CS3202: Logic, Specification and Verification

CS3202-LSV 2006–07

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Lecture 0 (06/02/2007):

Module overview

Module Overview, 0

- This is a module about
  - *logic*: the ‘science’ of reasoning
  - *specification*: the ‘art’ of modelling systems
  - and *verification*: proving properties of (models of) systems

Logic

- the ‘science’ of reasoning
  - from hypotheses to conclusions: *consequence relations*
  - language: *syntax*, including *rules of inference*
  - models: *semantics*
  - do the models support the language?: *interpretations* and *soundness*
  - does the language capture the models: *expressivity* and *completeness*
  - can we mechanize reasoning: *effectiveness* (computability and complexity)

Specification

- the ‘art’ of modelling systems
- *language*:
  - datatypes
  - operations
  - properties (static)
  - behaviour (dynamic)
- *abstraction*:
  - capture only those of interest
  - avoid implementation details
- have we got it right? *validation*

Verification

- proving properties of (models of) systems
- build a model $\mathcal{M}$
- *satisfaction*: does the property, ϕ, hold in the model?

$$\mathcal{M} \models \phi$$

Verification, II

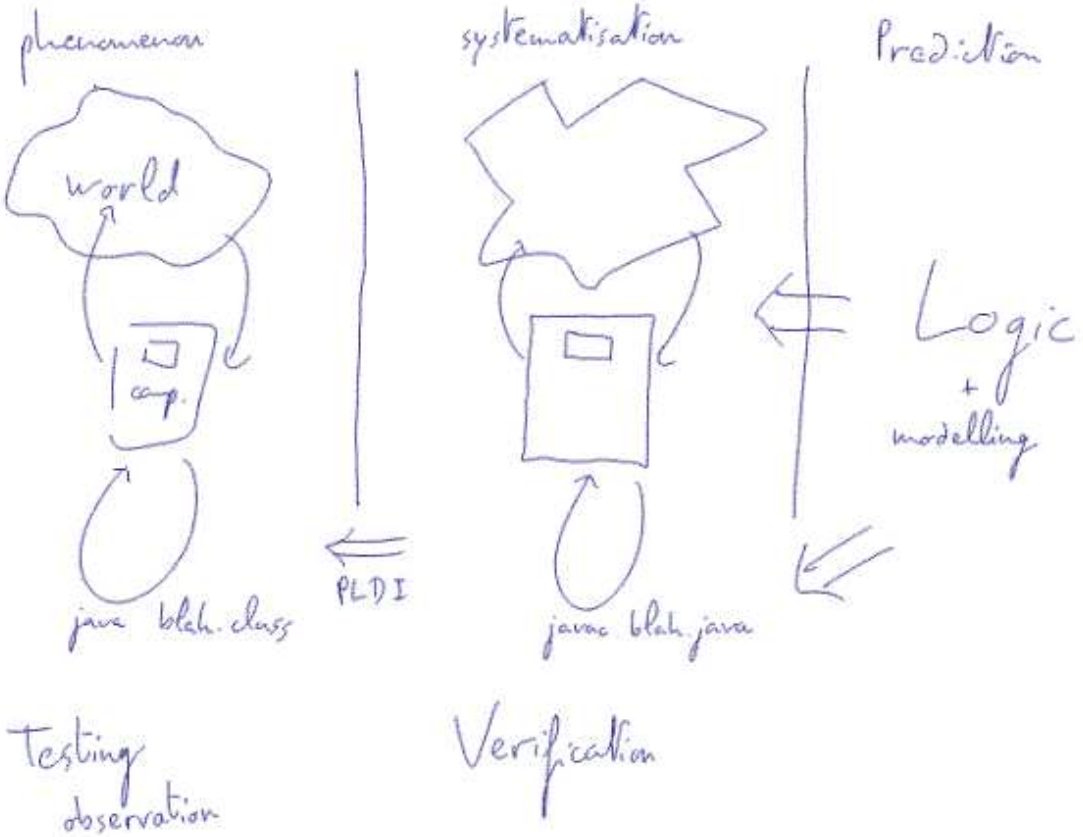
- factor the problem
- does the property follow from (simpler) hypotheses?

$$\phi_1, \ldots, \phi_n \vdash \phi$$

- does the model support the hypotheses?

$$\mathcal{M} \models \phi_1, \ldots \mathcal{M} \models \phi_n$$

- such steps might in general be interleaved
- forwards or backwards reasoning in proving $\phi_1, \ldots, \phi_n \vdash \phi$
- automatic checking of simple instances of $\mathcal{M} \models \phi_i$


phenomena
systematisation
Prediction
world
cap.
Logic
+
modelling
PLDI
java blah.class
javac blah.java
Testing
observation
Verification

Module Overview, I

- Part I: (review of) logic
  - propositional logic: truth table methods
  - logical consequence
  - natural deduction
  - soundness (and completeness)
  - predicate logic (non-finiteness of domains of interest)
  - beyond first-order logic
    - induction and recursion as distinctive features
    - typed logic
    - higher-order logic
    - logic *via* types: mechanisation in an interactive theorem prover

Module Overview, II

- Part II: specification
  - models and specification languages
  - propositional logic and first-order logic as specification languages
  - typed higher-order logic as a. . .
  - models of computation: the lambda calculus
  - Hoare logic (if time)

Module Overview, III

- Part III: verification
  - use of a specific tool: COQ(the national symbol of France/its rugby team)
  - propositional logic and first-order logic exercises
  - reasoning about simple functional programs
  - more advanced material (if time): inductive definitions of behaviour
  - emphasis on mechanised reasoning
  - some model checking and other tools (if time)

Timetable

- Mondays (W2, W4, W6, W8, W10): 10am here; regular lecture slot
- Tuesdays (each week): 10am–12noon
  - an hour of “lecture” material
  - an hour of “tutorial” material in the JH lab
  - working with the proof tool
  - log-in after this lecture, and fire up `coqide` at a terminal prompt
  - some flexibility: probably 5 such sessions
- TBA: there is a clash with CS4203 graphics, so we need to co-ordinate

  can we shift the “lab/tutorial” hour to Tuesday afternoons?

Textbooks and other resources

- In the Library, long loan (1 copy), 4-hour loan (1 copy), 3-day loan (2 copies) (check?):
  - *Coq'Art: Interactive Theorem Proving and Program Development*, Bertot and Castéran
  - Huth and Ryan, *Logic in Computer Science*, 2nd edition.
- Huth and Ryan: good for the introductory logic, excellent for model checking
- Bertot and Castéran: more extensive use after a while
- `http://coq.inria.fr/` reference manual, tutorial, IDE guide, libraries...

Requirements, Assessment, PtP

- Attendance at the Tuesday sessions is *REQUIRED*
- Reward is 10% of coursework assessment
- 3 practical assignments

  end Week 3 (TBC) 20% survey essay: "Why does specification and verification matter?"

  end Week 7 (TBC) 30%: basic proofs and verification in Coq

  end Week 11 (TBC) 40%: substantial verification exercise

Questions?