UML,

de la programmation à la modélisation :
vers le développement basé sur les modèles des systèmes embarqués

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The OMG organism

- Initially centered on *CORBA* with keywords
  "Object Driven Architecture"

- Takes *UML* standardization
  → *becomes main activities*

- Introduction of the *MOF* to unify
  all object concepts for CORBA, UML, etc.

- 6 technical meetings by years (US, Europe, Asia)

  – Work orientation is presented during the meeting

  – Only one vote by legal entity …

  → **www.omg.org**

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To « universal » modeling standard

OMT

Booch

OOSE

Fusion

Classe-Relation

ROOM

HOOD

etc...

End of 1990

- We must go from craft practices …
  … to industrial production solutions !
  - **High level modeling and component based development**
  - **Idea integration of complementary/concurrent modeling notations proposed for OO methods**

1995   Rational

OMG

1996

OMT
(Rumbaugh et al.)

Booch

Unified Method 0.8

OOSE
(Jacobson et al.)

UML 0.9

UML 1.1

Nov. 1997

UML 1.3

June 1999

UML 1.4

End of 2001

UML 2.0

...

Catalysis

ROOM

etc.

list

3
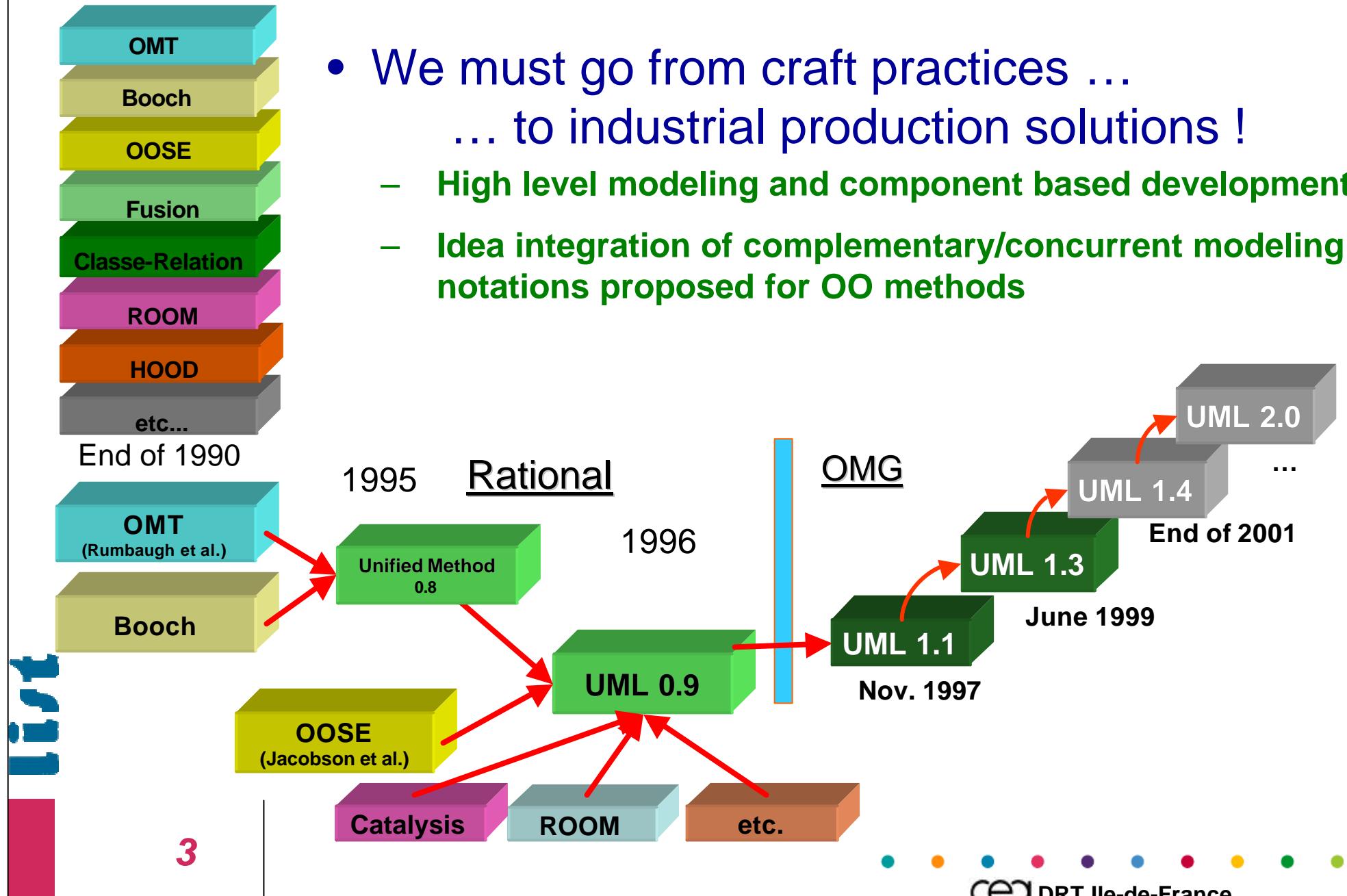
The UML' goals

- Define an easy-to-learn but semantically rich visual modeling language

- Include ideas from other modeling languages

- Incorporate industry best practices

- Address contemporary software develop[t]. issues
  - scale, distribution, concurrency, executability, etc.

- Provide flexibility for applying different processes

- Enable model interchange & define repository interf.

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The UML' features

- A graphical modeling language for:
  - specifying, constructing, visualizing and documenting
    the artifacts of a software-intensive system

- Core modeling concepts : the ***Object***
  → *get a global consensus from OO users*

- Generic and expressive

- Flexible (configurable, extensible) : Meta-model
  - Not a frozen standard!
    - Adaptable to specific domains without adding new diagrams;
    - Introduce a new notion as a specialization of an existing one.
  - The standard is regularly updated …
    → *formalized, detailed, enriched,…*

5

Method independency of the UML

- ## Method may not be generic!

  - Organization, culture and problem domain dependent
  - A solution to a given problem is not a fortiori a solution
    for another problem

- ## Method choice may depend on:

  - Problem class
  - Engineers skill / background
  - Targeted technologies

But, thanks to the UML, the basic language is the same independently of the chosen methodology !

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A four layer model architecture

Meta Meta Model (M3) — **MOF**

« instanceOf »

Meta Model (M2) — **UML**

« instanceOf »

Model (M1) — **User' model**

« instanceOf »

Objects (M0) — **User' model instance**

« instanceOf »

Class

« instanceOf »
« instanceOf »

« meta class » Attribute

« meta class » Class

« instanceOf »
« instanceOf »

Car
color : colorType

« instanceOf »
« instanceOf »

myCar
color : colorType = green
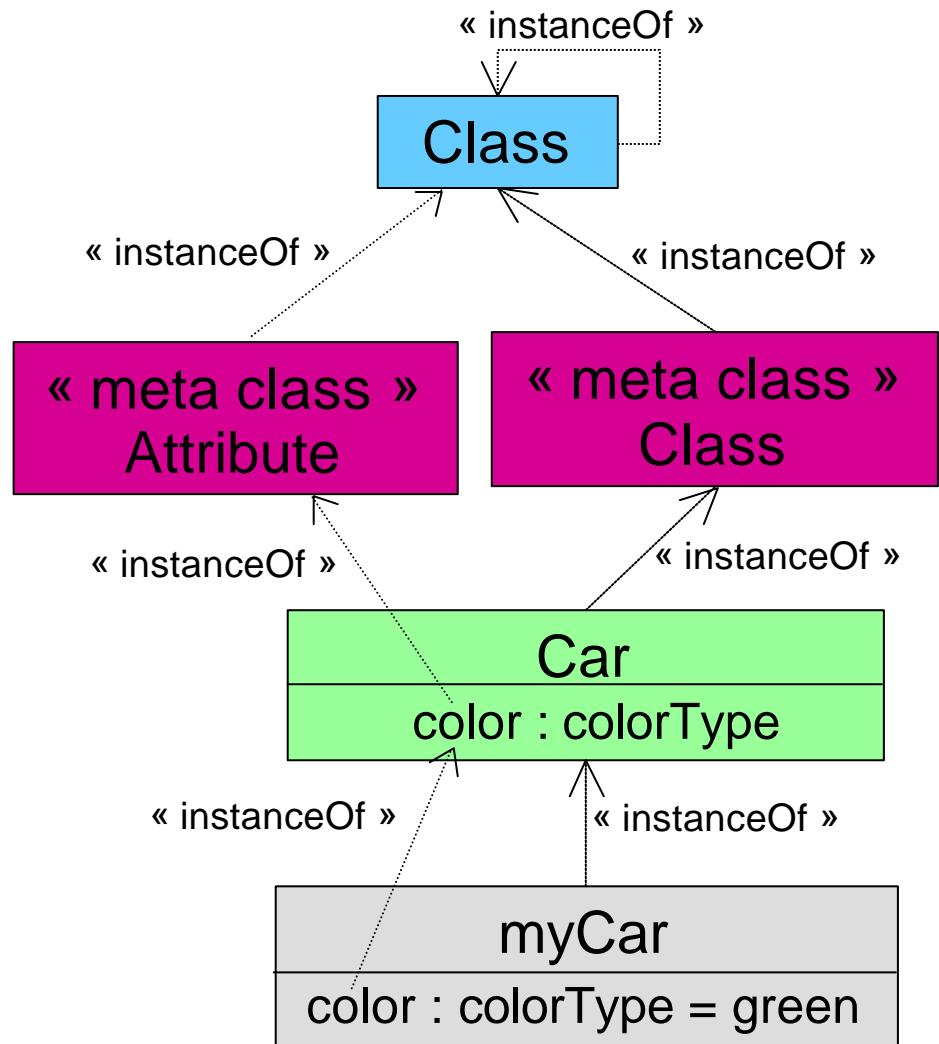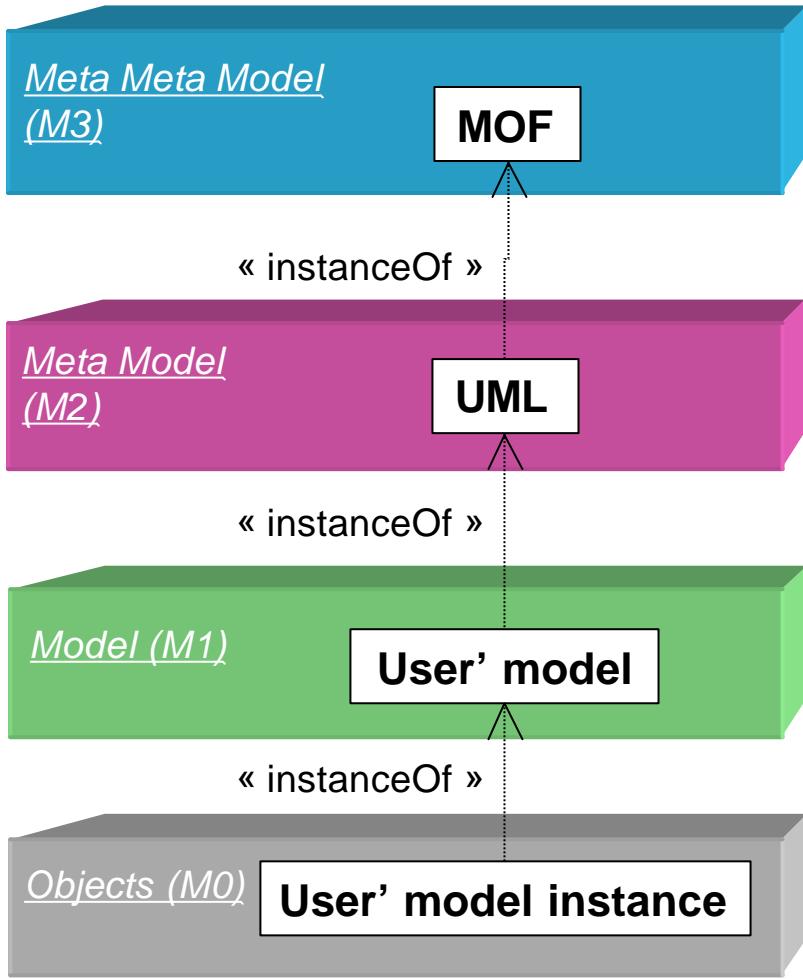
Unified Modeling Language

http://www.omg.org

- Language = syntax + semantics
  - ➔ *UML Notation Guide* = UML's graphic syntax
  - ➔ *UML Semantics* = defines UML's semantics

- UML 1.4: formal/2001-09-67,
  - ad/01-02-16 (XMI 1.1 DTD), ad/01-02-17 (Compilable OMG IDL)
    - Object Constraint Language
    - UML XML Metadata Interchange DTD
    - UML CORBAFacility Interface Definition
    - – OMG UML Tutorials: http://www.celigent.com/omg/umlrtf/tutorials.htm
    - – OMG UML Resources: http://www.omg.org/uml/

- Meta-Object Facility (MOF) 1.3: formal/2001-10-41

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The 9th diagrams ofUML…

- Fonctional :
    - Users needs / requirements   → *Use Case*

- Static (structural)
    - Concepts   → *Class*
             → *Object*

    - Implementation and deployement   → *Component*
             → *Deployement*

- Dynamics
    - Object Interactions   → *Sequence*
             → *Collaboration*

    - (object) Dynamics   → *State Machine*
             → *Activity*

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Complementary views

- Consistency rules for an unambigous modelling

… Complementary views for a complete model
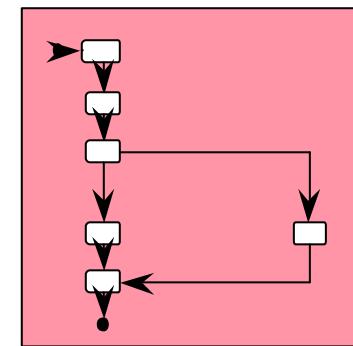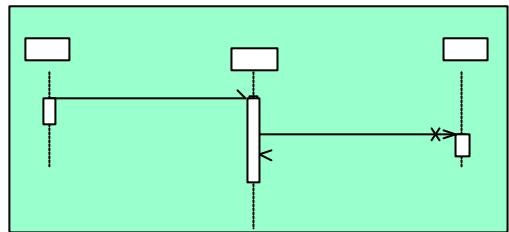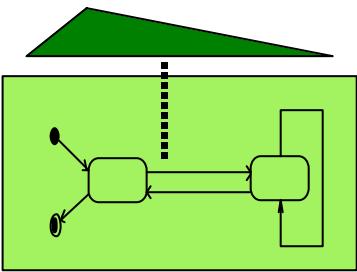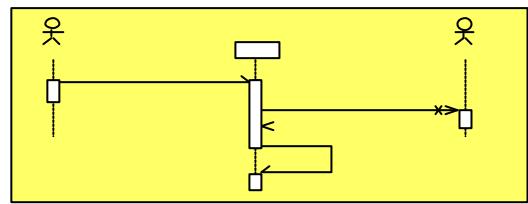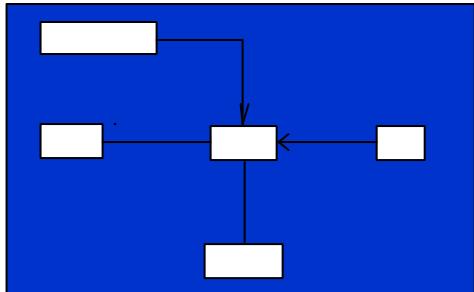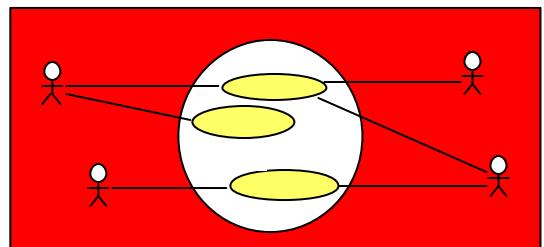
➔ Formal analysis becomes possible… !

UML organization

Meta Meta Model (M3)

MOF

. . .

Meta Model (M2)

UML   **SPE**

. . .

Standard profile (M2)

Real Time   **ActionLanguage**

ACCORD/UML

End-user specific Profile (M2)

Model (M1)

Objects (M0)

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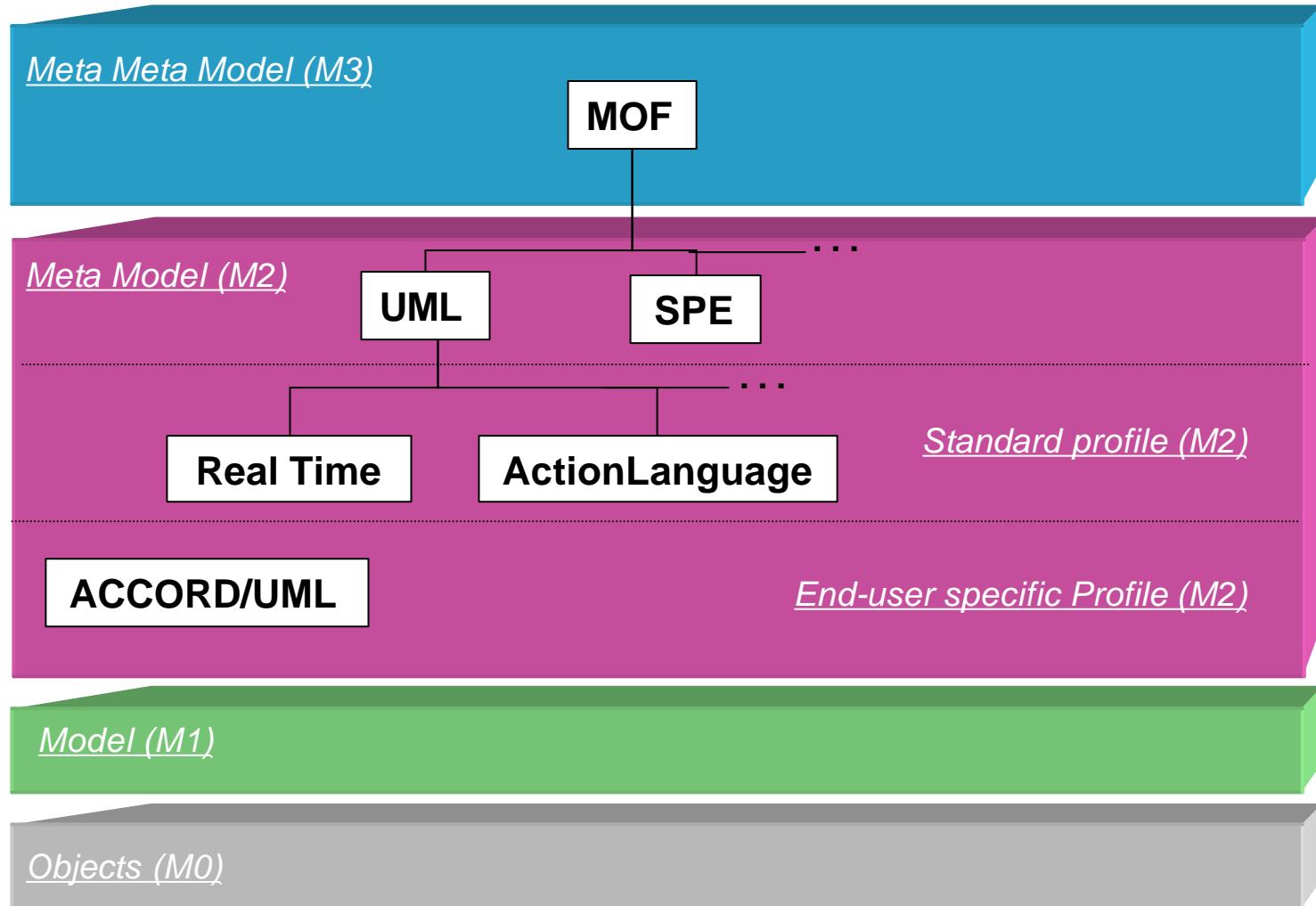
UML Standard Profiles

✓ *Software Development Processes*

✓ *Business Modeling*

✓ *Action Semantic*   http://www.kc.com/as_site/home.html

 – Profile for Action semantics: ad/01-08-04

✓ *Scheduling, Performance and Time*

 – Profile for Sched., Perf. & Time: ad/01-06-14

✓ *Ongoing works : UML 2.0*

 → Core simplification, Behavior, Component…
  + OCL, + Diagram interchange

list

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The Scheduling, Performance and Time Profile

- **Proposers and supporters:** *ARTiSAN, I-Logix, Rational, Telelogic, TimeSys, Tri-Pacific, CEA…*

- **Modeling Resources:** *quality of service (QoS)* uniform basis to attach quantitative information to UML specifications (required for RT analysis performing)
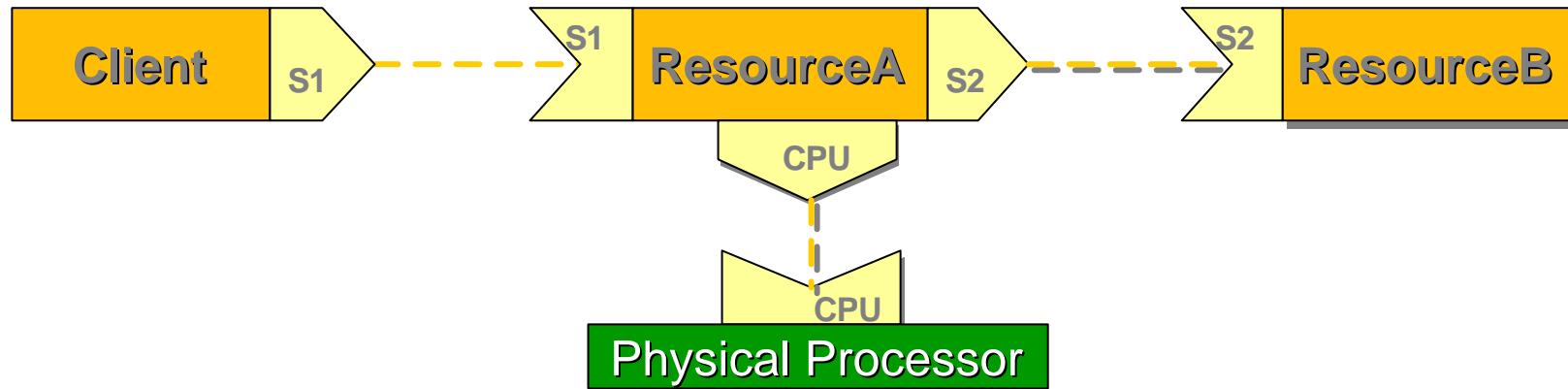
➔ *Not THE Real Time UML modeling profile… !*

Profile for Action Semantic

- **Consortium :** *Alcatel, Booz-Allen&Hamilton, Concept Five, I-Logix, INRIA, Kabira, Kenedy Carter, Project Technology, Rational, Motorola, Simware, Software Productivity Consortium, Telelogic, TVEC*

- Action Semantics: specif. of computational behavior
  - Early validation of system behavior in the dev. process
  - Possibilities of formal proofs
  - Reuse of software independent from target platform

- Actions are: base actions or composed actions:

  - Primitives, accesses, manipulation, computing, interaction, exception, collections

    ➔ *Notation is not part of the submission*

    ➔ *Too complex, not implemented...*

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What is a profile ?

Purpose

> Specialize a standard meta-model (as UML) in a specific meta-model dedicated to a particular end-user domain.

A profile may contain…

- The selected elements in the reference meta-model

- Extension mechanisms used

- Semantics description of the profile

- Supplementary notation keys

- Transformation, validation or presentation rule definitions

➔ Profile concept is going to be integrated in UML 2.0 !

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UML profile definition

- Purpose

> Specialize a standard meta-model (as UML) in a specific meta-model dedicated to a particular end-user domain.

☞ **A profile may contain…**

- The selected elements in the reference meta-model

- Extension mechanisms used

- Semantics description of the profile

- Supplementary notation keys

- Transformation, validation or presentation rule definitions

  ☞ See Philippe Desfray's white papers on *Profile* notion and *Model Driven Development*:

  http://www.objecteering.com/us/smot_uml_white.htm

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UML profile definition

A profile may contain…

Impacted meta-classes

• The selected elements in the reference meta-model,

• Extension mechanisms used,

Stereotypes, tagged values & constraints defined in the profile

• Semantics description of the profile,
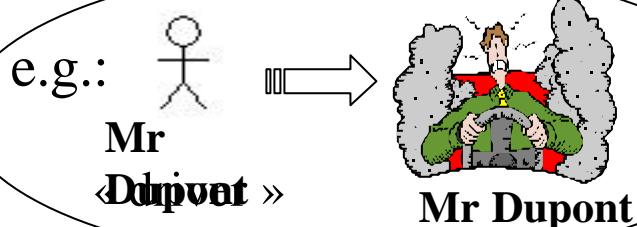
« Semantics Variation Points » & Semantics Ambiguous Points
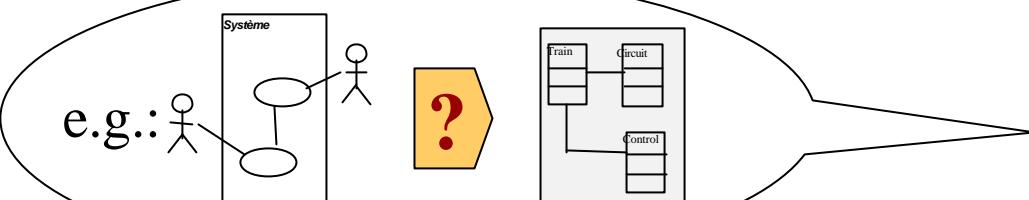
e.g.:

Mr
Dupont
« Dupont »

Mr Dupont

• Supplementary notation keys

Système

Train Circuit

?

Control

e.g.:

• Transformation, validation or presentation rule definitions.

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ACCORD :
UML development framework

ACCORD

ACCORD
coding rules

Requirements

Modeling

Application

Model

Code generation

Objecteering UML

Application C++ Source

ACCORD
kernel

ACCORD
virtual machine

Compilation & Link edition

Application

Solaris 2.5

Windows-NT

VxWorks

18

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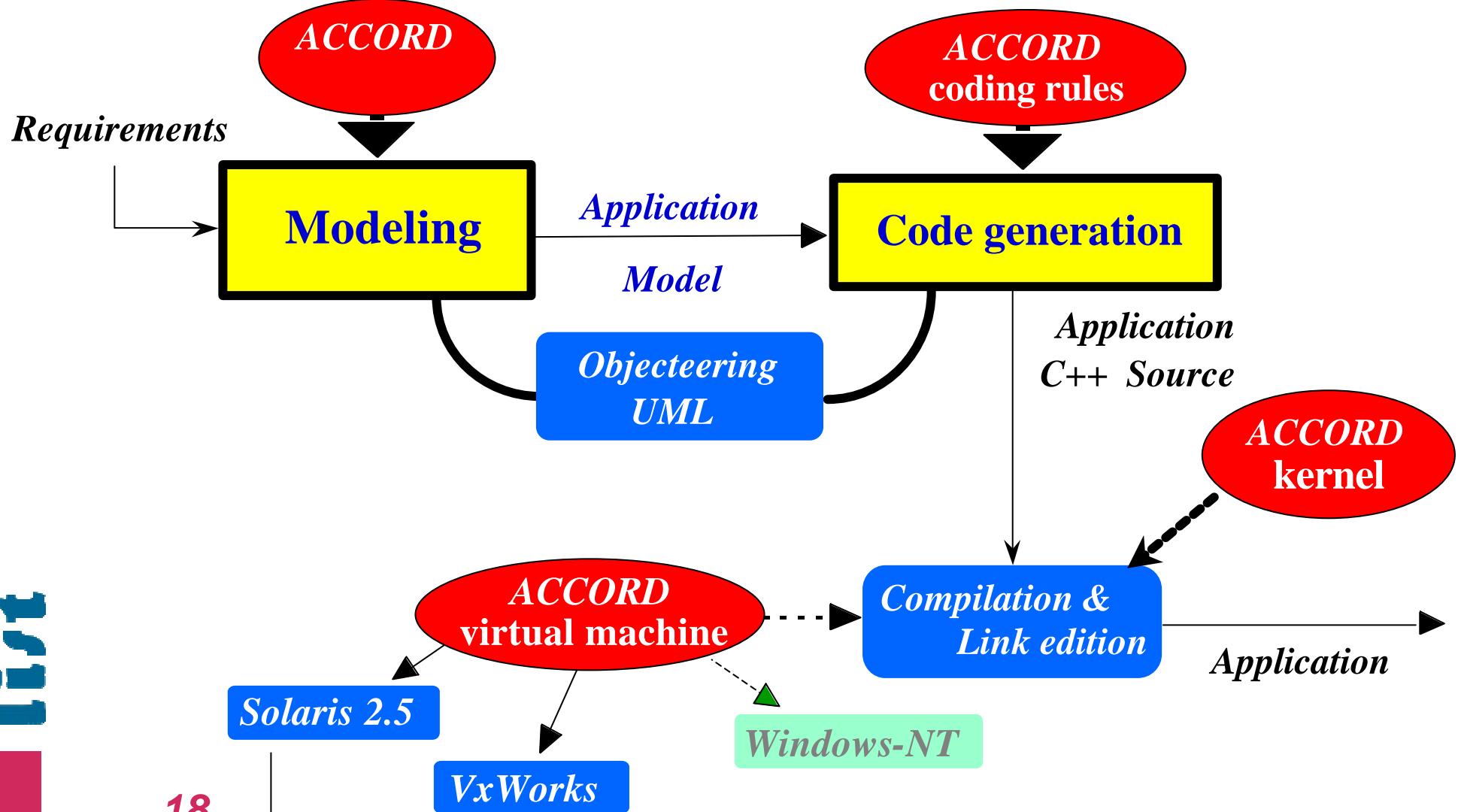
Overview of the process

The ACCORD/UML process is SPEM compliant !!!
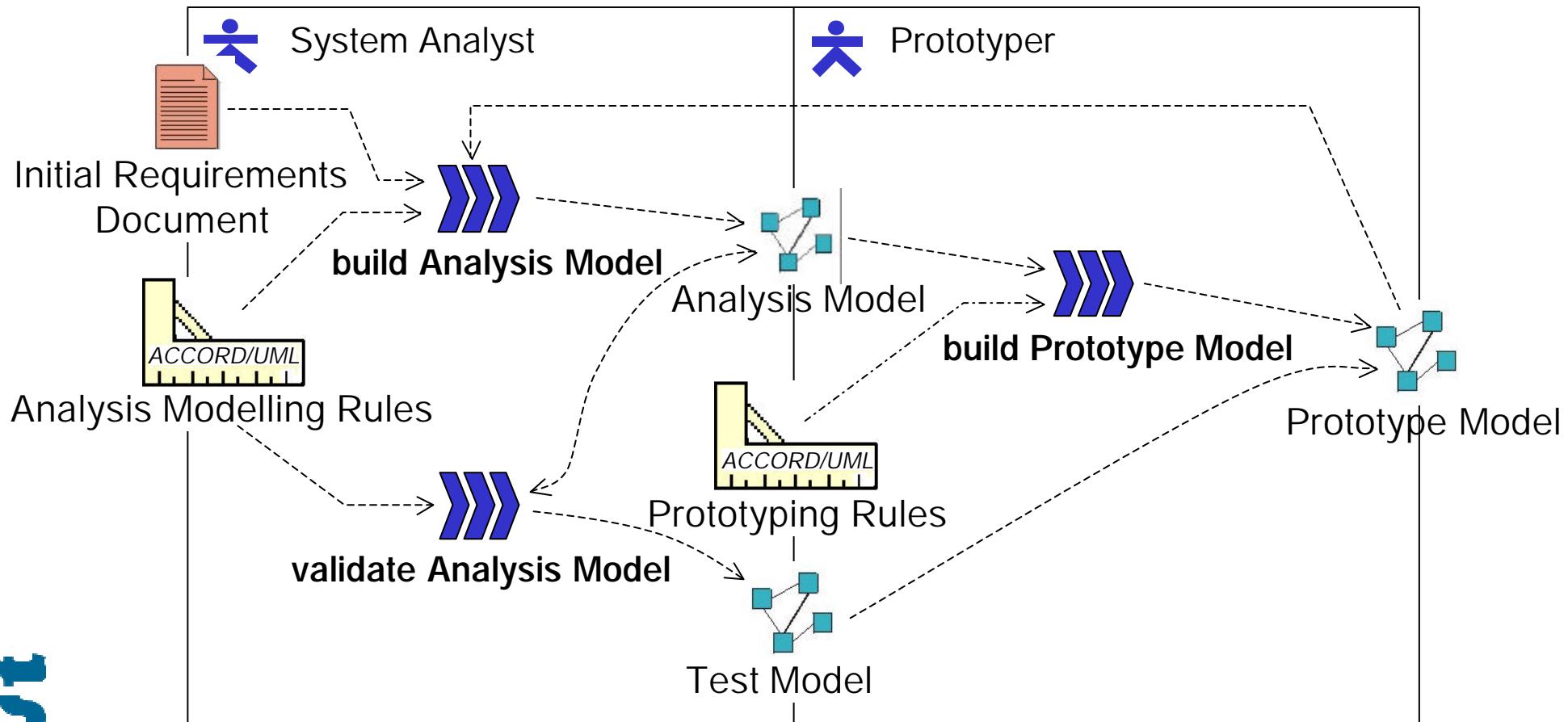
System Analyst   Prototyper

Initial Requirements Document

build Analysis Model

ACCORD/UML

Analysis Modelling Rules

Analysis Model

build Prototype Model

Prototype Model

ACCORD/UML

Prototyping Rules

validate Analysis Model

Test Model

ACCORD/UML

ACCORD/UML profile

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Utilisation de la « méta-modélisation » dans la plate-forme ACCORD

- **Introduction de concepts de modélisation « haut niveau »**
  - Objets temps réel
  - Signaux…

- **Introduction de règles de modélisation**
  - Structuration des modèles
  - Structuration des automates
  - Utilisation des signaux

- **Définition de mécanismes de mise en œuvre**
  - Pattern des signaux, des objets temps réel…
  - Génération automatique de code

- **Analyse de modèles pour la validation**
  - Génération automatique de séquences de tests

20

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The UML concept of active object
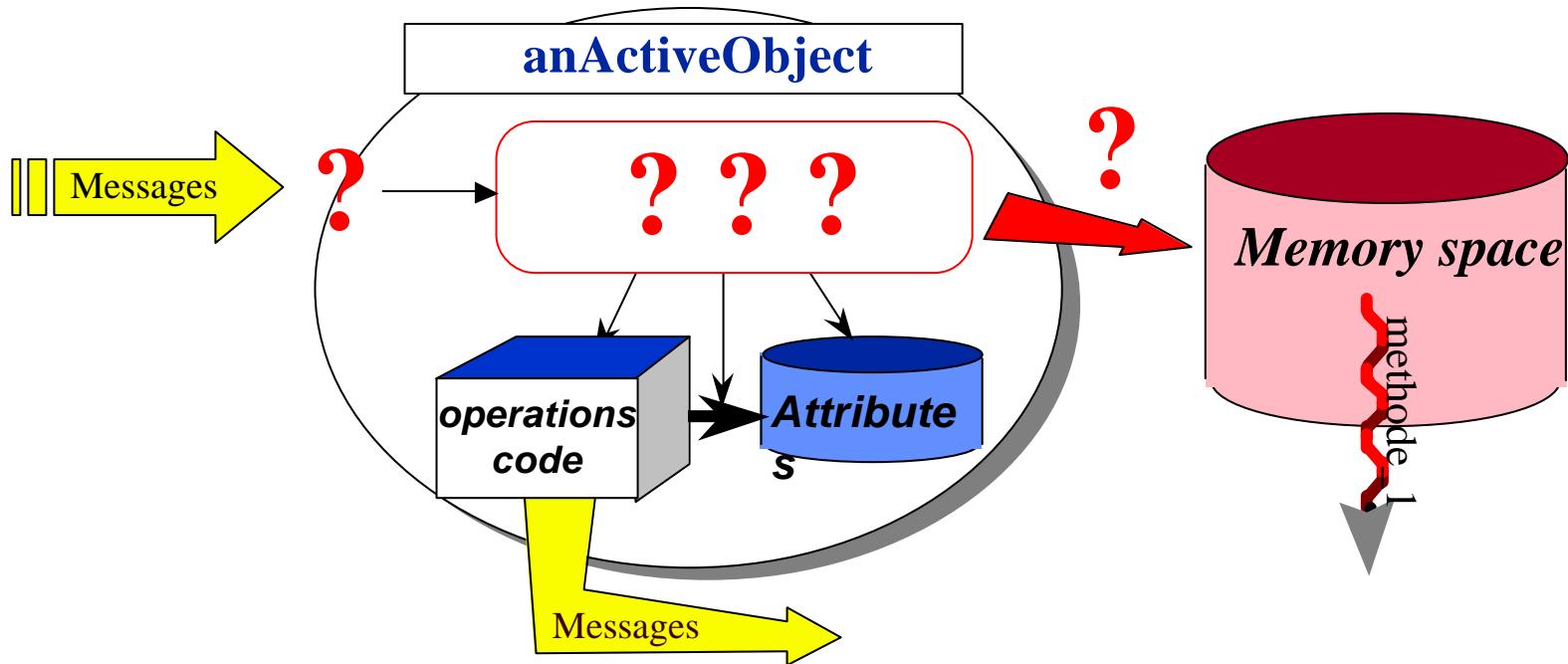

✓ **main characteristics of the UML active object**

- « mono thread » ?
- not well-defined behavior

➜ *New stereotype in Class diagram*

RegulatingLaw

regLaw

0..*

<<*RealTimeObject*>>
Regulator

Active objects

sp | 0..*

<<*RealTimeObject*>>
Speed

DRT Ile-de-France
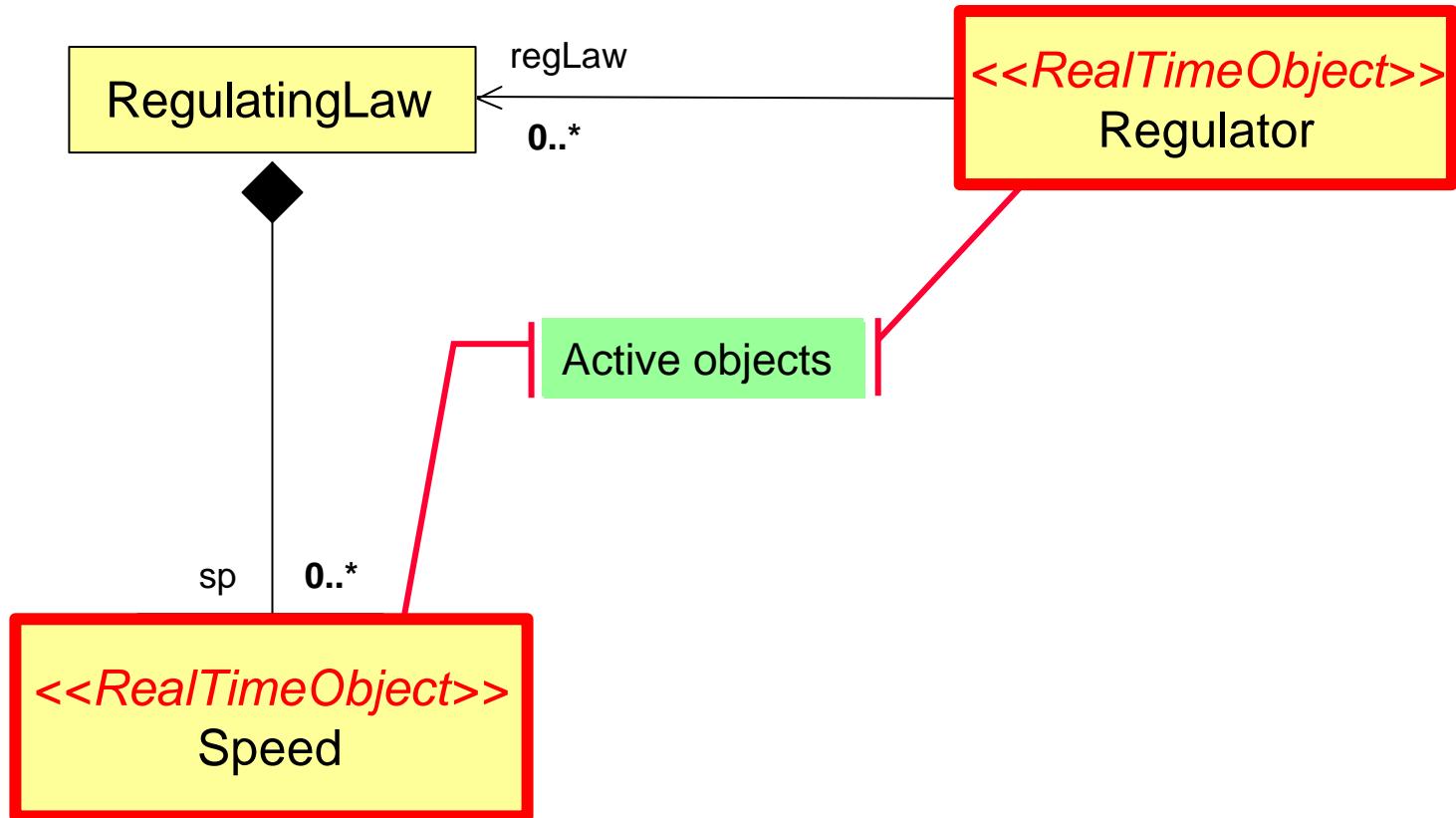
ACCORD Real-Time objects

• **User point of view :** *an autonomous computing entity with a standard UML object interface*
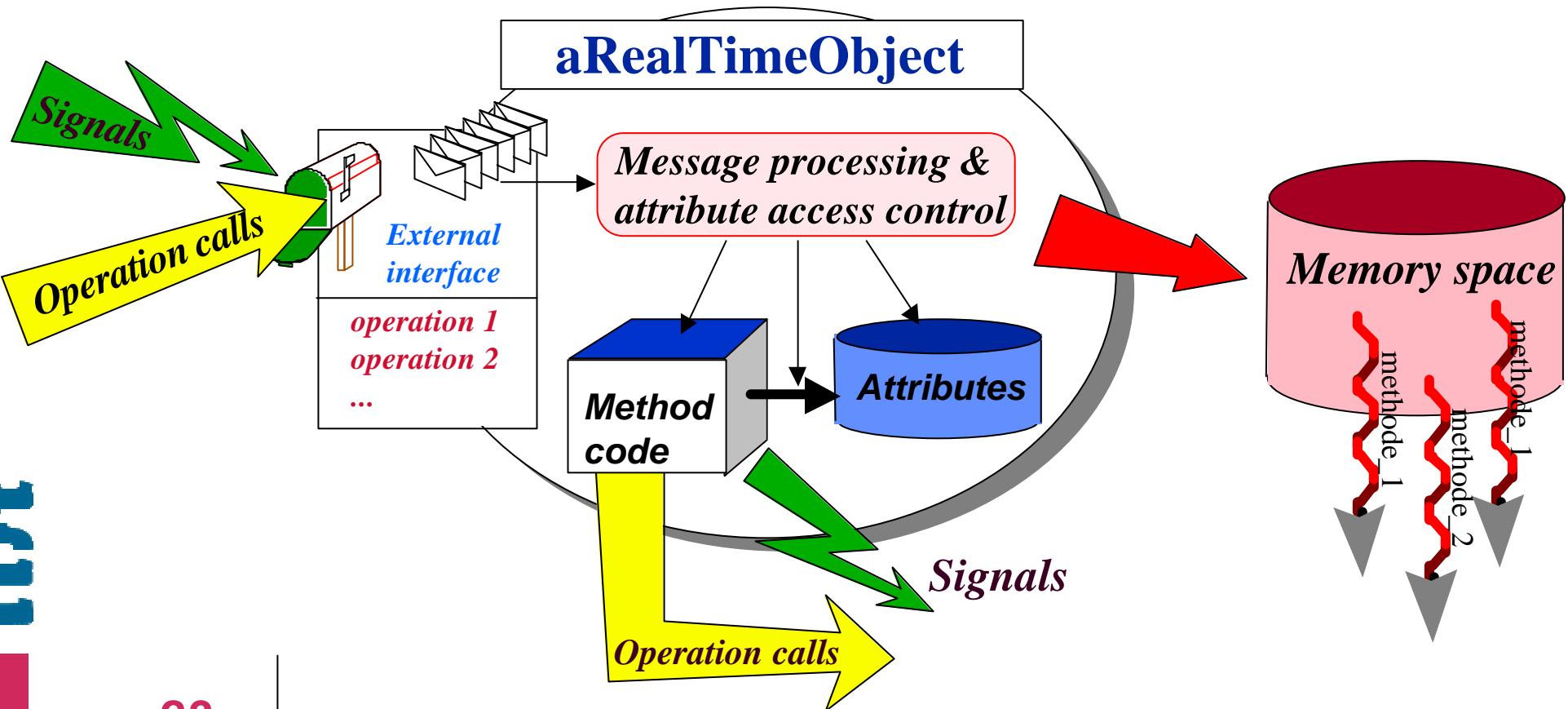
aRealTimeObject

Signals

Operation calls

External interface

operation 1
operation 2
...

Message processing & attribute access control

Method code

Attributes

Memory space

methode_1

methode_2

methode_1

Signals

Operation calls

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Utilisation de la « méta-modélisation » dans la plate-forme ACCORD

- *Introduction de concepts de modélisation « haut niveau »*
  - *Objets temps réel*
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- Introduction de règles de modélisation
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  - *Génération automatique de code*

- *Analyse de modèles pour la validation*
  - *Génération automatique de séquences de tests*

DRT Ile-de-France
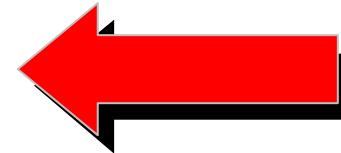
Usual modeling of the application behavior

Logic **&** **Algorithmic**

Regulator
targetSp: int
maintainSp() « Signal » OnOff()

onOff()[spSens->readSp()=<30]
/display("ON");

off

on

tm(100)[spSens->readSp()>30]
/carSp = spSens->readSp();

delta=k1*atan(targetSp-carSp);
engine->cmdConf(delta);

onOff()/display("OFF");

[carSp=<30]/display("OFF");
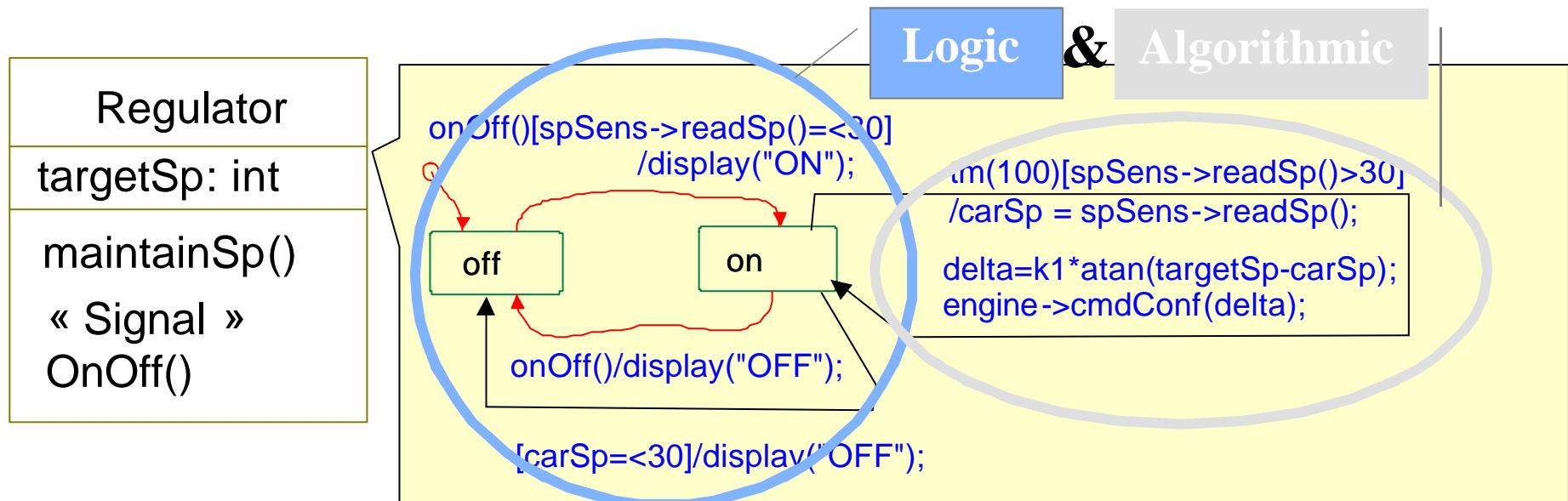
Readability ↘

Reusability ↘

25

ACCORD: separation of concerns

☞ **The control state machines (objective: UML 2.0)**

Þ **assign all action sequences to object operations**

Regulator
targetSp: int
« Signal » OnOff()
initReg() stopReg() maintainSp()

OnOff[spSens->readSp()>30]

/initReg()

off → on

OnOff

/stopReg()

[spSens->readSp()>30]

/stopReg()

tm(100)[spSens->readSp()>30]

/maintainSp() ;

maintainSp()

Begin

/ carSp = spSens->readSp();
delta=k1*atan(targetSp-carSp);
engine->cmdConf(delta);

End

method specification ➙

DRT Ile-de-France
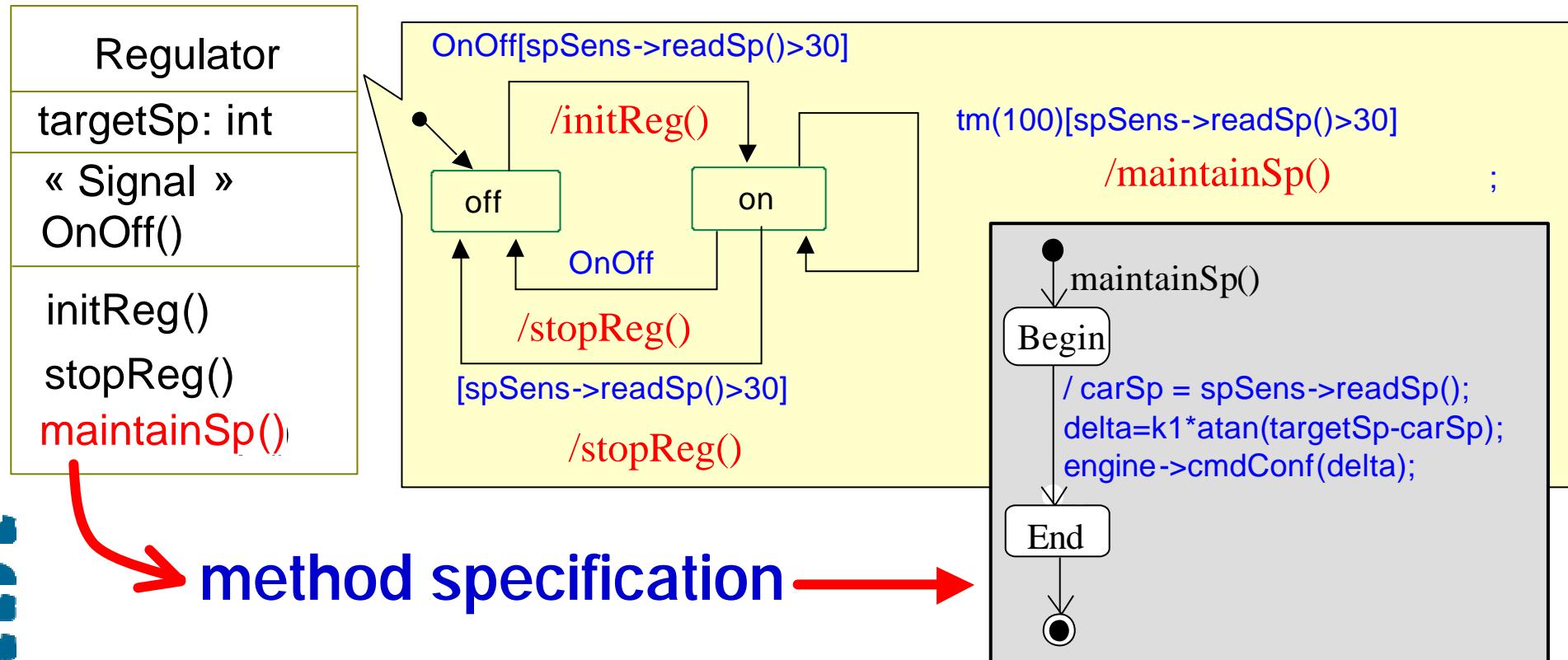
Exemple de règles de modélisation ACCORD/UML en OCL

SendAction

[3]   Les cibles d'une action de type *SendAction* est l'ensemble des instances possédant une réception attachée au type du signal émis.

self.target.body = "all"

SignalEvent

[1]   La direction des paramètres d'un événement signal doit être de type « in ».

self.parameter → forAll(p | p.kind = # in)

[2]   Un événement de type SignalEvent possède autant de paramètres que son signal associé possède d'attributs

self.parameter → size = self.signal.allAttributes → size

...

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# Utilisation de la « méta-modélisation » dans la plate-forme ACCORD

- *Introduction de concepts de modélisation « haut niveau »*
    - *Objets temps réel*
    - *Signaux...*

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    - *Structuration des automates*
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    - Pattern des signaux, des objets temps réel…
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- *Analyse de modèles pour la validation*
    - *Génération automatique de séquences de tests*

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Mise en œuvre de la communication par signal
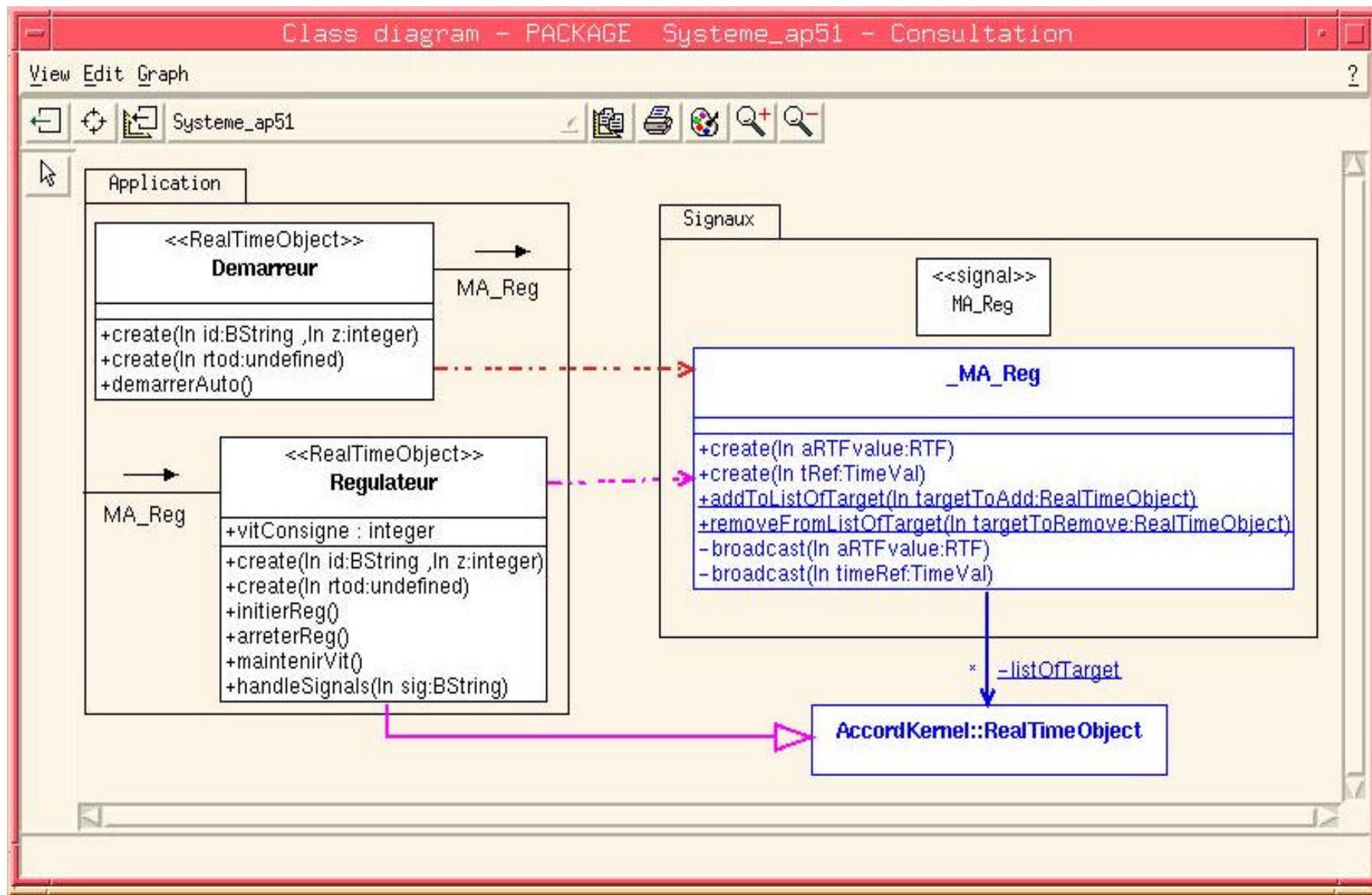
Utilisation de la « méta-modélisation » dans la plate-forme ACCORD

- *Introduction de concepts de modélisation « haut niveau »*
  - *Objets temps réel, signaux...*

- *Introduction de règles de modélisation*
  - *Structuration des automates*
  - *Structuration des automates*
  - *Utilisation des signaux*

- *Définition de mécanismes de mise en œuvre*
  - *Pattern des signaux, des objets temps réel...*
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  - Génération automatique de séquences de tests

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Static validation of model

Error : the composite state **On** has incoming transitions and no initial state.

The syntaxical verification of the state machine **Regulator** is ended with 1 error !

Check

Modify
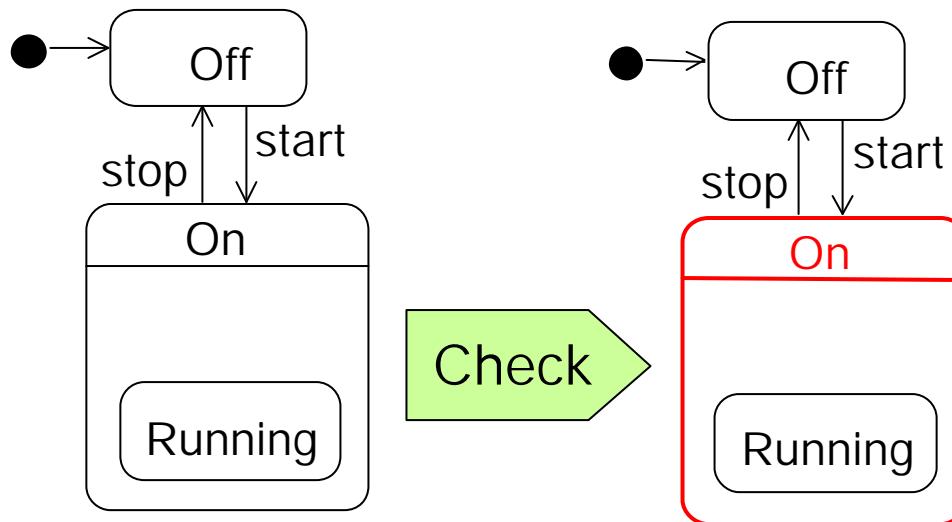
The syntaxical verification of the state **On** is OK.

Check

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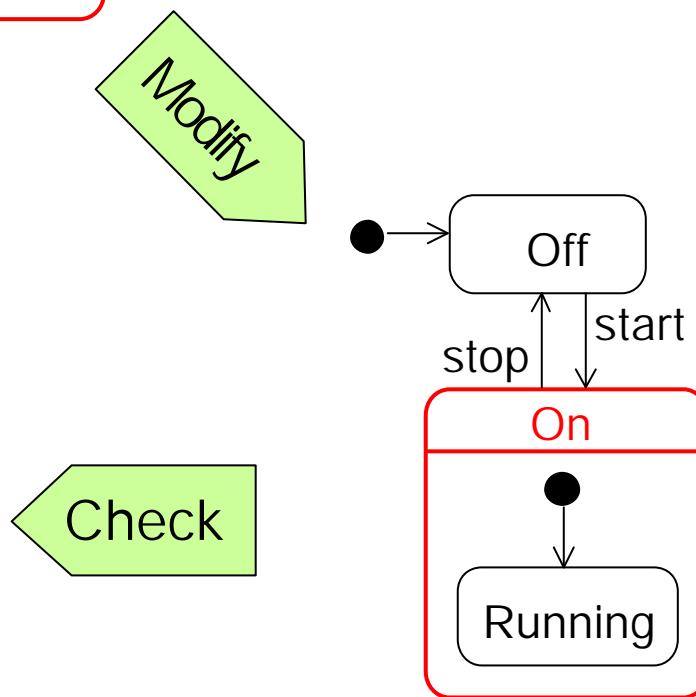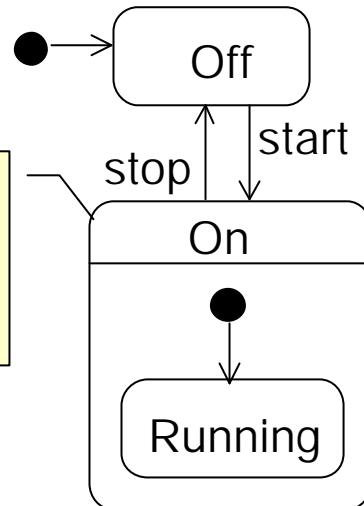
Automatic test generation

conversion

AGATHA

Product

| J1 = (Vit=120, dist=150) |
| J2 = (Reg=true, Vit=55) |
| … |

$\neg$ (Vit < 100) $\wedge$ (dist < 200)
(Reg = true) $\wedge$ (Vit $\geq$ 50)
…
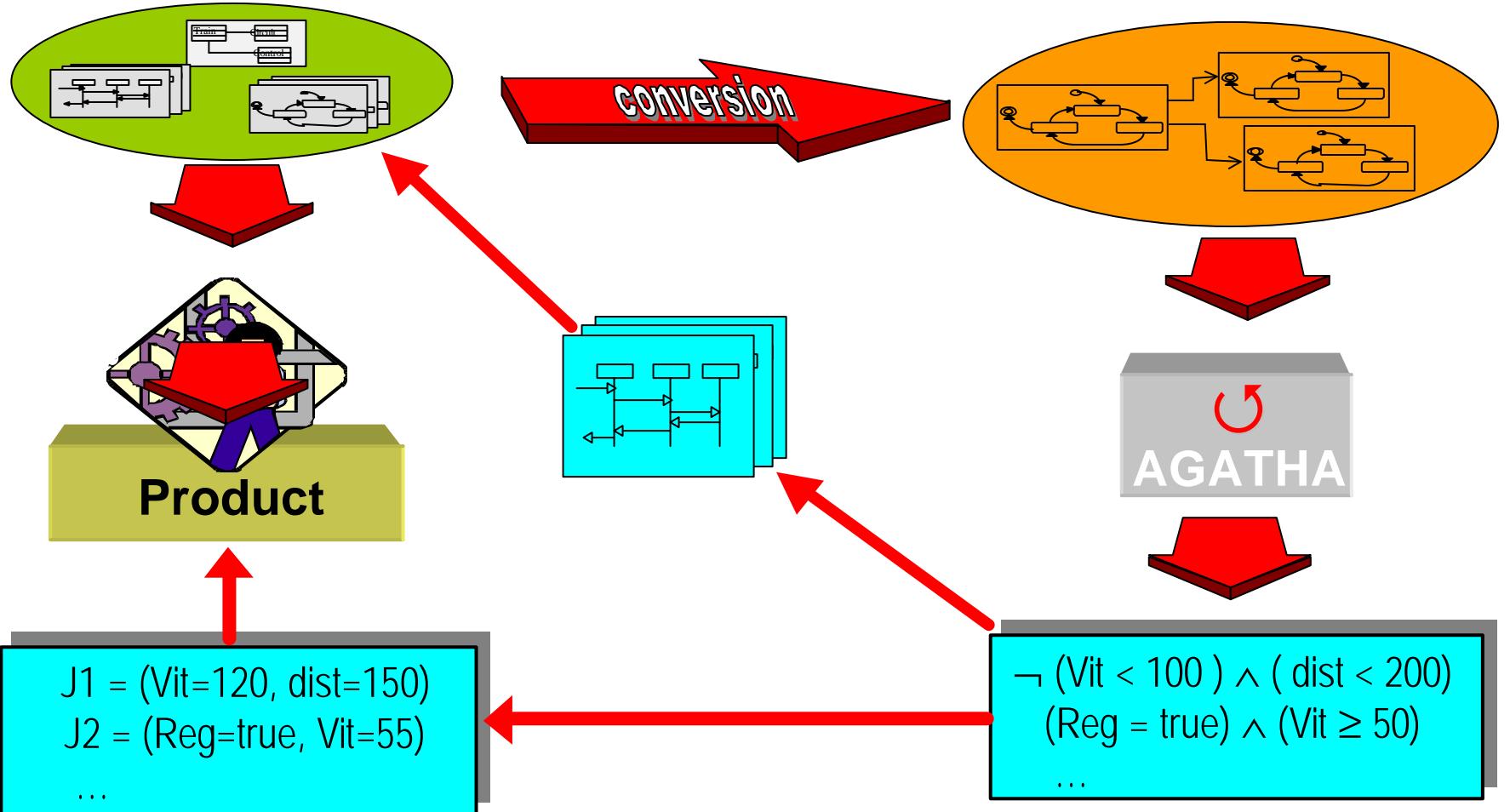
$\Rightarrow$ Fully **transparent** processus : the user does not need to know anything about underlying formal technics.

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MDA: *Model Driven Architecture*
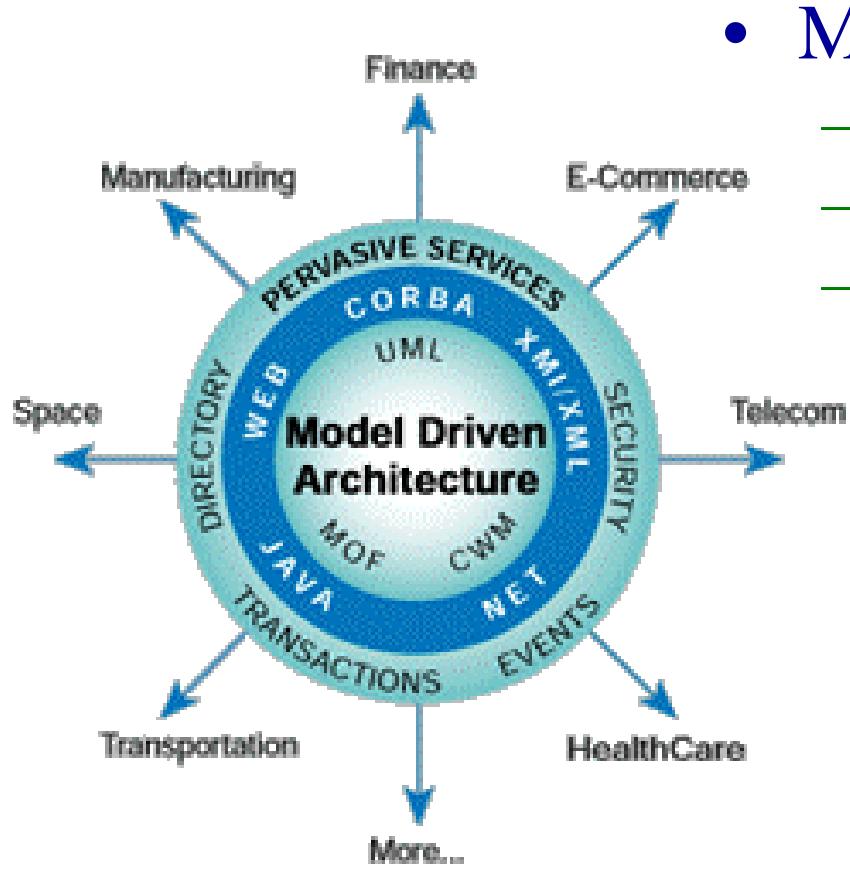
- ## Model Driven (UML, MOF…)
  - – Platform Independent Models (PIM)
  - – Platform Specific Models (PSM)
  - – Mappings : PIM <==> PSM
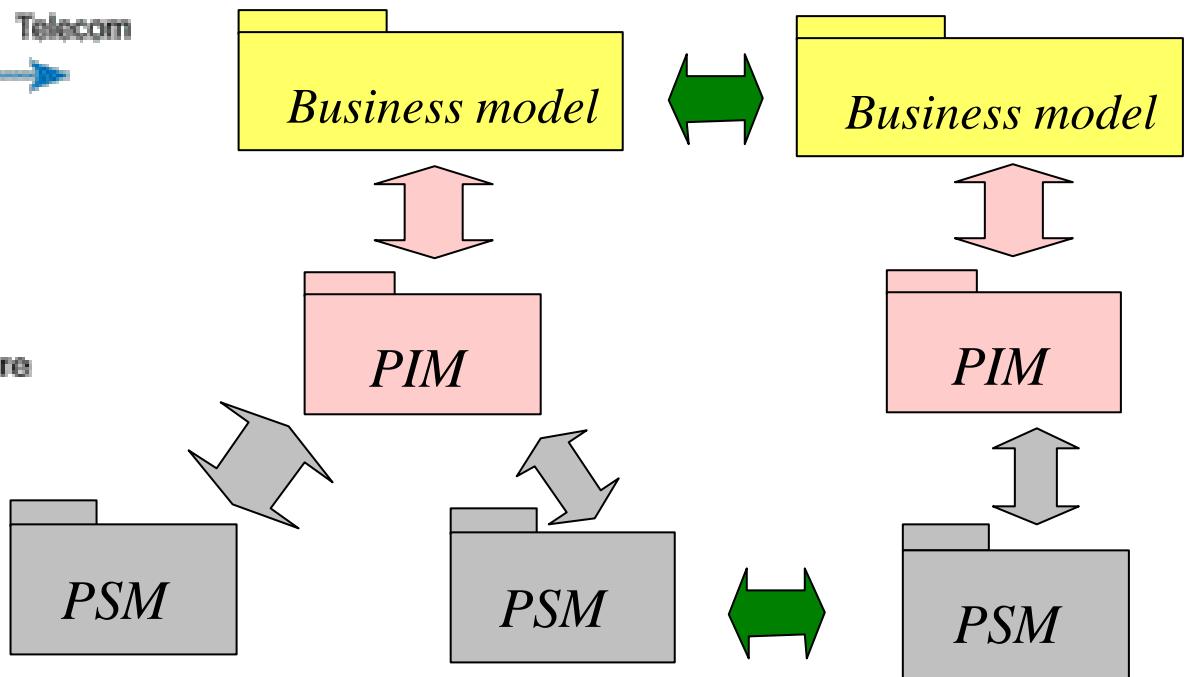
➔ *Profile for model transformation becomes essential concept*

# A full Model-driven approach

Modeling concepts

Modeling rules

PAM

Model enrichment

PIM level

DAM

Valid.

Model enrichment mapping

Model translation / filter

OS Interf. model

Code generation

PrM

PSM level

Runnable level

list

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UML automotive

http://www.automotive-uml.com
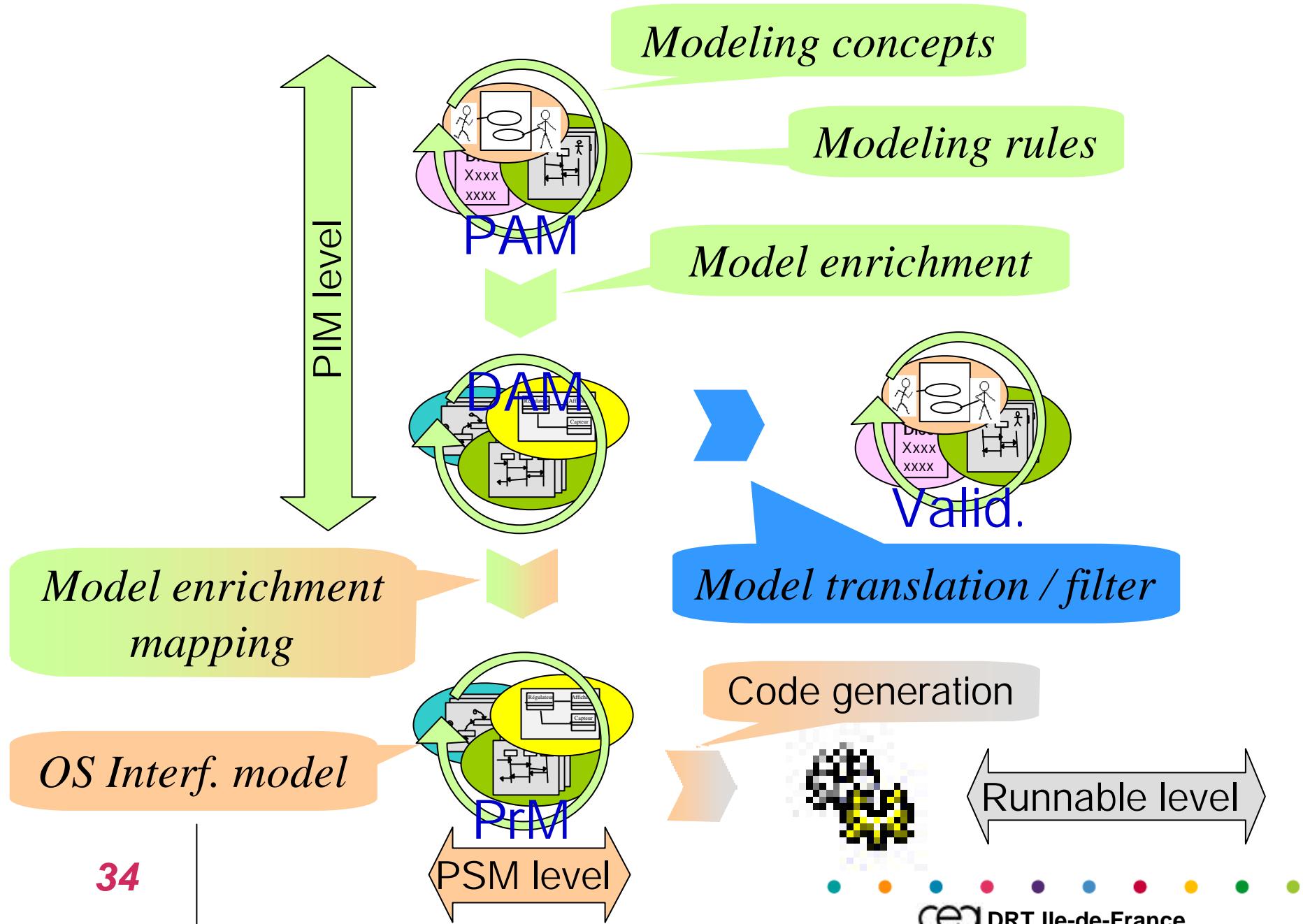
- Contact : Dr. Peter Hofmann, sdt@automotive-uml.de

system design
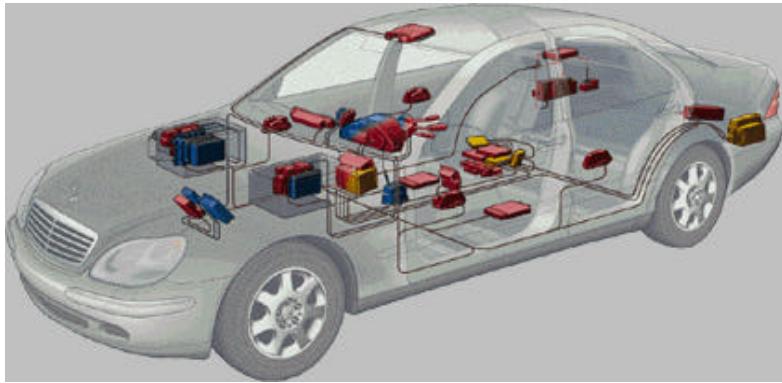
- Contest : OO modeling of a seat control
  OO implementation

  6 Motors, 28 Sensors driven and controlled
  by software

  - OMER workshop, supported by GROOM :
    Univ. Of Munchen, Germany, http://ist.unibw-muenchen.de/GROOM/

Some EC links, ITEA http://www.itea-office.org/

DESS : *Component based method for embedded systems*
Thales, Barco, Philips, DaimlerChrysler, Siemens, Esterel Technologies, INRIA…

`http://www.dess-itea.org/`

EAST-EEA : *Embedded Electronic Architecture,* Volvo, Audi,
BMW, Fiat, DaimlerChrysler, Opel, PSA, Renault, SAAB, Bosch, ZF, Siemens,
Valéo, Magneti Marelli, ETAS, C-LAB, IRCCyN, INRIA, Paderborn Univ., CEA

SOPHOCLES : *Cyber Entreprise and Virtual Component for embedded systems*, Thales, Philips, Esterel Technologies, IPiTEC,
ENEA, LIFL… `http://erg4146.casaccia.enea.it/SOPHOCLES/index.html`

EMPRESS : *Evolution Management and Process for Real-Time Embedded Software Systems,* Thales, Philips, Barco,
DaimlerChrysler, BMW, CEA… `http://www.empress-itea.org/`

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Some EC links

IST - Software Architecture & Components

http://www.cordis.lu/ist/ka4/tesss/projects.htm#SOFTWARE

CARTS : *Tool for description of RT software architectures*
TCP Sistemas e Ingenieria, Italtel., Danfoss Drives, Artal Tech., Univ. Polit. Madrid
http://www.tcpsi.es/carts/

WG –ECUA : *working group on COTS*, http://www.esi.es/ecua/
1st European COTS User Working Group Workshop, *2001 (host: ESI)*
2nd ECUA Workshop, *Orsay, France, 12-14 Nov. 2001 (host: Thales)*
3rd ECUA Workshop, *Copenhagen, Denmark, 6-7 May 2002*

AIT-WOODDES : *Workshop for OO Design & Dev of Emb Syst.,*
PSA, CEA, DELPHI/MECEL, I-Logix, Softeam, Uppsala Univ., OFFIS
http://wooddes.intranet.gr/project.htm
➔ *includes reports of workshops on UML & RT at ECOOP and UML 2000&2001*

ARTIST : *Advanced Real Time in IST,* network leaded by Verimag + Main
European labs in RT domain (in France : INRIA, CEA, ENS-LSV)
http://www.systemes-critiques.org/ARTIST/

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