Variability

Methods & Overloads



```
Key(
key(
Sec
```

```
static KeyGenerator getInstance(String algorithm)
                    Returns a KeyGenerator object that generates secret keys for the specified algorithm.
static KeyGenerator getInstance(String algorithm, Provider provider)
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Crypto APIs & Variability

Methods & Overloads

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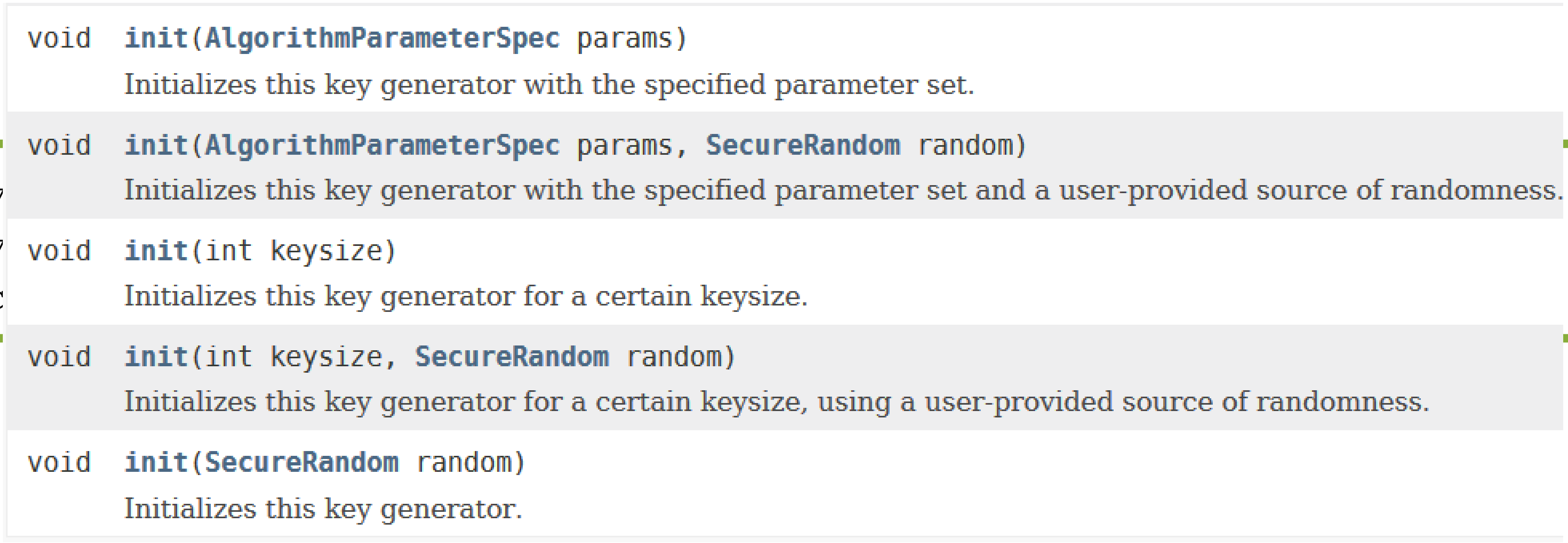

void	`init(AlgorithmParameterSpec params)` Initializes this key generator with the specified parameter set.
void	`init(AlgorithmParameterSpec params, SecureRandom random)` Initializes this key generator with the specified parameter set and a user-provided source of randomness.
void	`init(int keysize)` Initializes this key generator for a certain keysize.
void	`init(int keysize, SecureRandom random)` Initializes this key generator for a certain keysize, using a user-provided source of randomness.
void	`init(SecureRandom random)` Initializes this key generator.

DSL - Sample Specification – KeyGenerator

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i1: init(keySize);
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Crypto APIs & Variability

Parameter Values & Dependencies between them

AES, DES, Blowfish, …

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56, 128, 192, 256, 512, 1024, 2048, 4096, …

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Crypto APIs & Variability

Interaction between classes

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```
Cipher cipher = Cipher.getInstance("AES/CBC/PKCS5Padding");
cipher.init(Cipher.Encrypt_Mode, key, IV);
cipher.doFinal(data);
```

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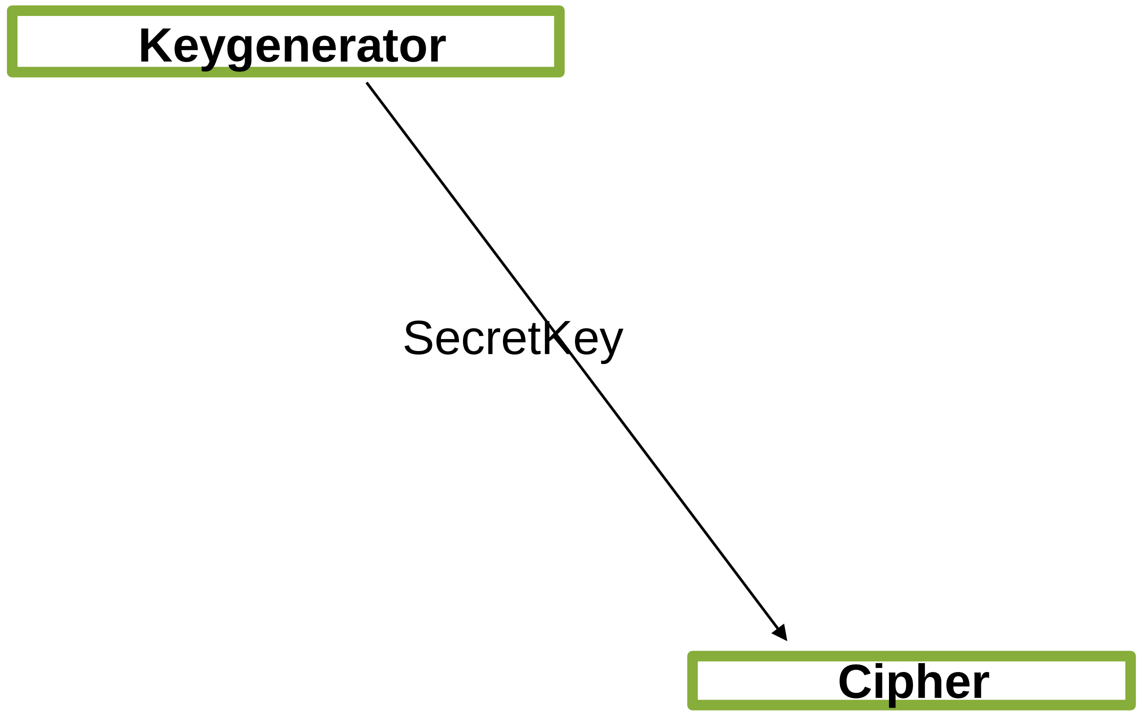

Crypto APIs & Variability

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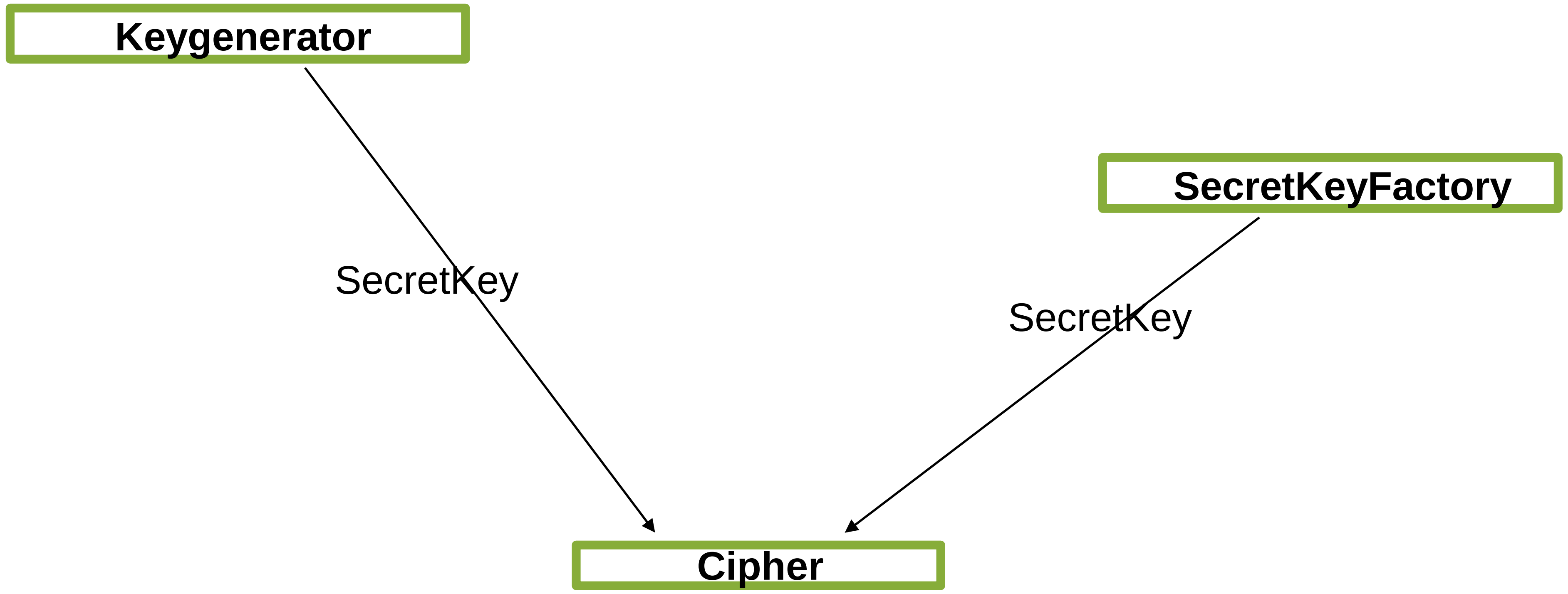

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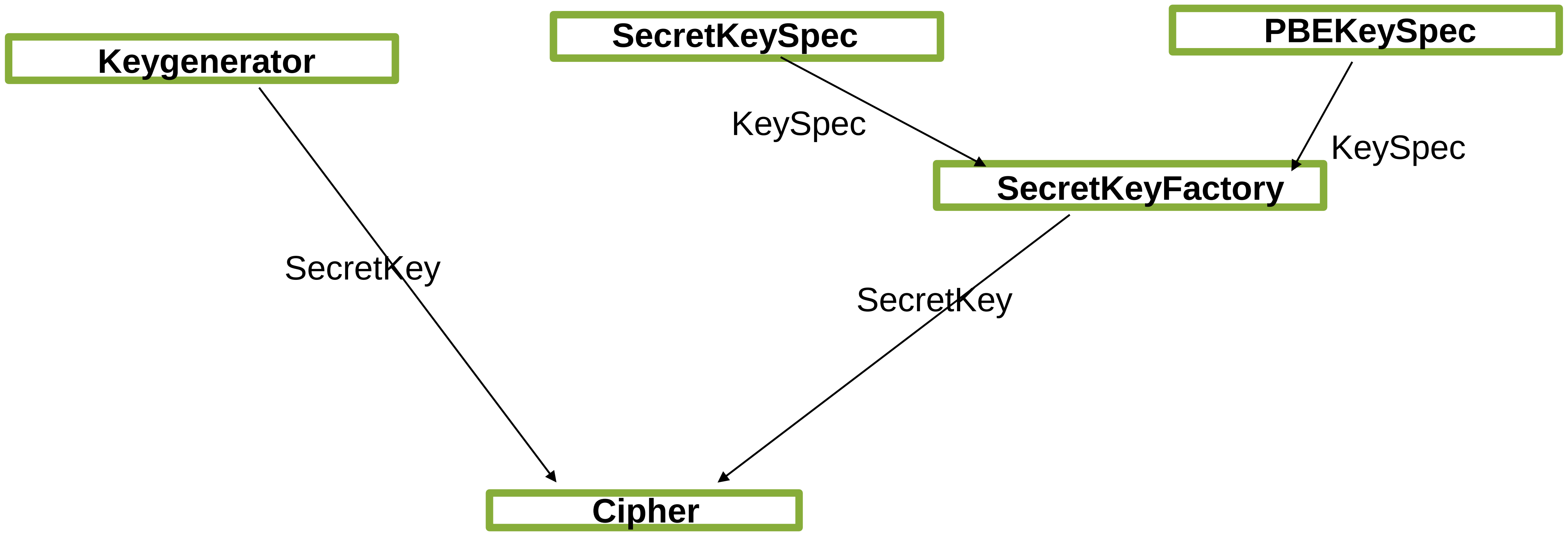

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    Gets := g1, g2;
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ENSURES
    generatedKey(key,alg);
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DSL - Sample Specification - Cipher

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Cipher ciph = Cipher.getInstance("AES/CBC/PKCS5Padding");
ciph.init(Cipher.Encrypt_Mode, key, IV);
ciph.doFinal(data);
```

```
SPEC javax.crypto.Cipher
USES_OBJECTS
    java.lang.String transformation;
    int encmode;
    javax.crypto.SecretKey key;
    java.security.spec.
          AlgorithmParameterSpec params;
    java.security.
          AlgorithmParameters param;

    int pre_plain_off;
    int pre_ciphertext_off;
    int plain_off;
    int ciphertext_off;

    byte[] pre_plaintext;
    byte[] pre_ciphertext;

    byte[] plainText;
    byte[] cipherText;
    java.nio.ByteBuffer plainBuffer;
    java.nio.ByteBuffer cipherBuffer;
```

```
REQUIRED_EVENTS
    g1: getInstance(transformation);
    g2:getInstance(transformation, _);
    Gets := g1, g2;

    i1: init(encmode, key);
    i2: init(encmode, _);
    i3: init(encmode, key, _);
    i4: init(encmode, key, param);
    i5: init(encmode, key, params, _);
    i6: init(encmode, key, param, _);
    i7: init(encmode, key, _);
    i8: init(encmode, _, _);
    IWOIV := i2, i8, i1, i7;
    IWIV := i3, i4, i5, i6;
    Inits := IWOIV, IWIV;
```

DSL - Sample Specification - Cipher

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Cipher ciph = Cipher.getInstance("AES/CBC/PKCS5Padding");
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ciph.doFinal(data);
```

```
u1: pre_ciphertext = update(pre_plaintext);
u2: pre_ciphertext = update(pre_plaintext, pre_plain_off, _);
u3: update(pre_plaintext, pre_plain_off, pre_len, pre_ciphertext);
u4: update(pre_plaintext, pre_plain_off, pre_len, pre_ciphertext, pre_ciphertext_off);
u5: update(pre_plaintext, pre_ciphertext);
updates := u1, u2, u3, u4, u5;

f1: cipherText = doFinal();
f2: cipherText =  doFinal(plainText);
f3: doFinal(cipherText, plain_off);
f4: cipherText = doFinal(cipherText, plain_off, len);
f5: doFinal(plainText, plain_off, len, cipherText);
f6: doFinal(plainText, plain_off, len, cipherText, ciphertext_off);
f7: doFinal(plainBuffer, cipherBuffer);
FINWOU := f2, f5, f6, f7;
DOFINALS := FINWOU, f1, f3, f4;

ENFORCES_ORDER
    Gets, Inits, (FINWOU | (updates+, DOFINALS))+
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ENFORCES_CONSTRAINTS
  alg(transformation) in {"AES", "Blowfish"}
  alg(transformation) in {"AES"} => mode(transformation) in {"CBC", "PCBC", "CTR", "CTS", "CFB"}
  alg(transformation) in {"Blowfish", "DESede"} => mode(transformation) in {"CBC", "PCBC", "CTR"}
  alg(transformation) in {"RSA"} => mode(transformation) in {"ECB"} && pad(transformation) in {"OAEPWithMD5AndMGF1Padding"}

  alg(transformation) in {"AES", "Blowfish", "DESede", "RC2"} => pad(transformation) in {"NoPadding", "PKCS5Padding"}

  mode(transformation) in {"CBC"} && encmode != 1 => noCallOf(IWOIV);

  generatedKey(key, alg(transformation));

  encmode >= 1 && encmode <= 4;
  pre_plaintext.length >= pre_plain_off + len;
  pre_ciphertext.length <= pre_ciphertext_off;
  plainText.length <= plain_off + len;
  cipherText <= ciphertext_off;

ENSURES
    encrypted(plainText, cipherText);
```
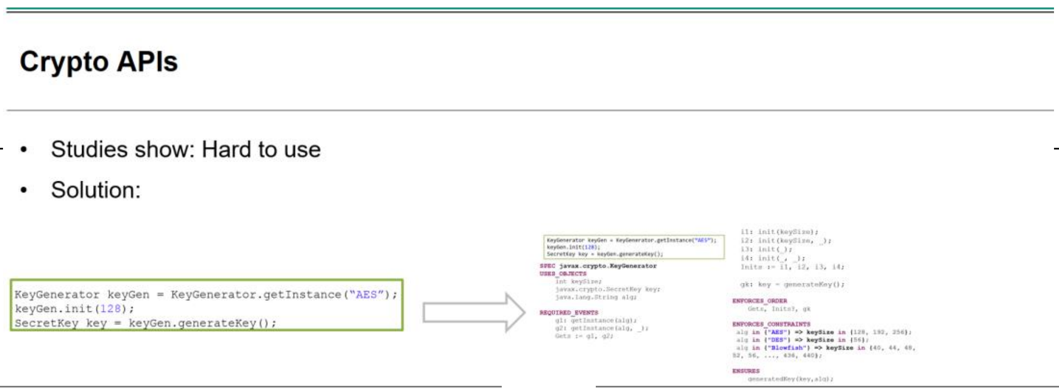

Summary



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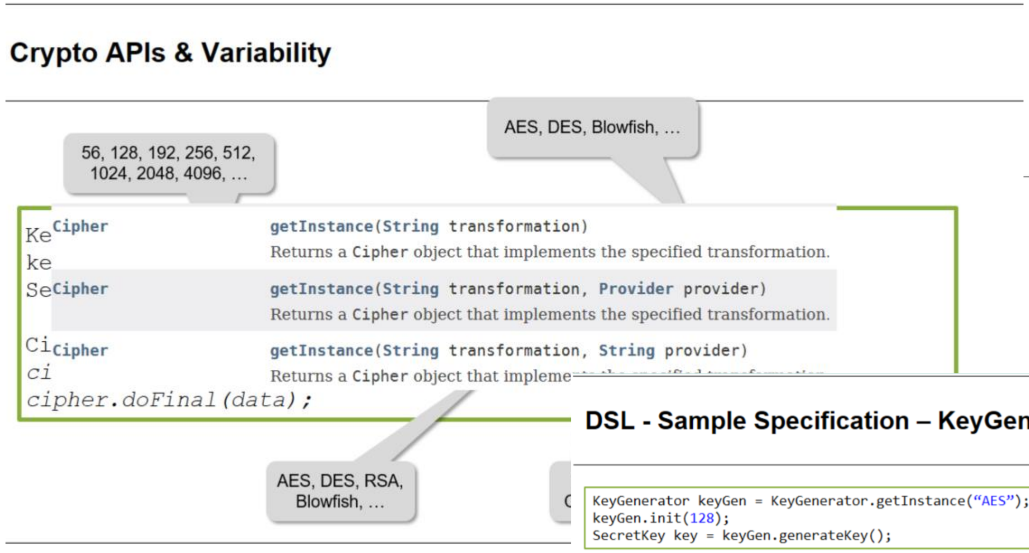

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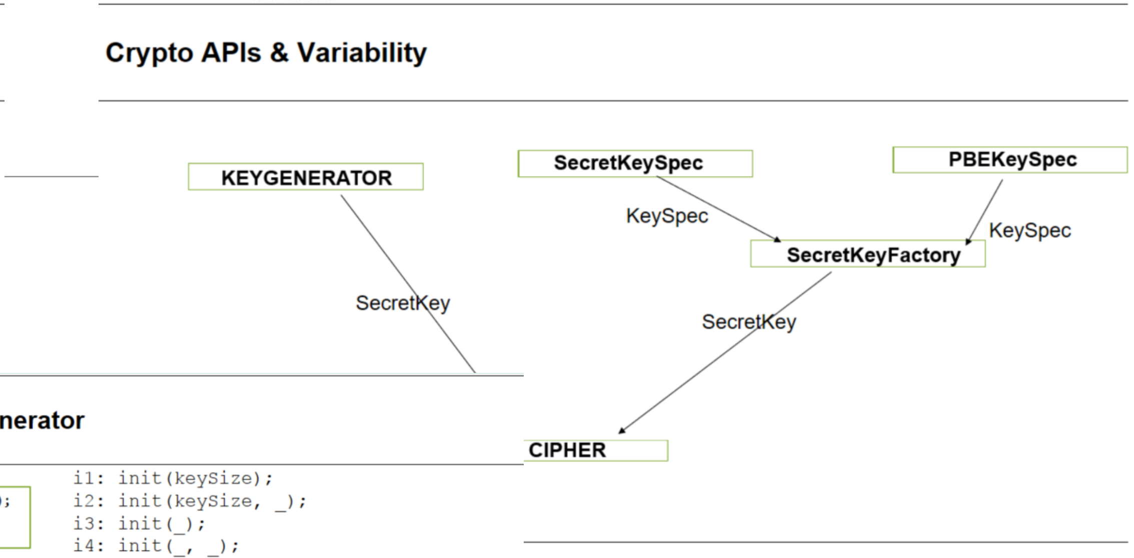

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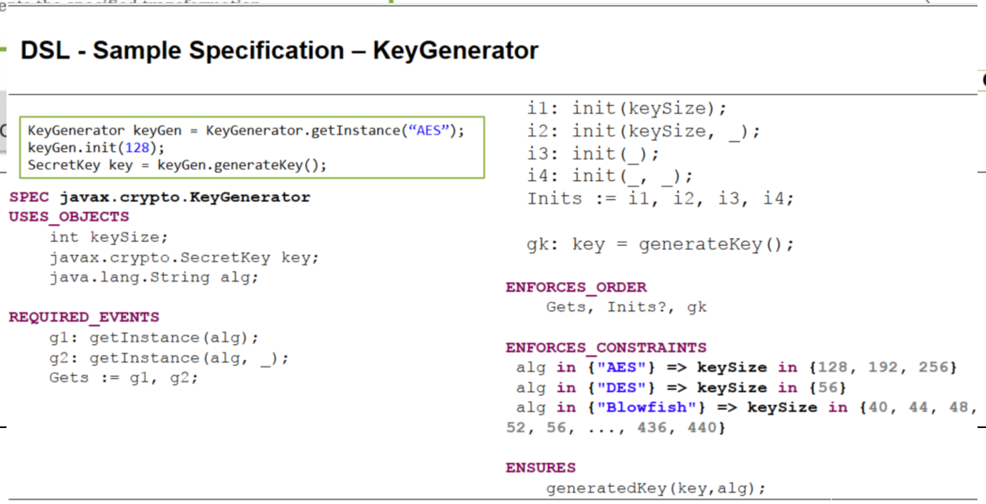

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