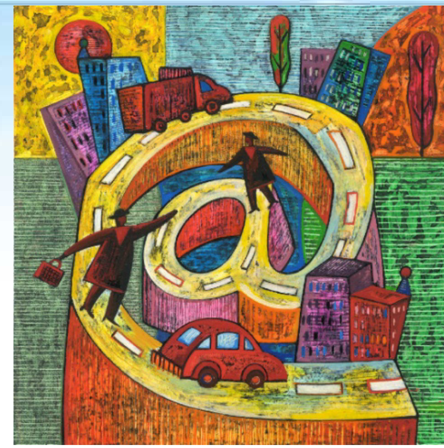


# Assigning Meanings to Models


Antonio Vallecillo

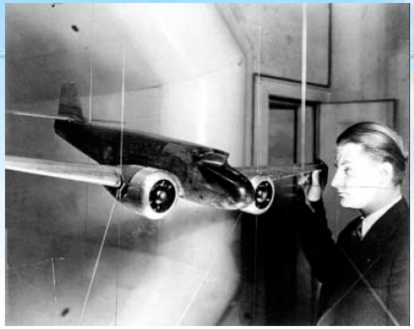
Francisco Durán, José E. Rivera

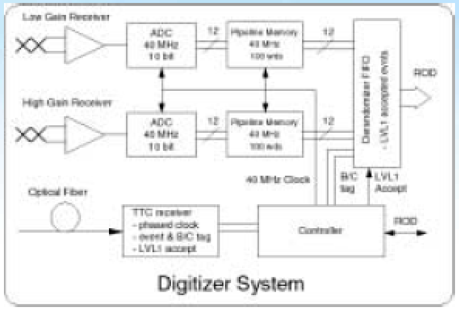
Atenea Research Group

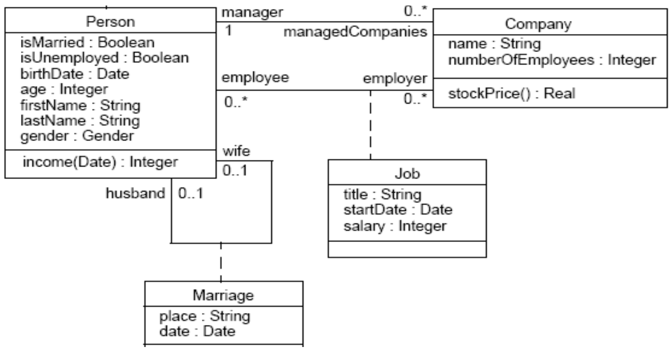

MtATL 2009. Nantes, July 8 2009

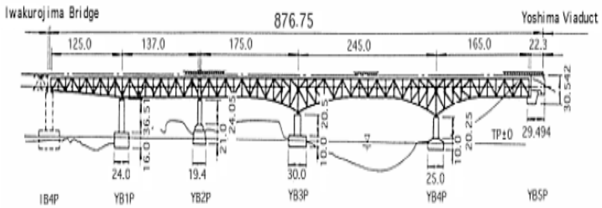
# Models

```
package VerySimpleStateMachine {
    class StateMachine {
        reference initialState [0-1] : State;
        reference containedState [*] container : State oppositeOf
        stateMachine;
    }
    class State {
        attribute name : String;
        reference stateMachine : StateMachine
                oppositeOf containedState;
        reference incoming [*] : Transition oppositeOf target;
        reference outgoing [*] : Transition oppositeOf src;
    }
    class Transition {
        attribute name : String;
        reference target : State oppositeOf incoming;
        reference src : State oppositeOf outgoing;
    }
}
```

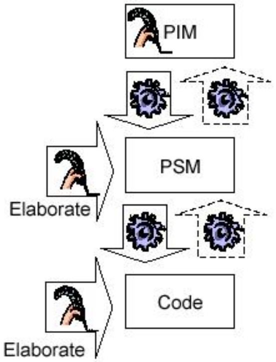


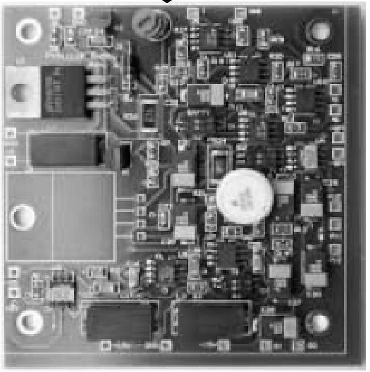


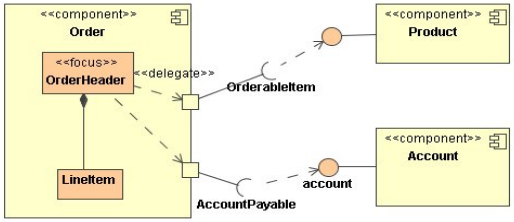




Elaborationist





# Model ~ Description



- “**A description or specification of a system and its environment for some certain purpose.** A model is often presented as a combination of drawings and text. The text may be in a modeling language or in a natural language.“ [MDA guide (V1 and 2, ab/2003-01-03, 23 January, 2003)]
- "**A model represents some concrete or abstract thing of interest, and does so with a specific purpose.** A model is related to the thing it represents by explicit or implicit correspondences between the elements of that model and the parts of that thing. This correspondence enables understanding the intended meaning of that model.” [MDA Guide (V3, ormsc/05-11-03, 30 November 2005)]
- "**A model captures a view of a physical system. It is an abstraction of the physical system, with a certain purpose.** This purpose determines what is to be included in the model and what is irrelevant. Thus the model completely **describes** those aspects of the physical system that are relevant to the purpose of the model, at the appropriate level of detail." [UML Superstructure 2.1.1 (formal/2007-02-05)]
- "**A description of (part of) a system written in a well-defined language**." (NOTE: Equivalent to specification.) [Kleppe, 2003]
- "**A representation of a part of the function, structure and/or behavior of a system**” [Model Driven Architecture (MDA) ormsc/2001-07-01]
- "**A set of statements about the system**.“ (Statement: expression about the system that can be true or false.) [Seidewitz, 2003]
- "**M is a model of S if M can be used to answer questions about S**" [D.T. Ross and M. Minsky, 1960]

# Model

http://www.merriam-webster.com/dictionary/model

1: obsolete : a set of plans for a building
2: dialect British : copy, image
3: structural design *<a home on the model of an old farmhouse>*
4: a usually miniature representation of something ; also : a pattern of something to be made
5: an example for imitation or emulation
6: a person or thing that serves as a pattern for an artist ; especially : one who poses for an artist
7: archetype
8: an organism whose appearance a mimic imitates
9: one who is employed to display clothes or other merchandise
10 a: a type or design of clothing b: a type or design of product (as a car)

11: a description or analogy used to help visualize something (as an atom) that cannot be directly observed

12: a system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs; also: a computer simulation based on such a system *<climate models>*

13: version
14: animal model

# Meaning

http://www.merriam-webster.com/dictionary/meaning

1 a: the thing one intends to convey especially by language: **purport**

1 b: the thing that is conveyed especially by language: **import**

2: something meant or intended: **aim**
*<a mischievous meaning was apparent>*

3: significant quality; especially: implication of a hidden or special significance *<a glance full of meaning>*

4 a: the **logical connotation** of a word or phrase

4 b: the **logical denotation** or extension of a word or phrase

# Semantics

- 1: *the study of meanings* [Merrian-Webster]

  a: the historical and psychological study and the classification of changes in the signification of words or forms viewed as factors in linguistic development

  b (1): semiotic (2): a branch of semiotic dealing with the relations between signs and what they refer to and including theories of denotation, extension, naming, and truth

- Formal semanticists are concerned with the *modeling of meaning in terms of the semantics of logic*. In computer science, where it is considered as an application of mathematical logic, *semantics reflects the meaning of programs or functions* [wikipedia]

# Models

10

# Sure?

"There are only 10 types of people in the world: Those who understand binary, and those who don't"

# Same model for different concepts

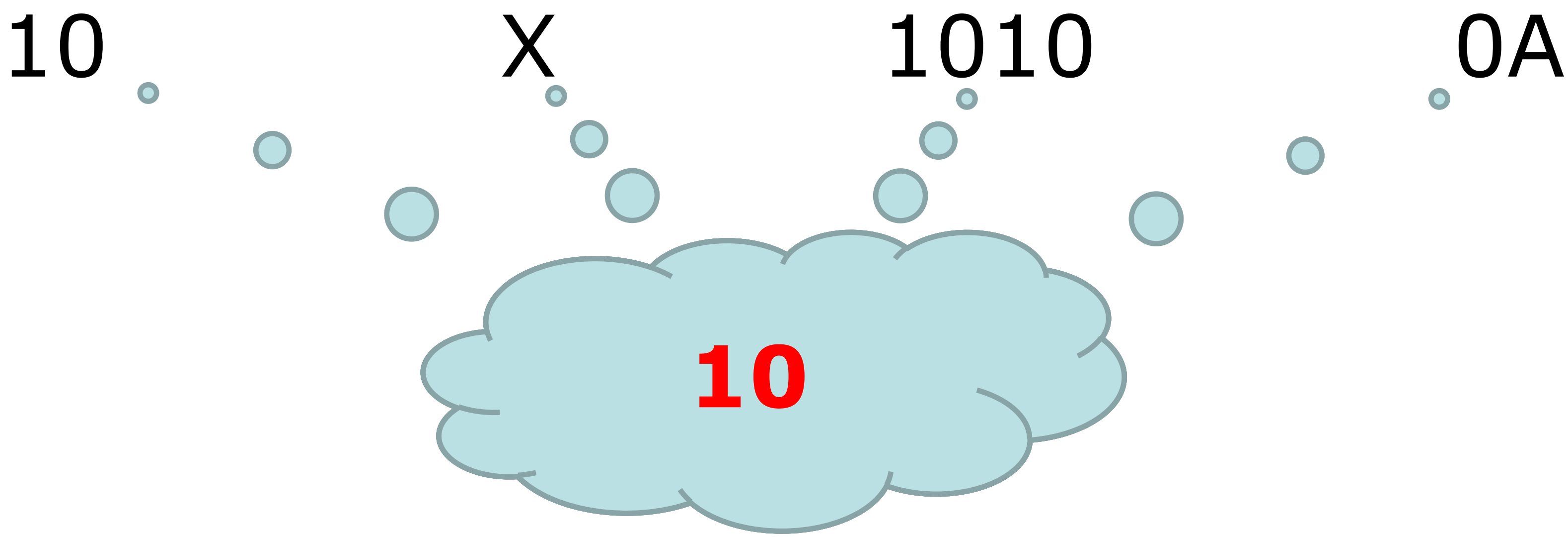
**10**

**2**

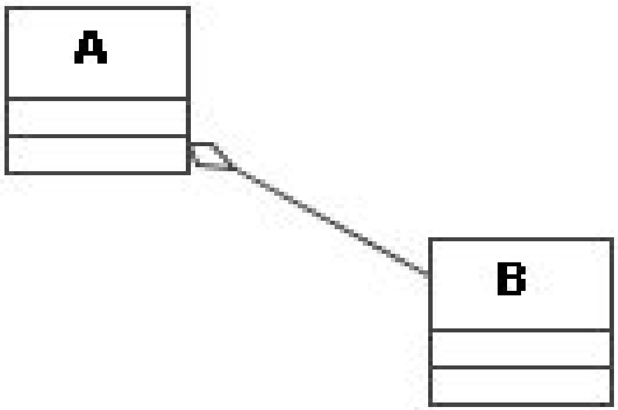
10

**Your meaning goes here…**

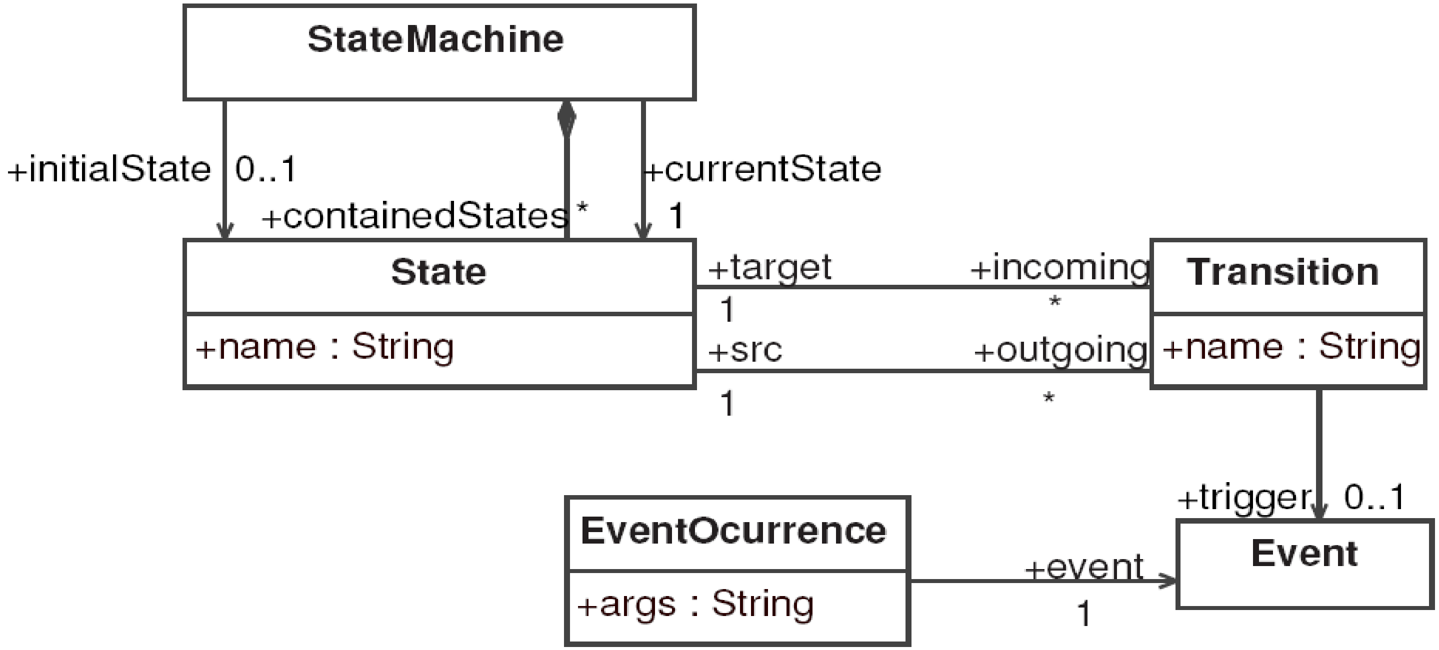
# Different models for the same concept

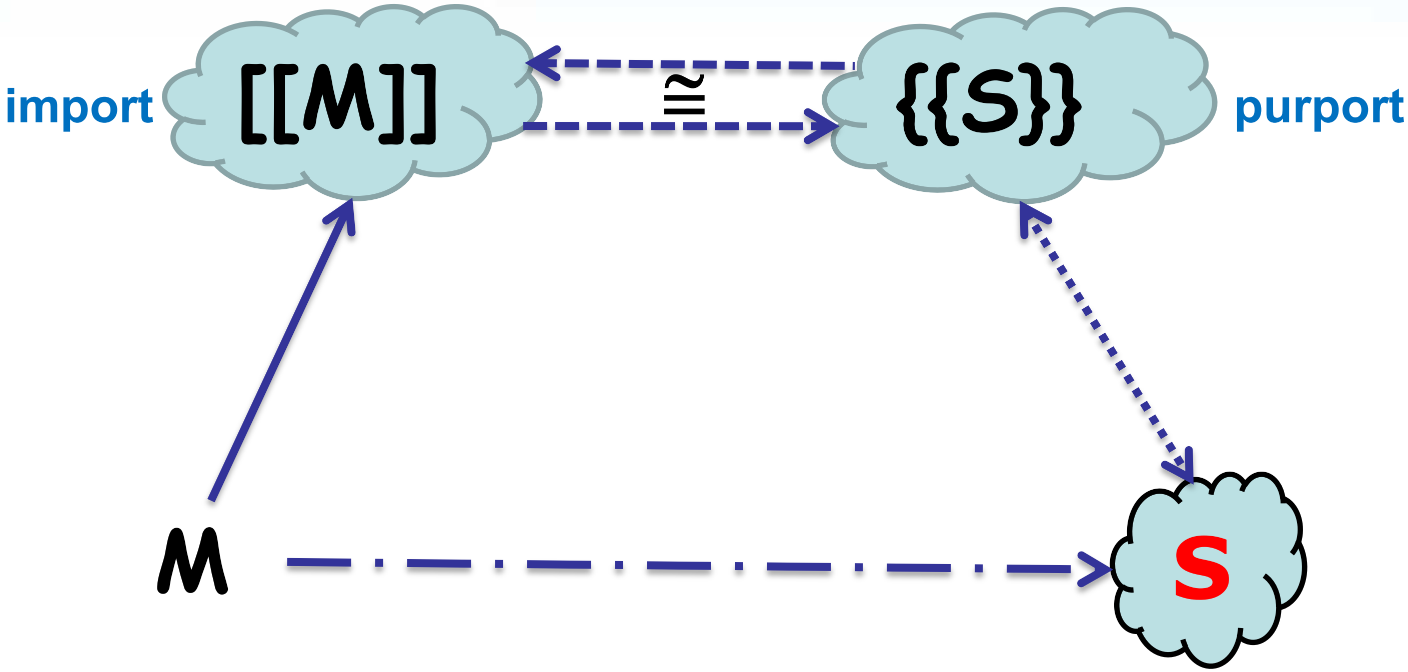


# What does this model mean?



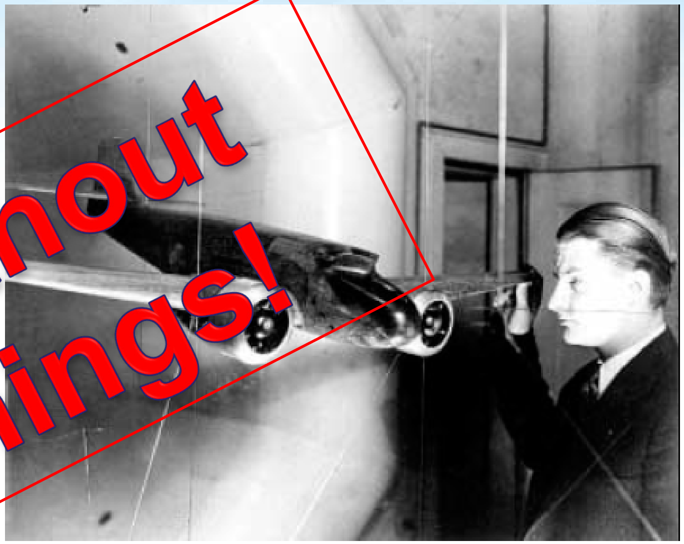
# What does this model mean?




import
[[M]]
≅
{{S}}
purport
M
S

# Why do I need to assign meanings to models?

- What do I need models for?
  - **Describe** the system
    - Structure, behaviour, ...
    - Separate concepts at different conceptual levels
    - Communicate with stakeholders
  - **Understand** the system
    - If existing (legacy applications)
  - **Validate** the model
    - Detect errors and omissions in design ASAP
      - Mistakes are cheaper at this stage
    - Prototype the system (execution of the model)
    - Formal analysis of system properties
  - **Drive implementation**
    - Code skeleton and templates, complete programs (?)



**[Selic, 2003]**

**Impossible without precise meanings!**

# How do we assign meaning?

- How do we express the meaning of
  - Structure?
  - Behavior?
  - Time-dependent functionality?
  - QoS properties?
  - …

- Which is the best **notation** for each of those aspects?
  - It depends on the **purpose** of the model…
  - …and must have a **precise** meaning

# Domain Specific Modeling Languages

# Each notation is more apt for a task

```
      MCMLXVII              1.967
+       DLXXIX          +     579
  ------------          ---------
           ???
```

# Each notation is more apt for a task

| | | | |
|---|---|---|---|
| | MCMLXVII | | 1.967 |
| + | DLXXIX | + | 579 |
| | ??? | | 2.546 |

# Each notation is more apt for a task

| | | |
|---|---|---|
| MCMLXVII | | 1.967 |
| + DLXXIX | | + 579 |
| ✓ MMDXLVI | ← | 2.546 |

# How do you solve this problem?

- A 40-years-old man has a daughter and a son. If the difference of age between the kids is 4 years, and the sum of their ages is half of the age of the father, how old are they?

$$\left.\begin{array}{rl} x - \cancel{y} &= 4 \\ +\quad x + \cancel{y} &= 20 \end{array}\right\} \Rightarrow \begin{array}{l} x = 12 \\ y = 8 \end{array}$$

$$2x = 24$$

**Solution**: the older is 12 and the younger is 8

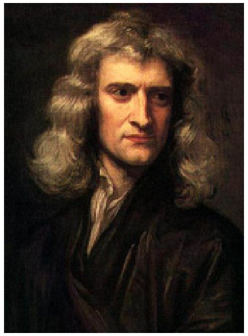
# Problems, Notations, Solutions

- An invariant through the history of mature disciplines is the search for notations that allow formulating problems in a language that allows their easy solution

$$\frac{\partial f}{\partial x_i}(a_1, \ldots, a_n) = \lim_{h \to 0} \frac{f(a_1, \ldots, a_i + h, \ldots, a_n) - f(a_1, \ldots, a_n)}{h}.$$

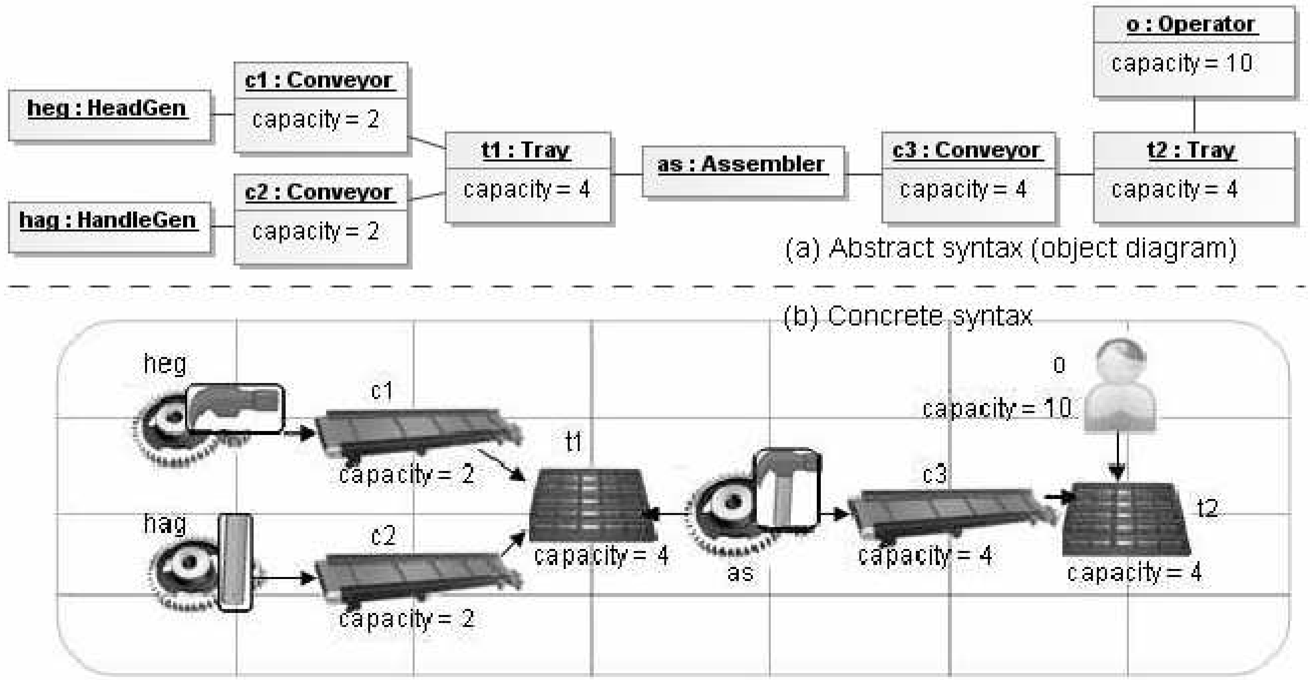
$$\vec{F} = \frac{\mathrm{d}}{\mathrm{d}t}(m\vec{v}) \qquad \int_{-N}^{N} f(x)\,dx \qquad \sum_{n=1}^{\infty} \frac{1}{n^2} \qquad \Box(p \to q) \to (\Box p \to \Box q)$$

$$\rho \left( \frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = -\nabla p + \nabla \cdot \mathbb{T} + \mathbf{f},$$

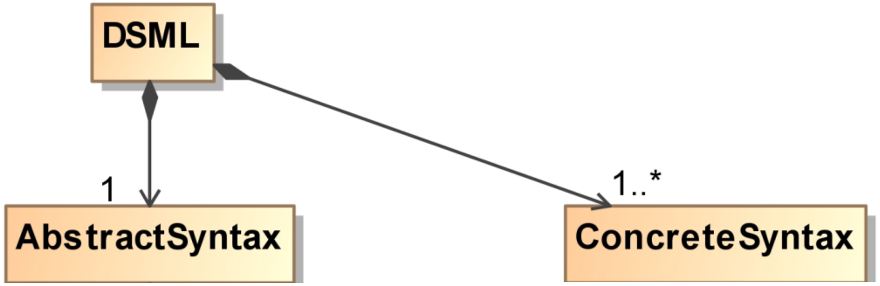


http://en.wikipedia.org/wiki/History_of_mathematical_notation
http://en.wikipedia.org/wiki/Temporal_logic

# Visual DSMLs



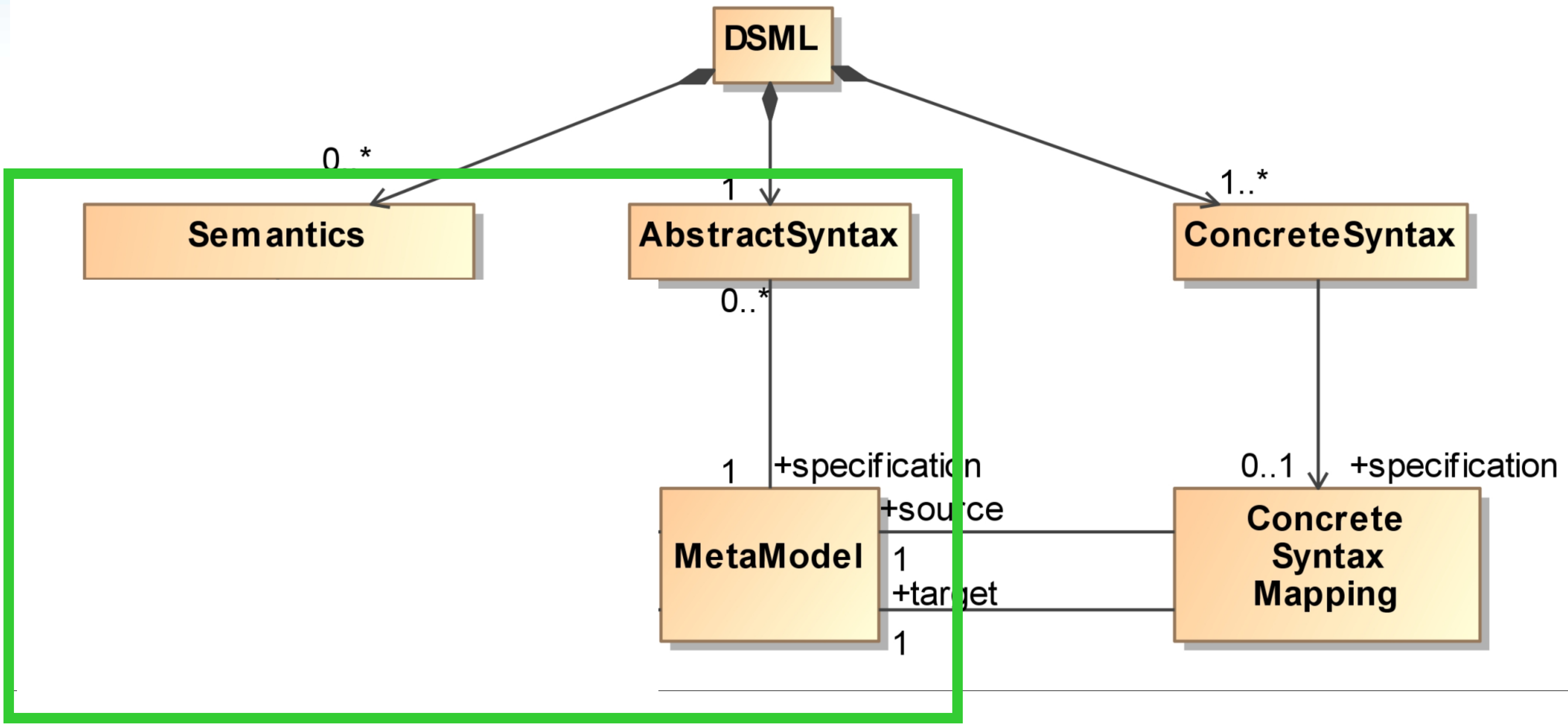
# Anatomy of a DSML (I)



# We need more than syntax…

- Describe **meaningful** models
  - At the appropriate level of abstraction
  - In a correct, complete and accurate manner
  - Using a notation natural to the target domain engineer
- **Animate** models
  - Explicitly define behavioral semantics of DSLs so that models can be understood, manipulated and maintained by both users and machines
  - Add Non-Functional Properties (Time, QoS,…) to DSLs
  - Make models amenable to simulation
- **Analyse** models
  - Connect DSLs to Analysis tools

# Anatomy of a DSML (II)

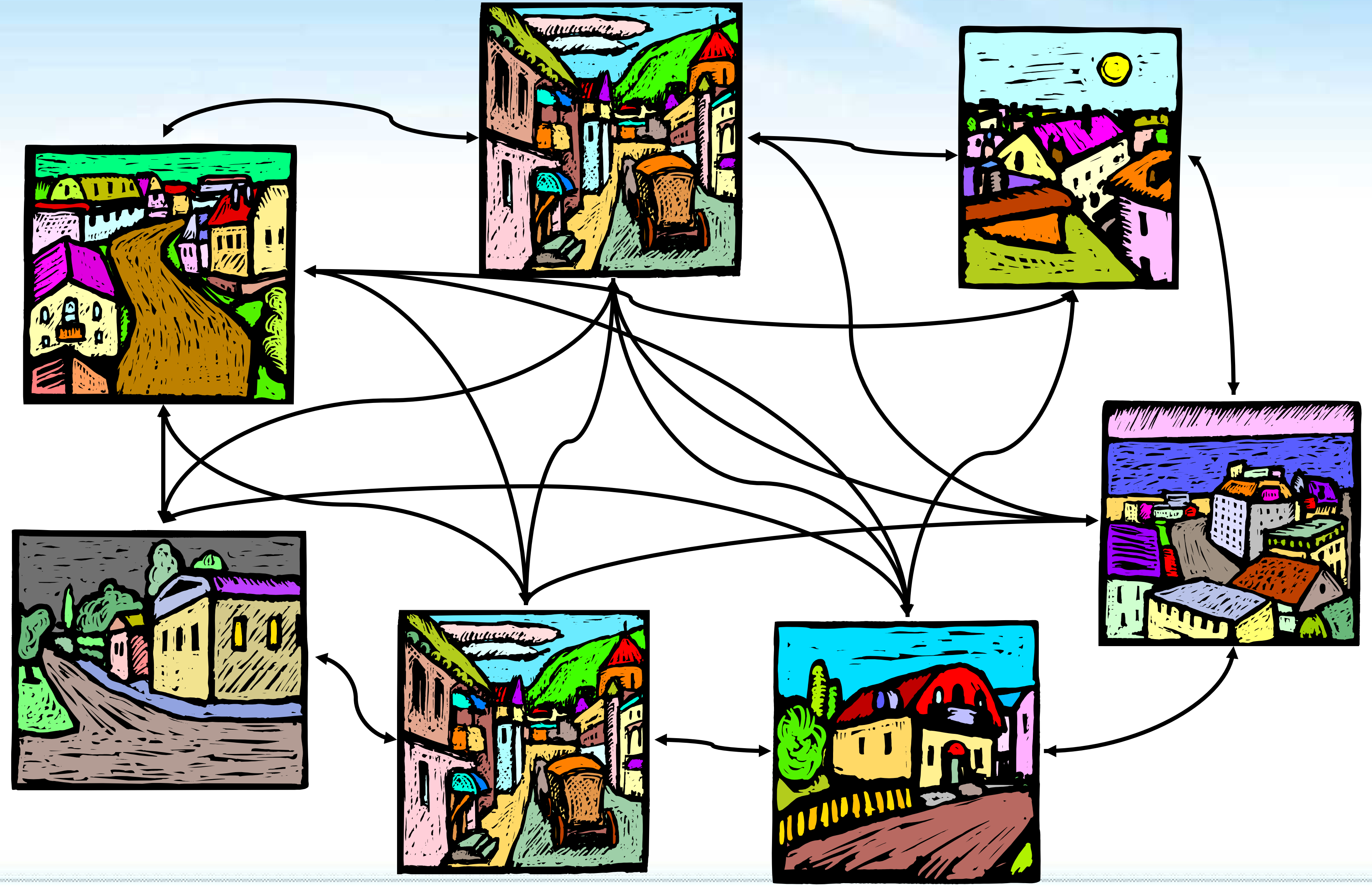


# Semantic (or "Meaningful") Domains

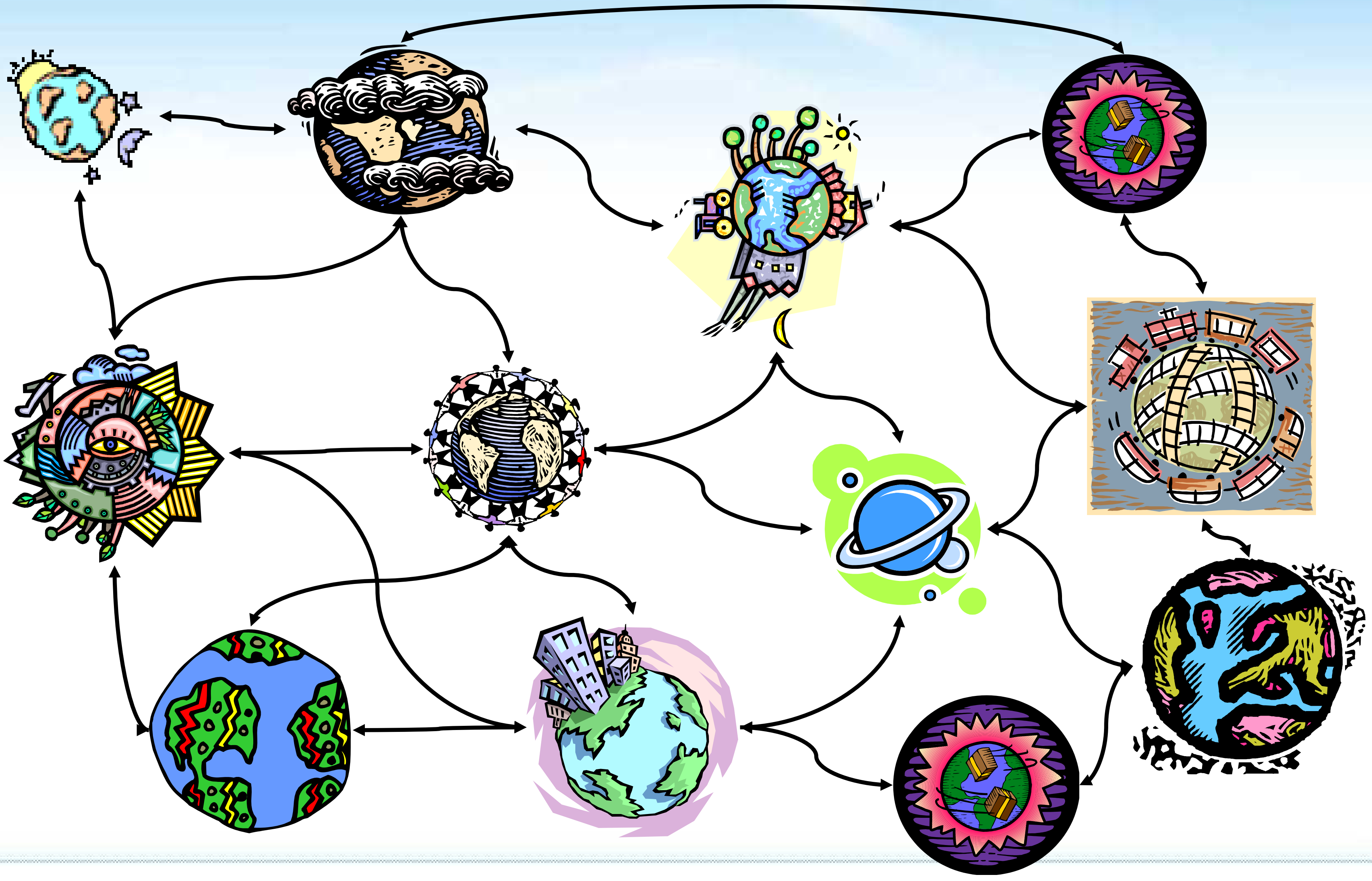
- The meaning of a model **M** in a given domain **D** is defined by its **interpretation** in a **meaningful** semantic domain **D'**.

- Each Meaningful Domain has
  - Precise semantics
  - A set of (equivalent) notations
  - A set of Analysis Tools
  - Underlying logic

# Bridges between Semantic Domains

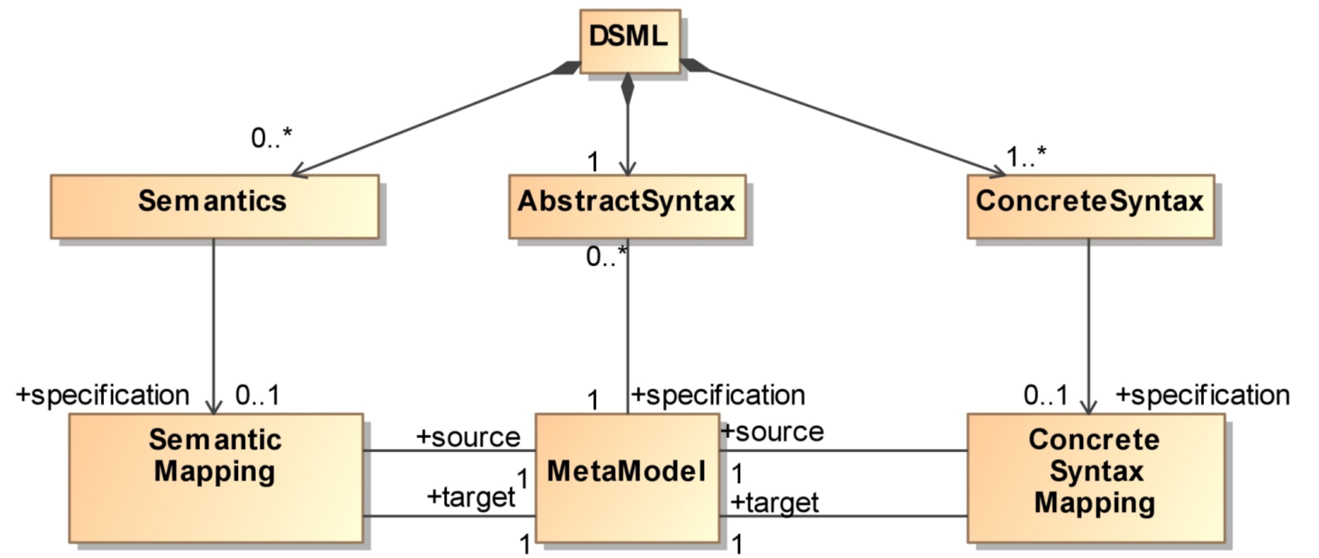


# Bridges between Semantic Domains



# How to implement Semantic Mappings?

- As Model Transformations!!!
- Types
  - Domestic
  - Horizontal
  - Vertical
  - Abstracting
  - Refining
  - Pruning
  - Forgetful
  - …

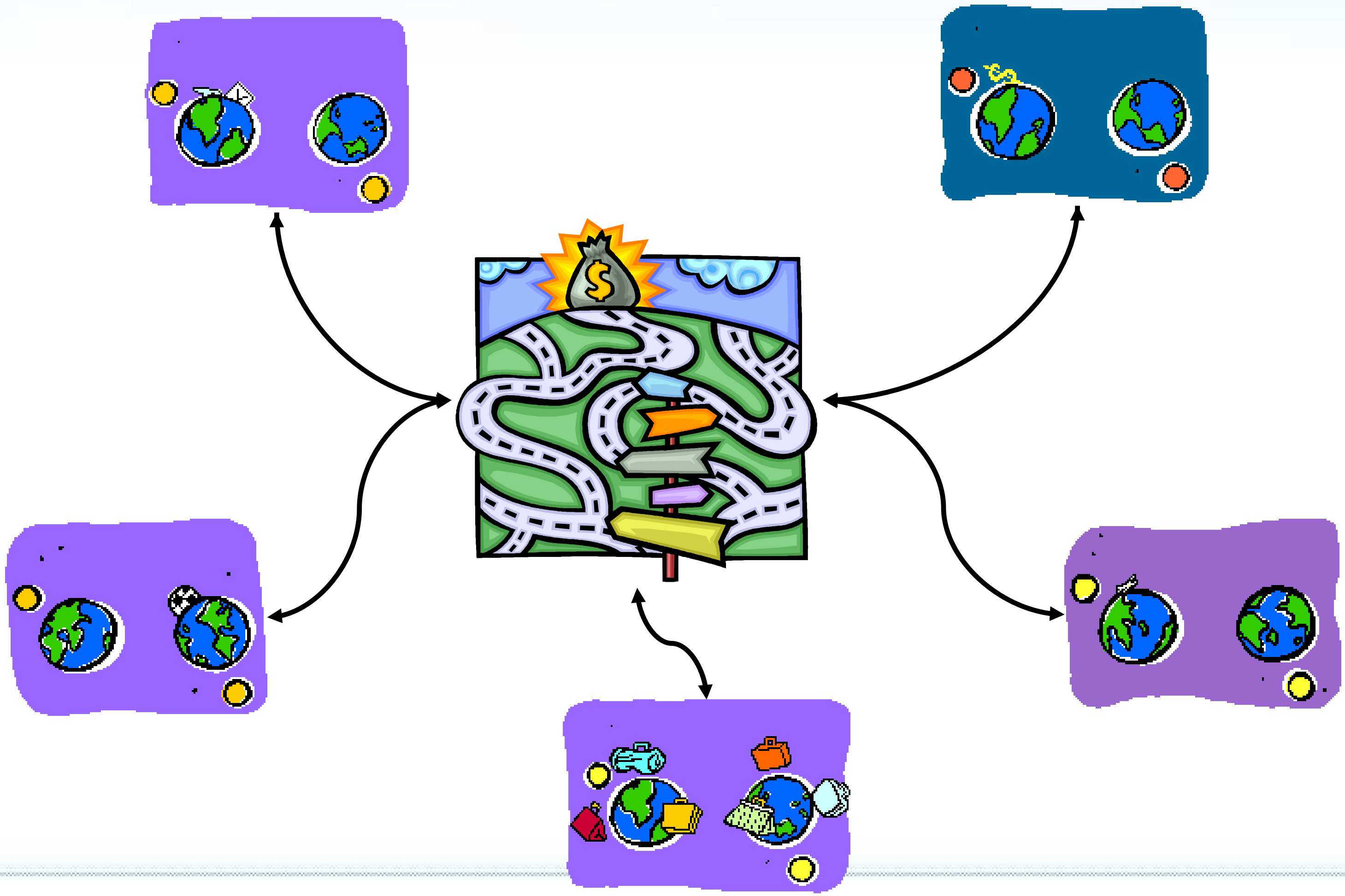



- The relationship between domains **D** and **D'** is defined by a model transformation **T:D->D'**.

$$\boxed{[[M]]_D := [[T(M)]]_{D'}}$$

# How do we analyse models?

- Crossing the bridges!!!

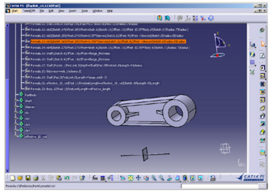


# Models to connect (analysis) tools!

## Design Tools

### MCAD Tools

*CATIA, NX, Pro/E*, …*



**Legend**

Tool Associativity

Object Re-use

### Materials Libraries

*In-House, …*

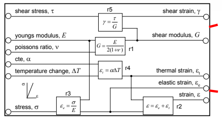
### Parts Libraries

*In-House*, …*

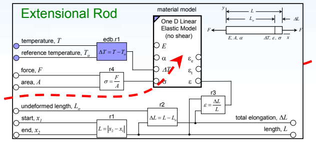
## Analysis Building Blocks *(ABBs)*

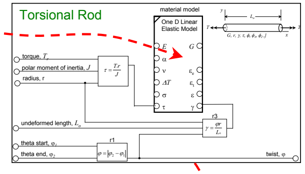
Material Model ABB:

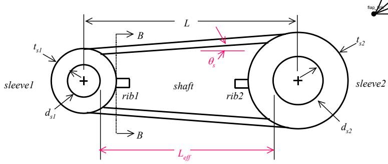
1D Linear Elastic Model

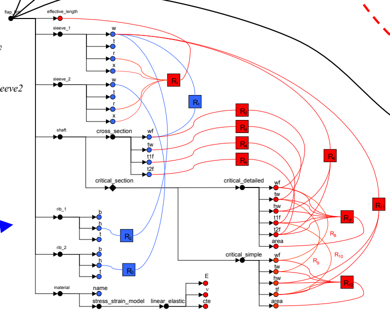


Continuum ABBs:



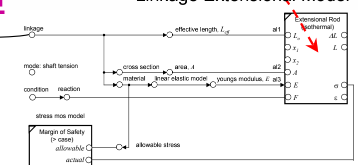
## Analyzable Product Model *(APM)*

## Analysis Templates of Diverse Behavior & *Fidelity* *(CBAMs)*

**Extension**

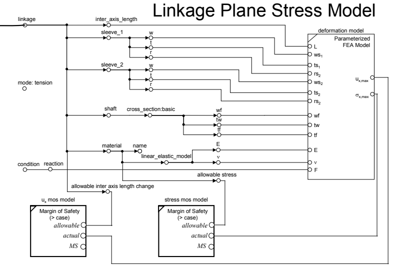
Linkage Extensional Model

**1D**



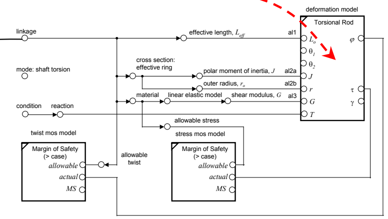
Linkage Plane Stress Model

**2D**



**Torsion**

**1D**



Linkage Torsional Model

## Analysis Solvers *(via SMMs)*

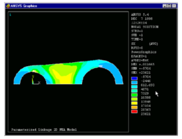
### General Math

*Mathematica*

*Matlab**

*MathCAD**

…



### FEA

*Ansys*

*Abaqus**

*CATIA Elfini**

*MSC Nastran**

*MSC Patran**

*NX Nastran**

…

* = Item not yet available in toolkit—all others have working examples 2007-04

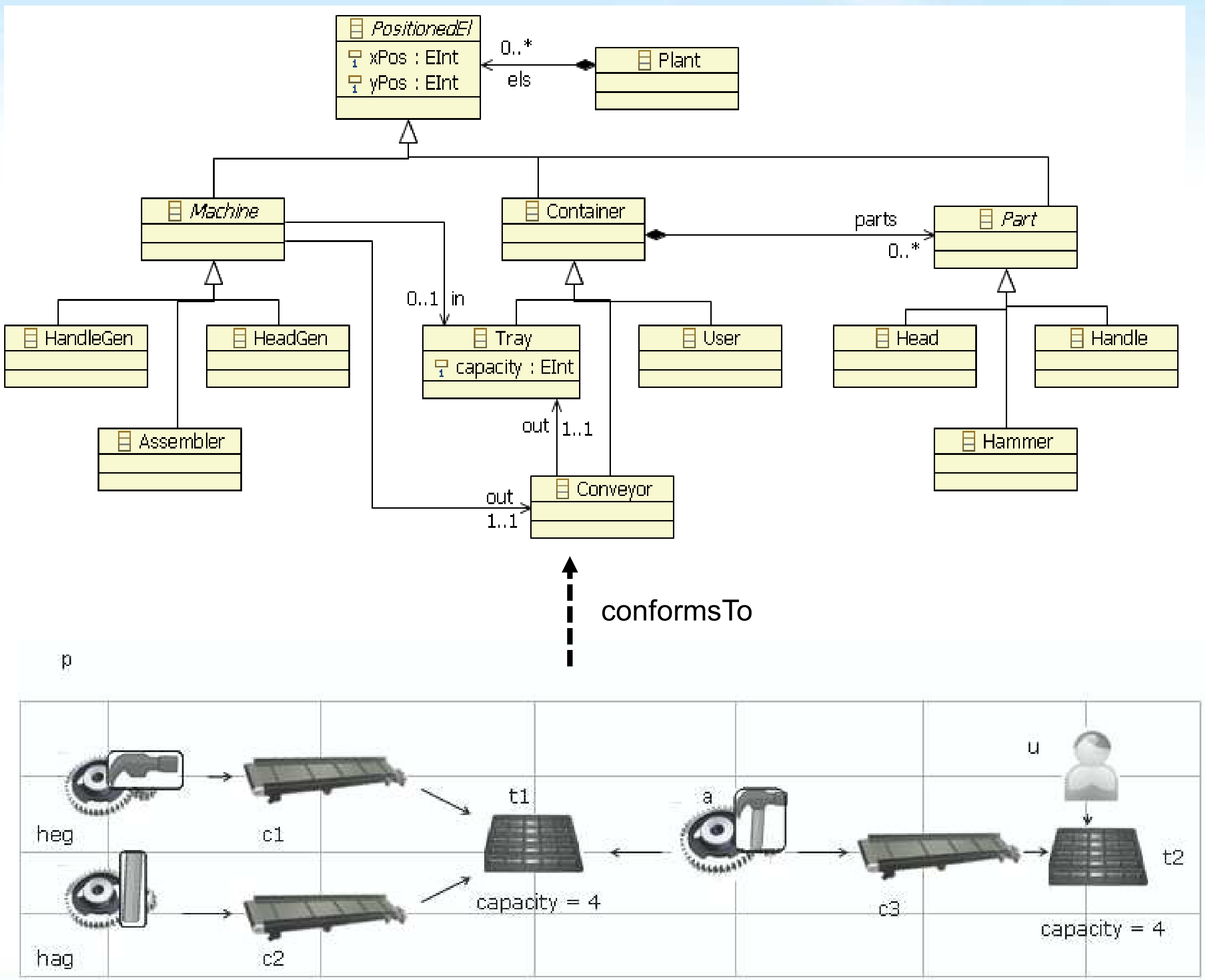
# Assigning Meanings to Models

(Using model transformations)

# Our proposal

- Specify the **structure** of Models/Metamodels with usual modeling notation and tools (Ecore, EMF, GMF, …)
- Specify the **behavior** of models using visual languages (including Time and QoS aspects)
- Specify the **structure** of models and metamodels using a formal system, i.e., a precise Semantic Domain (e.g., Maude)
- Specify the **behavior** of models using a formal system, i.e., in a Formal Semantic Domain (e.g., Maude)
- Define **mappings** between the visual and formal notations (the latter provides the meaning for the former)
- Make use of the **analysis tools** in the target domain to reason about the visual models

# A Production System Example

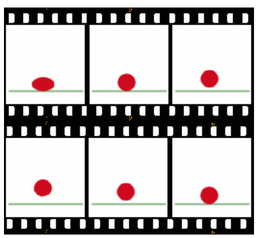


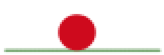
# Specifying dynamic behavior

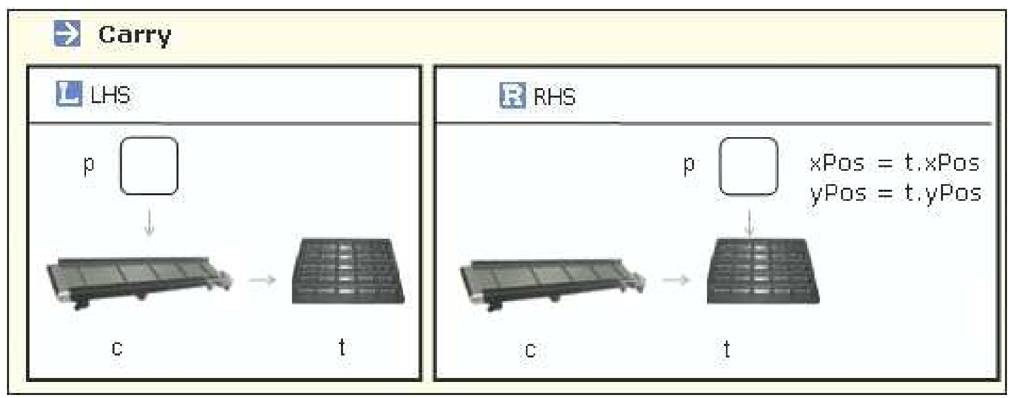
- Use of In-place Transformation Rules (e.g., graph transformations)
- Completely Independent from the underlying semantic framework (e.g., Maude)

e-Motions!

$$l{:}[NAC] \text{ x } LHS \rightarrow RHS$$

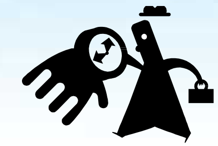




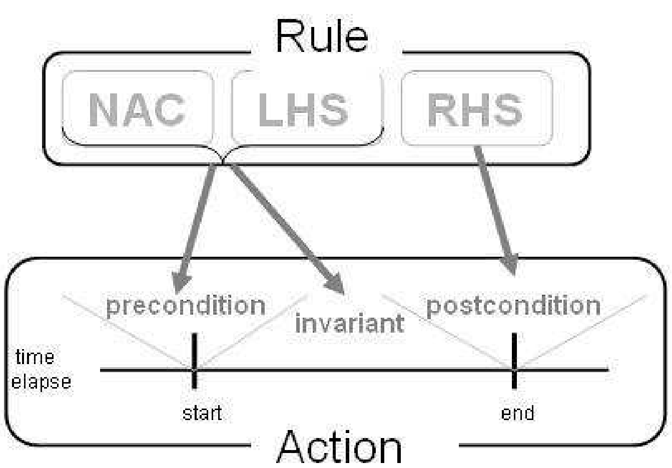


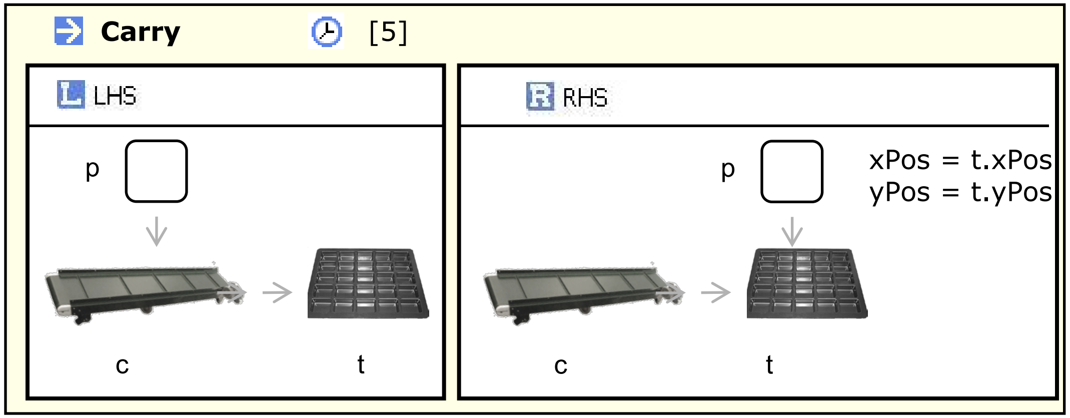
# Adding time to behavioral specifications

- Part of the e-Motions modeling notation
- Rule duration 
- Periodicity, soft scheduling
- Ongoing rules
- Access to the Global Time Elapse
  - Time stamps, scheduled actions



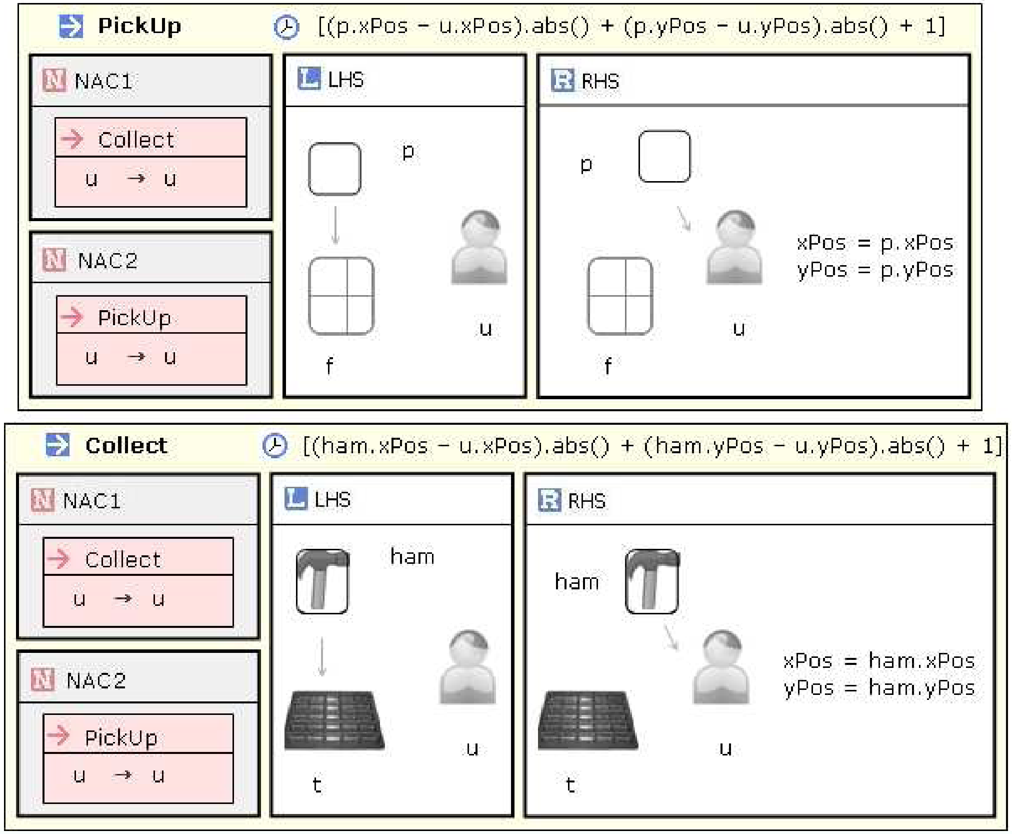
$$l\text{:}[NAC] \times LHS \xrightarrow{t} RHS$$

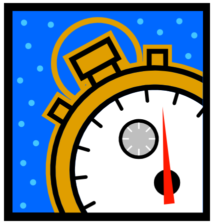


# Adding action executions

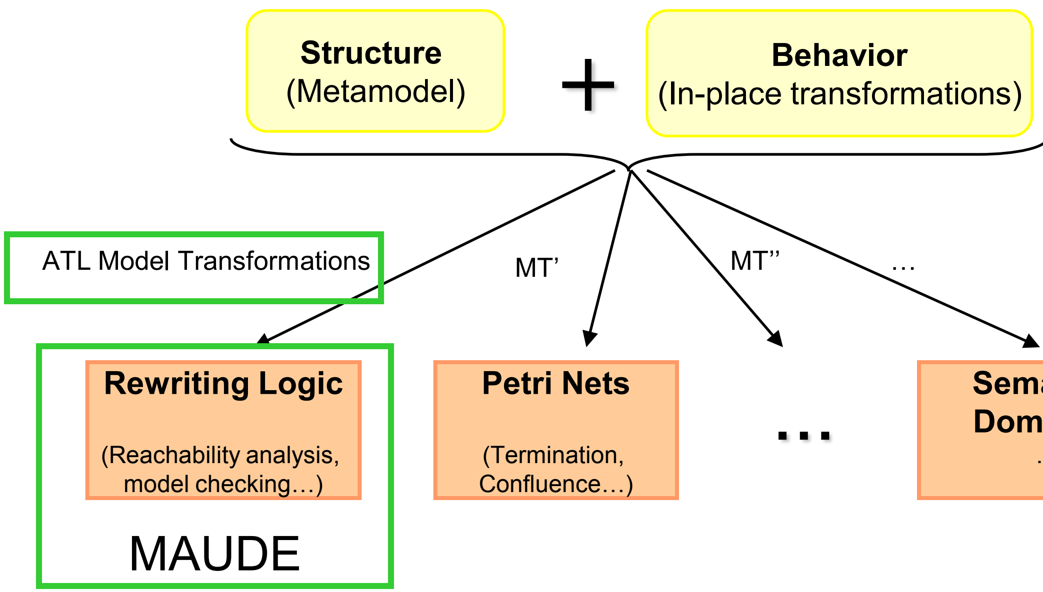
- Specification of action properties
  - Withouth the need of unnaturally modifying the metamodel



# Bridges between Semantic Domains

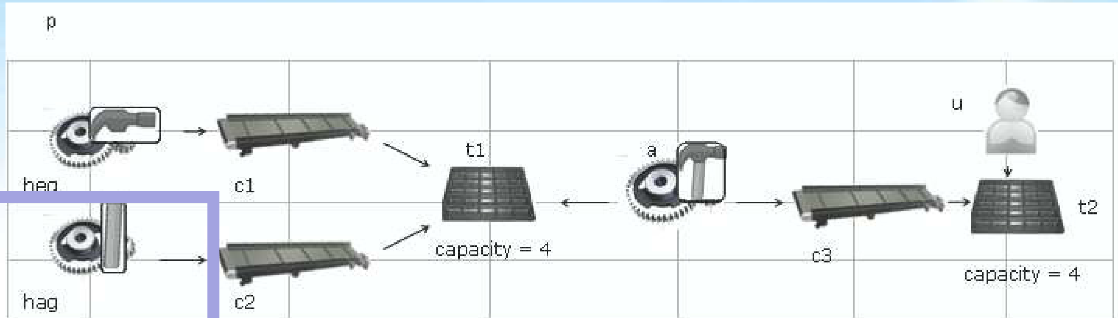
- Precise semantics
- A set of Analysis Tools
- Underlying logic




e-Motions

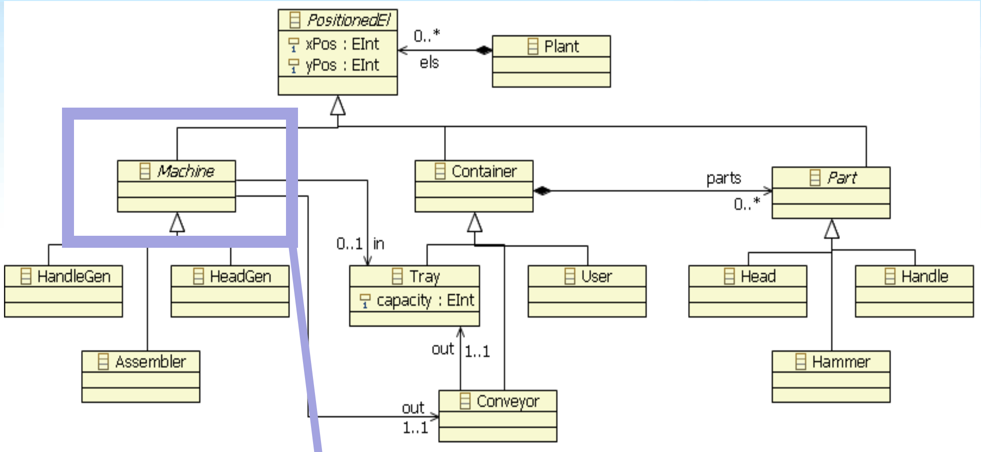
MAUDELING

# Representing Models with Maude




```
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 >
}
```

# Representing Metamodels with Maude



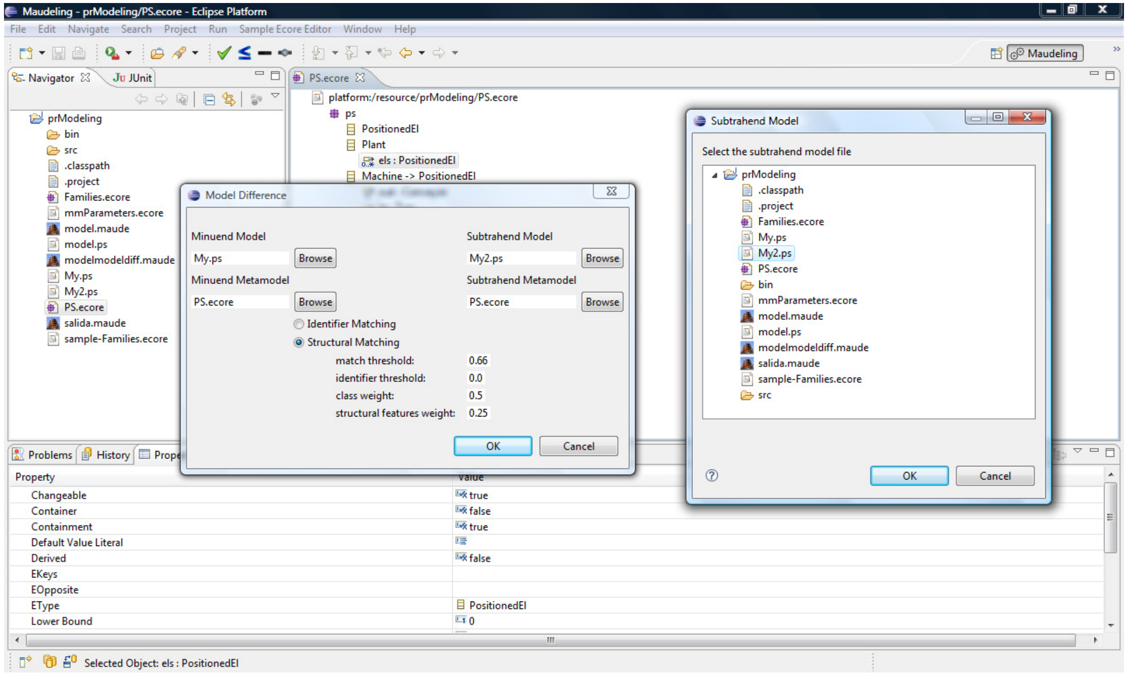

```
op ProductionSystem : -> @Metamodel .

op PS : -> @Package .

sort PositionedEl .
subsort PositionedEl < @Class .
op PositionedEl : -> PositionedEl .
  op xPos : -> @Attribute .
  op yPos : -> @Attribue .

sort Container .
subsort Container < PositionedEl .
op Container : -> Container .
  op parts : -> @Reference .

sort Machine .
subsort Machine < PositionedEl .
op Machine : -> Machine .
  op in : -> @Reference .
  op out : -> @Reference .

…
```

```
eq isAbstract(Machine) = true .
...
eq type(in) = Tray .
eq lowerBound(in) = 0 .
eq upperBound(in) = 1 .
...
eq type(out) = Conveyor .
eq opposite(out) = null .
eq lowerBound(out) = 1 .
eq upperBound(out) = 1 .
```

# Model management

- Model difference
- Model subtyping
- Model metrics
- …

MAUDELING

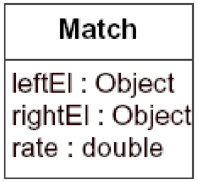



http://atenea.lcc.uma.es/index.php/Main_Page/Resources/Maudeling

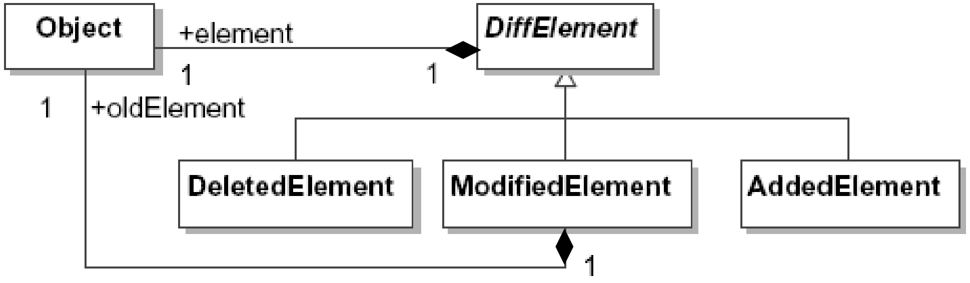
# Model difference: Comparison process

[TOOLS 2008]

- Matching
  - Finding different objects from both models that represent the same element
  - Model as a result
  - Persistent identifiers vs. structural similarities

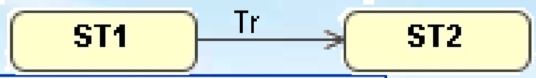



- Differencing:
  - Makes use of matching models to detect modified elements
  - Model as a result



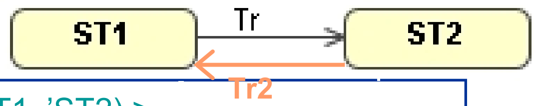

✓Self-contained
✓Compact
✓Independent of the metamodel of the source models

# A Model Difference Example




## (Subtrahend Model)

< ’SM : StateMachine | initialState : ’ST1, containedStates : (’ST1, ’ST2) >
< ’ST1 : State | name : "St1", stateMachine : ’SM, outgoing : ’TR, incoming : empty >
< ’ST2 : State | name : "St2", stateMachine : ’SM, outgoing : empty, incoming : ’TR >
< ’TR : Transition | name : "Tr", src : ’ST1, target : ’ST2 >




## (Minuend Model)

< ’SM : StateMachine | initialState : ’ST1, containedState : (’ST1, ’ST2) >
< ’ST1 : State | name : "St1", stateMachine : ’SM, outgoing : ’TR, incoming : **‘TR2** >
< ’ST2 : State | name : "St2", stateMachine : ’SM, outgoing : **’TR2**, incoming : TR >
< ’TR : Transition | name : "Tr", src : ’ST1 , target : ’ST2 >
**< ’TR2 : Transition | name : "Tr2", src : ’ST2 , target : ’ST1 >**

## (Difference Model)

**< 'ST1@MOD : ModifiedElement | element : 'ST1@NEW, oldElement : 'ST1@OLD>**
**< 'ST1@NEW : State | incoming : 'TR2 >**
**< 'ST1@OLD : State | incoming : empty >**
**< 'ST2@MOD : ModifiedElement | element : 'ST2@NEW, oldElement : 'ST2@OLD >**
**< 'ST2@NEW : State | outgoing : 'TR2 >**
**< 'ST2@OLD : State | outgoing : empty >**
**< 'TR2@ADD : AddedElement | element : 'TR2@NEW >**
**< 'TR2@NEW : Transition | name : "Tr2", src : 'ST2, target : 'ST1 >**

# Difference related operations

[TOOLS 2008]

- Operation ***do***
  - do(*Ms*, *Md*) = *Mm*
  - Applies to a model all the changes specified in a difference model
- *Operation* ***undo***
  - undo(*Mm*, *Md*) = *Ms*.
  - Reverts all the changes specified in a difference model

**undo(do(Ms, Md), Md) = Ms** **do(undo(Mm, Md), Md) = Mm**

- Sequential composition of differences
  - “Optimize" the process of applying successive modifications to the same model

# Model subtyping

[JOT 2007]

- Model type
  - Essentially its metamodel
- Model subtyping
  - Model operations reuse (megamodeling)
  - Type safety
  - Polimorphism in MDSD
  - *Model bus*, *metamodel matchmaking*, metamodel evolution

# Model subtyping

[JOT 2007]

- Metamodels M', M: $M' \leq M \leftrightarrow$ :

  $\forall K \in \{M.package\}\ \exists K' \in \{M'.package\} \bullet (K' \leq K)$

- Packages K', K: $K' \leq K \leftrightarrow$ :

  $isRelated(K'.name, K.name)\ \wedge$

  $\forall C \in \{K.class\}\ \exists C' \in \{K'.class\} \bullet (C' \leq C)$

- Classes C', C: $C' \leq C \leftrightarrow$ :

  $isRelated(C'.name, C.name)\ \wedge\ (C'.isAbstract \rightarrow C.isAbstract)\ \wedge$

  $\forall C \in \{C.superTypes\}\ \exists C' \in \{C'.superTypes\} \bullet (C' \leq C)$

  $\forall S \in \{C.structuralFeatures\}\ \exists S' \in \{C'.structuralFeatures\} \bullet (S' \leq S)$

- Attributes P', P: $P' \leq P \leftrightarrow$ :

  $isRelated(P'.name, P.name)\ \wedge\ (P'.type \leq P.type)\ \wedge$

  $(P'.isUnique = P.isUnique)\ \wedge\ (P.lower \leq P'.lower)\ \wedge\ (P'.isOrdered = P.isOrdered)$

  $((P.upper = P'.upper)\ \wedge\ (2 \leq P.upper \leq P'.upper))$

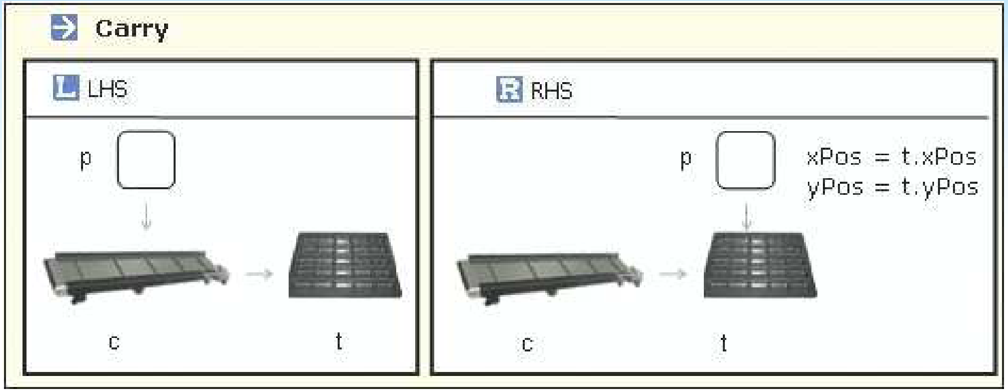
- References R', R: $R' \leq R \leftrightarrow$ :

  $isRelated(R'.name, R.name)\ \wedge\ (R'.type \leq R.type)\ \wedge$

  $(R'.isUnique = R.isUnique)\ \wedge\ (R.lower \leq R'.lower)\ \wedge\ (R'.isOrdered = R.isOrdered)$

  $((R.upper = R'.upper)\ \wedge\ (2 \leq R.upper \leq R'.upper))\ \wedge\ (R'.opposite \leq R.opposite)$

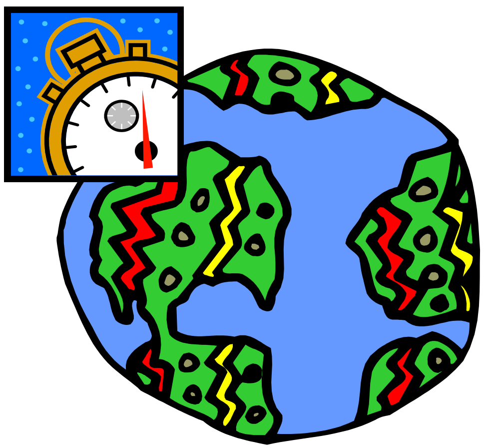
# Representing Behavior with Maude

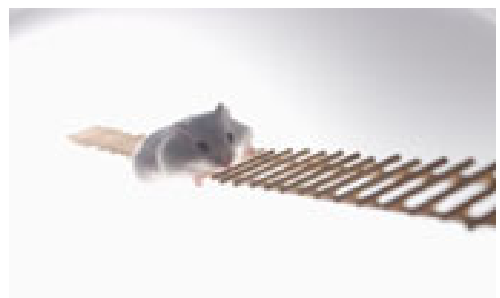



```
rl [Carry] :
 ProductionSystem {
  < p : P:Part | xPos : XPOS, yPos : YPOS, SFS >
  < c : Conveyor | parts : (p PARTS), out : t, SFS’ >
  < t : Tray | xPos : XPOS’, yPos : YPOS’, parts : PARTS’, SFS” >
  OBJSET }
=>
 ProductionSystem{
  < p : P:Part | xPos : XPOS’, yPos : YPOS’,SFS >
  < c : Conveyor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

# Precise Semantics of Timed Rules

- Defined by a Semantic Mapping to Real-Time Maude






- This makes models amenable to formal analysis using the Real-Time toolkit!

# Reasoning about temporal specifications

Humans are mortal

*Plato* is human

=> *Plato* is mortal

The President of the US is elected every 4 years

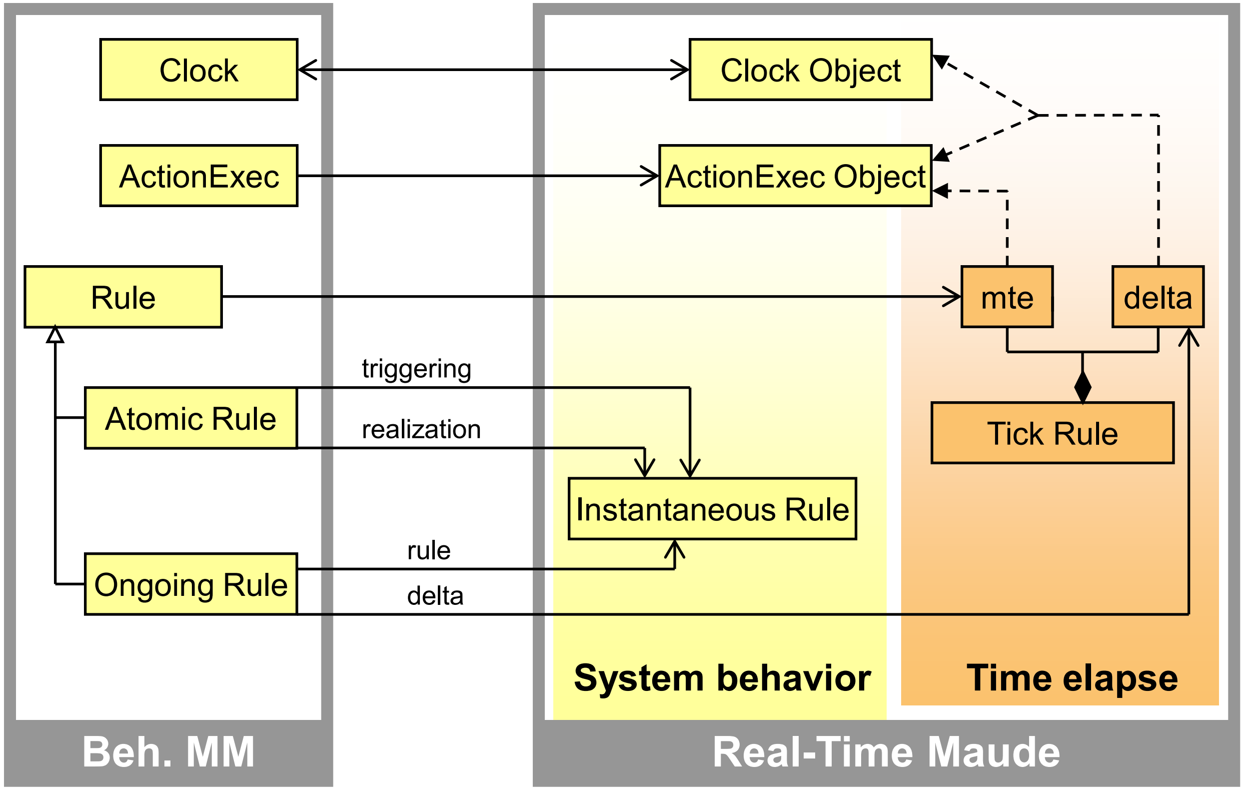
*Bush* is the President of the US

=> *Bush* is elected every 4 years

[Sowa, 89]

# Mapping to Real-Time Maude

- Real-Time Maude used to provide semantics to eMotions



# Model Simulation and Analysis with Maudeling

[Simulation 2009]

- Simulation/Execution of specifications

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

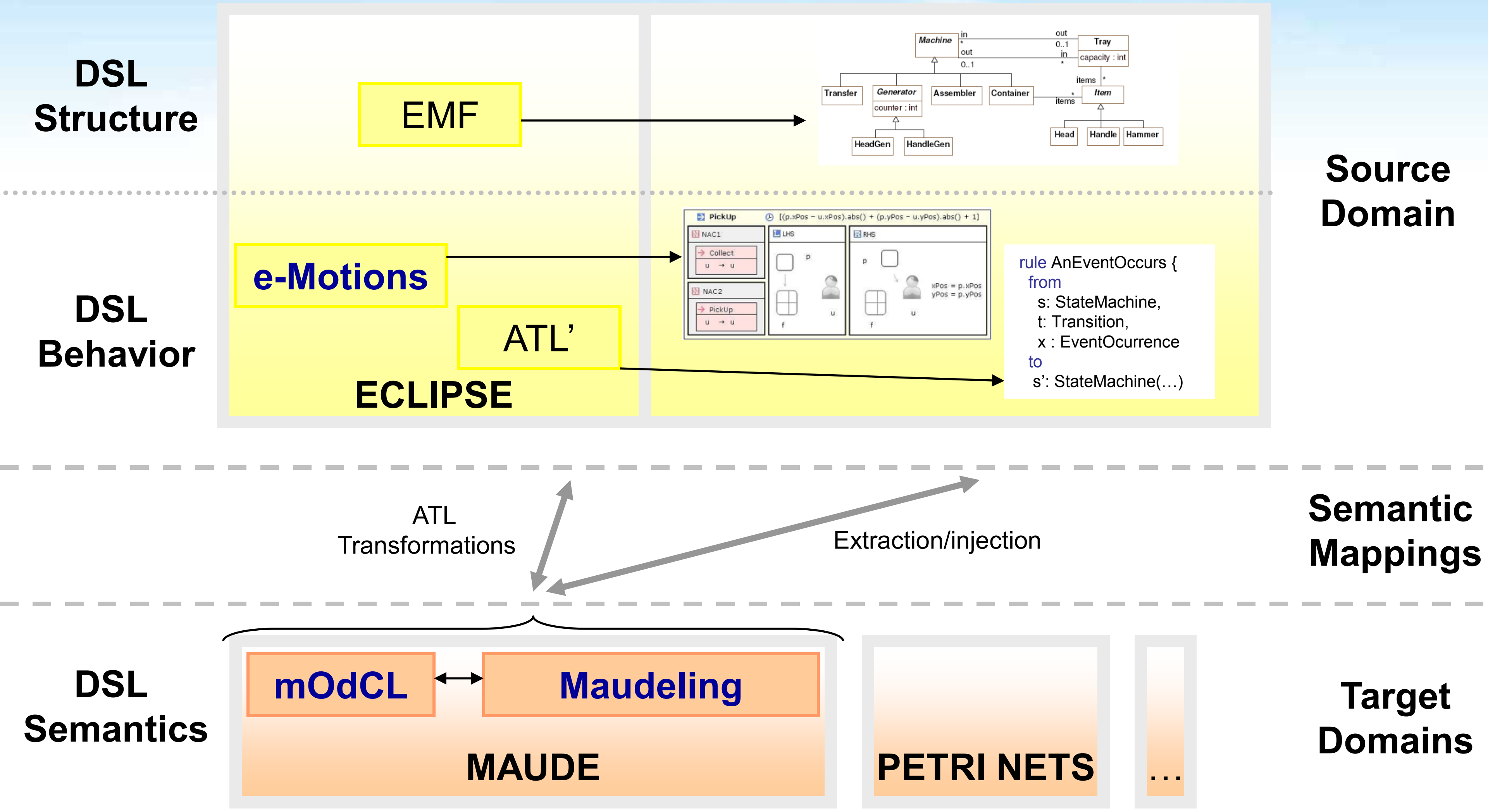
- Reachability Analysis
  - Deadlock
  - Invariants
  - Others

```
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 .)
```

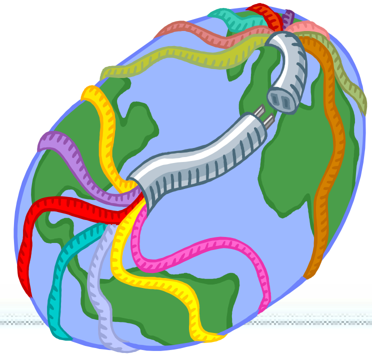
# Semantic Mappings



# More NFP required

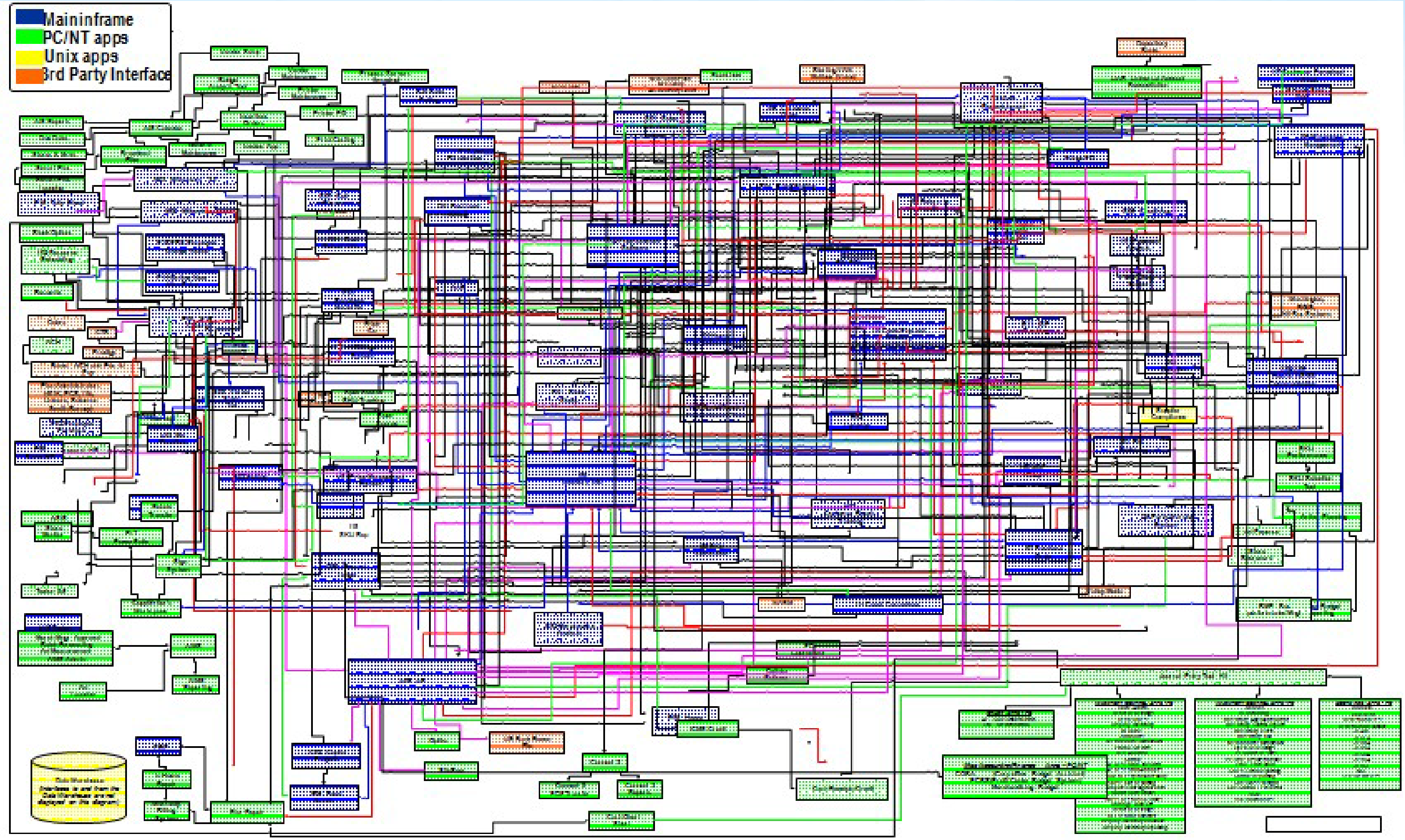
- In addition to time…
  - QoS Properties
  - Resource consumption
  - SLAs
  - …

- How to add them to our behavioral specifications?
- How to connect them to existing analysis tools?



# Other “kinds” of Semantics

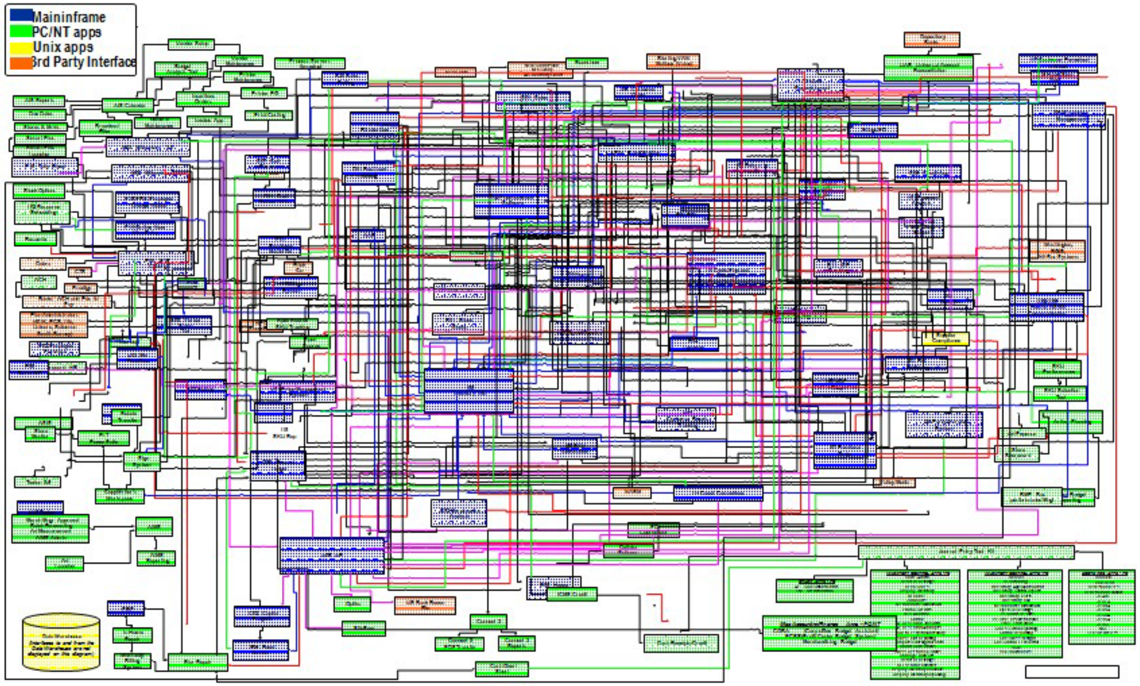
# Meaning?




*Design of a real Retail application*

# Meaning?

- How to understand the system?
- How to reason about it?
- How to detect design problems or anomalies?



# Visual metaphors

- An analogy which underlies a graphical representation of an abstract entity or concept with the goal of transferring properties from the domain of the graphical representation to that of the abstract entity or concept [Diehl, 2007]

- The representation of a new system by means of visual attributes corresponding to a different system, familiar to the user, that behaves in a similar way [Dürsteler, 2008]

**They are also semantic mappings!!!**

# VIASCO project

- A project to visualize component-based systems with the goal of detecting “anomalies”
- Defined as a chain of ATL model transformations
- Connects several tools
  - Parser
  - Clustering
  - Metrication
  - Visualization
- Uses Wires*

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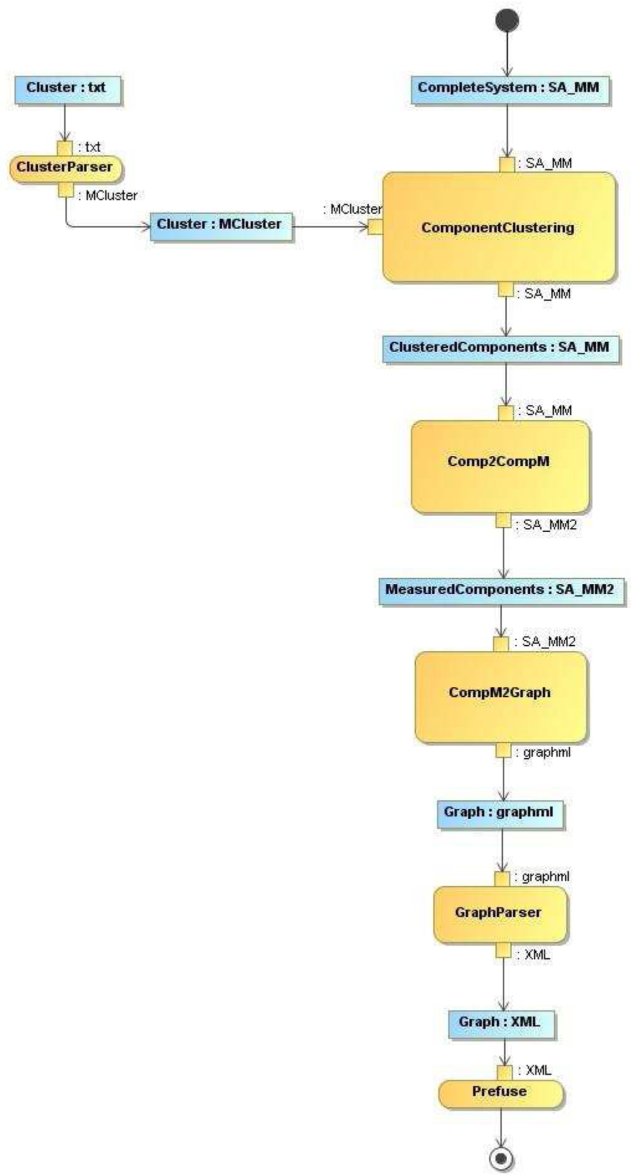
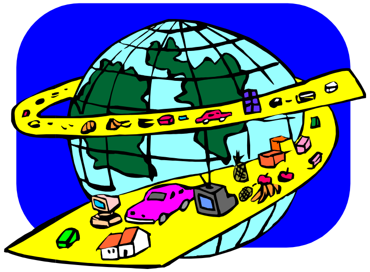
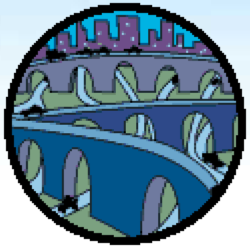


# Epilogue



# Summary

- Assigning Meanings to Models is required
  - For building tools
  - To explicitly and completely describe behavior
  - To disambiguate semantic variation points
  - To understand and reason about the systems



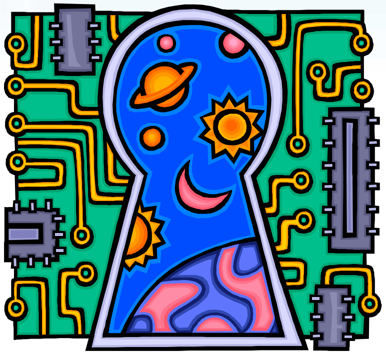
- (ATL) Model Transformations can be used to define semantics of models (realizing the “semantic bridges”)

$$\boxed{[[M]]_D := [[T(M)]]_{D'}}$$

- We have shown a proof-of-concept, that uses Maude
  - To specify models, metamodels and their behavior
  - To make use of Maude’s analysis tools
  - To provide formal semantics to other visual approaches (based on Eclipse, Graph grammars,…)

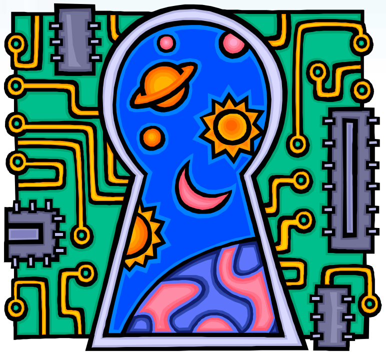
# Some challenges

- Composition mechanisms and type systems
  - 13. Silva et al. Composing Models with Five Different Tools. A comparison study
  - 5. Rivera et al. Orchestrating ATL Model Transformations.
  - 6. Vignaga et al. Typing ATL Models in Global Model Management.
- Testing/validating model transformations
  - 7. McQuillan et al. White-Box Coverage Criteria for Model Transformations.
  - 10. Fraternali et al. Mutation Analysis for Model Transformations in ATL.
- Enhanced traceability mechanisms
  - 8. Yie et al. Advanced Traceability for ATL.
  - 9. Vara et al. Leveraging Model Transformations by means of Annotation Models.
  - 11. Allilaire. Towards Traceability support in ATL with Obeo Traceability.
- Connections to other notations and tools
  - 1. Chenouard et al. Using ATL to define advanced and flexible constraint model transformations.
  - 3. Wimmer et al. On Using UML Profiles in ATL Transformations.
  - 14. Laarman. Achieving QVTO & ATL Interoperability.
- Querying models and View synthesis
  - 2. Chiprianov et al. An Approach for Constructing a Domain Definition Metamodel with ATL.
  - 4. Turki et al. Checking syntactic constraints on models using ATL model transformations.
  - 12. Vénisse. UMLQualityAnalysis: UML models measurements with ATL.



# Some more challenges

- Addition of more Non-Functional Properties to DSMLs
- Specification and development of more Semantic Bridges
  - Specially to semantic domains with powerful analysis tool support (Petri Nets, Alloy, …)



- Performance
  - Rule-based specs become unmanageable very soon
  - Performance is a big issue when dealing with LARGE models
- Global consistency checking of specifications
  - When dealing with multiple models of the same system…

# Thanks!

Acknowledgements:

Atenea
Modeling Software Systems

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

and, especially, to Jean, Frédéric, and the rest of the AtlanMod team!

… When we consider MDE with this unified vision, many well-known situations may be integrated into a more general consideration. To take one additional example, the seminal work of R. Floyd (**"Assigning meanings to programs"**, [12]) that founded the research field of programming axiomatics may be viewed as "decorating" a flowchart model with an axioms model. This may lead us first to consider decorations as models, then to understand the nature of the binding between the flowchart model and the axioms model, this binding being itself some kind of correspondence model. **Finally, these considerations may lead us to generalize R. Floyd's approach and to add on the research agenda a new item on "Assigning meaning to models".** Model weaving and model transformation will be essential to the study of this subject.

[Jean Bézivin, "On the Unification Power of Models", 2005]