Software specification in CASL - The Common Algebraic Specification Language

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Overview

- Why formal specification?
- Waterfall Model
- Example: sorting
- CASL – the Common Algebraic Specification Language
- Layers of CASL
- Overview of the course

Why formal specification?

Erroneous software systems may lead to

- *economic losses*
  (e.g.: loss of Ariane V and mars probe, pentium bug),
- *security problems* (e.g.: viruses),
- *damage of persons* (e.g.: death due to erroneously computed radiation dose)

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Axiomatic Specfication

- *loose requirements*, close to informal descriptions
- *clarification* of underlying mathematical *concepts*
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Waterfall Model (slide by M. Roggenbach)

	Requirement Elicitation and Analysis	
	↑↓	
Nat Lang.	Informal Specification	
	↑↓	Validation
Spec. Lang.	Formal Requirements Specification	
	↑↓	"Invent & Verify",
Spec. Lang.	Formal Design Specification	
	↑↓	Transformation or
Progr. Lang.	Implementation	
	↑↓	Systematic Testing
	Test	
	↑↓	
	Maintenance	

Example: sorting

Informal specification:

To sort a list means to find a list with the same elements, which is in ascending order.

Formal *requirements* specification:

- $is\_ordered(sorter(L))$
- $is\_ordered(L) \Leftrightarrow \forall L1, L2 : List;\; x, y : Elem\,.$
  $$L = L1 ++ [x, y] ++ L2 \Rightarrow x \leq y$$
- $permutation(L, sorter(L))$
- $permutation(L1, L2) \Leftrightarrow$
  $$\forall x : Elem\,.\; count(x, L1) = count(x, L2)$$

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Sorting (cont'd)

We want to show insert sort to enjoy these properties.
Formal *design specification*:

- $insert(x, []) \ = \ [x]$
- $insert(x, y :: L) \ =$
  $x :: y :: L) \ \ when \ \ x \leq y$
  $else \ \ y :: insert(x, L)$
- $insert\_sort([]) \ = \ []$
- $insert\_sort(x :: L) \ = \ insert(x, insert\_sort(L))$

Implementation (in Haskell)

```
insert :: Ord a => (a,[a]) -> [a]
insert(x,[]) = [x]
insert(x,y:l) = if x <= y then x:y:l
                   else y:insert(x,l)

insert_sort :: Ord a => [a] -> [a]
insert_sort([]) = []
insert_sort(x:l) = insert(x,insert_sort(l))
```

- de facto *standard* for specification of functional requirements
- developed by the "Common Framework Initiative" (an *open* international collaboration)
- approved by *IFIP WG 1.3* "Foundations of Systems Specifications"
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Foundations of CASL

- detailed *language summary*, with informal explantation
- formal definition of *abstract and concrete syntax*
- complete *formal semantics*
- *proof systems*
- libraries of *basic datatypes*

All this is contained in the *Reference Manual*
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CASL has rock-solid foundations

- the complete formal semantics maps the syntax to underlying mathematical concepts
- CASL specifications denote classes of models
- The semantics is largely indepdendent of the details of the logic (institution)
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CASL on the web

- CASL in general: http://www.cofi.info
- CASL tools: http://hets.dfki.de
- CASL libraries: http://www.cofi.info/Libraries

Layers of CASL

CASL consists of several major *layers*, which are quite independent and may be understood (and used) separately:

Basic specifications many-sorted first-order logic, subsorting, partial functions, induction, datatypes.

Structured specifications translation, reduction, union, and extension of specifications; generic (parametrized) and named specifications

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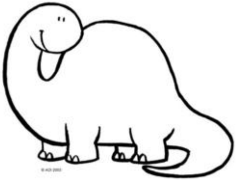
Why Modular Decomposition?

- reduction of *complexity*
- better *understanding* of specification and code (small pieces, well-defined interfaces)
- better *distribution of work*



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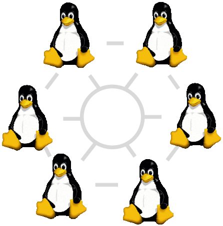

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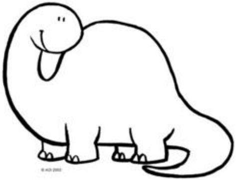

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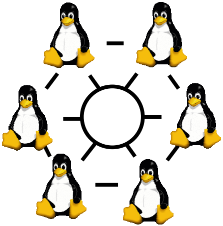

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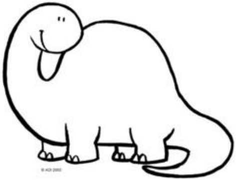

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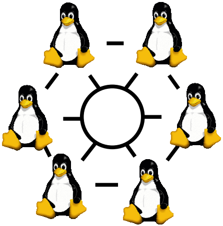

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Layers of CASL (cont'd)

Architectural specifications structuring of *implementation*: define how models of a specification may be constructed out of models of simpler specifications.

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Overview of the course

- recall basics of first-order logic
- loose + free specifications (case study: text formatting)
- CASL tools: Hets and SPASS
- partial functions, subsorting
- generated specifications
- a bit of semantics
- structuring and generic specifications
- architectural specifications
- case studies (invoice system, steam boiler, ontologies)
- outlook: CASL extensions

Continue with slides for CASL User Manual (by M. Bidoit and P.D. Mosses)