It wasn't me

How to Counter the Insecurity of Real World Cryptography

TECHNISCHE UNIVERSITÄT DARMSTADT

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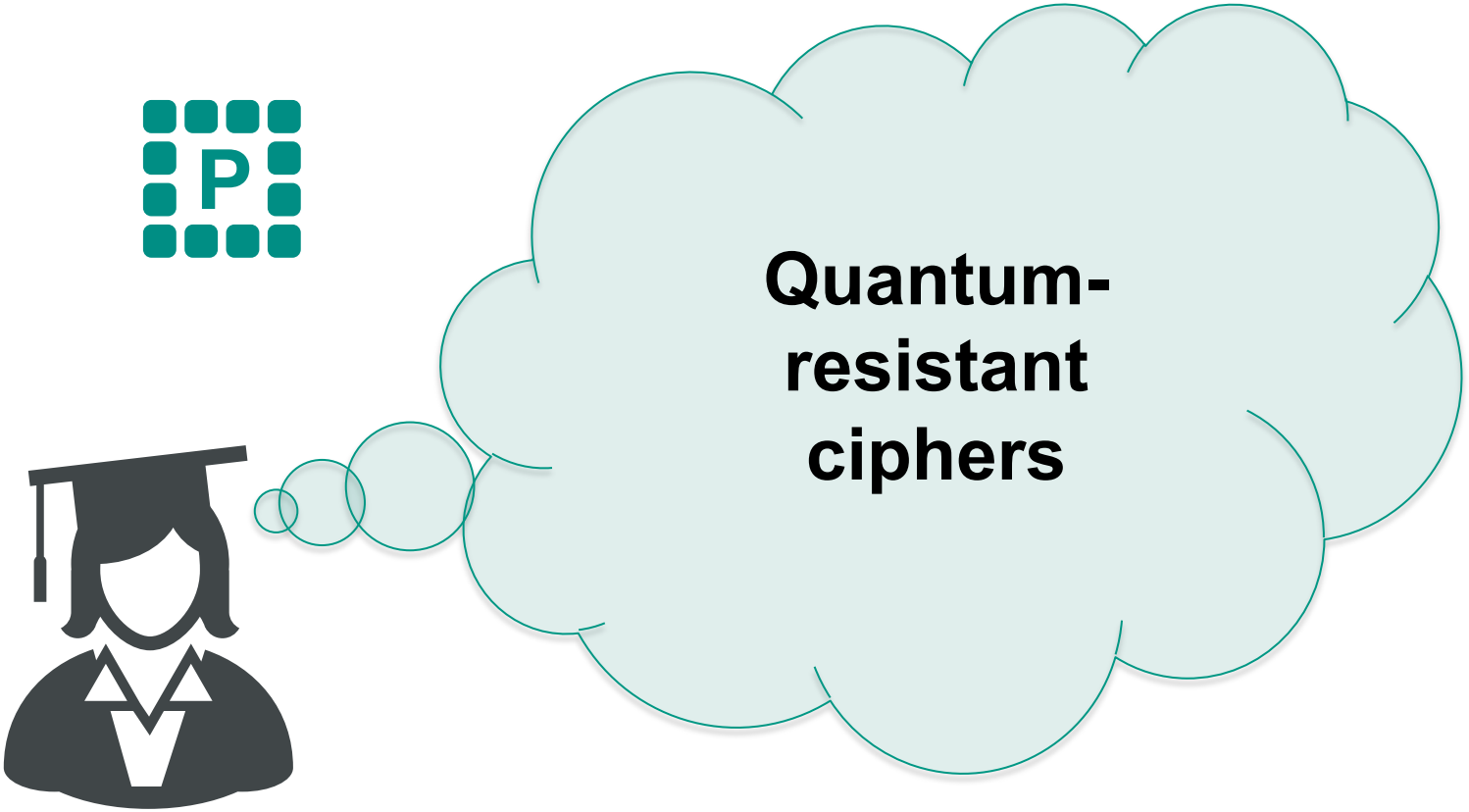
DFG Deutsche Forschungsgemeinschaft

CROSSING

Meet the mighty cryptographer...



Meet the mighty cryptographer...

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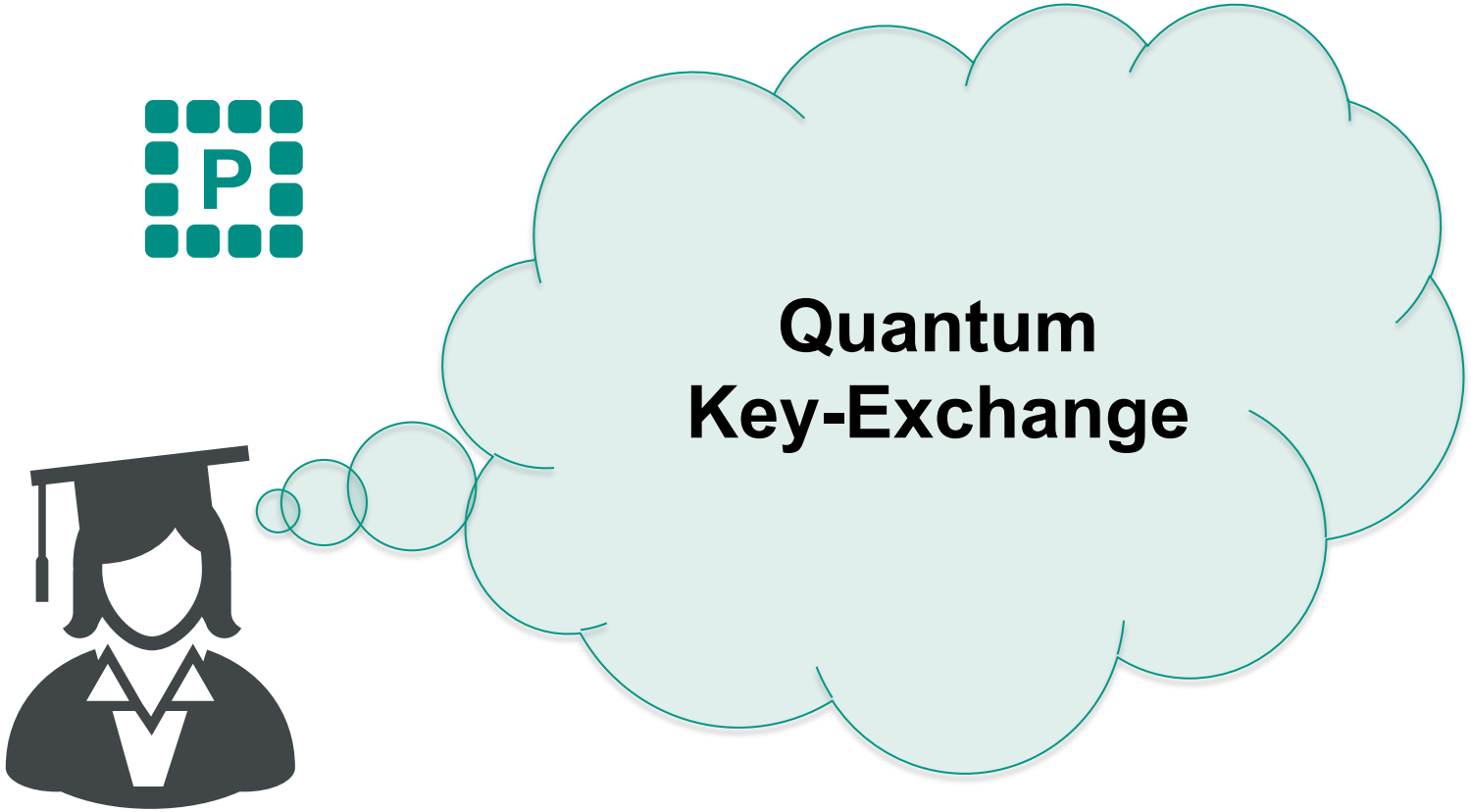

Meet the mighty cryptographer...

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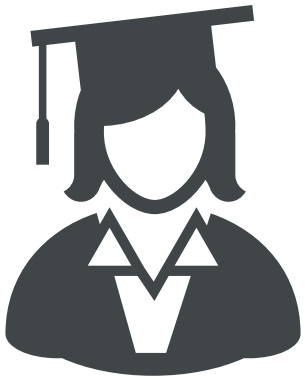
Strongly Secure Connection Establishment



Meet the mighty cryptographer...

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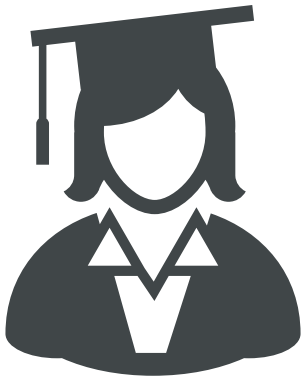
Long-Term
Secure Archiving



Meet the mighty developer...

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The most dangerous code in the world: validating SSL certificates in non-browser software
Georgiev et al., CCS 2012

Why eve and mallory love Android: an analysis of Android SSL (in)security
Fahl et al., CCS 2012

An empirical study of cryptographic misuse in Android applications
Egele et al., CCS 2013

Meet the mighty developer...

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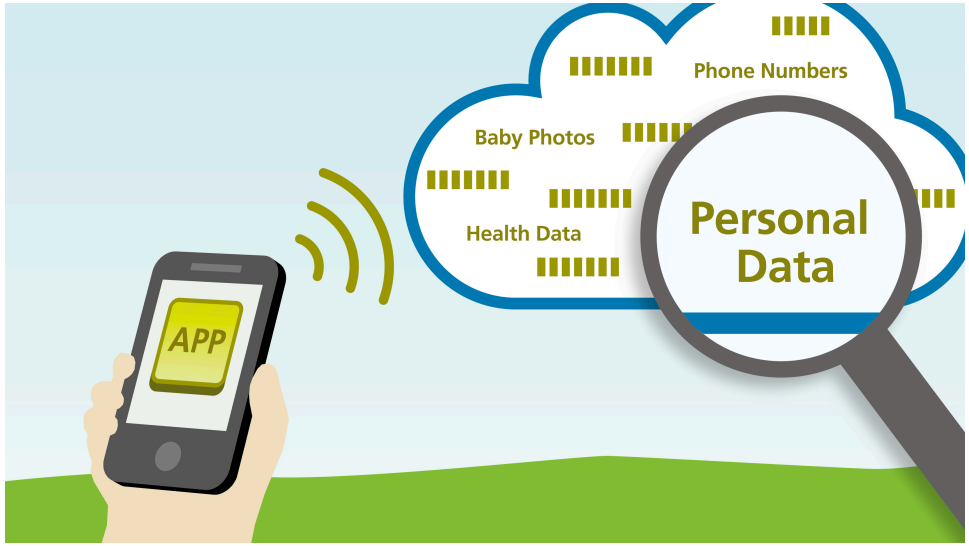

26.05.2015

Technische Universität Darmstadt and Fraunhofer SIT: App Data Vulnerability Threatens Millions of Users

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Meet the mighty developer...

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- How to securely connect to the server?
- How to encrypt app data on disk?
- How to send a message securely?

- What does (a)symmetric mean?
- What is an initialization vector?
- Do I need to ask for a password?
- How can I maintain compatibility?

Bridging the gap

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Traditional library

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Functional interface

```
Cipher.getInstance(String)
```

ORACLE Java SE Documentation

Oracle Technology Network Software Downloads Documentation

Java ™ Cryptography Architecture (JCA) Reference Guide

for Java™ Platform Standard Edition 6

Introduction

Design Principles
Architecture
JCA Concepts

Core Classes and Interfaces

55 A4 pages!!!

JCA, BouncyCastle,
FlexiProvider,
OpenSSL, NaCL

New concept: *active* library

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- Helps choose the right algorithm(s) and parameters
- Generates example code
- Assists and monitors the secure integration into your software
- Alerts of component changes
- Alerts of maintenance mistakes in application code

New concept: *active* library

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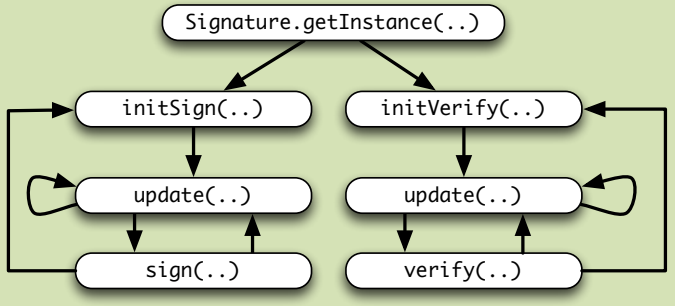
Functional interface

```
Cipher.getInstance(String)
```

Security interface

Usage pattern



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Encoding expert knowledge on variability space with CLAFER

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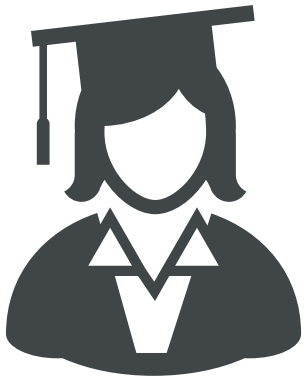
```
1  abstract Algorithm
2      name -> string
3      performance ->> integer
4      xor status
5        secure
6        insecure
7
8  abstract Digest : Algorithm
9      outputSize ->> integer //in bits
10
11 abstract KeyDerivationAlgorithm : Algorithm
12
13 abstract Task
14   name -> string
15 DigestAlgorithms
16   md5: Digest
17     [name = "MD5"]
18     [performance = 4 ]
19     [ insecure ]
20     [outputSize = 128]
21
22   sha_224 : Digest
23     [name = "SHA-224"]
24     [outputSize = 224 ]
25     [secure]
26     [performance = 2 ]
27
28   sha_256: Digest
29     [name = "SHA-256"]
30     [outputSize = 256 ]
31     [secure]
32     [performance = 2 ]
33   sha3_384: Digest
34     [name = "SHA3-384"]
35     [outputSize = 384 ]
36     [secure]
37     [performance = 2 ]
38
39
40 KeyDerivationAlgorithms
41   pbkdf : KeyDerivationAlgorithm
42     [name = "PBKDF"]
43     [performance = 2 ]
44     [secure]
45
46   bcrypt : KeyDerivationAlgorithm
47     [name = "Bcrypt"]
48     [performance = 1 ]
49     [secure]
50
51   scrypt : KeyDerivationAlgorithm
52     [name = "Scrypt"]
53     [performance = 1 ]
54     [secure]
55
56 PasswordStoring : Task
57   [name = "Password Storing"]
58   digestToUse -> Digest ?
59   kdaToUse -> KeyDerivationAlgorithm ?
60     [kdaToUse = pbkdf => digestToUse]
61     [kdaToUse != pbkdf => no digestToUse]
62   [kdaToUse || digestToUse]
63   [no digestToUse.status.insecure]
64
```

Variability Model



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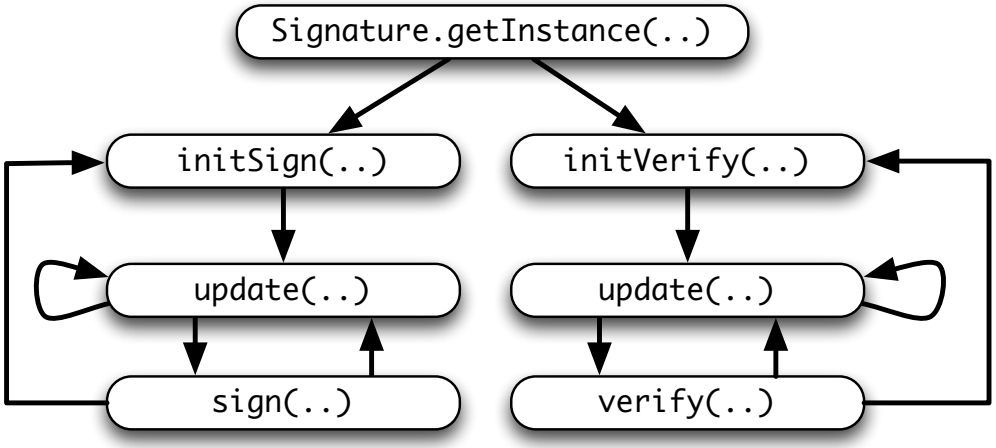
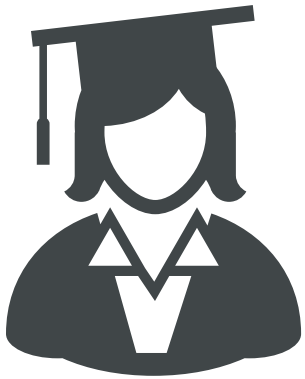
Encoding expert knowledge on usage protocols with TS4J

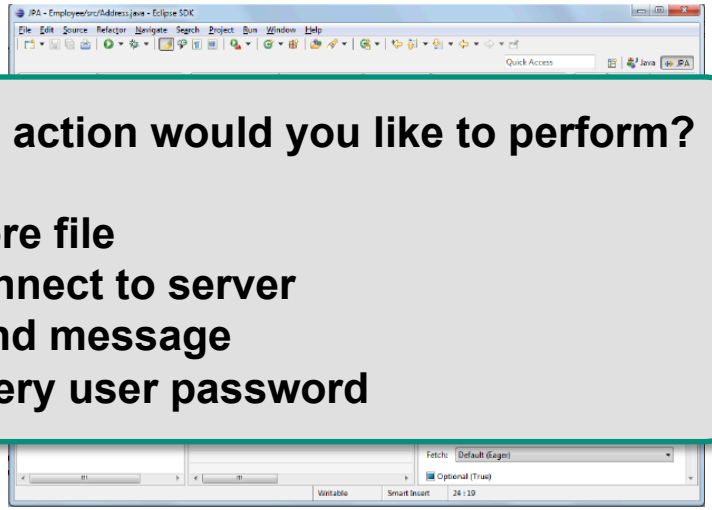


Variability Model

Protocol Model

Rules encoded in lightweight syntax, allowing for simple and direct encoding



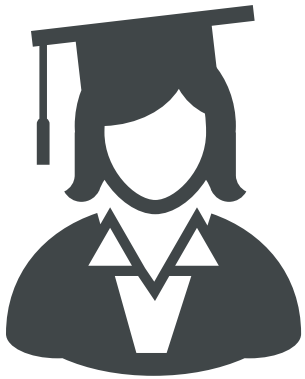


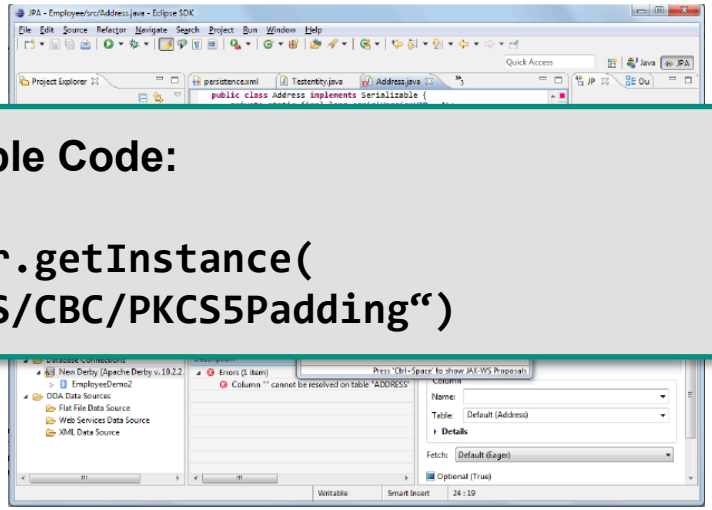
Which action would you like to perform?

- ○ Store file
- ○ Connect to server
- ○ Send message
- ○ Query user password

Variability Model

Protocol Model



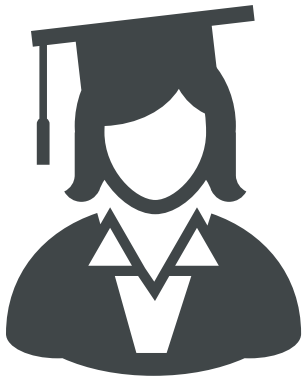


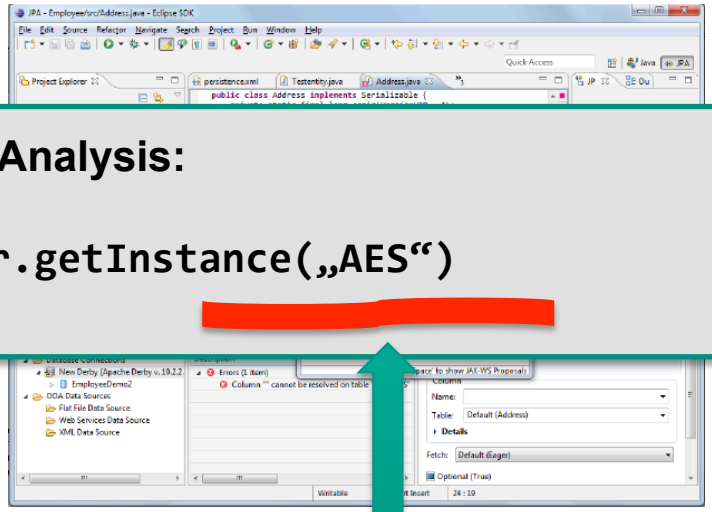
Example Code:

```
Cipher.getInstance(
   „AES/CBC/PKCS5Padding“)
```

Variability Model

Protocol Model



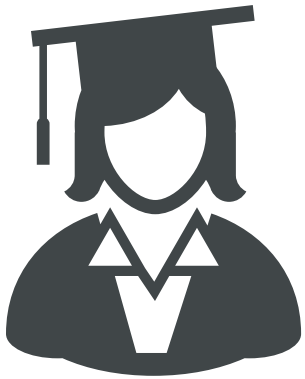


Static Analysis:

`Cipher.getInstance(„AES“)`

Variability Model

Protocol Model



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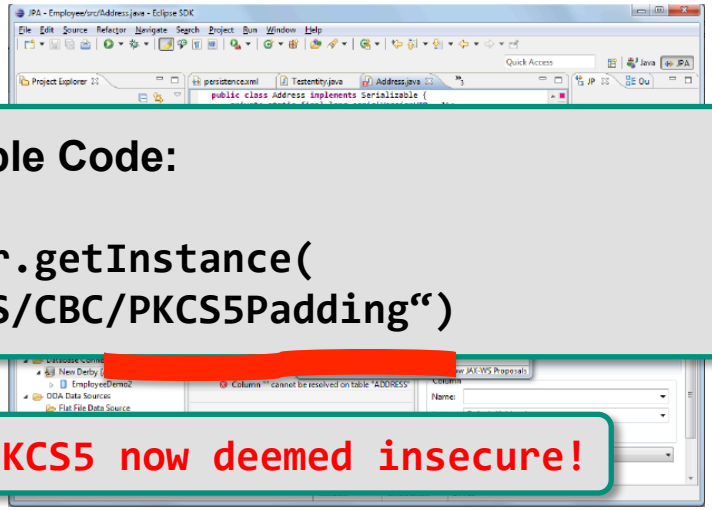


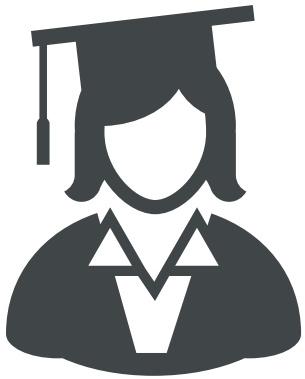
Example Code:

```
Cipher.getInstance(
  „AES/CBC/PKCS5Padding“)
```

PKCS5 now deemed insecure!

Variability Model

Protocol Model



Open questions & important challenges

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- What common crypto-usage scenarios exist?
- What are the common misuses?

- How can one comprehensively model correct crypto-API usages?
- How to auto-generate example code from those models?
- How to auto-generate static-analysis engines?

- How can different modes/parameters impact the API protocols?
- How to adapt to protocol and/or code changes?

Interested? Visit our poster & demo!

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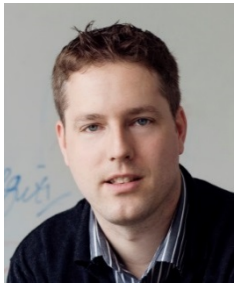

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