Formal Validation of Domain-Specific Languages with Derived Features and Well-Formedness Constraints

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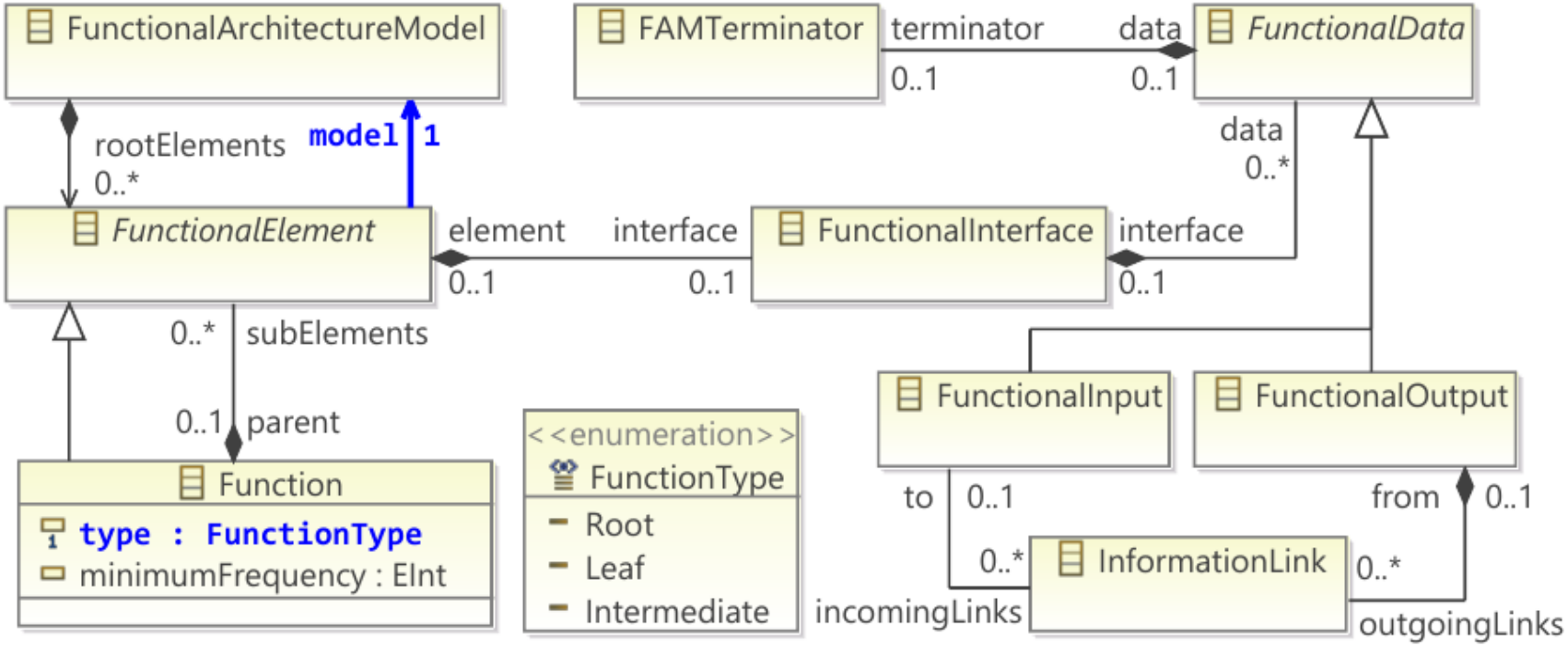
February 05, 2018

Overview

- Motivation
- DSL Validation Tool
- DSL Validation Workflow
- Experimental Results
- Conclusions

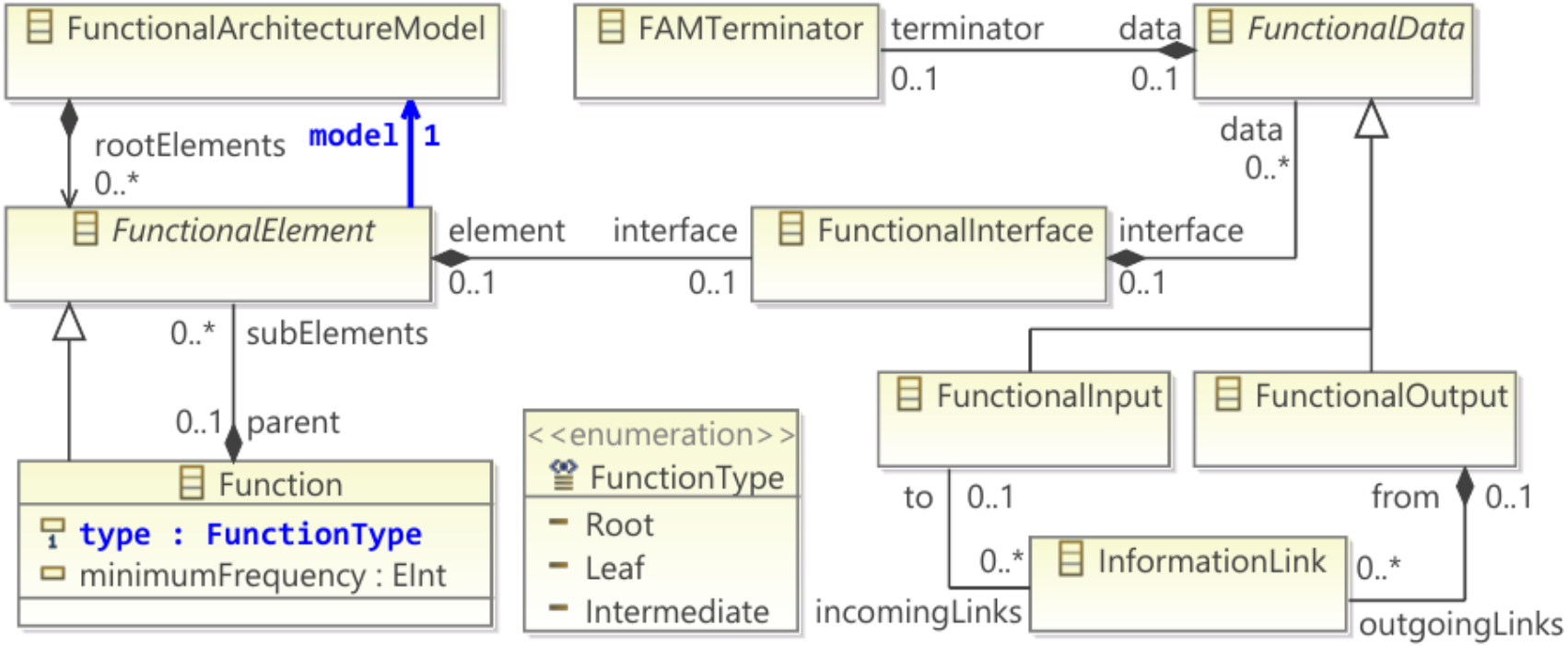
Domain Specific Languages (DSLs)

- **Components of a DSL**
  - Metamodel
  - Derived features
  - Well-formedness constraints



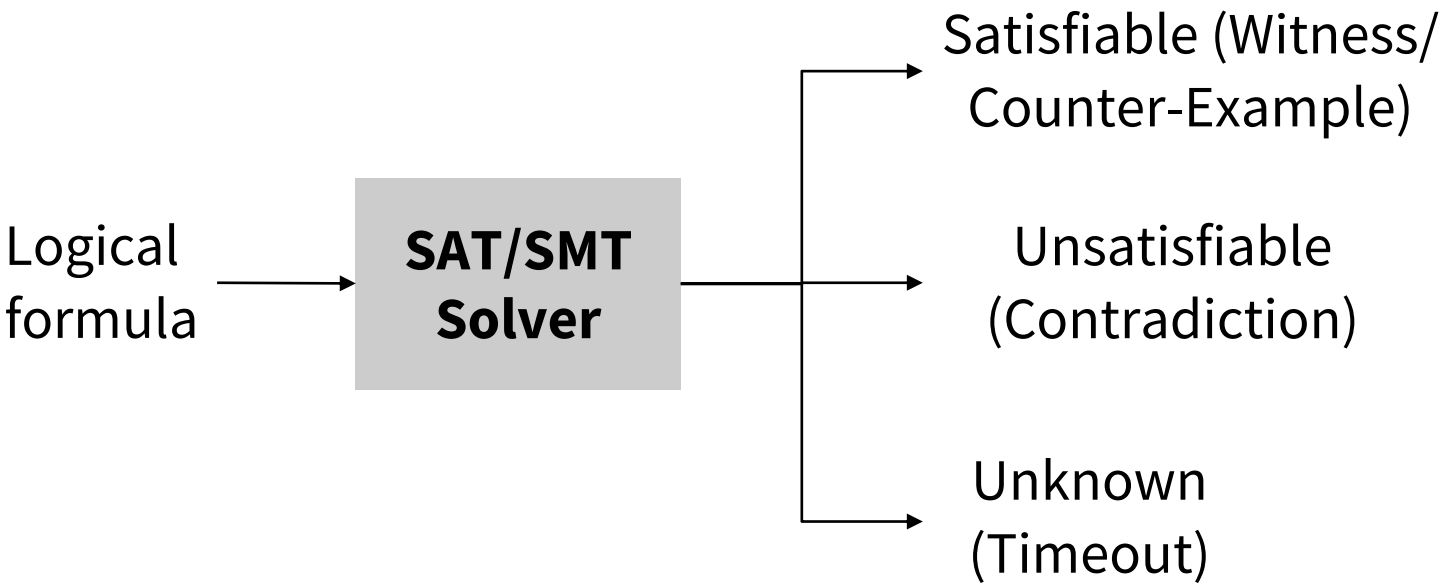
Domain Specific Languages (DSLs)

- **Validation Challenges**
  - Complex metamodel and constraints
  - Infinite range of models

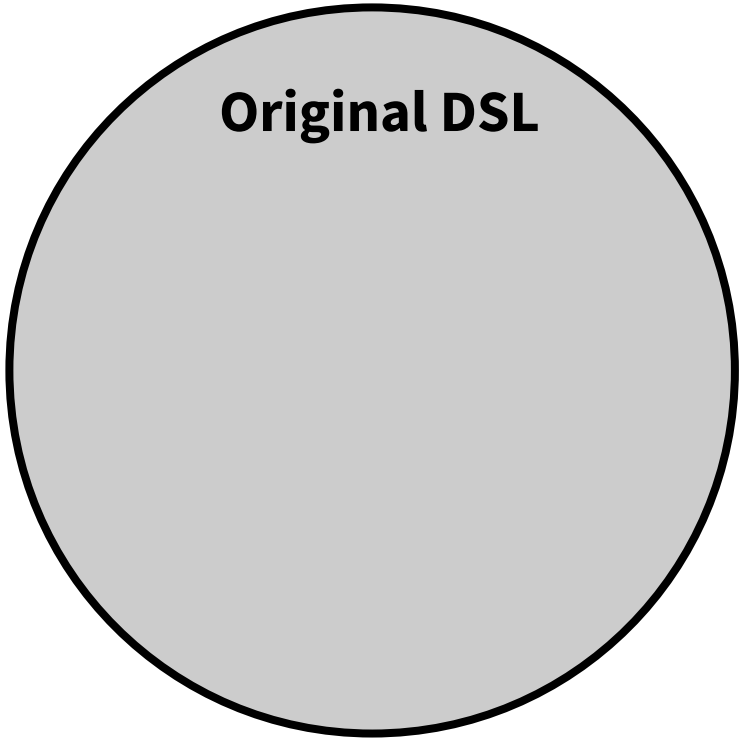


SAT/SMT Solvers

- **Properties**
  - Checks satisfiability of a logical claim.
  - SMT is more expressive than SAT



First-Order Logic (FOL) Approximation



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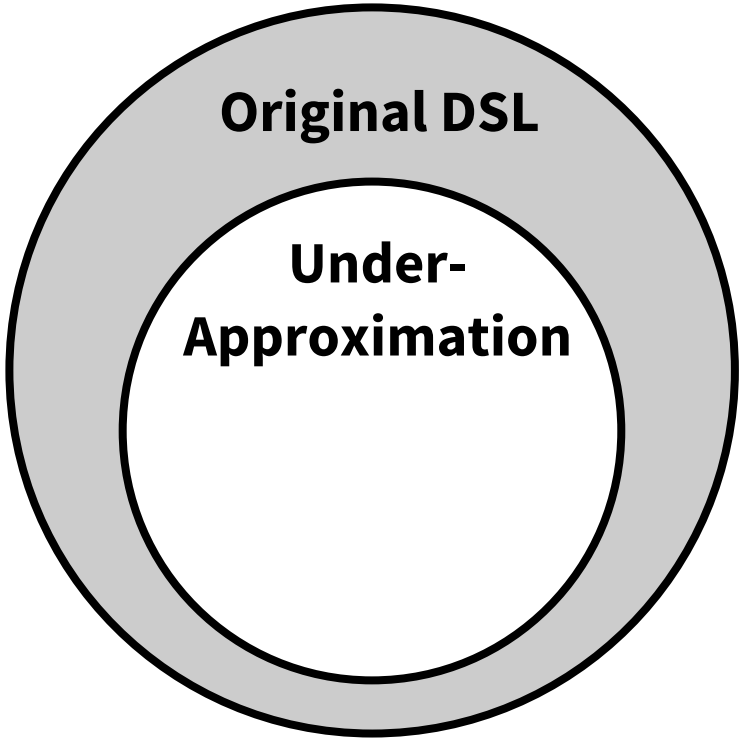

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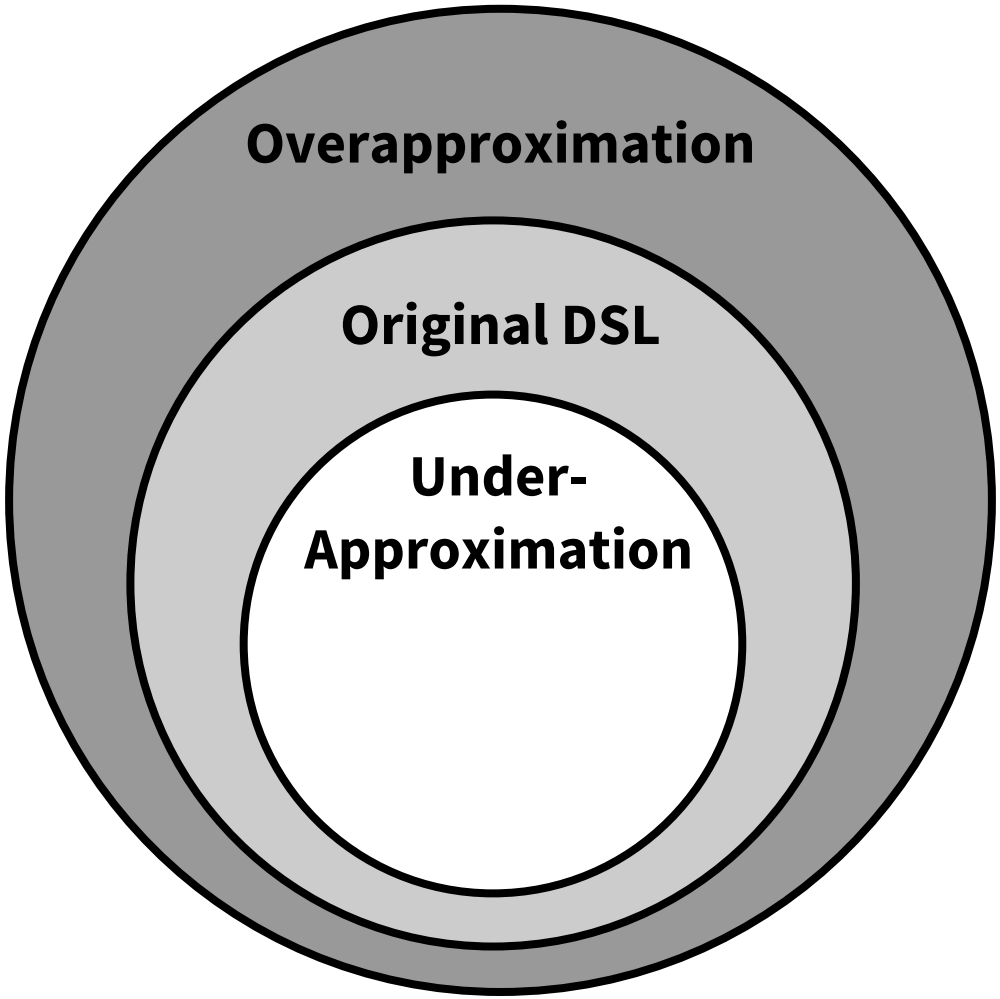
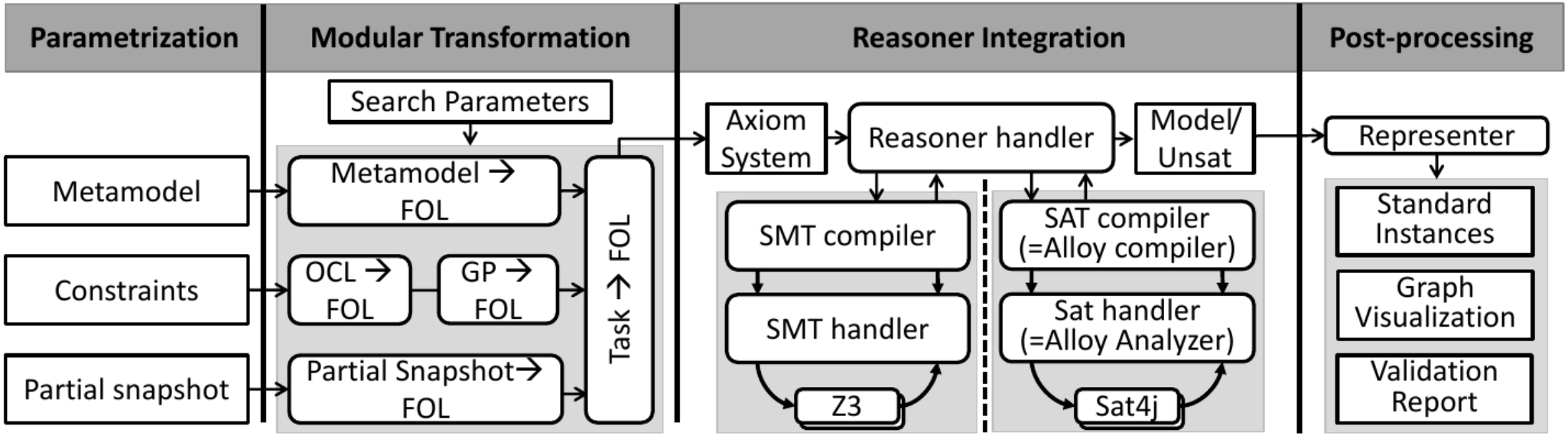
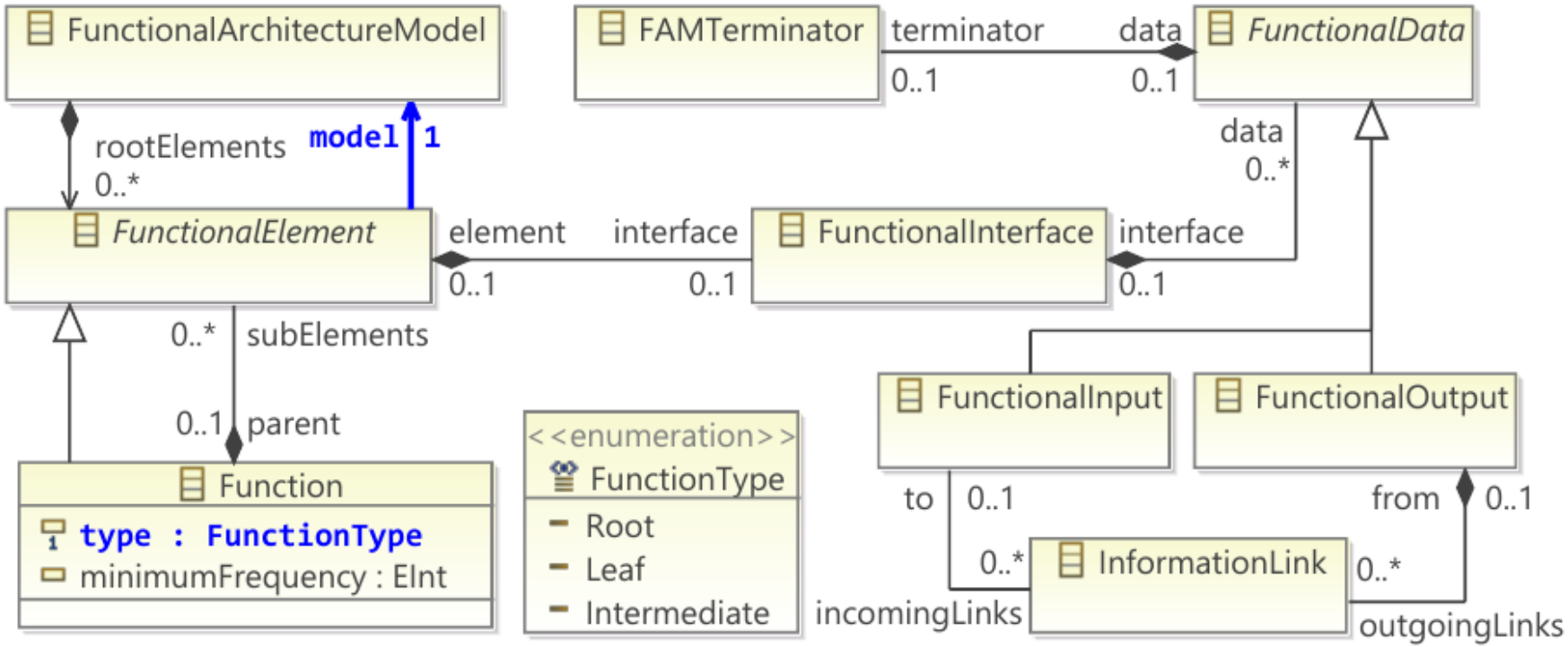


DSL Validation Tool



Formalisation of the Metamodel



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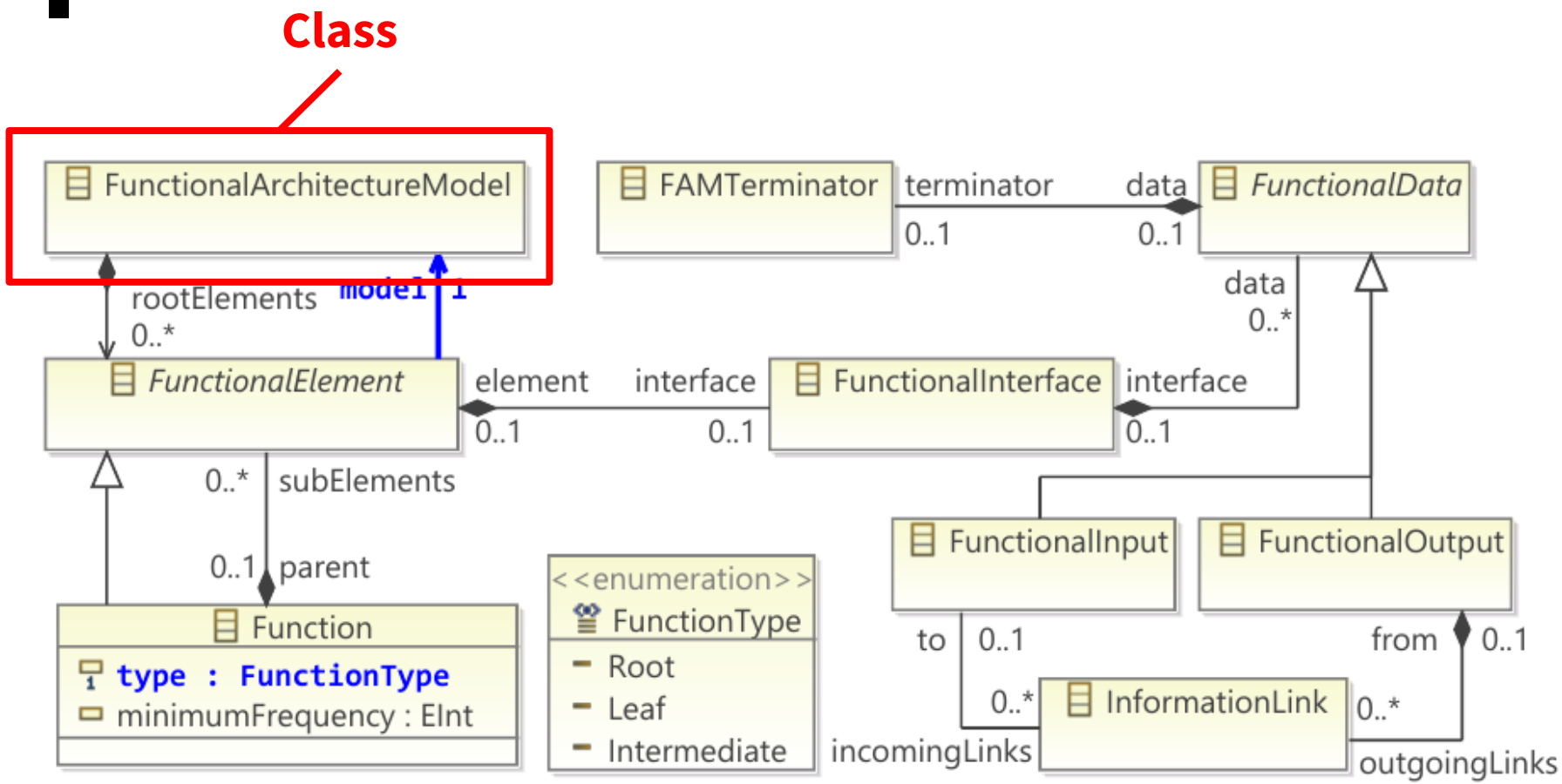

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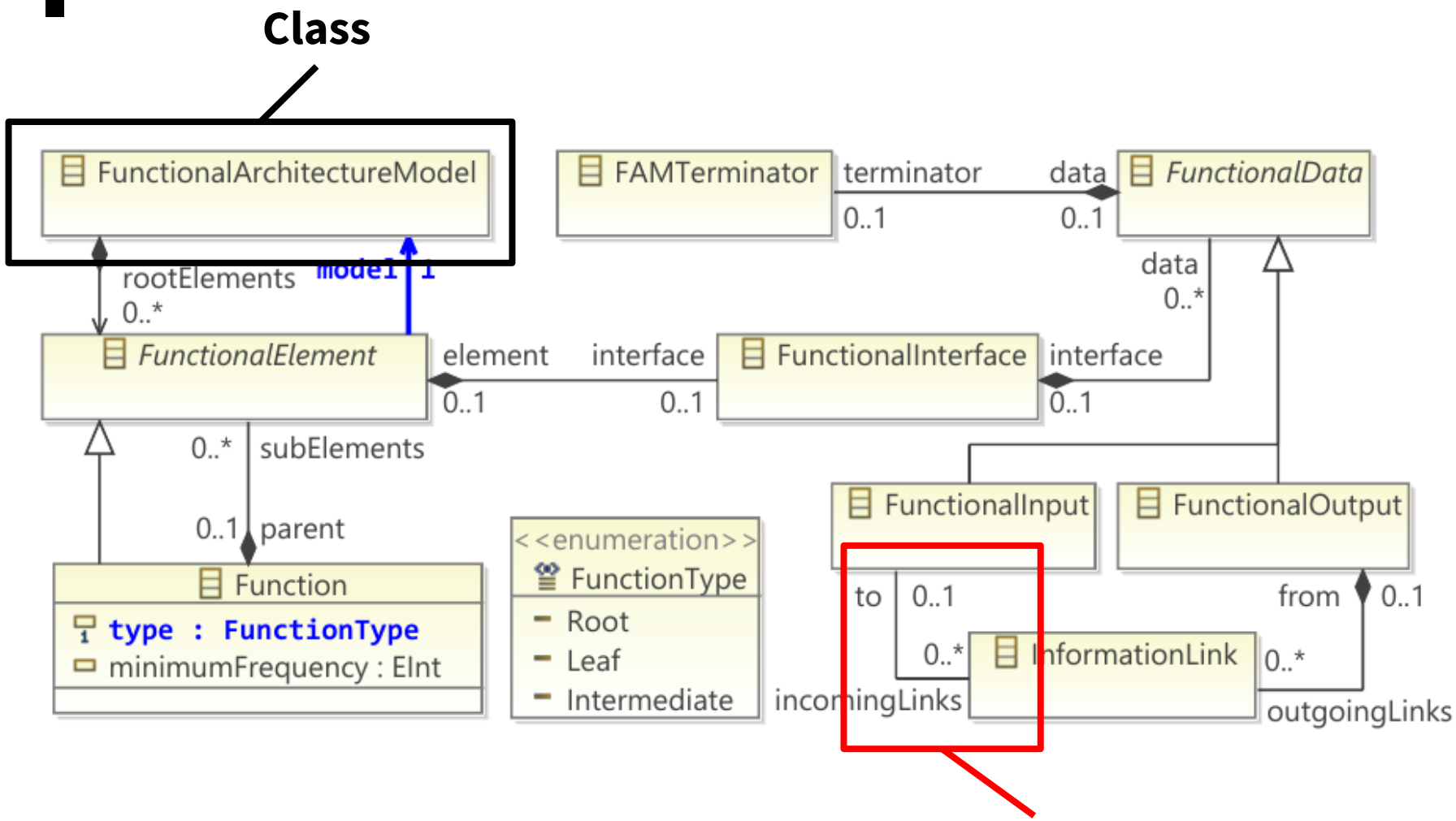

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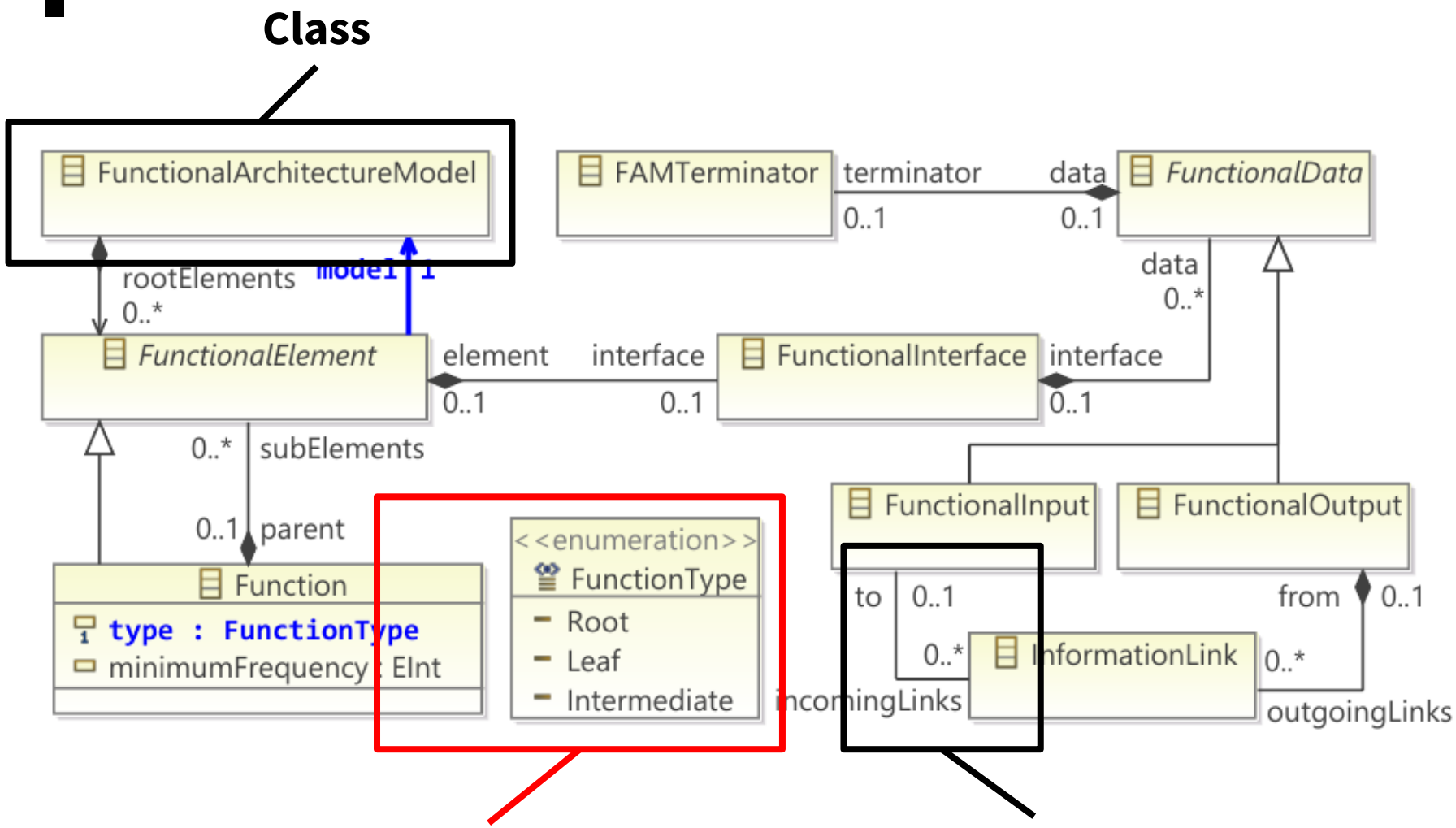

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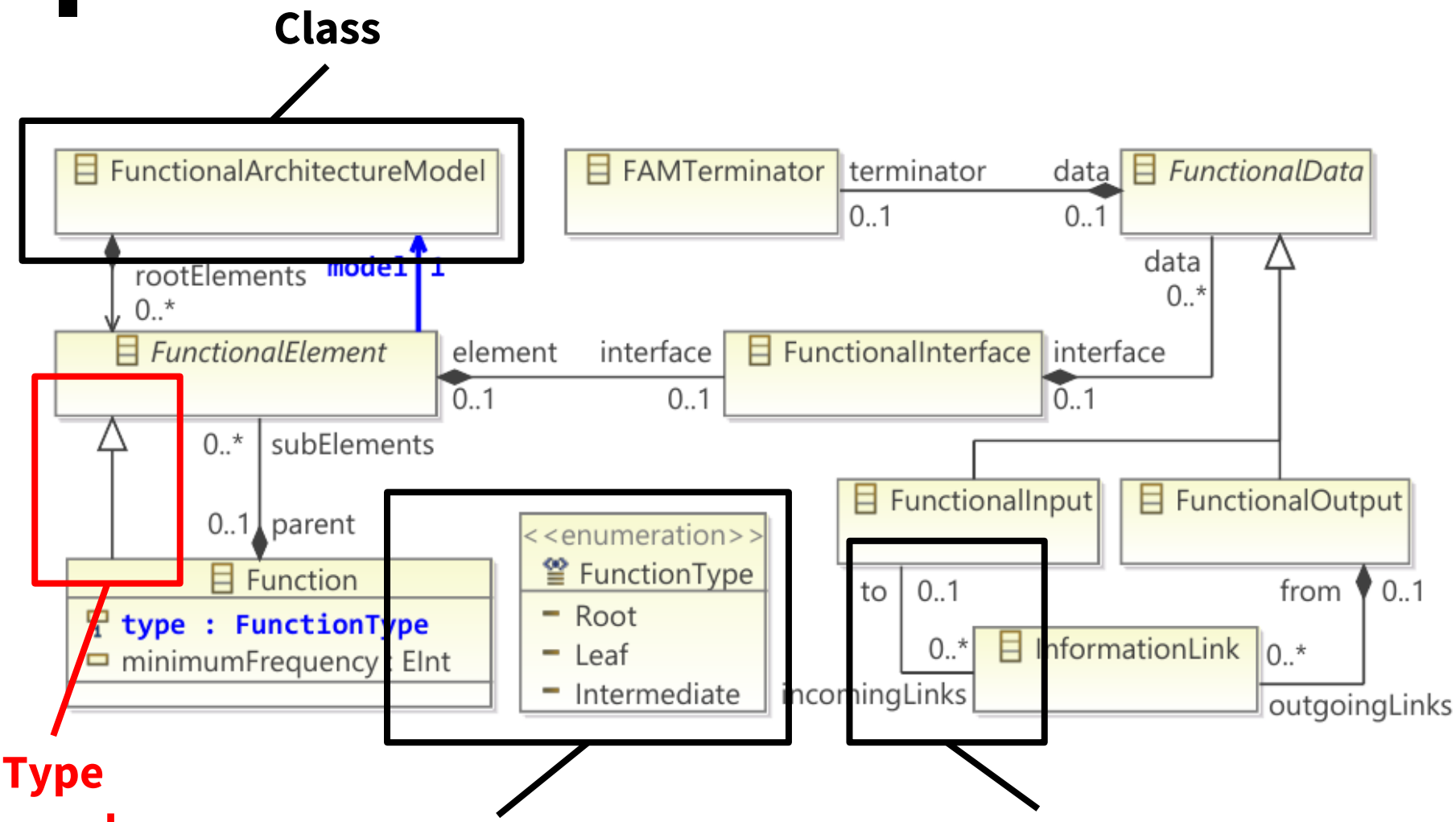

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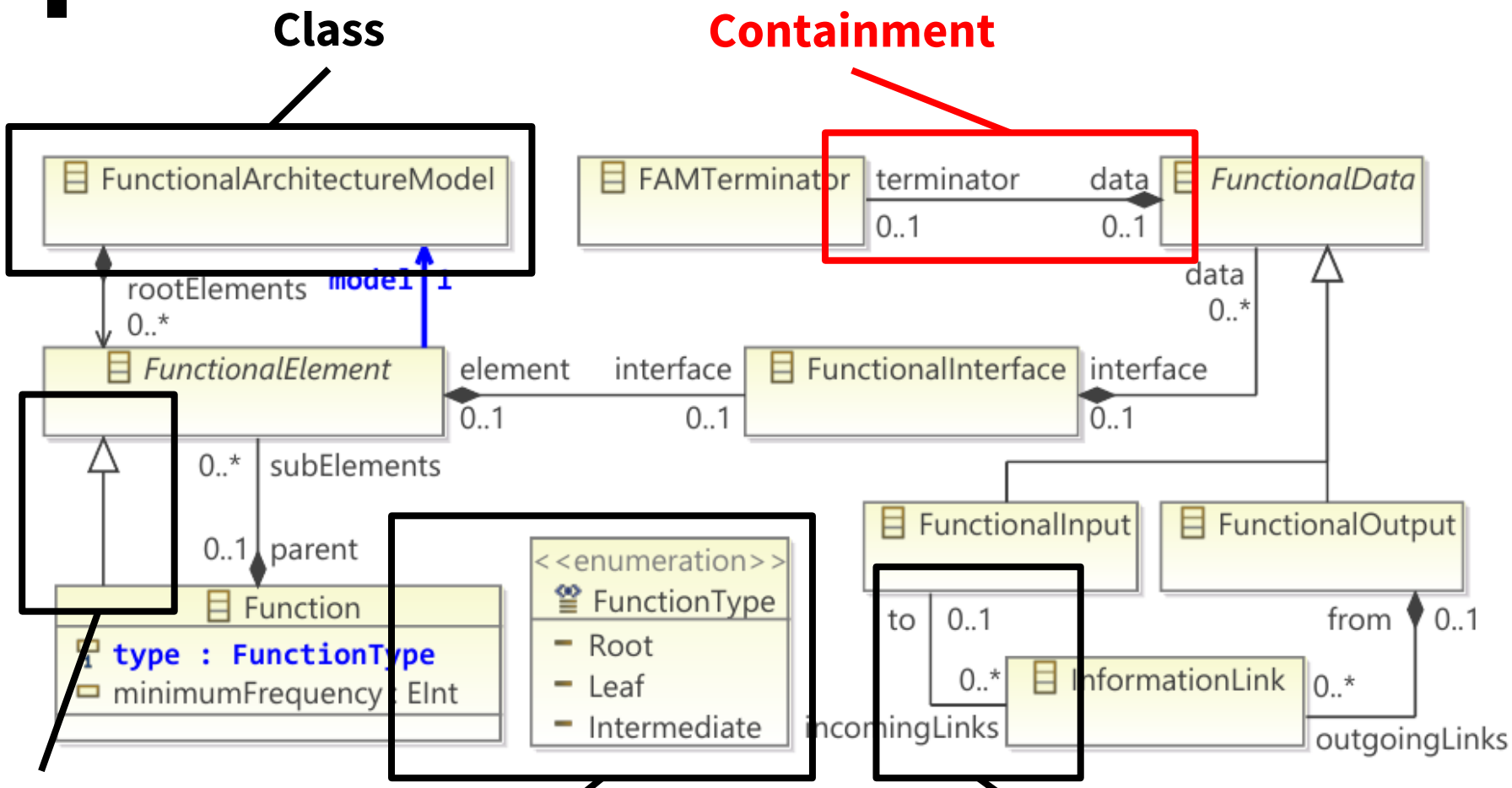
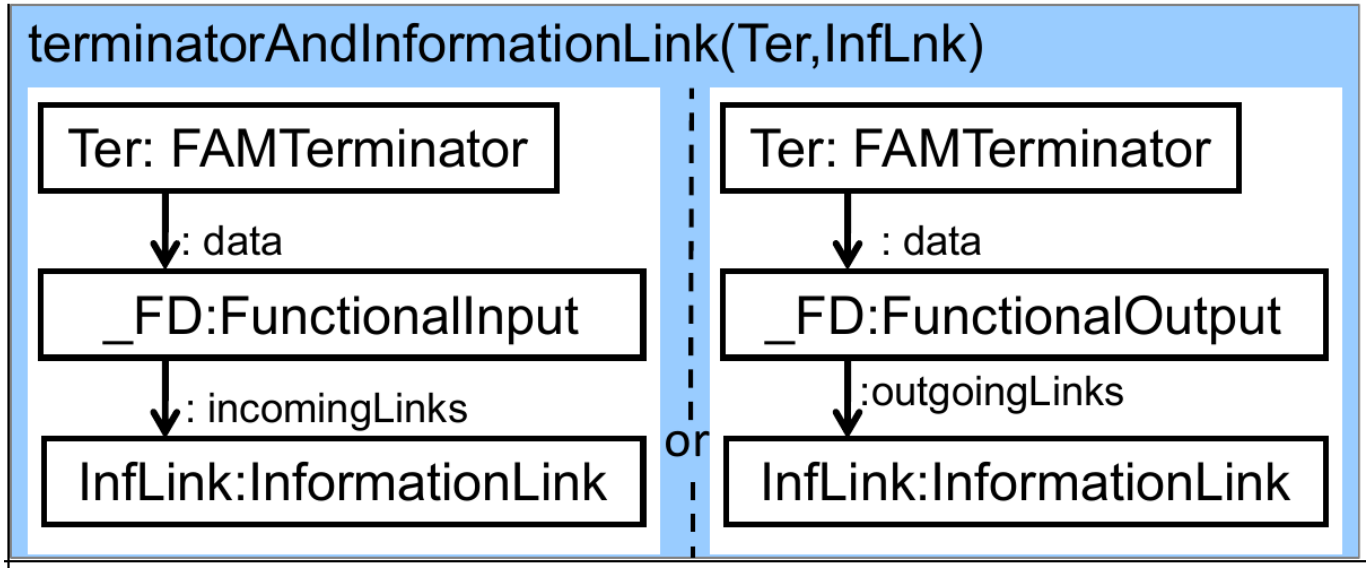


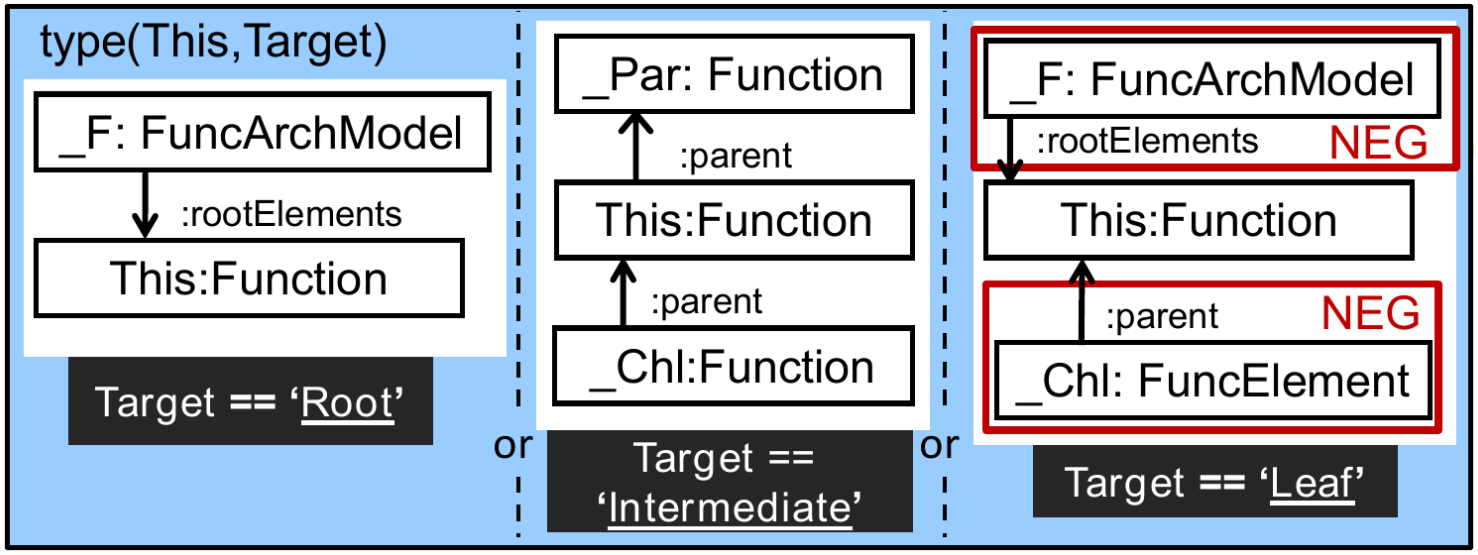
Formalisation of Constraints

- **Supported Constraints**
  - Classifier
  - Path
  - Equality
  - Pattern call
  - Check



Formalisation of Constraints

- **Supported Constraints**
  - Classifier
  - Path
  - Equality
  - Pattern call
  - Check
- **Usage**
  - Well-formed constraints
  - Derived patterns



Partial Snapshots

- **Relaxed Constraints**
  - Undefined attributes
  - Abstract objects
  - Unconnected partitions
  - Missing/extra edges
  - Removed objects

r1: Function
type = ::Root minimumFrequency = ?

r2: Function
type = ::Root minimumFrequency = ?

i1: Function
type = ::Intermediate minimumFrequency = ?

i2: Function
type = ::Intermediate minimumFrequency = ?

l1: Function
type = ::Leaf minimumFrequency = ?

l2: Function
type = ::Leaf minimumFrequency = ?

Partial Snapshots

- **Relaxed Constraints**
  - Undefined attributes
  - Abstract objects
  - Unconnected partitions
  - Missing/extra edges
  - Removed objects
- **Semantic Modifiers**
  - Positive/Negative
  - Injective/Shareable
  - Modifiable/Unmodifiable

r1: Function
type = ::Root minimumFrequency = ?

r2: Function
type = ::Root minimumFrequency = ?

i1: Function
type = ::Intermediate minimumFrequency = ?

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type = ::Intermediate minimumFrequency = ?

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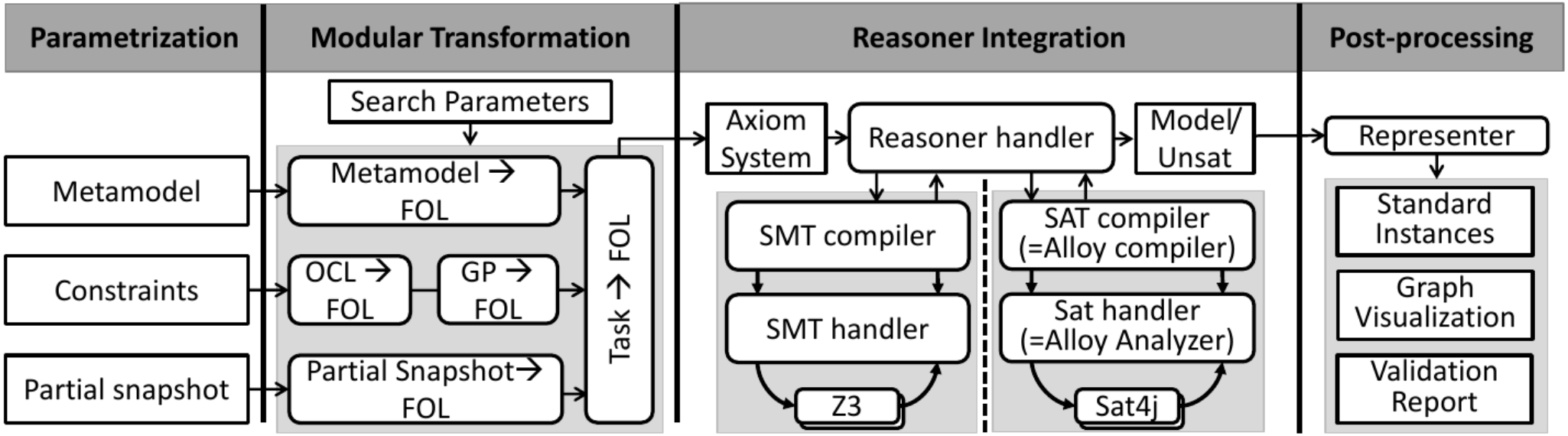
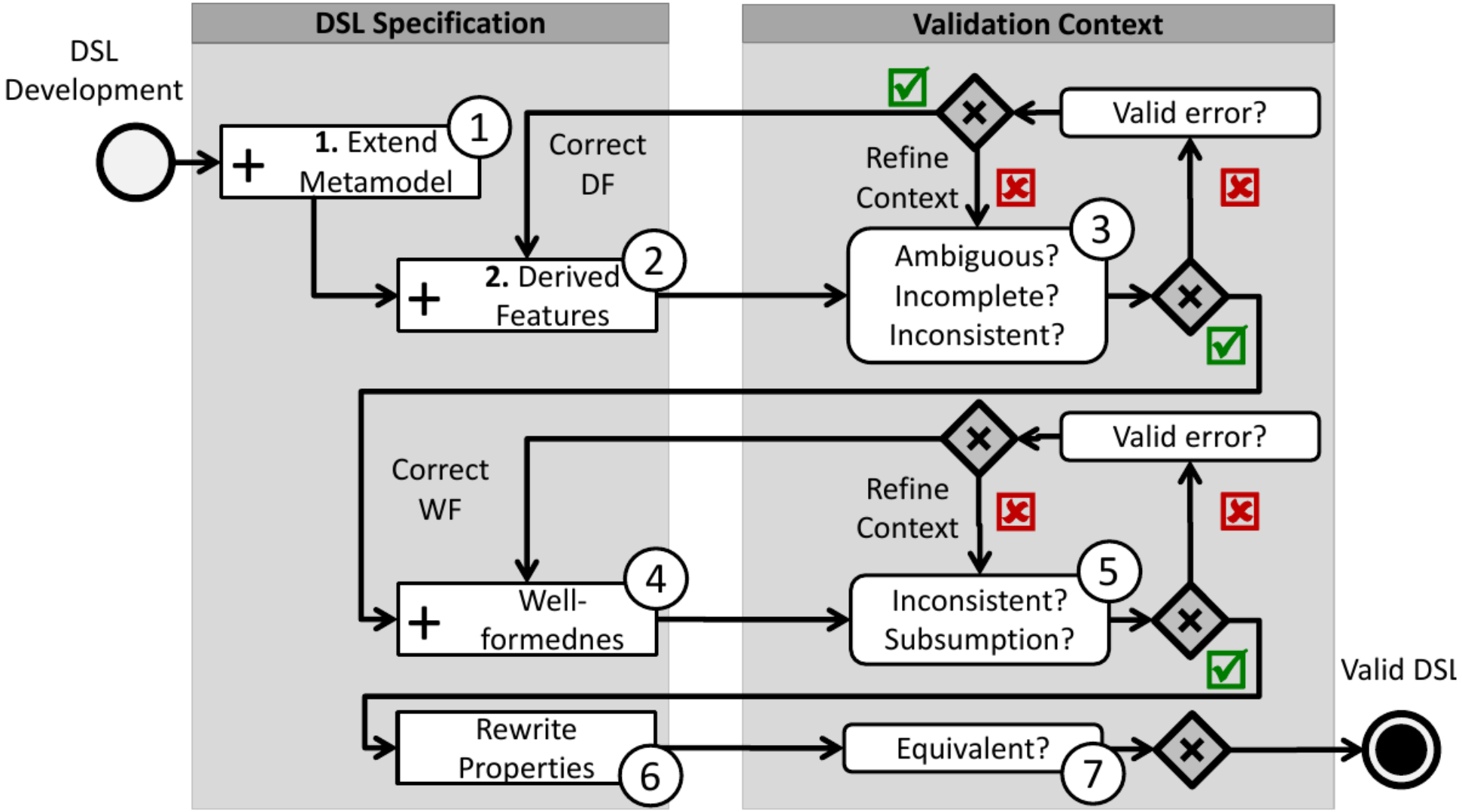
DSL Validation Tool



DSL Validation Workflow



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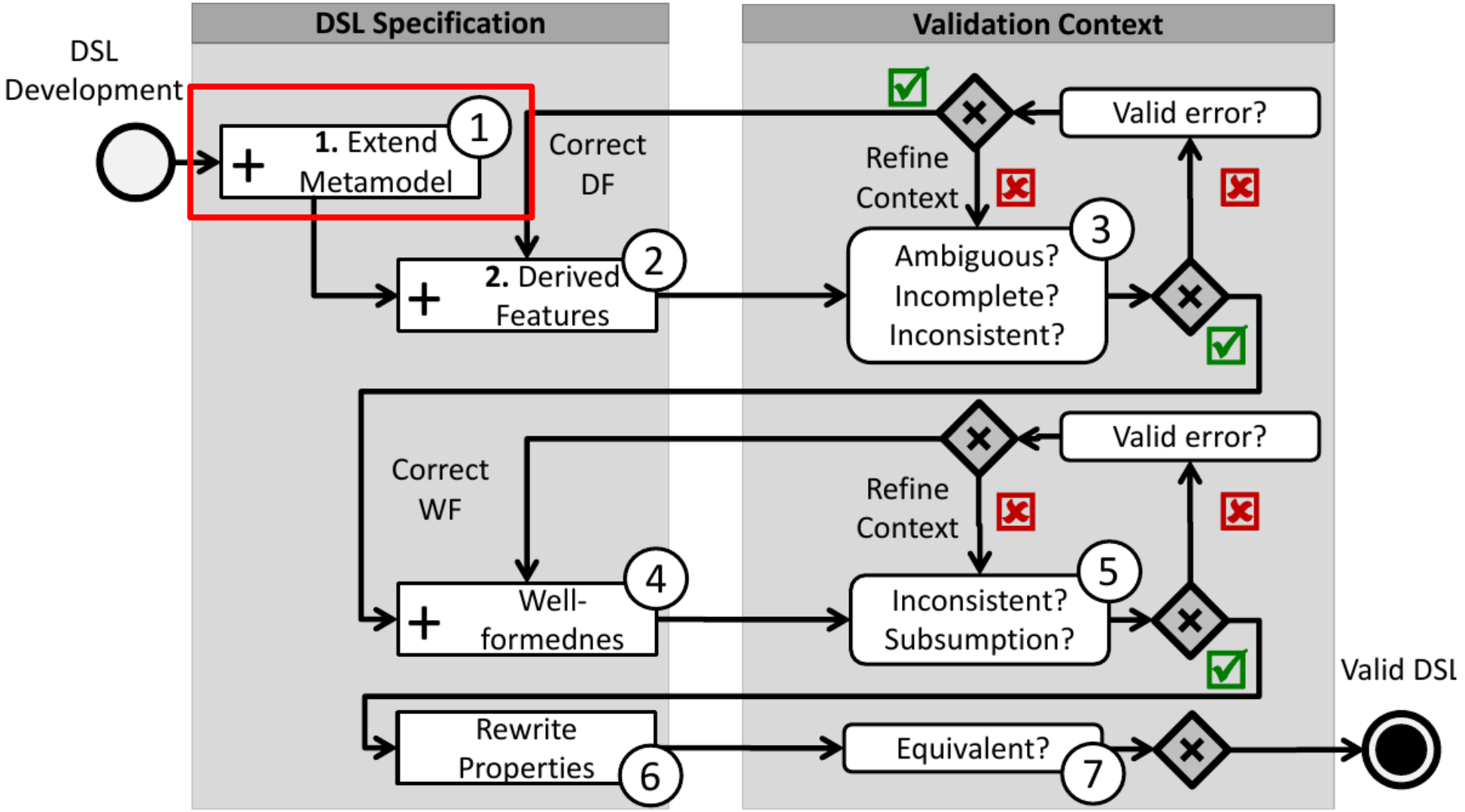
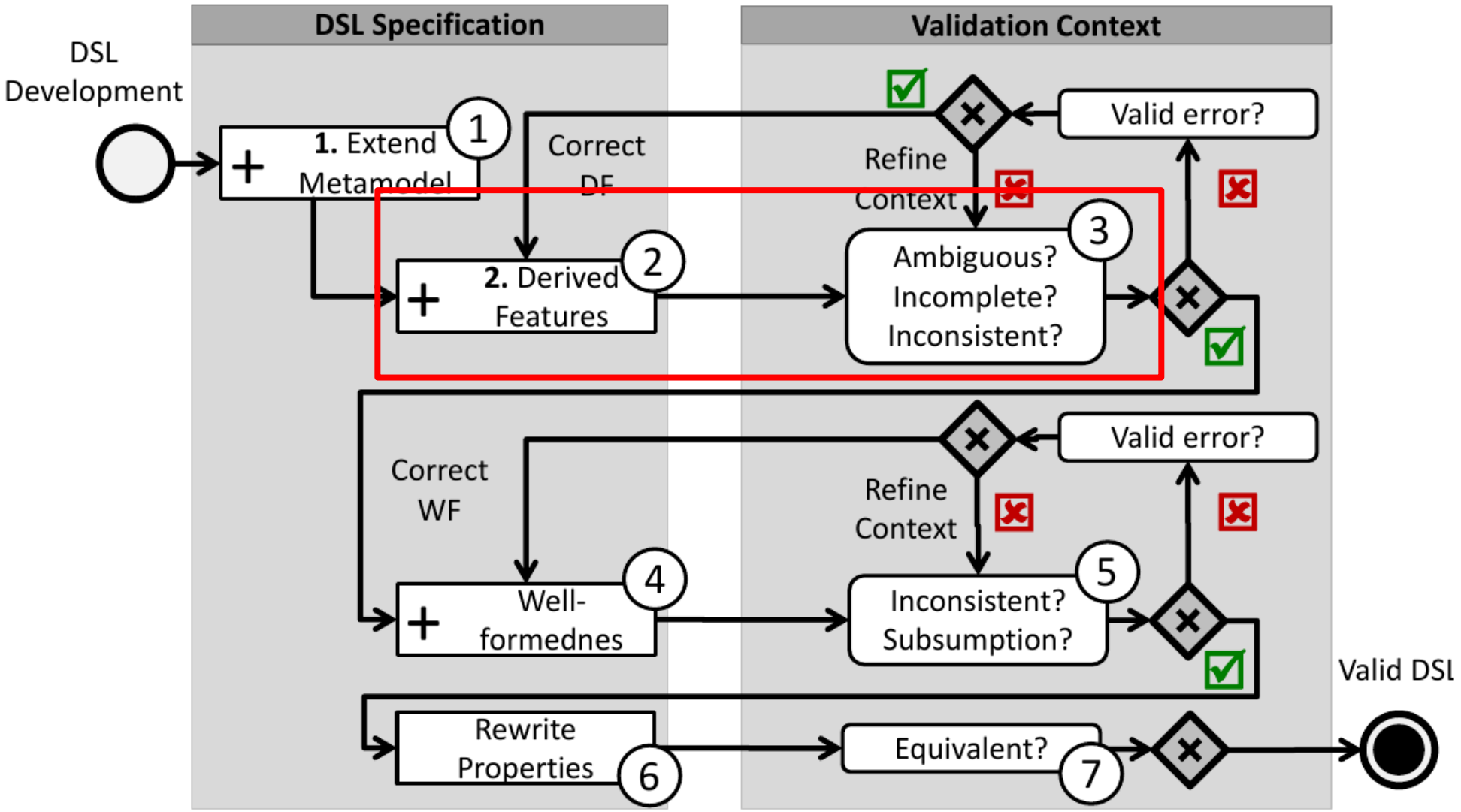


DSL Validation Workflow



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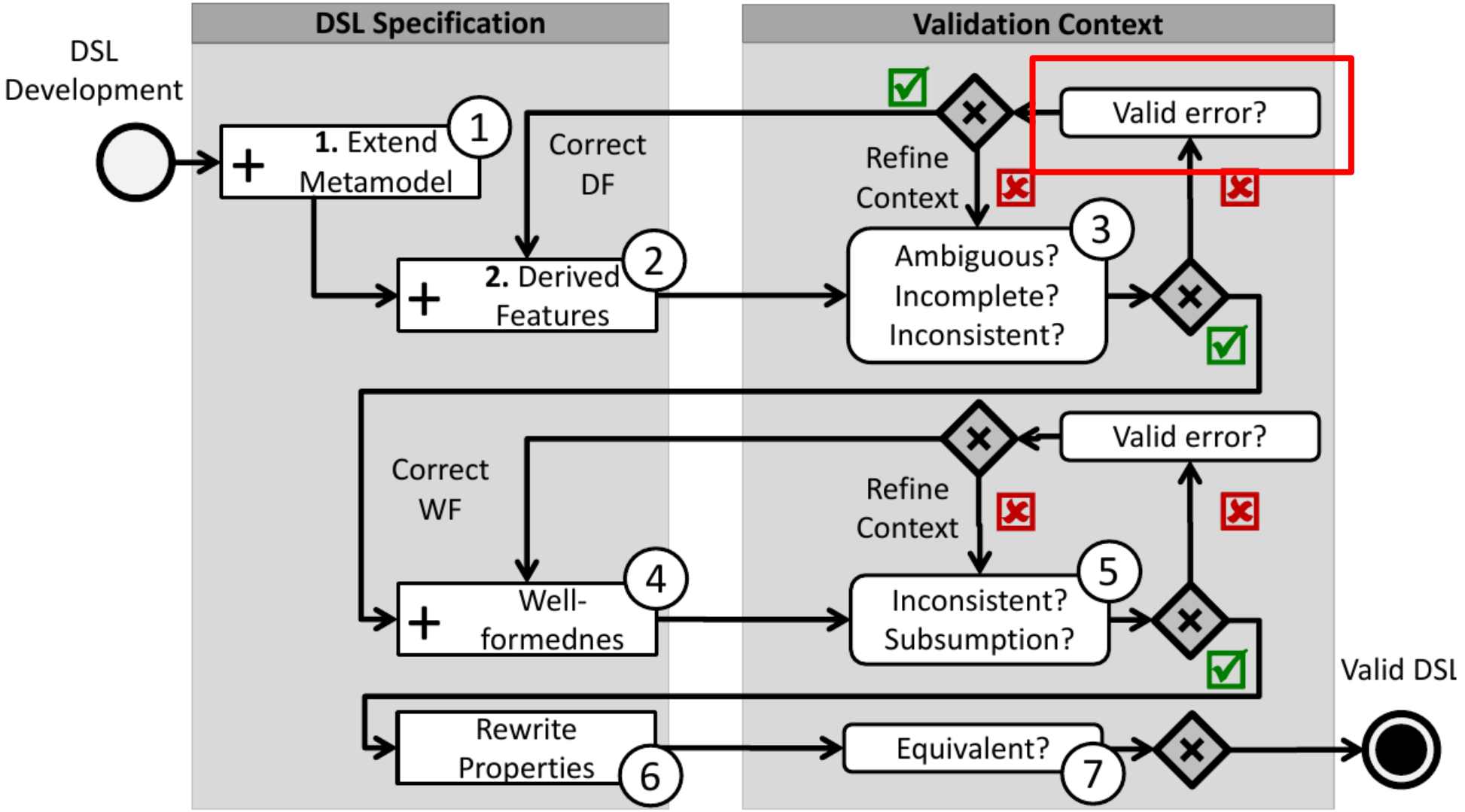

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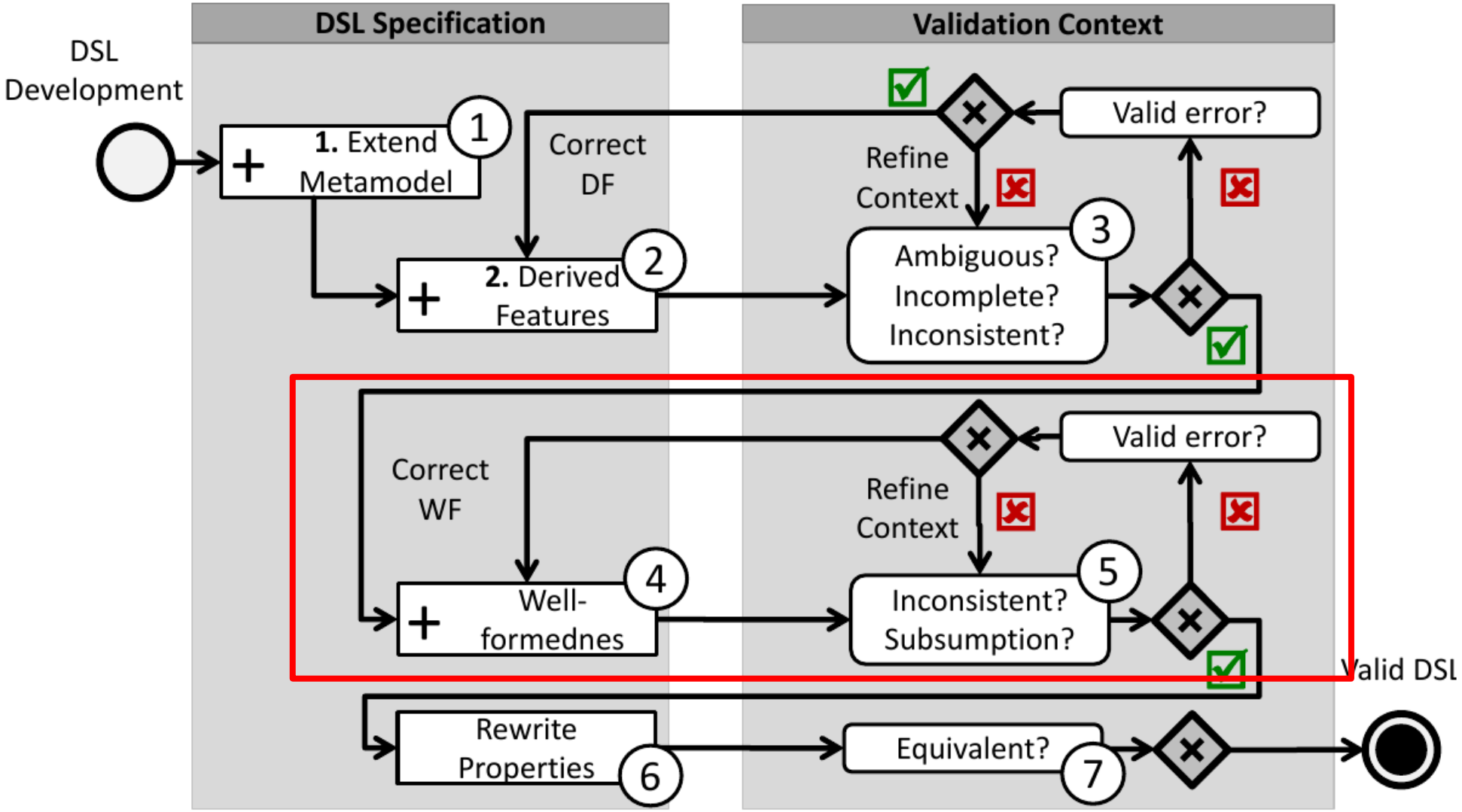

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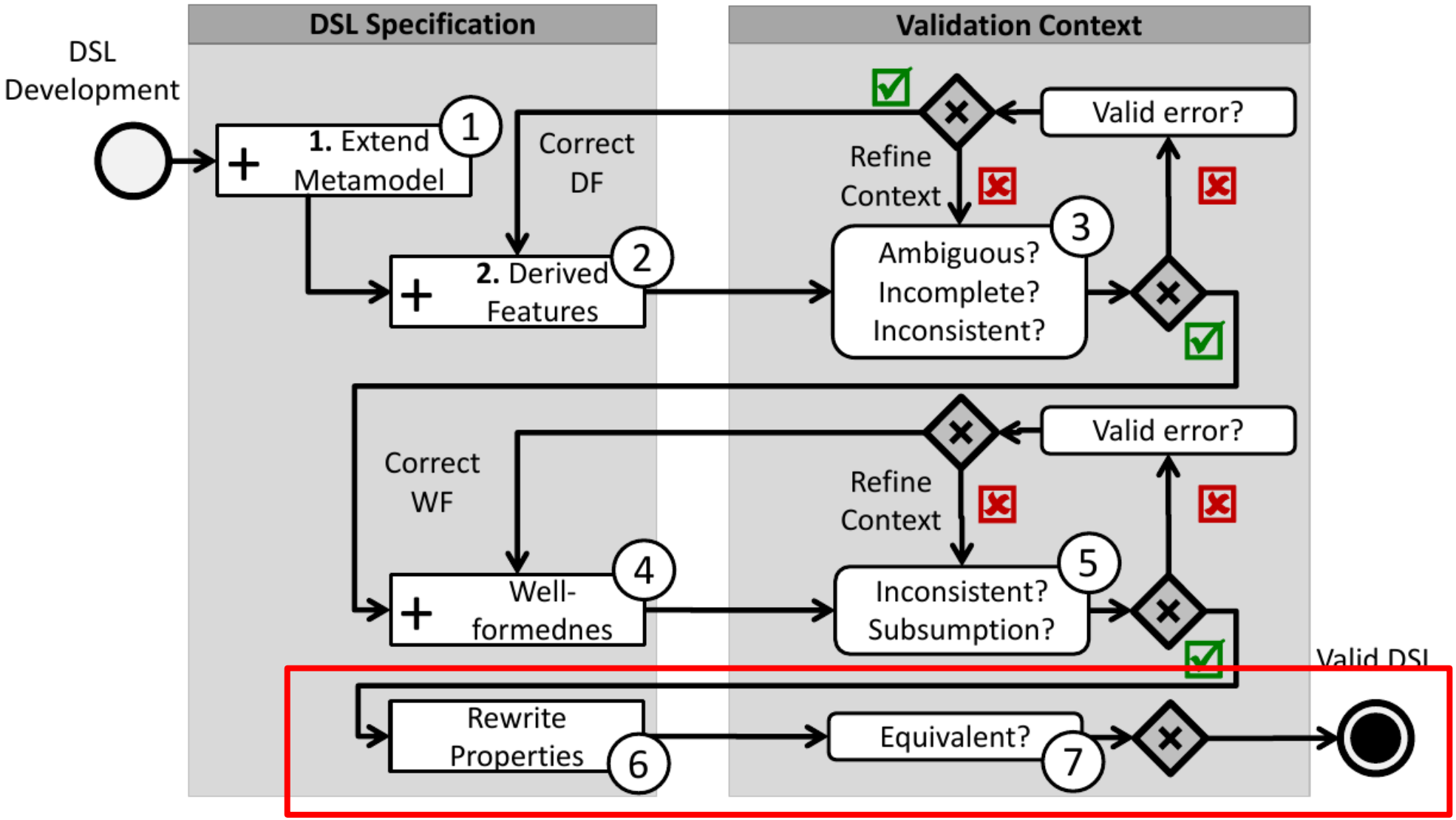
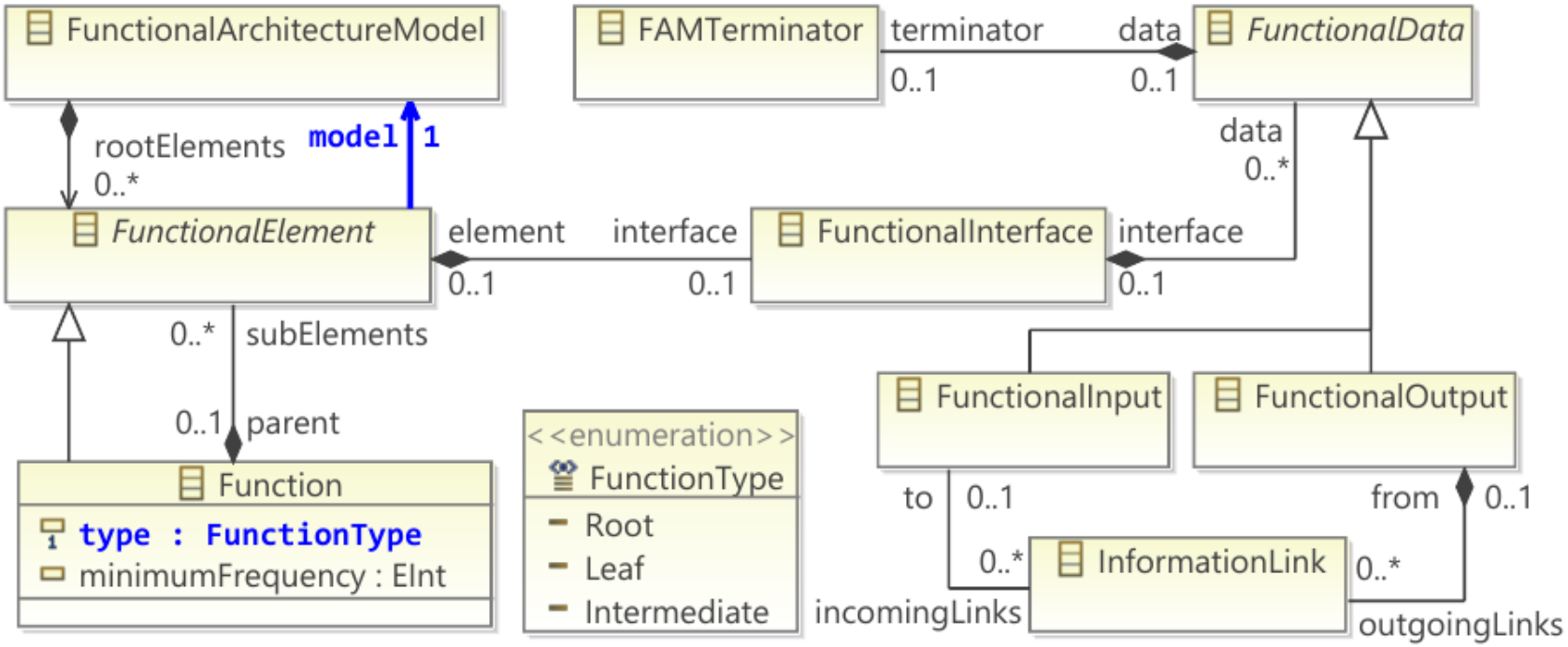


Runtime Measurements

- **Preliminary Results**
  - Z3 (SMT) generally outperforms Alloy (SAT)
  - Alloy outperforms Z3 in model structure generation



The End

- **Problem**
  - Validation of complex DSLs
- **Approach**
  - Approximate DSL in first-order logic
  - Check for satisfiability of resulting formula
  - Convert witness/counterexample into model
- **Discussion Points**
  - How well does the approach scale?
  - Is it applicable to validating UML?
  - What are “useful” constraints for a DSL?
  - Is it applicable to synthesising constraints?