VML Semantics

Dynamic Meta Modeling and beyond

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Agenda

1. What are „Semantics“?
2. Why are they hard for VMLs?
3. Some classical approaches
4. (How) Can GTs help?
What is the meaning of semantics?

The cat, Felis silvestris catus, is a small carnivore that has been domesticated for several millennia. The term cat most commonly means a domestic cat, although it can also be used to refer to the other members of the feline family.
What do we need Semantics for, anyway?

Syntax establishes whether a model conforms to the prescribed form of a language

Syntax descriptions in VMLs is given in terms of meta models

Model

Semantics is required to
- understand a model
- execute/simulate a model
- analyze a model
- compare two models (equivalence, consistency)

A Semantics Description must be
- understandable
- formal
- established theory
- expressive

Visual Modeling Languages are special – as always

- What do, e.g., Programming Languages do?
  - Compiler + Description

- Some special problems of VMLs (UML in particular)
  - No tree structures – graphs rule!
  - Abstract and incomplete – no execution possible
  - Multiple overlapping views
  - User additions possible
  - Independent of specific computing architecture/technology/tools

=> There can never be a single "UML compiler"
Let's just explain it then!

Why is a description no solution?

- Human interpretation only
- No systematic derivation of knowledge
- No automation
- No analysis for gaps, contradictions etc.

=> heated debates
http://www.omg.org/issues/

A semantical problem

Final Adopted Spec*:
- Fork: When an offered token is accepted on all the outgoing edges, duplicates of the token are made and one copy traverses each edge
- Join: If there is a token offered on all incoming edges, then tokens are offered on the outgoing edge
- "send invitation" will never be reached (in case of "same guests..")
- Difference between "intuitive" and "specified" semantics
- Only detectable by rigorous inspection

* Fixed in the Finalization of UML 2.0
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Denotational Semantics – What something is

- Basic idea: Relate something unknown to something known
  - "Kradostilo" - "Barbequeue" - "Grill"
  - "if...endif" - "test 0 jump" [this is what a compiler does]
  - UML Action – Petri Net Transition
  - Recursive method – Fix point function

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Abstract Syntax ------ semantic relation ----> Semantic Domain
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Denotational Semantics – Java as a Semantics Domain

Denotational Meta Modeling

Syntax Definition «Meta Model»

Model Elements

Language Elements

Expression

Semantic Domain «Meta Model»

„Runtime“ Elements

Meaning

Semantic Instance
### Denotational Semantics - Example

- **Syntax Definition**
  - "Meta Model"
  - Expression
  - Model Elements
    - Semantics Domain
      - "Meta Model"
      - "Runtime"
    - Elements
      - Meanings
      - Semantic Instance
      - SD MM
        - instance.type=
        - class.name
      - Language
        - Elements
          - UML MM
            - Class
              - name:String
            - Property
              - name:String
          - Model
            - Video
              - rentID:String
          - SD MM
            - Instance
              - type:String
              - name:String
            - Slot
              - name:String
          - Meaning
            - x12:Video
              - rentID="dvd1234"
            - x23:Video
              - rentID=TRUE
            - x24:Video
              - RID="dvd2345"

### The Good, The Bad and the Relations

- **Some problems:**
  - Complexity of Mapping too high to specify descriptively (rather: Code Templates)
  - Semantic Domain not very helpful, Dynamics!?  
  - Denotations work well with static semantics and if the SD and AS have similar structures
Operational Semantics

- For behavioral elements it is more natural to say what something *does*.

![Operational Semantics Diagram]

Operational Semantics - Rule

- An operational semantics is made up from rules, leading from state to state.
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Operational Semantics with Graph Transformation

- Programming Languages: Expressions/States are trees
- VML: Expressions/States are Graphs
  - Graph Transformations are an ideal tool to express rules of an operational semantics for VMLs!
  - But what exactly are these graphs?
Adding Graphical Operational Semantics

Dynamic Meta Modeling
Interpreting a Model with DMM

DMM is a hybrid semantics approach

- **denotational part** = static semantics
  - explicit introduction of semantic concepts
  - precise instance notion
- **operational part** = dynamic semantics
  - visual rules
  - convenient control features (not shown here)
  - easy to interpret

**in combination:**

- precise instance notion (which states does a model imply?)
- precise simulation (which state transformations does a model imply?)
- analysis of complete transition systems (which behaviors are (not) implied by the model)