Some Uses and Challenges of (bi-directional?) Model Transformations

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http://atenea.lcc.uma.es

GRACE Meeting on Bi-Directional Transformations

Japan, Dec 2008

Atenea

- Atenea is a group of researchers from the GISUM group at the University of Málaga, interested in **Modeling Software Systems**

- Atenea conducts basic and applied research on **Modeling Software Systems**, and on the provision of Engineering Tools to design, analyse, evaluate, implement and maintain distributed information systems

Fundamental to this objective is the recognition that information systems must be realized in an environment where data and processing are distributed across heterogeneous IT resources and multiple organizational domains, and are mainly developed and deployed by re-using or integrating existing components and applications, most of which are either commercial off-the-shelf artefacts (models, components), legacy systems, or external applications

Atenea activities around MDE

- Domain Specific Modeling / DSLs
  - Model Management
  - Model Simulation and Analysis
  - Viewpoint Modeling (and Synchronization)
  - Formal Semantics of Models/Metamodels

- Contexts
  - ISO/IEC and ITU-T work on RM-ODP
    http://www.rm-odp.net
  - Model-Driven Web Engineering (UWE, WebML,...)
    http://www.lcc.uma.es/~nathalie/WEI/
    http://www.pst.ifi.lmu.de/projekte/mdwenet/index.php/Main_Page
  - Eclipse-based tools (moving to Web-services)
    http://atenea.lcc.uma.es/index.php/Main_Page/Resources/Maudeling
    http://atenea.lcc.uma.es/index.php/Main_Page/Resources/E-motions

Our approach to MDE

- Eclipse-based tool for Model Management
  - Use of Maude as underlying platform (logic)
    - Semantic Mappings from EMF and other domains
  - Implements a set of Model Management operations
    - Difference, Subtyping, Type Inference, Model Metrics…

  http://atenea.lcc.uma.es/index.php/Main_Page/Resources/Maudeling

- Model Simulation and Analysis
  - Specification of the dynamic behavior of DSLs
  - Semantic Mappings from EMF, Graph Transformations to Maude and other formalisms with tool support
    - Simulation
    - Reachability Analysis
    - Model Checking

  http://atenea.lcc.uma.es/index.php/Main_Page/Resources/E-motions

Our approach to Viewpoint Modeling

- In the context of ISO/IEC | ITU-T RM-ODP
  - UML Profiles for ODP viewpoints and correspondences
  - MagicDraw plugin for ODP

    http://www.rm-odp.net

    http://atenea.lcc.uma.es/index.php/Main_Page/Resources/MagicDraw_v15%2B_plugin_for_RM-ODP_and_UML4ODP
  - Formalization of individual viewpoints
  - Correspondence modeling
  - Change propagation and viewpoint synchronization

- In the context of Web Engineering (UWE, WebML,MDWEnet)
  - Interoperability between MDWE notations and tools
  - Common metamodel vs. pair-wise mappings

    http://www.lcc.uma.es/~nathalie/WEI/

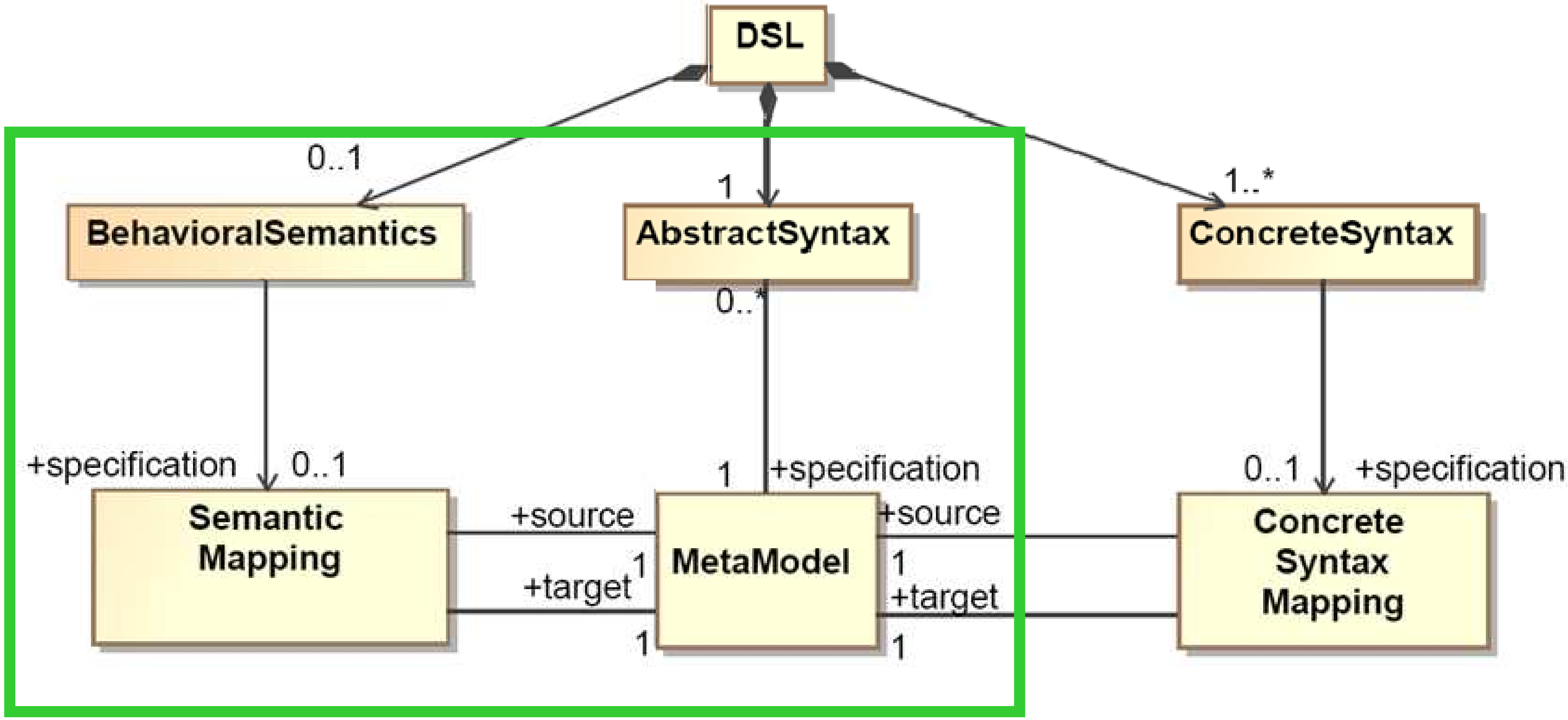
    http://www.pst.ifi.lmu.de/projekte/mdwenet/index.php/Main_Page

Our issues today

- Use of bi-directional transformations for implementing semantic mappings
  1. Not only for providing semantics to DSLs, but also for accessing analysis tools from different domains

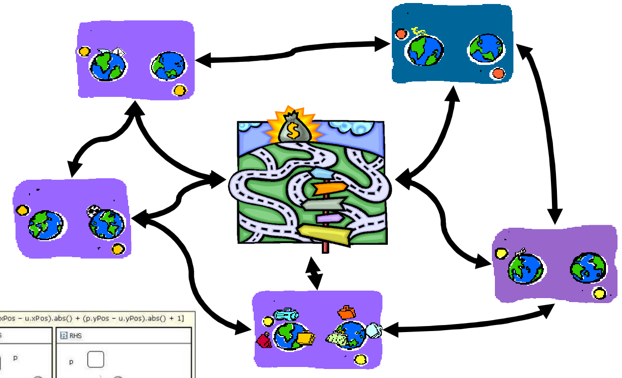
- Use of bi-directional transformations for expressing correspondences
  2. To express correspondences in a usable way
  3. To deal with change propagation and viewpoint synchronization

Definition of a DSL

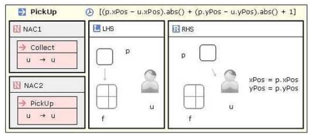


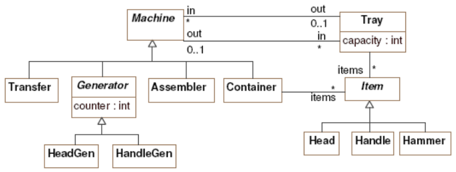
Bridges between Semantic Domains

- Precise semantics
- A set of Analysis Tools
- Underlying logic



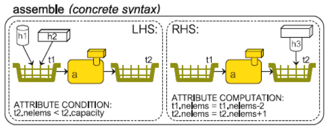
e-Motions





Structure (Metamodel) + **Behavior** (In-place transformations)

ATOM³



KM3 + ATL*

```
rule AnEventOccurs {
  from
    s: StateMachine,
    t: Transition,
    x : EventOcurrence
  to
    s': StateMachine(…)
```

Model Transformations MT1, MT2, MT3, MTN

Rewriting Logic	Petri Nets	…	Semantic Domain N
(Reachability analysis, model checking…)	(Termination, Confluence…)		…

MAUDELING

Model Simulation and Analysis with Maudeling

- Simulation/Execution of specifications

```
(trew initModel in time <= 20 .)
```

- Reachability Analysis
  - Deadlock
  - Invariants
  - Others

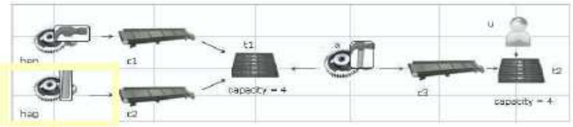
```
search initModel =>*
  ProductionSystem {
    < O : Tray | capacity : CAP, parts : PARTS, SFS >
    OBJSET }
(find earliest {initModel} =>* {ProductionSystem {
< T : ActionExec | rule : "Collect", value : null,
SFS@T > OBJSET }} .)
```

- LTL Model checking
  - Liveness properties

```
(mc {initModel} |=t
  [](ensembled('he10.ha10) -> collected('he10.ha10))
in time <= 100 .)
```

Issues

- Bi-directional model transformations can be of great help to define semantic mappings



```
ProductionSystem {
< 'p : Plant | els : 'heg 'hag 'c1 'c2 't1 'a 'c3 't2 'u >
< 'hag : HandleGen | in : null, out : 'c2, xPos : 1, yPos : 1 >
< 'heg : HeadGen | in : null, out : 'c1, xPos : 1, yPos : 3 >
< 'c1 : Conveyor | parts : nil, out : 't1, xPos : 2, yPos : 3 >
< 'c2 : Conveyor | parts : nil, out : 't1, xPos : 2, yPos : 1 >
< 't1 : Tray | parts : nil, capacity : 4, xPos : 3, yPos : 2 >
< 'a : Assembler | in : 't1, out : 'c3, xPos : 4, yPos : 2 >
< 'c3 : Conveyor | parts : nil, out : 't2, xPos : 5, yPos : 2 >
< 't2 : Tray | parts : nil, capacity : 4, xPos : 6, yPos : 2 >
< 'u : User | parts : nil, xPos : 6, yPos : 3 >
}
```


```
rl [Carry] :
  ProductionSystem {
    < p : P:Part | xPos : XPOS, yPos : YPOS, SFS >
    < c : Conveyor | parts : (p PARTS), out : t, SFS' >
    < t : Tray | xPos : XPOS', yPos : YPOS', parts : PARTS', SFS'' >
    OBJSET }
=>
  ProductionSystem{
    < p : P:Part | xPos : XPOS', yPos : YPOS',SFS >
    < c : Conveyor | parts : PARTS, out : t, SFS' >
    < t : Tray | xPos : XPOS', yPos : YPOS', parts : (p PARTS'), SFS'' >
    OBJSET }
.
```

- But how to define MTs to map the logics?

???

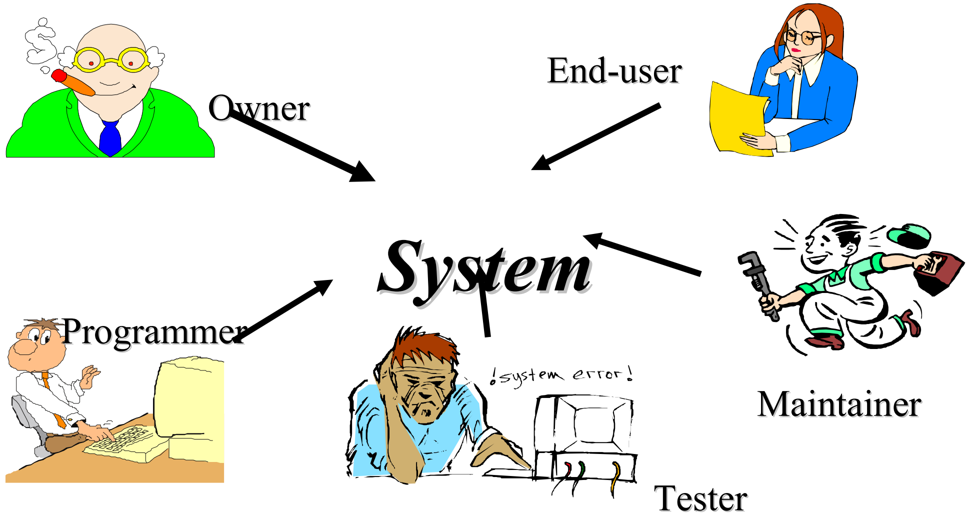
```
(mc {initModel} |=t
  [](assembled('he10.ha10) -> collected('he10.ha10))
in time <= 100 .)
```

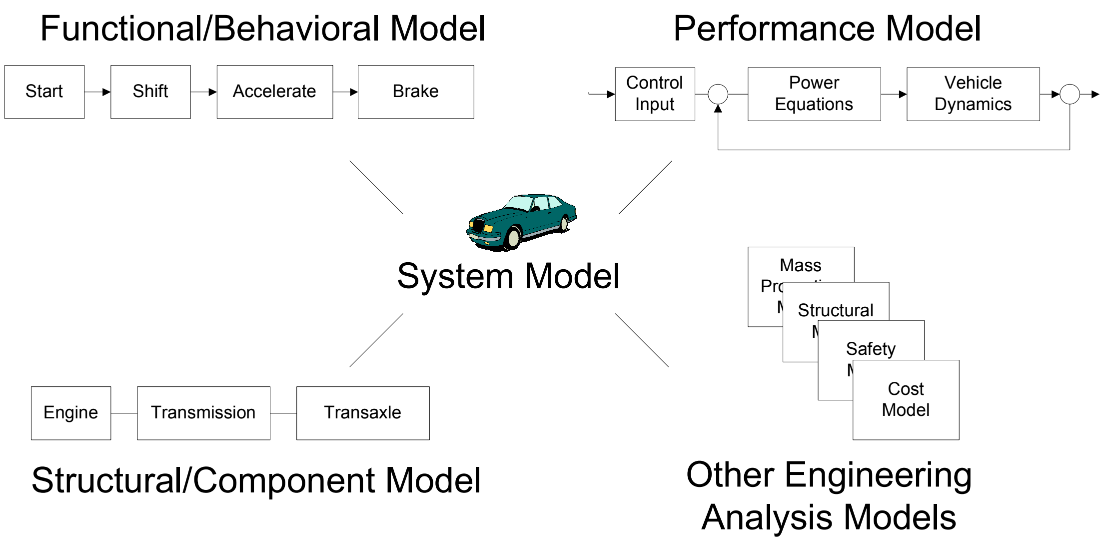
???

```
Solution 1 (state 210)
  OBJSET -->
  < 'as : Assembler | in : 't3, out : 't4 >
  < 'co : Container | in : 't4, out : null, items : empty >
  ....
```

Multiviewpoint specifications

Different stakeholders' views

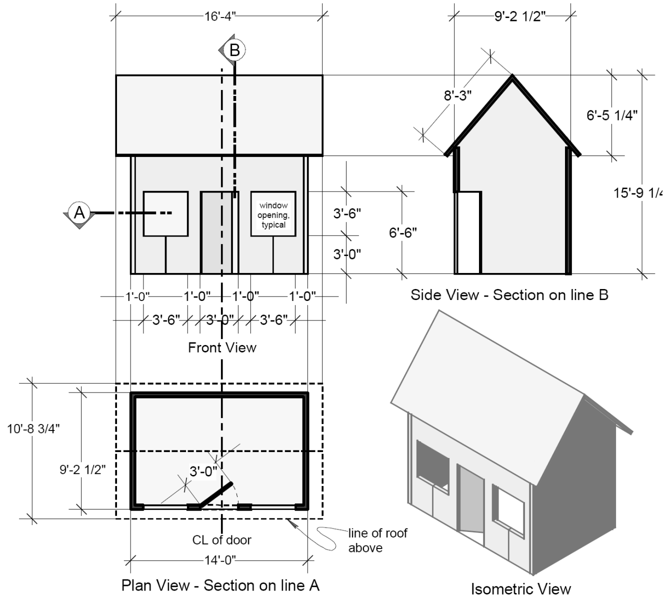




Multiple aspects of a system: Consistency

Multiviewpoint specifications

- Viewpoint modeling tackles complexity but introduces other problems
  - What is (in) a multiviewpoint specification?
  - Viewpoint integration?
  - Change propagation?
  - Viewpoint synchronization?
  - And many others…



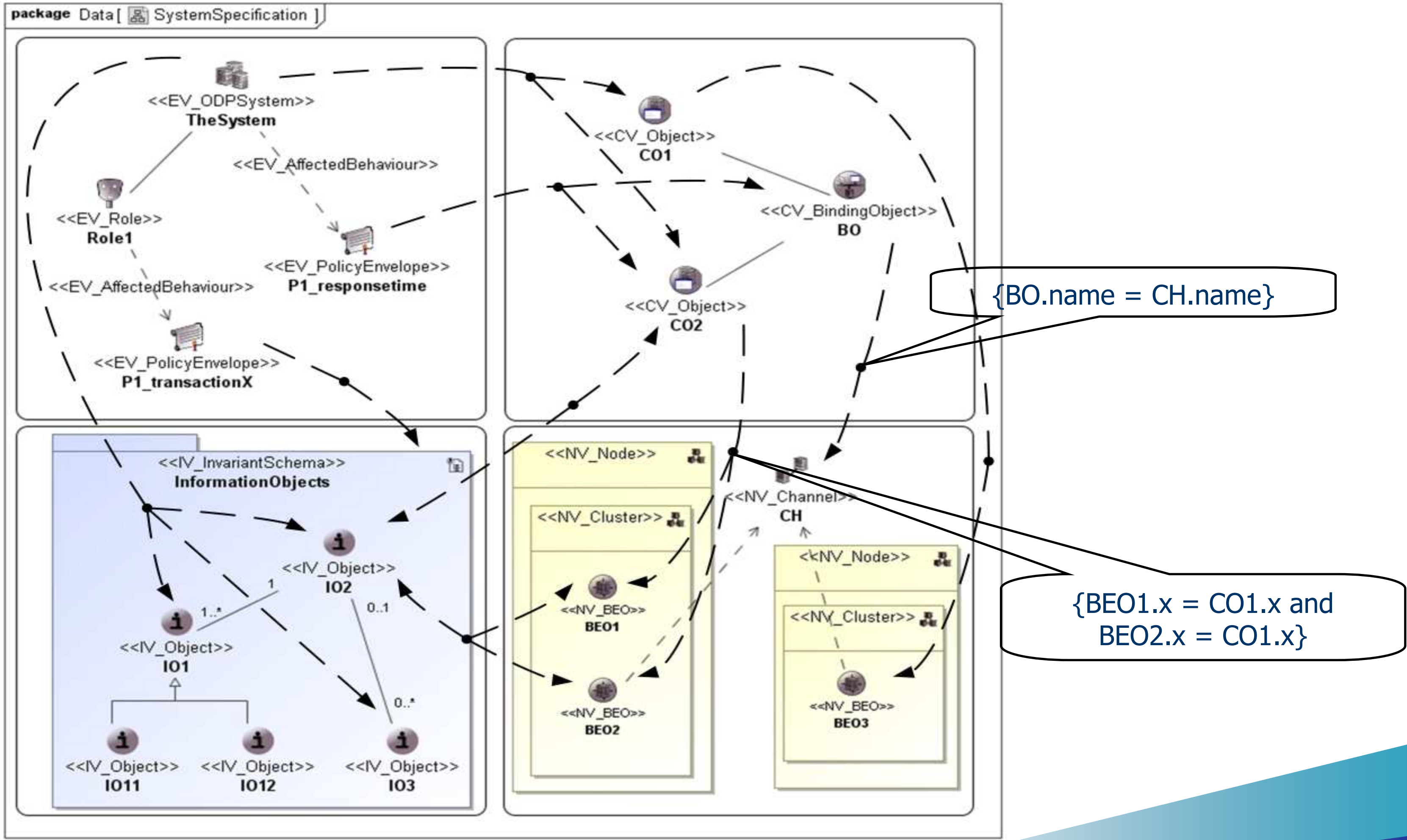
Multiviewpoint Specification

~~**Definition 1 (Initial)** *A* System Specification *consists of a set of views* $V = \{V_1, \ldots, V_n\}$*. Each view* V_i *is a model that conforms to a metamodel* $\mathcal{M}_i$ *(the viewpoint language).*~~

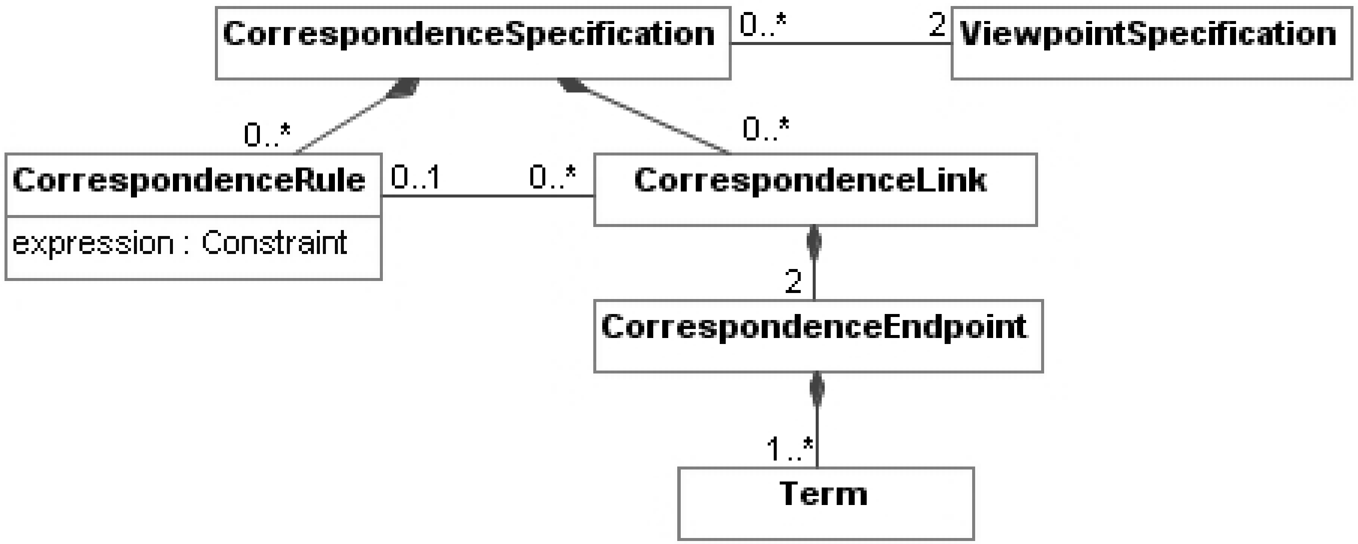
Definition 2 (With explicit correspondences) *A* System Specification *consists of a set of views* $V = \{V_1, \ldots, V_n\}$ *and a set of correspondences* $C = \{C_{(1,2)}, C_{(1,3)}, \ldots, C_{(n-1,n)}\}$ *between the views. Each view* V_i *is a model that conforms to a metamodel* $\mathcal{M}_i$ *(the viewpoint language). Correspondences are also models, and each* $C_{(i,j)}$ *conforms to a correspondence metamodel* $\mathcal{C}$*.* [1]

Correspondences

Identify sets of related elements in each view



ODP Correspondence metamodel



Expressing well-formed correspondences

Correspondences are not enough…

Definition 3 (With well-formed correspondences) *A* System Specification *consists of a set of views* $V = \{V_1, \ldots, V_n\}$, *a set of correspondences* $C = \{C_{(1,2)}, C_{(1,3)}, \ldots, C_{(n-1,n)}\}$ *between the views, and a set of rules* $R = \{r_1, \ldots, r_k\}$ *that describe the constraints that the correspondences of* C *should fulfil in order for a specification to be well-formed. Each view* V_i *is a model that conforms to a metamodel* $\mathcal{M}_i$ *(the viewpoint language). Correspondences are also models, and* $C_{(i,j)}$ *conforms to a correspondence metamodel* $\mathcal{C}$. *Rules are expressed as constraints on the correspondence elements, using any constraint language (e.g., OCL).*

Well-formed rules for correspondences

- Define constraints and invariants on the set of correspondences between the viewpoints
  - Check that the correspondences obey the ODP rules
  - Check that no correspondences are missing

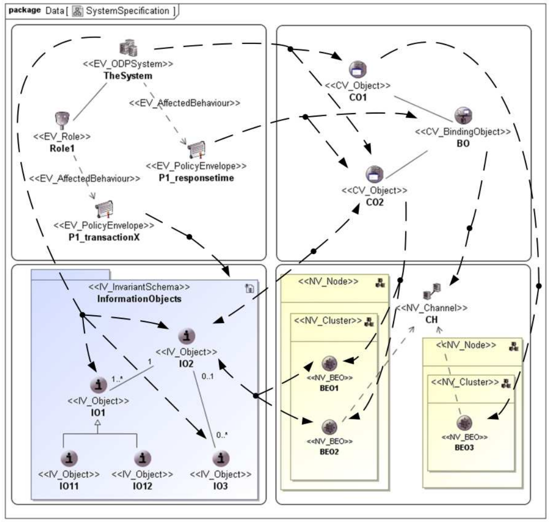
- Examples (from RM-ODP)
  - "Each computational object that is not a binding object corresponds to a set of one or more basic engineering objects (and any channels which connect them)"

```
context CorrespondenceSpecification inv:
 let CVOBJECTS = self.viewpointSpecification->
       select(o:CV_Metamodel::CV_Object | not oclIsTypeOf(CV_Metamodel::Binding)) in
 let NVOBJECTS = self.viewpointSpecification->select(n : NV_Metamodel::BEO) in
 let CORRESPONDENCES = CorrespondenceLink->allInstances()->select(…) in

  (CVOBJECTS->size()) = (CORRESPONDENCES->size()) and
  NVOBJECTS->forAll(n | CVOBJECTS->exists(o | isRelated(o,n)) and
  CVOBJECTS->forAll(o1,o2 | isRelated(o1,n) and isRelated(o2,n) implies o1 = o2)))
```

However…

- Scalability?
  - The number of correspondences does not scale
  - How to define correspondences over complete sets of elements at once?
- Usability?
  - How to deal with correspondences without obtaining cluttered and unusable models?
- Completeness
  - How do we check that all required correspondences are indeed specified?
- Expressiveness
  - How to describe the well-formed rules that the set of correspondences between views elements should obey

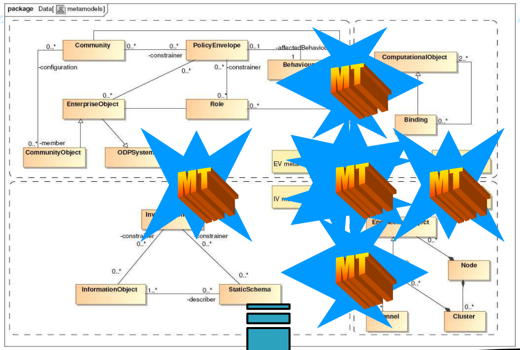


- We need better tool support for dealing with correspondences between the views
- Case studies:
  - RM-ODP; Model-Driven Web Engineering (WEI, UWE)

Our Approach

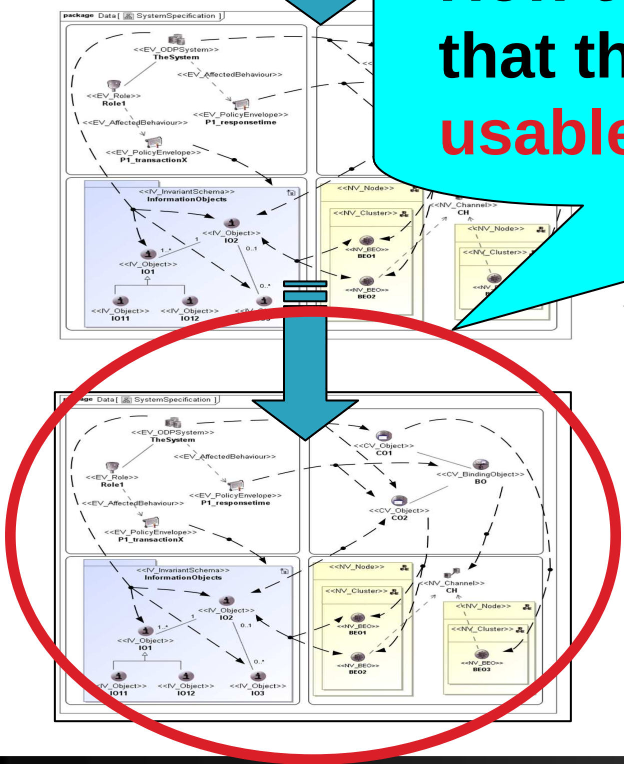
- Use QVT relations to define correspondences "intensionally"
- Generate the associated trace instances from QVT relations
- Trace instances can then be transformed to correspondenceSpecifications at model level (i.e., correspondences are given "extensionally")
- Well-formed rules are then checked against this full specification at model level
- The user normally works at the two levels!!!

Some issues



The user defines Relations at metamodel level

How to present them to the user so that they become manageable and usable?

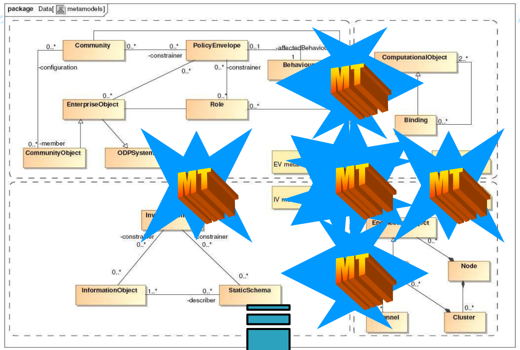


Transformation into correspondenceSpecifications

The final model with all correspondences!

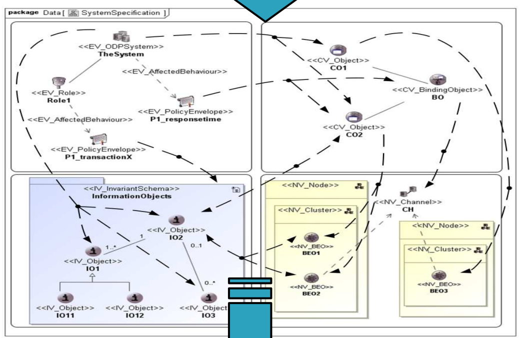
Well-formed rules are then checked in the set of correspondences

Some issues



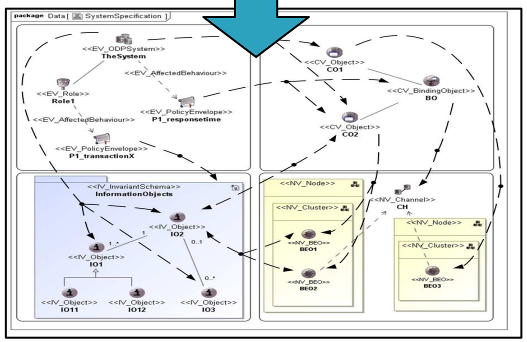
The user defines Relations at metamodel level

Generation of Trace instances



How to express the well-formed rules at the meta-model level?

Transformation into correspondenceSpecifications



The final model with all correspondences!

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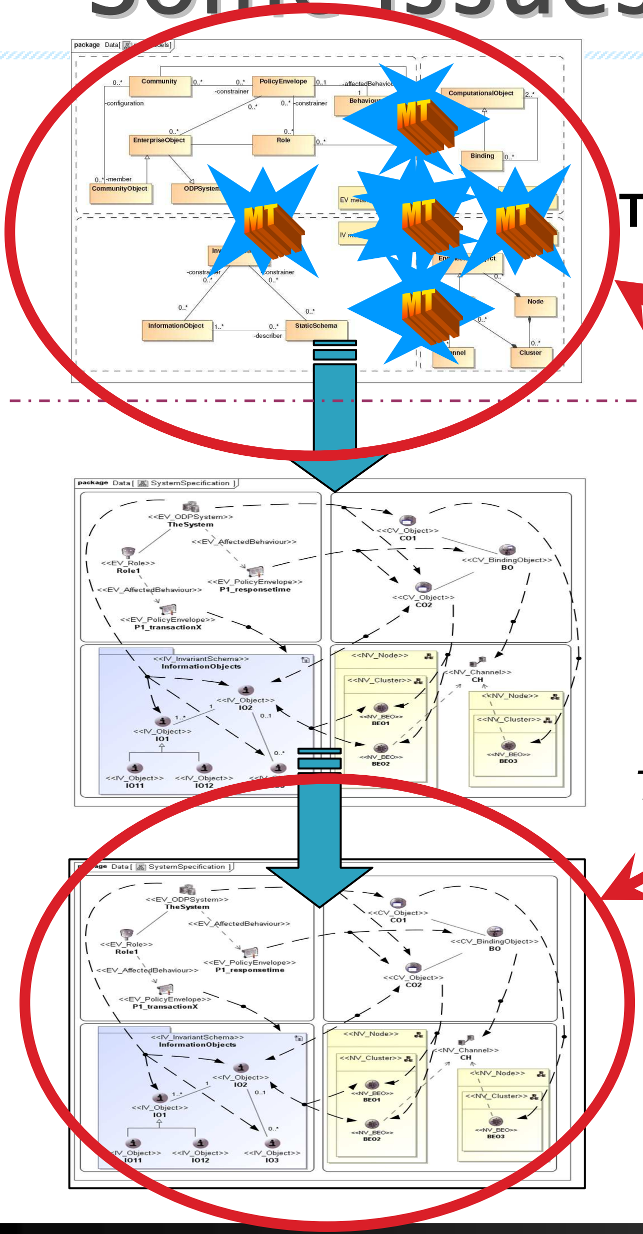
Some issues



The

How to synchronize the correspondences and the QVT transformations above?

Generation of Trace instances

Transformation into correspondenceSpecifications

The final model with all correspondences!

Well-formed rules are then checked in the set of correspondences

And now?

- Suppose that we already count on a tool for expressing correspondences between views…

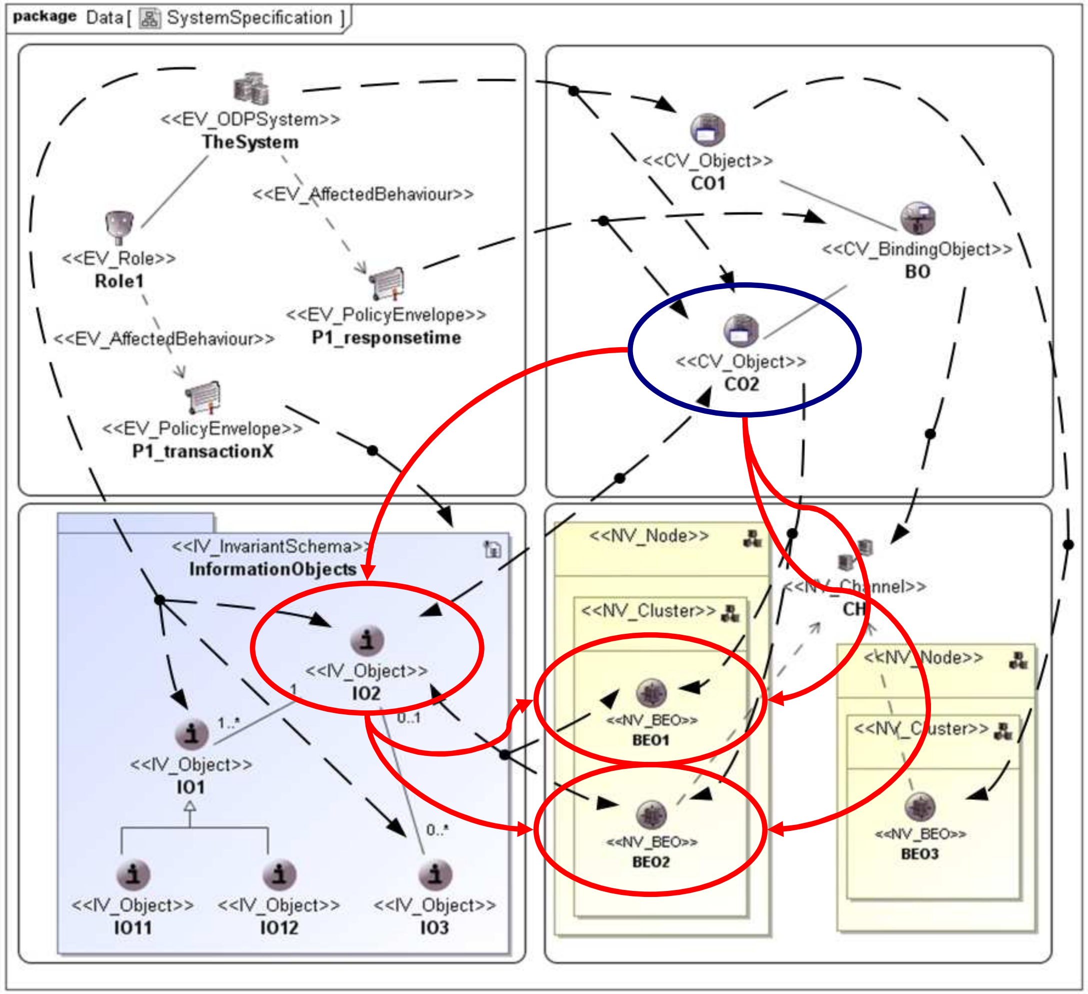
- What can I use it for?

Viewpoint synchronization(*)

- During its life cycle, a software system evolves and its specification changes
  - The specification of a view should not conflict with the specification of another view
  - A modification in a view may induce a modification in another views to preserve consistency
- One solution is the adoption and implementation of synchronization mechanisms able to propagate the changes on the related views

(*) Joint work with Alfonso Pierantonio and Romina Eramo

Change propagation



Eventual talk (20 min)

- Eventual talk (20 min.)
  - “Viewpoint correspondences: realization and other open issues”

- Alternatively: participate on a discussion on
  - “Viewpoint correspondences: realization and other open issues”

modeltransformation

INTERNATIONAL CONFERENCE ON MODEL TRANSFORMATION (ICMT) 2009

Theory and Practice of Model Transformations

Co-located with TOOLS EUROPE 2009

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http://www.model-transformation.org/ICMT2009/

CALL FOR PAPERS

Modelling is now essential for dealing with the complexity of IT systems during their development and maintenance processes. Models allow engineers to precisely capture relevant aspects of a system from a given perspective and at an appropriate level of abstraction. As models grow in use for developing IT systems, transformations between models grow in importance. Model transformations allow the definition and implementation of operations on models, and also provide a chain that enables the automated development of a system from its corresponding models. Furthermore, model transformations may also be realized using models, and are, therefore, an integral part of any model-driven approach.

There are already several proposals for model transformation specification, implementation, and execution, which are beginning to be used by Model-Driven Engineering (MDE) designed to inform the community of the state-of-the-art in tooling for model transformation.

ICMT 2009 participants will explore the practical problems of existing languages, tools, and environments for transforming models, and discuss the new challenges ahead. In particular, the conference will address questions about the nature and features of model transformations, their composability and combination to build new model transformations and implement high-level model management operations (e.g., merge, union, difference). The conference will also address the classification of languages for expressing transformations, the measurement of the quality and extra-functional requirements of model transformations (e.g., scalability, robustness, adaptability, reusability), and the definition of development methodologies that allow exploiting all their potential benefits. A special interest of the conference is on the relationships between model transformation theory and

Thanks!

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