Interactive Proof Documents

Theorem Provers for User Interfaces

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Motivation

Aims

- Renovate and reform traditional "LCF-style" theorem proving for coming generations of users.
- Catch up with technological shifts, e.g. advanced user-interfaces, parallel computing.
- Support novel models for interactive proof checking.

Proof Documents

Documents

Classical structure: definition — statement — proof

Example: Isabelle/Isar

datatype $foo = Foo \mid Bar\ foo$

lemma fixes $x :: foo$ **shows** $P\ x$
proof $(induct\ x)$
  case Foo
  then show $P\ Foo$ $\langle proof \rangle$
next
  case $(Bar\ x)$
  note $\langle P\ x \rangle$
  then show $P\ (Bar\ x)$ $\langle proof \rangle$
qed

Scripts (1)

```
datatype foo = Foo | Bar foo
lemma fixes x :: foo shows "P x"
proof (induct x)
case Foo
then
show "P Foo"
sorry
next
case (Bar x)
note ‘P x‘
then
show "P (Bar x)"
sorry
qed
```

Scripts (2)

Problems with proofs scripts:

- No structure.
- Inefficient checking.
- Prover policies enforce bad habits.

Proof document structure

General interactive provers:

1. definitions / statements: sequential dependency
2. proofs: irrelevant $\longrightarrow$ independent $\longrightarrow$ parallel checking

Isabelle/Isar:

0. theories: graph structured (DAG)
1. definitions / statements: sequential
2. toplevel proofs: parallel
3. local proofs: hierarchical (tree)

Intermission: parallel proof checking

1. Native threads in Poly/ML (David Matthews 2007/2008)
2. Value-oriented parallel computations (summer 2008)

```
type 'a future
fork: (unit -> 'a) -> 'a future
join: 'a future -> 'a
cancel: 'a future -> unit
```

3. Proof objects with holes (last week)

   $promise\ a[\overline{\alpha}]$: φ where $FV\ \varphi = \{\}$ and $TV\ \varphi = \overline{\alpha}$

   $fulfill\ a = p$

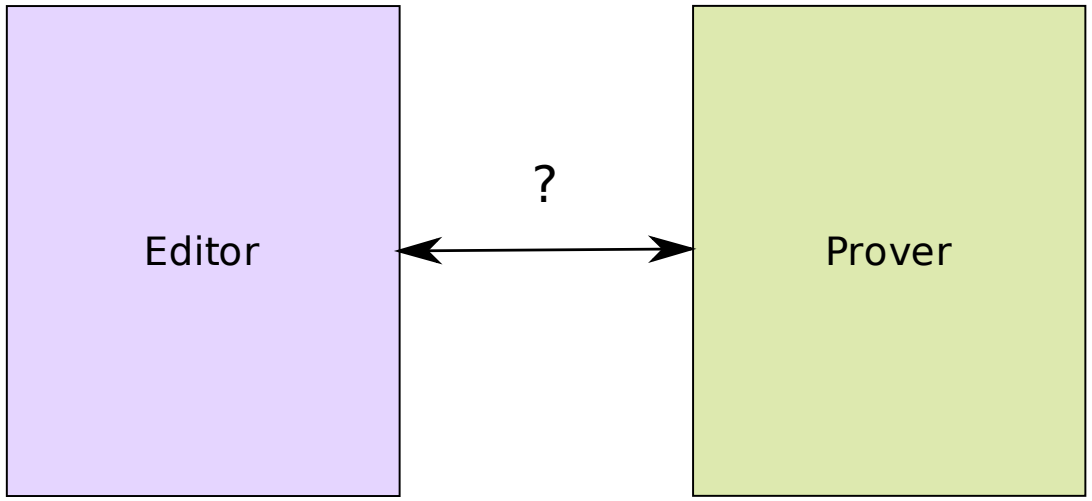
4. Extended "LCF" inference kernel (fall 2008)

```
Thm.future: (unit -> thm) -> term -> thm
Thm.force_proof: thm -> unit
```

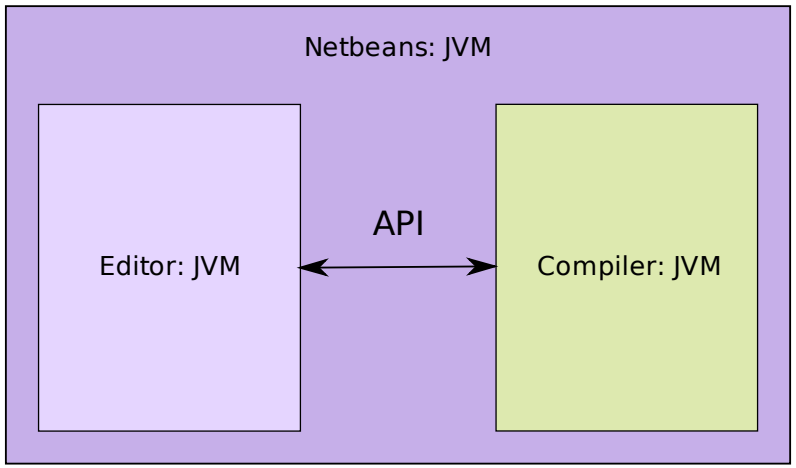
5. Extended Isar/VM ("goal package") (summer 2008)
6. Extended Isabelle/Isar toplevel and interaction protocol

Interface Architecture

Editor versus Prover



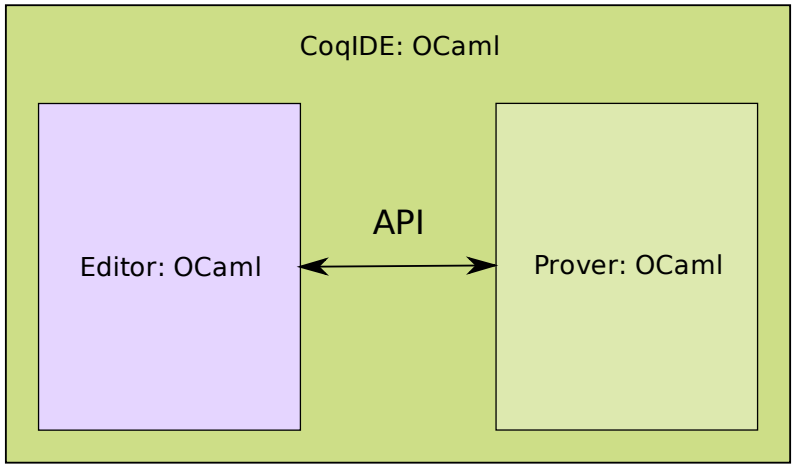
Example: Java IDE



Characteristics:

+ Conceptually simple — no rocket science.
+ It works well — mainstream technology.
−− Provers are not implemented in Java!
− Even with Scala/JVM, the JVM is not ideal for LCF-style provers.

Example: Coq IDE



Characteristics:

\+ Conceptually simple — no rocket science.

+− It works . . . mostly.

− Many Coq power-users ignore it.

− GTK/OCaml is a niche market; GTK/SML is unavailable.

−− Need to duplicate editor implementation efforts.

Mixed platforms

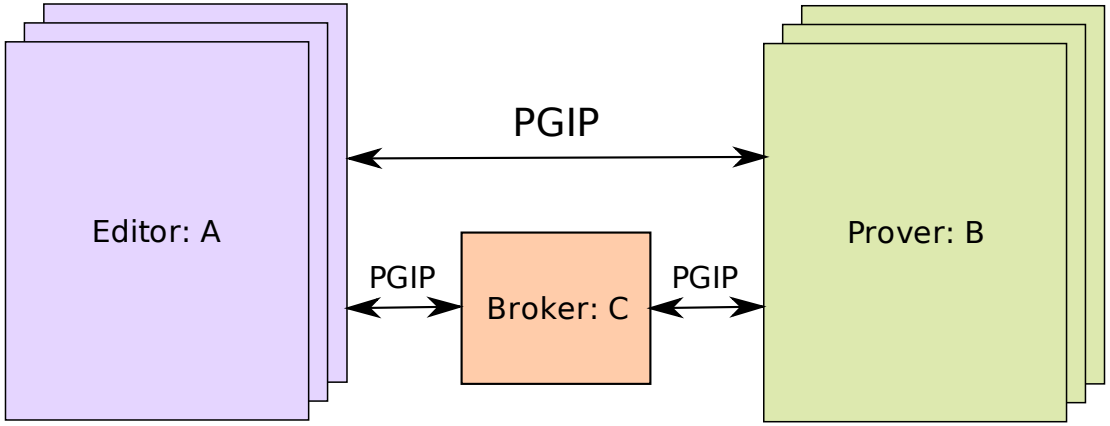
Realistic assumption:

- Prover: SML (or OCaml or Haskell)
- Editor: Java/JVM (or . . .)

Big problem: How to integrate the two worlds?

- Separate processes: requires marshalling, serialization, protocols.
- Different implementation languages and programming paradigms.
- Different cultural backgrounds!

Example: PGIP framework



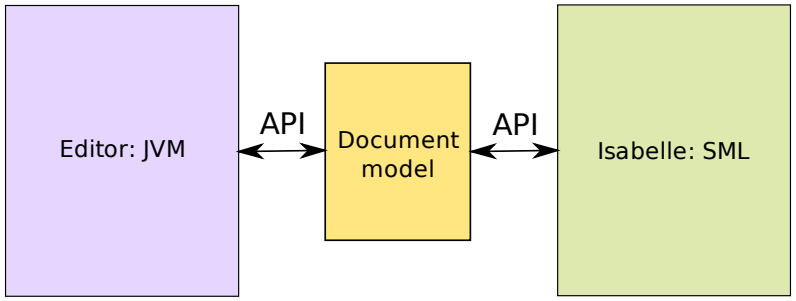
Characteristics:

+ Very general architecture of distributed components.
– Significant effort for protocol definition.
– Significant effort for implementation, integration, and maintenance.

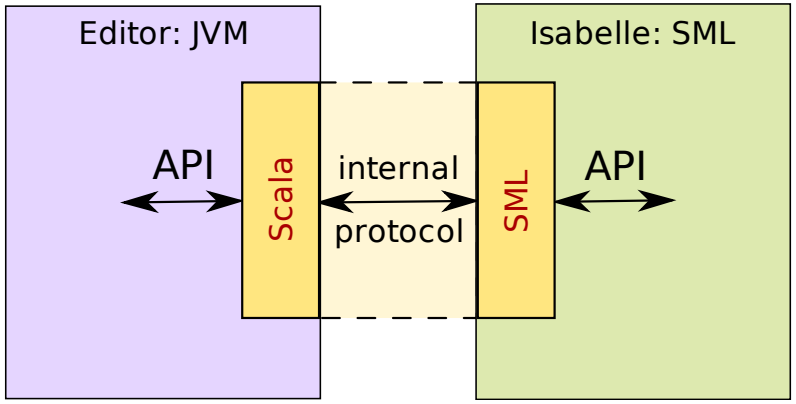
Note: fundamental difference of API vs. protocol

Future Isabelle/Isar architecture (1)

Conceptual view:



Implementation view:



Future Isabelle/Isar architecture (2)

Characteristics:

+ Regular API, based on internal protocol.
+ Supports mixed environments: Scala/JVM vs. SML.
+ Conceptual advances in proof document model: parallel checking, asynchronous interaction.
– Significant effort for design and initial implementation.
– Provers need to be adapted to interface needs.
– Biased towards particular platforms.
+ Focussed on particular platforms.

Actual Implementation

Isabelle process wrapper

- Type: JVM library implemented in Scala
- Features:
  - process management
  - message model
  - XML / YXML transfer
  - Isabelle symbol recoding
- Developed as integral part of Isabelle
  see `~~/lib/classes/Pure.jar` and `~~/src/Pure`

Isabelle / Netbeans

- Type: standalone Java application within the Netbeans framework
- Features:
  - basic "Proof General" functionality
  - uses old version of Isabelle process wrapper
  - implements first version of IAPP document model
- Developed by Holger Gast (Universität Tübingen)
  within a few weeks (including learning Netbeans)

Isabelle / jEdit

- Type: plugin written in Scala, for Java-based editor framework
- Features:
  - basic support for forthcoming proof document model
  - discontinues typical "Proof General" interaction
- Developed by Johannes Hölzl (TU München)
  within several weeks (undergraduate programming project)

Reasonable technologies

- Scala/JVM, not Java
- potentially Scala/.NET
- Swing
- abstract XML trees, not DOM etc.
- XML/XHTML rendering with CSS 2 (JavaDesktop)
- PDF rendering (JavaDesktop)
- jEdit (JavaDesktop)
- Netbeans framework

Demo?