Multilevel modeling: What's in a level?
A position paper

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The 3 guideline questions

- What is the essence of “level” in MLM?
- What is the role and status of “level” in MLM?
  - syntax
  - semantics
- Can MLM be compositional with respect to “level”?
  - Formal inductive definition
  - Reuse of “level” theory

Formal level-based pragmatic theory of MLM
A class model enriched with instance-of relations
Is that a multilevel model?

Try automatic level marking based on instance-of relations.
The intended levelling

Based on
Reinhartz-Berger and Sturm, "Utilizing domain models for application design and validation", 2009
LEVEL is a conceptual notion

- Levelling cannot be automatically marked, based on structural features
  - turns “level” dynamic:
    - instance-of modification $\rightarrow$ levelling modification
- A level is not a collection of elements having the same level marking
- A level is a conceptual unit:
  - Has an aspect/facet of class model
- A level is a building block of multilevel models

MLM is composed of conceptual levels
What is a conceptual level?

A level has two facets:

- **Instance facet:** Relation to immediate upper
  - based on *instance-of* relations between level elements
- **Class facet:** Relation to immediate lower
  - based on *type-of* relations between level elements

A multilevel level is an **overlapping pair**:

\[ <O, C> \quad \text{mediator}(O) \subseteq C \]

Requires **terminology mediation** between levels:

- Objects → classes
- Links → associations
- Properties → renamed
- Attributes → renamed
How to glue the conceptual levels?

- Total ordering of levels: An **ontological dimension**
- Option I:

  \( O_i \) is a legal instance of \( C_{i+1} \) \( (O_i \in C_{i+1}) \)

Potency 0: not instantiated by a clabject

Problem: \( O_i \) is a not legal instance of \( C_{i+1} \)
How to glue the conceptual levels?

- Total ordering of levels: An **ontological dimension**
- Option II:

  $O_i$ is a **partial** legal instance of $C_{i+1}$  

  (\(O_i \in C_{i+1}\))

  ![Diagram of Clock and Controller]

  - **Potency 0**: not instantiated by a clabject

  - **Class Clock** is instantiated in every legal instance
  - **Its instance** is not a clabject – not part of the class facet
Summary: Compositional syntax of MLM

- An MLM is an **ontological dimension**(s) composed of levels (possibly overlapping)
- A level is an **overlapping pair**: 
  \( < O_i, C_i > \) mediator\((O_i) \subseteq C_i \)

**Semantic relationship** between **syntactic** levels:

- **Partial instance (semantics):**
  1. \( O_i \) is a **partial instance** of \( C_{i+1} \)
  2. \( O_i \) satisfies all \( C_{i+k} \) \((k>0)\) constraints

- A **syntactically correct MLM dimension**: 
  1. Partial instance restriction
  2. Satisfy higher constraints
Semantics of MLM

- A MLM is a finite structure – a model

A possible denotation (extension):

- compositional semantics – instantiates the levels
- Instances *extend the levels* – include the clabjects
- not a flat graph of sets and their members
Compositional Semantics of MLM

Semantics of MLM – composed of level semantics:

– A **sequence of instances** of the class facets of the levels

– **Glue** between the **semantic and the syntactic** instances:
  • An instance of level \( i \) **includes** its partial instance in level \( i-1 \)
  • An instance of level \( i \) **satisfies** all constraints in higher levels
MLM semantic mechanisms

• **Potency**: interlevel inheritance of features

• **Inter-level** semantic interactions:
  – constraints
  – Inference rules
  – associations

• **Non-compositional interactions**
  – Deferred instantiation – Frank
  – Leap potency for classes – MetaDepth

Reformulated as inter-level relations
Summary

“level” is

- a building block of syntax and semantics of MLM
- Has a class model facet

Compositional formal MLM:

- Natural extension of class models
- Reuse of class model theory, methods, experience

Our CAISE-2018 paper defines:

- Level-based compositional MLM theory
- Provably-correct FOML translation
  - https://sourceforge.net/projects/pathlp/files/foml/
Thank you