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jCardSim – Java Card is simple!

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Agenda

- Brief history of Java Card
- Basics standards
- How is that works?
- Developer Tools
- Writing our first real life Java Card application
- NFC and Java Card
- jCardSim: real story of real open source project

Birth of Java Card

Sun Microsystems announces Java Card API

MOUNTAIN VIEW, Calif.--(BUSINESS WIRE)--Oct. 29, 1996--
Sun Microsystems, Inc. today announced completion of the Java(TM) Card application programming interface (API) specification.
The Java Card specification will bring the power of Java to hundreds of millions of smart cards worldwide.
Quotes by Gemplus, IBM, Integrity Arts, OKI Electric Industry Co., NTT, Philips, Schlumberger, Texas Instruments, Toshiba, Visa International

First steps

February 2, 1997, the first Java card was received from the factory

June, 2005
Sun Microsystems, Inc. announces that 1 billion Java Card cards have been sold.

Standardization

12 February, 1997
Leading Smart Card Manufacturers Announce Formation of Java Card Forum - Industry initiative endorsed by Sun, creator of the Java™ Card API standard

20 October, 1997
Public review on version 2.0 of the Java Card specification

March, 1999
Java Card version 2.1 announced. There are three specifications: Java Card API, Java Card Runtime Environment, Java Card Virtual Machine

May, 2006
Java Card version 2.2.2 announced. Adds contactless capabilities and biometry support for smart card chip manufacturers

New Age

March, 2008
Java Card version 3.0 announced. Classic and Connected Editions.

- Classic Edition is an evolution of the Java Card 2.2.2
- Connected Edition is a revolution technology for high-end smart cards

Today

- More than 10 billion Java technology based smart cards have been deployed
- NFC wallets requires Java Card
- Secure M2M Solutions

Basic Standards

- ISO 7816
- ISO 14443
- Java Card Specification
- Global Platform

ISO 7816 standards

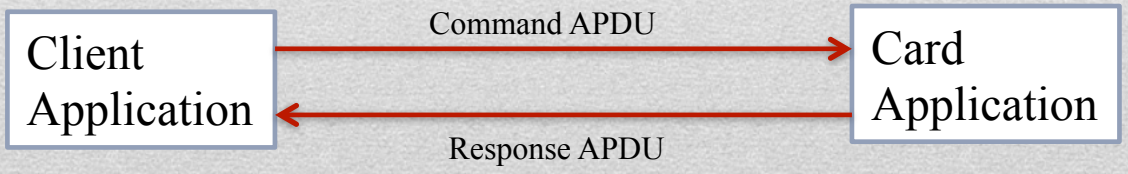
- 7816-1 – Physical characteristics
- 7816-2 – Dimension and locations of contacts
- 7816-3 – Electrical interface and transmission protocols (T0/T1)
- 7816-4 – Organization, security and commands for interchange

ISO 14443 standards (Contactless)

- 14443-1 – Physical characteristics
- 14443-2 – Radio frequency power and signal interface
- 14443-3 – Initialization and anticollision
- 14443-4 – Transmission protocol

Must know facts about smartcards and ISO-standards

- Smartcard – small secure computer on chip
  - CPU
  - Crypto Processor
  - ROM
  - EEPROM
  - FLASH
- Smart card requires terminal (contact/contactless). It provides supply and clock.
- Communication protocol is command-response based.



APDU Structure (1/2)

Command APDU

Field	Length	Description
CLA	1	Class of instruction
INS	1	Instruction code
P1	1	Instruction parameter 1
P2	1	Instruction parameter 2
Lc	1 or 3	Number of bytes present in the data field of the command
Data	Lc	String of bytes sent in the data field of the command
Le	1 or 3	Maximum number of bytes expected in the data field of the response to the command

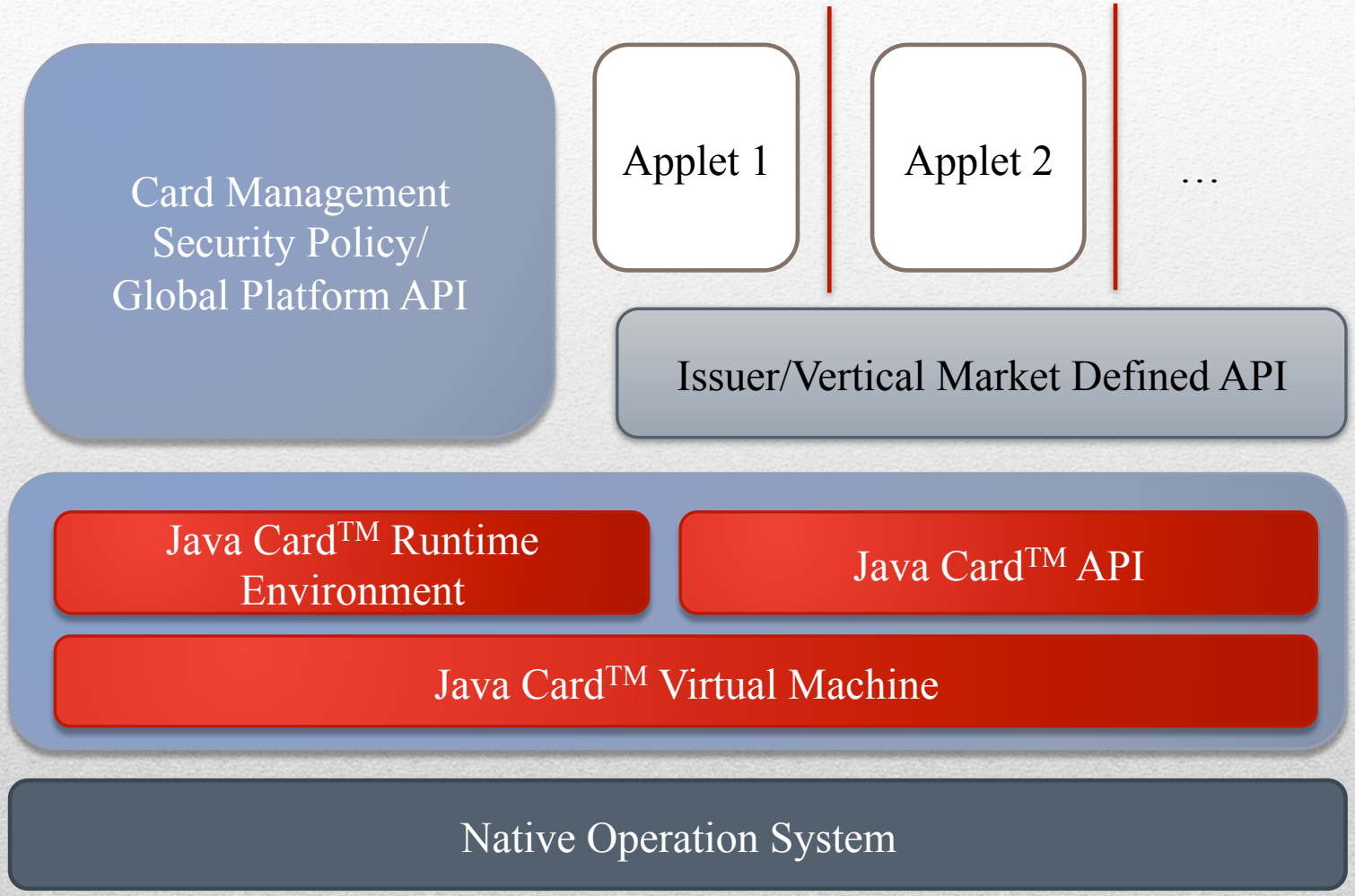
APDU Structure (2/2)

Response APDU

Field	Length	Description
Data	Lr	String of bytes received in the data field of the response
SW1	1	Command processing status
SW2	1	Command processing qualifier

The favorite response code is 0x9000 – SW_NO_ERROR

Java Card Classic Architecture



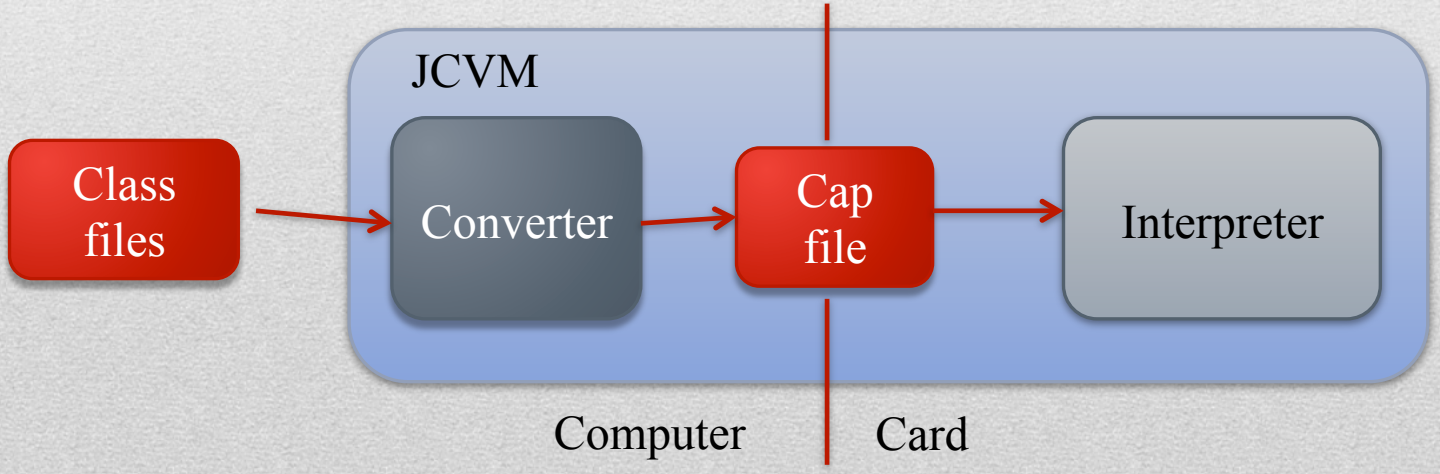
Native Operation System

- File System Operations
- Crypto Algorithms
- Data integrity
- Memory/Transactions management
- Hardware Interfaces
- Access Controller

Java Card Classic Virtual Machine (version 3.0.4) 1/3

Split VM Architecture

- Off-card
  - Class loading, linking and name resolution
  - Bytecode verification, optimization and conversion
- On-card
  - Bytecode execution and security enforcement



Java Card Classic Virtual Machine (version 3.0.4) 2/3

- Unsupported Features
  - Dynamic Class Loading
  - Security Manager
  - Finalization
  - Threads
  - Cloning
  - Access Control in Java Packages
  - Typesafe Enums
  - Enhanced for Loop
  - Varargs
  - Runtime Visible Metadata (Annotations)
  - Assertions
- Unsupported Types

The Java Card platform does not support types char, double, float and long. It also does not support arrays of more than one dimension.

Java Card Classic Virtual Machine (version 3.0.4) 3/3

- Supported Features
  - Packages
  - Dynamic Object Creation
  - Virtual Methods
  - Interfaces
  - Exceptions
  - Generics
  - Static Import
  - Runtime Invisible Metadata (Annotations)
  - Runtime Visible Metadata (Annotations)
  - Assertions
  - GC (optional)
- Supported Types

Java programming language types boolean, byte, short are supported. Objects (class instances and single-dimensional arrays) are also supported.
The int keyword and 32-bit integer data support is optional.

Java Card Runtime Environment (version 3.0.4)

- Card resource management
- Communications
- Applet execution
- Applet security (firewall)

Firewall

- Provides isolation between applications
- Operates dynamically at run-time
- Isolation is at the package level
- Applets can explicitly share objects (javacard.framework.Shareable)

Java Card API (version 3.0.4)

- java.io
- java.lang
- java.rmi
- javacard.framework
- javacard.security
- javacardx.annotations
- javacardx.apdu
- javacardx.biometry
- javacardx.crypto
- javacardx.external
- javacardx.framework.math
- javacardx.framework.string
- javacardx.framework.tlv
- javacardx.framework.util
- javacardx.framework.util.intx

Global Platform

Global Platform Card Specification is a secure, dynamic card and application management specification

- Security Domains
- Secure channels
- Application Management
- Card Management

http://www.globalplatform.org/

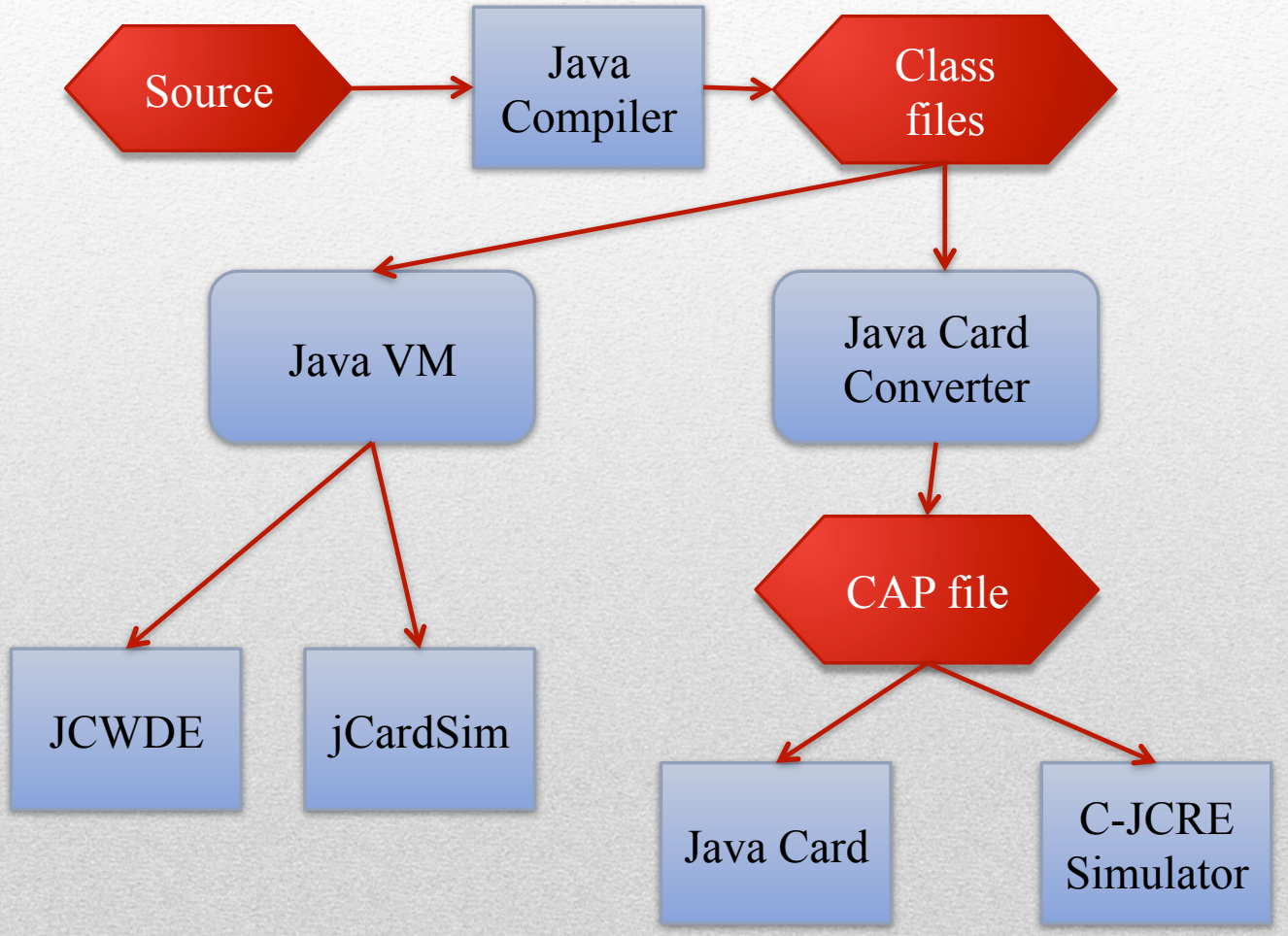
- Application Model
- Development Workflow

How is that works ?

Application Model

- Java Card Application is always a subclass of the javacard.framework.Applet class
- Each applet has unique id - AID
- Only one active applet at a time
- Several applet can be selected at the time but can not work in parallel
- Applet class provides the following entry points:
  - install(..)
  - register(..)
  - deselect(..)
  - select(..)
  - selectingApplet(..)
  - process(..)
  - getShareableInterfaceObject(..)

Development Workflow



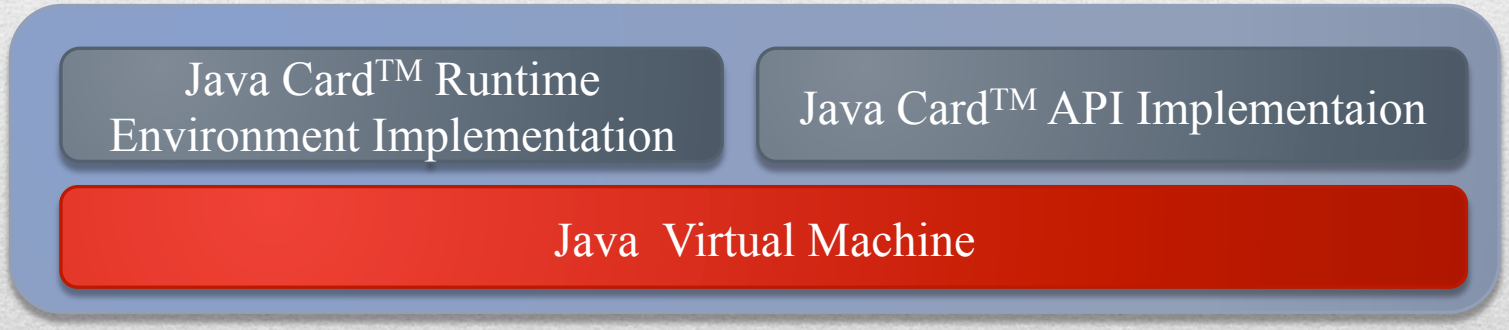
Developer Tools

- Java Card Development Kit
- GPShell
- JCOP Tools from NXP (IBM)
- jCardSim

jCardSim (1/3)

jCardSim is an open source simulator implements Java Card, v.2.2.1

- javacard.framework
- javacard.security
- javacardx.crypto



jCardSim (2/3)

Key Features

- Rapid application prototyping
- Ease of writing Unit-tests
- Emulation of Java Card Terminal, ability to use javax.smartcardio
- APDU scripting (scripts are compatible with apdutool from Java Card Development Kit)
- Ease of verification tests creation

jCardSim (3/3)

What is the difference from JCWDE?

- Implementation of javacard.security

One of the main differences is the implementation of javacard.security: current version is analogous with NXP JCOP 31/36k card. For example, in jCardSim we have support an on-card KeyPair.ALG_EC_F2M/ALG_RSA_CRT-key generation

- Simulator API

jCardSim has simple and usable API, which allows you to work with simulator like with real Java Card using javax.smartcardio

- Cross-platform

jCardSim completely written in Java and can therefore be used at all platforms which supports Java (Windows, Linux, MacOS, etc)

- PetID – ePassport for home pets
- Concepts
- Architecture
- Implementation Notes
- Protocol
- Demo

Writing our first real life Java Card application

PetID – ePassport for home pets

Nowadays, one of the main applications of Java Card is electronic identity cards (i.e. ePassport)

Are pets worse than men?

Lets create Java Card application – ePassport for Pets

Concepts

- The application must provide the ability to store, receive and transmit information about a pet.
- Must provide protection against modification of the data from a malicious person.

Information to be stored in ePassport:

- Pet’s name
- Date of birth
- Sex
- Breed

Architecture

- Client Application – JavaFX application with the following functionality:
  - ePassport application initialization
  - Store pet's information
  - Read pet's information

- Java Card Application
  - Supported Commands
    - Personalize
    - Store Pet Info
    - Read Pet Info

Implementation Notes

- Way to interact with the Java Card – javax.smartcardio
- Version of Java Card API - 2.2.1
- Protection against modification (digital signature)
  - Elliptic curve cryptography
  - Issuer Public Key stored in Personalize phase
  - Store commands data is signed

Protocol (1/4)

PERSONALIZE

Field	Value
CLA	AA
INS	0
P1	0
P2	0
Lc	Issuer public key length
Data	Issuer public key

Protocol (2/4)

STORE_PET_INFO

Field	Value
CLA	AA
INS	1
P1	0
P2	0
Lc	Pet info data length
Data	Pet info data

Protocol (3/4)

PET_INFO DATA (TLV-encoded)

Tag	Value
01	Pet name
02	Date of birth
03	Breed
04	Sex
05	Signature

Protocol (4/4)

LOAD_PET_INFO

Field	Value
CLA	AA
INS	2
P1	0
P2	0

CODING

Source Applet (1/2)

```
public class PetIDApplet extends Applet {

    private final static byte BASE_CLA = (byte) 0xAA;
    private final static byte PERSONALIZE_INS = 0x00;
    private final static byte STORE_PET_INFO_INS = 0x01;
    private final static byte LOAD_PET_INFO_INS = 0x02;
    private ECPublicKey issuerPublicKey;
    private byte[] petInfoData;

    public PetIDApplet () {
       petInfoData= new byte[4086];
       register();
    }

    public static void install(byte[] bArray, short bOffset, byte bLength) throws
ISOException {
        new PetIDApplet ();
    }
```

Source Applet (2/2)

```
public void process(APDU apdu) throws ISOException {
        if (selectingApplet()) return;
        byte[] buffer = apdu.getBuffer();
        if (buffer[ISO7816.OFFSET_CLA] != BASE_CLA) {
            ISOException.throwIt(ISO7816.SW_CLA_NOT_SUPPORTED);
        }
        byte ins = buffer[ISO7816.OFFSET_INS];
        switch (ins) {
            case PERSONALIZE_INS:
                personalize(apdu);
                break;
            case STORE_PET_INFO_INS:
                storePetInfo(apdu);
                break;
            case LOAD_PET_INFO_INS:
                loadPetInfo(apdu);
                break;
            default:
                ISOException.throwIt(ISO7816.SW_INS_NOT_SUPPORTED);
        }
    }
```

Source PetInfo

```
public class PetInfo {
    // tlv types
    private final static byte NAME_TAG = 1;
    private final static byte BIRTH_TAG = 2;
    private final static byte BREED_TAG = 3;
    private final static byte SEX_TAG = 4;
    private final static byte SIGNATURE_TAG = 5;
    //
    private String name;
    private boolean sex;
    private String breed;
    private Calendar dateOfBirth;
  …
}
```

Source Unit-test (1/3)

```
System.setProperty("com.licel.jcardsim.smartcardio.applet.0.AID", TEST_APPLET_AID);
System.setProperty("com.licel.jcardsim.smartcardio.applet.0.Class",
"samples.PetIDApplet");

if (Security.getProvider("jCardSim") == null) {
      JCardSimProvider provider = new JCardSimProvider();
       Security.addProvider(provider);
}

TerminalFactory tf = TerminalFactory.getInstance("jCardSim", null);
CardTerminals ct = tf.terminals();
List<CardTerminal> list = ct.list();
CardTerminal jcsTerminal = null;
for (int i = 0; i < list.size(); i++) {
     if (list.get(i).getName().equals("jCardSim.Terminal")) {
           jcsTerminal = list.get(i);
          break;
      }
 }
```

Source Unit-test (2/3)

```
// create applet data = aid len (byte), aid bytes, params lenth (byte), param
 byte[] aidBytes = Hex.decode(TEST_APPLET_AID);
 CommandAPDU createApplet = new CommandAPDU(0x80, 0xb8, 0, 0);
 ResponseAPDU response = jcsChannel.transmit(createApplet);
 assertEquals(response.getSW(), 0x9000);
 assertEquals(true, Arrays.equals(response.getData(), aidBytes));


 // select applet
 CommandAPDU selectApplet = new CommandAPDU(ISO7816.CLA_ISO7816, ISO7816.INS_SELECT, 0,
0,       Hex.decode(TEST_APPLET_AID));
 response = jcsChannel.transmit(selectApplet);
 assertEquals(response.getSW(), 0x9000);

 // create issuer keys & PERSONALIZE
 KeyPairGenerator kpg = KeyPairGenerator.getInstance("EC", "BC");
 ECGenParameterSpec ecsp = new ECGenParameterSpec("sect113r1");
 kpg.initialize(ecsp);
 KeyPair kp = kpg.generateKeyPair();
 CommandAPDU personalizeApplet = new CommandAPDU(0xAA,0, 0, 0,
kp.getPublic().getEncoded());
 response = jcsChannel.transmit(personalizeApplet);
 assertEquals(response.getSW(), 0x9000);
```

Source Unit-test (3/3)

```
// store pet info
PetInfo pet = new PetInfo("Leon", "Cat", "male", "28.01.2005");
CommandAPDU storePetInfo = new CommandAPDU(0xAA, 1, 0, 0,
pet.getEncoded(kp.getPrivate()));
response = jcsChannel.transmit(storePetInfo);
assertEquals(response.getSW(), 0x9000);


// load pet info
CommandAPDU loadPetInfo = new CommandAPDU(0xAA, 2, 0, 0);
response = jcsChannel.transmit(loadPetInfo);
assertEquals(response.getSW(), 0x9000);
PetInfo test = new PetInfo(response.getData());
assertEquals(pet, test);
```

DEMO

- NFC Brief Overview
- Secure Element

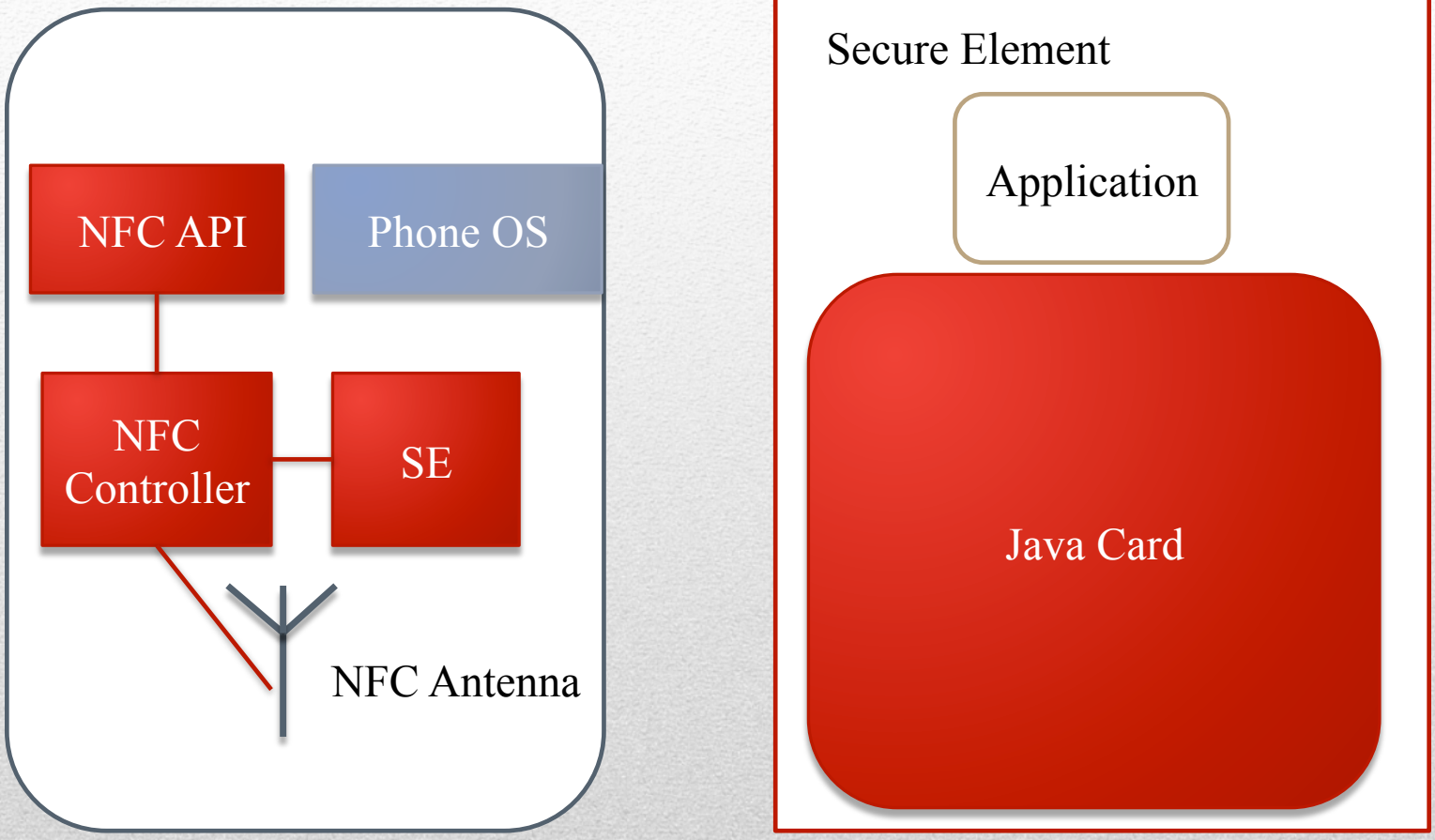
NFC and Java Card

NFC

NFC - A new radio communication interface for mobile phones

- Range 2 – 4 cm
- 13.56 MHz
- Approx. 100 million devices shipped in 2012
- Modes
  - Tag read/write
  - P2P
  - Card emulation (”secure NFC”)

Secure NFC


NFC API
Phone OS
NFC Controller
SE
NFC Antenna
Secure Element
Application
Java Card

jCardSim Facts

- The initial project team consisted of three developers
- First public release has been announced in December 2011
- In June 2012 the official site, jcardsim.org, has been started and available in following languages: English, Russian, Spanish
- Main audience of the project is students which are learning Java Card and professional Java Card developers

jCardSim RoadMap

2Q 2013

- Shareable Interface Support
- Service Framework Support
- Multiple Logical Channels

3Q 2013

- Application Firewall Support
- Basic Global Platform functionality

THANKS!

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