Security Protocol Project

Cristian Daniele & Erik Poll
Digital Security
Radboud University Nijmegen

This course: form

- Lectures & some reading material
- Group project to design, build and document a JavaCard smartcard application
  in groups of 4 students
- Grade based on group project
- *Form groups of 4 persons asap !*

Learning objectives

- Experience the whole process from high-level design, given security requirements and assumptions, down to actual code on real hardware

- Appreciate complexity & interplay of
  - design considerations & constraints,
  - key management & distribution,
  - protocols,
  - low level implementation details,
  - silly hardware limitations, weird crypto padding, …
  - practicalities of *getting all of this working*

- How to document this whole process

Prerequisites

- Very basic knowledge of (a)symmetric crypto:
  - hashing
  - using (a)symmetric crypto for encrypting, signing, MACing
  - the use of certificates with asymmetric crypto

- Knowledge of basic security concepts such as CIA

Group project

You have been contracted to build a system

- electronic purse
- loyalty card
- petrol rationing
- car rental
- swimming pool card

that uses a smartcard

So you must

- design security protocols for this smartcard to interact with terminals,
- think about keys, certificates, PIN codes, etc. this requires,
- implement all this
  - with only bare-bones implementation of the terminals & back-end

Design constraints

1. you must use a *JavaCard smartcard*

   which can (securely) execute code and store data, incl. use of PIN codes & standard (a)symmetric crypto (eg AES and RSA)

2. you must store *some modifiable info on the card*

   - not just fixed crypto keys but also eg. card balance, credits, logs, counters, …

   so that some terminals can operate offline (maybe temporarily)

In our increasingly online world, a solution where cards only store keys for authentication and everything happens online in a central back-end makes perfect sense, but for this assignment it is not allowed.

AD

Weer de komende dagen | TV-Gids | Digitale Krant | Shop

NIEUWS REGIO SPORT SHOW PLAY PODCAST PUZZEL

Binnenland Buitenland Politiek Economie Bizar Wetenschap Reizen Opinie

Inchecken in trein kan vanaf vandaag ook met bankpas, creditcard of Apple Pay

MET VIDEO **Reizigers met de trein kunnen vanaf dinsdag inchecken met hun bankpas of creditcard. Die mogelijkheid, met de naam OV Pay, wordt door de Nederlandse Spoorwegen aangezet in heel het land. Dat gebeurt na eerdere tests. Ook QBuzz gaat de bankpasjes aanzetten voor zijn treinen in de regio Dordrecht. Arriva doet dat voor de Limburgse treinen.**

Binnenlandredactie 31 jan. 2023 Laatste update: 31-01-23, 12:57

Exit smartcards in a few years?

Or do they simply re-appear as TEEs in smartphones?

Smartcard basics (more details later)

A smartcard is simply a tiny, low-power computer

- few KB of RAM (aka volatile memory)
- a bit more EEPROM (aka persistent memory) that acts as SSD/hard drive
- very low-bandwidth communication, with messages usually just a few dozen bytes

It can execute arbitrary code and store arbitrary data,

e.g. a card number, customer ID, cryptographic keys, certificates, PIN codes, counters, JPEGs, …

Smartcard basics (more details later)

A smartcard is secure and tamper-resistant computer, i.e.

- Data & software on the card cannot be read or modified, so card ensures
  - integrity of the software
    - also confidentiality of the software
  - confidentiality & integrity of all data

- Installing code on the card is tightly controlled and usually disabled before the card is issued.

Smartcard attack basics (more details later)

Attackers can always do

- Man-in-the-Middle attacks on communication between the card & the terminal
- card tear attacks by removing the card from the terminal & its power supply
  - Special case of MitM attack: it abruptly aborts the program executing on the card *and* wipes the RAM memory content.

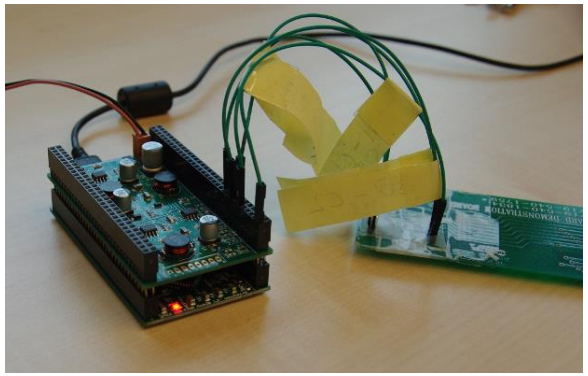
and may be able to do

- side-channel attacks
  - eg. analysing power consumption to retrieve cryptographic keys

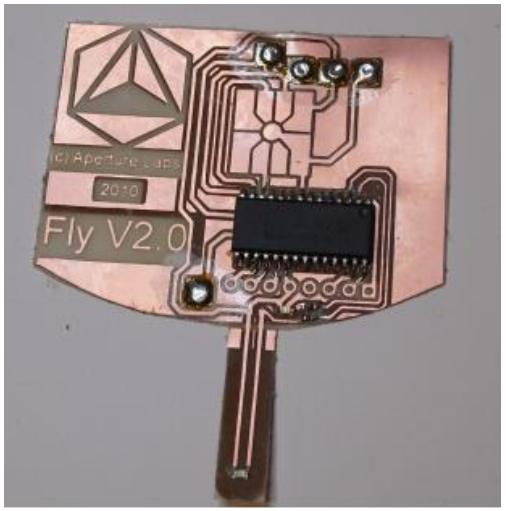
  So you should make sure that different cards use different keys.

Lots more about side-channel attacks in 'Physical Attacks on Secure Systems' (NWI-IMC068) & 'Selected topics on hardware for security' (NWI-IMC065) by Lejla Batina & Ileana Buhan.

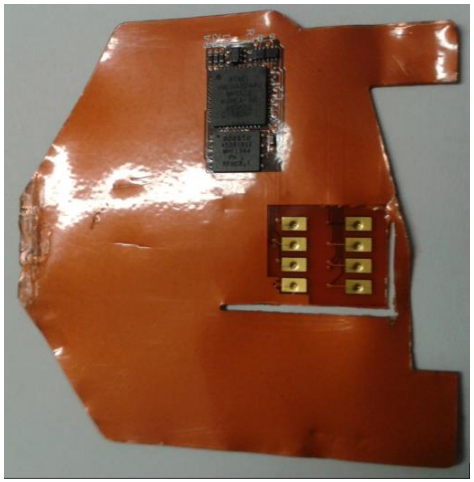
Man-in-the-Middle attacks using shims



Smartlogic tool by Gerhard de Koning Gans



Commercial shim



Shim found inside an ATM
https://krebsonsecurity.com/tag/atm-shimming/

Side-channel attacks

Using side-channel analysis attacker may be able to extract a key from the smartcard
so you should *not* have the same key in all cards

Topic of course "Physical Attacks on Secure Systems"

1st step: write a high level design document

Concise & clear document that outlines and motivates your design

- including *security requirements*, *threat / attacker model*, *trust assumptions*, *design decisions*
- down to details like
  - key & certificate distribution
  - abstract security protocols
    - as MSC or in Alice-> Bob style
    - with clearly stated security goals (eg. authentication, non-repudiation, …)
    - use of PIN codes or not,
    - which info gets logged, …
- 8 pages max, but try to use less

Target audience: security professional that has to assess the security of the proposed system (so no silly marketing blurb)

More info in Brightspace & coming lectures.

Attacker model & trust assumptions

Your attacker model must include

- active Man-in-the-Middle attacks on all communications between cards & terminals
- card tear attacks
- side channel attacks to extract keys from individual card

W.r.t. your trust assumptions :

- the software on the smartcard will be in the TCB
- you may also need to trust terminals and employees (and maybe even customers?) for some specific properties.

NB even if you cannot prevent some attack by a component or actor, you may be able to detect it.

Use cases: *personalisation, issuance & end-of-life?*

- Cards need to be personalised
  - installing software, initialising keys, PIN codes, IDs, names, …

  before it is issued to the user (aka card holder)

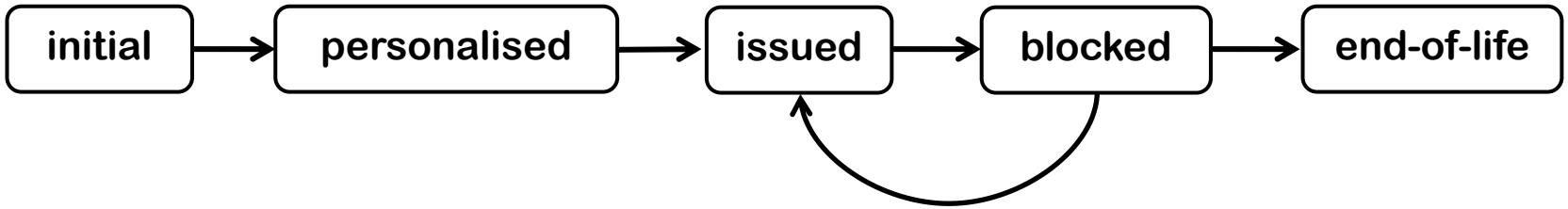
  This will typically require a separate (trusted) terminal.
  - In addition to say point-of-sale terminal.
  - Personalisation may happen in several stages.

- Cards may also need to be disabled, eg. at the end-of-life?
  - Or still be able to report data for fraud investigations?

Be explicit about the life-cycle of the card, eg with a state diagram

Persistent life cycle state

Card always has to record some life cycle state



This state has to be recorded & maintained in persistent memory (ie EEPROM)

Your report MUST include a state machine like this!

Getting started

- Next week: more discussion of the design document & any questions you may have

- Deadline for the initial design document: Feb 21.
  But the sooner you hand it in, the better.

- Lots more info in Brightspace.