On-board Credentials

N. Asokan

Nokia Research Center, Helsinki

Joint work with Jan-Erik Ekberg, Kari Kostiainen, Pekka Laitinen, Aarne Rantala (VTT)

Outline

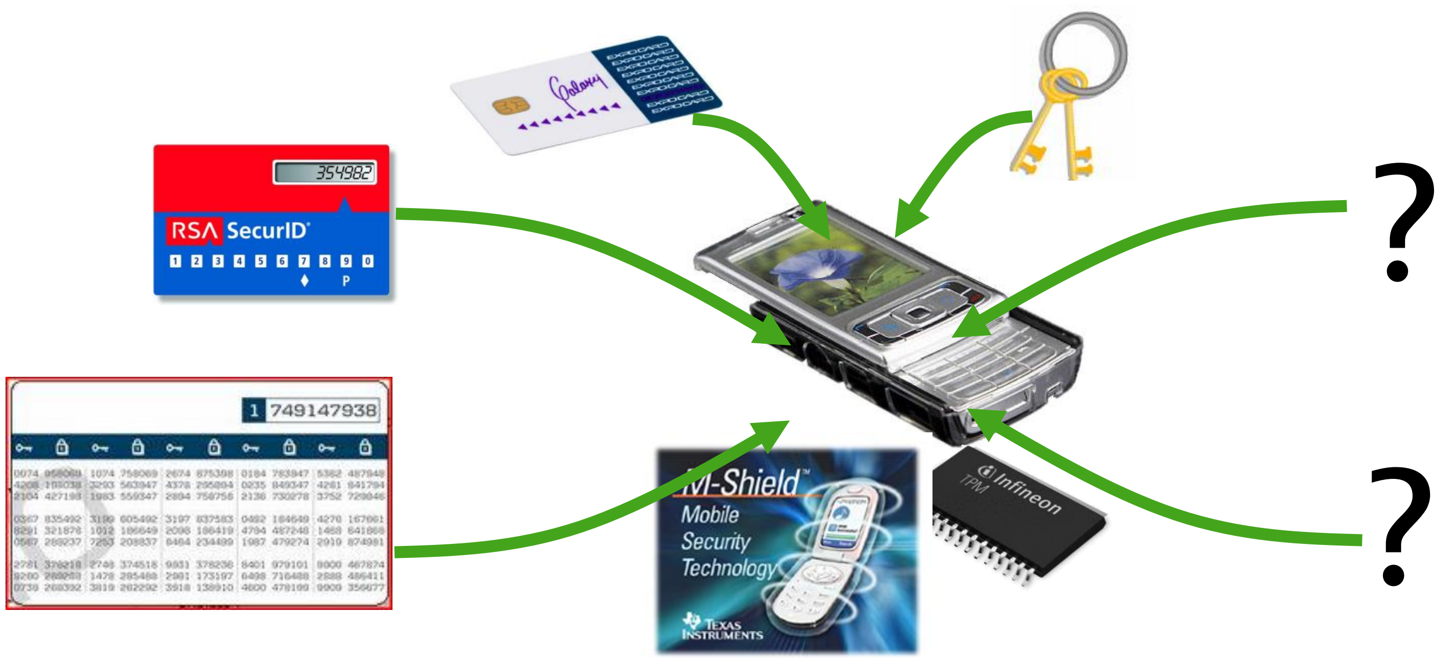
- On-board Credentials (ObCs): What and Why
- ObC Architecture
- Secure Provisioning of ObCs
- Instantiations of the Architecture
- Deployment Considerations
- ObCs in Action
- Status

This is a talk about a research project. Opinions stated here do not necessarily imply Nokia's official strategy

On-board Credentials: What and Why

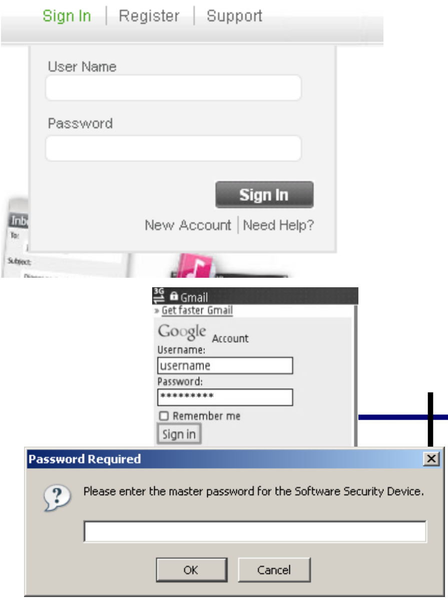
On-board Credentials (ObCs)

An open credential platform that leverages on-board trusted execution environments



Secure yet inexpensive

On-board user credentials: what and why



On-board
Credentials

SW-only credentials

Dedicated HW credentials

On-board user credentials: design goals

- Credential programs can be executed securely
    - Use a trusted execution environment (TrEE)
- Credential secrets can be stored securely
    - Use a device-specific secret in TrEE for secure storage
- Anyone can create and use new credential types
    - Need a security model to strongly isolate credential programs from one another
    - Avoid the need for centralized certification of credential programs
- Anyone can provision credential secrets securely to a credential program
    - Need a mechanism to create a secure channel to the credential program
    - (certified) device keypair; unique identification for credential programs
- Protection of asymmetric credentials is attestable to anyone
    - Anyone can verify that a private key is protected by the TrEE

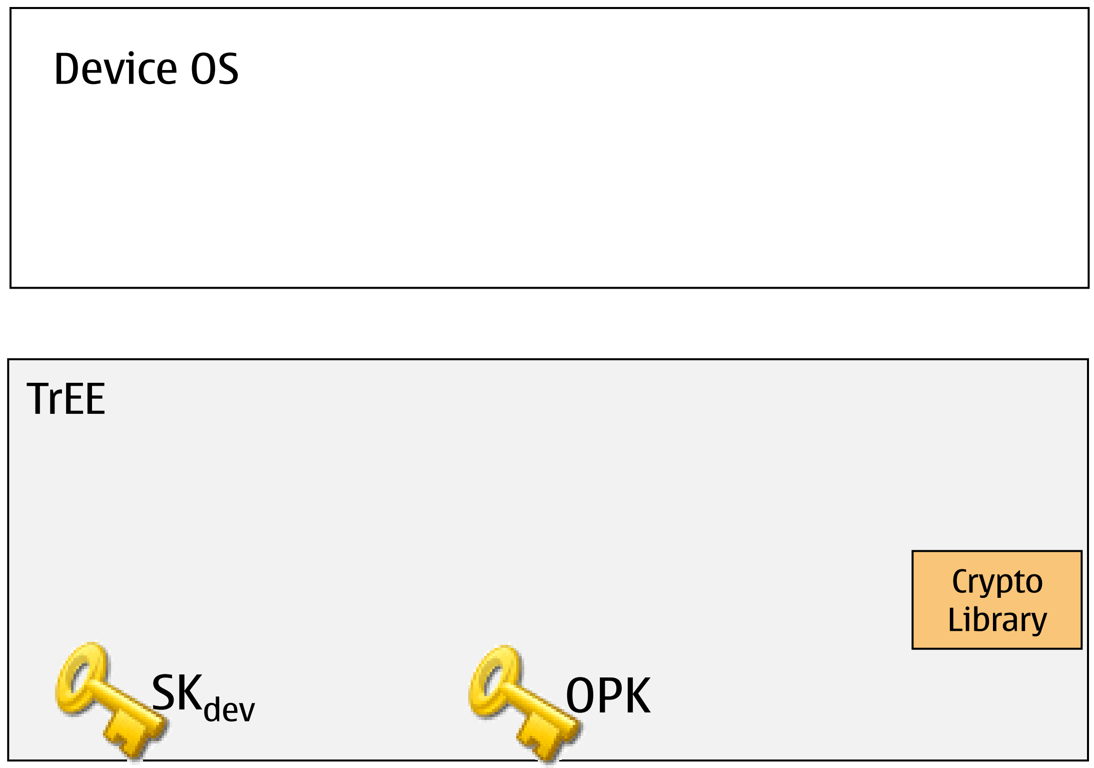
Credential = program + secret

ObC Architecture

ObC Architecture

On Trusted Execution Environments (TrEEs) with

- Secure execution (within TrEE)
- Secure storage (secret key in TrEE)
- Certified device keypair (PK_{dev}/Sk_{dev} in TrEE)



ObC Architecture

Credential = program + secret

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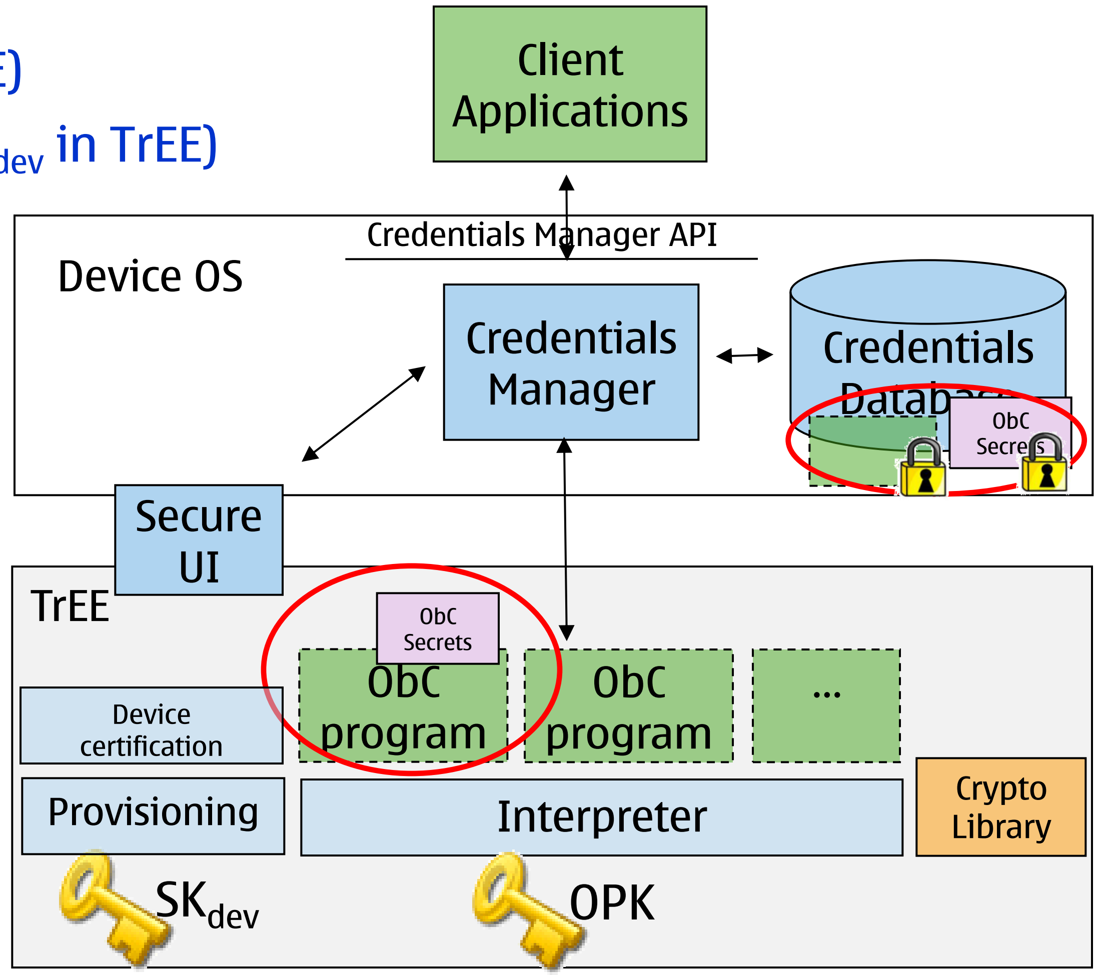

More in ACM ASIACCS '09 paper

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Isolation of ObC Programs

Isolating the platform from programs

- Constraining the program counter, duration of execution, ...

Isolating programs from one another

- Only one ObC program can execute at a time
- An ObC program can “seal” data for itself
    - Sealing key is different for every independent ObC program

      Sealing-key = KDF (OPK, program-hash)
    - A program can invoke functions like “seal(data)” (unsealing happens automatically on program loading)

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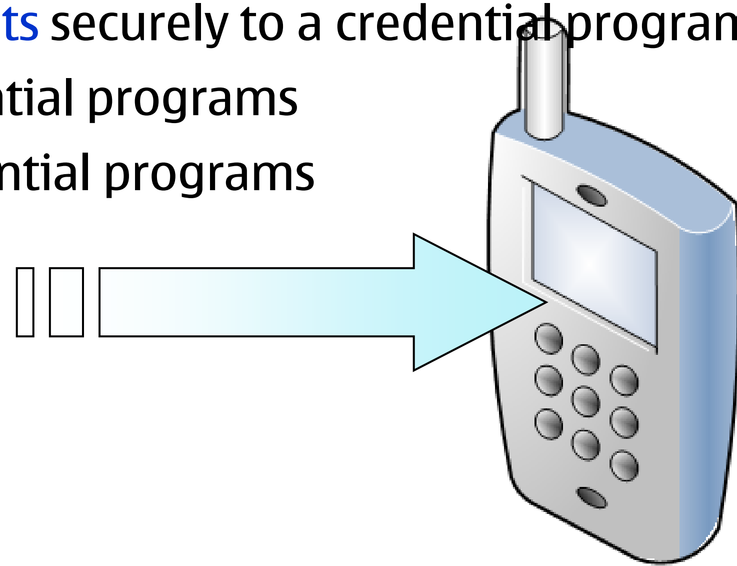
Secure Provisioning of ObCs

Requirements for Provisioning Credential Secrets

- Provisioning protocols typically focus on **user authentication** only
  - CT-KIP, Open Mobile Alliance Device Management (OMA DM), ...
- IETF keyprov working group is defining Dynamic Symmetric Key Provisioning Protocol (DSKPP)
  - Allows **device authentication** as well
- We need more...
  - provision a key so that it can be accessed by **specific credential programs**
- Subject to...
  - "Anyone can provision credential secrets securely to a credential program"
  - Support for multiple versions of credential programs
  - Support for several co-operating credential programs



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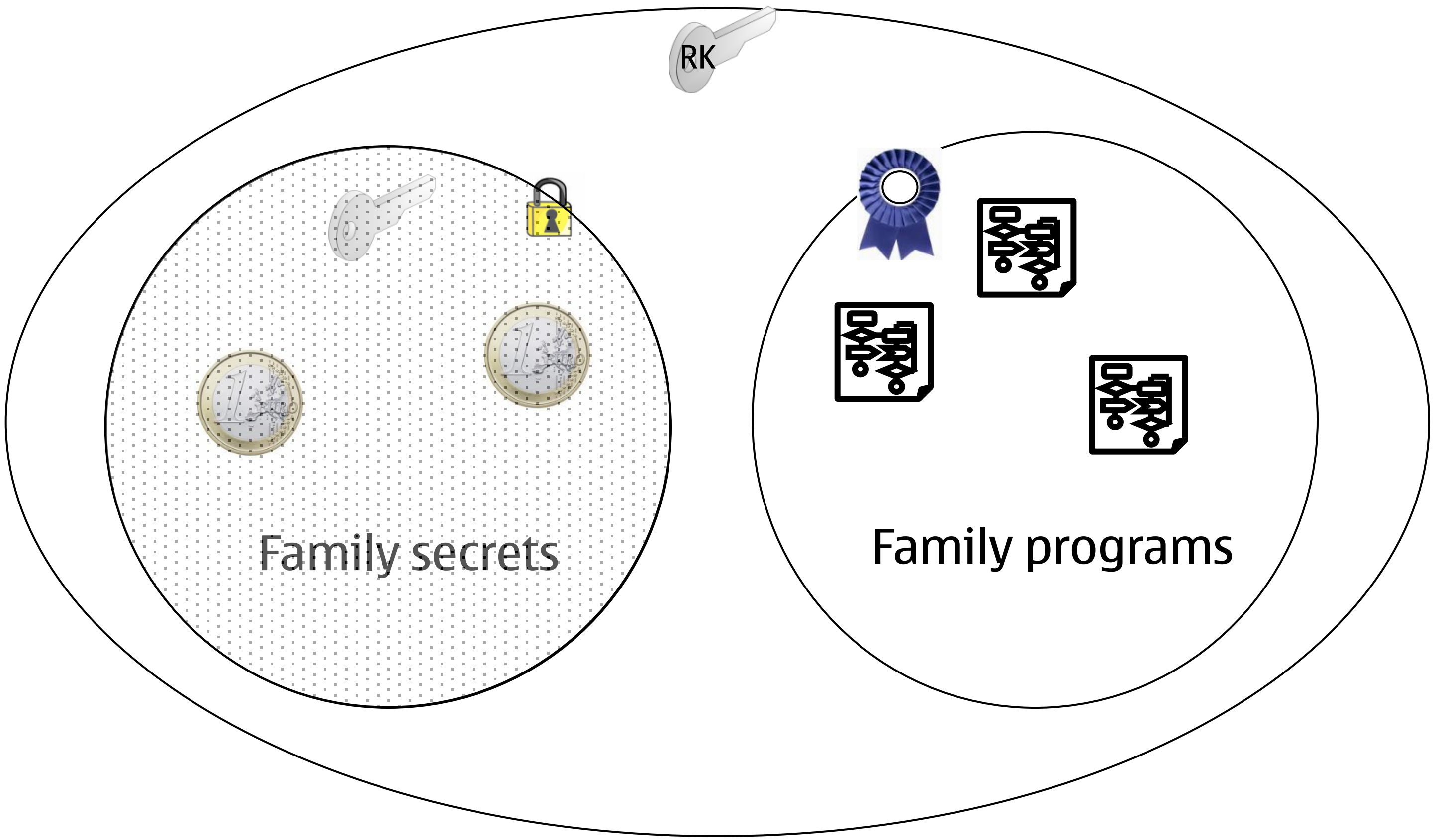
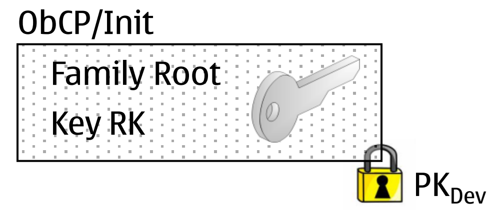
Provisioning credential secrets (1/4)

Basic Idea: the notion of a **family** of credential secrets and credential programs endorsed to use them

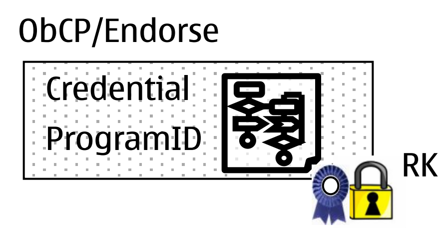


Provisioning credential secrets (2/4)

- Provision a family **root key** to the device
  - using ***authentic* device public key** PK_{Dev}



- Transfer encrypted credential secrets
  - using authenticated encryption (AES-EAX) with RK



- Endorse credential programs for family membership
  - Program ID is a cryptographic hash of program text
  - using authenticated encryption (AES-EAX) with RK

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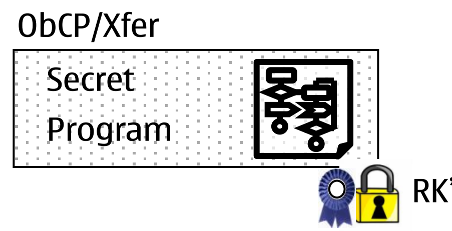
Provisioning credential secrets (3/4)

- Anyone can define a family by provisioning a root key
- Multiple credential secrets and programs can be added to a family

- Credential Programs can be encrypted as well



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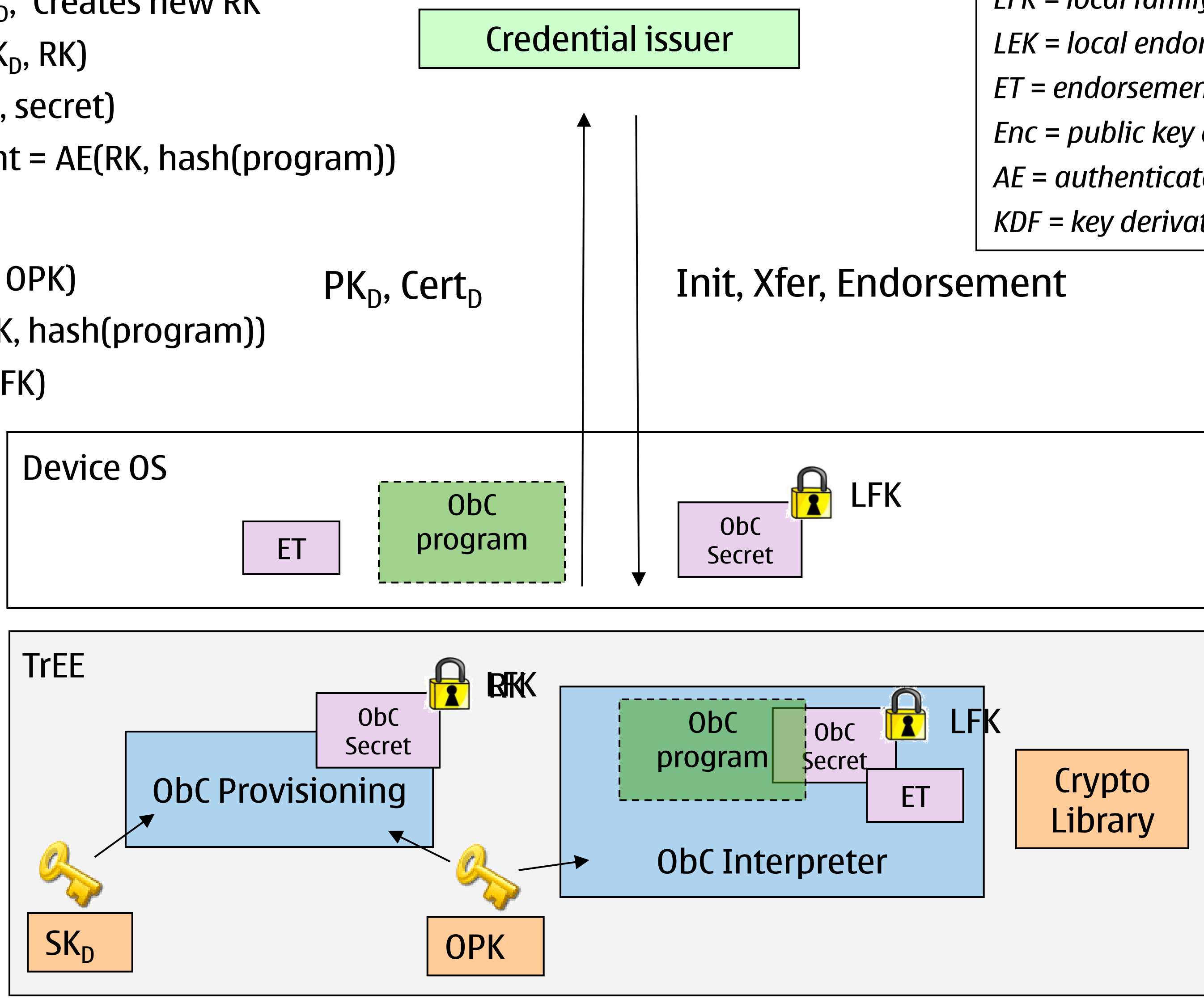
Provisioning credential secrets (4/4)

PK_D/SK_D = device keypair
$Cert_D$ = manufacturer certificate for PK_D
RK = family root key
LFK = local family key
LEK = local endorsement key
ET = endorsement token
Enc = public key encryption
AE = authenticated encryption
KDF = key derivation function

Verifies $Cert_D$, Creates new RK
Init = Enc(PK_D, RK)
Xfer = AE(RK, secret)
Endorsement = AE(RK, hash(program))

LFK = KDF(RK, OPK)
LEK = KDF(OPK, hash(program))
ET = AE(LEK, LFK)



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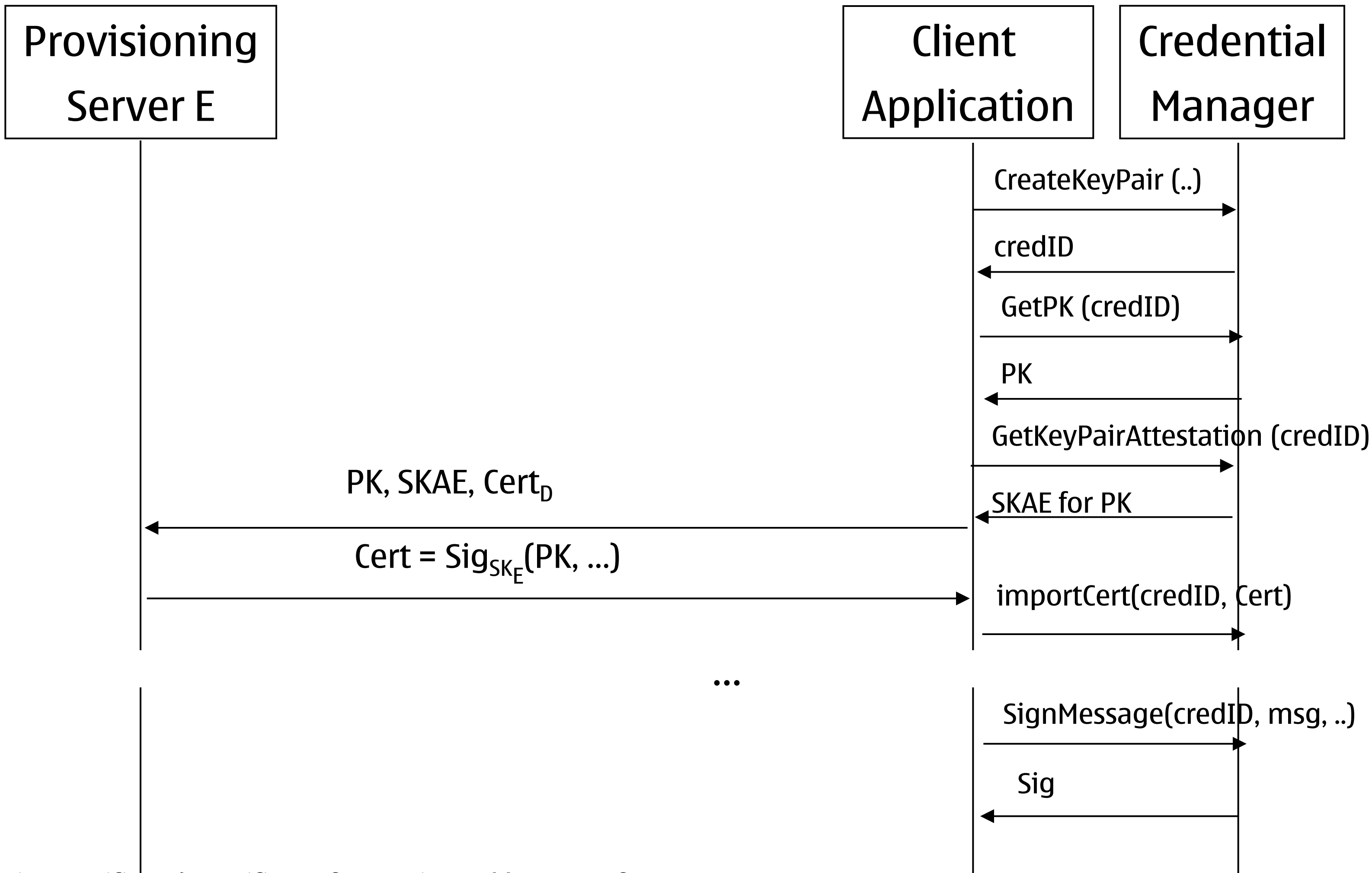
Asymmetric ObCs



$Cert_D$ (Device certificate) Certificate for PK_D issued by manufacturer

SKAE (Subject Key Attestation Evidence) for PK: Signature on PK issued by SK_D, attesting that SK is within the TrEE

Instantiations of the Architecture

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M-Shield™: Example hardware TrEE #1

M-Shield provides

- Secure boot
- Chip-specific secret key (e-fuse)
- Secure execution of certified "Protected Applications" (PAs)
- On-chip RAM for PAs
- … (hardware RNG, crypto accelerators, …)

http://focus.ti.com/pdfs/wtbu/ti_mshield_whitepaper.pdf

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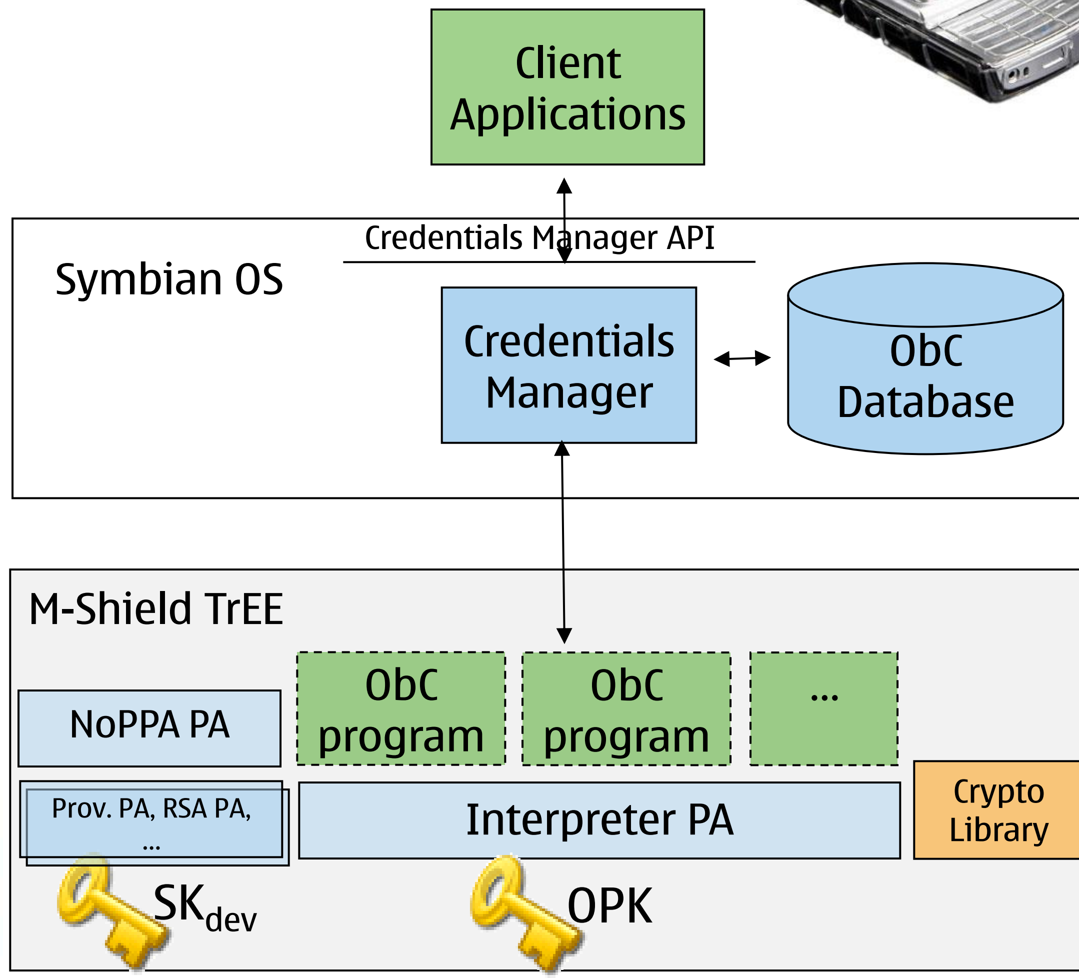
ObC on Symbian/M-Shield secure h/w (2007-2009)

- M-Shield secure boot used for validation of OS
- Interpreter , Provisioning subsystem are PAs
  - Use on-chip RAM
- OPK from chip-specific secret
- Device key pair
  - generated by Prov. PA
  - protected by chip-specific secret key
  - certified by manufacturer



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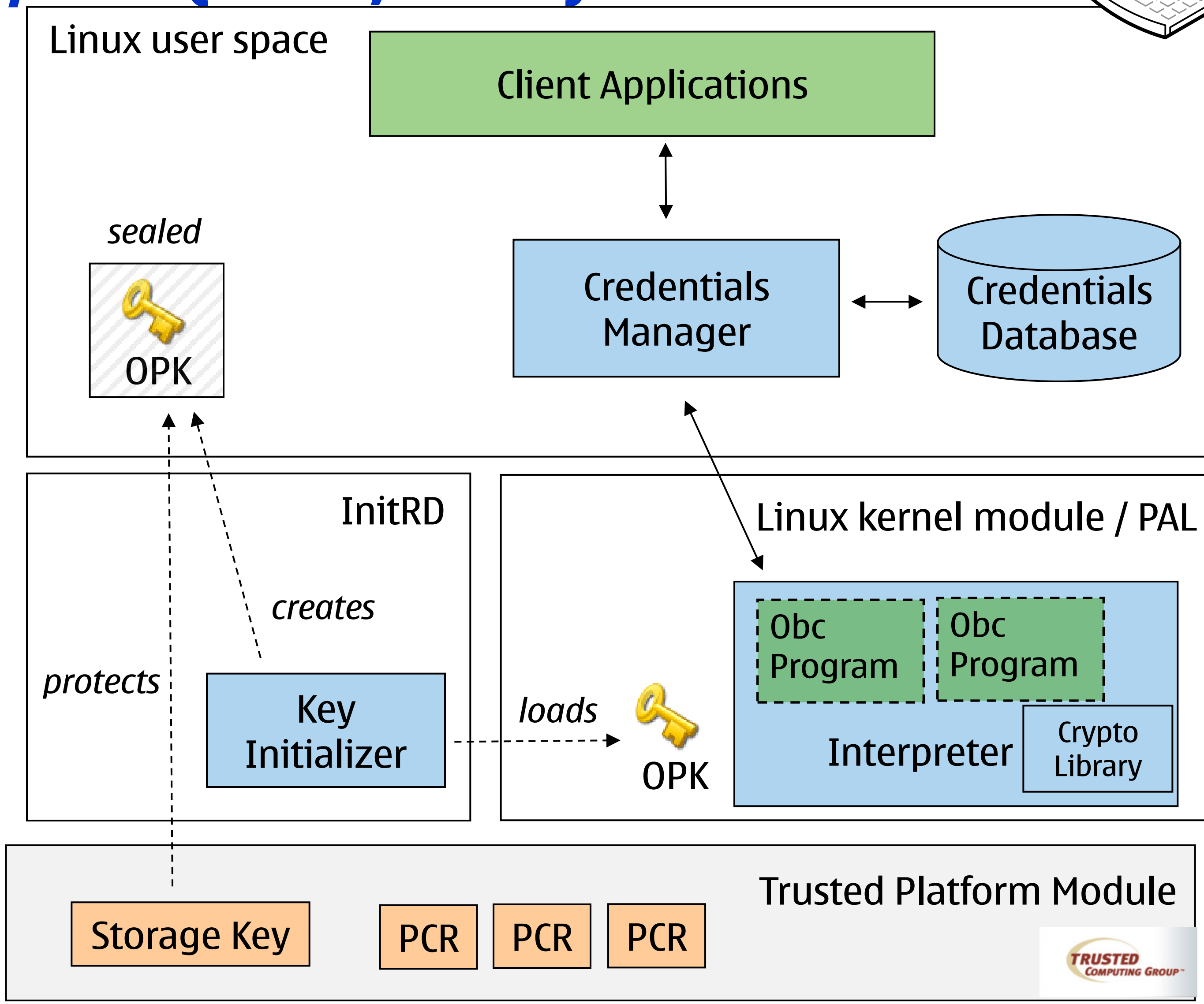
TPM: Example hardware TrEE #2

TPM provides

- Authenticated boot
  - Components during boot measured and recorded in Registers (PCRs) within TPM
  - A set of PCR values = a “configuration”
- Secure storage for keys bound to a specific configuration
- Ability to seal arbitrary data bound to a specific configuration
- Secure execution of selected cryptographic operations
- … (remote attestation, …)

ObC using Linux/TPM (2006, 2009)

- Interpreter in kernel module on InitRD
- KeyInitializer in InitRD creates OPK on first use and seals for current configuration
- KeyInitializer unseals OPK on subsequent invocations.
- Security of execution improved using dynamic root of trust (2009): Flicker "PAL" instead of kernel module.



MSc thesis work:
http://asokan.org/asokan/research/Aish-Thesis-final.pdf

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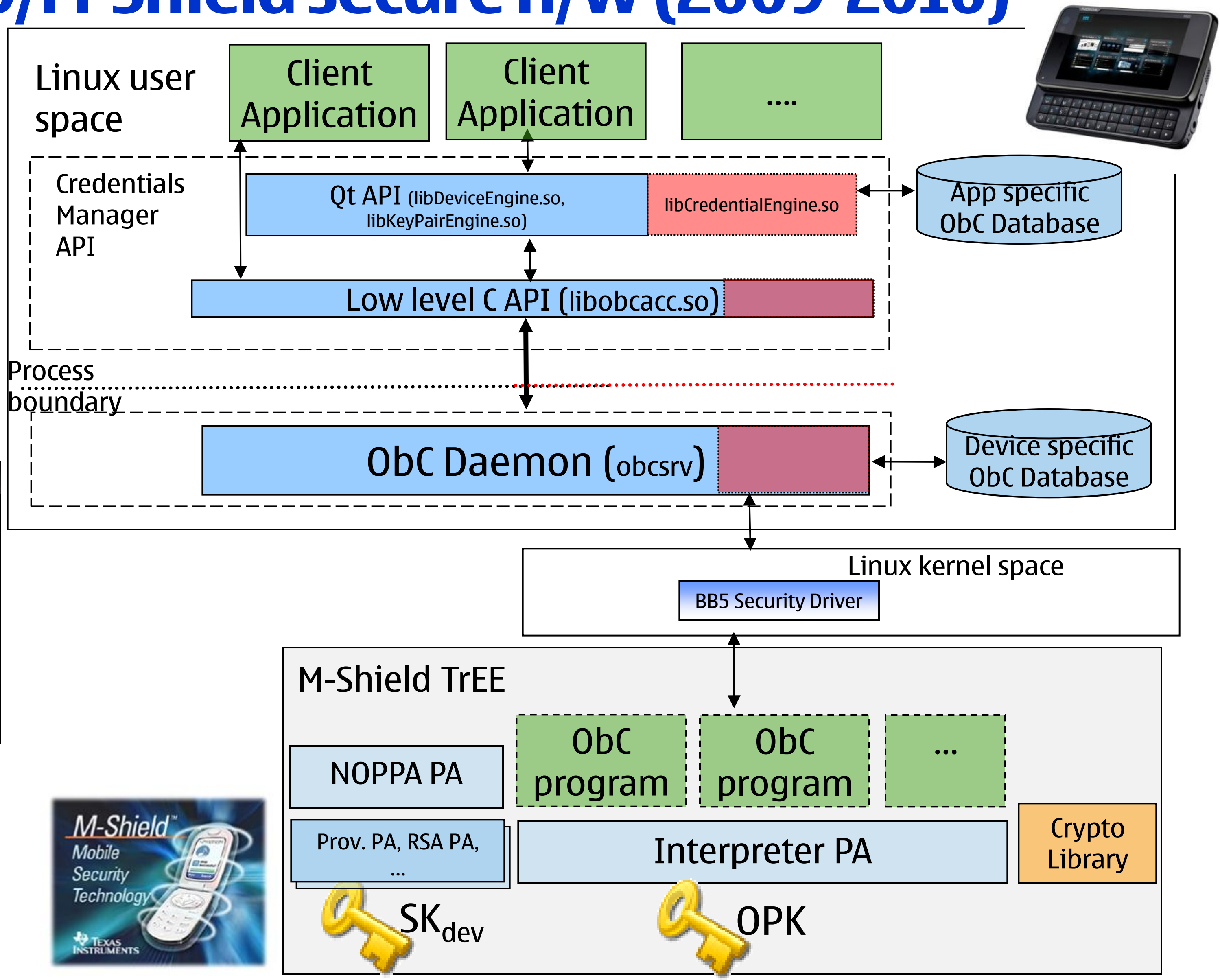
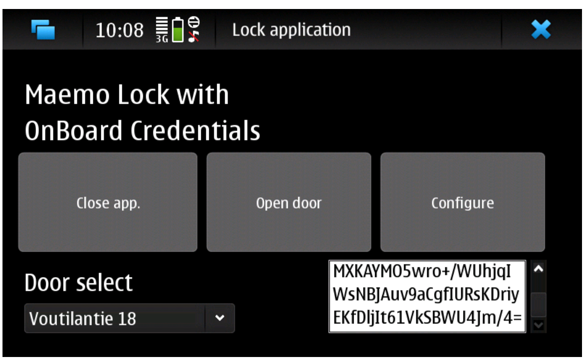
ObC on Maemo/M-Shield secure h/w (2009-2010)

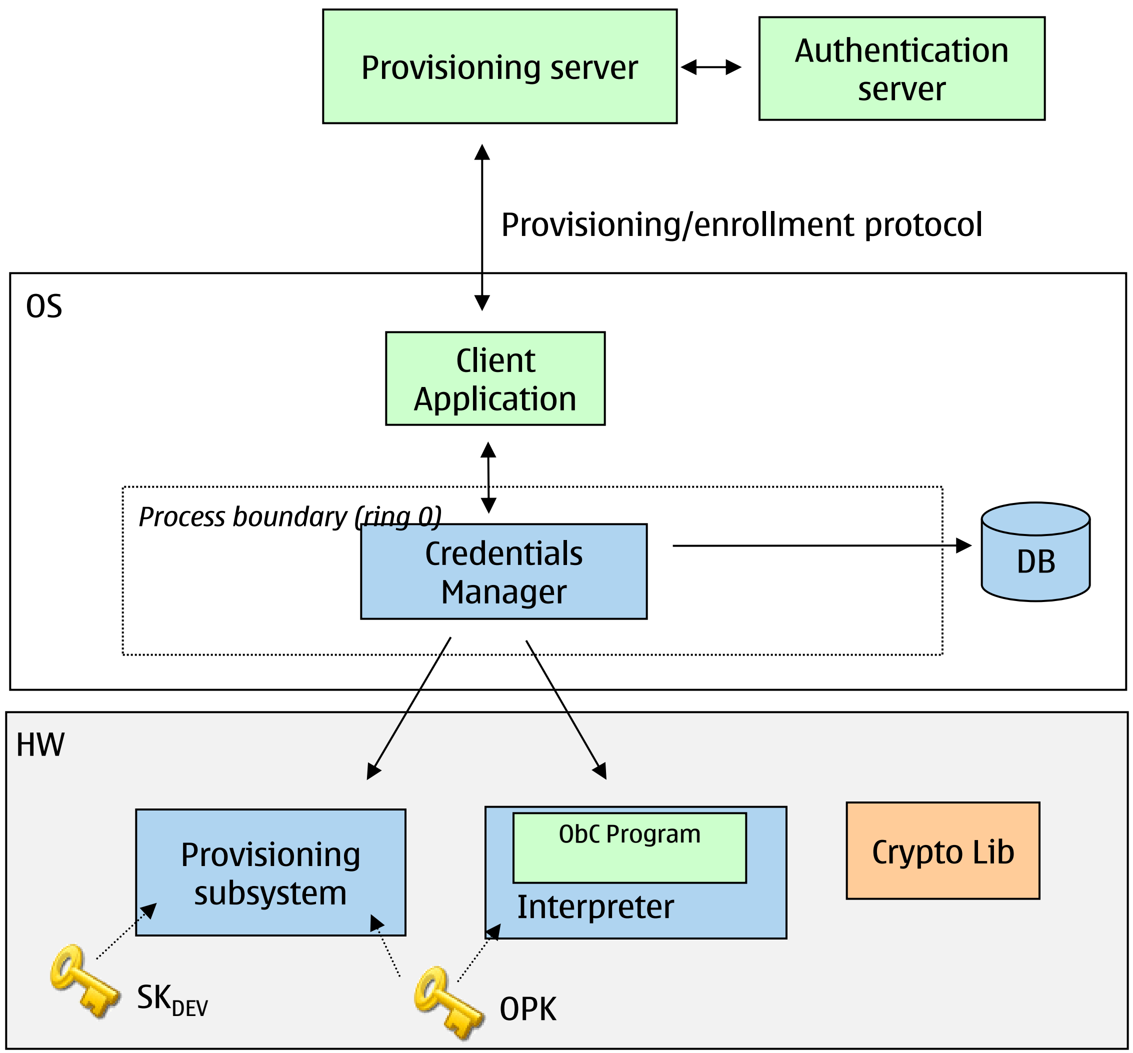




Deployment considerations

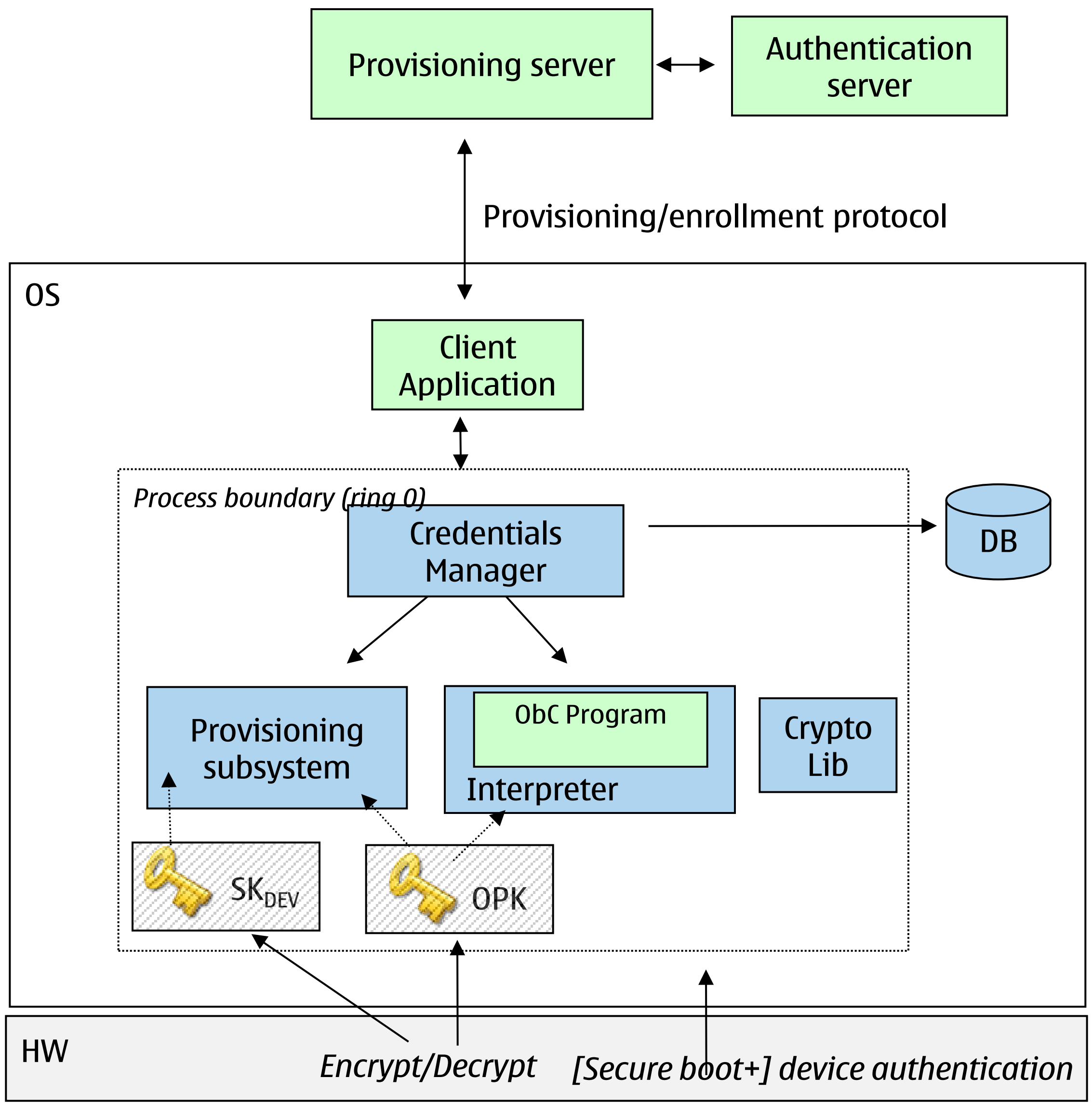
Skip to "ObCs in action"

1. ObC: Full use of secure hardware



- ObC secret and algorithm (ObC program) protected by hw TrEE
  - PK_{Dev} to protect provisioning or attestation
  - Secrets not accessible to OS
  - Cannot be copied between devices
  - Hardware attack typically destructive and device-specific
- Encrypted secret stored in Credentials Manager database
  - Can be backed up
- Works on certain existing device models (e.g., N900)

2. ObC: Partial use of secure hardware



- ObC PAs emulated in the Credential Manager (OS process)
- Secure HW used to enable secure storage and device authentication
- ObC program runtime execution protected by OS platform security
- Works on most recent off-the-shelf Symbian devices

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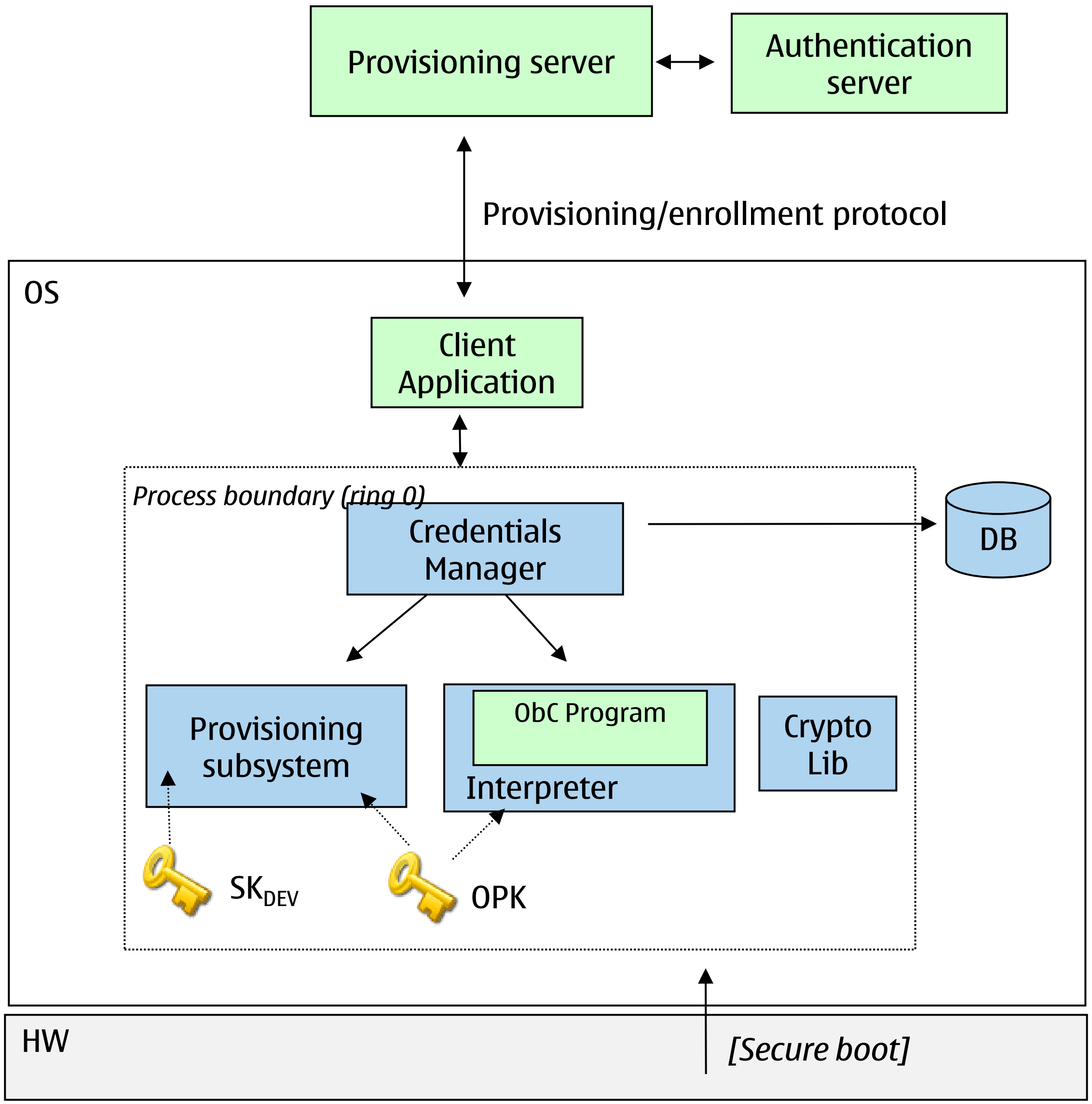
3. ObC: Emulated

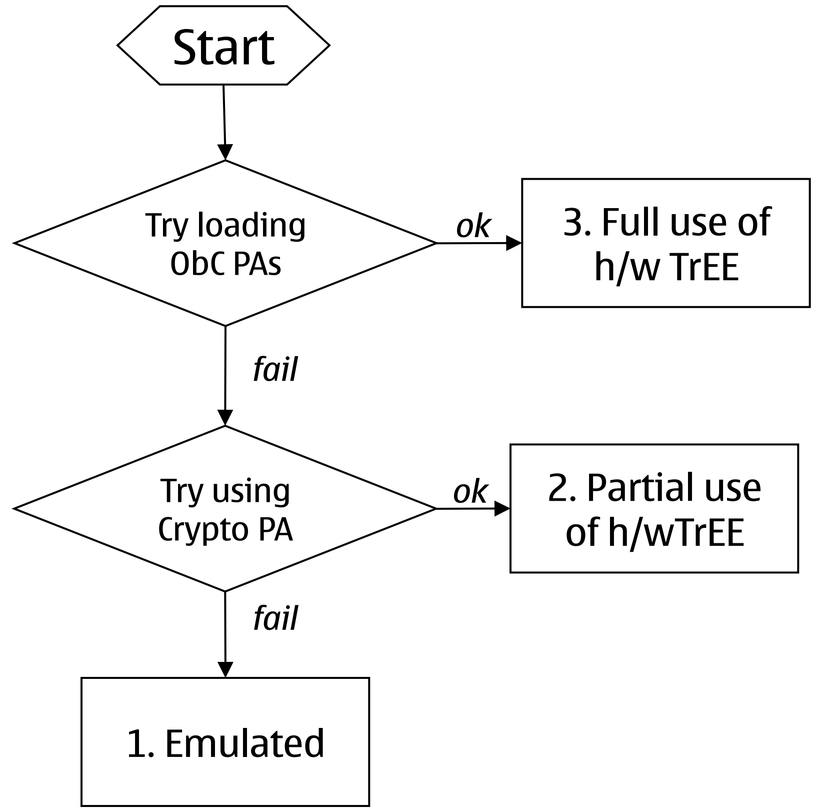


- ObC PAs emulated in the Credential Manager (OS process)
- Secure HW may be used for secure boot
- Storage ObC secrets and ObC program runtime execution protected by OS platform security
- No device authentication

- For debugging/development

ObC implementation supports all 3 variants

- Implementation contains code for emulating TrEE PAs (interpreter+provisioning+crypto)
- Same software package can be installed in any Symbian device
  - automatically decides the variant to use
- (“PA” = “Protected Application” refers to code that runs in the M-Shield hardware TrEE)



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ObCs in action

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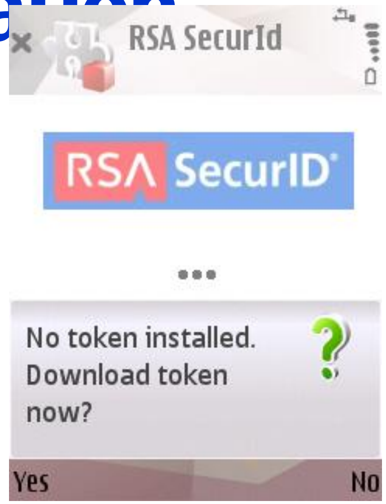
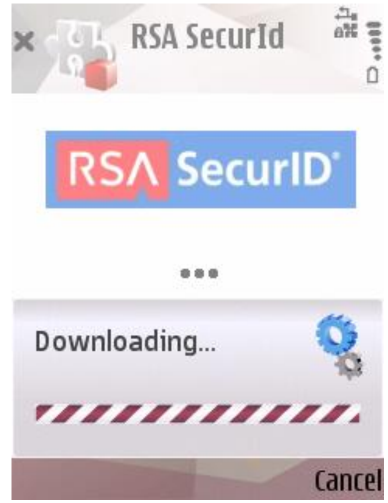
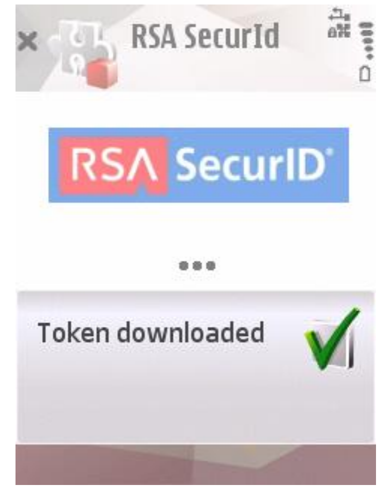
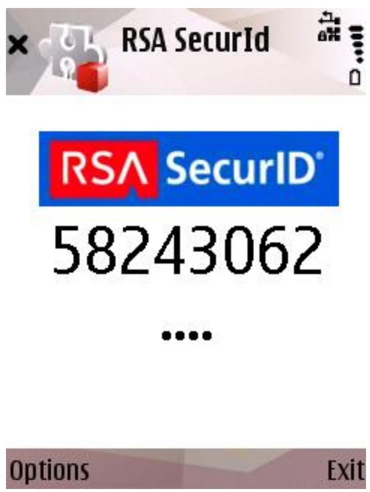
An Example ObC: SecurID one-time password authentication









Joint research project with RSA security

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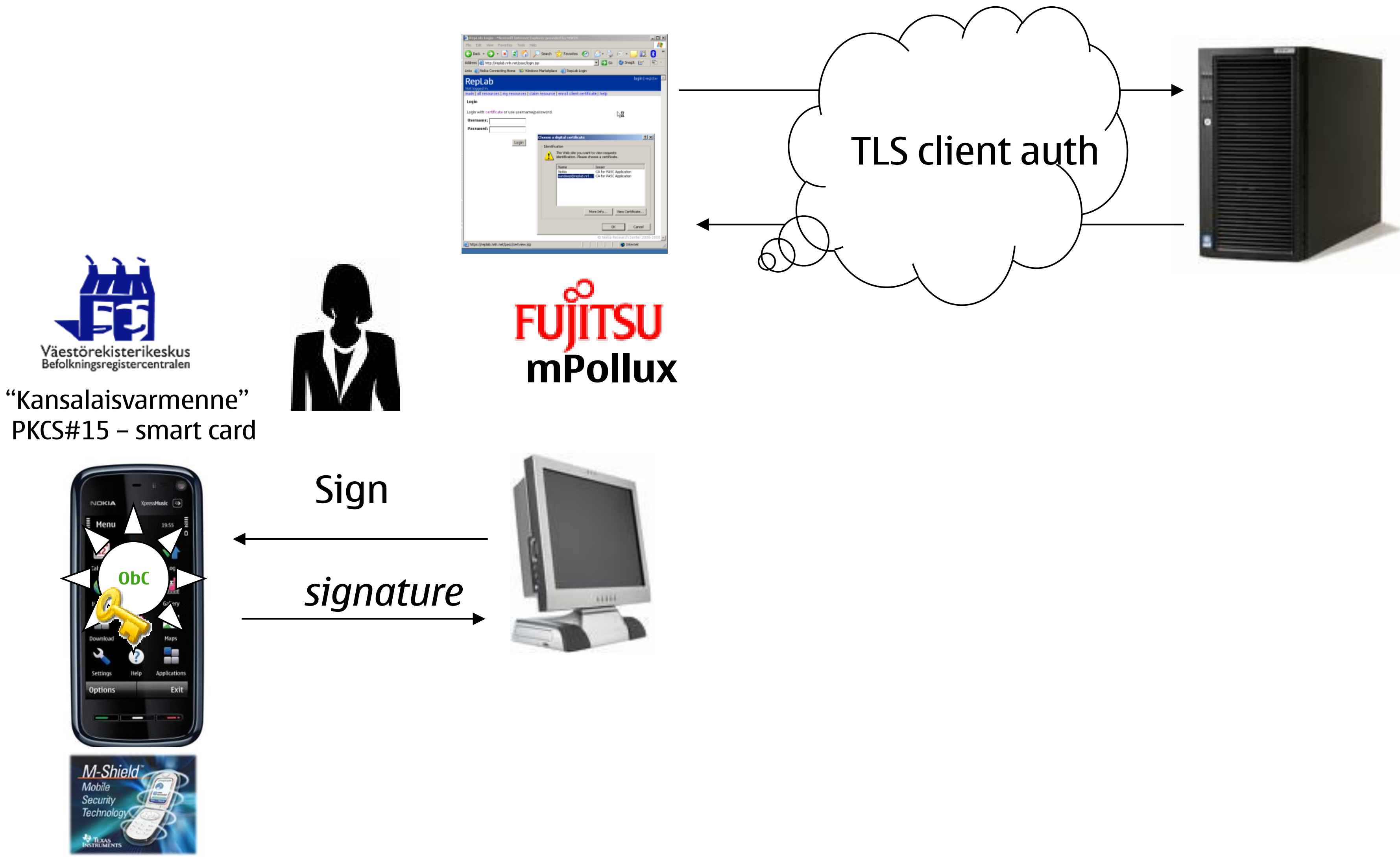
Phone as smartcard (PASC)

- Applications use public key (PK) cryptography via standard frameworks
  - Crypto API (windows), Cryptoki (Linux, Mac), Unified Key/cert store (Symbian)
  - Agnostic to specific security tokens or how to communicate with them

→Any PK-enabled smartcard can be used seamlessly with PK-aware applications!

What if mobile phone can present itself as a PK-enabled smart card?

Demo: Mobile device as secure token for client auth



Secure yet inexpensive

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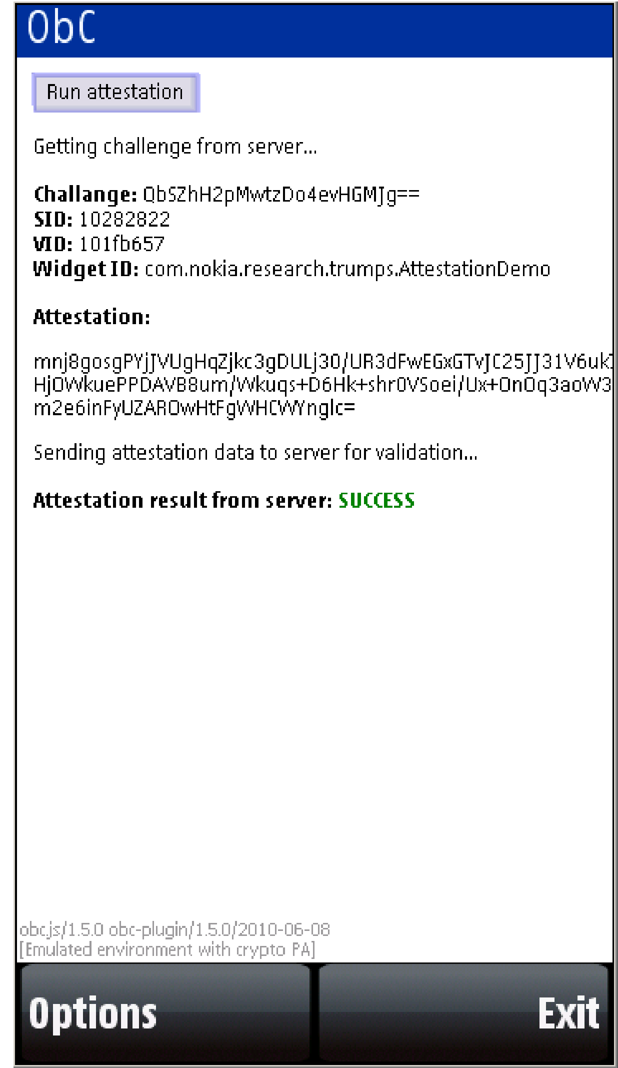
Demo: Remote Attestation

Challenge

Challenge, attestation data, sig(chal., att. data)



Mobile terminal proves that it is running the right widget in the right web runtime

ObC Status

ObC Status (1/2)

ObC available for Symbian and Maemo

- Binary package installable on any recent Nokia Symbian/Maemo device
- Development environment for ObC programs (Windows, Linux)
- Credential Manager and interfaces (native, python, javascript)
- Available under limited license agreement for research and testing

ObC Status (2/2)

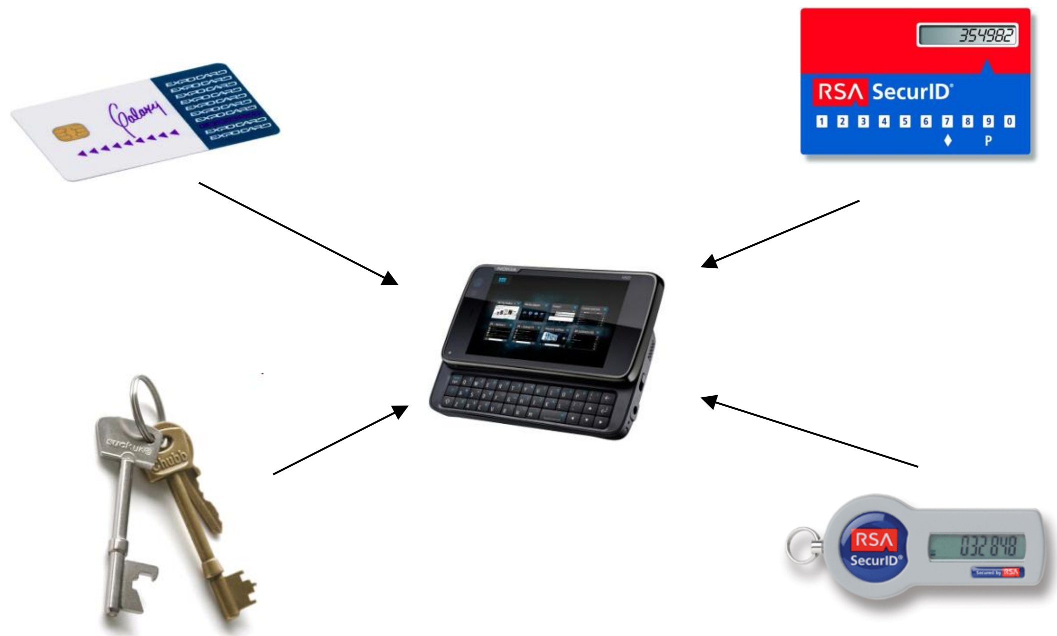
- On-going research to address several extensions
  - E.g., Credential transfer, validation, new types of hardware TrEEs
- Useful for several applications
  - Device authentication, financial services, secure messaging, ...
  - Pragmatic means to solve otherwise hard privacy/security problems in distributed computing (e.g., secure multi-party computation)

Summary

- On-board Credentials platform
  - inexpensive
  - open
  - secure

- A step towards the vision of a **personal trusted device**

- **Available for you to build on**



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How to make it possible to build trustworthy information protection mechanisms that are simultaneously easy-to-use and inexpensive to deploy while still guaranteeing sufficient protection?

Security

Usability

Deployability/Cost