# Mobius

## Mobility, Ubiquity and Security

Enabling proof-carrying code for Java on mobile devices

http://mobius.inria.fr

## Mission

Mobius is a European Integrated Project developing novel technologies for trustworthy global computing, using ***proof-carrying code*** to give users independent guarantees of the safety and security of Java applications for their mobile phones and PDAs.

Global computing means that applications today may run anywhere, with data and code moving freely between servers, PCs and other devices: this kind of mobility over the ubiquitous internet magnifies the challenge of making sure that such software runs safely and reliably.

In this context, the Mobius project focuses on securing applications downloaded to the Java MIDP platform: globally deployed across a host of phones, this is the common runtime environment for a myriad mobile applications.

Techniques of ***static analysis*** make it possible to check program behaviour by analysing source code before it ever executes. But mobile code means that this assurance must somehow travel with the application to reach the user. Conventional digital signatures use cryptography to identify who supplied a program; the breakthrough of ***proof-carrying code*** is to give mathematical proofs that guarantee the security of the code itself. We can strengthen digital signatures with digital evidence.

Key features of the Mobius security architecture are:

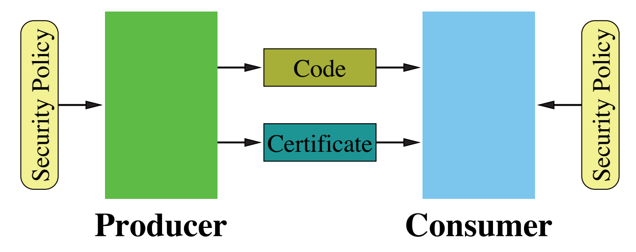
- **Innovative trust management**, with digital evidence of program behaviour that can be independently checked by users or any third party.
- **Static enforcement**, checking code before it starts; adaptable to manage a range of user security concerns, and configurable to match the real-world mix of mobile platforms.
- **Modularity**, allowing developers to build up trusted applications from trusted components.

Mobius is a consortium of leading academic and industrial research partners, at 16 sites across ten countries. Members bring international expertise in software security, Java, mobile telecoms and smart devices. All these combine with the aim of delivering a platform for innovative trust management in the next generation of mobile applications.

## Proof Carrying Code

Proof Carrying Code (PCC, developed by Necula, Lee and others in the 1990s) is a general technique for mobile code security which associates security information (***certificates***) to programs.

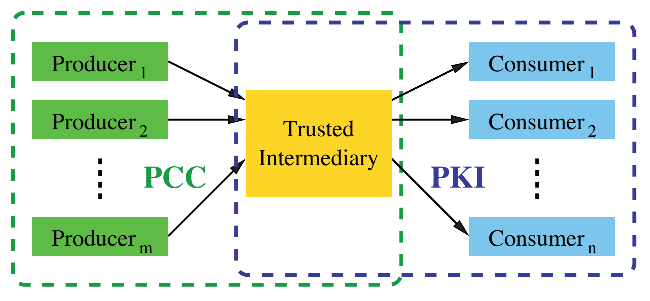
- **Producer** generates certificate (or proof) of compliance with security policy by using a ***certifier*** at compile time.
- **Consumer** receives the untrusted package “program + certificate” and runs a ***checker*** to verify compliance with security policy.



PCC has many uses in systems whose trusted computing base is dynamic, either because of mobile code or because of regular updates. Examples include extensible operating systems, Internet browsers capable of downloading code, active network nodes and safety-critical embedded controllers.

The proof carrying code paradigm can be combined with ***trust by reputation***.

- **Producers** submit programs and certificates to a trusted intermediary.
- **Trusted intermediary** - any trusted third party chosen by consumers, e.g. the phone operator - checks certificates and signs checked programs.
- **Consumers** receive programs from trusted intermediary and check signatures (not certificates).



***Wholesale PCC***

### Challenges

PCC shifts some of the burden of ensuring compliance with a desired security policy from the code consumer to the producer. To enable the use of PCC technology widely, Mobius will:

- define ***expressive security policies*** covering a wide range of properties,
- develop ***easy-to-use certificate generators***, and
- design ***reliable and efficient checkers*** for certificates.

## Mobius Platform

Mobius targets Java-enabled embedded execution frameworks that can run third party applications which must be checked against a platform security policy. Focus on devices (e.g. mobile phones) that support the Mobile Information Device Profile (MIDP version 2) and the Connected Limited Device Configuration (CLDC) of the Java 2 Micro Edition.

Reasons for choosing CLDC/MIDP:

- Uniform access to many resources specific to mobile devices (e.g. persistent store, players, camera, geolocalisation).
- Available on many devices (> 1 billion).
- Interesting subset of the Java language.
- Thousands of existing applications.
- Standardised through the Java Community Process.

## Security Requirements

### Information flow

Policies prevent or limit the disclosure of sensitive information (e.g. contacts, diary entries, photos, credit card numbers) to untrusted parties, in order to protect the user's privacy or assets.

Mobius targets confidentiality policies for:

- non-interference and
- declassification.

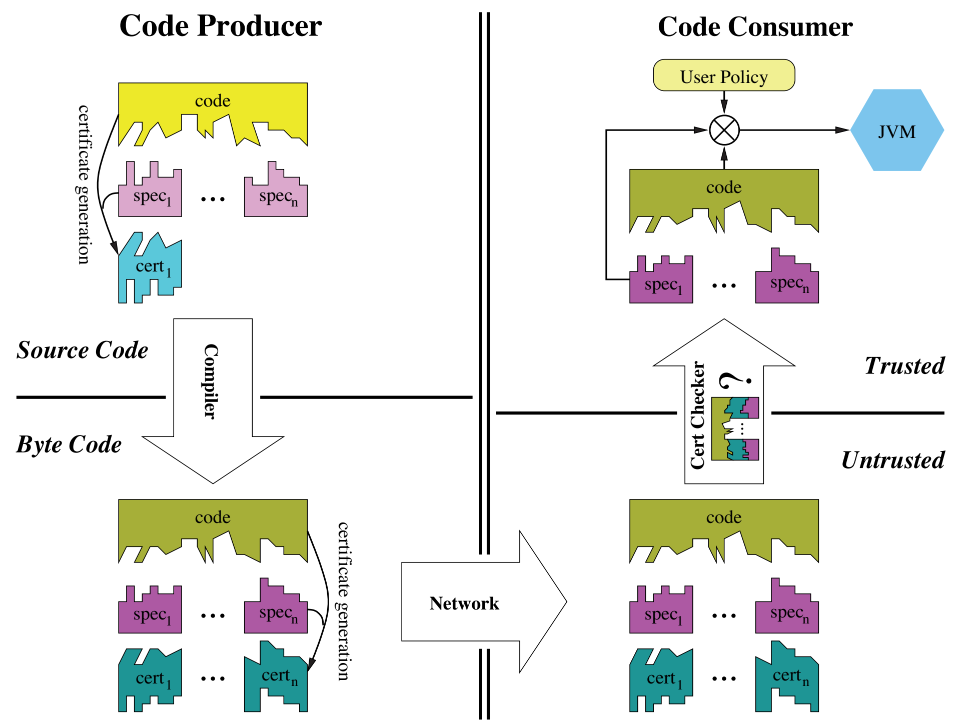
### Resource usage

Policies bound the use of certain resources because they are expensive or their abuse compromises availability.

Mobius targets policies for:

- CPU time,
- memory space (stack, heap, persistent store), and
- billable events (e.g. sending text messages).

## Enabling Technologies



### PCC infrastructure

Mobius develops infrastructure for proof carrying code on all stages of the development and deployment cycle.

- ***Proof-transforming compilers*** translate code, specifications (types or logical assertions) and certificates from the source code to the byte code level. Alternatively, ***certifying compilers*** may generate certificates directly at the byte code level.
- In a ***wholesale PCC*** scenario, trusted intermediaries check certificates and sign checked code for transmission over the network. Consumers rely on a PKI for checking signatures.
- With the Coq proof assistant a ***verified certificate checker*** can be mechanically extracted from the formalized proof of soundness for a program logic, analysis or type system.

### Three flavours of PCC

Historically, the first approaches to proof carrying code have been based on formal proofs in a program logic. Later approaches have extended the notion of proof to any form of evidence that is efficiently checkable. Mobius uses three different flavours of PCC.

#### Logic-based PCC

Specifications are expressed in a general-purpose program logic, such as Hoare logic or the Java Modeling Language (JML). Certificates are proofs in this program logic, and checking a certificate means checking that a given proof tree is well-formed.

+ Flexible due to highly expressive program logic.

+ Proofs in the program logic as ***lingua franca*** for certificates.

- Certificate generation (= proof search in the program logic) requires human intervention.

#### Type-based PCC

Specifications (e.g. information flow properties, resource boundedness, aliasing relationships) are expressed as typability in special purpose type systems. Certificates are type derivations, and certificate checking amounts to checking the well-formedness of a given type derivation.

+ Automatic certificate generation by type inference.

+ Type derivations can be translated to proofs in a program logic.

- Analysis may be too conservative.

- Each type system is customized to a particular property.

#### Abstract interpretation PCC

Specifications are expressed as systems of equations in complete lattices. Certificates are representations of fixpoint solutions. Certificate checking amounts to checking that a given representation is a fixpoint.

+ Automatic certificate generation by abstract interpretation.

- Different properties require customized abstractions.

## Mobius Consortium

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- INRIA, France *(Coordinator)*
- TLS Technologies, Poland
- ETH Zürich, Switzerland
- Radboud Universiteit Nijmegen, the Netherlands
- Ludwig-Maximilians-Universität, Munich, Germany
- The University of Edinburgh, United Kingdom
- Institute of Cybernetics, Tallinn, Estonia
- Chalmers Technical University, Sweden
- Imperial College, London, United Kingdom
- University College Dublin, Ireland
- University of Warsaw, Poland
- Trusted Labs, France
- France Telecom, France
- Universidad Politecnica de Madrid, Spain
- SAP AG, Germany
- RWTH Aachen, Germany (till March 2007)
- Technische Universität Darmstadt, Germany (since April 2007)

SIXTH FRAMEWORK PROGRAMME

Information Society Technologies