From Model-Driven Development to Graph Transformations and Back Again

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SegraVis Advanced Summer School
8th – 11th September 2006
Leicester, UK

OR:

MOF LON = MOF Meta-Object Facility + FUJABA Tool Suite

OR:

„Smuggling“ (Fujaba‘s) Graph Transformations into the World of OMG Standards

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OR:

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Outline of Presentation

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- 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

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OMG´s Model Driven Architecture

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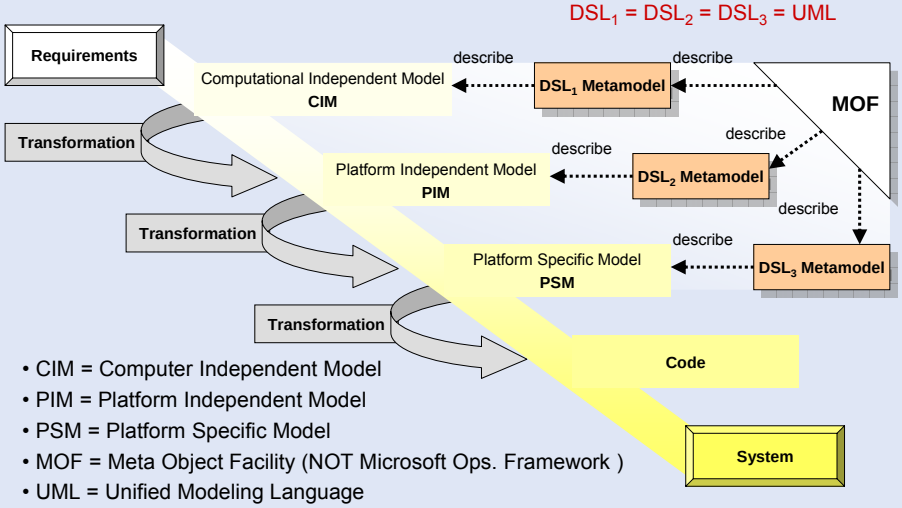
OMG often recommends:
$DSL_1 = DSL_2 = DSL_3 = UML$



- CIM = Computer Independent Model
- PIM = Platform Independent Model
- PSM = Platform Specific Model
- MOF = Meta Object Facility (NOT Microsoft Ops. Framework)
- UML = Unified Modeling Language
- DSL = Domain-Specific Language

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OMG´s Model Driven Architecture

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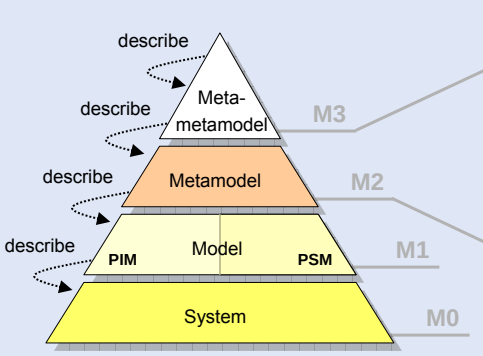
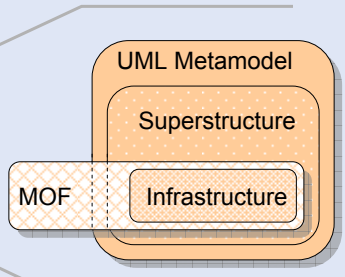


(Meta-)Modeling Levels



Infrastructure = UML ∩ MOF

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Real Model-Driven Development Scenario

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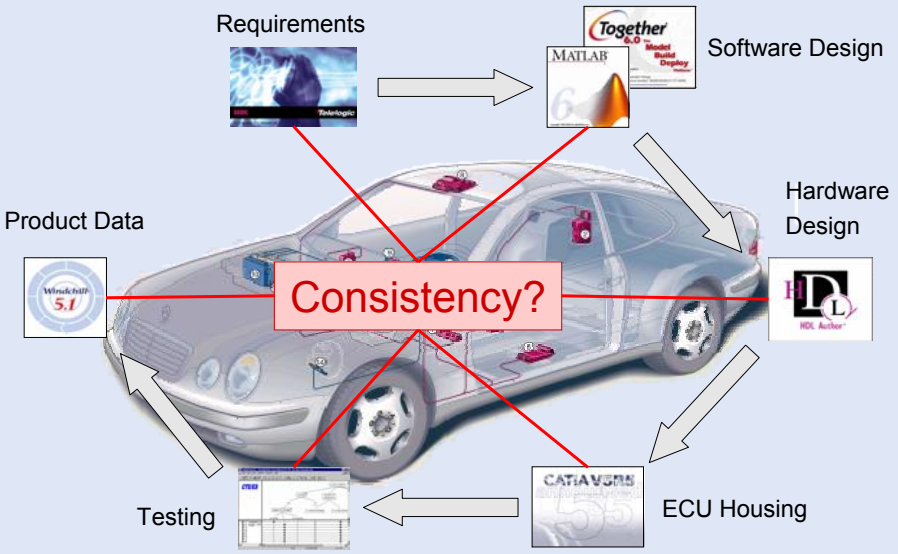

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Model-Driven Development Requirements

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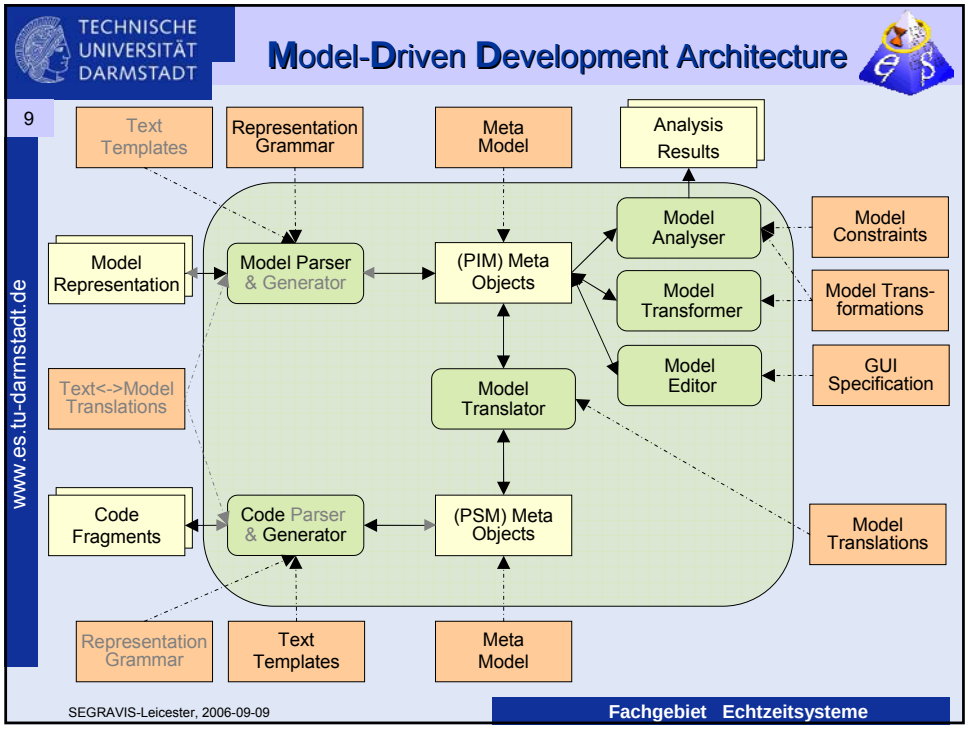
Rapid Development (generating) of

- Tool wrappers for „COTS“ tools
- New tools for domain-specific languages
- Local model analysis/transformation support
- Inter-model consistency checking / change propagation
- Traceability link management support
- Bidirectional model update propagation
- Data import / export (code generators, parser, …)
- Integrated model version management
- …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Model-Driven Development Architecture
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Text Templates
Representation Grammar
Meta Model
Analysis Results
Model Representation
Model Parser & Generator
(PIM) Meta Objects
Model Analyser
Model Transformer
Model Editor
Model Constraints
Model Trans-formations
GUI Specification
Text<->Model Translations
Model Translator
Code Fragments
Code Parser & Generator
(PSM) Meta Objects
Model Translations
Representation Grammar
Text Templates
Meta Model
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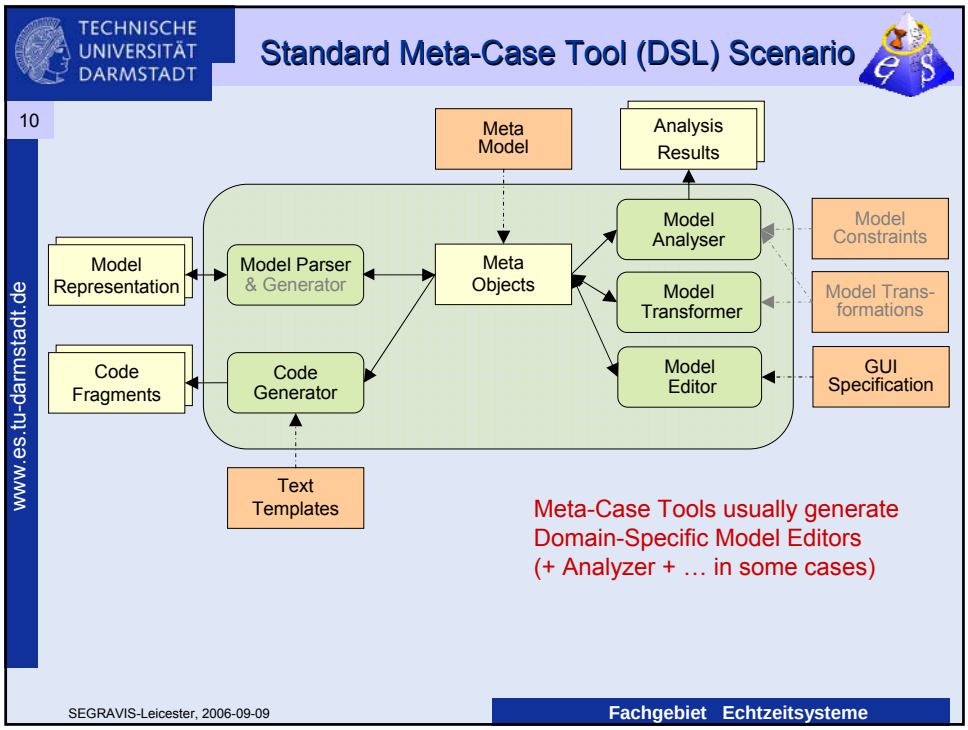
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Standard Meta-Case Tool (DSL) Scenario
10
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Meta Model
Analysis Results
Model Representation
Model Parser & Generator
Meta Objects
Model Analyser
Model Transformer
Model Editor
Model Constraints
Model Trans-formations
GUI Specification
Code Fragments
Code Generator
Text Templates
Meta-Case Tools usually generate
Domain-Specific Model Editors
(+ Analyzer + … in some cases)
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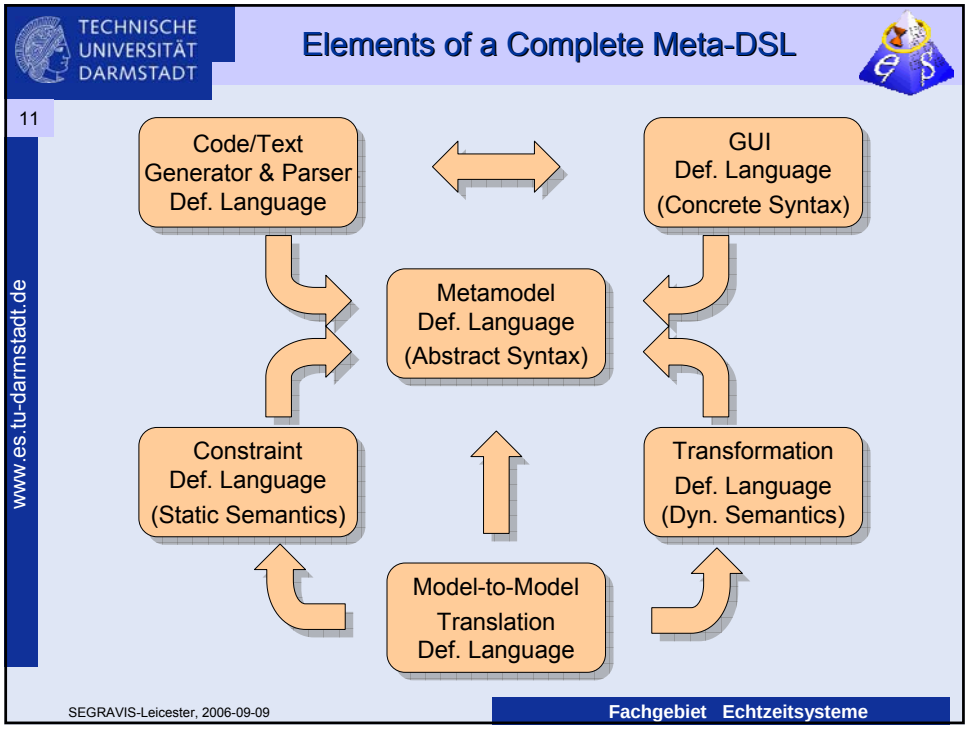
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Elements of a Complete Meta-DSL
11
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Code/Text Generator & Parser Def. Language
GUI Def. Language (Concrete Syntax)
Metamodel Def. Language (Abstract Syntax)
Constraint Def. Language (Static Semantics)
Transformation Def. Language (Dyn. Semantics)
Model-to-Model Translation Def. Language
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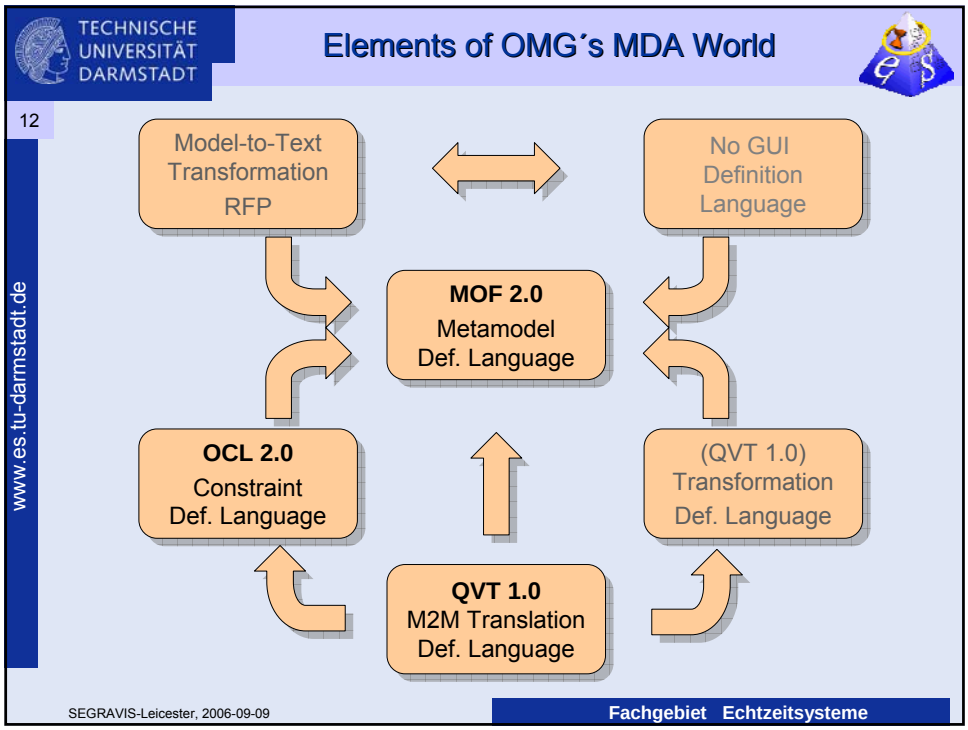
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Elements of OMG´s MDA World
12
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Model-to-Text Transformation RFP
No GUI Definition Language
MOF 2.0 Metamodel Def. Language
OCL 2.0 Constraint Def. Language
(QVT 1.0) Transformation Def. Language
QVT 1.0 M2M Translation Def. Language
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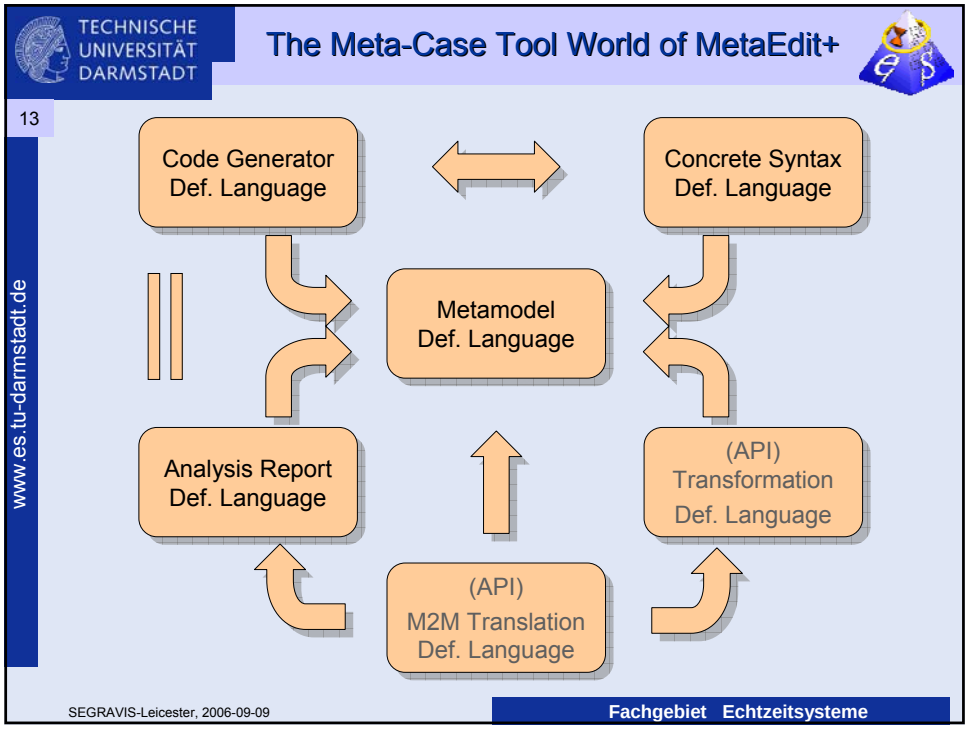
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The Meta-Case Tool World of MetaEdit+
13
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Code Generator Def. Language
Concrete Syntax Def. Language
Metamodel Def. Language
Analysis Report Def. Language
(API) Transformation Def. Language
(API) M2M Translation Def. Language
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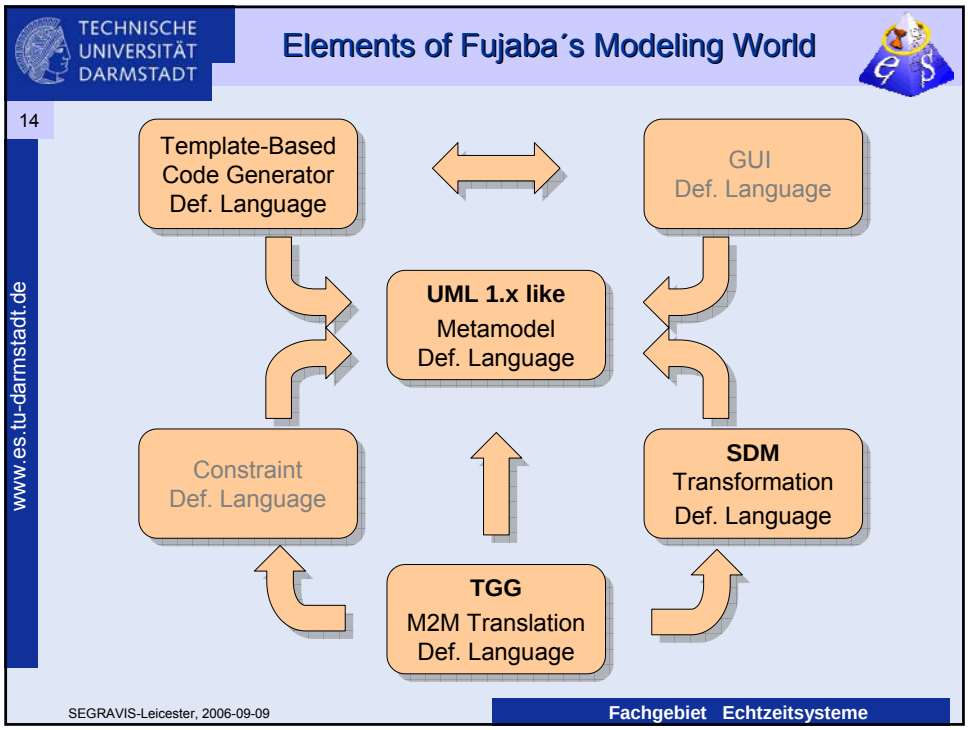
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Elements of Fujaba´s Modeling World
14
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Template-Based Code Generator Def. Language
GUI Def. Language
UML 1.x like Metamodel Def. Language
Constraint Def. Language
SDM Transformation Def. Language
TGG M2M Translation Def. Language
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MDD / DSL Languages - Summary

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	OMG Languages	AMMA (INRIA)	Arc-Styler	GME (Vanderbilt)	…	Fujaba
Metamodel Def. Lang.	MOF	KM3	UML Profile	GME 5.0		UML 1.x
GUI Def. Lang.	-	-	-	GME 5.0		-
Constraint Def. Lang.	OCL	ATL / OCL	OCL	-		-
Model Trafo Def. Lang.	QVT[1]	ATL	?	GReAT		SDM
M2M Trans. Def. Lang.	QVT	ATL / AMW[2]	AIM[2]	GReAT[2]		TGG
Code Gen. Def. Lang.	-	TCS	Cart-ridges	-		Velocity

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

2: ATL, AIM, and GReAT are unidirectional model translation languages

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MOFLON = OMG Standards + Fujaba

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- MOF 2.0 as metamodeling language
  - standard-complaint metamodeling approach
  - new modularization / model refinement concepts
- OCL 2.0 as constraint definition language
  - well-known textual model property definition language
  - Dresden OCL Compiler (planned add-on: incr. evaluation)
- SDM = graph transformations + UML activity diagrams
  - UML-inspired visual model transformation language
  - multi-paradigmatic (rule-based, imperative) approach
- (V)TGGs = MOF-compliant triple graph grammars
  - bidirectional, declarative model translation approach
  - planned add-on: declarative view-definition approach
- JMI-compliant Java code generators (Sun Standard)

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Elements of MOFLON´s World

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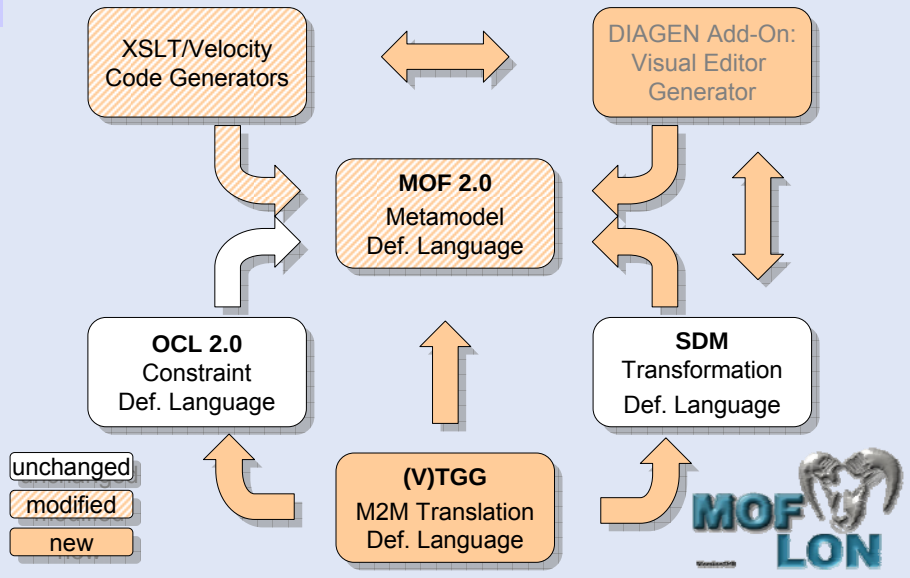

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Why Modifications of MOF 2.0 ?

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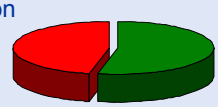
From 90 analyzed constraints of the specification

42 (47%) are erroneous



48 (53%) are correct

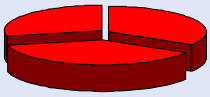
With further 86 constraints 101 improvements were made, whereas

50 (50%) are additional

51 (50%) are corrections

From the 51 corrections of the specification

16 (29%) are due to a wrong metamodel reference



19 (34%) are due to wrong semantics

21 (37%) are due to wrong syntax

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Typical MOFLON Applications

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- system engineering tool integration
  (ToolNet project with DaimlerChrysler et al.)
- model analysis / design guideline checking
  (Matlab Simulink/Stateflow 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)
- …

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MOFLON Architecture

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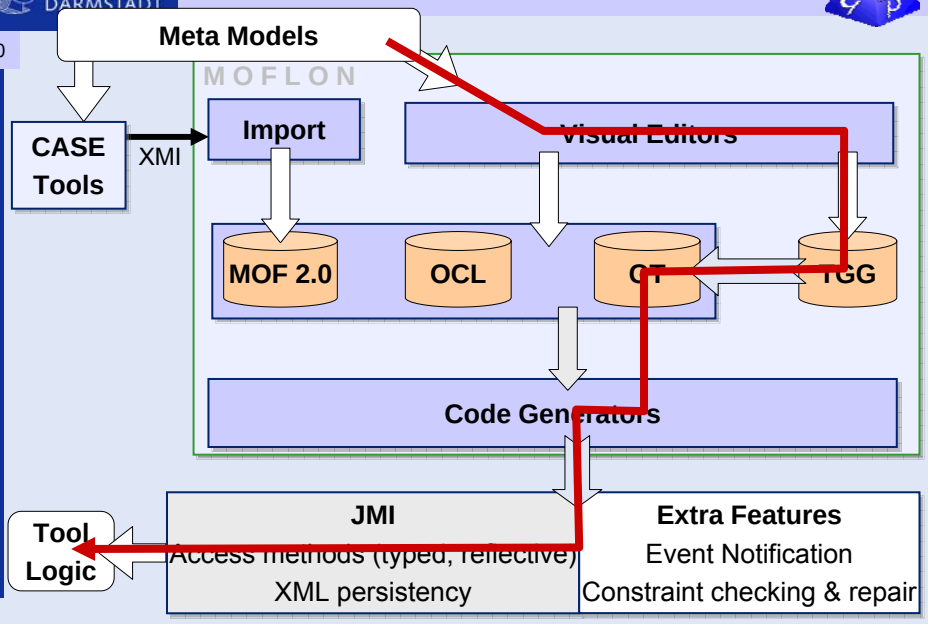
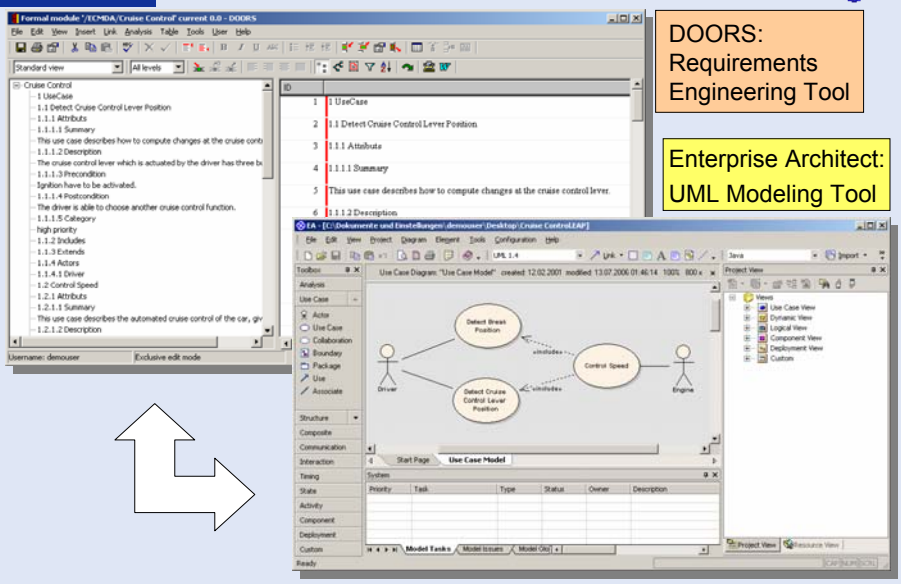
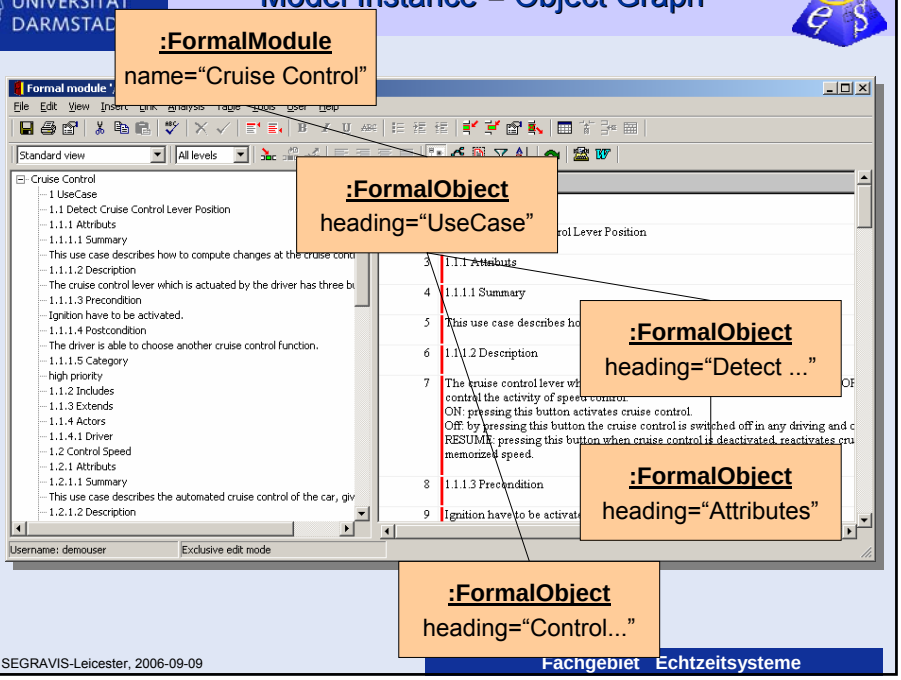


Running Example: Model integration



Model Instance = Object Graph



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Metamodel for DOORS

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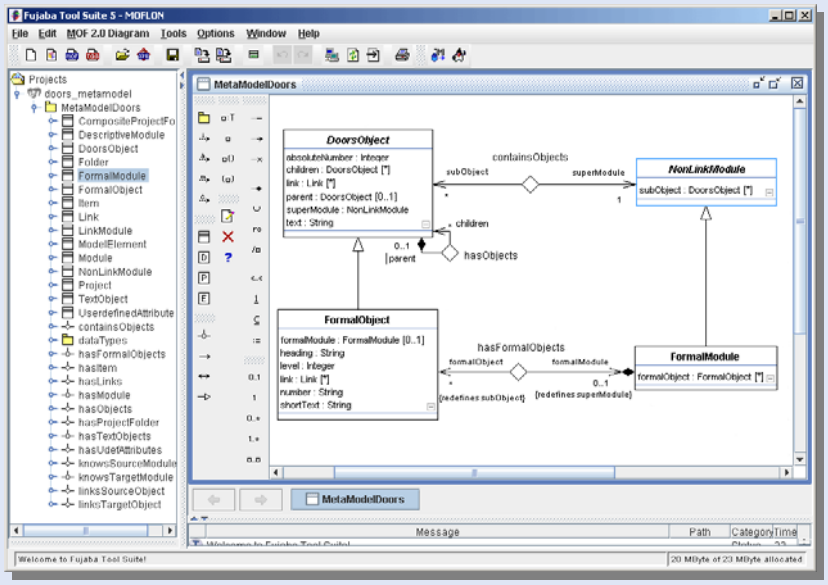

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Metamodel for Enterprise Architect

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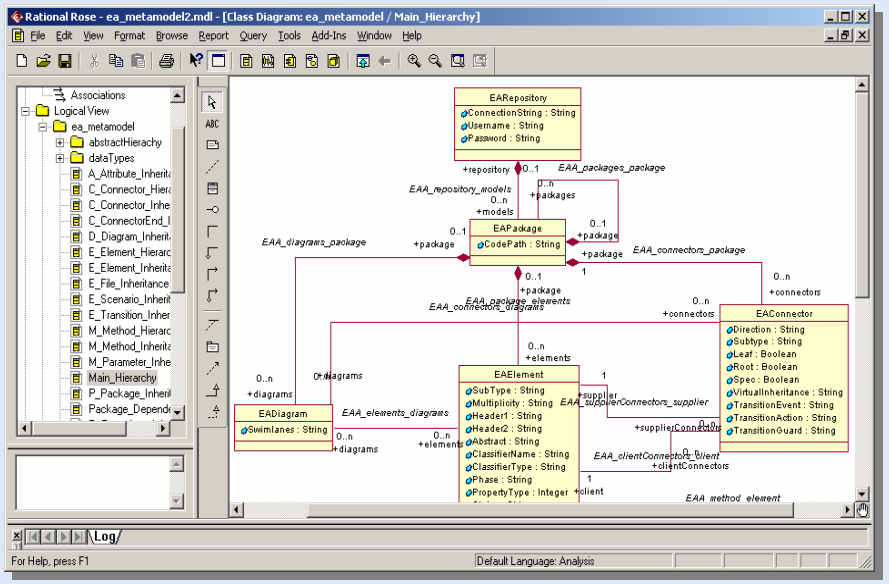

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Triple Graph Grammar Integration Schema

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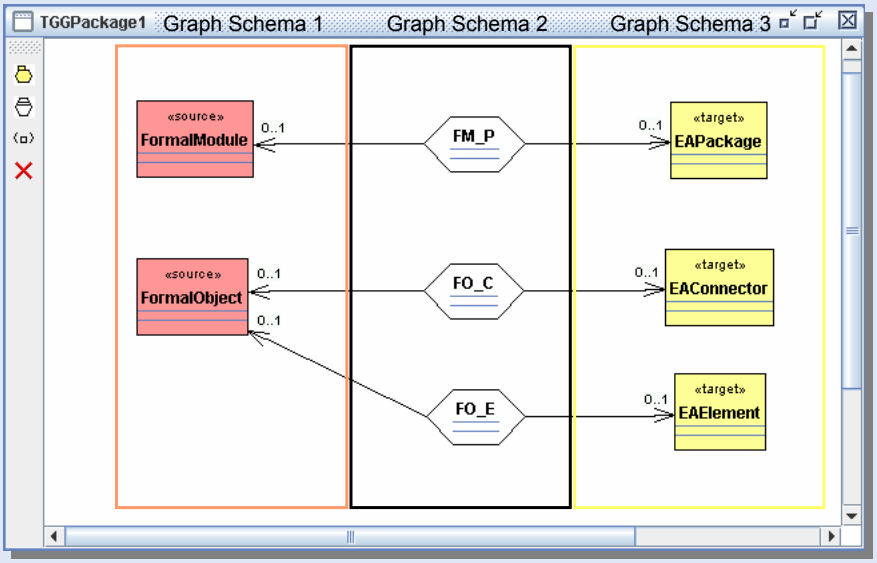

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Triple Graph Grammar Integration Rule

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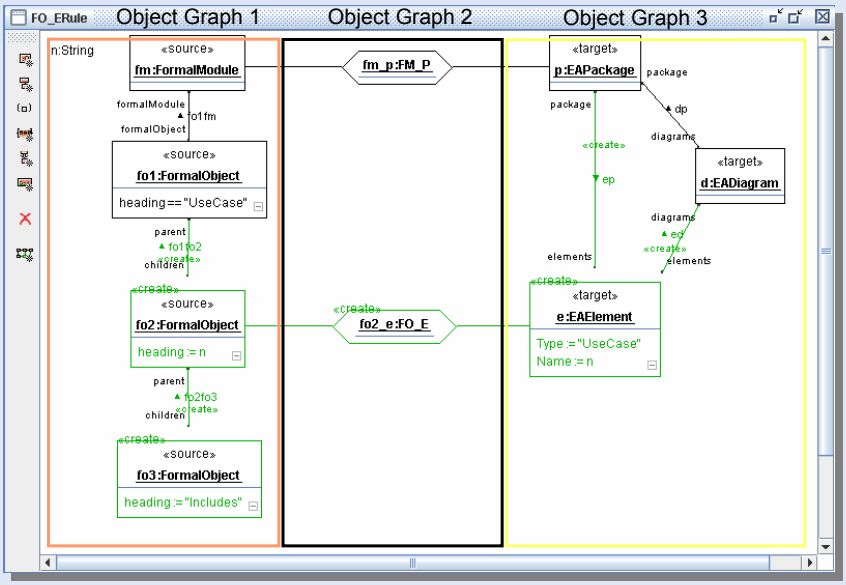
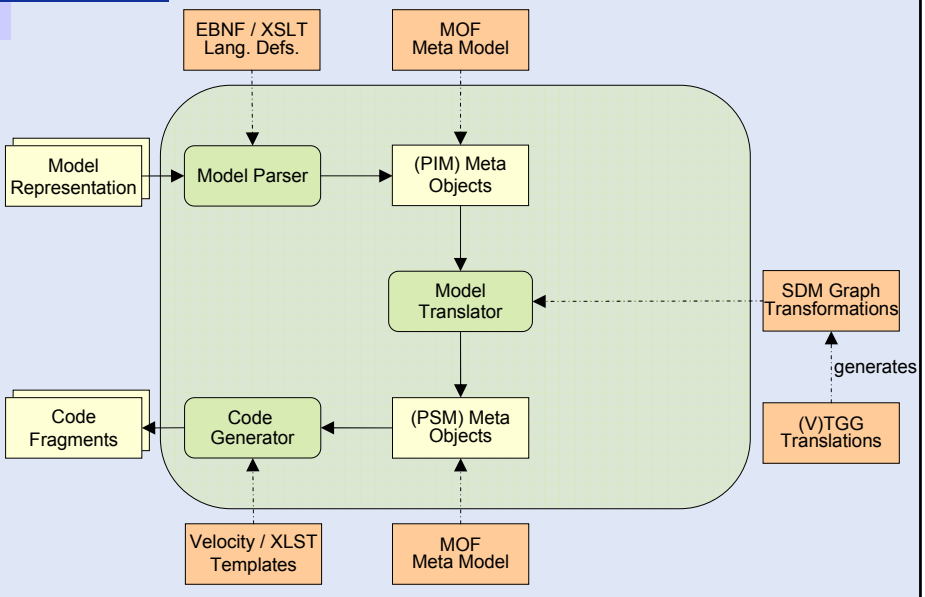


Generating Operational Rules

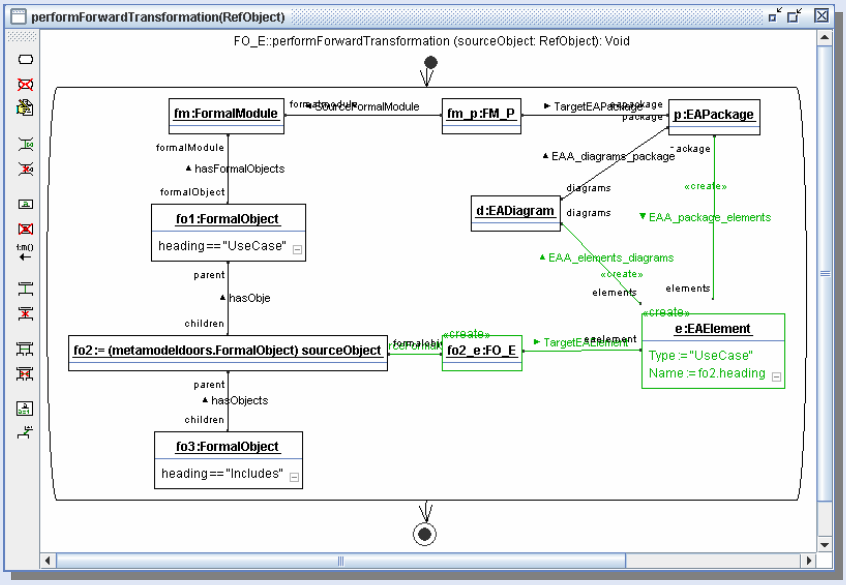
- Integration rules are declarative
- Standard SDM rules are generated:
  - check consistency
  - create traceability links
  - forward transformation
  - backward transformation
  - forward attribute propagation
  - backward attribute propagation
  - remove traceability links
  - forward deletion propagation
  - backward deletion propagation
  - …

Example: Generate use case diagrams from requirements

Forward Transformation Scenario

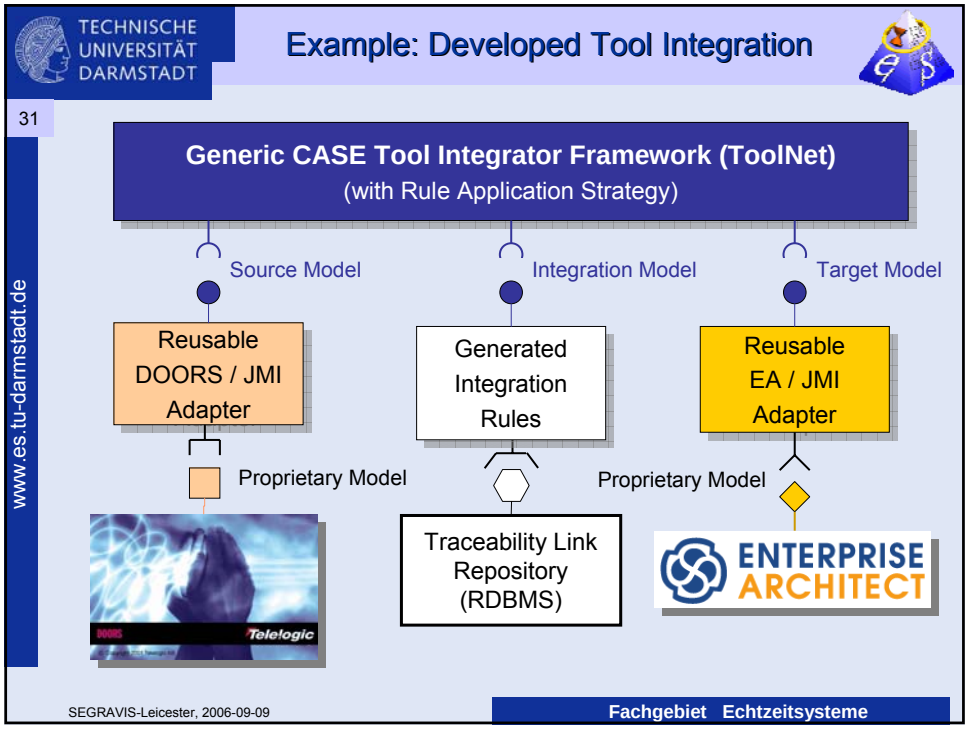


Stamdard SDM Transformation Rule



Java Code Generation from SDM

- JMI-compliant Java code
  - in-memory repository
  - type-safe interfaces
  - reflective/generic interfaces
  - XML persistency
- operational transformation rules → method bodies
- MDR-compatible interfaces and event mechanism (MDR = Sun's Meta Data Repository)
- Under Development:
  - code for constraint checking (from OCL constraints)
  - code for constraint repairs (from transformations)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Example: Developed Tool Integration
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Generic CASE Tool Integrator Framework (ToolNet)
(with Rule Application Strategy)
Source Model
Integration Model
Target Model
Reusable DOORS / JMI Adapter
Generated Integration Rules
Reusable EA / JMI Adapter
Proprietary Model
Proprietary Model
Traceability Link Repository (RDBMS)
ENTERPRISE ARCHITECT
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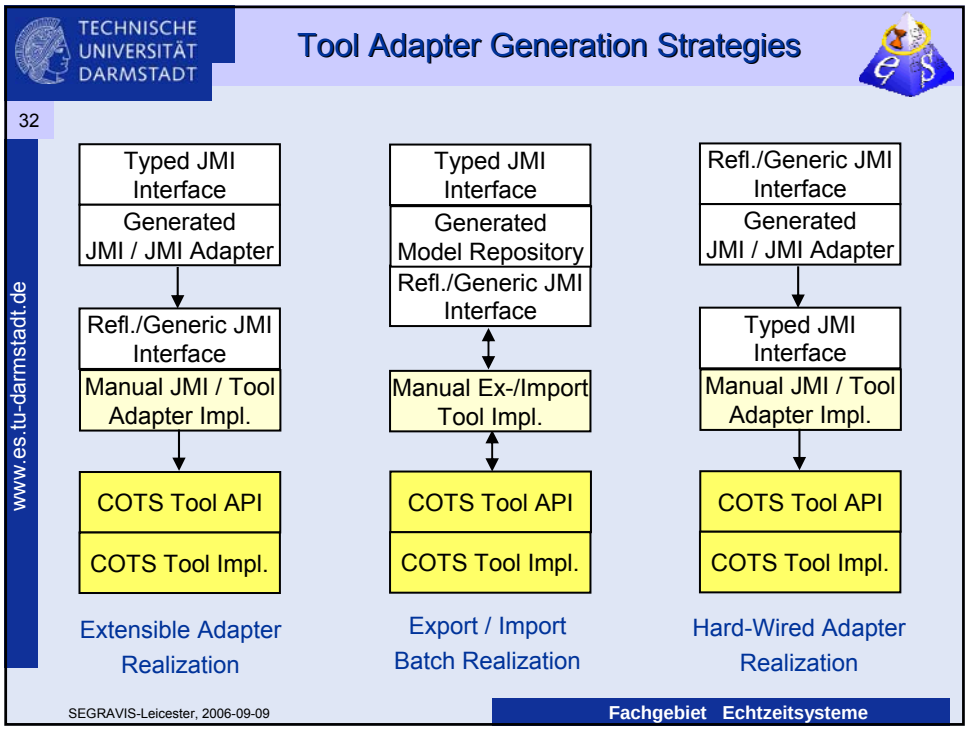
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Tool Adapter Generation Strategies
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Typed JMI Interface
Generated JMI / JMI Adapter
Refl./Generic JMI Interface
Manual JMI / Tool Adapter Impl.
COTS Tool API
COTS Tool Impl.
Extensible Adapter Realization
Typed JMI Interface
Generated Model Repository
Refl./Generic JMI Interface
Manual Ex-/Import Tool Impl.
COTS Tool API
COTS Tool Impl.
Export / Import Batch Realization
Refl./Generic JMI Interface
Generated JMI / JMI Adapter
Typed JMI Interface
Manual JMI / Tool Adapter Impl.
COTS Tool API
COTS Tool Impl.
Hard-Wired Adapter Realization
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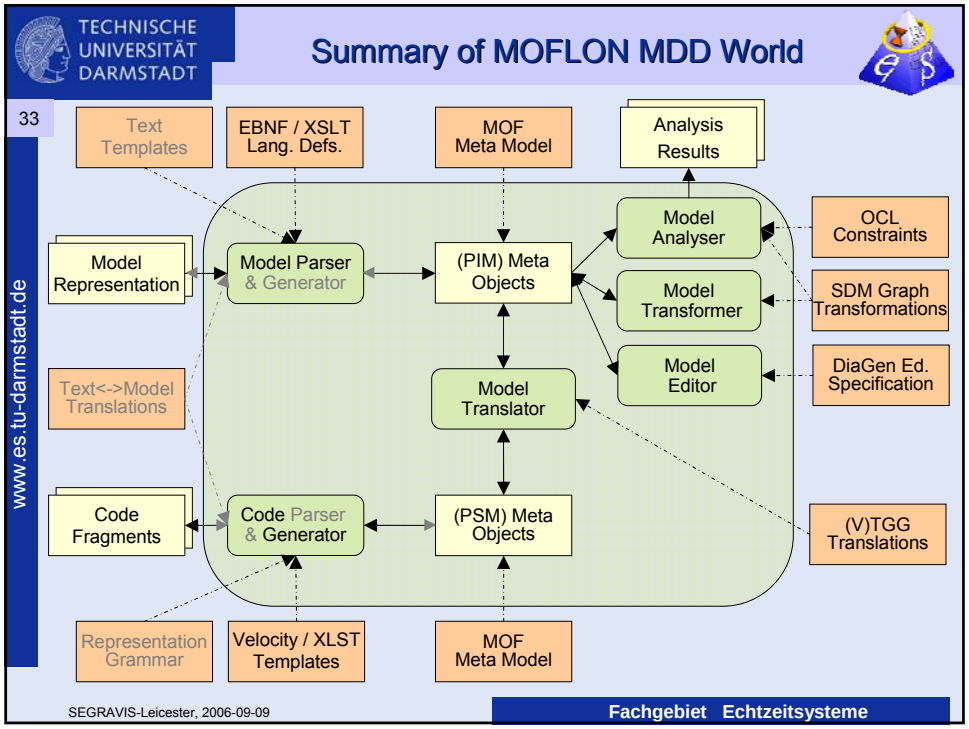
Summary of MOFLON MDD World



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Open Problems & Ongoing Work

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- 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
  - handling of complex attribute evaluations (still a problem!)
  - …
- Integration with Editor Generator Framework DiaGen

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… 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 techniques of last millenium
  - meta-modeling / meta-case tool technology
  - stepwise refinement of specifications / models
  - compiler compiler technology
  - …
- OMG’s MDA and other institution’s Meta-Case Tools for Domain-Specific Languages (DSLs) are variations of MDD
- Currently available (commercial / academic) MDD tools
  - support only subsets of all MDD activities
  - lacks formal definition (available for graph transformations)