

Software Design, Modelling and Analysis in UML

Lecture 21: Wrapup

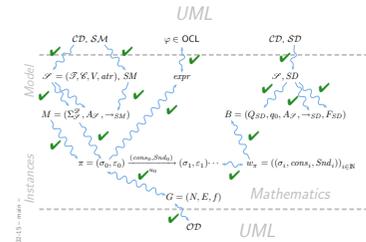
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Content

- 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
- Lecture 7: Class Diagrams II
- Lecture 8: Class Diagrams III
- Lecture 9: Class Diagrams IV
- Lecture 10: Core State Machines I
- Lecture 11: Core State Machines II
- Lecture 12: Core State Machines III
- Lecture 13: Hierarchical State Machines I
- Lecture 14: Hierarchical State Machines II
- Lecture 15: Hierarchical State Machines III
- Lecture 16: Methods, Live Sequence Charts II
- Lecture 17: Live Sequence Charts II
- Lecture 18: Live Sequence Charts III, Inheritance I
- Lecture 19: Inheritance II, Meta-Modelling I
- Lecture 20: Meta-Modelling II, Inheritance III
- Lecture 21: Wrapup & Questions

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)

Wrapup: Motivation

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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?

7/25

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?

8/25

Wrapup: Modelling Structure

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9/25

Wrapup: Modelling Structure

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 τ_C related?

10/25

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?

11/25

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"?

12/25

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?

13/25

Wrapup: Modelling Behaviour, Constructive

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14/25

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.

15/25

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)?

16/25

Wrapup: Modelling Behaviour, Constructive

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?

17/25

Wrapup: Modelling Behaviour, Constructive

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?

18/25

Wrapup: Modelling Behaviour, Constructive

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?

19/25

Wrapup: Modelling Behaviour, Reflective

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20/25

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.?

21/25

Wrapup: Inheritance

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22/25

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?

23/25

Meta

24/25

Hmm...

- Open book or closed book...?

- "what happens if we send metrics in to ..."

Question:

① transitive reflexive closure

$$R \subseteq A \times A$$

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

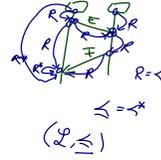
② up to semantics / den. incl.

$$\cup \{ (a, b) \mid \exists a_1, \dots, a_n = (a_1, a_2), (a_2, a_3), \dots, (a_{n-1}, a_n) \in R, a = a_1, b = a_n \}$$

③ OCL exercises



"relaxation": \triangleleft
 "relaxation*": \triangleleft^*
 "flow": \rightarrow



$$\triangleleft^* \rightarrow^*$$

$$(\triangleleft, \triangleleft^*)$$

③ OCL diff of slopes of one register differs by at most 2



context M inv:

$$\forall f. sl \rightarrow \text{forall } (s1 \mid \#f.sl \rightarrow \text{forall } (s2 \mid \text{abs}(s1, r - s2, r) \leq 2))$$