

# *Software Design, Modelling and Analysis in UML*

## *Lecture 21: Wrapup*

2012-02-15

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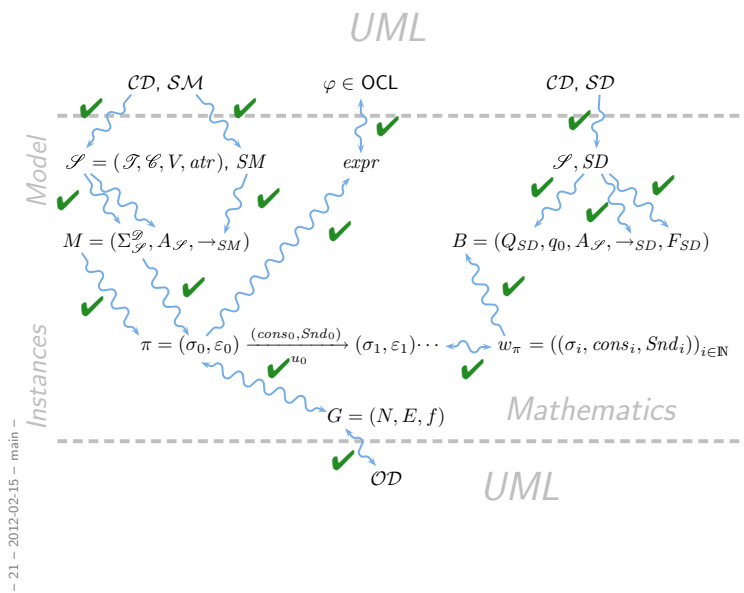
- 21 - 2012-02-15 - main -

## Content

- Lecture 1: Introduction
- Lecture 2: Semantical Model
- Lecture 3: Object Constraint Language (OCL)
- Lecture 4: Object Diagrams, Class Diagrams I
- Lecture 5: Class Diagrams I
- Lecture 6: Type Systems and Visibility
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- Lecture 18: Live Sequence Charts III, Inheritance I
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- Lecture 20: Meta-Modelling II, Inheritance III
- Lecture 21: Wrapup & Questions

- 21 - 2012-02-15 - main -

## Course Path: Over Map



- Motivation
- Semantical Model
- OCL
- Object Diagrams
- Class Diagrams
- State Machines
- Live Sequence Charts
- Real Time
- Components
- Inheritance
- Meta-Modeling
- (MDA, MDSE)

3/25

## Wrapup: Motivation

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-21 - 2012-02-15 - main -

4/25

## Wrapup: Motivation

### Lecture 1:

- **Educational Objectives:** you should
  - be able to explain the term **model**.
  - know the idea (and hopes and promises) of **model-driven** SW development.
  - be able to explain how **UML** fits into this general picture.
  - know **what** we'll do we've done in the course, and **why**.
  - thus be able to decide whether you want to stay with us...

### Lecture 22:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - How can UML help with software development?
  - Where is which sublanguage of UML useful?
  - For what purpose? With what drawbacks?

## Wrapup: Examining Motivation

- what is a model? for example?
- "a model is an image or a pre-image" — of what? please explain!
- when is a model a good model?
- what is model-based software engineering?
  - MDA? MDSE?
  - what do people hope to gain from MBSE? Why? Hope Justified?
  - what are the fundamental pre-requisites for that?
- what are purposes of modelling guidelines?
  - could you illustrate this with examples?
  - how can we establish/enforce them? can tools or procedures help?
- what's the qualitative difference between the modelling guideline "all association ends have a multiplicity" and "all state-machines are deterministic"?
- ...

## Wrapup: Examining Motivation

- what is UML (definitely)? why?
- what is it (definitely) not? why?
- how does UML relate to programming languages?
- what are the intentions of UML?
- what is the history of UML? Why could it be useful to know that?
  
- where can (what part of) UML be used in MBSE?
  - for what purpose? to improve what?
- we discussed a notion of “UML mode” by M. Fowler.
  - what is that? why is it useful to think about it?

## Wrapup: Examining “The Big Picture”

- what kinds of diagrams does UML offer?
- what is the purpose of the X diagram?
- what do the diagrams X and Y have in common?
  
- what is a UML model (our definition)? what does it mean?
  
- what is the difference between well-formedness rules and modelling guidelines?
  
- what is meta-modelling?
  - could you explain it on the example of UML?
- what is a class diagram in the context of meta-modelling?
- what benefits do people see in meta-modelling?
- the standard is split into the two documents “Infrastructure” and “Superstructure”. what is the rationale behind that?
- in what modelling language is UML modelled?

## Wrapup: Modelling Structure

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## Wrapup: Modelling Structure

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### Lecture 2:

- **Educational Objectives:** Capabilities for these tasks/questions:
  - Why is UML of the form it is?
  - Shall one feel bad if not using all diagrams during software development?
  - What is a signature, an object, a system state, etc.? What's the purpose in the course?
  - How do Basic Object System Signatures relate to UML class diagrams?

### Lecture 3:

- **Educational Objectives:** Capabilities for these tasks/questions:
  - Please explain/read out this OCL constraint. Is it well-typed?
  - Please formalise this constraint in OCL.
  - Does this OCL constraint hold in this (complete) system state?
  - Can you think of a system state satisfying this constraint?
  - Please un-abbreviate all abbreviations in this OCL expression.
  - In what sense is OCL a three-valued logic? For what purpose?
  - How are  $\mathcal{D}(C)$  and  $\tau_C$  related?

## Wrapup: Modelling Structure

### Lecture 4:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What is an object diagram? What are object diagrams good for?
  - When is an object diagram called partial? What are partial ones good for?
  - How are system states and object diagrams related?
  - What does it mean that an OCL expression is satisfiable?
  - When is a set of OCL constraints said to be consistent?
  - Can you think of an object diagram which violates this OCL constraint?
  - Is this UML model  $\mathcal{M}$  consistent wrt.  $Inv(\mathcal{M})$ ?

### Lecture 5:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What is a class diagram?
  - For what purposes are class diagrams useful?
  - Could you please map this class diagram to a signature?
  - Could you please map this signature to a class diagram?
  - What is a stereotype? What does it mean? For what can it be useful?

## Wrapup: Modelling Structure

### Lecture 6:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - Is this OCL expression well-typed or not? Why?
  - How/in what form did we define well-definedness?
  - What is visibility good for? Where is it used?

### Lecture 7 & 8:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - Please explain/illustrate this class diagram with associations.
  - Which annotations of an association arrow are (semantically) relevant? In what sense? For what?
  - What's a role name? What's it good for?
  - What's "multiplicity"? How did we treat them semantically?
  - What is "reading direction", "navigability", "ownership", ...?
  - What's the difference between "aggregation" and "composition"?

## Wrapup: Modelling Structure

### Lecture 9:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What are purposes of modelling guidelines? (Example?)
  - When is a class diagram a good class diagram?
  - Discuss the style of this class diagram.

### Lecture 20 & 21:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's the effect of inheritance on System States?
  - What does the Liskov Substitution Principle mean regarding structure?
  - What is the subset, what the uplink semantics of inheritance?
  - What's the idea of Meta-Modelling?

## Wrapup: Modelling Behaviour, Constructive

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## Wrapup: Modelling Behaviour, Constructive

### Main and General:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What does this State Machine mean?
  - What happens if I inject this event?
  - Can you please model the following behaviour.

## Wrapup: Modelling Behaviour, Constructive

### Lecture 10:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's the difference between reflective and constructive descriptions of behaviour?
  - What's the Basic Causality Model?
  - What does the standard say about the dispatching method?
  - What is (intuitively) a run-to-completion step?

### Lecture 11:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - Can you please model the following behaviour.
  - What is: trigger, guard, action?
  - Please unabbreviate this abbreviated transition annotation.
  - What is an ether? Example? Why did we introduce it?
  - What's the difference: signal, signal event, event, trigger, reception, consumption?
  - What's a system configuration?
  - When is an object stable (intuitively, formally)?



## *Wrapup: Modelling Behaviour, Constructive*

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### Lecture 12 & 13:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What is a transformer? Example? Why did we introduce it?
  - What is a re-use semantics? What of the framework would we change to go to a non-re-use semantics?
  - What labelled transition system is induced by a UML model?
  - What is: discard, dispatch, commence?
  - What's the meaning of stereotype "signal,env"?
  - Does environment interaction necessarily occur?
  - What happens on "division by 0"?

### Lecture 14:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What is a step (definition)? Run-to-completion step (definition)? Microstep (intuition)?
  - Do objects always finally become stable?
  - In what sense is our RTC semantics not compositional?

## *Wrapup: Modelling Behaviour, Constructive*

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### Lecture 15:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's a kind of a state? What's a pseudo-state?
  - What's a region? What's it good for?
  - What is: entry, exit, do, internal transition?
  - What's a completion event? What has it to do with the ether?

### Lecture 16:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's a state configuration?
  - When are two states orthogonal? When consistent?
  - What's the depth of a state? Why care?
  - What is the set of enabled transitions in this system configuration and this state machine?

## *Wrapup: Modelling Behaviour, Constructive*

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### Lecture 17:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's a history state? Deep vs. shallow?
  - What is: junction, choice, terminate?
  - What is the idea of "deferred events"?
  - What is a passive object? Why are passive reactive objects special? What did we do in that case?
  - What's a behavioural feature? How can it be implemented?

## *Wrapup: Modelling Behaviour, Reflective*

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## Wrapup: Modelling Behaviour, Reflective

### Lecture 18 & 19:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - Is each LSC description of behaviour necessarily reflective?
  - There exists another distinction between “inter-object” and “intra-object” behaviour. Discuss in the context of UML.
  - What does this LSC mean?
  - Are this UML model's state machines consistent with the interactions?
  - Please provide a UML model which is consistent with this LSC.
  - What is: activation (mode, condition), hot/cold condition, pre-chart, cut, hot/cold location, local invariant, legal exit, hot/cold chart etc.?

## Wrapup: Inheritance

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## Wrapup: Inheritance

### Lecture 20 & 21:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's the effect of inheritance on LSCs, State Machines, System States?
  - What's the Liskov Substitution Principle?
  - What is commonly understood under (behavioural) sub-typing?
  - What is the subset, what the uplink semantics of inheritance?
  - What is late/early binding?
  - What's the idea of Meta-Modelling?

*Meta*

Hmm...

- Open book or closed book...?

• "what happens if we send orbits in to ..."

Question:

- ① transitive reflexive closure
- ② uplink semantics / dom. incl.
- ③ OCL exercises

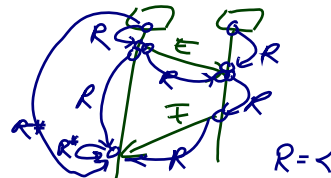
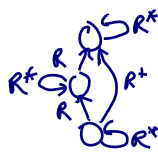
$$R \subseteq A \times A$$

$$R^* = \{ (a, a) \mid a \in A \}$$

$$\cup \{ (a, b) \mid \exists a_1, \dots, a_n \bullet (a_i, a_{i+1}) \in R, 1 \leq i < n \wedge a = a_1 \wedge b = a_n \}$$



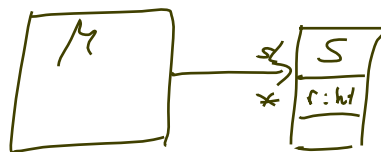
"instance":  $\triangleleft$   
 "instance\*":  $\preceq = \triangleleft^*$   
 "flows"



$$\preceq = \preceq^*$$

$$(\preceq, \preceq)$$

③ OCL RST of slaves of one master differs by at most 2



context M inv:

~~ref.~~ s1  $\rightarrow$  forall (s1 | ~~ref.~~ s1  $\rightarrow$  forall (s2 | abs(s1.r - s2.r)  $\leq$  2))