MDD with OMG Standards MOF, OCL, QVT & Graph Transformations

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Outline of Presentation

- Languages and Tools for Model-Driven Development
  - OMG´s Model Driven Architecture (MDA)
  - Model-Driven Software Development (MDD)
  - MDD requirements derived from industrial case study
- From MDD to the World of Graph Transformations
  - Comparison of Meta-Case, Model/Graph Transformation Tools
  - MOFLON = OMG standards + graph transformation technology
  - MOFLON architecture and sublanguages
- … and Back Again
  - Status quo and future of MOFLON
  - Status quo of MDA/MDD/DSL/Meta-Case/… tools in general

Motivation

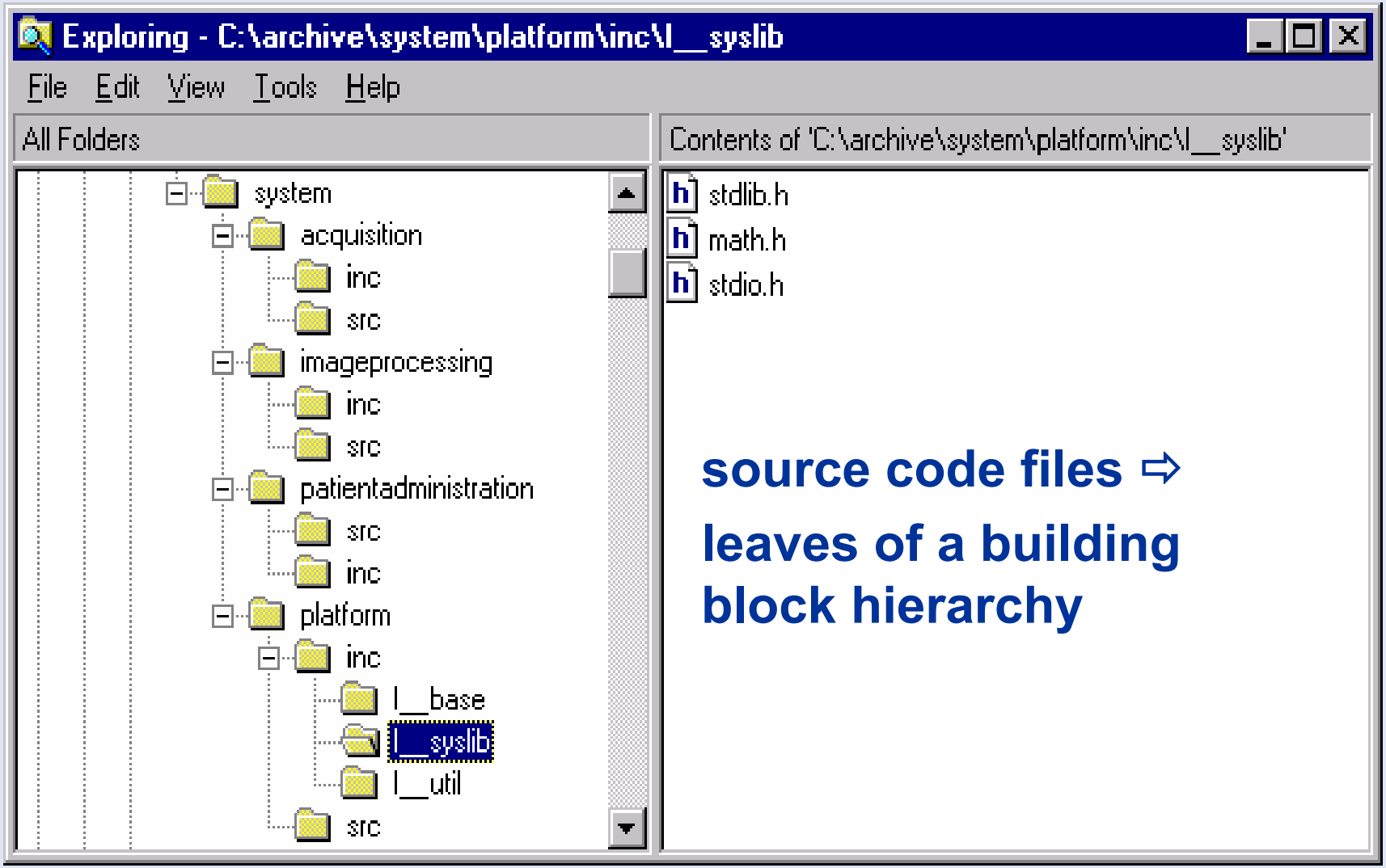
An Industrial Case Study

Magnetic Resonance Imaging System

- Real-Time
- Safety-Critical
- …

- 3D volume scan
- Quickly evolving technology
  - Scan speed
  - Image resolution
- More clinical applications
  - Motionless tissues
  - […]
  - Heart surgery
- 3.5++ MLOC, 3 computers, 80 processes
- 200++ SW developers (engineers, scientists)

Source code organization



source code files ⇨

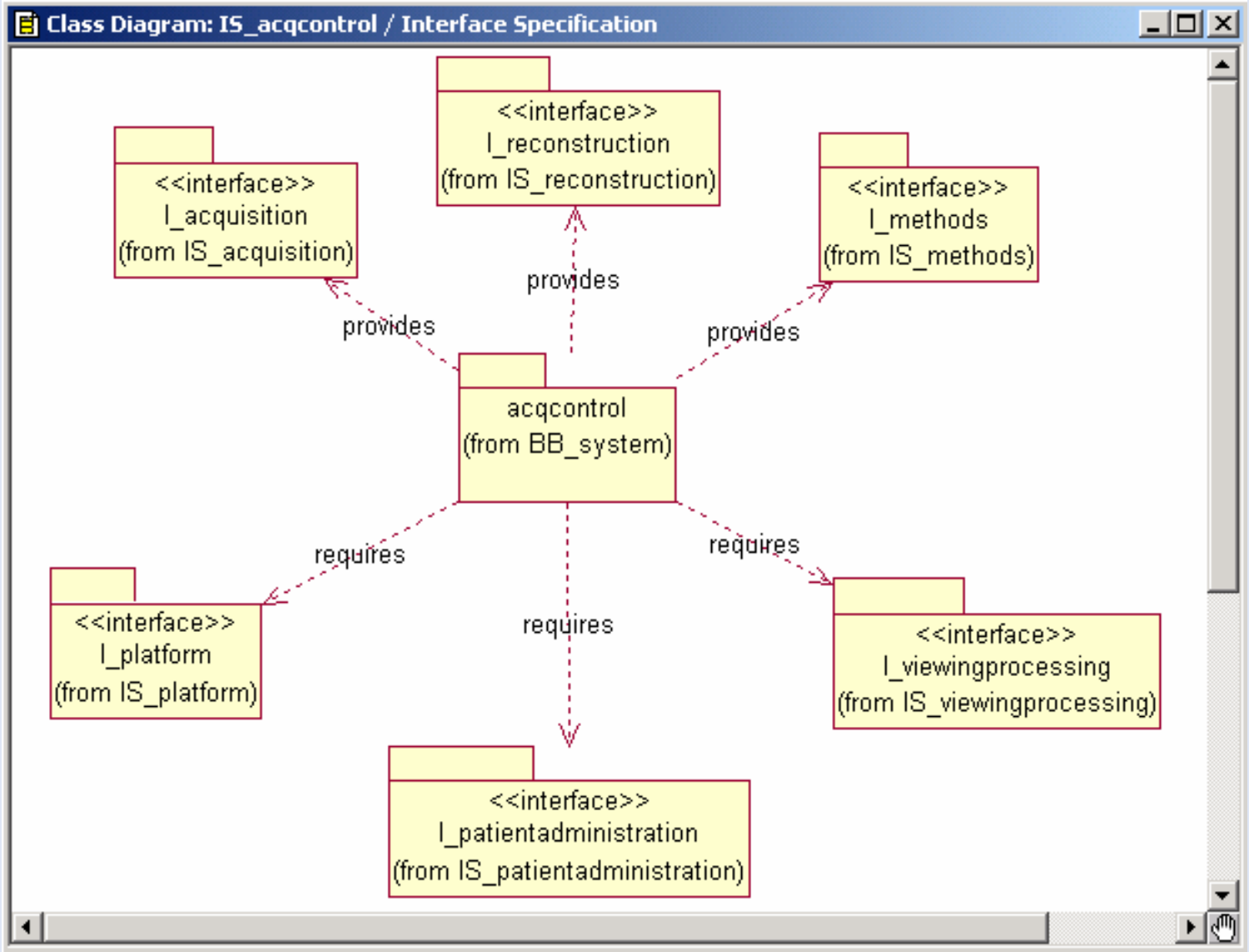
leaves of a building block hierarchy

Domain-Specific Architecture Concepts

A **Building Block** is a separated unit of

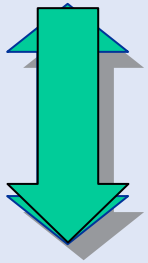
- Ownership and Responsibility
  - Software Architect for the System
  - Senior Designer for a Subsystem
  - …
- Product-related documents
  - Requirements Specification
  - Design & Interface Specification
  - Test Specification & Reports
  - …
- Functionally related code
- Encapsulation (information hiding)
- Hierarchy of Subblocks

Mapping of Building Blocks to UML



Different Levels of Abstraction

High-Level Architecture
(Domain-Specific Language)



Consistency ?

Low-Level Architecture
(Unified Modeling Language)

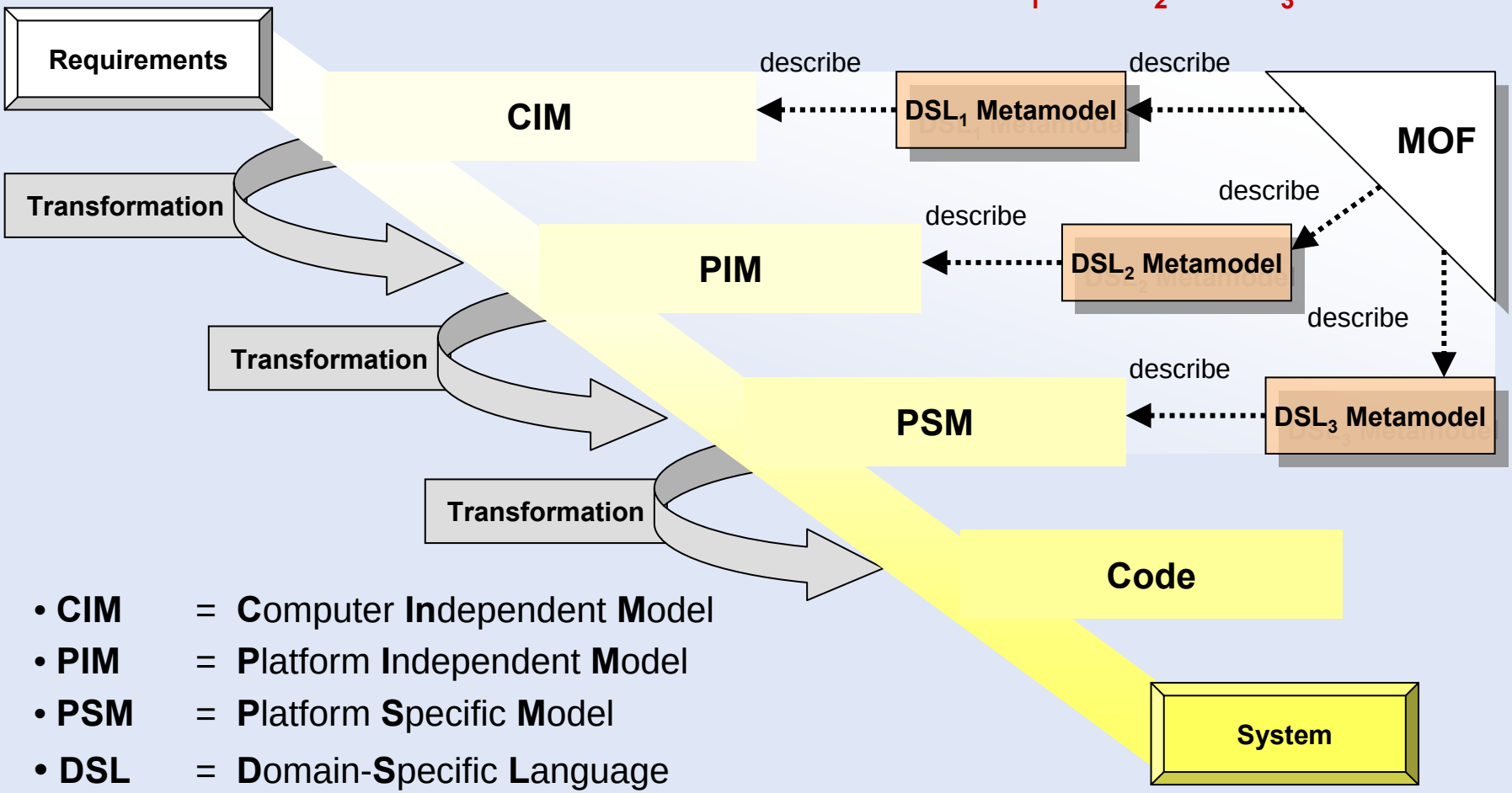
Consistency ?

Implementation
(C-Code, …)

OMG´s Model Driven Architecture

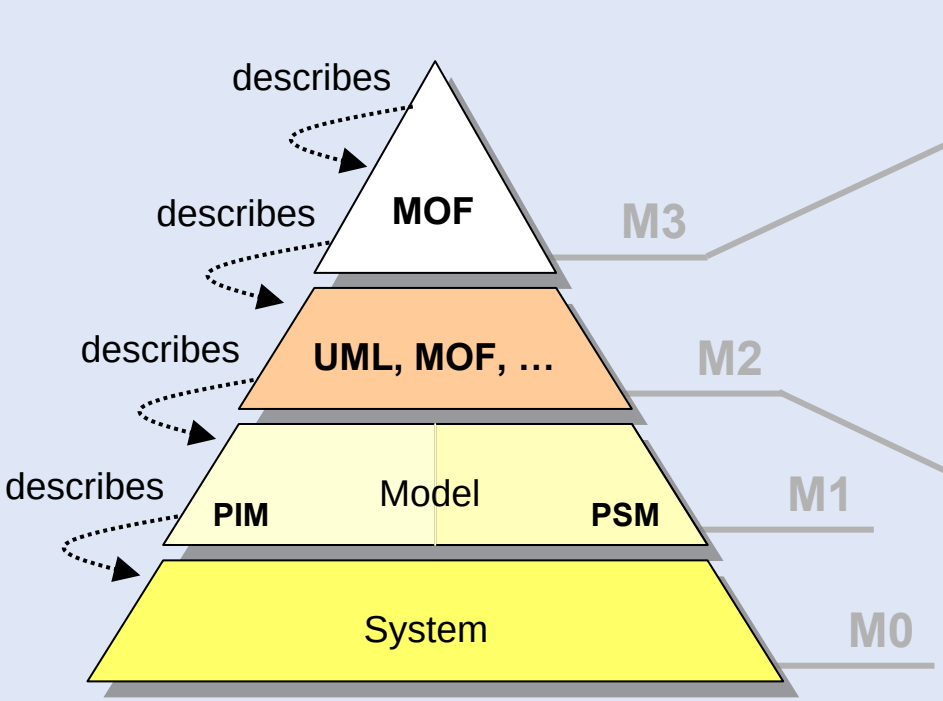
OMG often recommends:

$DSL_1 = DSL_2 = DSL_3 = UML$

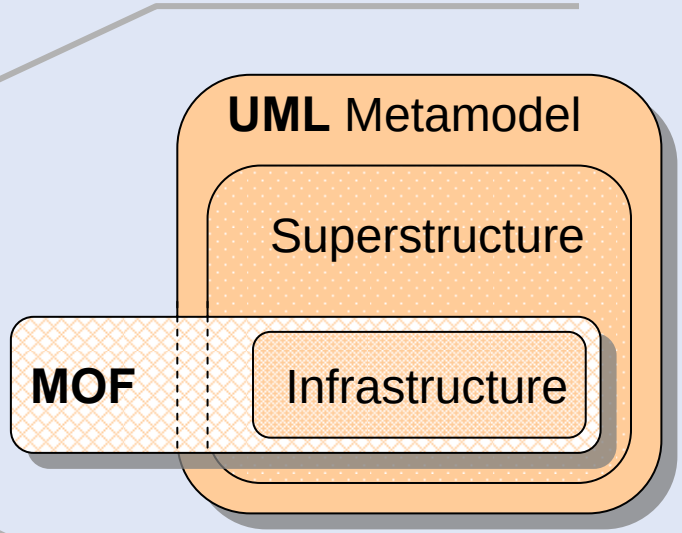


- **CIM** = **C**omputer **I**ndependent **M**odel
- **PIM** = **P**latform **I**ndependent **M**odel
- **PSM** = **P**latform **S**pecific **M**odel
- **DSL** = **D**omain-**S**pecific **L**anguage
- **MOF** = **M**eta **O**bject **F**acility
- **UML** = Unified **M**odeling **L**anguage

OMG´s Model Driven Architecture



(Meta-)Modeling Layers



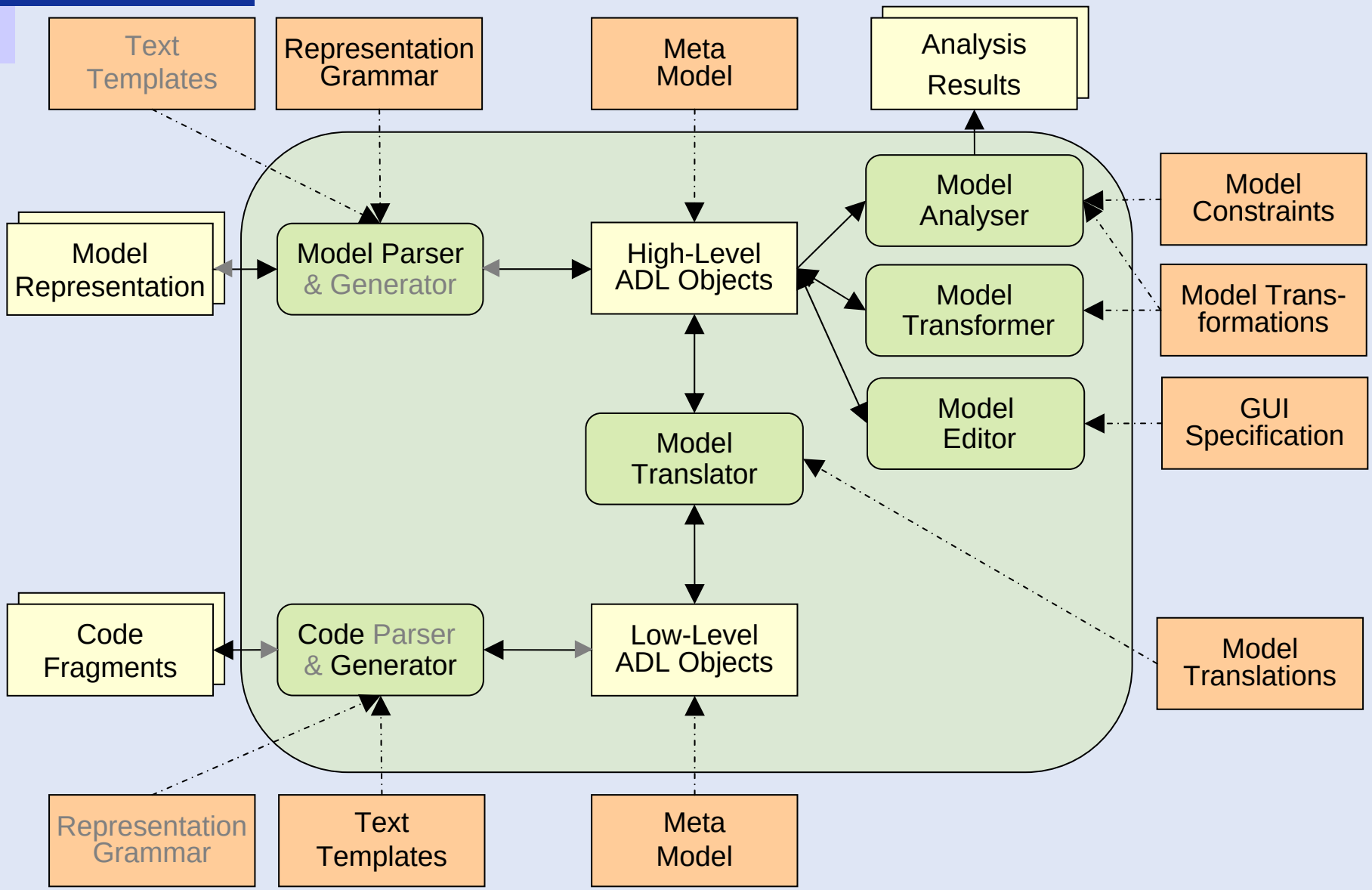
Infrastructure = UML ∩ MOF

MDD/MDA Tool Requirements

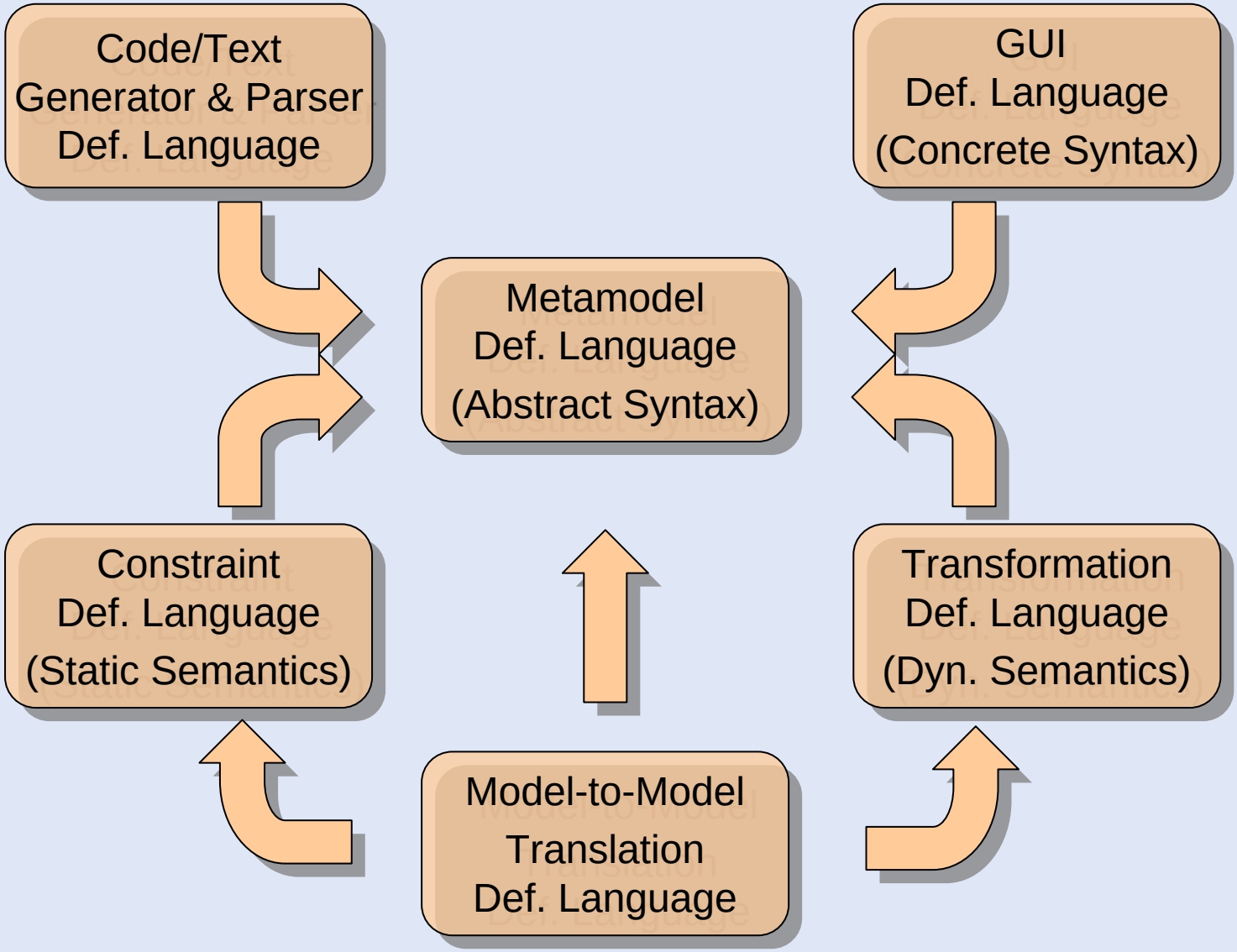
Rapid Development (generating) of

- Local model analysis/transformation support
- Inter-model consistency checking
- Traceability link management support
- Bidirectional model update propagation
- Model import / export (code generators, parser, …)
- Tool wrappers for „COTS“ tools
- New tools for domain-specific languages
- Integrated model version management
- …

MDD Tool Chain



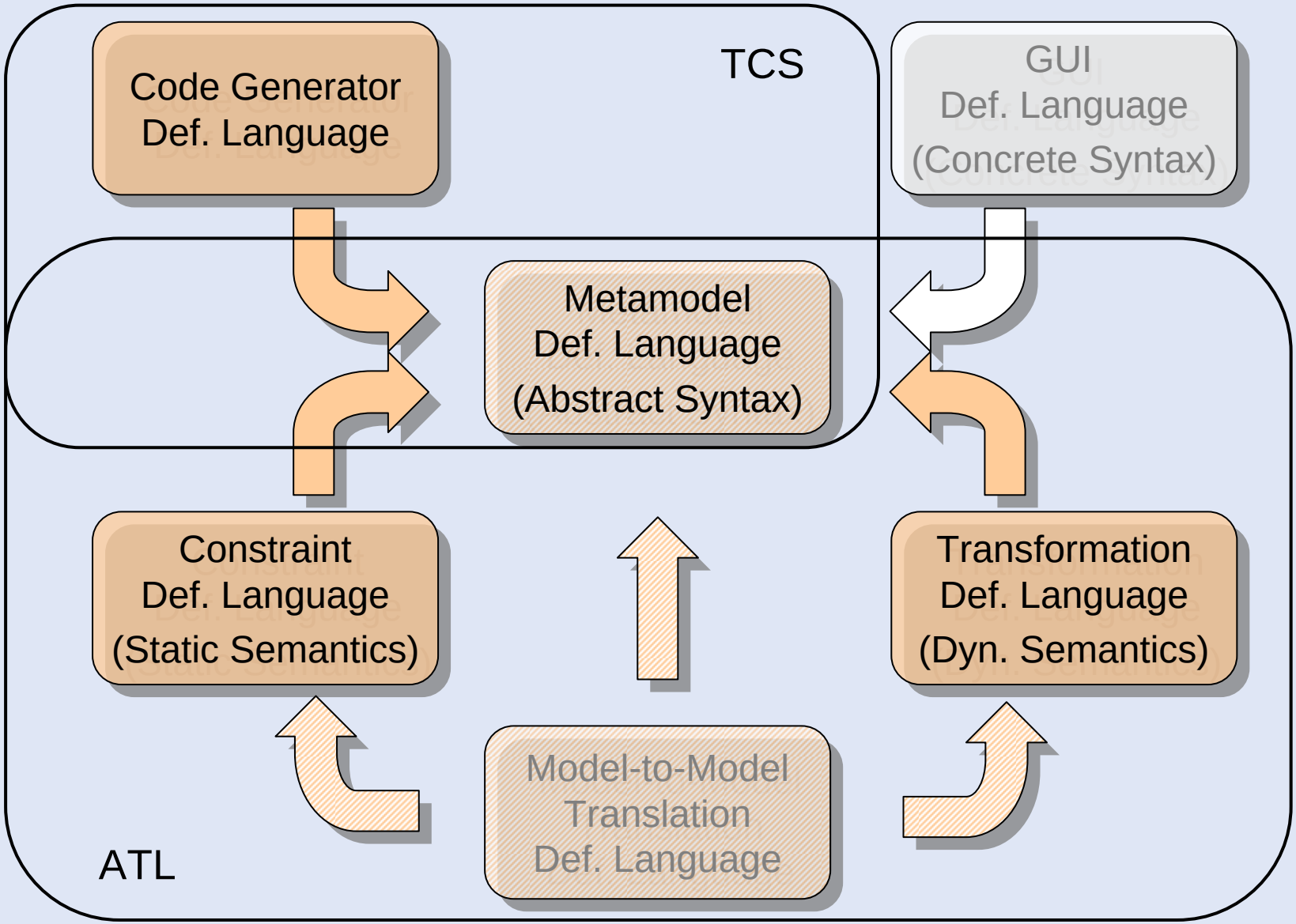
Integrated Metamodeling Language



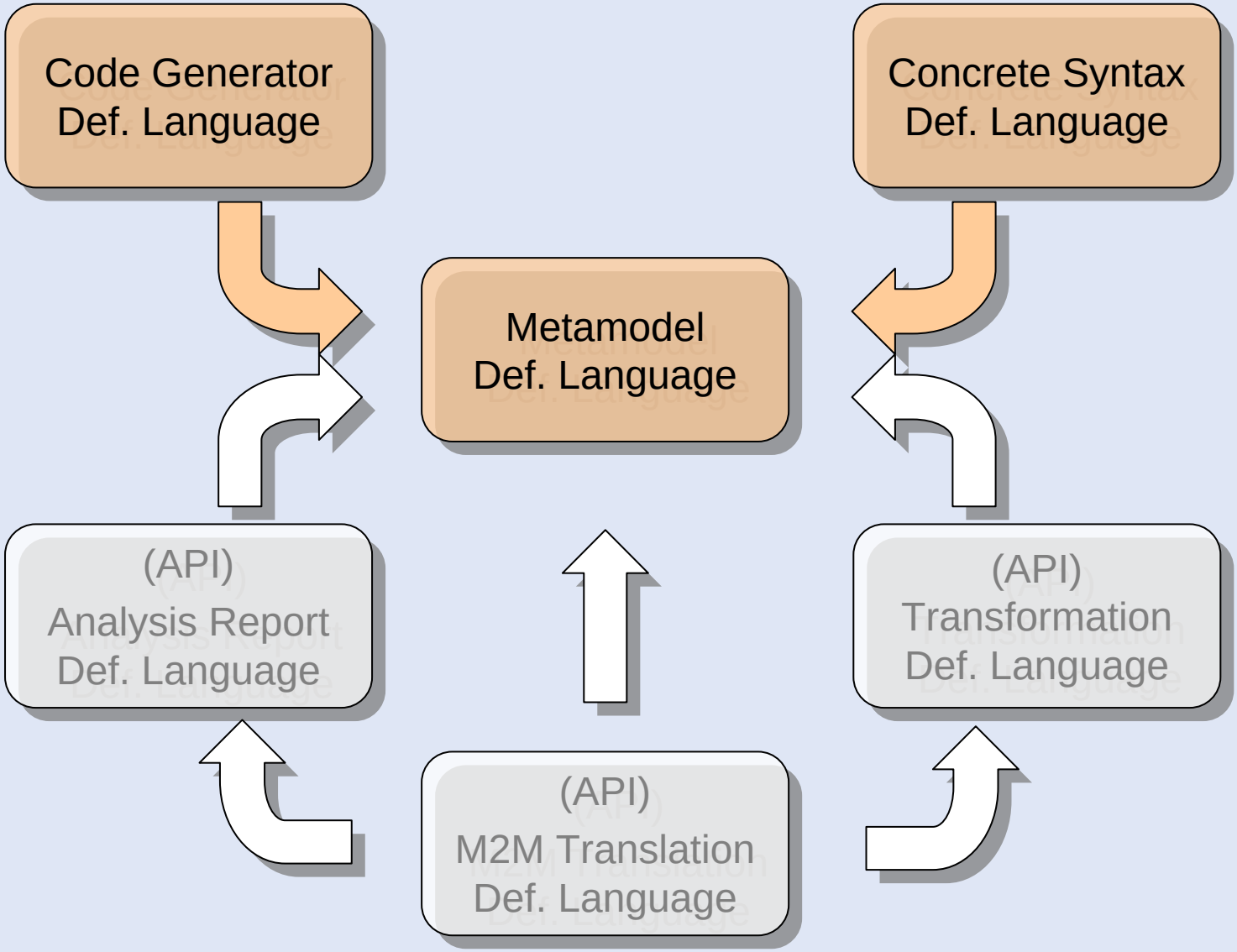
Categories of MDD Tools

- „Pure“ Model Transformation Tools
  - AMMA / ATL (INRIA)
  - ArcStyler (Interactive Objects Software GmbH)
  - …
- „Pure“ DSL Editor Generators
  - Microsoft DSL
  - MetaEdit+ (MetaCase)
  - …
- Integrated Approaches
  - GME (Vanderbilt University)
  - (OMG Standards)
  - MOFLON / Fujaba (Uni. Darmstadt, Paderborn, Kassel,…)
  - …

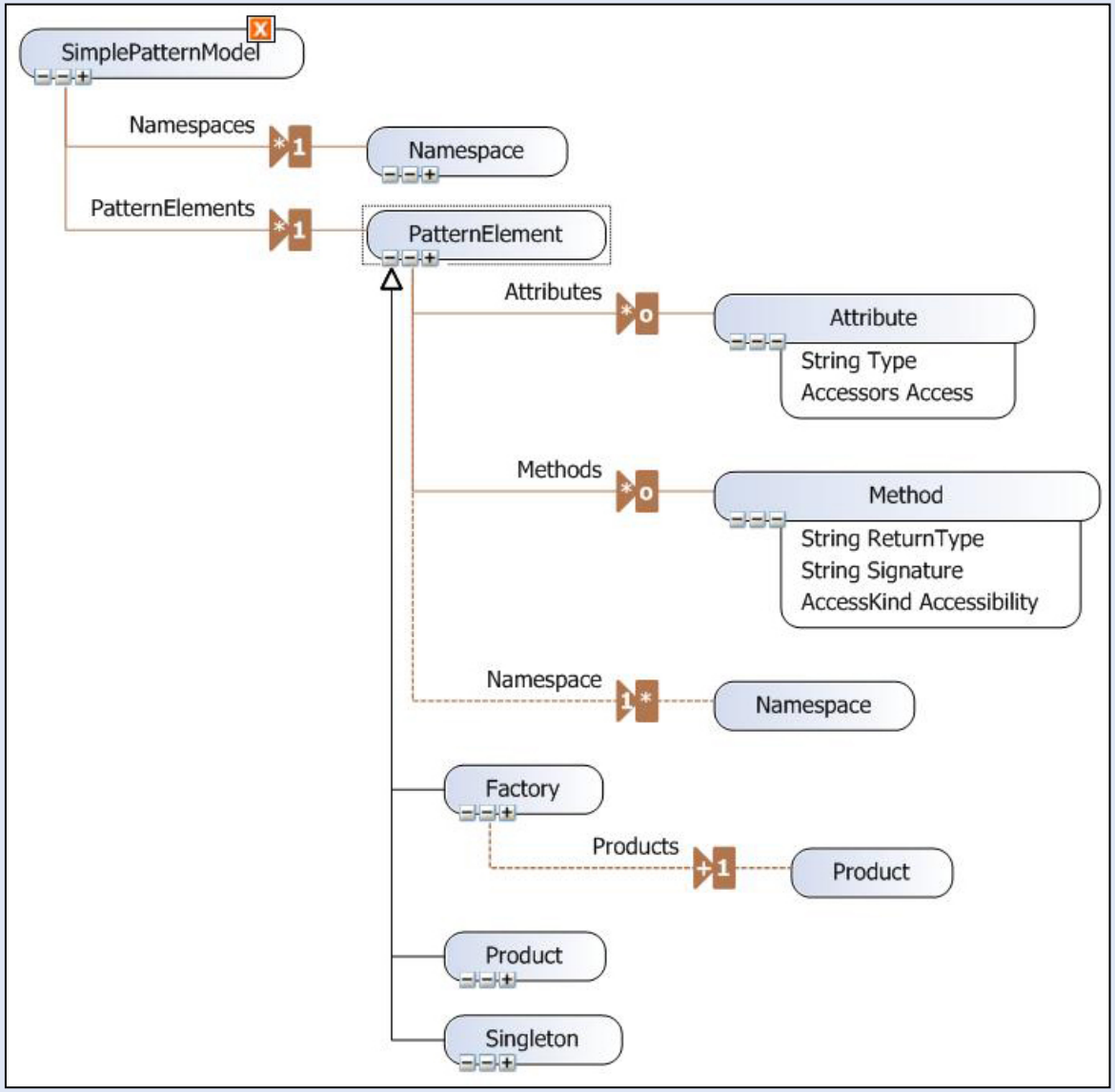
Model Transformation with AMMA



The Microsoft DSL Tools



Microsoft DSL - Metamodellierung



Beispiel Editor Definition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<shape name="FactoryShape" geometry="Rectangle">
  <decorators>
    <shapeText name="Name" position="Center"/>
    <expandCollaps position="InnerTopRight"/>
  </decorators>
  <fillColor color="DarkOrange"/>
  <outlineColor color="DarkOrange"/>
</shape>
```

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<shapeMap>
  <class>DomainModel.SPL/Factory</class>
    <mclCollectionExpression>
      <role>DomainModel.SPL/SimplePatternModel/PatternElements</role>
    </mclCollectionExpression>
  <shape>Designer.SPLDiagram/Shapes/FactoryShape</shape>
  <textMaps>
    <textDecorator>Designer.SPLDiagram/Shapes/FactoryShape/Decorators/Name</textDecorator>
      <valueExpression>
        <valueProperty>DomainModel.SPL/Factory/Name</valueProperty>
      </valueExpression>
  </textMaps>
</shapeMap>
```
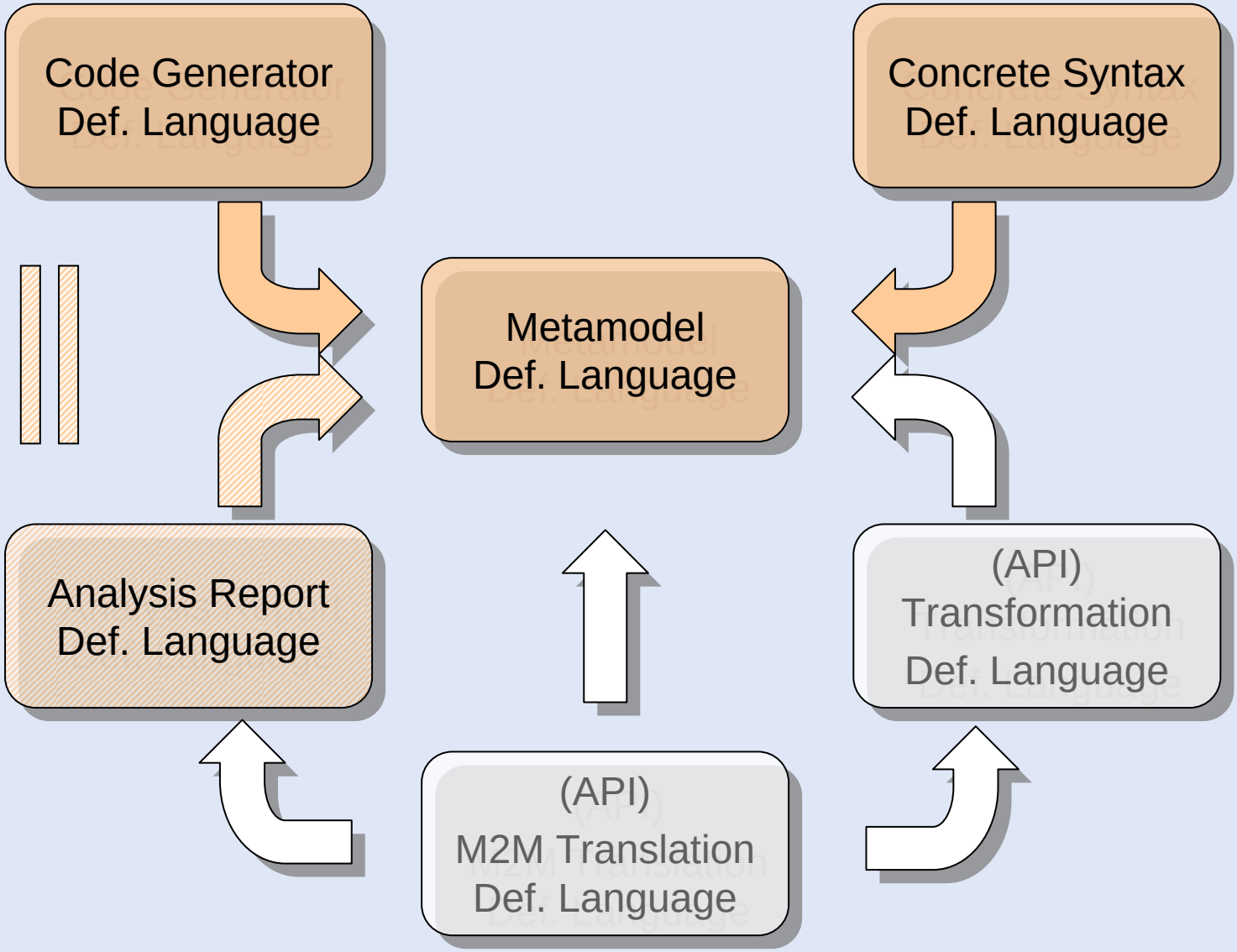
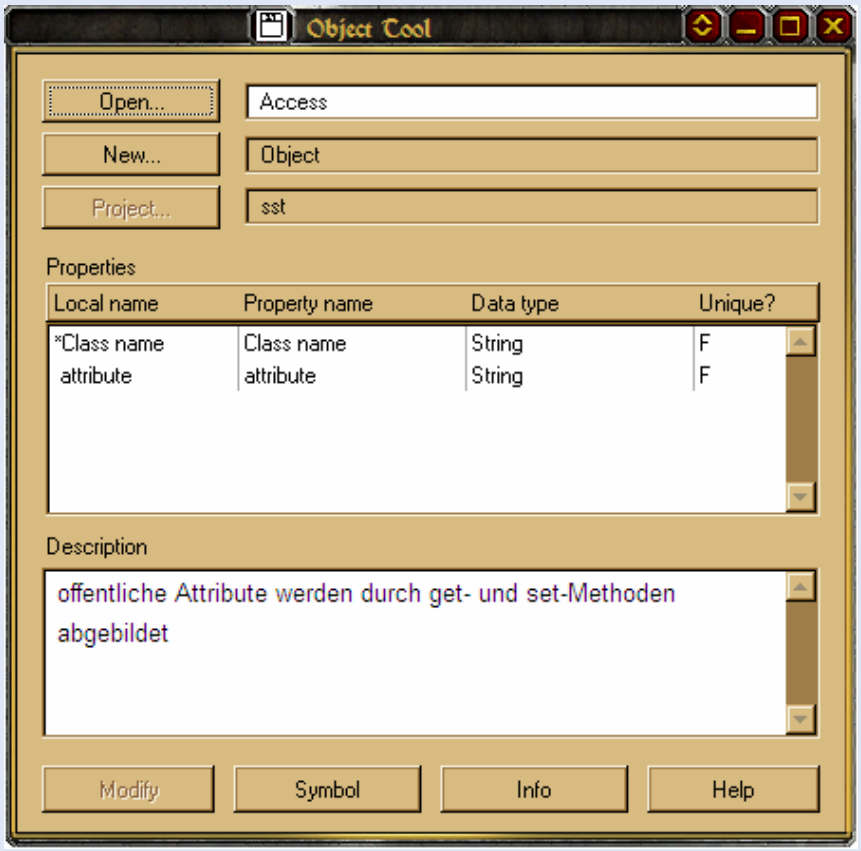

The Meta-CASE Tool MetaEdit+

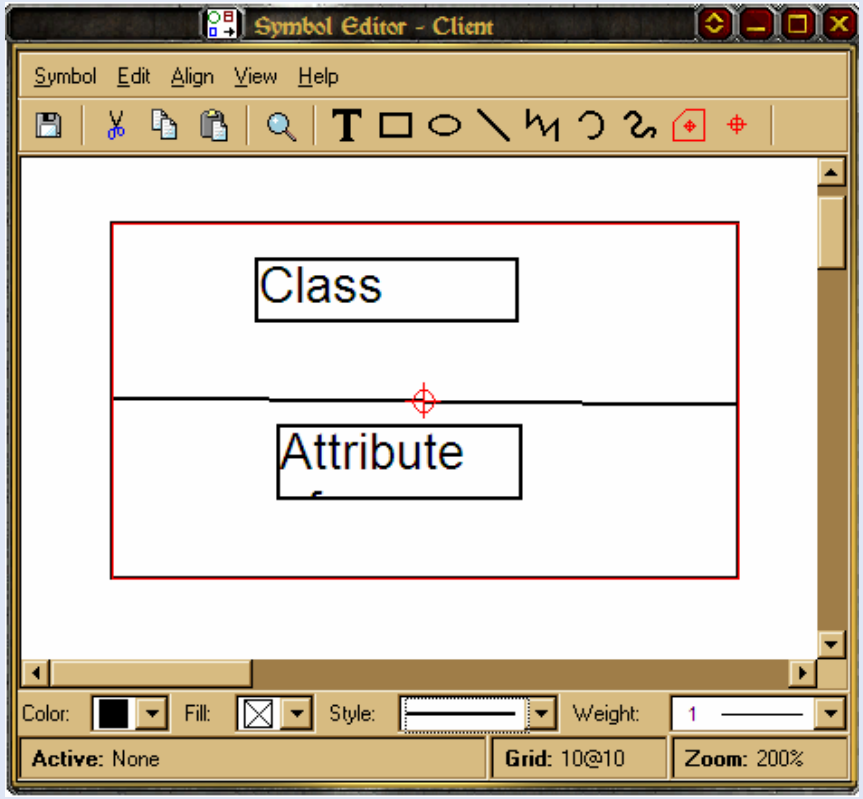


Meta-Edit+ DSL Definition

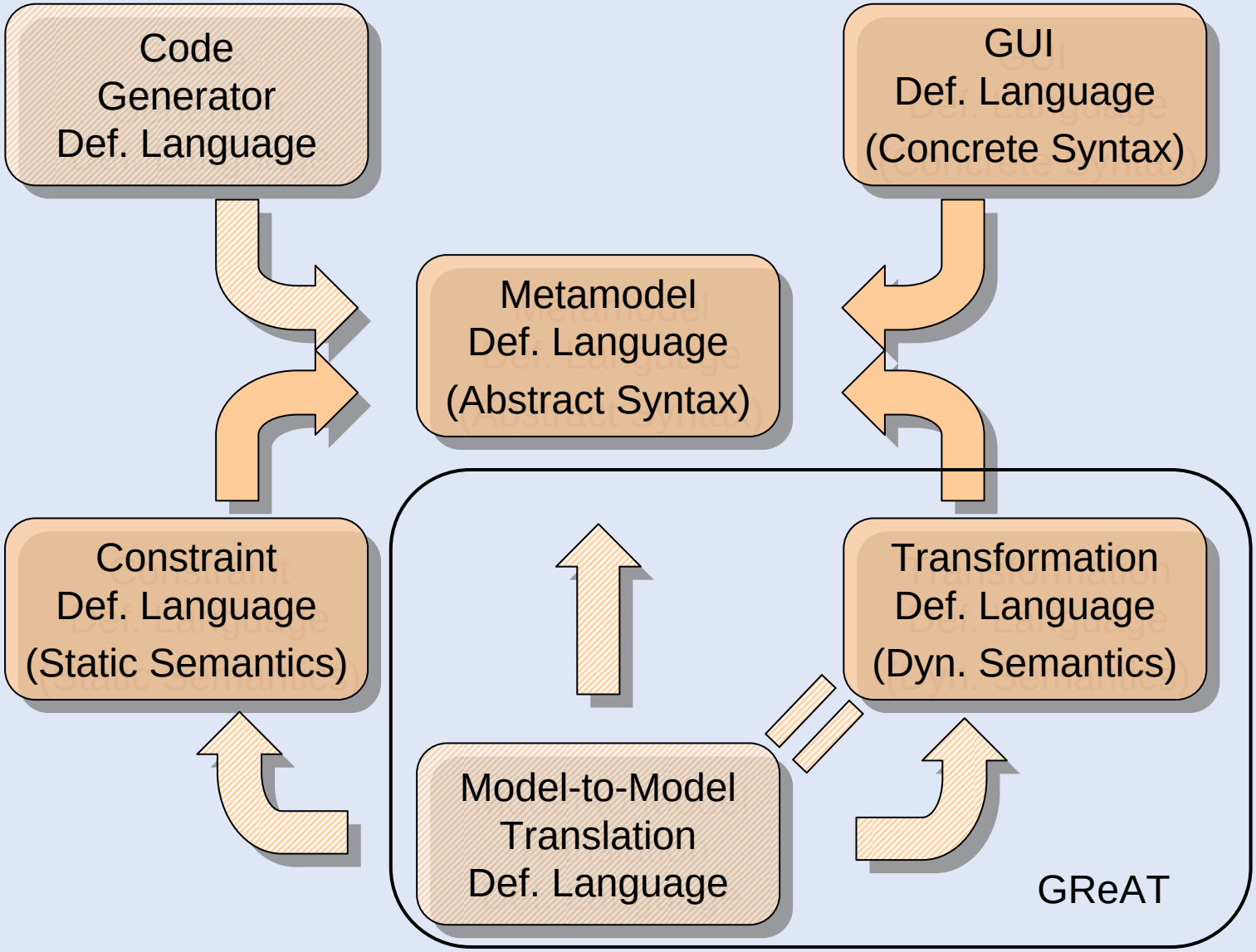
Abstract Syntax Definition



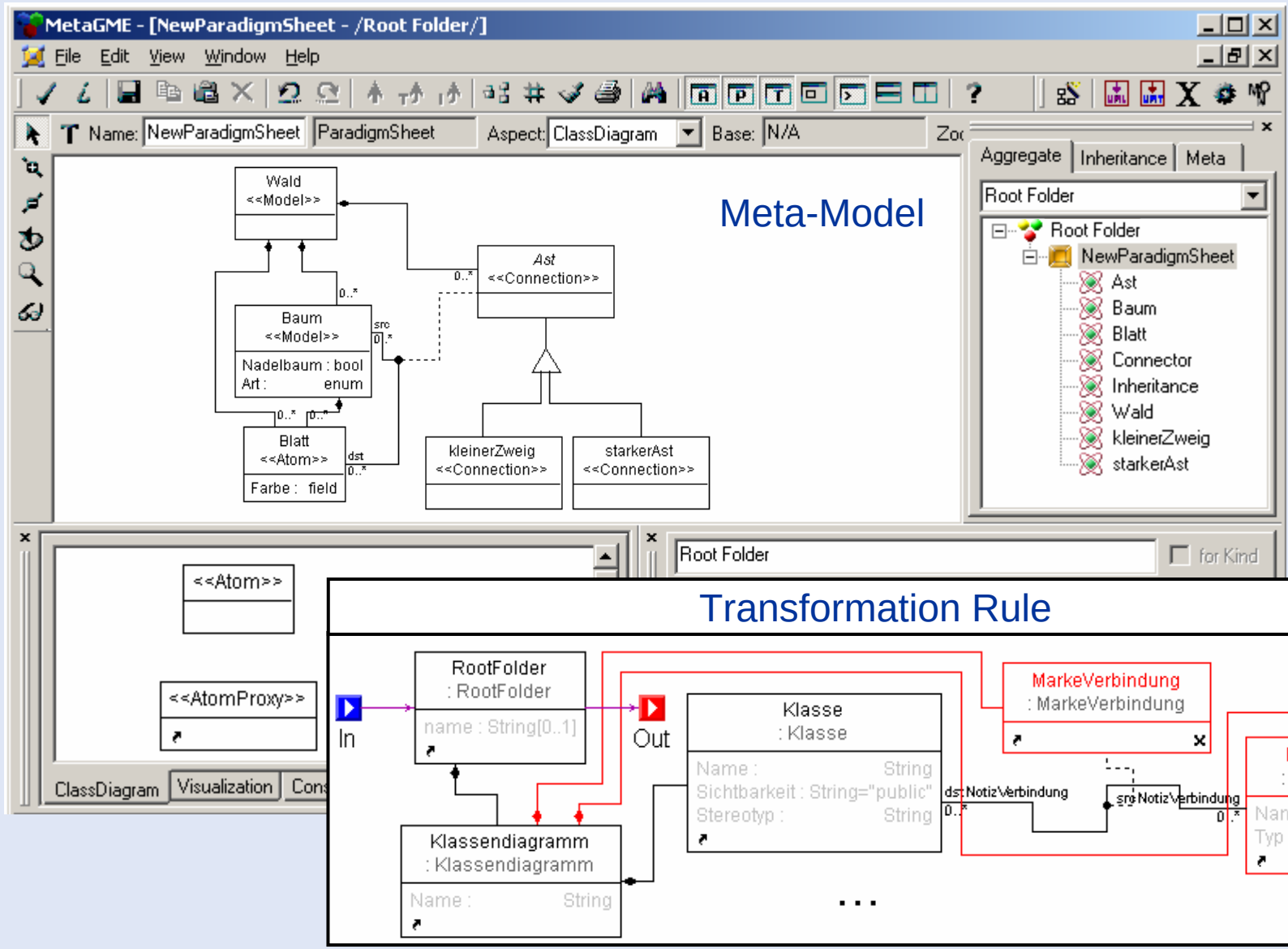
Concrete Representation Definition



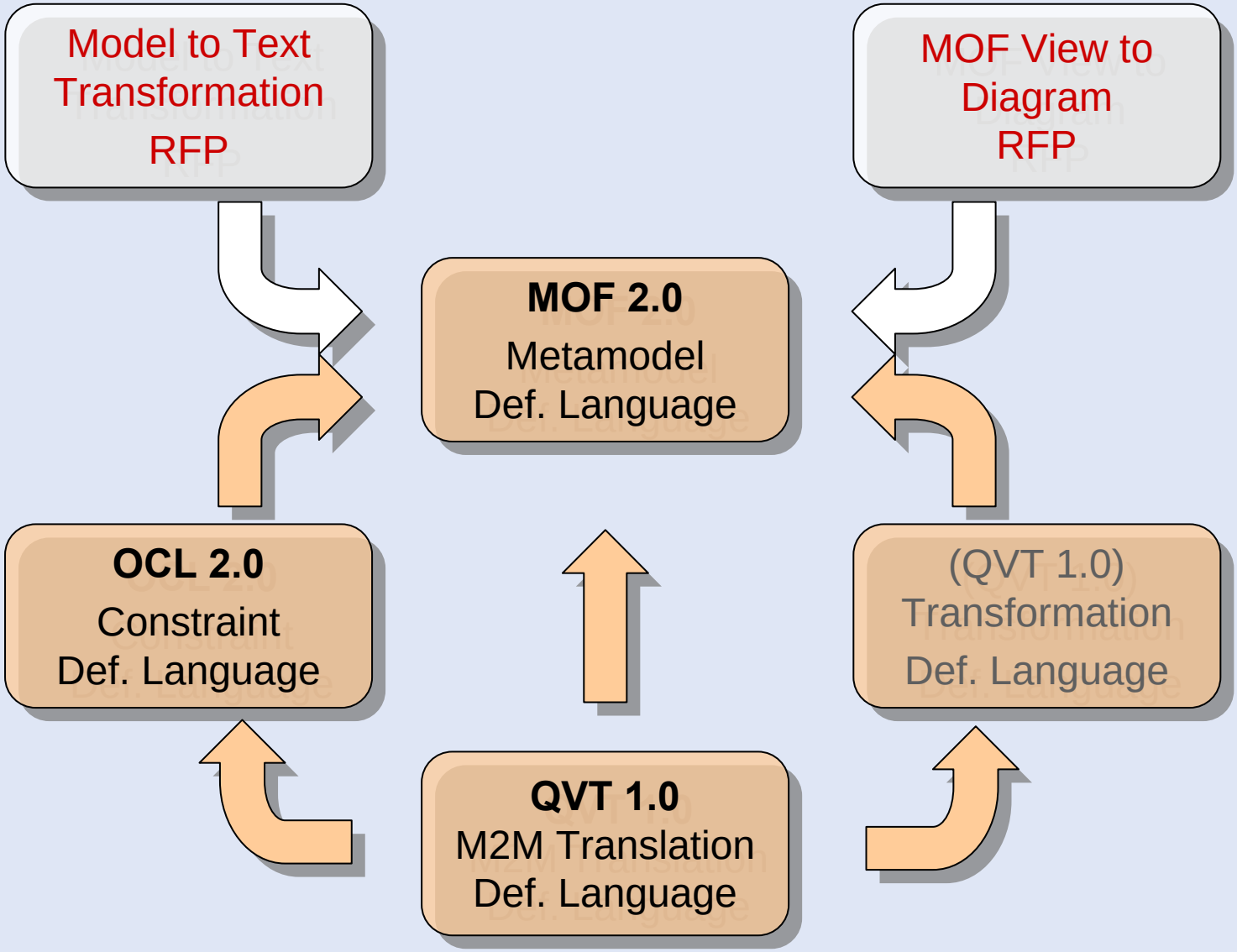
The Meta-CASE Tool GME



GME + GReAT


MetaGME - [NewParadigmSheet - /Root Folder/]
File Edit View Window Help
Name: NewParadigmSheet
ParadigmSheet
Aspect: ClassDiagram
Base: N/A
Meta-Model
Wald
<<Model>>
Ast
<<Connection>>
Baum
<<Model>>
Nadelbaum : bool
Art : enum
Blatt
<<Atom>>
Farbe : field
kleinerZweig
<<Connection>>
starkerAst
<<Connection>>
Aggregate
Inheritance
Meta
Root Folder
NewParadigmSheet
Ast
Baum
Blatt
Connector
Inheritance
Wald
kleinerZweig
starkerAst
<<Atom>>
<<AtomProxy>>
ClassDiagram
Visualization
Root Folder
for Kind
Transformation Rule
RootFolder
: RootFolder
name : String[0..1]
In
Out
Klasse
: Klasse
Name : String
Sichtbarkeit : String="public"
Stereotyp : String
MarkeVerbindung
: MarkeVerbindung
Guard
Marke
: Marke
Name : String
Typ : String
dst:Notiz\Verbindung
src:Notiz\Verbindung
Klassendiagramm
: Klassendiagramm
Name : String

Elements of OMG´s MDA World



MDD / DSL Tools - Summary

	OMG Languages	AMMA (INRIA)	MS DSL (Microsoft)	GME (Vanderbilt)	…	Fujaba (UPB, UKa)
Metamodel Def. Lang.	MOF	KM3	+	GME 5.0		UML 1.x
GUI Def. Lang.	-	-	+	GME 5.0		-
Constraint Def. Lang.	OCL	ATL / OCL	-	-		-
Model Trafo Def. Lang.	QVT[1]	ATL	-	GReAT		SDM
M2M Trans. Def. Lang.	QVT	ATL / AMW[2]	-	GReAT[2]		TGG
Code Gen. Def. Lang.	-	TCS	+	-		Velocity

1: QVT has been designed for model-to-model translation purposes

2: ATL and GReAT are unidirectional model translation languages

„Fujaba Goes to the OMG“

	OMG Languages				…	Fujaba (UPB, UKa)
Metamodel Def. Lang.	MOF					UML 1.x
GUI Def. Lang.	-					???
Constraint Def. Lang.	OCL					-
Model Trafo Def. Lang.	-					SDM
M2M Trans. Def. Lang.	QVT	←	—	—	→	TGG
Code Gen. Def. Lang.	-					Velocity

OMG Standard + Graph Transformation

Velocity, XSLT
Codegenerierung

DiaMeta
Editorgenerierung

University BW Munich

MOF 2.0
Metamodel
Def. Language

University of Techn. Darmstadt

University of Techn. Dresden

OCL 2.0
Constraint
Def. Language

SDM
Fujaba Graph
Transformations

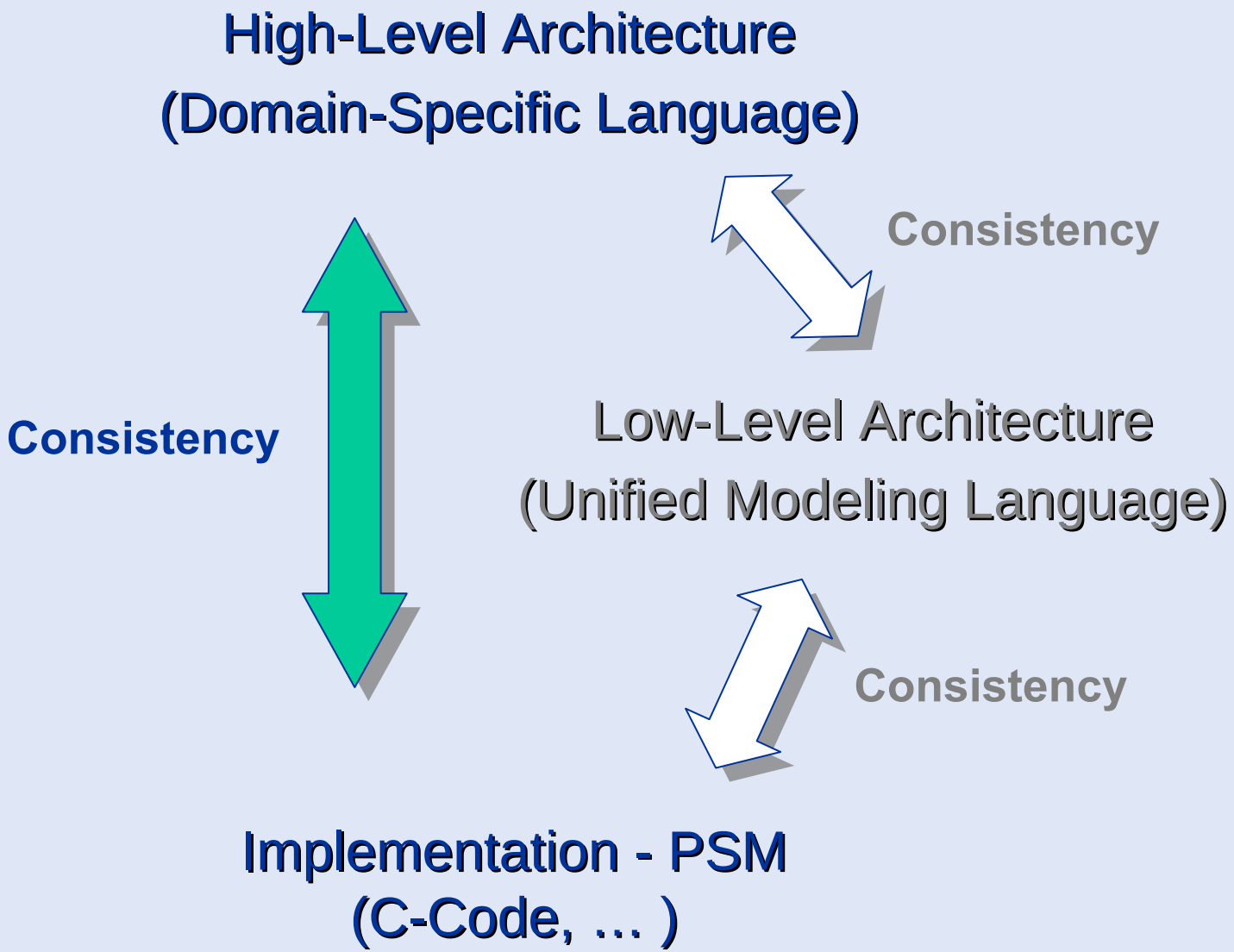
University of Kassel
University of Paderborn

TGG (QVT Subset)
M2M Translation
Def. Language

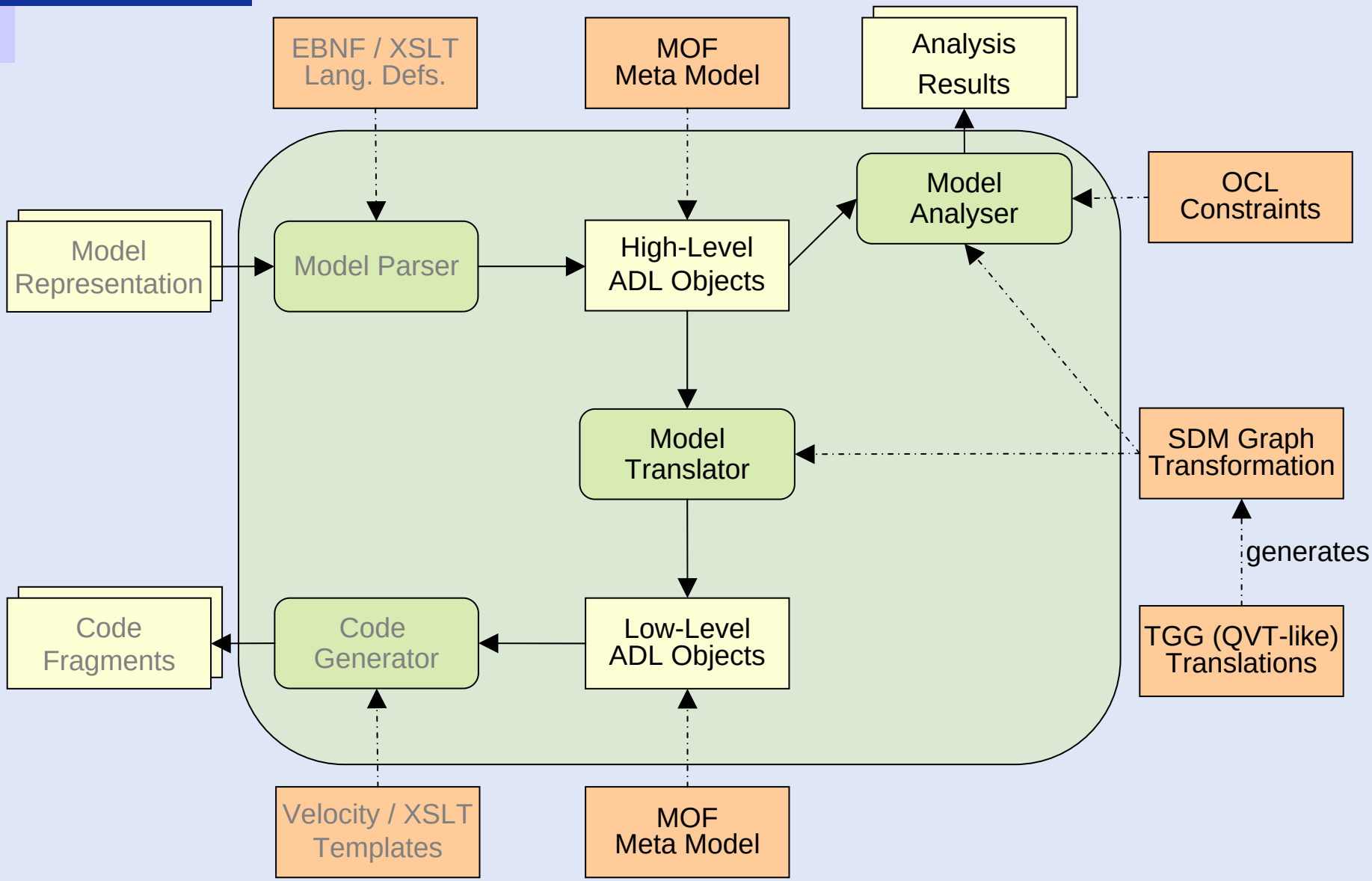
University of Paderborn
University of Techn. Darmstadt

Back to the Running Example

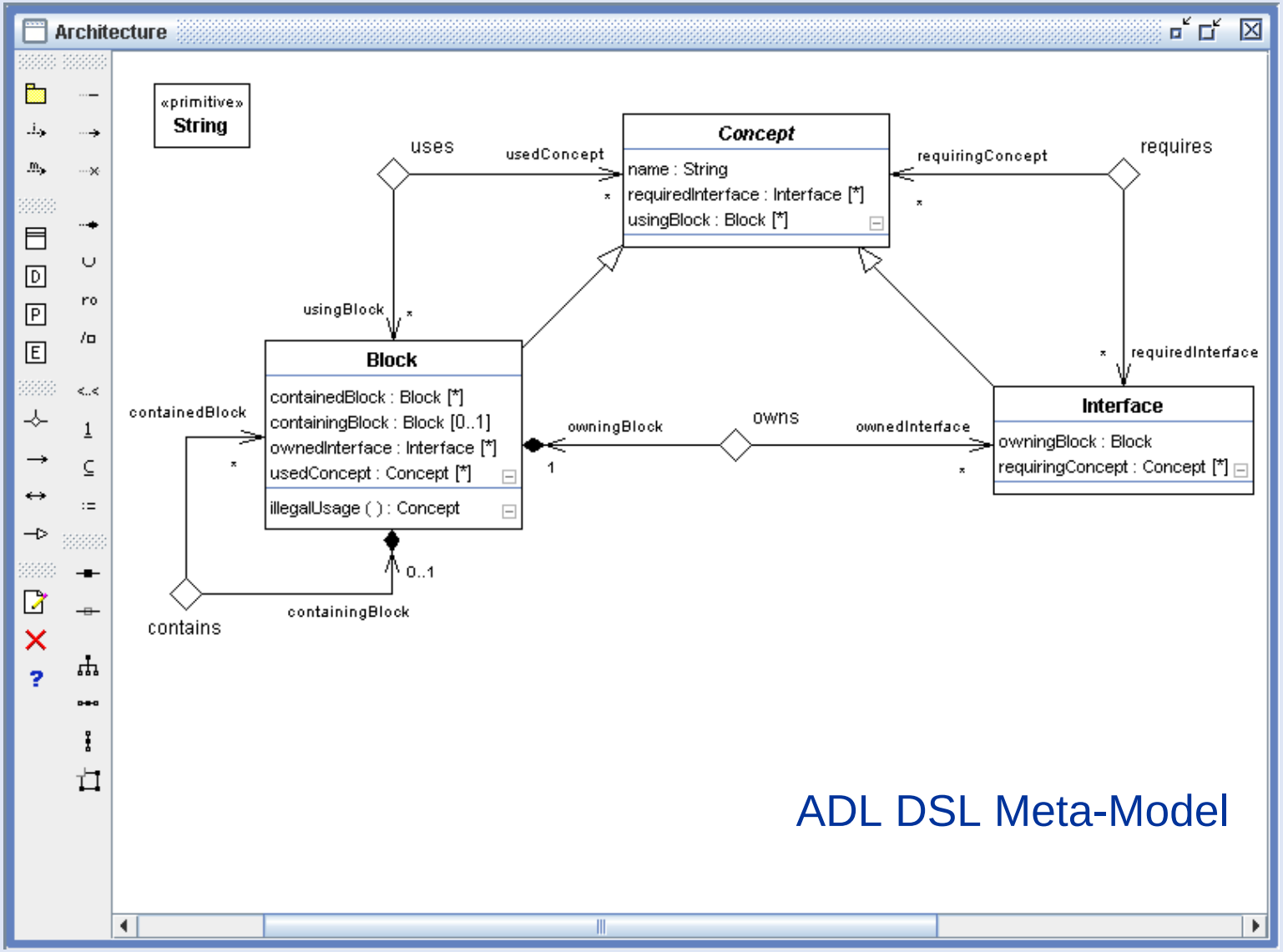
Simplified Running Example



Forward Transformation Scenario

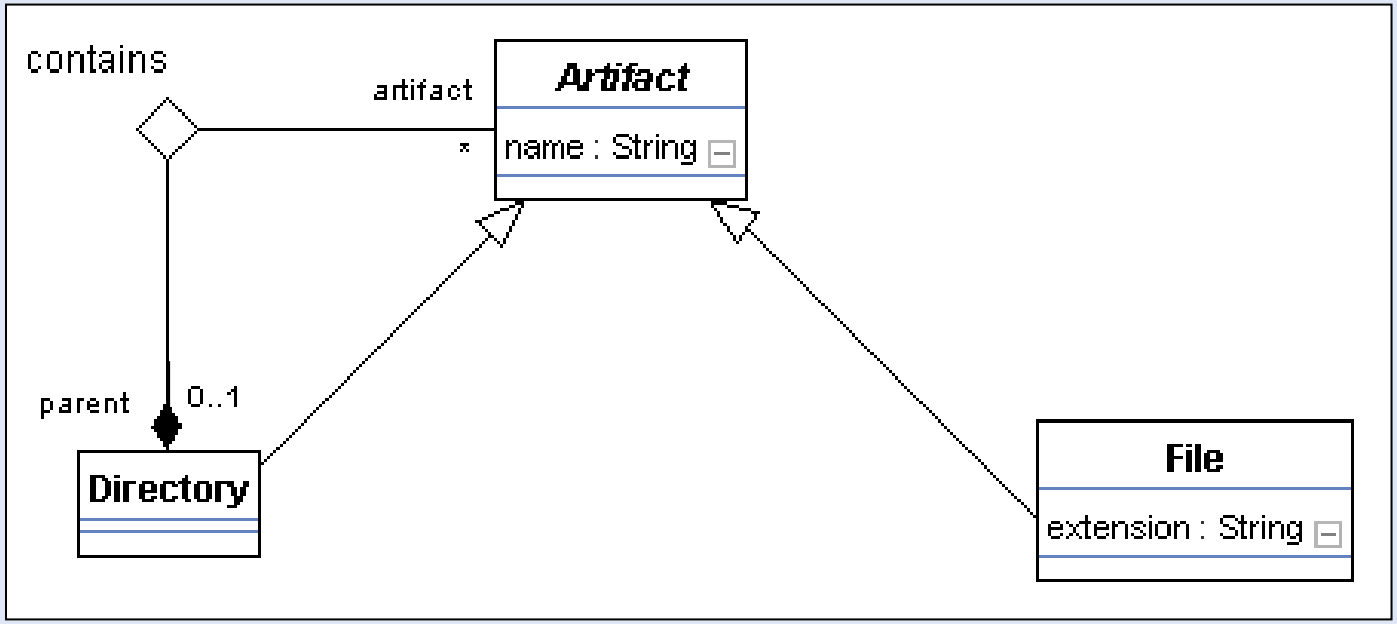


Meta-Modeling with MOF 2.0 - 1



ADL DSL Meta-Model

Implementation Meta-Model



contains association:

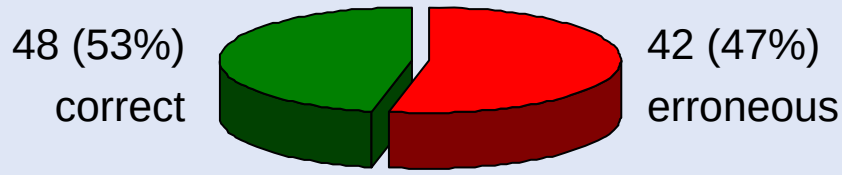
- „heavy-weight“ association (implemented as relation)
- association owns association ends (and not class)
- association ends are not navigable (from classes)
- …

Unique Features of MOF 2.0

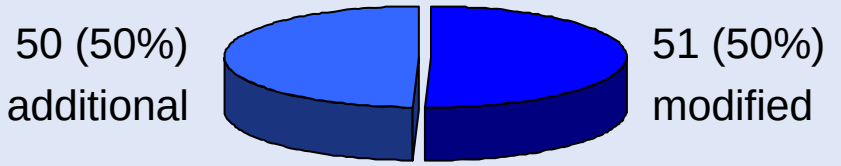
- Different sorts of associations
  - pointers versus real associations
  - navigability (for API method selection)
  - ownership of association ends (for DBMS schemata)
- Excellent support for model refinement
  - class inheritance hierarchies
  - refinement of associations (subset, redefines, …)
  - refinement of packages
- Powerful modularization concepts
  - hierarchies of packages
  - import/export relationships
  - merging of packages

Static Semantics of MOF 2.0

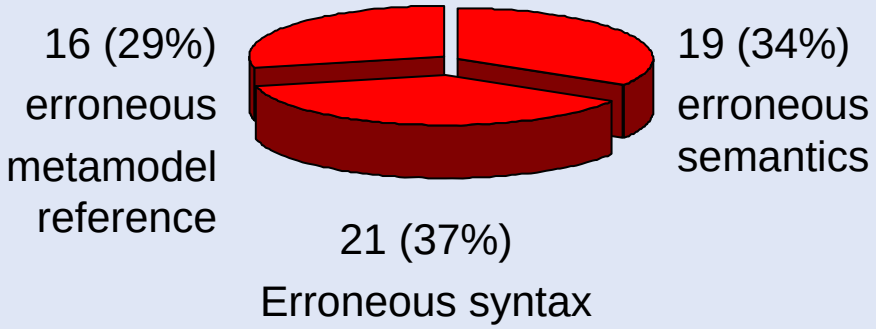
From 90 MOF constraints are



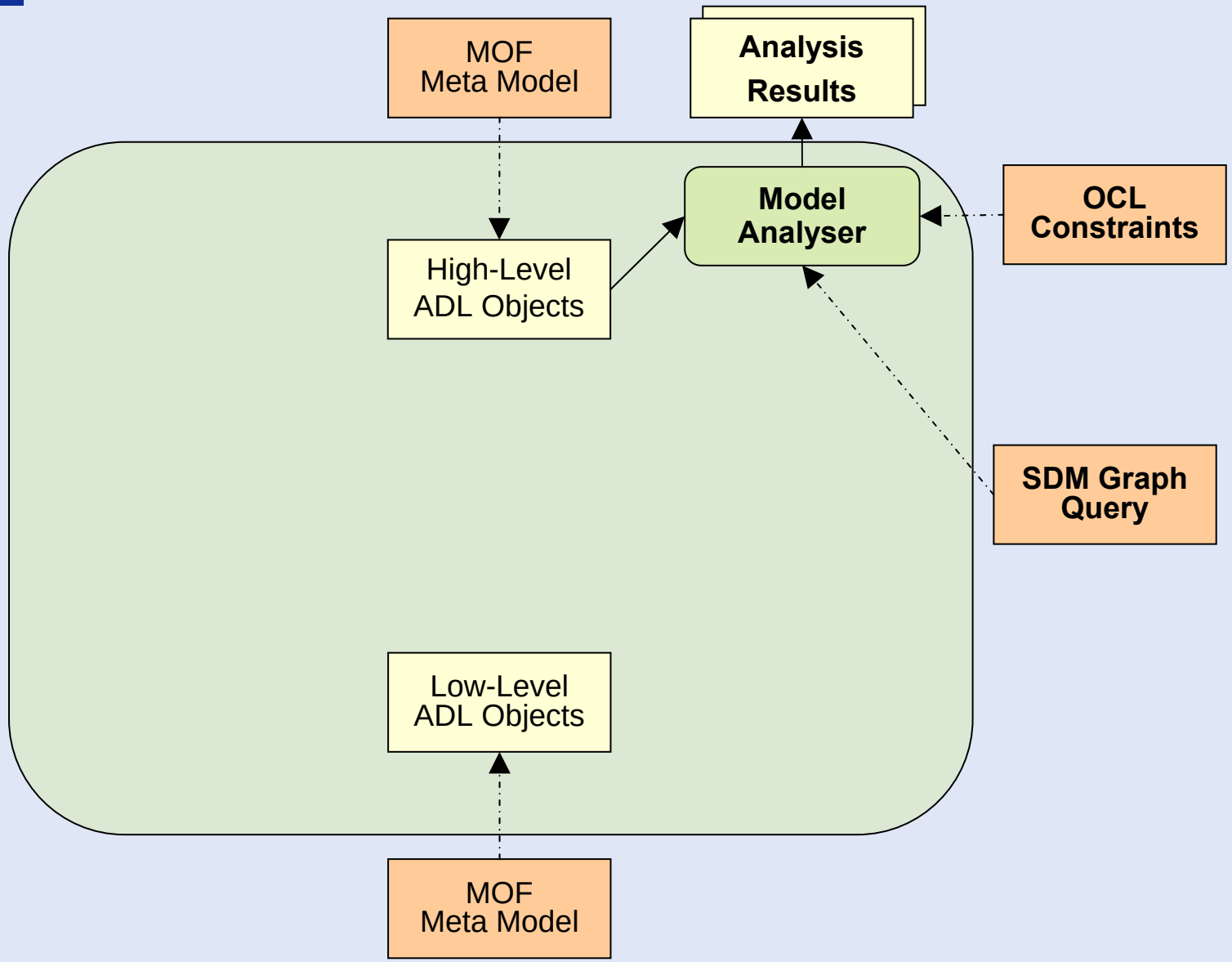
We added 86 constraints



Reasons for 51 bug fixes are

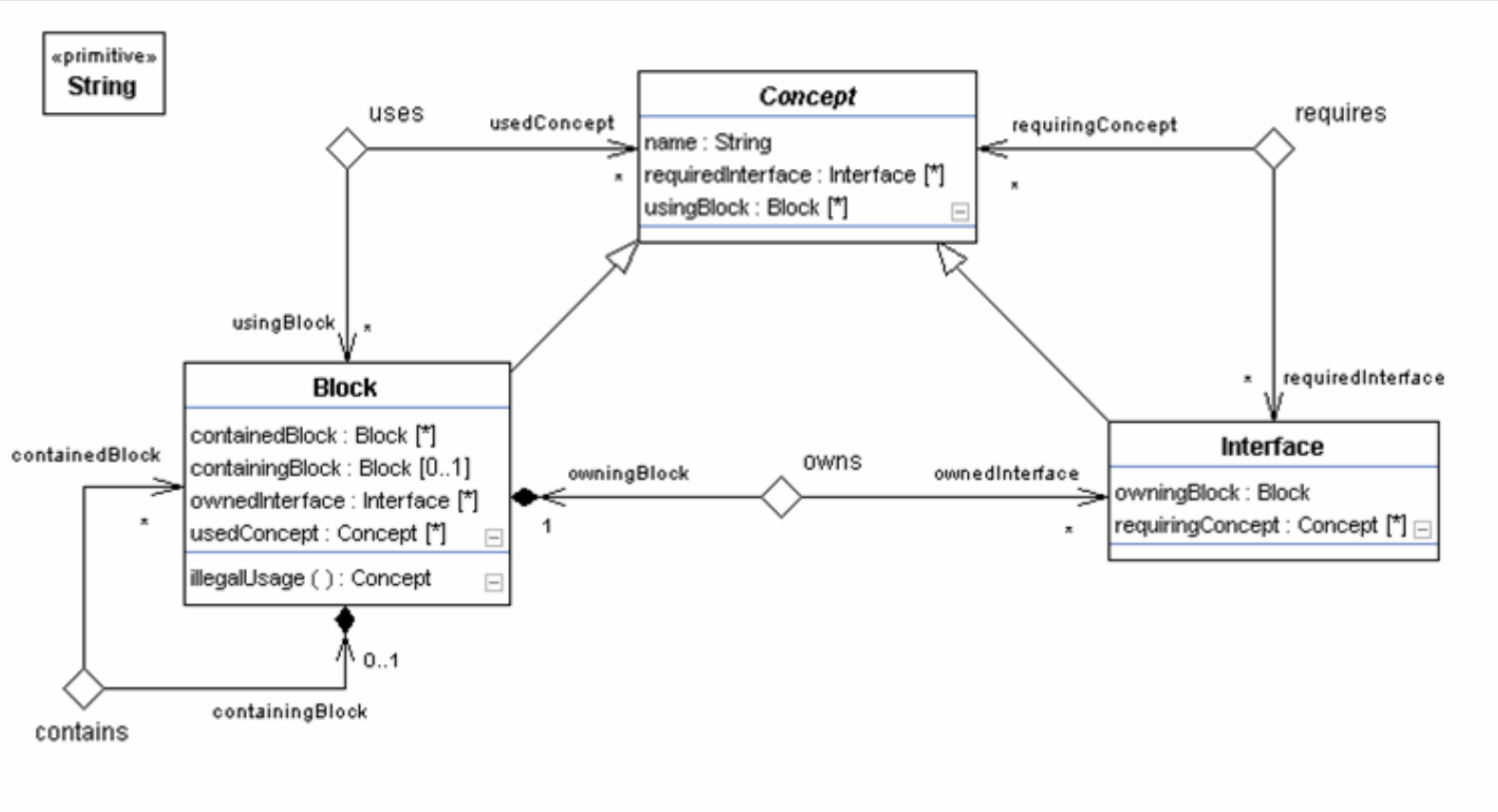


Forward Transformation Scenario

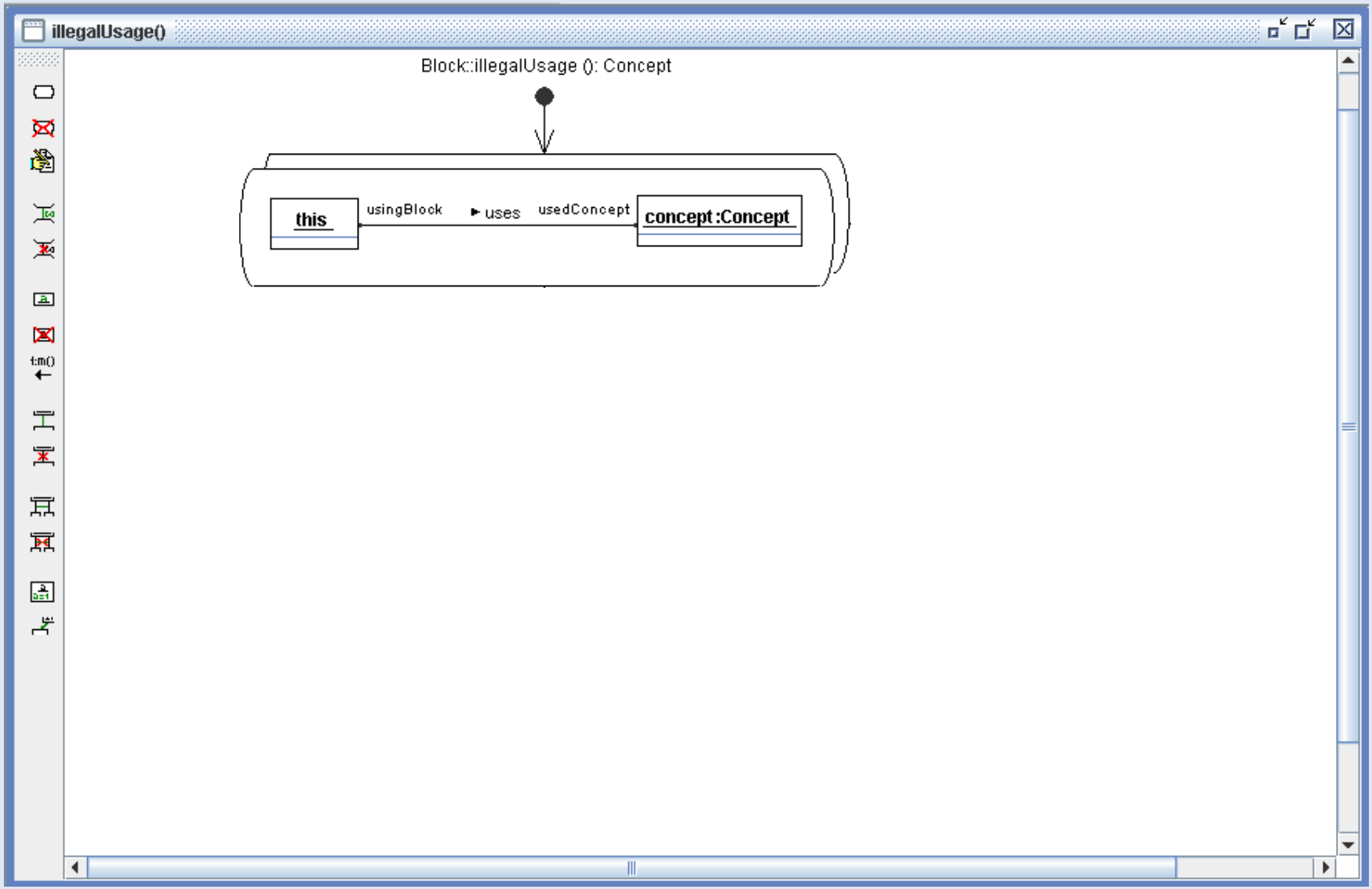


Consistency rules for ADL

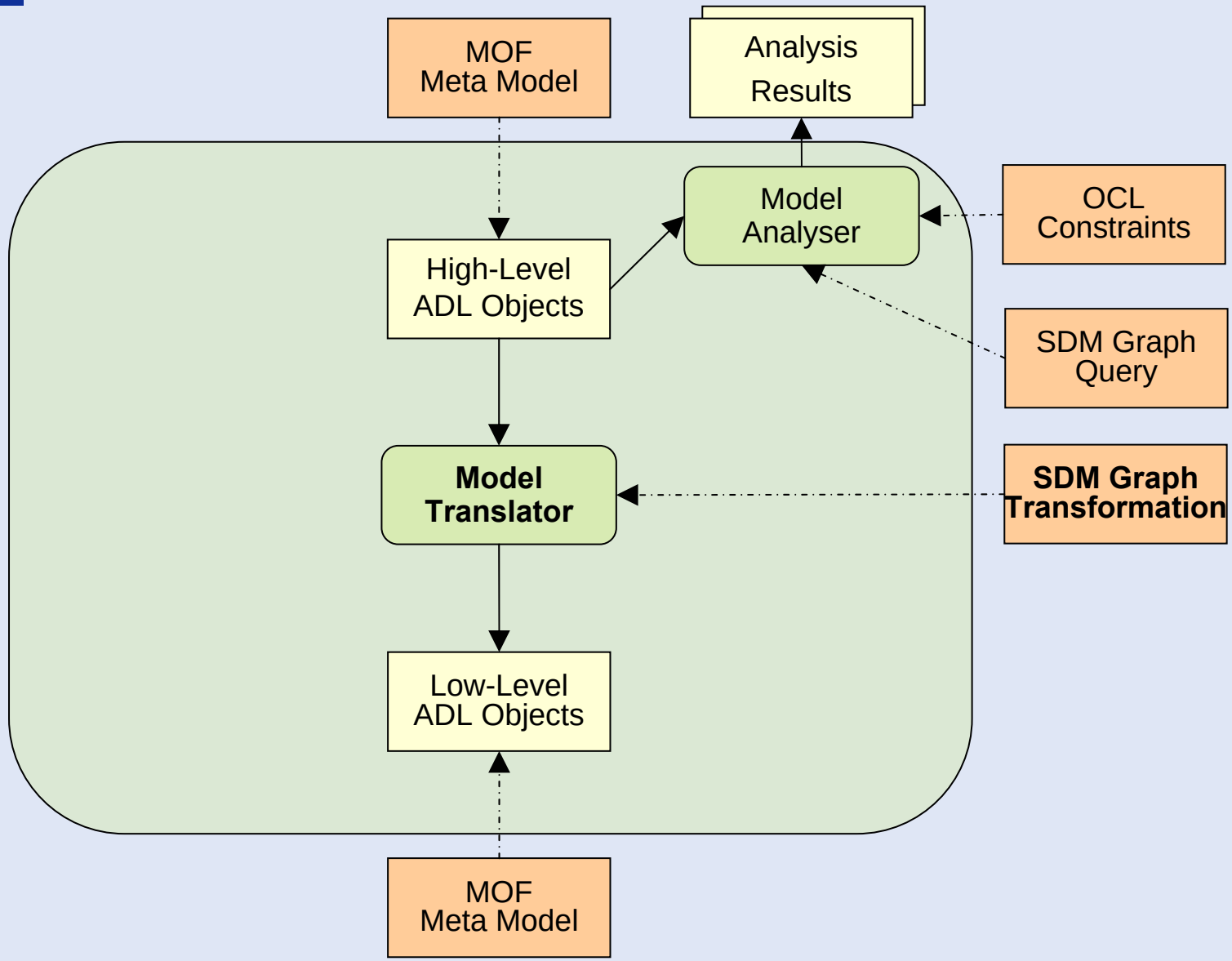
- A block uses interfaces that are required interfaces
- A block uses blocks that own required interfaces



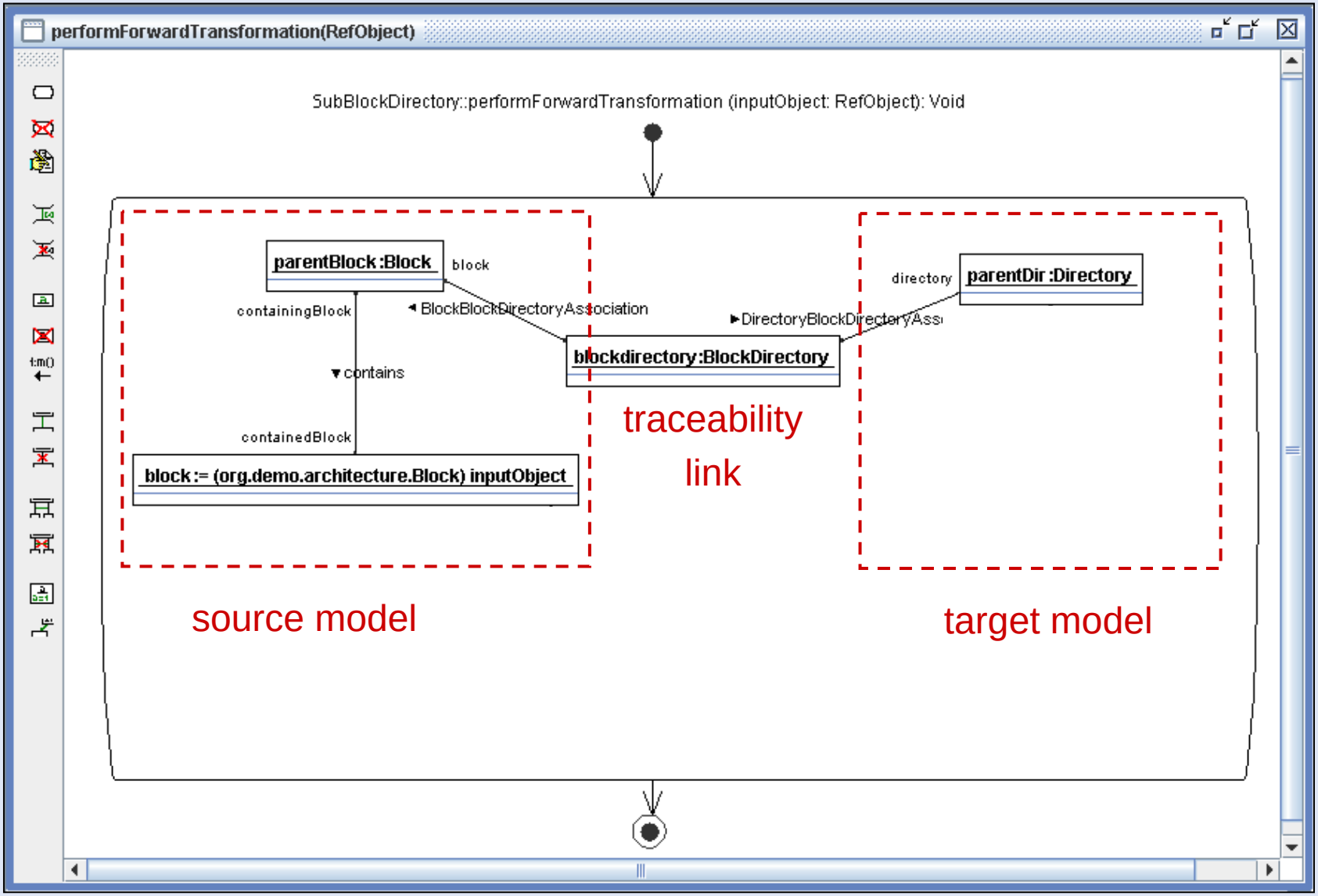
Constraint Definition with Graph Query



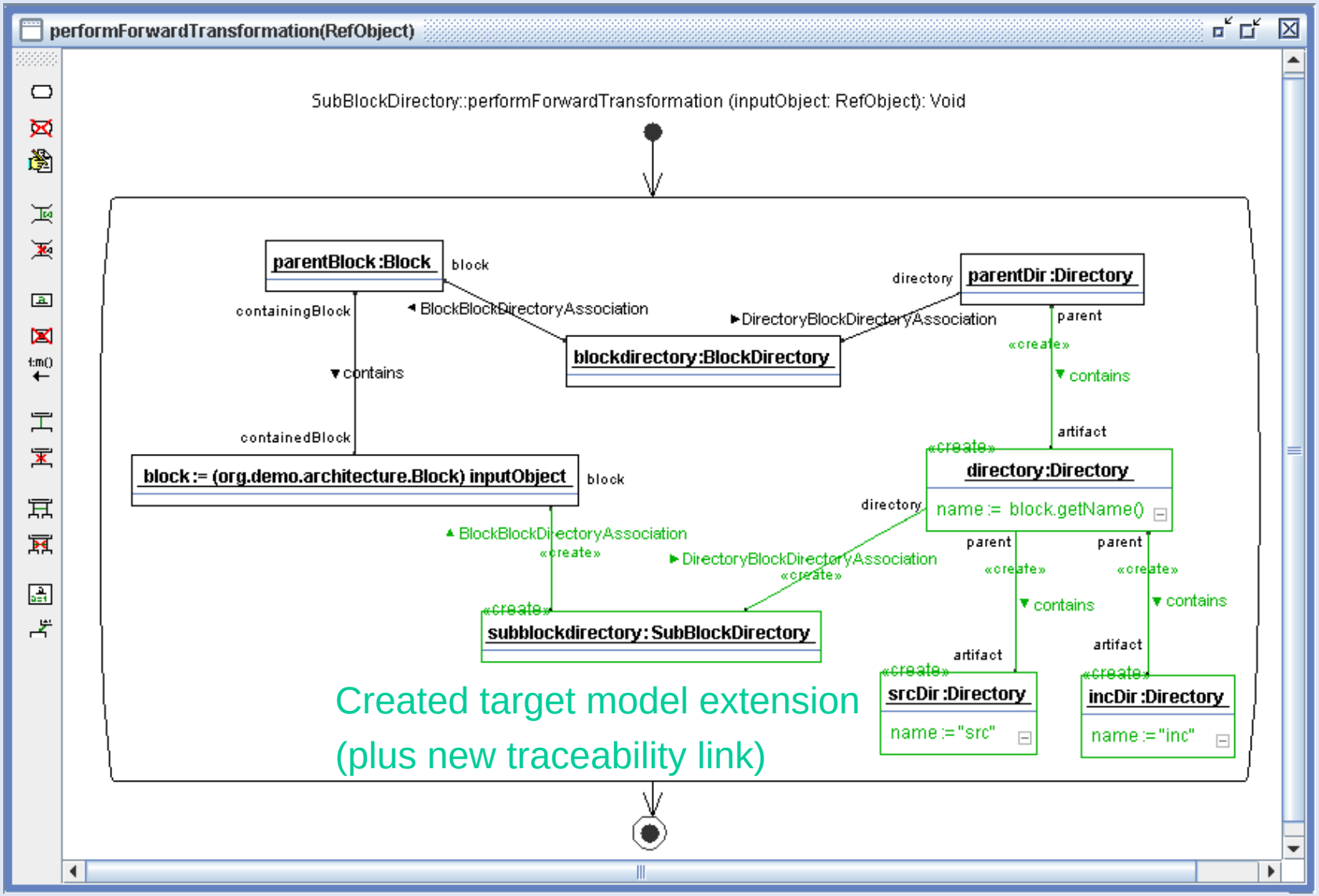
Forward Transformation Scenario



Forward Transformation - Context



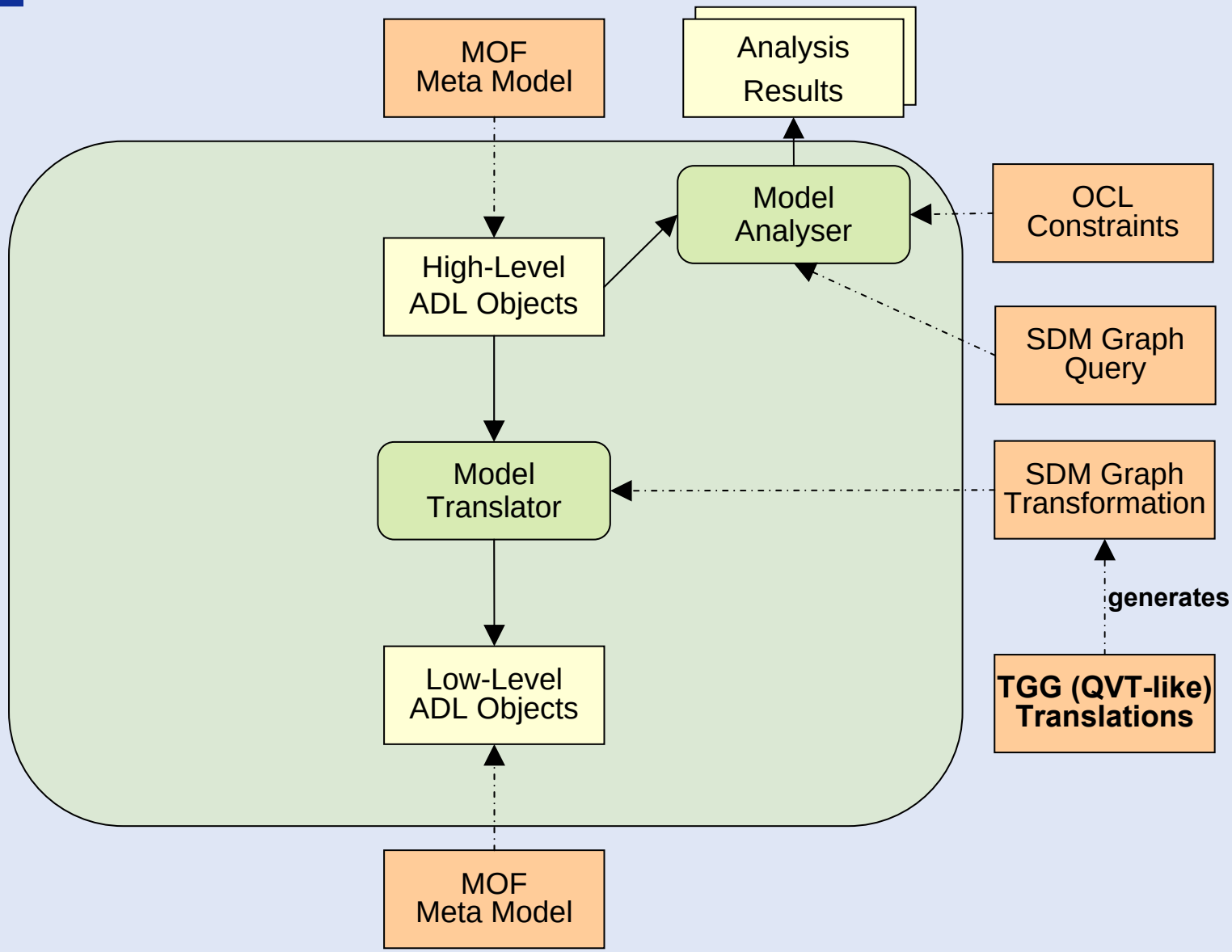
Forward Transformation - Complete



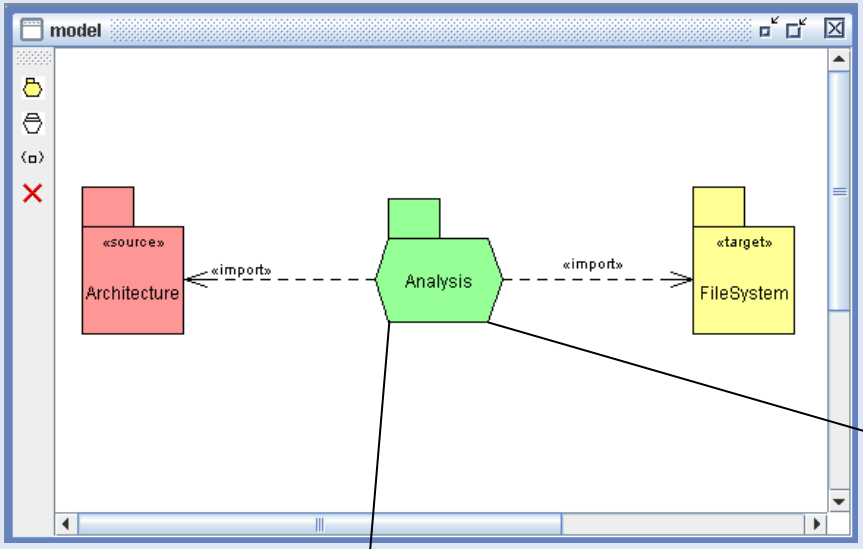
Generating Operational Rules

- Needed model transformation rule sets:
  - forward transformation
  - backward transformation
  - create traceability links only
  - check traceability link consistency
  - forward/backward attribute propagation
  - remove traceability links
  - forward/backward deletion propagation
  - …
- Generate all transformation rule sets from single declarative bidirectional model integration rules
  - QVT core/relational = Triple Graph Grammars (TGG)

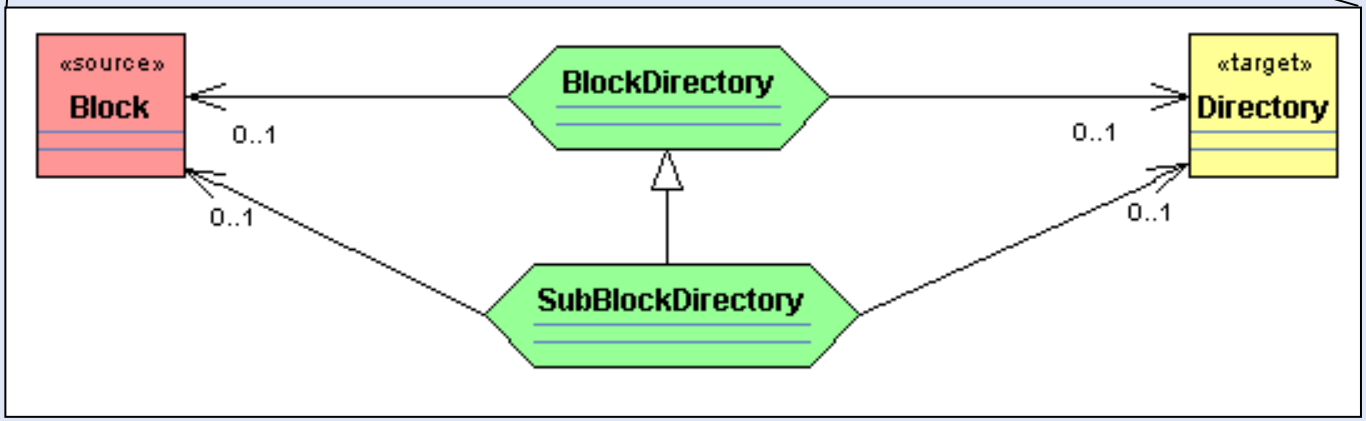
Forward Transformation Scenario



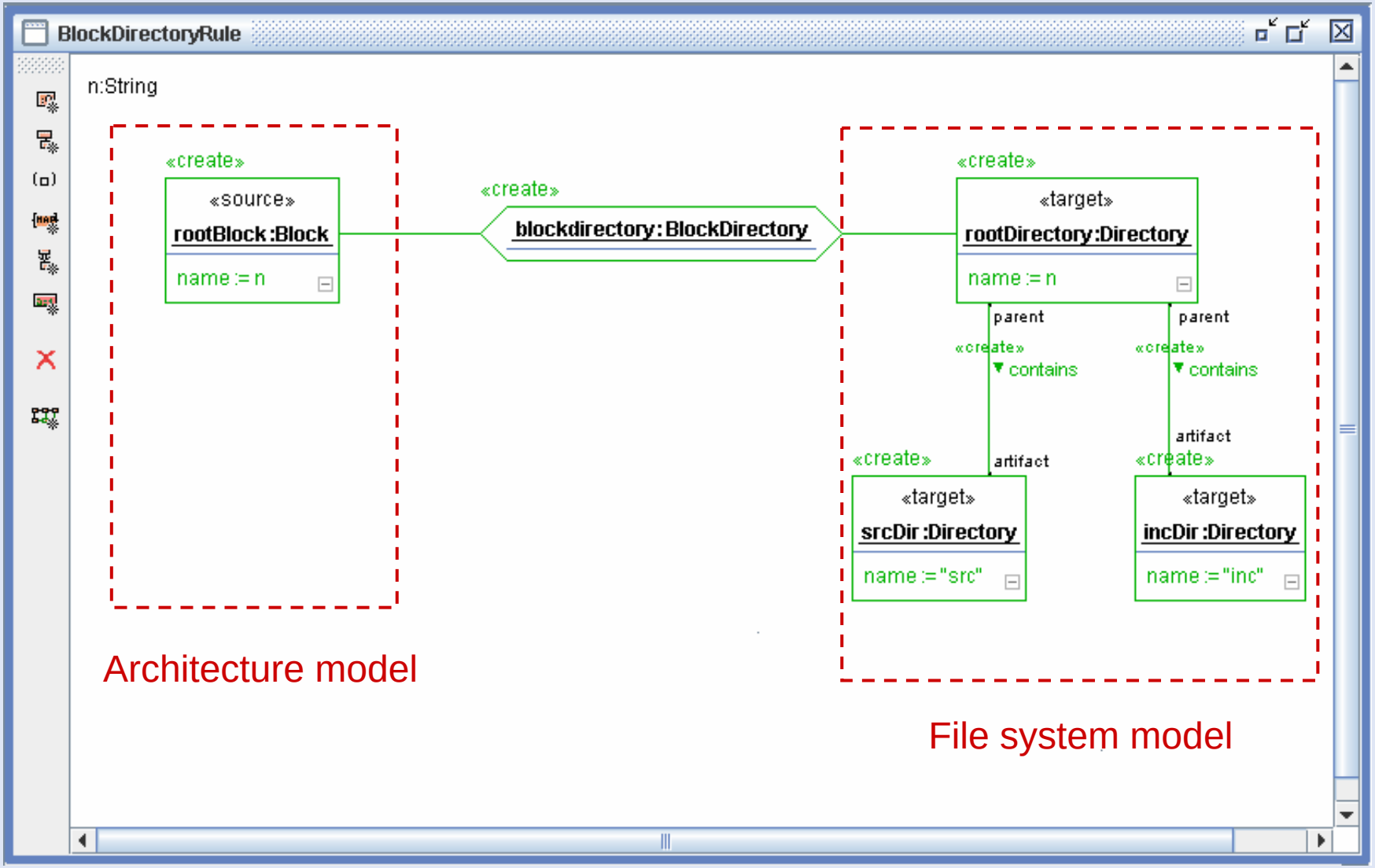
TGG (QVT-like) Specification



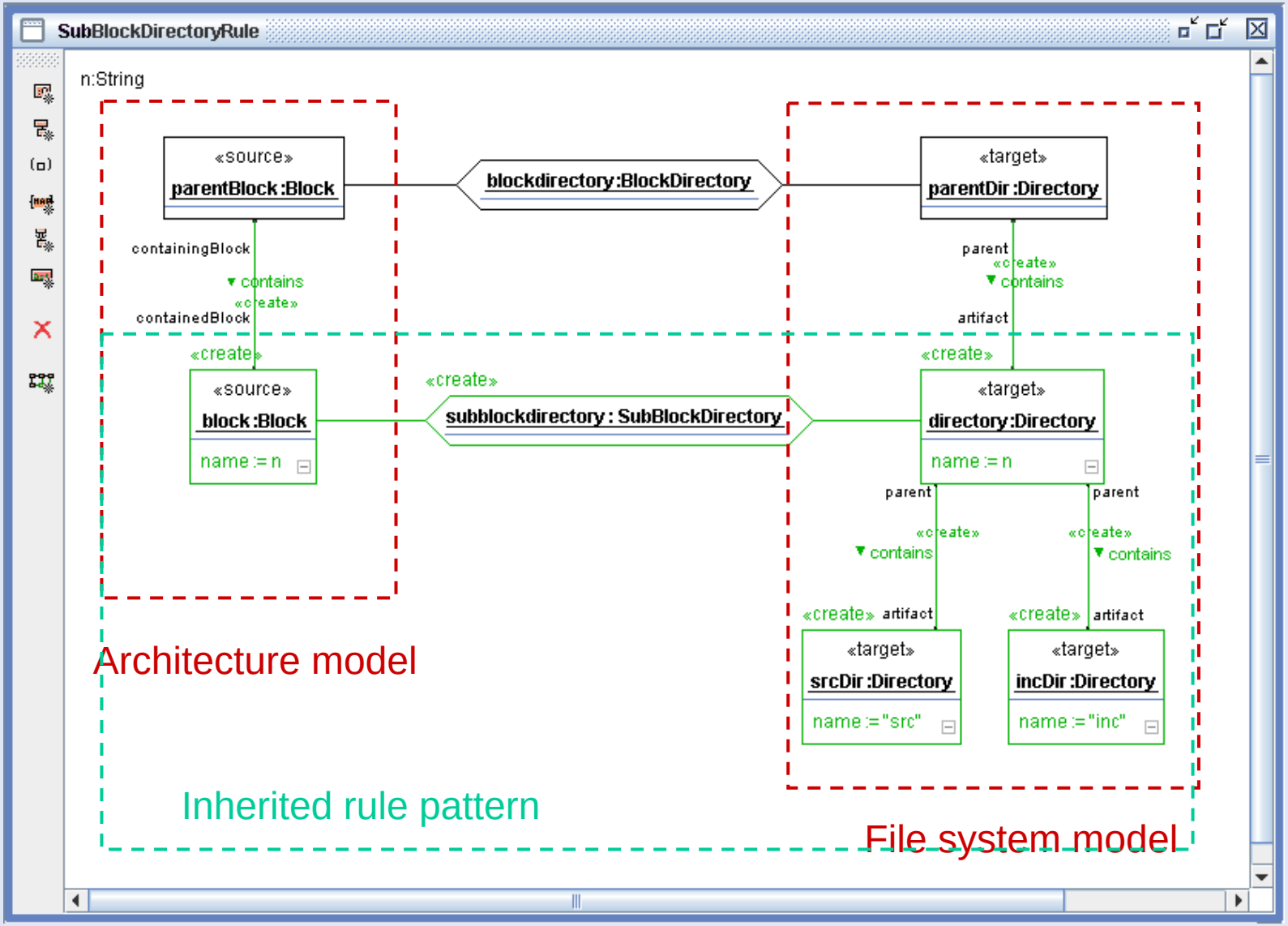
Declaration of
Traceability Relationships
(Mappings) with associated
bidirectional translation rules



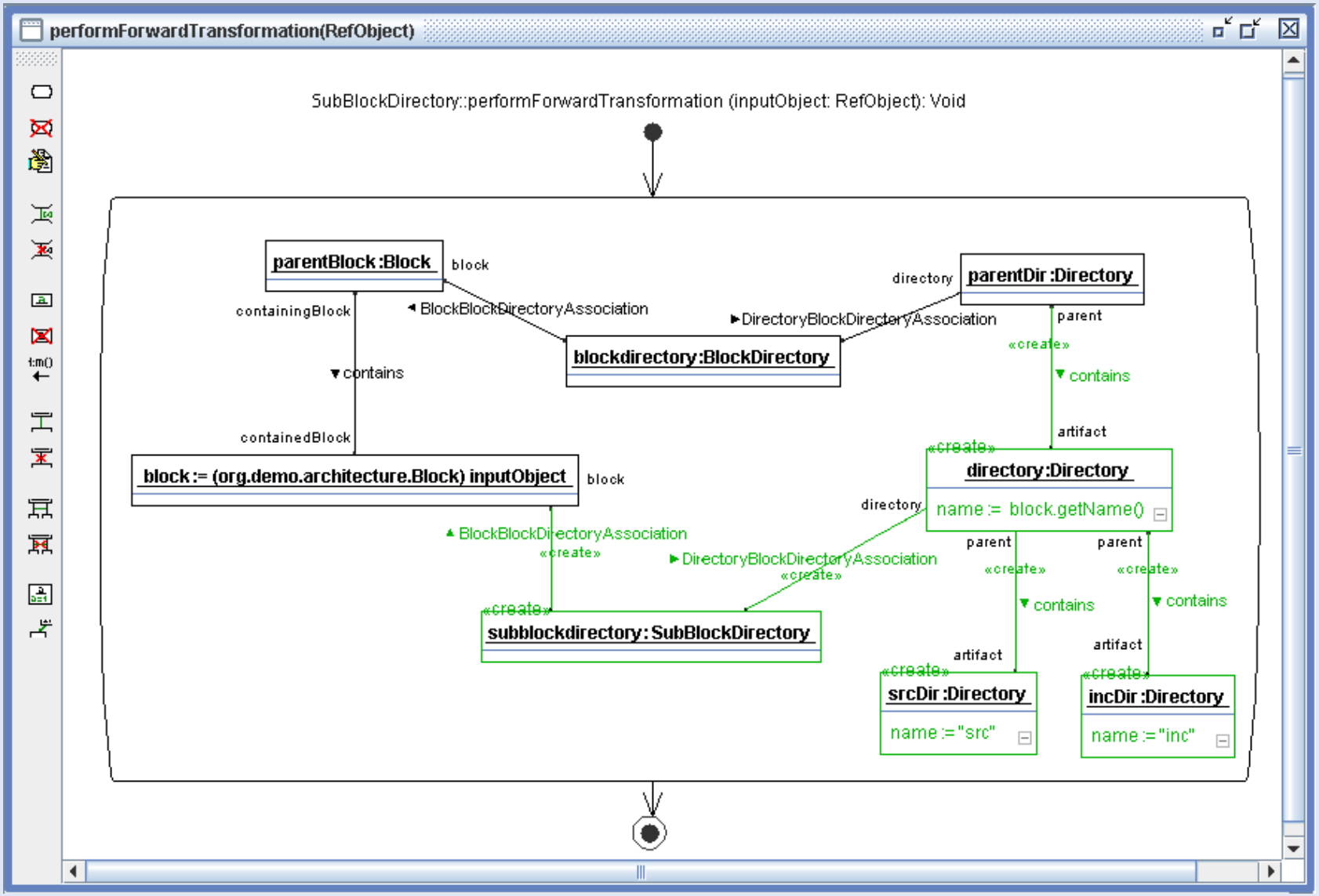
TGG (QVT-like) Rule for Blocks



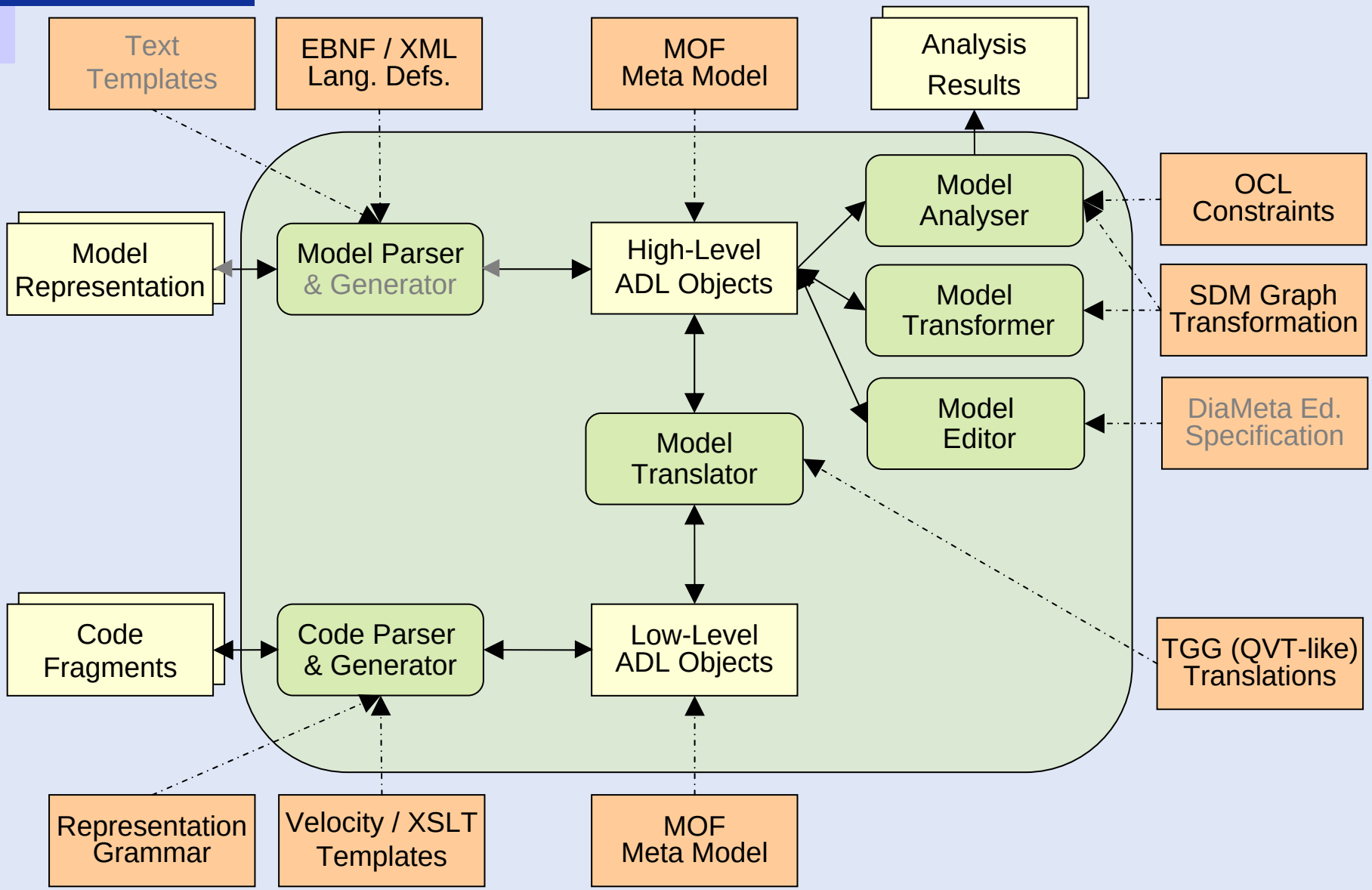
TGG (QVT-like) Rule for Subblocks



Generated Forward Transformation



Summary of MOFLON MDD World



Conclusions

… and Back Again to MDD

- Model-Driven Development (MDD) is a “hot topic” of the Software Engineering Community
  - with all the resulting pros and cons
  - …
- MDD combines established technology
  - meta-modeling / meta-case tool technology
  - compiler compiler technology
  - …
- Currently available (commercial / academic) MDD tools
  - support only subsets of all MDD activities
  - lack precise definition (available for graph transformations)
  - …

OMG Standard + Graph Transformation

Velocity, XSLT
Codegenerierung

DiaMeta
Editorgenerierung

University BW Munich

MOF 2.0
Metamodel
Def. Language

University of Technoloy Darmstadt

University of Technology Dresden

OCL 2.0
Constraint
Def. Language

SDM
Fujaba Graph
Transformations

University of Kassel
University of Paderborn

TGG (QVT Subset)
M2M Translation
Def. Language

University of Paderborn
University of Technology Darmstadt

Typical MOFLON Applications

- system engineering tool integration

  (ToolNet project with DaimlerChrysler et al.)
- model analysis / design guideline checking

  (MATE project with DaimlerChrysler et al.)
- software analysis / reverse engineering

  (based on experiences at Philips Medical Research)
- visual DSL editor development

  (ECLIPSE plug-ins in cooperation with UniBw)
- …

Open Problems & Ongoing Work

- Metamodeling with MOF 2.0
  - missing UML concepts (association classes)
  - integration with UML profile definition
- Constraint Definition with OCL 2.0
  - incremental (event-driven) constraint checking
  - integration with transactions & repair actions
- Local Model Transformations with SDM
  - handling of composition hierarchies (still a problem!)
  - integrated formal definition of language mix
- Model To Model Transformations with TGGs
  - merging TGGs with QVT Relational
  - …
- Integration with Editor Generator Framework DIAMETA

Model-Driven Development with OMG Standards Graph Transformations

Version 1.0
(Queen)

Questions?

Download/Feedback: http://www.moflon.org/