Software Design, Modelling and Analysis in UML

Lecture 18: Inheritance I

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Contents & Goals

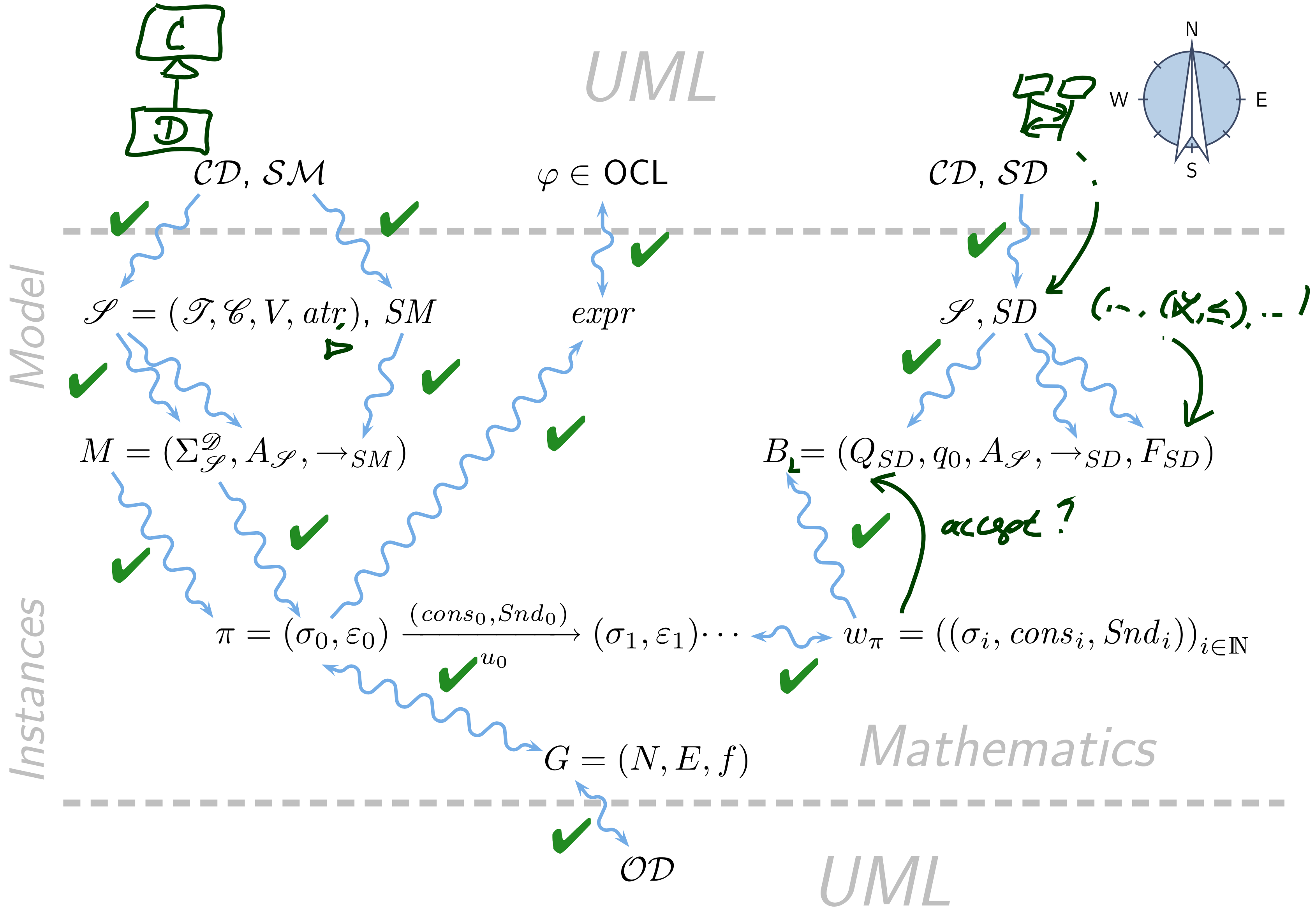
Last Lecture:

- Live Sequence Charts Semantics

This Lecture:

- **Educational Objectives:** Capabilities for following tasks/questions.
  - What's the Liskov Substitution Principle?
  - What is late/early binding?
  - What is the subset, what the uplink semantics of inheritance?
  - What's the effect of inheritance on LSCs, State Machines, System States?
  - What's the idea of Meta-Modelling?
- **Content:**
  - Inheritance in UML: concrete syntax
  - Liskov Substitution Principle — desired semantics
  - Two approaches to obtain desired semantics

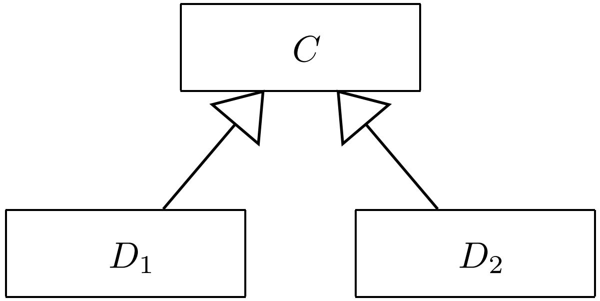
Course Map



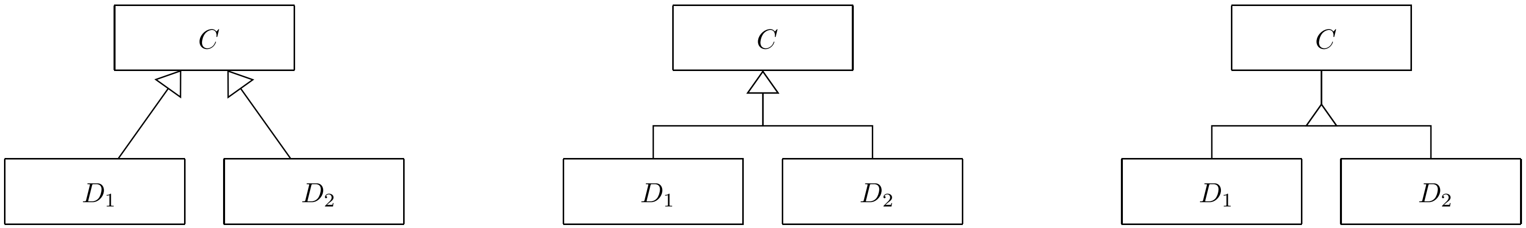
UML
$\mathcal{CD}$, $\mathcal{SM}$
$\varphi \in$ OCL
$\mathcal{CD}$, $\mathcal{SD}$
N
W
E
S
Model
$\mathscr{S} = (\mathscr{T}, \mathscr{C}, V, atr)$, SM
$expr$
$\mathscr{S}$, SD
$M = (\Sigma_{\mathscr{S}}^{\mathscr{D}}, A_{\mathscr{S}}, \to_{SM})$
$B = (Q_{SD}, q_0, A_{\mathscr{S}}, \to_{SD}, F_{SD})$
accept ?
Instances
$\pi = (\sigma_0, \varepsilon_0) \xrightarrow[u_0]{(cons_0, Snd_0)} (\sigma_1, \varepsilon_1) \cdots$
$w_\pi = ((\sigma_i, cons_i, Snd_i))_{i \in \mathbb{N}}$
$G = (N, E, f)$
Mathematics
$\mathcal{OD}$
UML

Inheritance: Syntax

Inheritance: Generalisation Relation



- **Alternative renderings**:



- **Read**:
  - C **generalises** D_1 and D_2; C is a **generalisation** of D_1 and D_2,
  - D_1 and D_2 **specialise** C; D_1 **is a** (specialisation of) C,
  - D_1 **is a** C; D_2 **is a** C.

- **Well-formedness rule**: No **cycles** in the generalisation relation.

Abstract Syntax

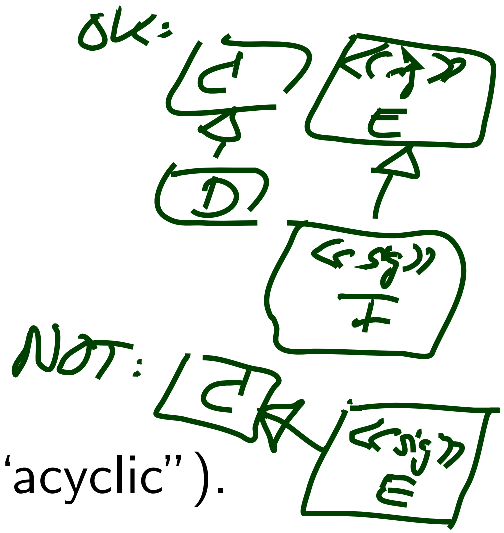
Recall: a signature (with signals) is a tuple $\mathscr{S} = (\mathscr{T}, \mathscr{C}, V, atr)$.

Now (finally): extend to

$$\mathscr{S} = (\mathscr{T}, \mathscr{C}, V, atr, F, mth, \lhd)$$

where F/mth are methods, analogously to attributes and

$$\lhd \;\subseteq (\mathscr{C} \times \mathscr{C}) \cup (\mathscr{E} \times \mathscr{E})$$

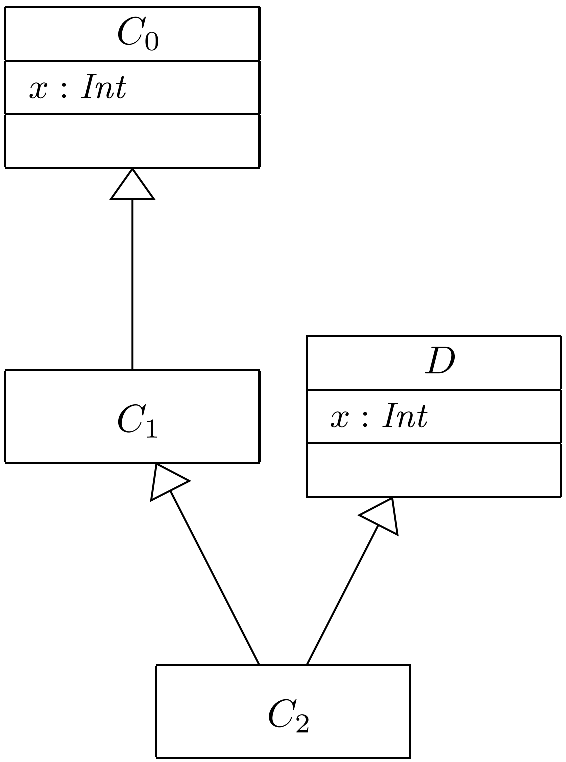


is a **generalisation** relation such that $C \lhd^+ C$ for **no** $C \in \mathscr{C}$ ("acyclic").

$C \lhd D$ reads as

- C is a generalisation of D,
- D is a specialisation of C,
- D inherits from C,
- D is a sub-class of C,
- C is a super-class of D,
- ...

Mapping Concrete to Abstract Syntax by Example



$\leadsto$

$$\mathcal{S} = (\{Int\}, \{C_0, C_1, D, C_2\}, \{C_0::x : Int, D::x : Int\}, \{C_0 \mapsto \{C_0::x\}, D \mapsto \{D::x\}, C_1 \mapsto \emptyset, C_2 \mapsto \emptyset\}, \{C_0 \lhd C_1, C_1 \lhd C_2, D \lhd C_2\})$$

NOT: $atr(C_2) = \{C_0::x, D::x\}$

Note: we can have **multiple inheritance**.

Reflexive, Transitive Closure of Generalisation

Definition. Given classes $C_0, C_1, D \in \mathscr{C}$, we say D inherits from C_0 **via** C_1 if and only if there are $C_0^1, \dots C_0^n, C_1^1, \dots C_1^m \in \mathscr{C}$ such that

$$C_0 \lhd C_0^1 \lhd \dots C_0^n \lhd C_1 \lhd C_1^1 \lhd \dots C_1^m \lhd D.$$

We use '$\preceq$' to denote the reflexive, transitive closure of '$\lhd$'.

In the following, we assume

- that all attribute (method) names are of the form

$$C{::}v, \quad C \in \mathscr{C} \cup \mathscr{E} \qquad (C{::}f, \quad C \in \mathscr{C}),$$

- that we have $C{::}v \in atr(C)$ resp. $C{::}f \in mth(C)$ **if and only if** v (f) appears in an attribute (method) compartment of C in a class diagram.

We still want to accept "context C inv : $v < 0$", which v is meant? Later!

References

References

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