



Interactive Theorem Proving using Isabelle/HOL

Session 12

René Thiemann

Department of Computer Science

- Session Management
- Document Preparation
- Type Classes

RT (DCS @ UIBK)

session 12

2/17

Session Management

Session Management

Isabelle Sessions

- **session** is “project” consisting of collection of theory files
- sessions can be defined hierarchically (import of other sessions); root of hierarchy: HOL
- sessions are defined in ROOT files
- processing sessions may take considerable time
- possible to capture state of sessions in persistent **heap image/session image**

Session Specifications

```
session ::= session name = name + description? options? sessions? theories*  
description ::= description <text>  
options ::= options [(key=value | key)+]  
sessions ::= sessions name+  
theories ::= theories [(key=value | key)+]? name+
```

RT (DCS @ UIBK)

session 12

4/17

Example Session

```
session Test_Session = HOL + (* load and import HOL *)
  description ⟨This is a test session⟩
  options [timeout = 600] (* 600 seconds *)
  sessions
    "HOL-Library" (* import HOL-Library *)
  theories
    Test (* may import theories HOL.XXX and HOL-Library.XXX *)
```

Invoking the Build Process

use '\$ isabelle build [OPTIONS] S1 ... SN' to run sessions S1 to SN with OPTIONS:

```
-d dir search for ROOT files in dir
-D dir search for ROOT file in dir and select all its sessions
-b build heap image
-o option override Isabelle option (syntax: name=val or name)
-v be verbose
-h show further build options (help)
```

Some Available Options

- `browser_info` – output HTML browser info (default: `false`)
- `document=pdf` – output PDF document
- `document_output=dir` – specify alternative directory `dir` for generated output
- `quick_and_dirty` – accept proof by `sorry`
- `names_short` – do not use qualified names in output
- `show_question_marks` – control printing of question marks for schematic variables

Using Sessions for Interactive Development

often invoked: '\$ isabelle jedit -l Some_Session Some_Theory.thy'

- starts Isabelle/jEdit as usual opening `Some_Theory.thy`
- builds heap-image of `Some_Session` on demand
- all theories of `Some_Session` are immediately available in interactive session

Document Preparation

Sectioning and Structuring

- `chapter`, `section`, `subsection`, ... – different levels of sectioning
- `■` – for itemizations
- `▶` – for enumerations
- `text` ⟨ ... ⟩ – plain text and \LaTeX code

Isabelle Symbols – Lists

symbol	internal	abbreviation
■	<code>\<^item></code>	<code>\iitem</code>
▶	<code>\<^enum></code>	<code>\enum</code>

General Structure of Document Antiquotations

```
antiquotation ::= @{name options? arguments}
                | \<^name> cartouche
                | cartouche
options ::= [ ] | [ option (,option)* ]
option ::= name | name = name
```

Antiquotations

- `text` – uninterpreted inner syntax
- `theory_text` – uninterpreted outer syntax
- `theory` – session-qualified theory name
- `thm fact*` – theorem statements
- `thm [source] fact*` – names of theorems
- `prop φ` – well-typed proposition φ
- `term t` – well-typed term t

Antiquotations (cont'd)

- `value t` – result of evaluating t
- `term_type t` – well-typed term t together with its type
- `typeof t` – type of well-typed term t
- `const c` – constant c
- `typ τ` – well-formed type τ
- `type κ` – type constructor κ
- `method m` – proof method m
- `datatype τ` – data type specification of τ
- `verbatim` – uninterpreted text in typewriter font
- ...
- complete list: [print_antiquotations](#)
- advantage of antiquotations: hyperlinked, checked, maintainable

Setting Up a Session Root Directory

- use `$ isabelle mkroot dir` to set up directory `dir` (can be `.`) as session root
- results in:
 - `dir/ROOT` – session setup for document preparation (note the `document_files` section)
 - `dir/document/root.tex` – \LaTeX setup
- for Bib \TeX (together with `cite` antiquotation) create file `document/root.bib` and add `root.bib` to `document_files` section in `ROOT` file

Type Classes

Type Classes in Isabelle

- mechanism to collect all types that support certain operations (like being ordered or having a size/hash/... function)
- each type class comes with an accompanying **sort** (of same name)
- sorts are used to track type class membership, that is, “being of sort s ” is synonymous with “being an instance of class s ”
- each type τ has a collection of sorts s_1, \dots, s_n , written $\tau :: \{s_1, \dots, s_n\}$
- special case $\tau :: \{s\}$ written $\tau :: s$
- default for each type τ is $\tau :: \text{type}$

Demo12.thy – Transforming Arbitrary Values to Strings

- **CHR** `'c'` – literal for character “c” (strings are lists of characters)
- **class** c – introduces new type class c
- **instantiation** $t :: c$ – starts instantiation of type t into class c
- **instance** – start actual instantiation proof

General Form

```
class c = ... +
  fixes c1 and ... and cn
  assumes "... " and ... and "... "
begin
...
end
```

Demo12.thy – Total Orders

- type class may assume properties of fixed constant(s) (the comparison relation of a partial order is reflexive, antisymmetric, and transitive)
- type classes may build on each other (total orders are partial orders that are total)

Advantage of Type Classes

- algorithms can be written in generic way; example
 - sorting algorithm: `sort :: 'a :: linorder list \Rightarrow 'a list`
- type classes are integrated into type-checking algorithm; examples
 - typing `sort [3, 5]` will enforce `3 :: 'a :: linorder`
 - typing `sort [3 :: int, 5]` will succeed (no manual proof required)
 - typing `sort [(3 :: int, 5 :: int), (2, 7)]` will succeed depending on whether a `linorder`-instance for pairs has been defined/imported





Limitations of Type Classes

- “one shot” instances (if you chose instance once, it is fixed)
- only single type variable as parameter, hence
- no multi-parameter type classes (e.g., consider a vector-field with field elements of type `'a` and vectors of type `'b`)

Locales

- more generic than type-classes
 - several parameters
 - several instances
- less automation
- more information: `isabelle doc locales`

Further Reading

-  Makarius Wenzel.
The Isabelle System Manual.
Isabelle documentation, 2021.
-  Makarius Wenzel.
Chapter 4 – Document preparation.
In *The Isabelle/Isar Reference Manual*, pages 70–90. 2021.
-  Florian Haftmann.
Haskell-style type classes with Isabelle/Isar.
Isabelle documentation, 2021.
-  Clemens Ballarin.
Tutorial to Locales and Locale Interpretation.
Isabelle documentation, 2021.