Model Integrated Design of Embedded MPSoC

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Overview

- **MDA**
  - An emerging paradigm for software development
- **Domain-Specific MDA: MIC**
  - From DSL-s to DSML-s
  - The role of transformations
- **Example**
- **Challenges and opportunities**
  - Tool Integration
  - Semantic Foundation
- **Conclusions**

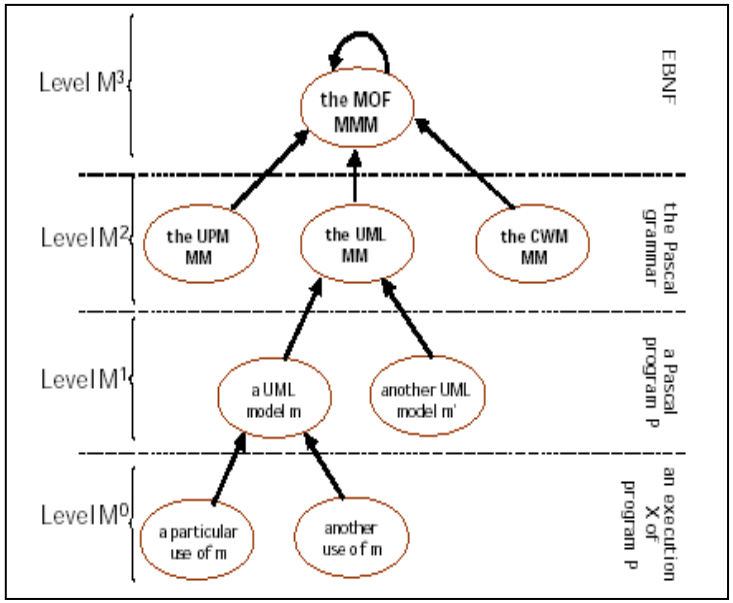
Model-Driven Architecture
A Paradigm for Software Development

History:

- OMA (CORBA) → UML → MDA:
  - –Object composition
    - –Models for software
      - –Models in development

Key points:

1. Models are not *accidental* but *essential* to system development
2. Models are expressed in *modeling languages*
3. Models are *built, analyzed and transformed* during development that lead to executables



Source: Jean Bézivin : "From Object Composition to Model Transformation with the MDA" TOOLS USA, August 2001, Santa Barbara

Model-Driven Architecture
The Role of Modeling Languages

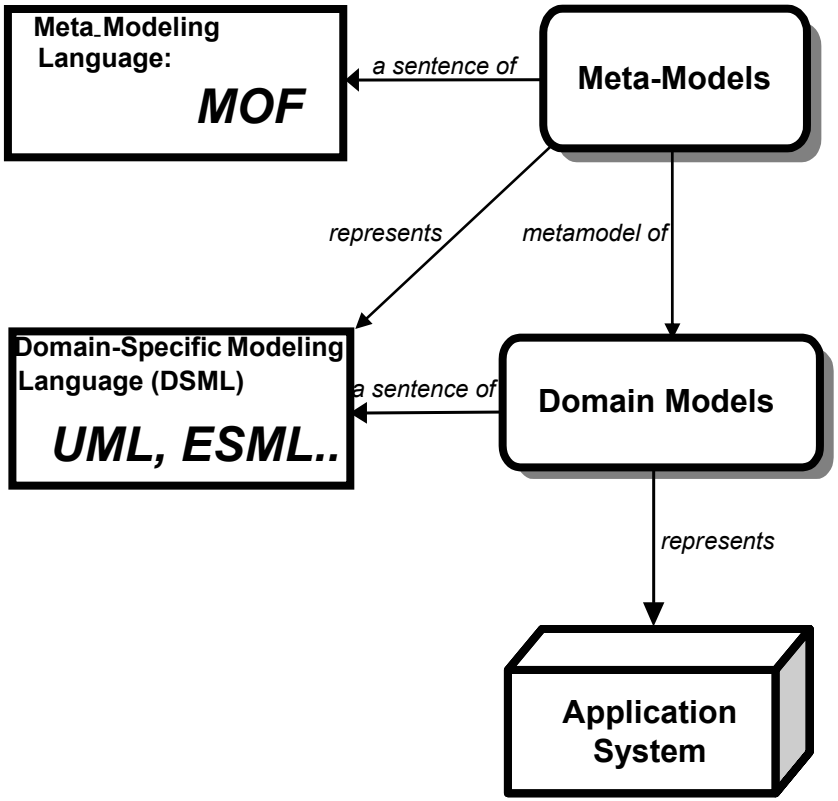
Development process:

- Platform Independent Model:
  - UML
  - extension with UML profiles or metamodeling
- Platform Specific Model:
  - UML
  - extension with UML profiles or metamodeling

Key points:

1. 4-layer metamodeling architecture
2. MOF is the metalanguage
3. Not specific to CORBA

4-Layer Meta-Model Language Architecture:



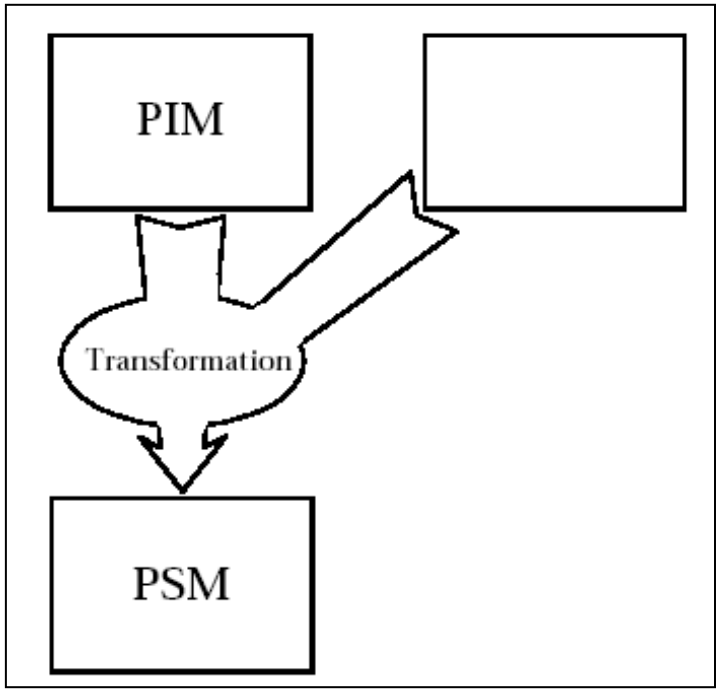
Model-Driven Architecture
The Role of Transformations

Development process:

- Platform Independent Model: a view of the system from a platform independent viewpoint
- Platform Specific Model: a view of the system from a platform-specific viewpoint

Key points:

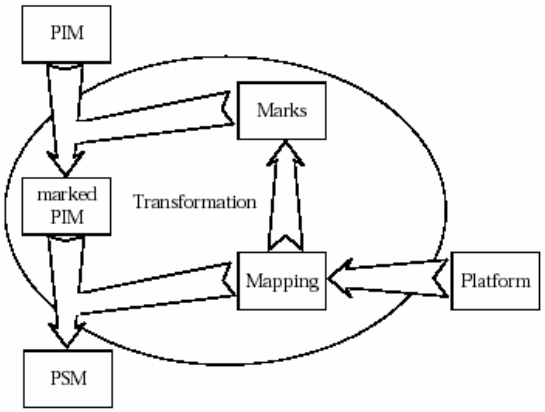
1. Most relevant issue: *platform-independence* (CORBA/EJB/.NET)
2. Additional (*P/S*) information is used to map PIM into a PSM
3. Transformations are *models*



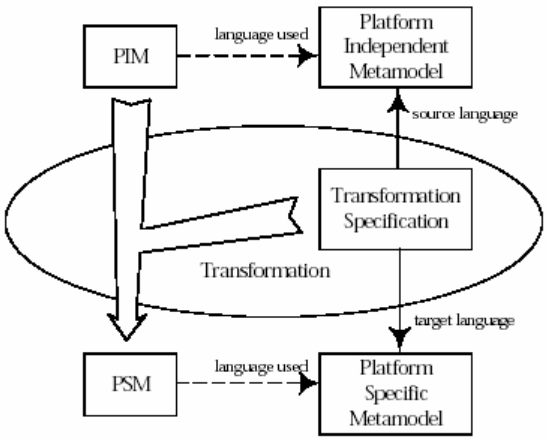
Source: MDA Guide V 1.0.1 (www.omg.org)

Model-Driven Architecture
Model Transformation Variants

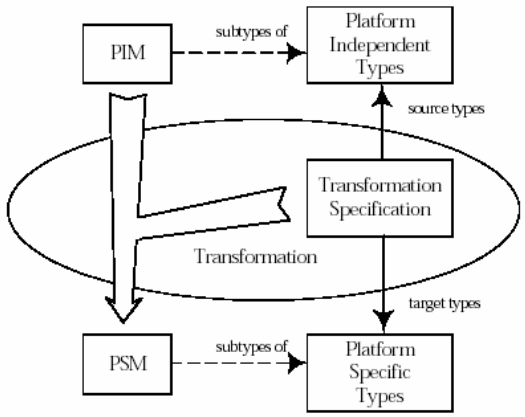
Marking:



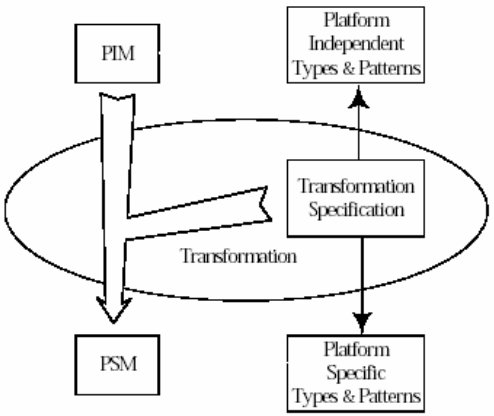
Metamodel-based:



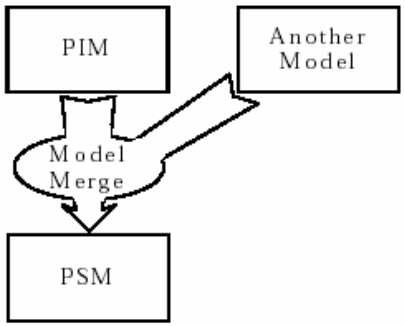
Type-based:



Pattern-based:



Model merge:



Source: MDA Guide V 1.0.1 (www.omg.org)

Model-Integrated Computing:
Domain-Specific MDA

Development starts with domain engineering

Understand and capture domain concepts and invariants

Develop Domain-Specific Modeling Language(s) (DSML) that capture

- Domain concepts and relationships
- Domain invariants as well formedness rules

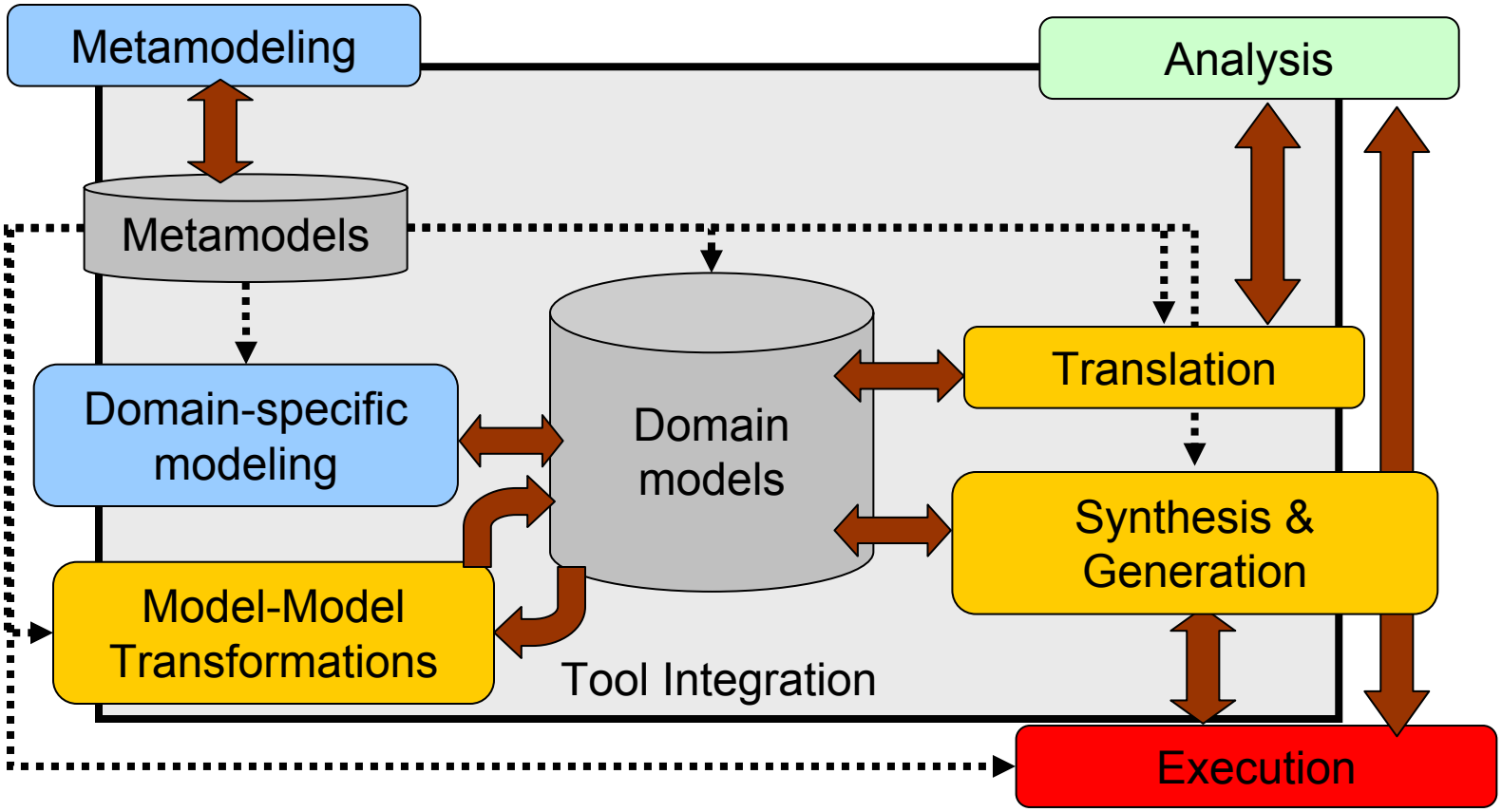
Systems are constructed from domain-specific models

Analysis and generation are core activities

Domain-Specific Tool Suites play a key role in the development process

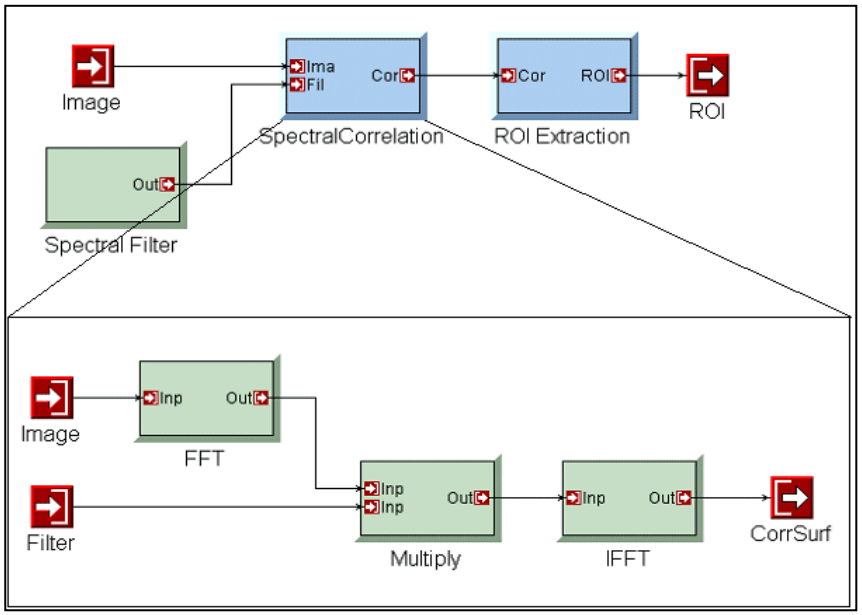
- Modeling environment(s) for DSML-s
- Model transformation tools
- Model analysis tools
- Model-based generators

MIC Components



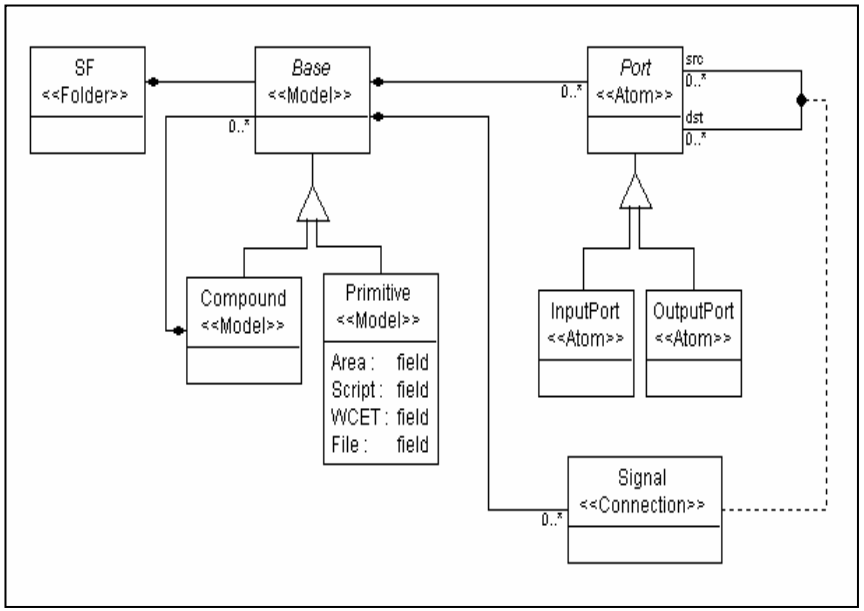
MIC Approach to Metamodeling

DSML for Signal Processing: SF



Describes the structure of a design

Metamodel for SF:



Specifies the invariants in all designs (Domain architecture)

The Role of Metamodeling in MIC

DSML-s are *affordable* only if tools are still reusable.
"Meta-programmable" tools:

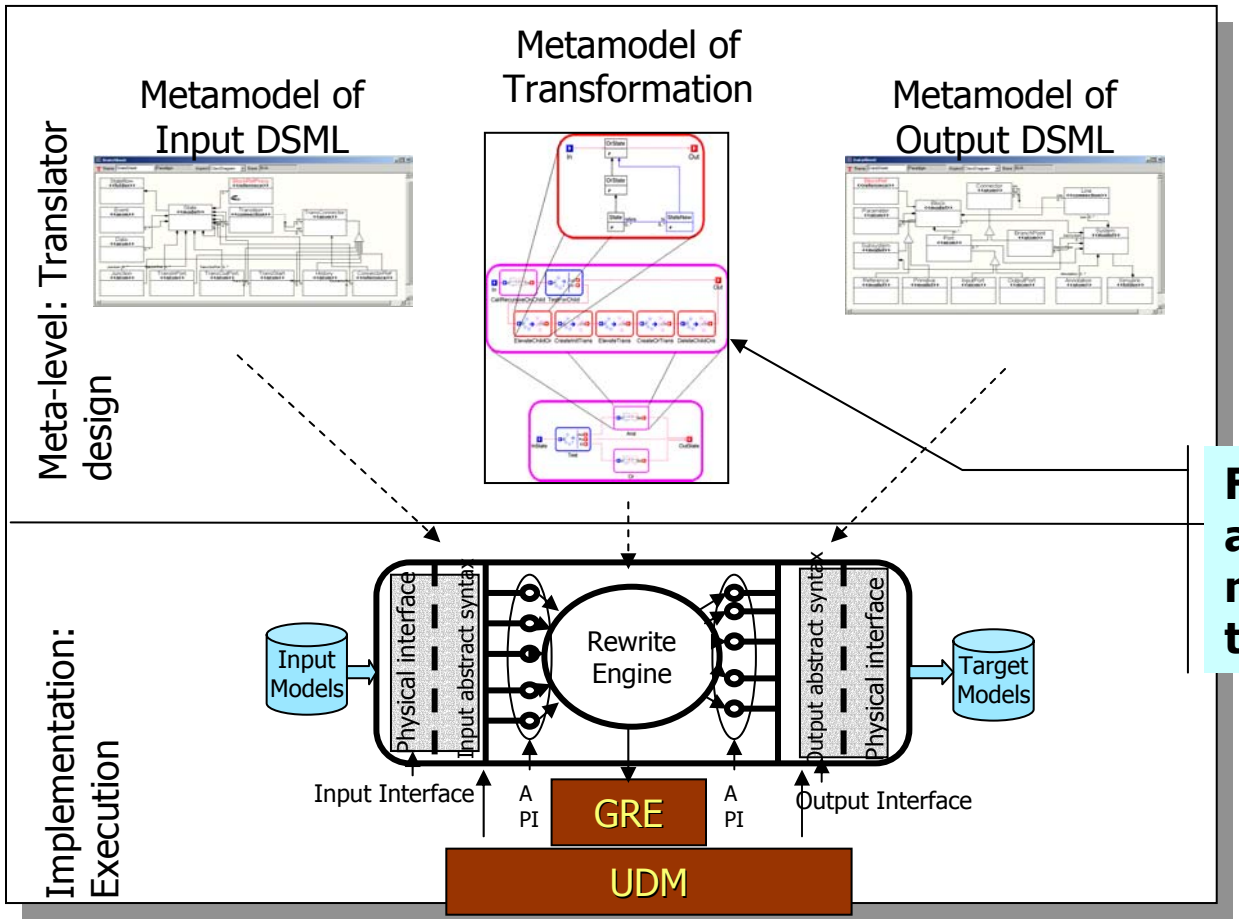
1. Model repositories
2. (Visual) modeling environments
3. Model transformation tools

Common underlying theme:

Tools are configured through metamodels

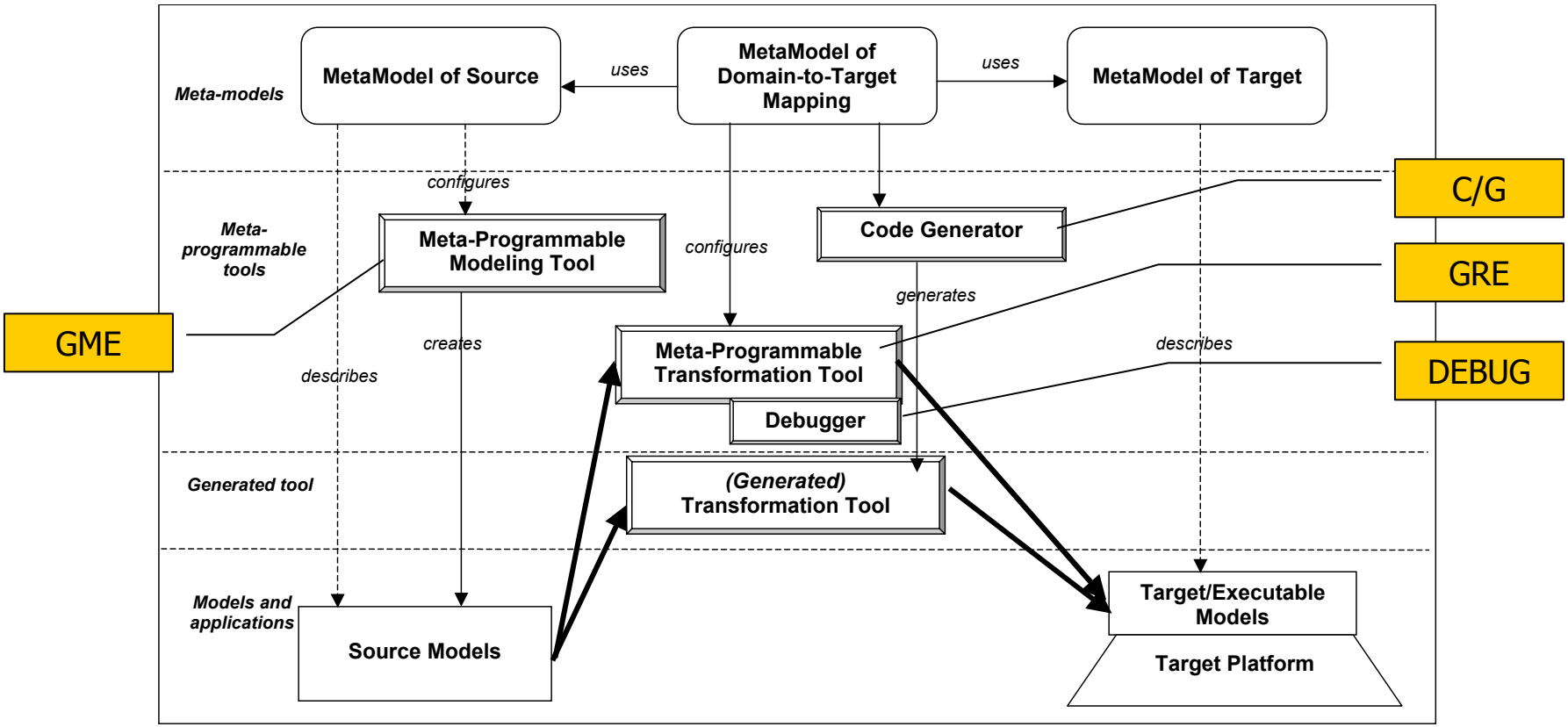
Metaprogrammable Tool	Metamodel
Model repository	**Schema, consistency/integrity rules**
Modeling editor	**Abstract and concrete syntax of DSML Static semantics**
Model transformation	**Abstract syntax of source and target Model transformation process**

MIC Approach to Model Transformations



Formal, explicit, and precise model of the transformations

Model Transformation Tool Chain

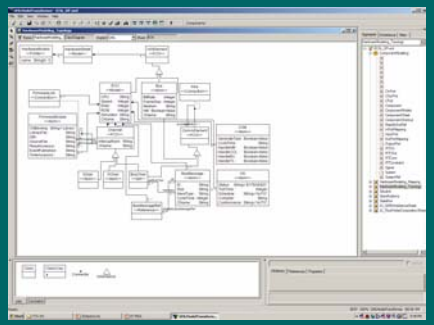


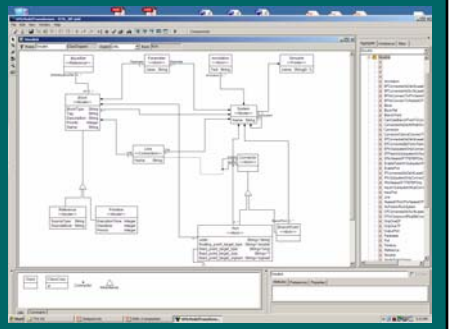
Tools: UMT Language, GRE (engine), C/G, GR-DEBUG

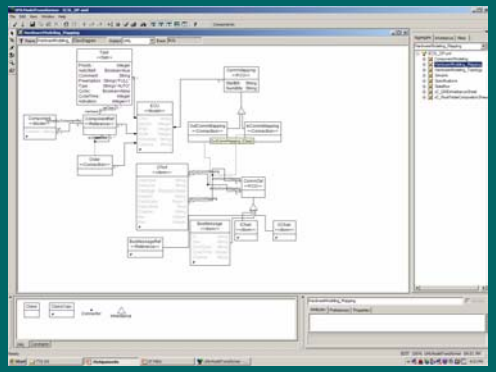
See Karsai

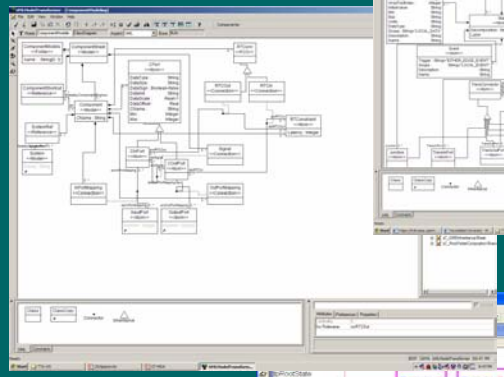
http://www.isis.vanderbilt.edu

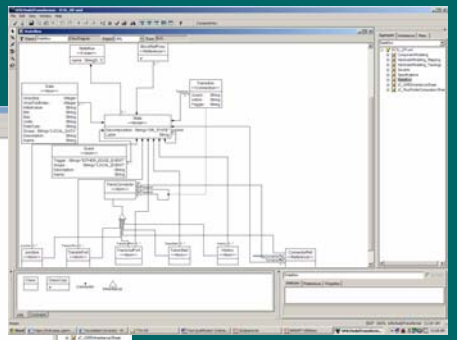
Example: Simplified Automotive Design Flow

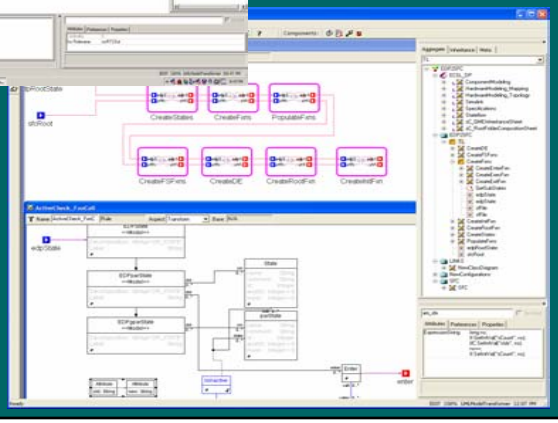




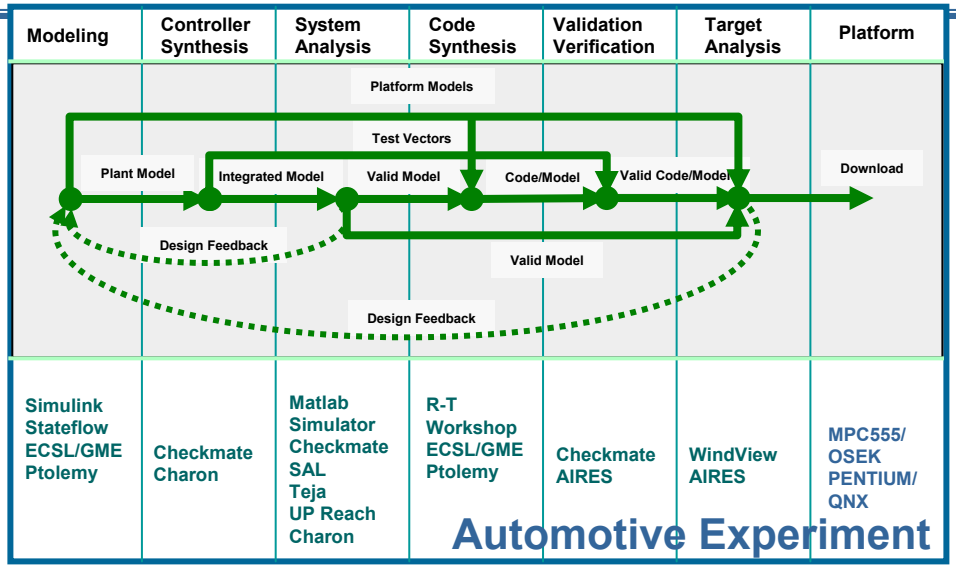


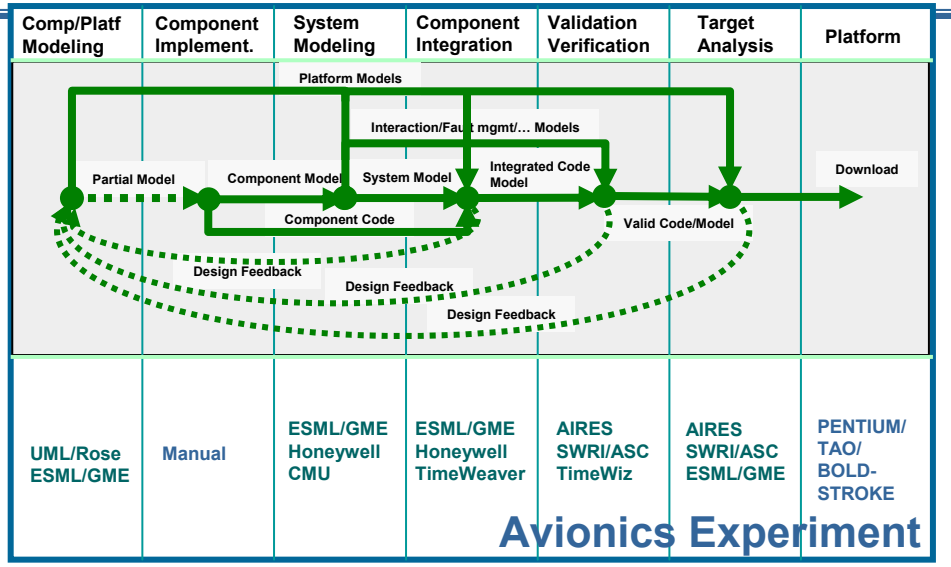


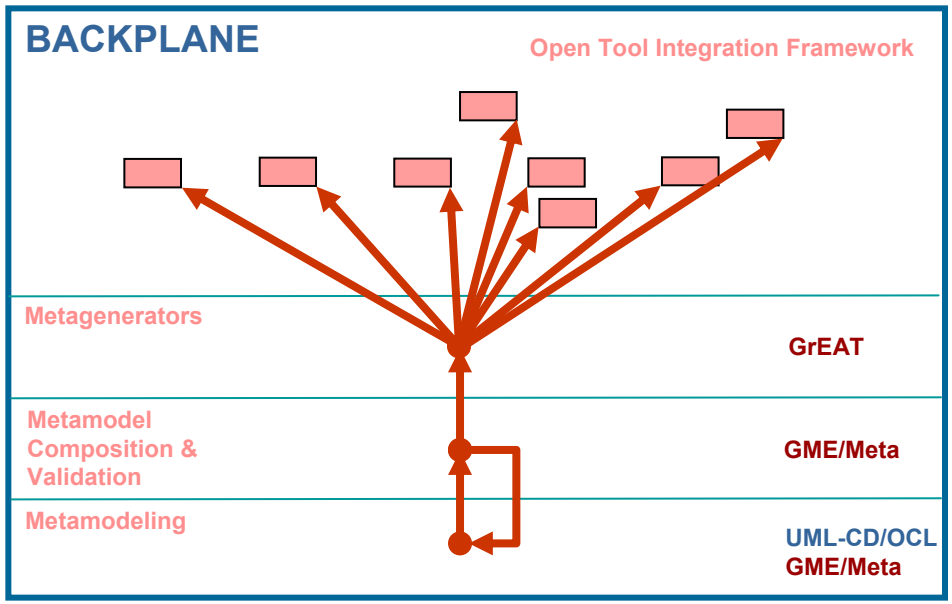




Opportunities: Composable Tool Chains

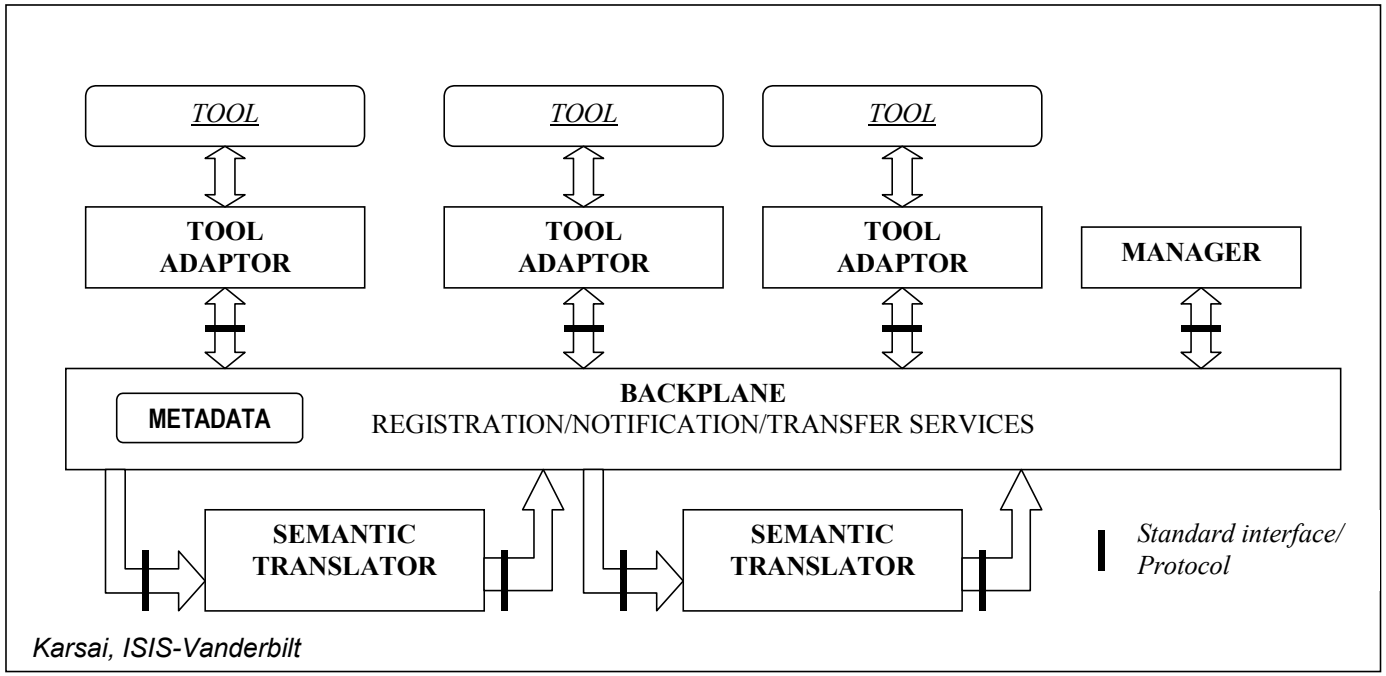






- Integrated Physical/Computational Modeling and Analysis
- Model-based Generators
- Hybrid System Analysis
- Customizable (metaprogrammable) modeling tools and generators
- Open tool integration framework; configurable design flow and composable design tool chains

Solution: Open Tool Integration Framework (OTIF)



RFP is Discussed at MIC PSIG OMG

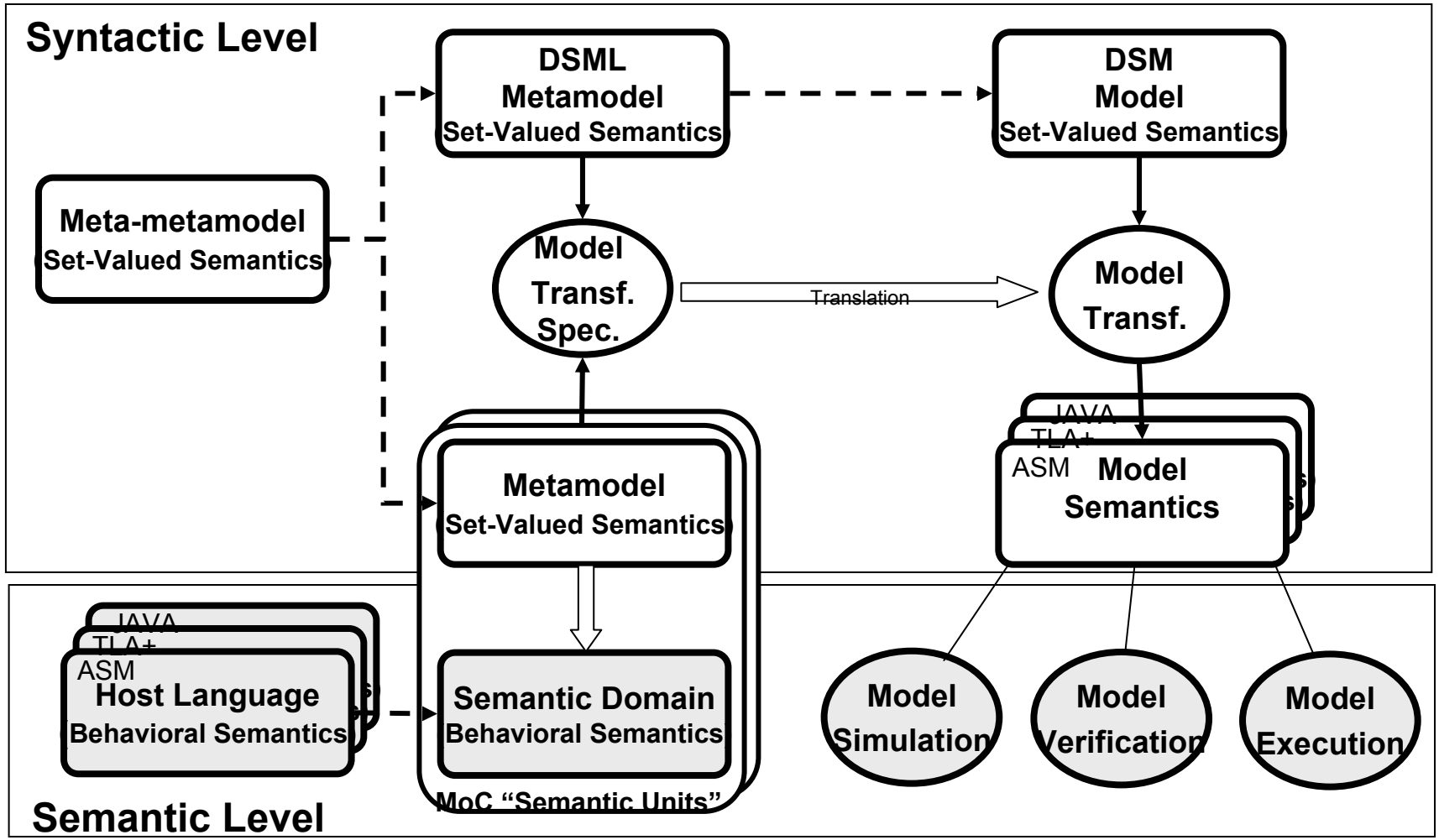
Share models **using Publish/Subscribe Metaphor**

Status:

- Completed, tested in several tool chains
- Protocols in OMG/CORBA
- CORBA as a transport layer
- Integration with ECLIPSE

http://www.isis.vanderbilt.edu/Projects/WOTIF/default.html

Challenges: Semantic Anchoring of DSML-s



Conclusion

- The hard problem of building complex MPSoC embedded systems is the integrated design of physical and computational components
- Domain-specific modeling languages and model transformations are key technologies for future progress
- Model-Integrated Computing evolves to be a mature technology for the development of complex applications