14th International Conference on Enterprise Information Systems

7th International Conference on Evaluation of Novel Approaches to Software Engineering

Hybrid Modelling

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The University of Vienna …

Was founded by **Duke Rudolph IV in 1365**. It is the oldest University in the German-speaking cultural area and one of the largest in Central Europe.

The University of Vienna is the largest teaching and Research institution in Austria, with ca. 6,200 persons academic staff. It aims to sustain a wide range of studies as well as to promote new and innovative fields of research.

Currently, about 72,000 students are enrolled in more than 130 courses, of which 34 are Diploma Programmes, 26 Bachelor Programmes and 46 Master Programmes.

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Business Informatics at the universität wien

- Business Informatics research supposed to be beneficial for society and business, based primary on !
  - Behavioristic research
  - Design-oriented research
- Most prominent objective:
  - To position design-oriented IS research in the international research community.
  - Produce practically beneficial, business relevant results.

Memorandum on Design-Oriented Information System Research:
www.dke.univie.ac.at

Hubert Österle, Jörg Becker, Ulrich Frank, Thomas Hess, Dimitris Karagiannis, Helmut Krcmar, Peter Loos, Peter Mertens, Andreas Oberweis and Elmar J. Sinz

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Agenda

- Motivation
- Conceptual Foundations
- The EU-Project ComVantage
- Evaluation
- Conclusion

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Why Model ?!

REVEAL THE APPARENTLY SIMPLE (COMPLEX)
TO BE COMPLEX (SIMPLE)

DESIGN AND REDESIGN

SUGGEST EFFICIENCIES

DISCOVER NEW QUESTIONS

ANALYZE AND SIMULATE

DEMONSTRATE TRADEOFFS

PREDICTION

DOCUMENTATION

OPTIMIZE

ILLUMINATE UNCERTAINTIES

EXECUTION

DATA COLLECTION

EXPLAIN

Modelling as Horizontal Function!

- Covering all domains of Computer Science

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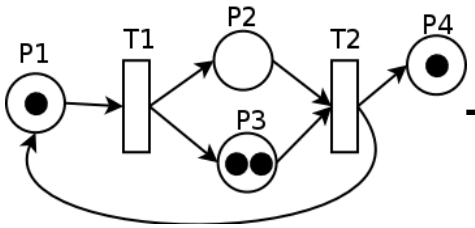
Apply a Modelling Method: Examples

Petri Nets

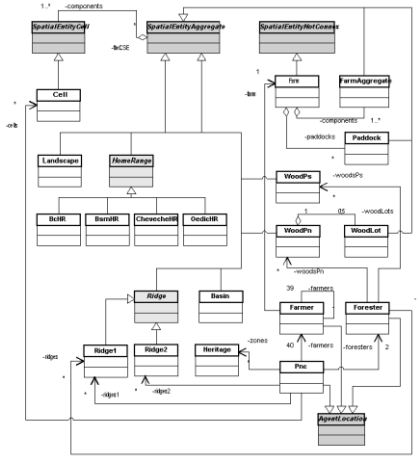


Computer Hardware Engineer

Integrated Circuit

Material

UML



Computer Software Engineer

Software

Immaterial

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BP Modelling Languages: A Selection

Integrated Definition Methods IDEF3

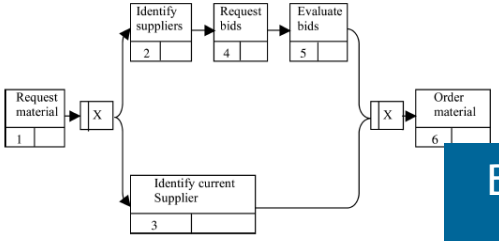


Fig. 5. A process diagram in IDEF3 (adapted from Mayer et al. [1995]).

Petrinets

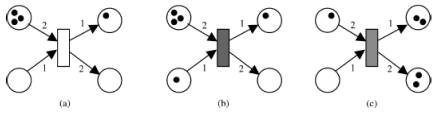
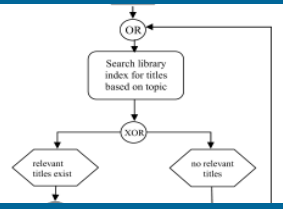
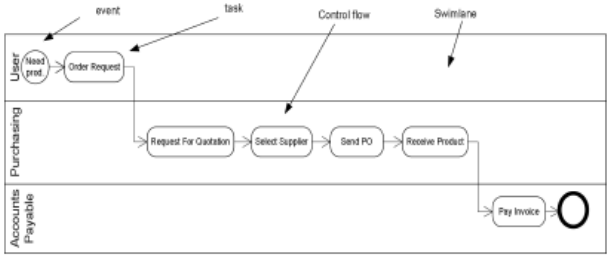


Fig. 7. A Petri net: (a) the transition is not triggered because the bottom left place does not have a token; (b) the transition is now triggered with a token moving in the bottom left place; (c) after firing, each input (output) place loses (gains) an equal number of tokens to the weight of the arc.

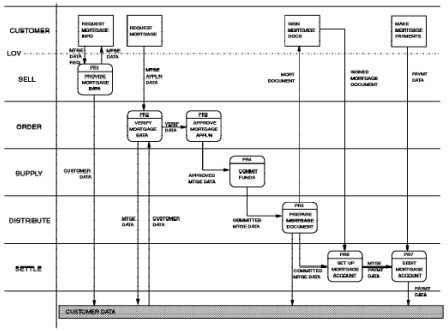
Event Driven Process Chains (EPC)



Business Process Modelling Notation (BPMN)



LOVEM



Role Acitivity Diagrams (RAD)

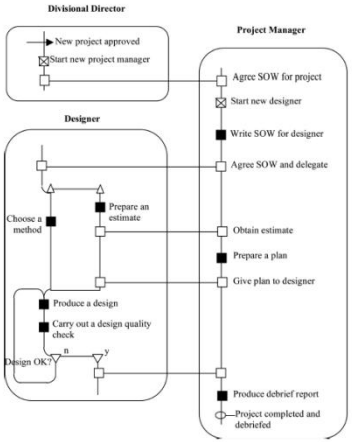
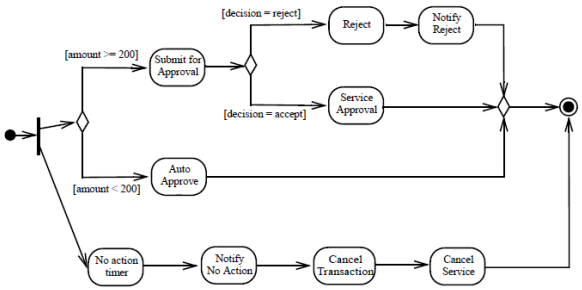
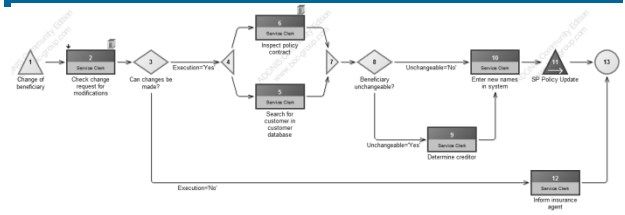


Fig. 8. Role activity diagram for carrying out a project.

UML Activity Diagram



ADONIS BPMS



Source: UML AD [OM10], LOVEM [IB95], ADONIS BPMS (sample models ADONIS), remaining [MT10]

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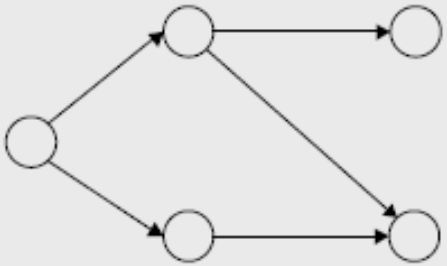
BP Modelling Languages - Types

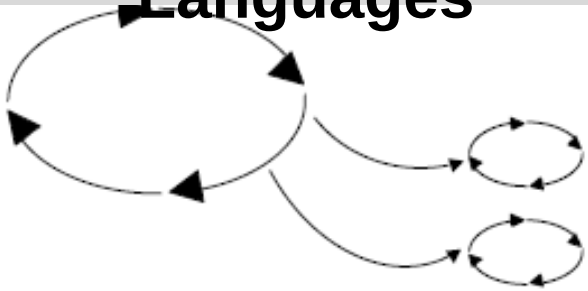
Graphbased Languages



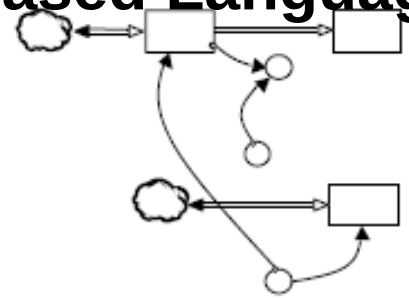
Rulebased Languages

IF (Activity of ?Current.Process is
?Send.product.to.customer)
(Activity of ?Current.Process is
?Check.customer.creditability)
. . .
THEN
(a.Subsequent.Activitiy of
?Send.product.to.customer
is ?Check.customer.creditability)

Speechact based Languages



Systemdynamic based Languages



Source: adapted after [Ju00]

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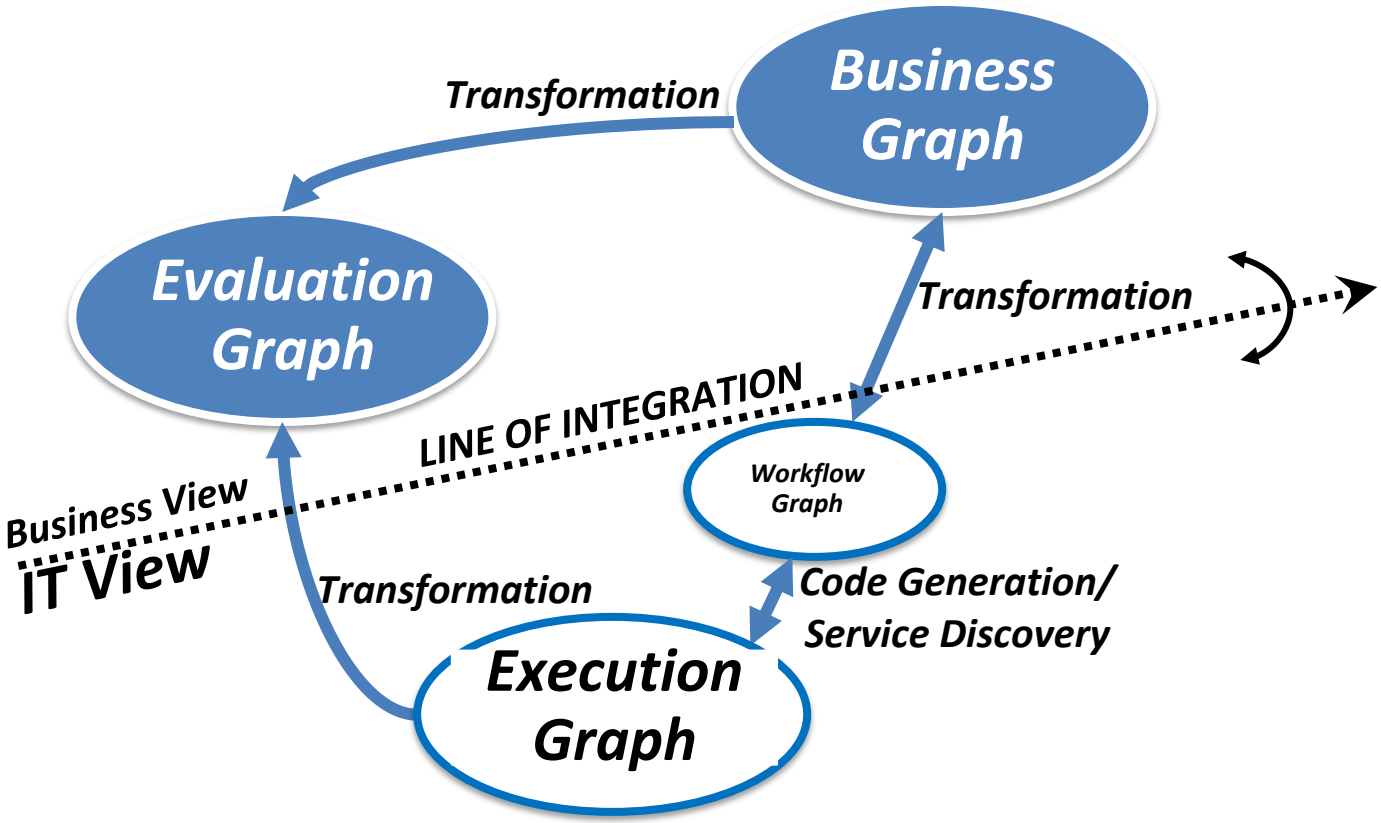
Apply different Modelling Methods



Source: adapted after [KJ96]

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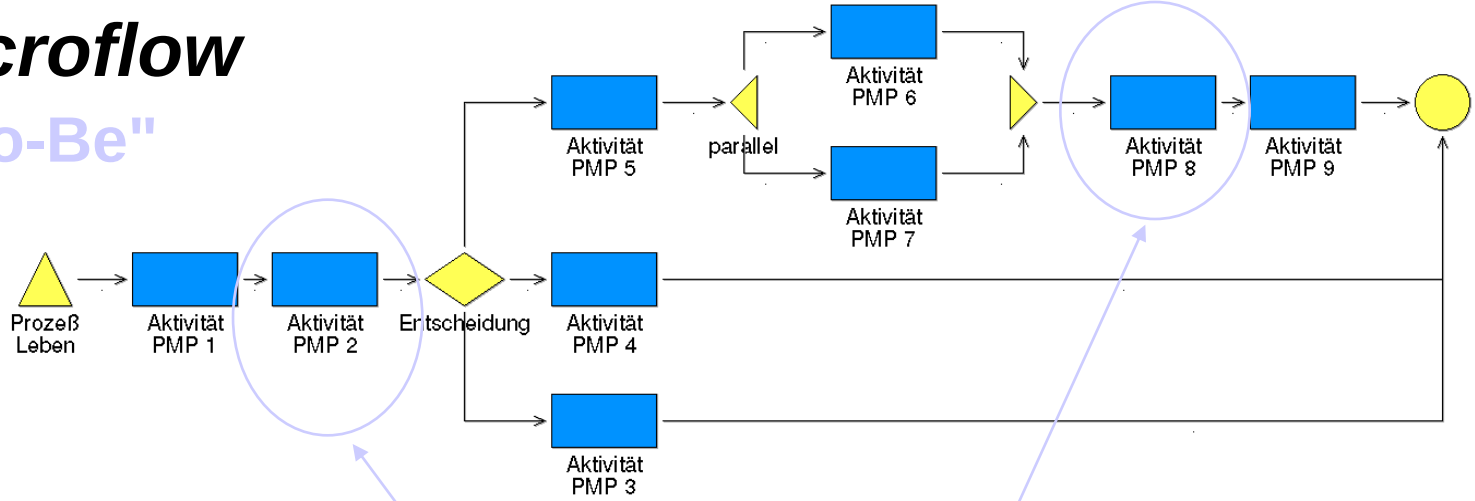
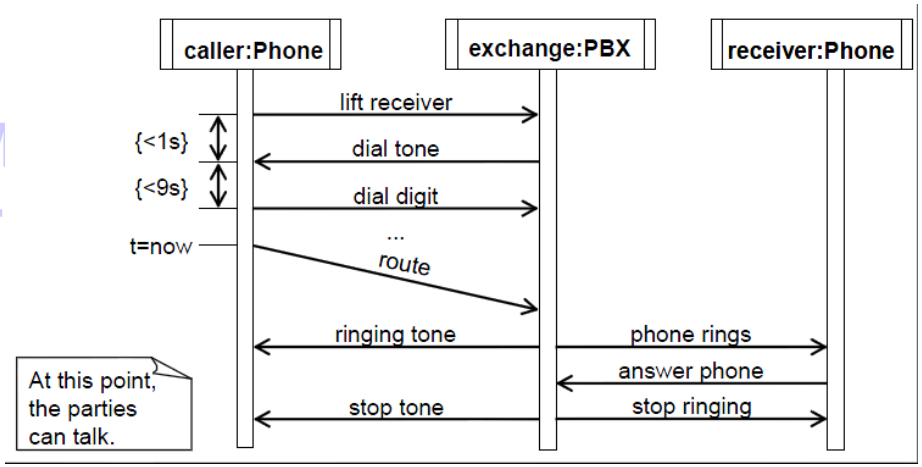
Macroflow

"To-Be"



Microflow

Technical Details, e.g. UM Sequence Diagr



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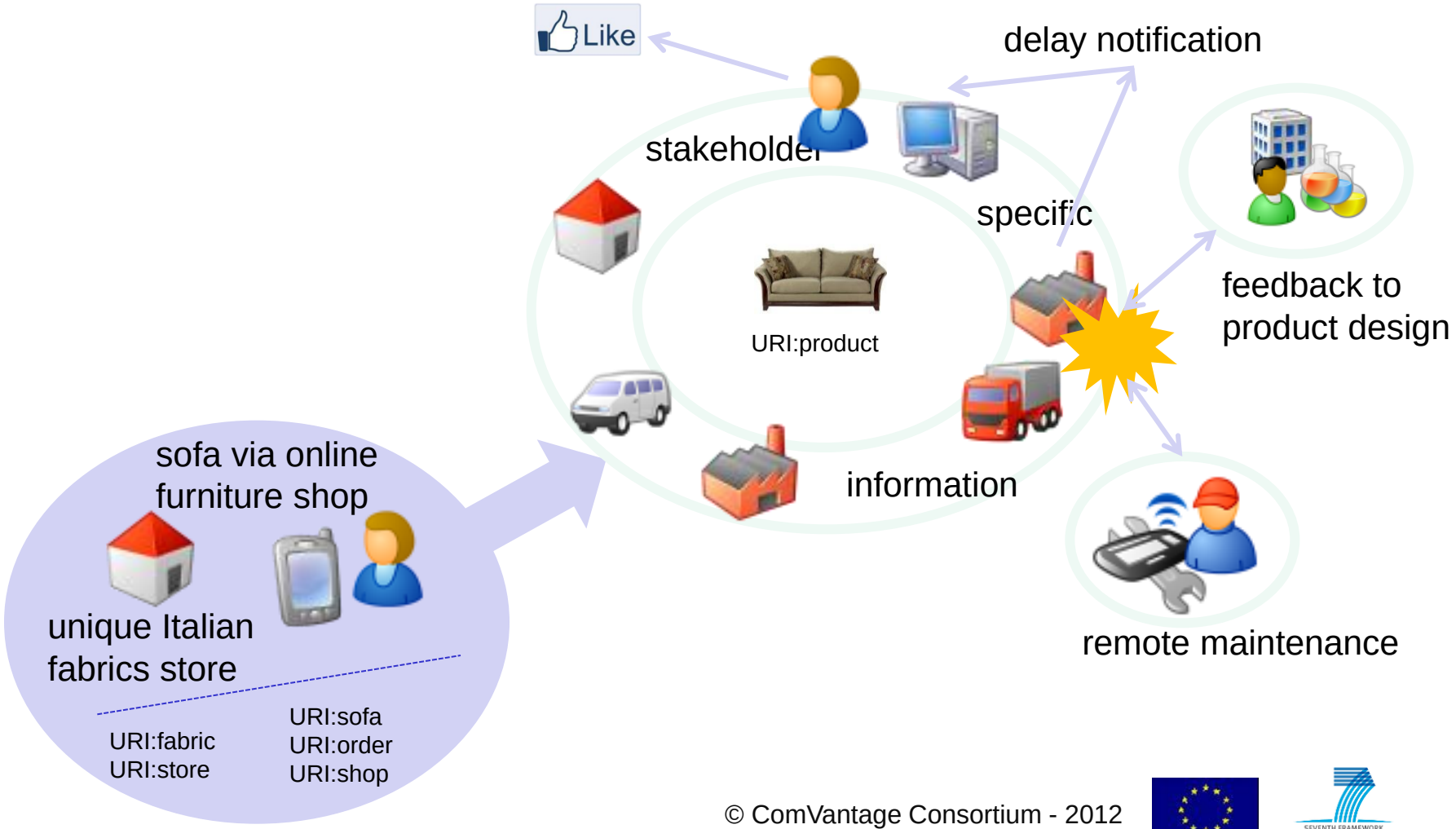
A *ComVantage* Vision Scenario



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Enterprise Modelling: The ComVantage Project

- Aims at providing a product centric information space for cross-organizational information that is shared during production time and beyond.

http://www.comvantage.eu

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Challenge

What is the most appropriate approach to cover all of the FInEIS modelling aspects?

Hybrid Modelling!

focus

Conceptual Foundations of Modelling Methods

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Hybrid Modelling

- Fundamental ***integration problem*** among metamodels (modelling languages):
  - ***Vertically different*** (they vary in the level of details they describe);
  - ***Horizontally different*** (concepts on the same abstraction level describe different aspects);
  - Both vertically and horizontally different metamodels.
- There is a need to overcome ***syntactical, structural*** and ***semantic*** discrepancy of metamodels, in order to join their concepts together.

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Hybrid Modelling: Heterogeneity

- ***Syntactical heterogeneity***
  - Represents the difference in formats intended for the serialization of metamodels.
- ***Structural heterogeneity***
  - *Representational heterogeneity*: metamodels are represented using different metamodelling languages, each of them showing difference in its expressive power of available modelling primitives (classes, attributes, …);
  - *Schematic heterogeneity*: equal concepts are modelled either with different modelling primitives or with different number of primitives.
- ***Semantic heterogeneity***
  - Difference in the meaning of the considered metamodel concepts.

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Hybrid Modelling: Platform Support

- Metamodelling platforms should be realized on a component-based, distributable, and scalable architecture.
- The meta-metamodel, most important element of the platform, needs to define all the necessary concepts.
- The model repository needs to be designed to accommodate the reuse of already developed modelling method constructs.
- Hybrid modelling methods can be developed using chunks and pieces from the repository by binding them together using appropriate mapping and integration rules.

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Conceptual Foundations

How do we like to do that?

Proposed Approach: „Meta-modelling" as a concept

A "Meta-modelling" as an idea is introduced to rise the level of abstraction and to simplify the development of modelling languages, modelling methods, and finally, modelling tools.

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Why Metamodel !?

- Understand and describe the problem domain
- Define a vocabulary for the elements in this domain
- Help other understand the problem domain by using the same language
- Manage complexity by raising the level of abstraction at which we think and design
- ***Additional functionality*** for a specific domain of application should be engineered upon the meta-metamodel of the metamodelling platforms. That way a new generation of ***more specialized*** platforms will emerge

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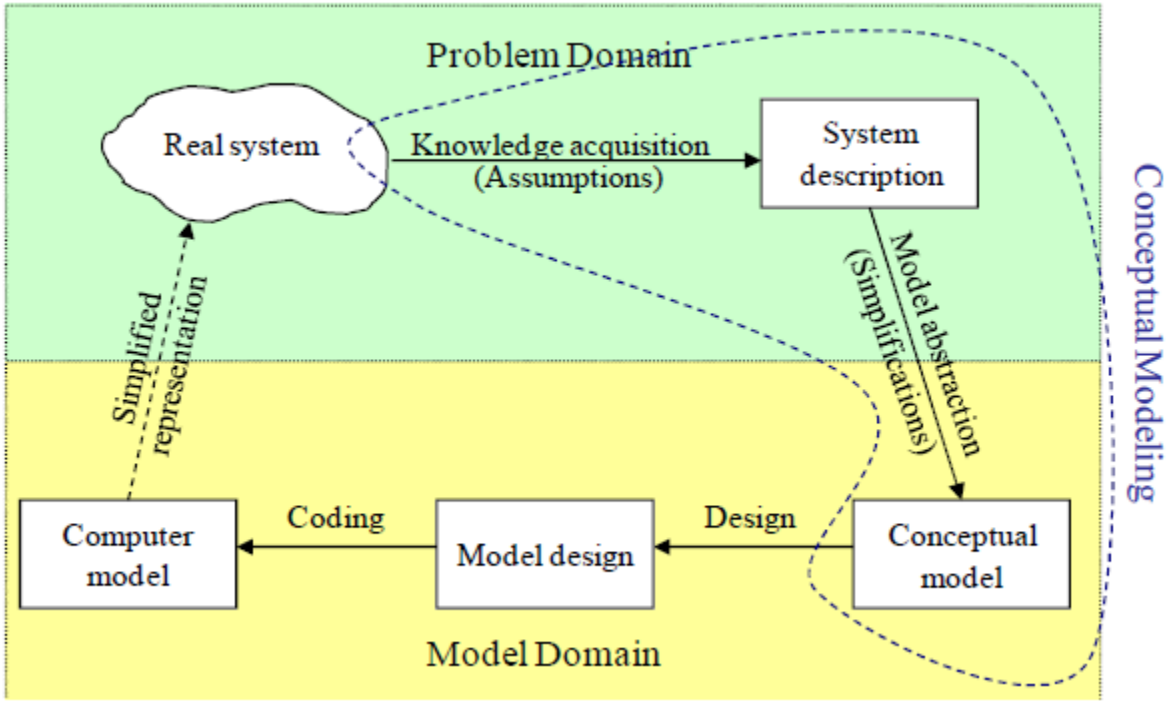

Conceptual model, also known as domain model, represents concepts (entities) and relations between them, and is independent of design or implementation concerns.

Expresses the meaning of terms and concepts used by domain experts to discuss the problem, and to find the correct relationships between different concepts.

Robinson, S.: Designing Simulations that are better then the Rest: Conceptual Modelling for Simulation. In Proceedings: YoungOR 17, 5 – 7 April 2011

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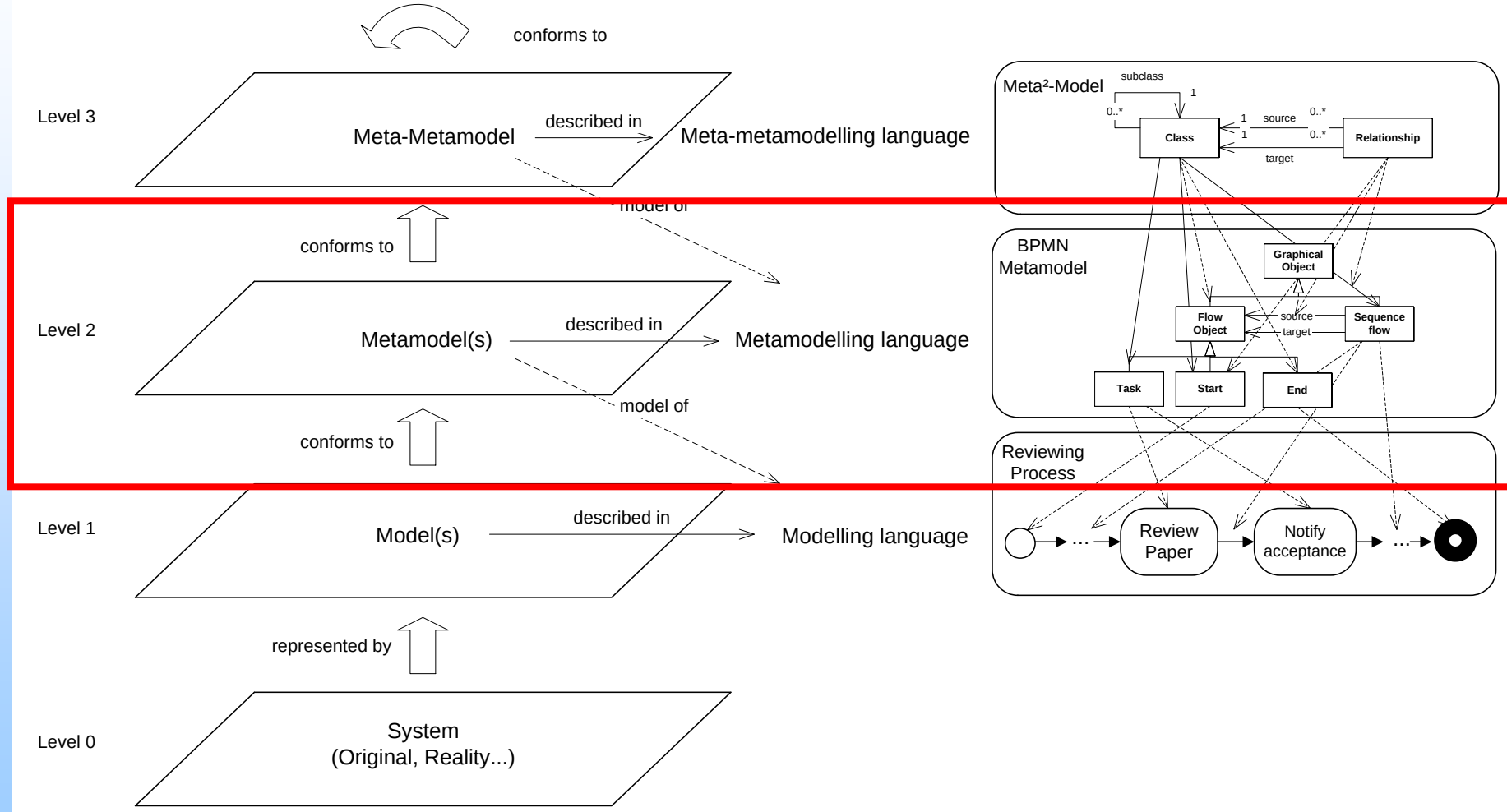
Focus on the Metamodel-Level



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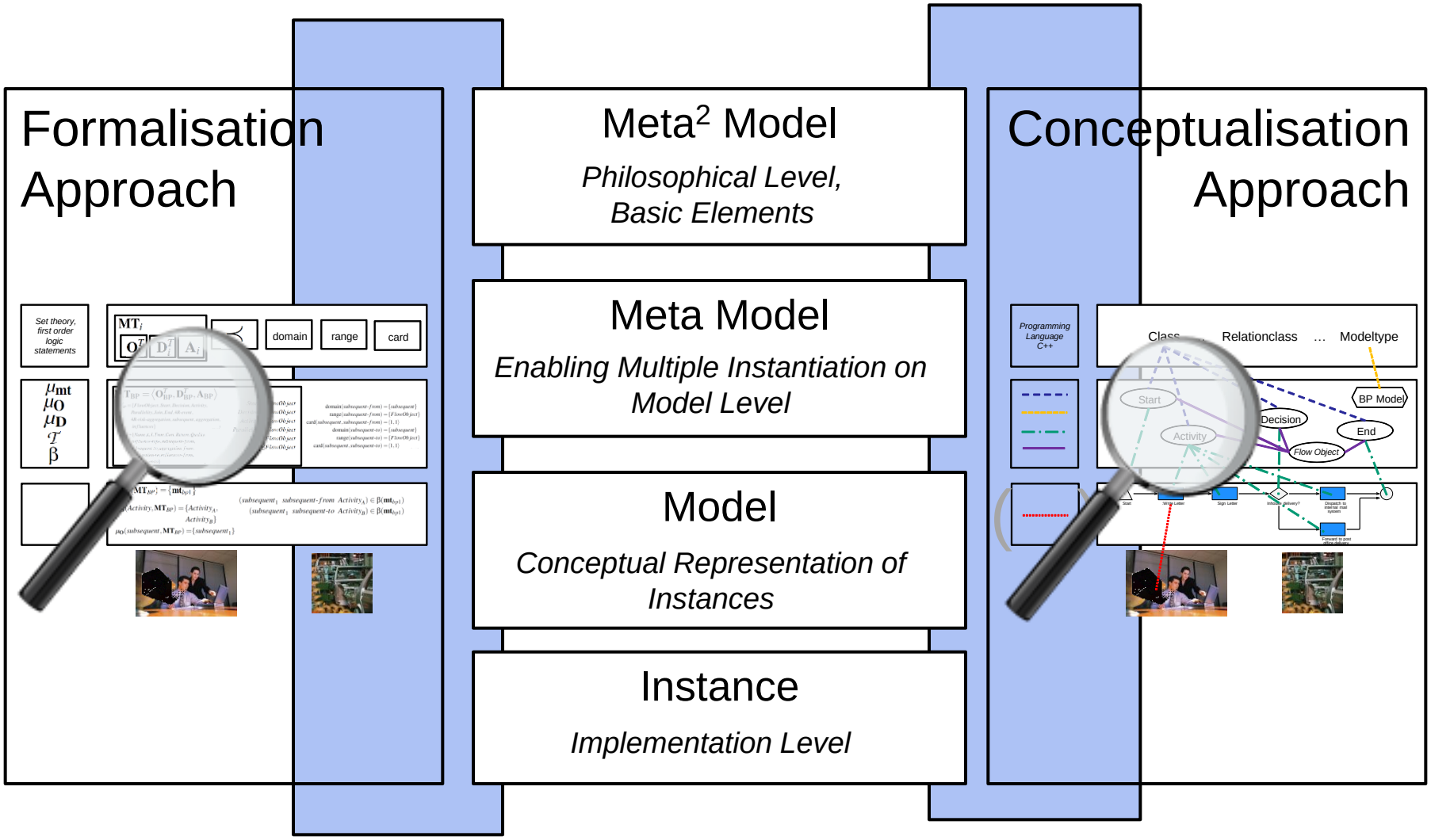
Aspects of Meta-Modelling



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FDMM: A Formalisation Approach

Set theory, first order logic statements

$\mu_{\mathbf{mt}}$
$\mu_{\mathbf{O}}$
$\mu_{\mathbf{D}}$
$\mathcal{T}$
β

$\mathbf{MT}_i$ $\mathbf{O}_i^T$ $\mathbf{D}_i^T$ $\mathbf{A}_i$ $\prec$ domain range card

Meta² Model

$\mathbf{MT}_{\mathrm{PO}} = \langle \mathbf{O}_{\mathrm{PO}}^T, \mathbf{D}_{\mathrm{PO}}^T, \mathbf{A}_{\mathrm{PO}} \rangle$

$\mathbf{O}_{PO}^T = \{Business\text{-}transaction, relates\text{-}business\text{-}transaction\}$

$\mathbf{D}_{PO}^T = \{String, Float, \mathbf{Enum}_{view}\}$

$\mathbf{A}_{PO} = \{ID, W, RE, RI, WE, \rho, relates\text{-}from, relates\text{-}to, Process, View\}$

$\mathrm{domain}(W) = \{Business\text{-}transaction\}$

$\mathrm{range}(W) = \{Float\}$

$\mathrm{card}(Business\text{-}transaction, W) = \langle 0, 1 \rangle$

Meta Model

$\mu_{\mathbf{MT}}(\mathbf{MT}_{PO}) = \{\mathbf{mt}_{po1}\}$

$\mu_{\mathbf{O}}(Business\text{-}transaction, \mathbf{MT}_{PO}) = \{BT_P, BT_Q\}$

$\mu_{\mathbf{D}}(Float) = \{25.00, 55.00, 60.00\}$

$(BT_P \ W \ 25.00) \in \beta(\mathbf{mt}_{po1})$

Model

Hans-Georg Fill, Timothy Redmond, Dimitris Karagiannis (2012): FDMM: A Formalism for Describing ADOxx Meta Models and Models, to appear in ICEIS'2012

World

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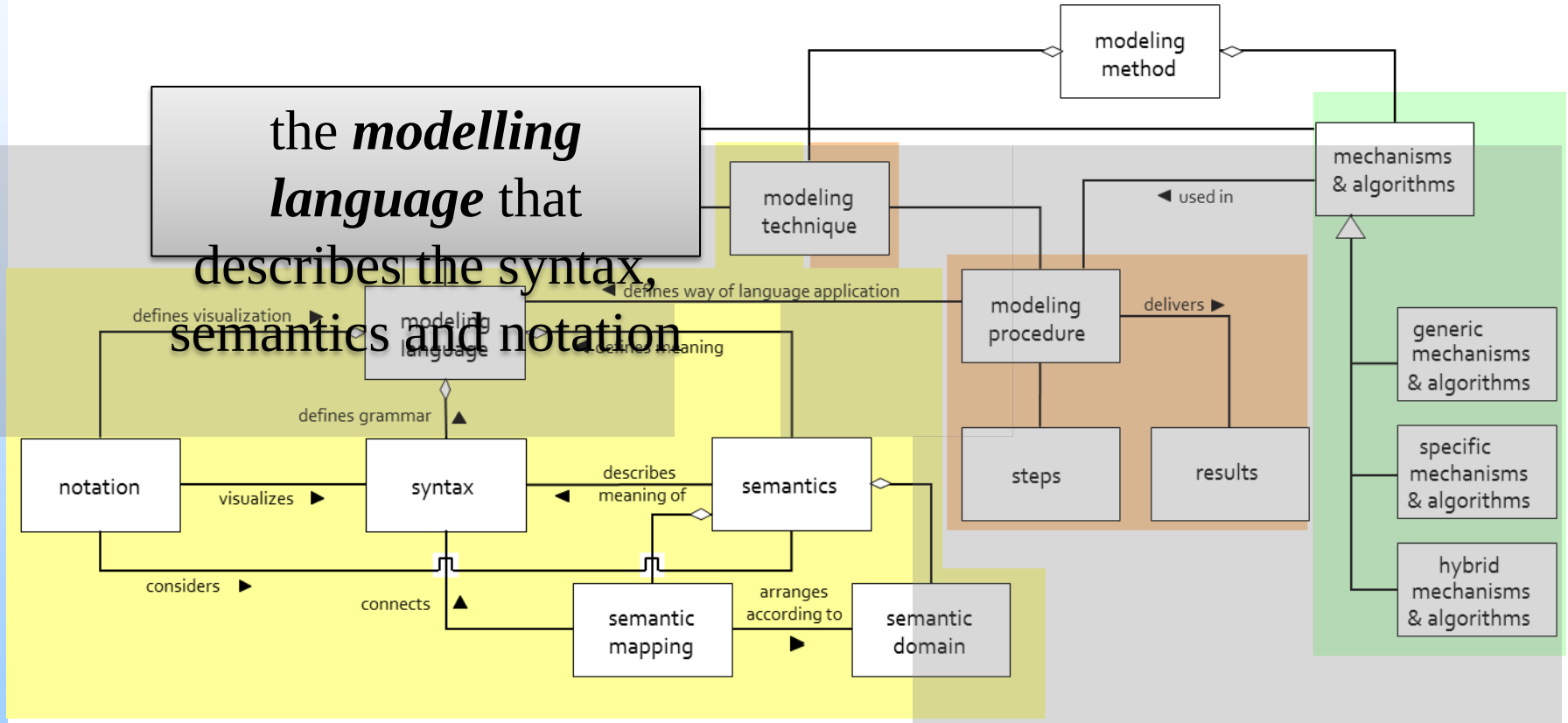
Generic Modelling Method Framework

Describes modelling methods on three major parts



the ***modelling language*** that describes the syntax, semantics and notation

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Modelling Language:

Semantics for Syntactic Elements

- Aspects of a modelling language that **cannot** be described with mechanisms for syntax definitions are pushed into the semantics area[1]
- Operational Semantics
  - The basic interest is on the "execution" of models based on an abstract machine, e.g. Interpreter for Petri-Nets or Statecharts
- Denotational Semantics
  - The denotation is expressed through a mapping of syntactic constructs to constructs of a commonly accepted domain that is assumed to be well understood, e.g. Control-Flow of BPEL denoted in terms of Petri-Nets

1) cf., David Schmidt, Denotational Semantics: A Methodology for Language Development, 1986

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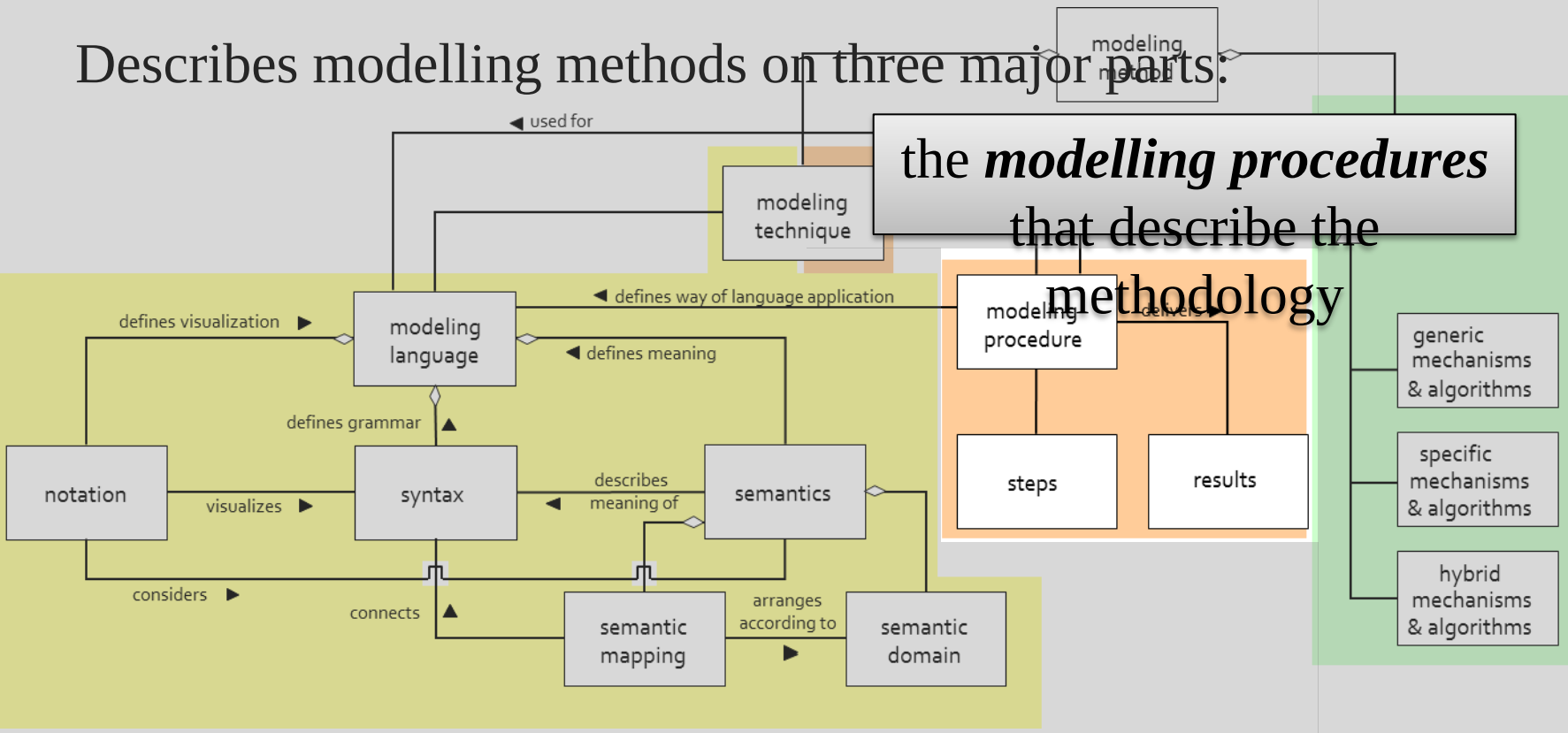
Generic Modelling Method Specification Framework

Describes modelling methods on three major parts:

the ***modelling procedures*** that describe the methodology



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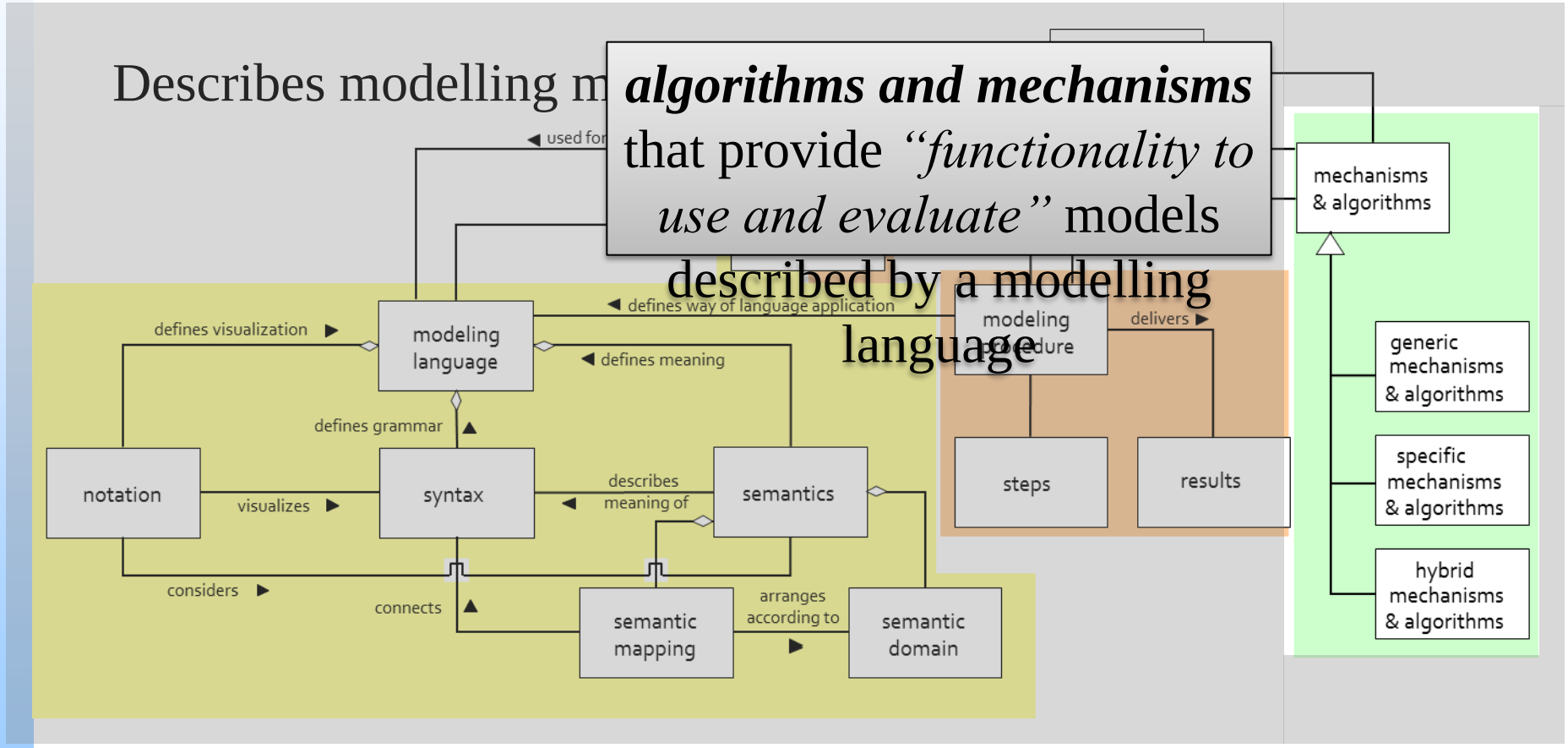
Generic Modelling Method Specification Framework



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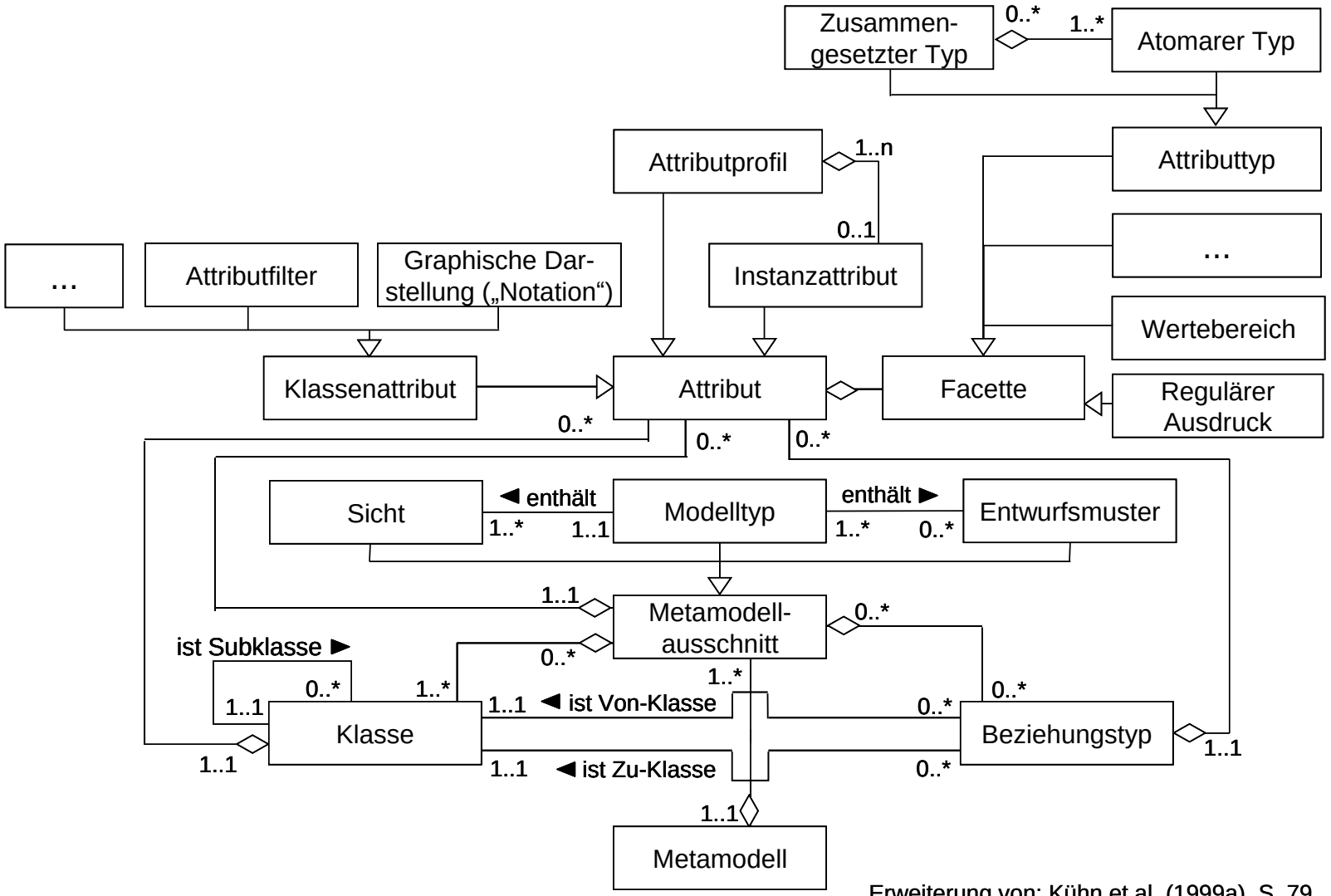
Metamodel of a Metamodelling Language



Erweiterung von: Kühn et al. (1999a), S. 79

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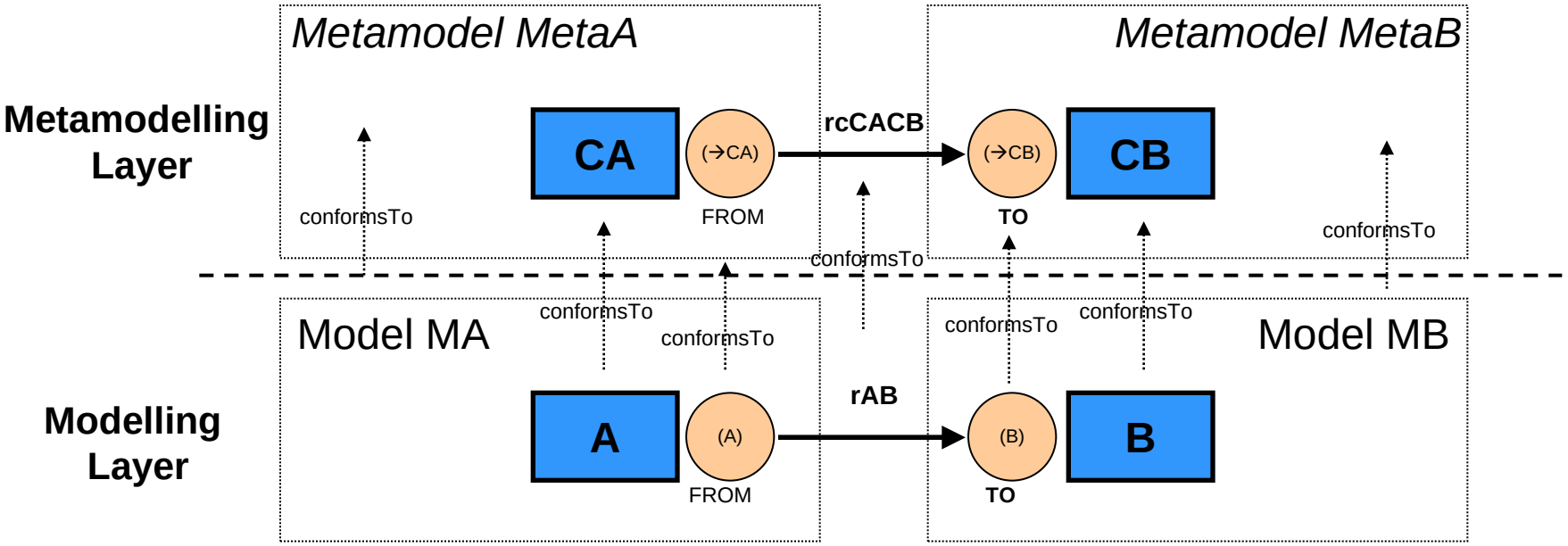
Metamodel Element: Relation Class

- Relations in ADOxx® are customized – by the use of the Meta^2 Construct “Relation Class”
- A Relation Class
  - describes relationship between two or more classes or modeltypes;
  - has endpoints defining which classes a relation class can connect.
- An “InterRef” is a special configuration of a relation class.



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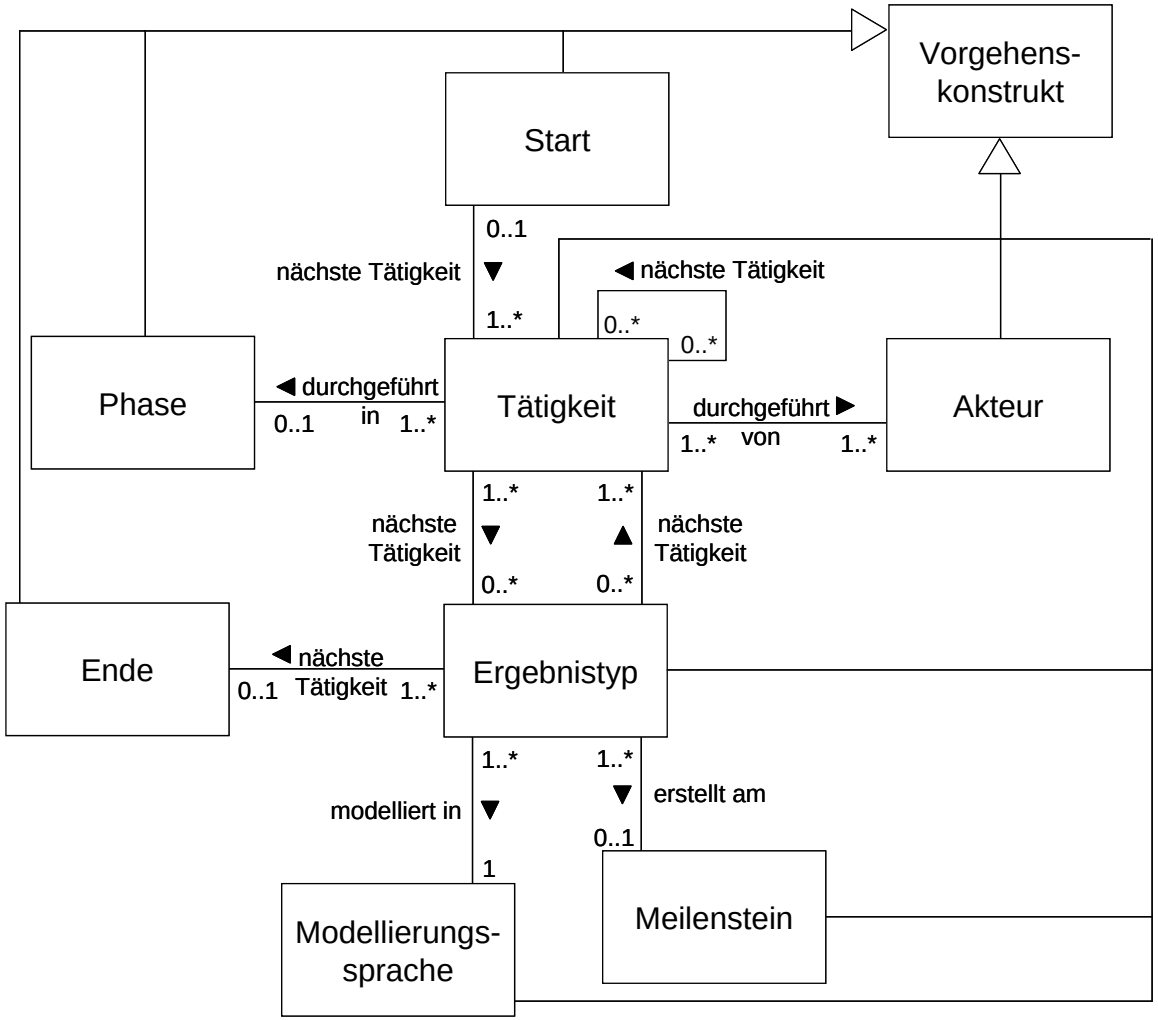
Metamodel of a Procedure Definition Language



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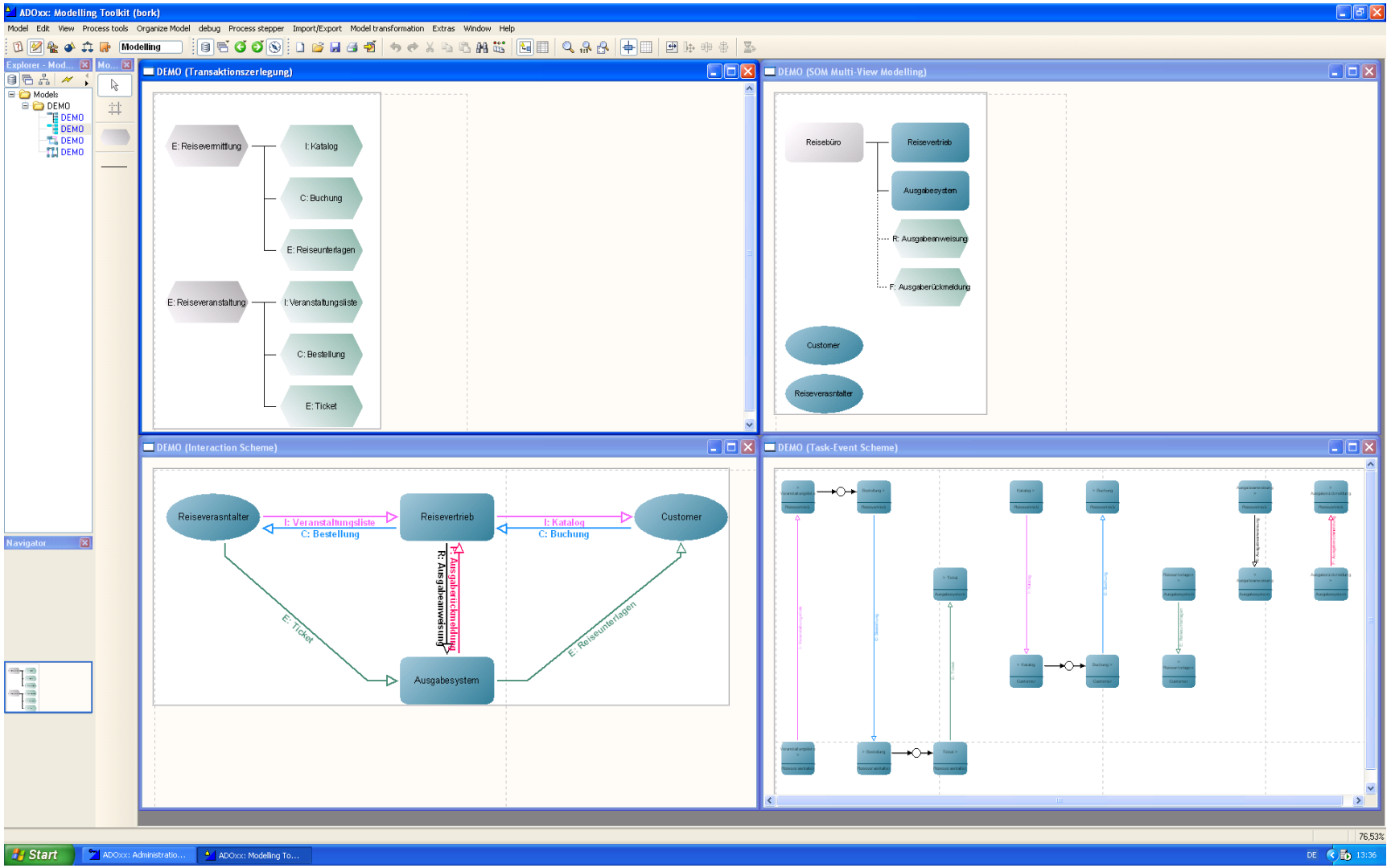
Semantic Object Model on ADOxx®



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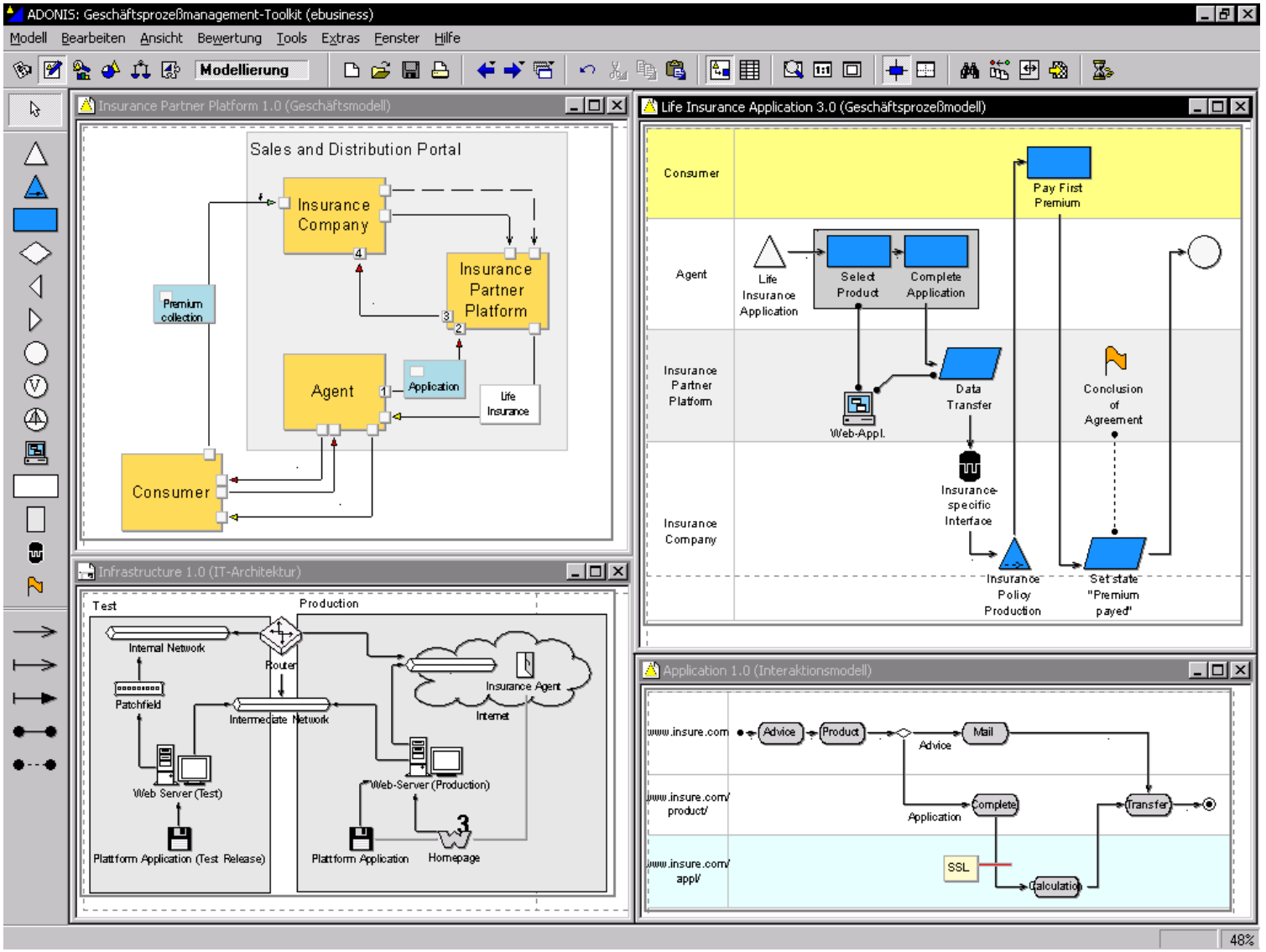
Metamodel Integration: An Example



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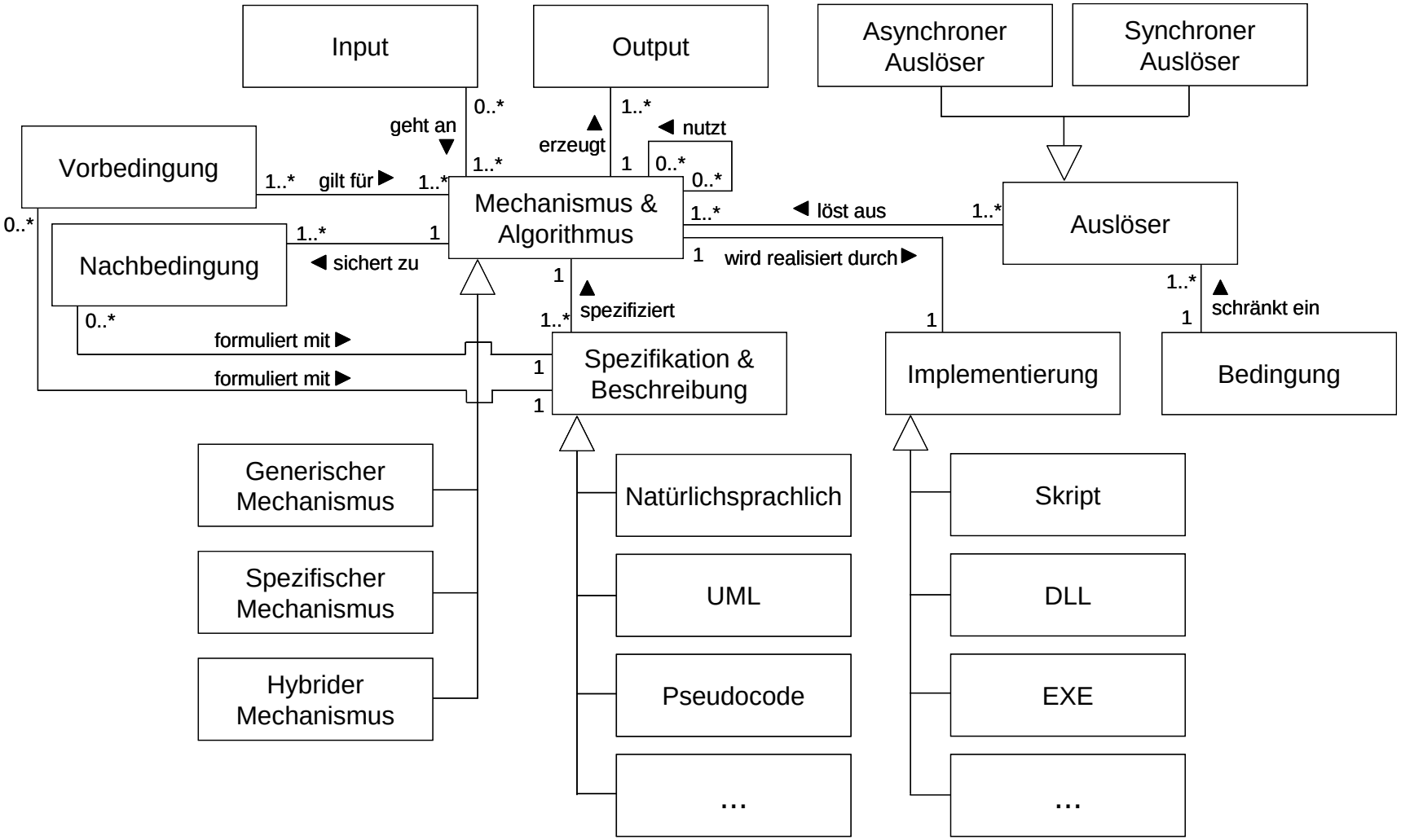
Metamodel of a M&A Definition



Kühn, H. (2004). Methodenintegration im Business Engineering. PhD Thesis, University of Vienna

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Mechanisms & Algorithms: A Process-based Compliance Scenario

- **Frequency of Occurrence**
  e.g. How many regulations show the different paths in contrast to the total fitting of the business process?

- **Average Regulation Fitting for the Business Process**
  e.g. What is the average fitting with regulations for the entire business process?

- **Probability of Regulation Fitting (Weighted)**
  e.g. How likely is it that a path result regarding the regulation fitting occur?

- **Probable Average Occurrence of a Regulation (Weighted)**
  e.g. What is the average probability of a specific regulation within the business process?

Margit Schwab, “Process-based Compliance: Probabilities” 6th International Conference on Research Challenges in Information Science, May 16th - 18th 2012, Valencia, Spain.

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Mechanisms & Algorithms: A Process-based Compliance Scenario

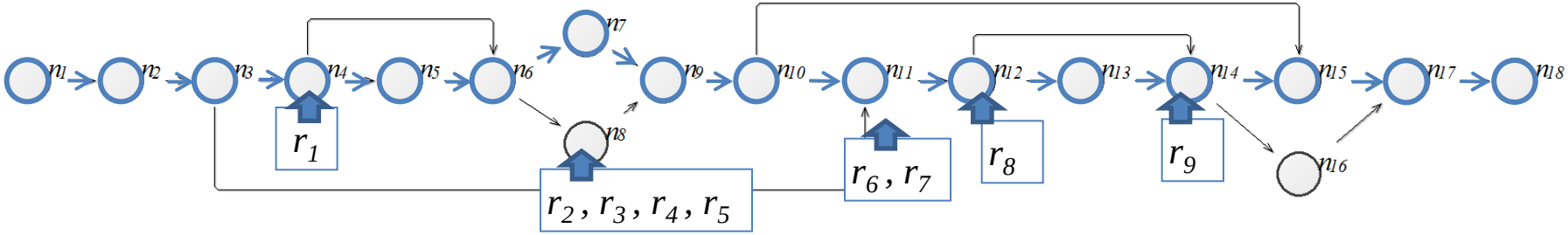
Algorithm: Frequency of Occurrence

$$rf = \frac{\sum_{j=1}^{l} |\, cnrs_j \,|}{|\, RS \,|}$$

rf = Regulation Fitting (Indicator)
RS = Regulation Set
cnrs = compliance node regulation set

$\sum |cnrs_j| = 5$
x is kept constant $\bar{x}$
RS: $\bar{x} = 9$
$rf_{path_1} = ?$

$$rf_{path_1} = \frac{\sum_{j=1}^{l} |\, cnrs_j \,|}{|\, RS \,|} = \frac{cnrs_4 + cnrs_{11} + cnrs_{12} + cnrs_{14}}{|\, RS \,|} = \frac{5}{9} = 0.55\dot{5}$$



$path_1 = \{n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_9, n_{10}, n_{11}, n_{12}, n_{13}, n_{14}, n_{15}, n_{17}, n_{18}\}$

Assumption:
A typical business process model shows several different paths.

Application Scenario: Process-based Compliance

Margit Schwab, "Process-based Compliance: Probabilities"
6th International Conference on Research Challenges in Information Science, May 16th - 18th 2012, Valencia, Spain.

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Mechanisms & Algorithms: A Process-based Compliance Scenario

Algorithm: Average Regulation Fitting for the Business Process

No.	Path Description	Excluded Nodes	Absolute Number of Regulations	Regulation Fitting, *rf*
1	$n_1, n_2, n_3, n_4, n_5, n_6, n_8, n_9, n_{10}, n_{11}, n_{12}, n_{13}, n_{14}, n_{15}, n_{17}, n_{18}$	n_7, n_{16}	9	1
2	$n_1, n_2, n_3, n_{11}, n_{12}, n_{13}, n_{14}, n_{15}, n_{17}, n_{18}$	$n_4, n_5, n_6, n_7, n_8, n_9, n_{10}, n_{16}$	4	0,444
3	$n_1, n_2, n_3, n_4, n_5, n_6, n_8, n_9, n_{10}, n_{15}, n_{17}, n_{18}$	$n_7, n_{11}, n_{12}, n_{13}, n_{14}, n_{16}$	5	0,555
4	$n_1, n_2, n_3, n_4, n_5, n_6, n_8, n_9, n_{10}, n_{11}, n_{12}, n_{14}, n_{15}, n_{17}, n_{18}$	n_7, n_{13}, n_{16}	9	1
5	$n_1, n_2, n_3, n_{11}, n_{12}, n_{14}, n_{15}, n_{17}, n_{18}$	$n_4, n_5, n_6, n_7, n_8, n_9, n_{10}, n_{13}, n_{16}$	4	0,444
6	$n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_9, n_{10}, n_{11}, n_{12}, n_{13}, n_{14}, n_{15}, n_{17}, n_{18}$	n_8, n_{16}	5	0,555
7	$n_1, n_2, n_3, n_4, n_5, n_6, n_8, n_9, n_{10}, n_{11}, n_{12}, n_{13}, n_{14}, n_{16}, n_{17}, n_{18}$	n_7, n_{15}	9	1
8	$n_1, n_2, n_3, n_{11}, n_{12}, n_{13}, n_{14}, n_{16}, n_{17}, n_{18}$	$n_4, n_5, n_6, n_7, n_8, n_9, n_{10}, n_{15}$	4	0,444
9	$n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_9, n_{10}, n_{15}, n_{17}, n_{18}$	$n_8, n_{11}, n_{12}, n_{13}, n_{14}, n_{16}$	1	0,111
10	$n_1, n_2, n_3, n_4, n_5, n_8, n_9, n_{10}, n_{15}, n_{17}, n_{18}$	$n_5, n_7, n_{11}, n_{12}, n_{13}, n_{14}, n_{16}$	5	0,555
	$n_6, n_7, n_9, n_{10}, n_{11}, n_{12}, n_{14}, n_{15}, n_{17}, n_{18}$	n_8, n_{13}, n_{16}	5	0,555
	$n_6,$	n_{13}, n_{15}	9	1
	n	$n_5, n_6, n_7, n_8, n_9, n_{10}, n_{13}, n_{15}$	4	0,444
	$n_6,$	n_{15}	5	0,555
15	$n_1, n_2, n_3, n_4, n_6, n_7, n_9, n_{10}, n_{15}, n_{17}, n_{18}$		1	0,111
16	$n_1, n_2, n_3, n_4, n_6, n_7, n_9, n_{10}, n_{11}, n_{12}, n_{14}, n_{16}, n_{17},$		5	0,555
			$\sum$	**9.328**

$$rf_{avg} = \frac{\sum_{n=1}^{h} rf_{path_n}}{n}$$

$$rf_{avg} = \frac{9.328}{16} = 0.583$$

rf_{avg} = *Average Regulation Fitting (Indicator)*

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Metamodelling Platforms: Some Features

- Extensible, repository-based metamodelling platform
- Three-step modelling hierarchy with a rich meta-metamodel
- Can be customized using metamodelling techniques
- Extendable with custom specific components
- Platform kernel provides basic modules for managing models and metamodels
- Graphical and tabular model editing
- Scripting language for defining mechanisms and algorithms

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Metamodelling Environments: An Overview

In general, metamodelling environments can also be used to specify and implement “domain-specific” modelling tools.

Metamodelling Platforms:

- ADOxx
- MetaEdit+
- Obeo Designer
- GME
- ConceptBase
- …

Metamodelling Frameworks:

- Eclipse: EMF (GEF, GMF), and others
- Visual Studio: Visualization & modeling SDK
- …

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Agenda

- Why Hybrid Modelling
- Conceptual Foundations
- The EU-Project ComVantage
- Evaluation
- Conclusion

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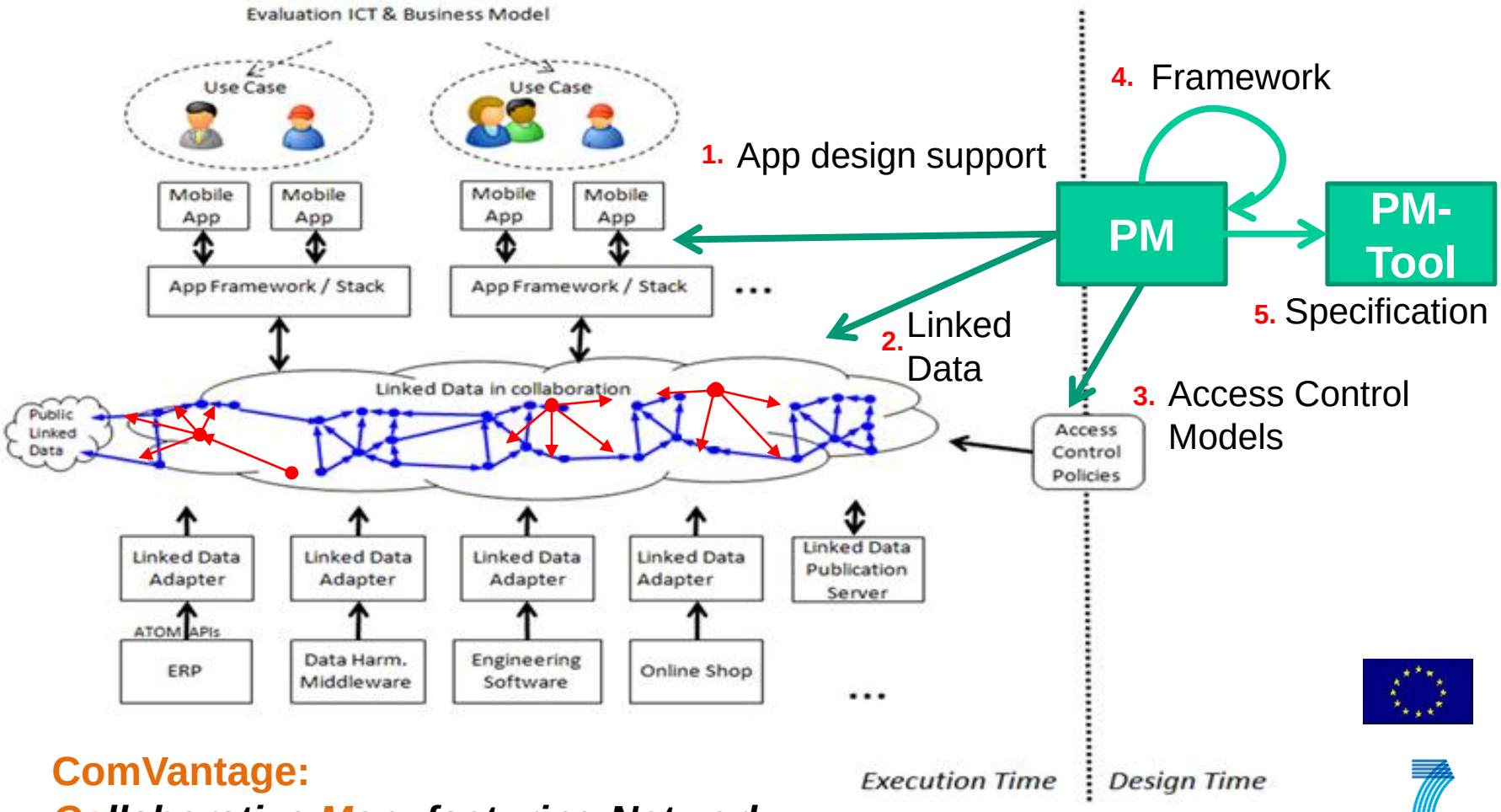
Modelling Method Specification Context

www.comvantage.eu

ComVantage



ComVantage:
Collaborative Manufacturing Network for Competitive Advantage

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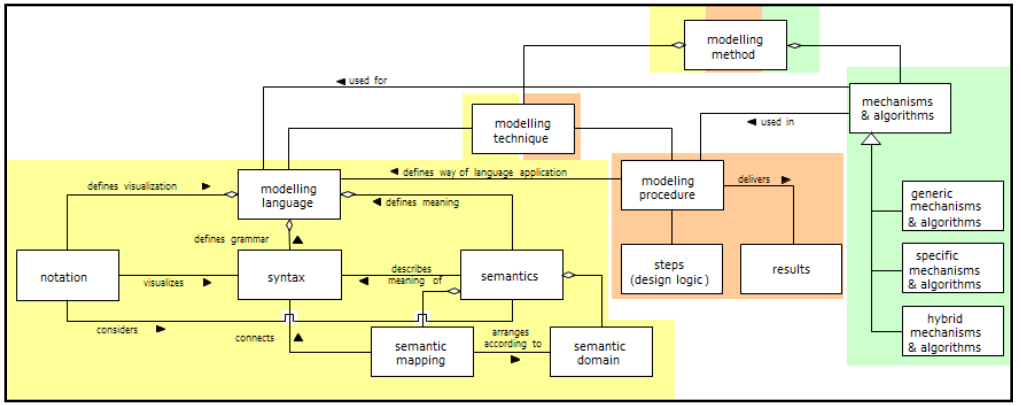
Theoretical Research Foc

ComVantage

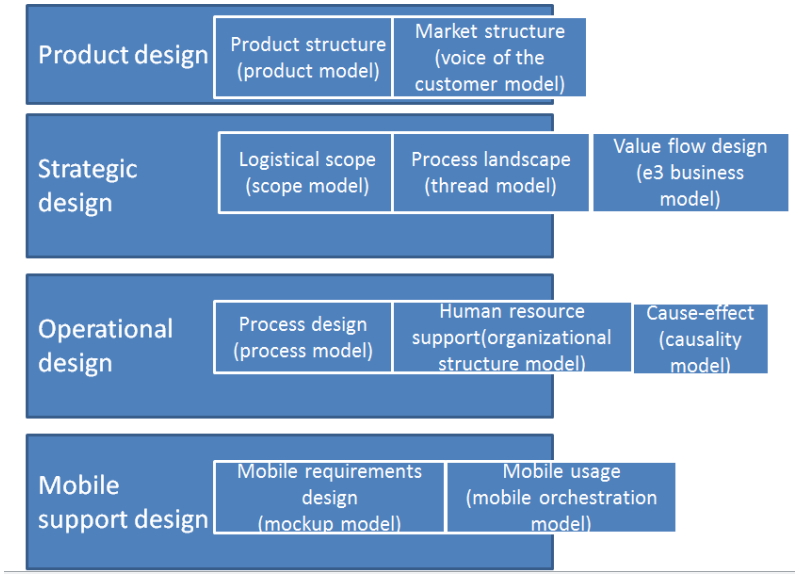
Modelling Framework

1. What **formalism** is needed to describe a metamodelling framework?
2. What are the **atomic elements** on which a modelling method can be built?



Modelling Stack

1. What are the **explicit model types (and their concepts)** that are relevant to ComVantage requirements?
2. What are the **implicit model types (and their concepts)** that should be derived through mechanisms?
3. What is the integration model for ComVantage?



SEVENTH FRAMEWORK PROGRAMME

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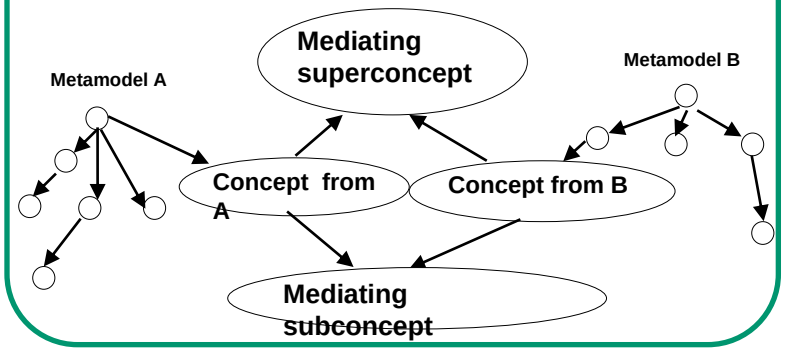
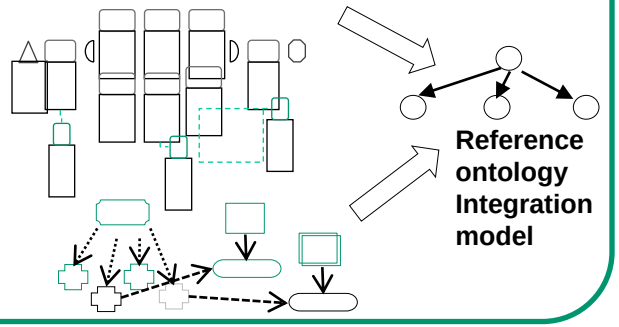
Hybrid Modelling

Formal Concepts on Domain Layer

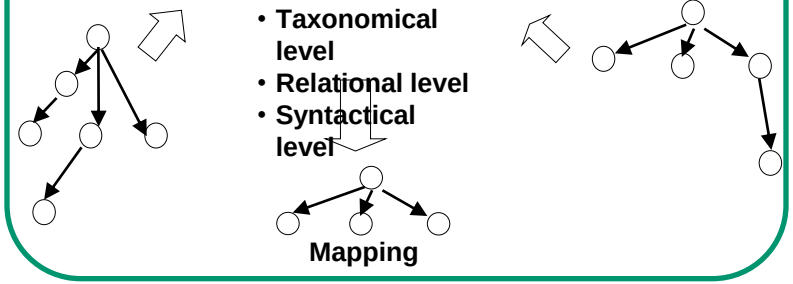
Semantic Mediation



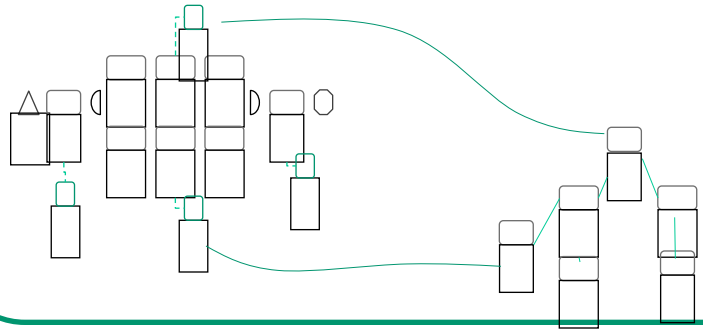
Reference Alignment



Similarity Discovery



Underlying Graph or Query Rewriting Rules



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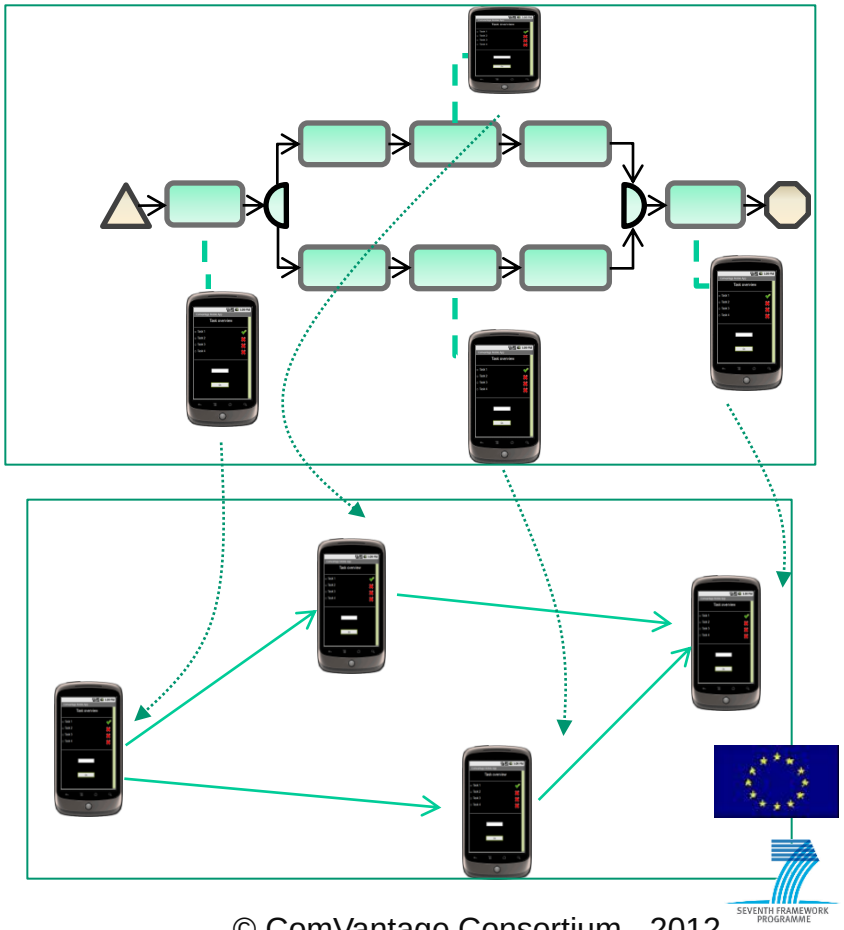
ComVantage: Graph Rewriting

Definition: Transformation of one graph into another by means of graph grammars.

A graph grammar provides rules for transforming occurrences of certain graph patterns (subgraphs) into new patterns, thus generating a new graph.

Main Applications:

- Image processing (transformations)
- Model driven software engineering
- Artificial intelligence (inference engines)



References:

Handbook of Graph Grammars and Computing by Graph Transformations. Volume 1-3. World Scientific Publishing

Design and implementation of a graph grammar based language for functional-structural plant modeling http://opus.kobv.de/btu/volltexte/2009/593/pdf/thesis.pdf

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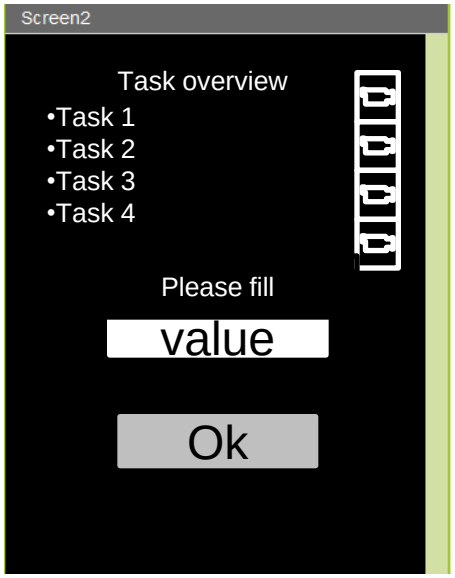
ComVantage: Apps Model

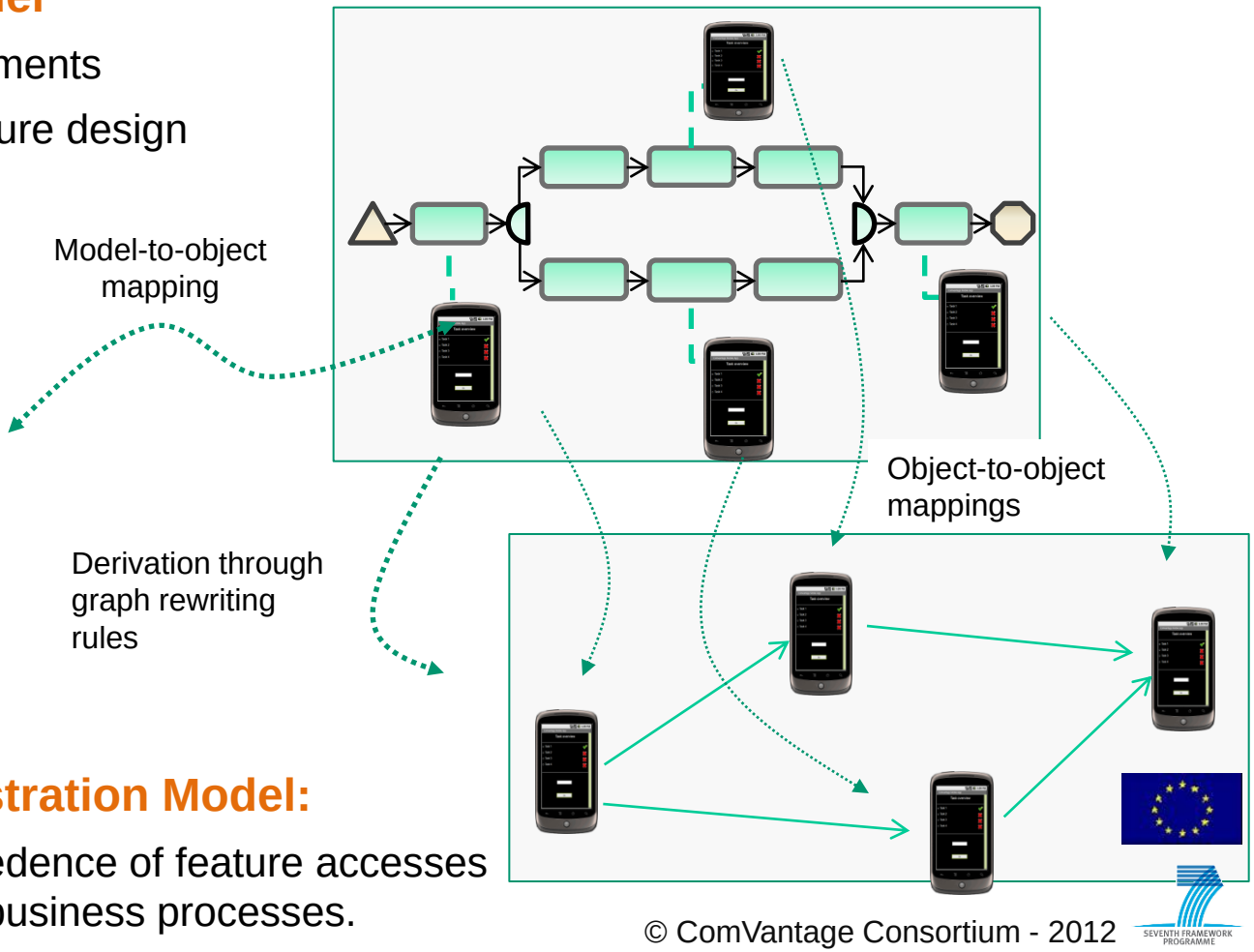
Business Process Model

- Classes are activities, decisions, hubs, mobile support
- Supports design for business processes with mobile support

Mobile Mockup Model

- Classes are GUI elements
- Supports Mobile feature design





App Orchestration Model:

Reflects precedence of feature accesses derived from business processes.

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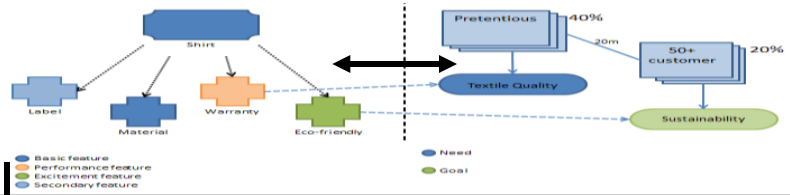
The ComVantage Method: Current State

Product Design

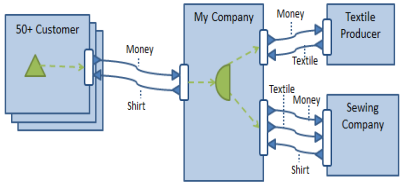
Product structure models



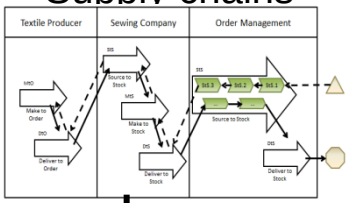
Market structure models

Strategic Design

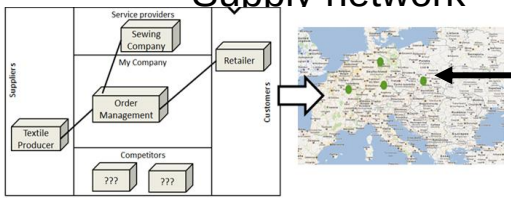
Business model



Supply chains

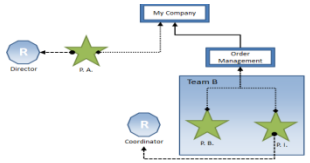


Supply network

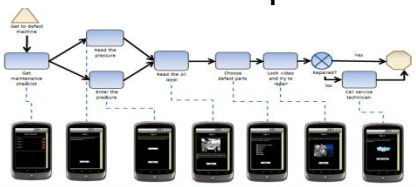


Opera-tional Design

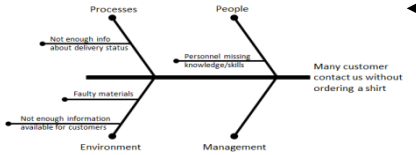
Organisational structure



Business processes



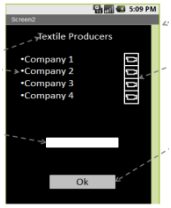
Causality models



Mobile Support Design

Mobile app orchestration models

Mobile mockup models



ComVantage

Design, Analyse, Optimise

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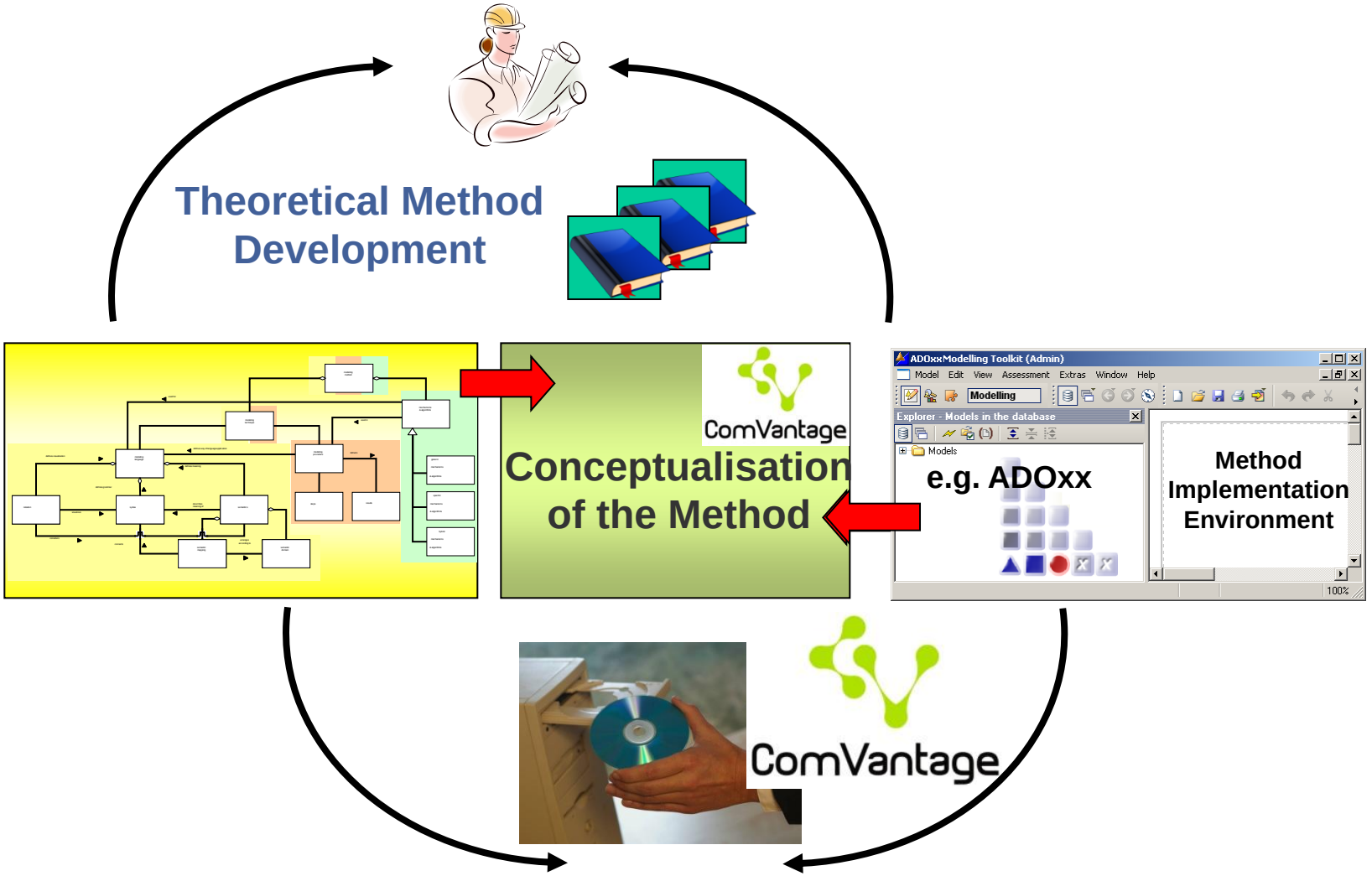
The ComVantage Method

Conceptualisation Process



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What is ADOxx® ?

ADOxx® is a metamodeling development and configuration platform for design/implement modelling methods

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Agenda

- Motivation
- Conceptual Foundations
- The EU-Project ComVantage
- Evaluation
- Conclusion

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Evaluation

Open Model Initiative

A) Scientific: The Open models initiative

www.openmodels.at

B) Business: The BOC-Management Office

www.adonis-community.com

A Spin-off from the University of Vienna

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Evaluation: Selected Methods

Name	Members	University / Institute
BEN	13	University of St. Gallen
CIDOC	4	FORTH Greece
eduWeaver	10	University of Klagenfurt
eGPM	5	University of Hamburg
InSeMeMo	4	St. Poelten University of Applied Sciences
EKD	10	University of Manchester
iStar	31	UPC Barcelona
MeLCa	8	University of Technology, Sydney
OKM	19	FHNW, Olten
PetriNets	8	Humboldt University Berlin
PROMOTE	5	University of Vienna
SemFIS	16	University of Vienna
SOM	16	Otto-Friedrich University of Bamberg
VLML	3	University of Zürich

Open Model Initiative

OMI Platform Users	
Members	All
182	**311**

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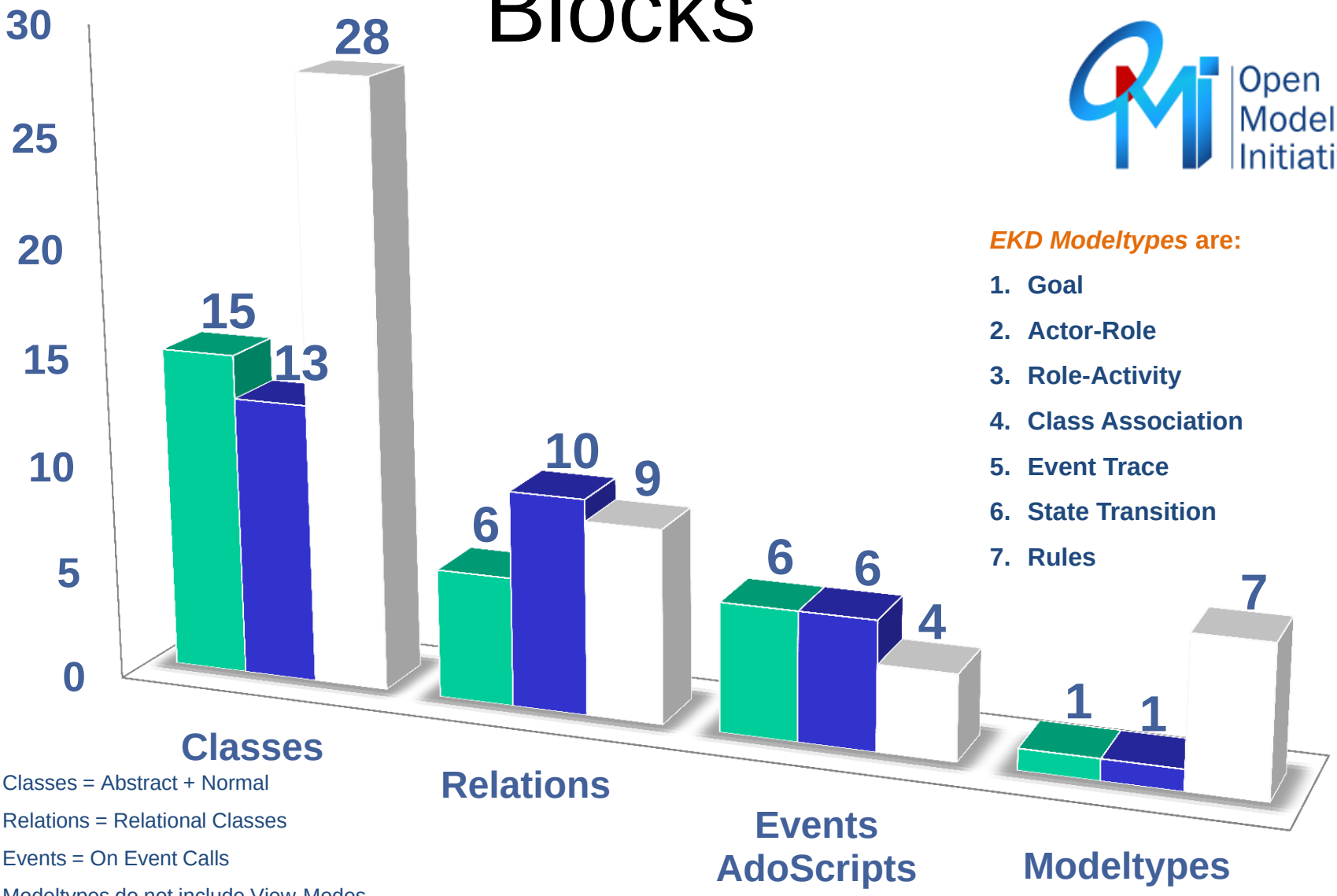
Evaluation: Method Building Blocks



Classes = Abstract + Normal

Relations = Relational Classes

Events = On Event Calls

Modeltypes do not include View-Modes

***EKD Modeltypes* are:**

1. **Goal**
2. **Actor-Role**
3. **Role-Activity**
4. **Class Association**
5. **Event Trace**
6. **State Transition**
7. **Rules**

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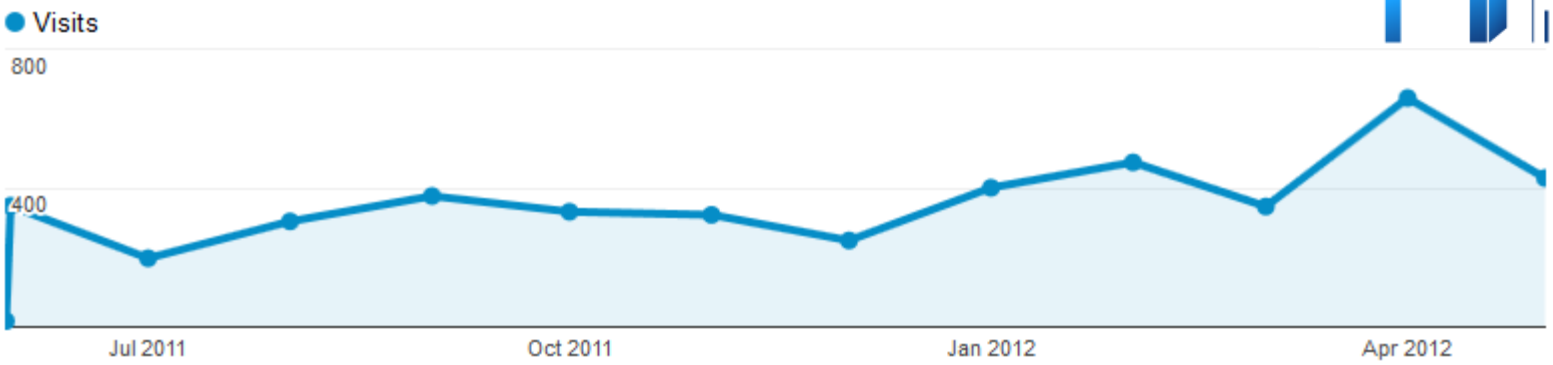
Evaluation: *openmodels.at*

May 31, 2011 – May 31, 2012



Visits: 4,459

Unique Visitors: 2,187

Pageviews: 24,384

Pages/Visit: 5.47

Avg. Visit Duration: 00:04:39

Bounce Rate: 43.49%

% New Visits: 47.12%

52.86% Returning Visitor
2,357 Visits

47.14% New Visitor
2,102 Visits

27.54% Search Traffic
1,228 Visits

31.37% Referral Traffic
1,399 Visits

41.09% Direct Traffic
1,832 Visits

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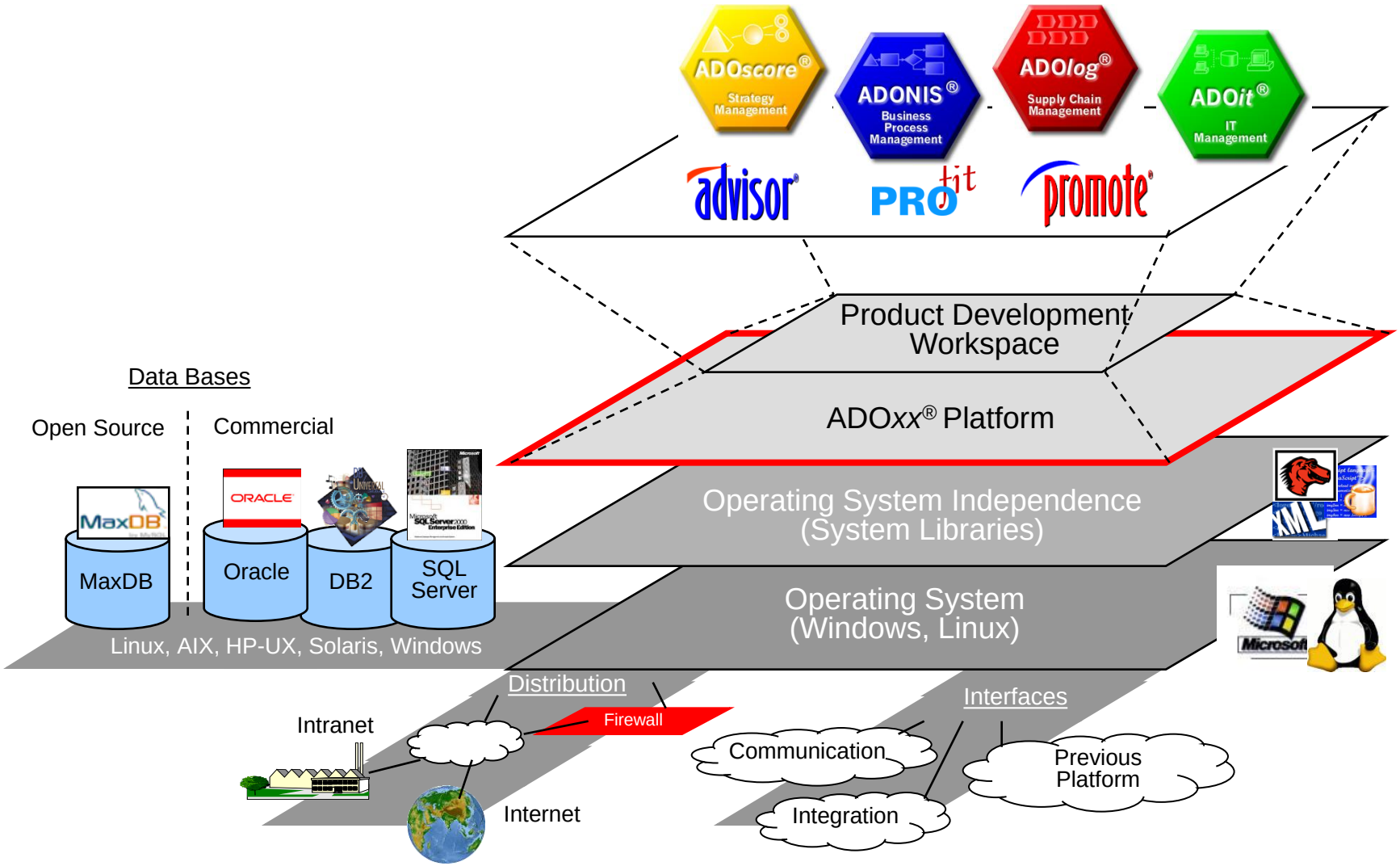
Evaluation: Enterprise Modelling Tools



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Agenda

- Motivation
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Key Messages

1) **Observation that one Modelling Method** – e.g. UML, BPMN, BPEL - **is not enough** to cover all Modelling Aspects of Next Generation Enterprise Systems

2) **Hybrid Modelling** as **Solution** Approach

3) **Best Practice Samples** of FInES Cluster Projects / EU FP7 Projects: ComVantage (www.comvantage.eu) and BIVEE (bivee.eu/)

4) **Outlook towards Open Models Initiative** as Collaboration Platform

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Some Research Issues (I)

- ***Alignment of business process and security*** (prevention strategies against social engineering attacks, addressing security risks in business process modelling, security threats identification, etc.).

- ***Optimizing information flow and efficient reuse of existing knowledge*** as part of the business strategy of viable enterprises (approaches and solutions for active, viable, and agile information systems, information logistics and knowledge supply, etc.).

- ***Intelligent educational systems*** (collaborative learning environments, virtual and distant education, internet based tutoring systems, etc.).

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Some Research Issues (II)

- ***Information integration*** (event based data integration, user centric data integration, streaming data integration; solving information overflow problem for the users, etc.).
- ***Interoperability*** (completely understandable interfaces to share data between different systems, people, and businesses, etc.).
- New ***architectures for information systems*** (enterprise architecture frameworks, ERP development approaches, etc.).
- New ***modelling methods***, ***modelling*** and ***metamodelling tools***.

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Selected Actual Related Work by DKE

- Karagiannis, D., Visic, N. (2011): “Next Generation of Modelling Platforms”, BIR 2011, Riga, Latvia, 6th – 8th October, 2011.
- Schwab, M. (2012): “Process-based Compliance: Probabilities”, RCIS 2012, Valencia, Spain, May 16th - 18th, 2012.
- Fill, H. G. (2012): “An Approach for Analyzing the Effects of Risks on Business Processes Using Semantic Annotations”, accepted for ECIS 2012, Barcelona, Spain, June 10th – 13th, 2012.
- Karagiannis, D., Moser, C., Mostashari, A. (2012): “Compliance Evaluation with Heatmaps”, accepted for CAiSE 2012, Gdańsk, Poland, 25th – 29th June, 2012.
- Fill, H. G., Redmond, T., Karagiannis, D. (2012): “FDMM: A Formalism for Describing ADOxx Meta Models and Models”, accepted for ICEIS 2012, Wroclaw, Poland, 28th June – 1st July, 2012.

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Conclusion

There are no bad modelling methods, but only ***not appropriate*** *ones!*

For Enterprise Information Systems ***one*** *modelling method is not* ***sufficient****!*

Hybrid *modelling methods are required.*

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Thank You For Your Attention!

Any

Questions ?

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