Conceptual Modelling

Knut Hinkelmann

Models

Model

A reproduction of the part of reality which contains the essential aspects to be investigated.

There can be different kind of models, e.g.

- logical models
- conceptual model
- graphical model
- textual description
- mathematical model
- physical model

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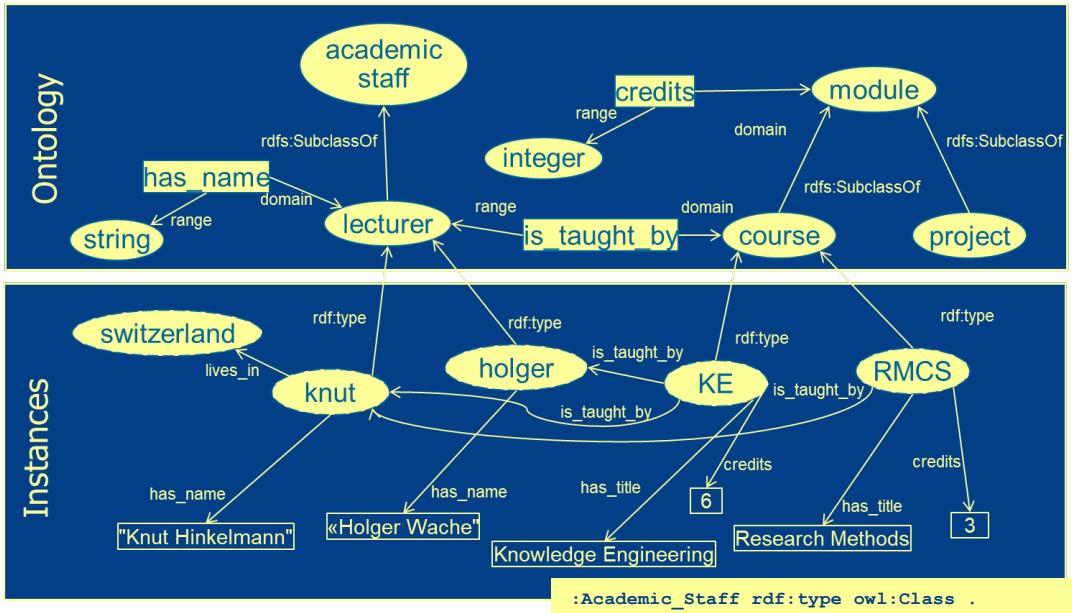
Knowledge Engineering = Modelling

A Knowledge Base is a representation of reality

Reality

Model

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:knut rdf:type :lecturer ;
      :name "Knut Hinkelmann" .
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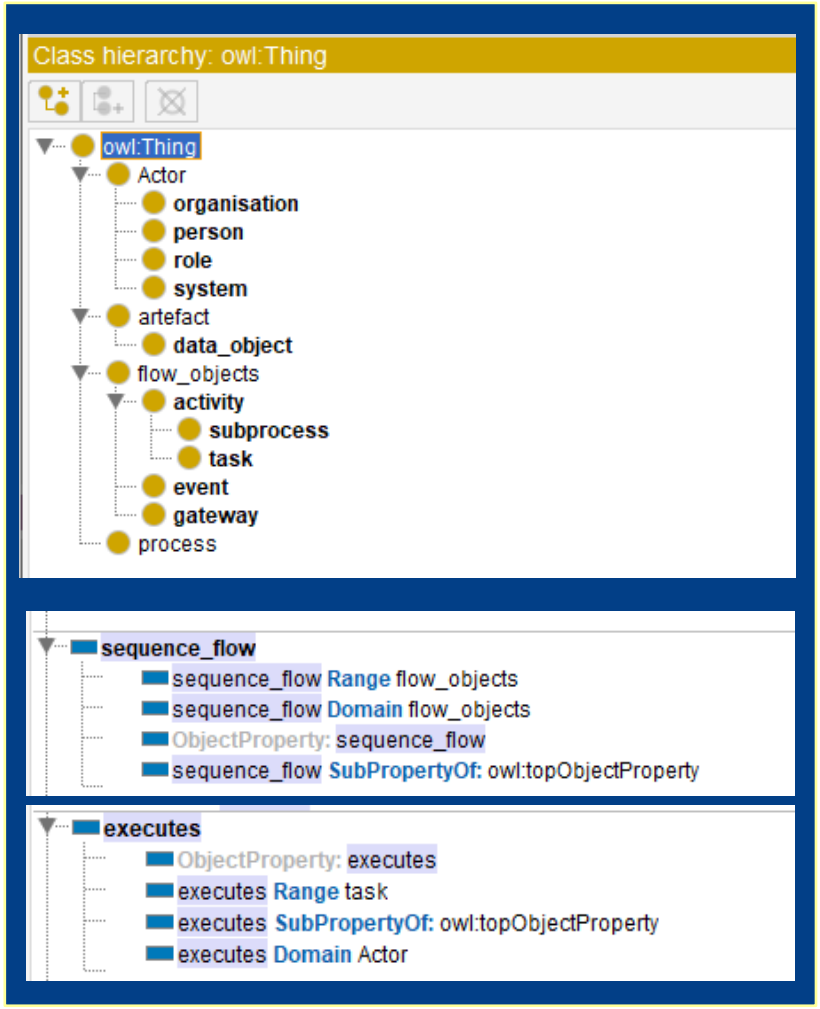
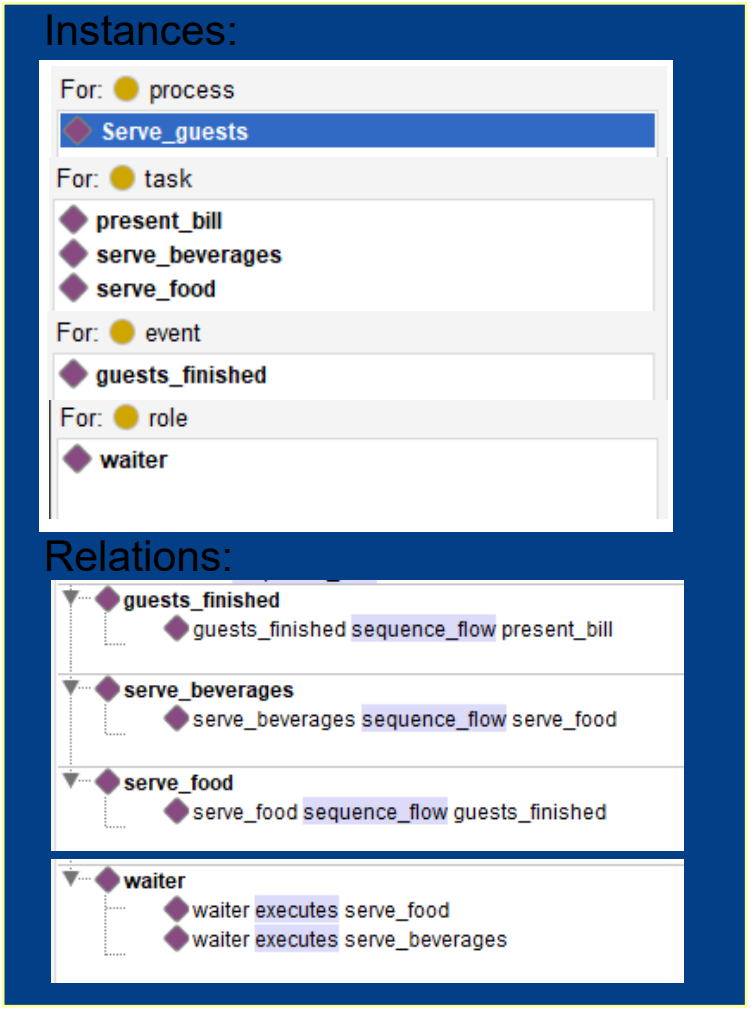
Example: Concepts and Instances for Process Modelling

Business Process Ontology (Metamodel):



Process Model for Serve Guests



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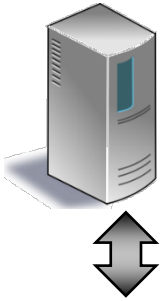
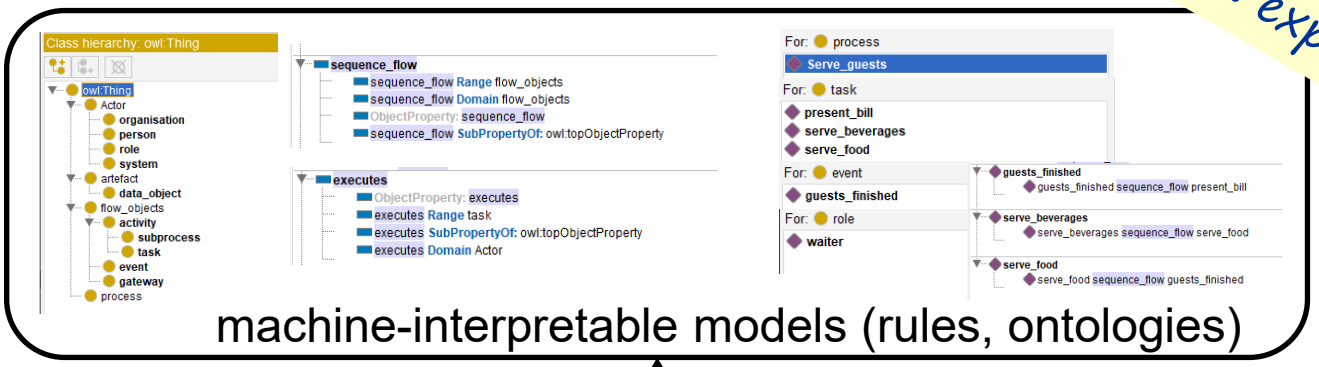
Knowledge Engineering = Modelling

Reasoning/ Decision Making



Models



machine-interpretable models (rules, ontologies)

Reality

Creating knowledge graphs requires skills in modeling language – difficult for domain experts

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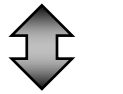
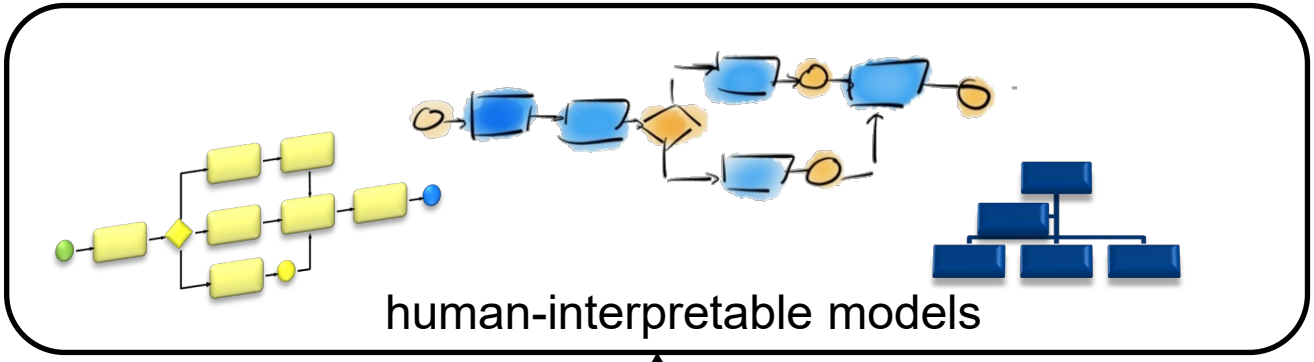
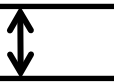
Graphical Models are appropriate for Humans

Communication/
Analysis/
Decision Making

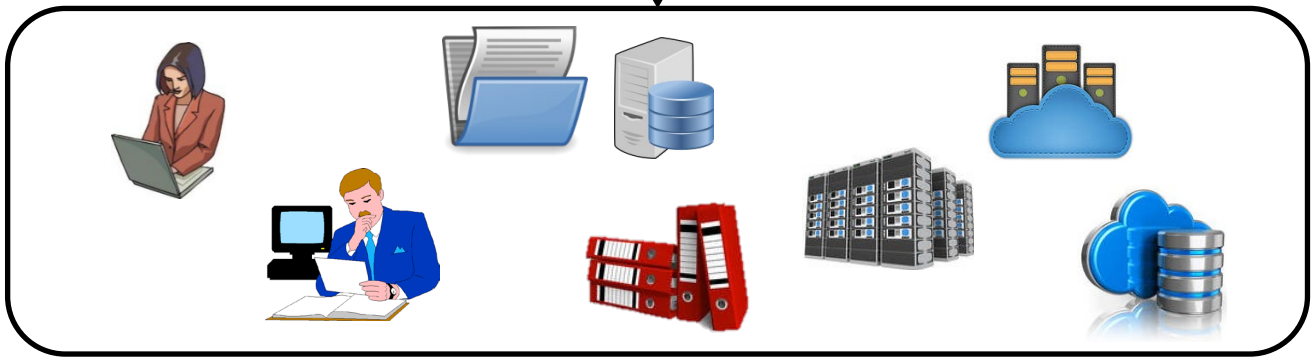


Models

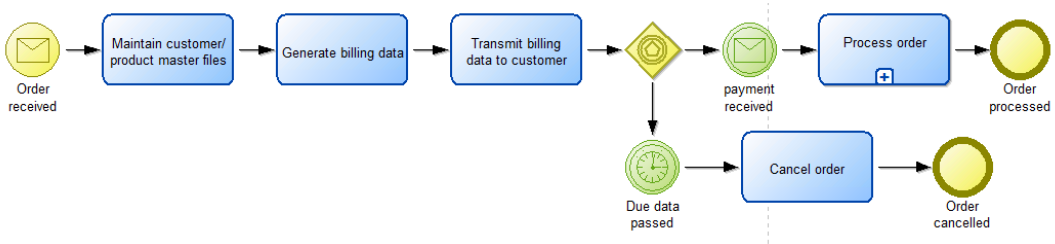


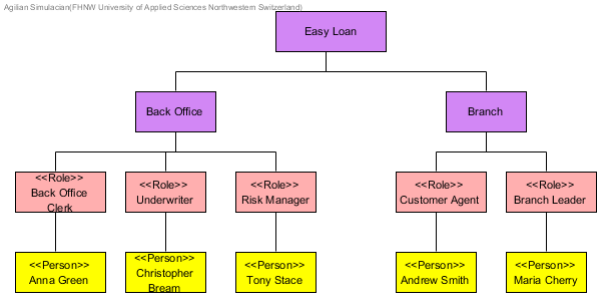


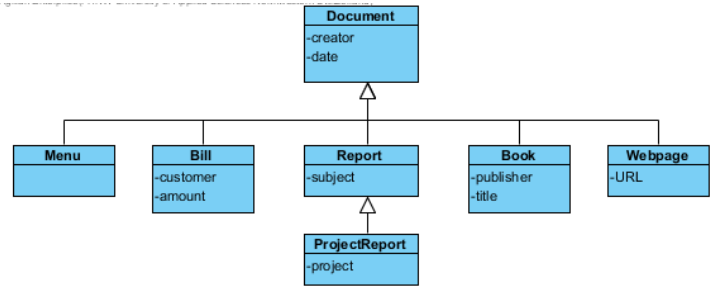
Reality

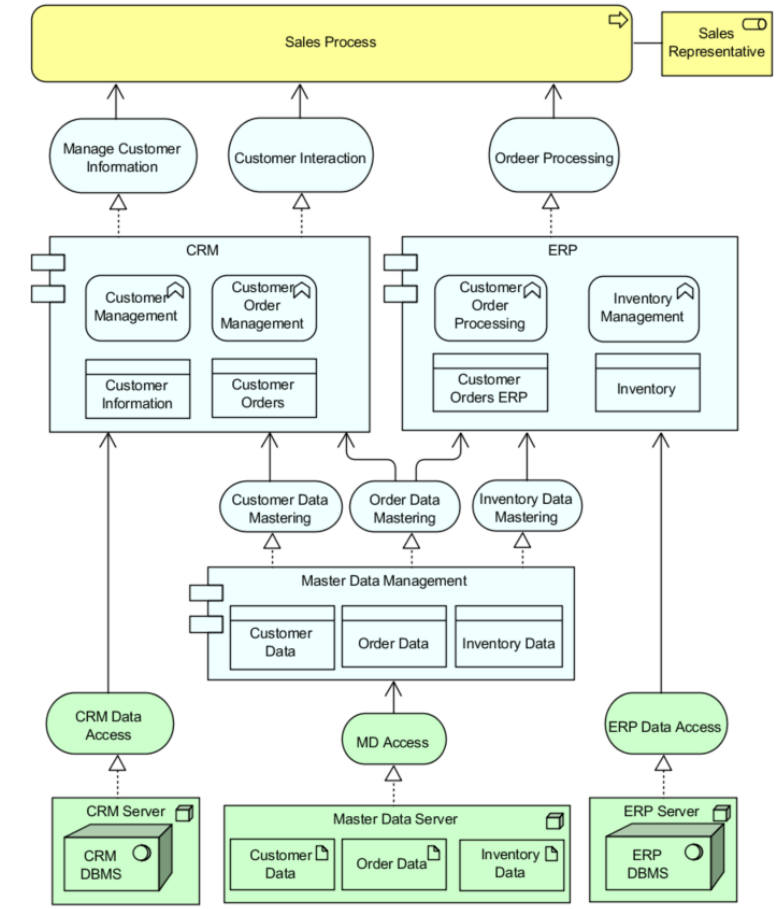


Enterprise Models using Domain-Specific Graphical Modeling









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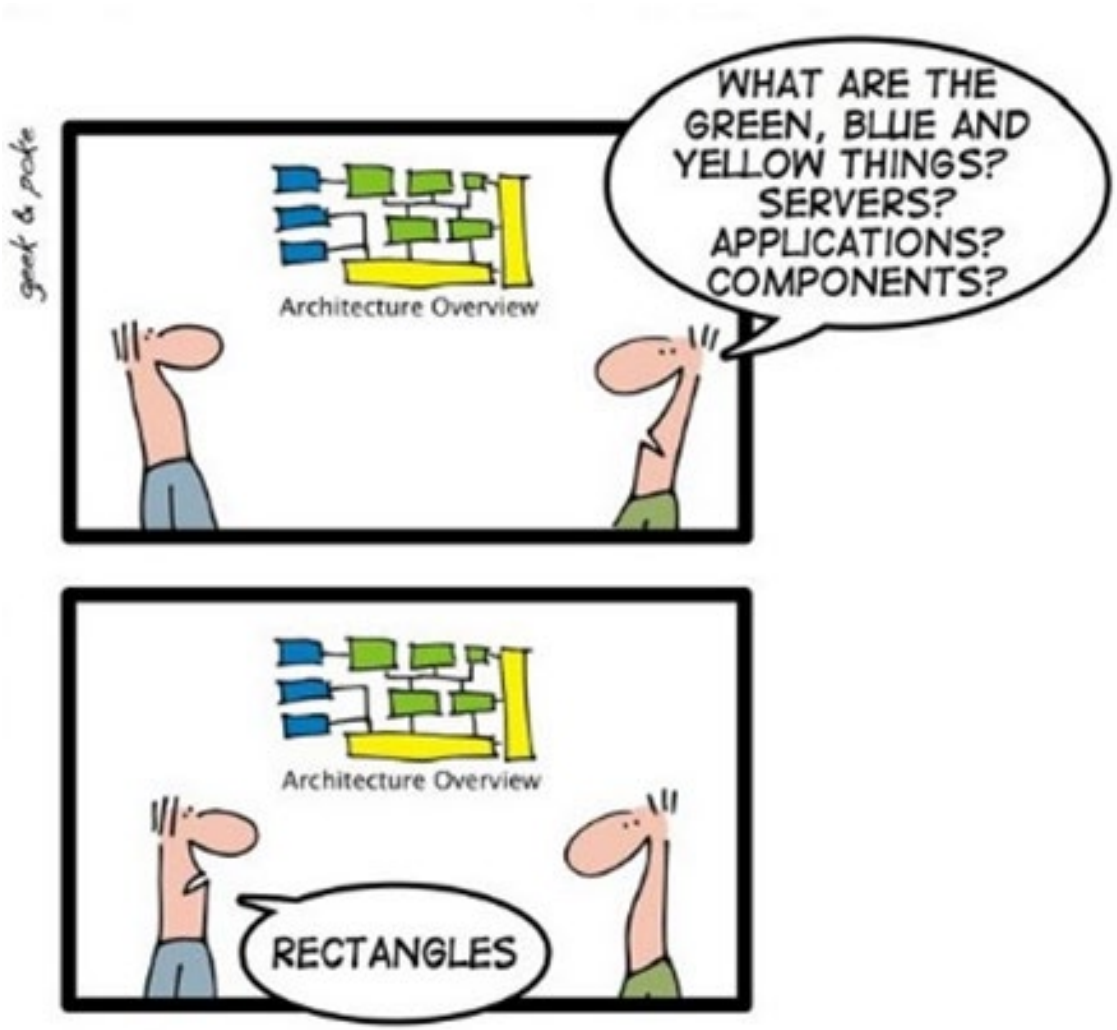
Drawing



Cartoon adapted by K. Hinkelmann

Models

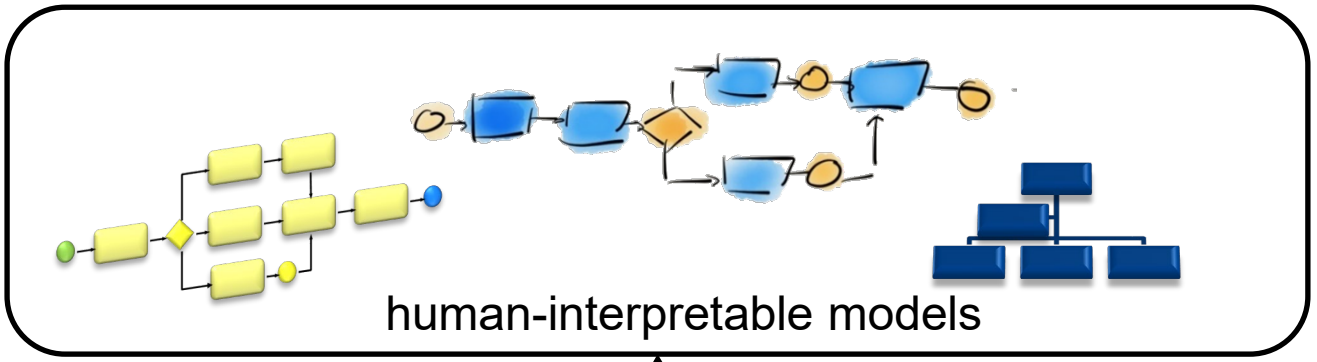
- Models are not mere pictures; rather, they
  - provide a precise, meaningful description that can be visualized in different ways for different stakeholders;
  - can also be used to analyze the impact of changes, cost, risk, security, compliance and other relevant KPIs.

http://blog.bizzdesign.com/how-to-not-fail-when-implementing-strategy

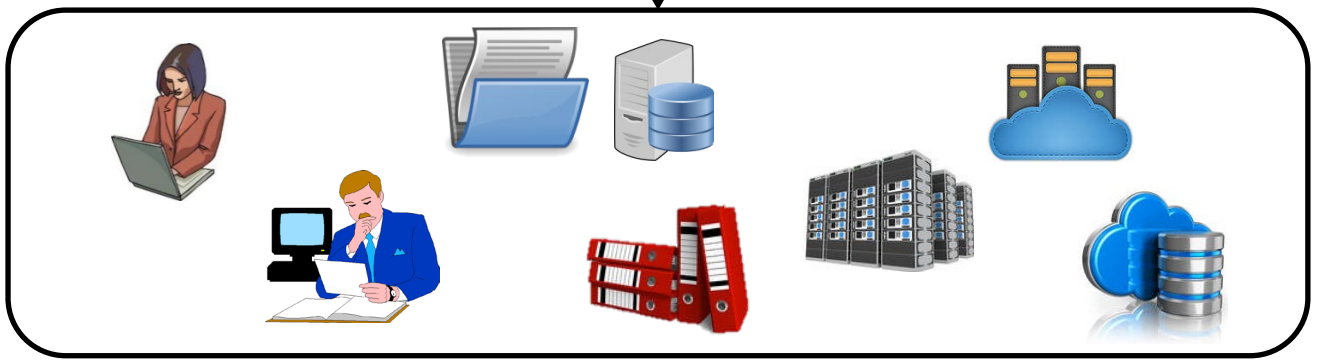
Humans use Knowledge to interpret Models

Communication/
Analysis/
Decision Making

Models



Reality



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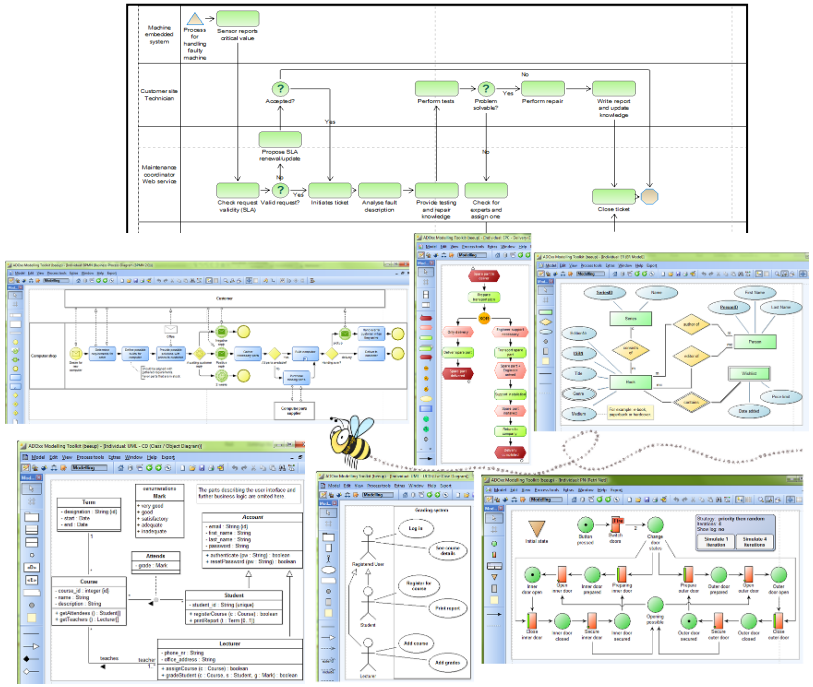
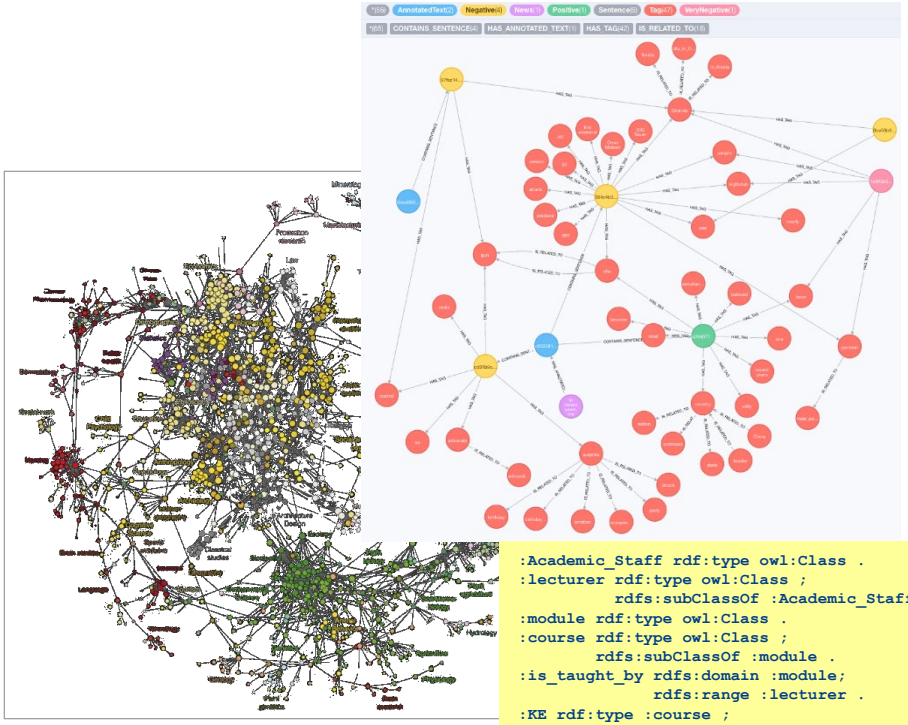
Conceptual Graphical Models



Modeling using predefined *concepts*

Knowledge Graphs



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    :title "Knowledge Engineering" .
:knut rdf:type :lecturer ;
      :name "Knut Hinkelmann" .
```

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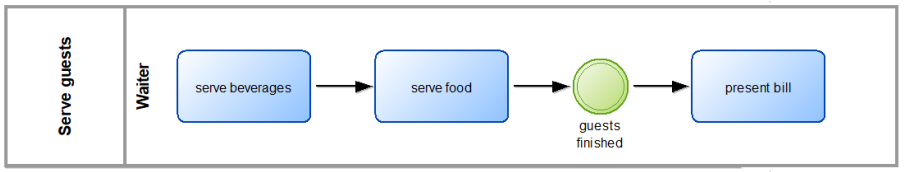
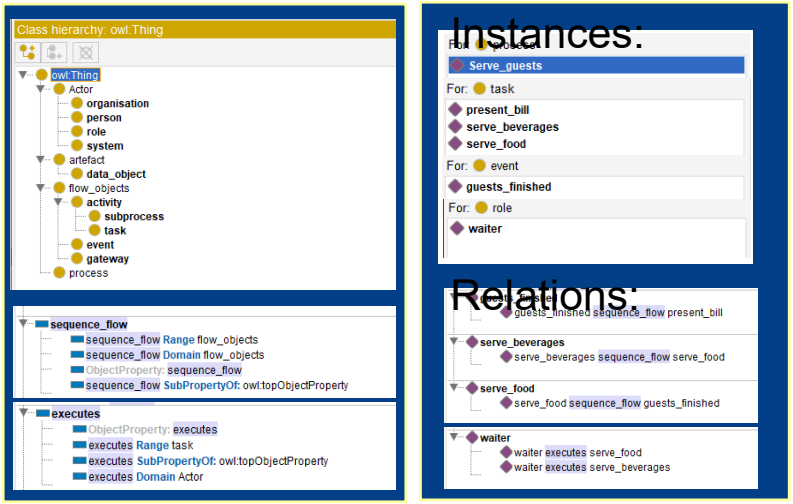
Objective: Combining Knowledge Graphs and Graphical Modeling

- Creating knowledge graphs is difficult for domain experts – it requires skills in modeling language
- Creating graphical models is more adequate for domain experts
- Objective: Create ontologies (knowledge graphs) from graphical models





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Conceptual Modelling

Creating models using predefinded concepts.

Conceptual Modeling consists of two phases

- Metamodeling: Defining (domain-specific) concepts
- Modeling: Creating models by instantiating these concepts

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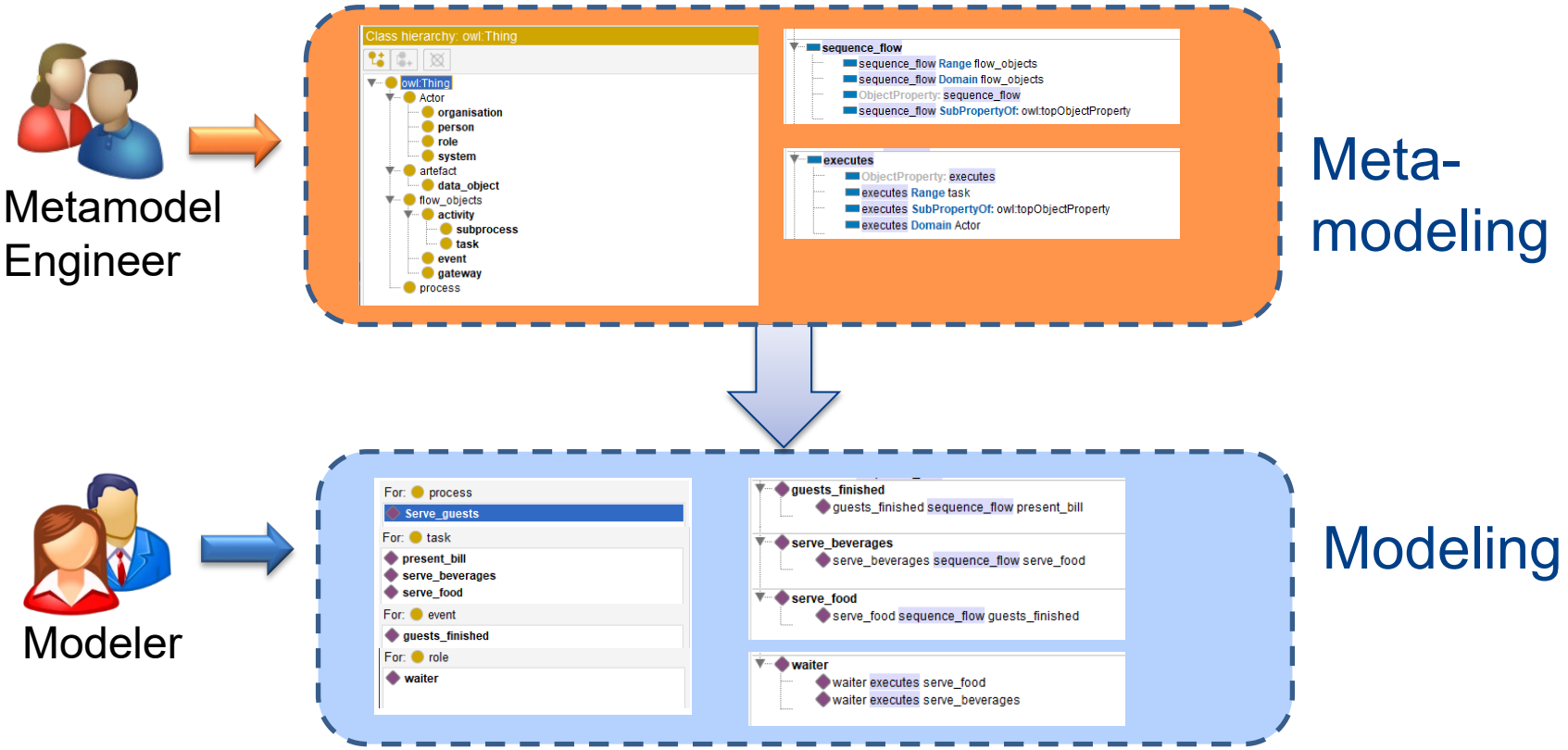
Conceptual Modeling using Ontologies



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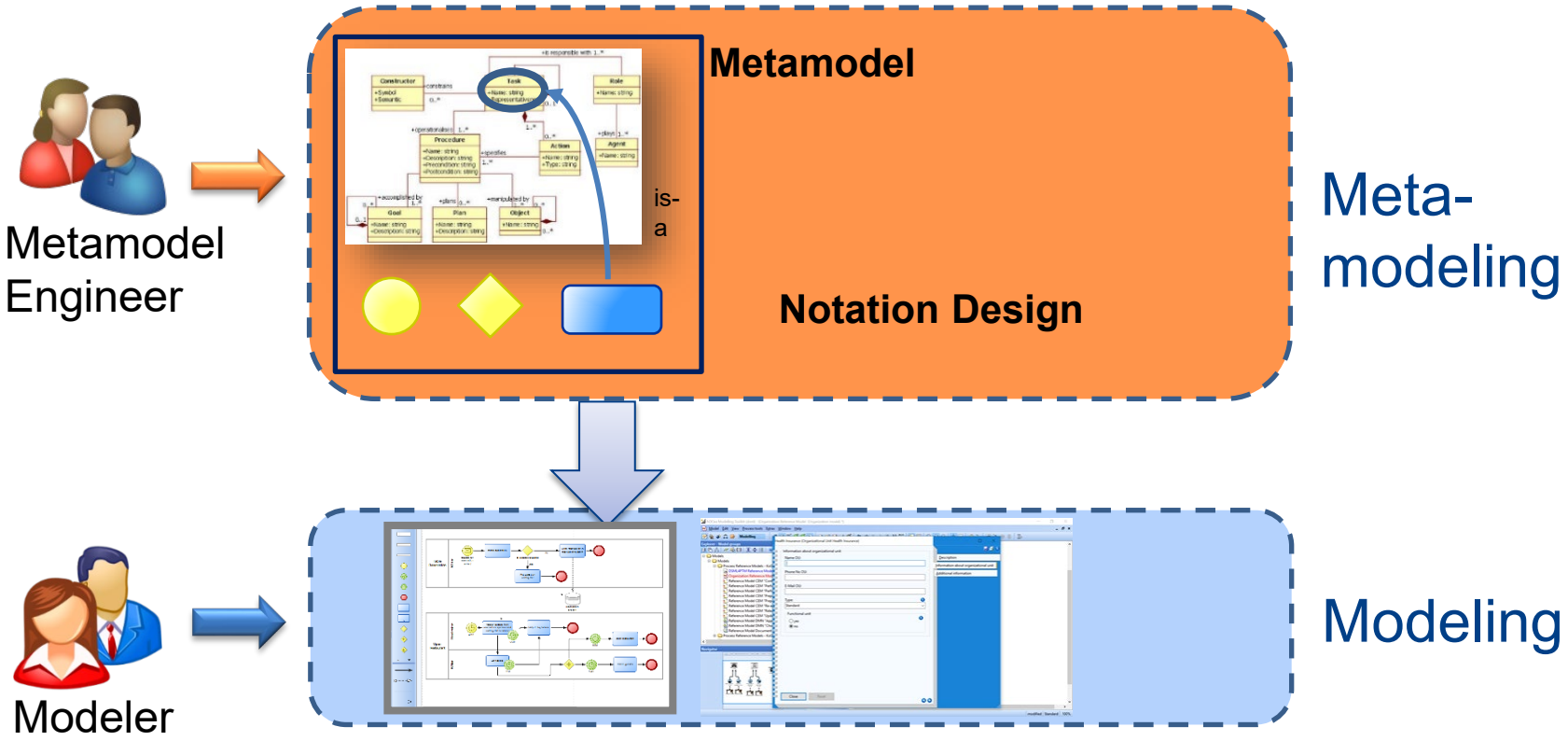
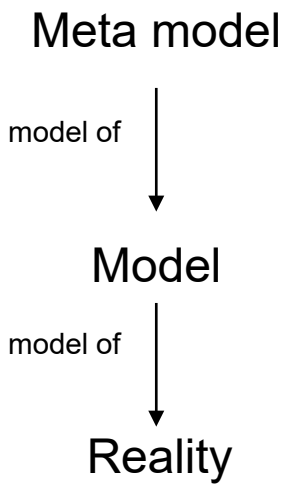
Conceptual Modeling with Graphical Models



Meta-model

Meta Model

The specification of the domain-specific concepts that can be used for modeling



- A meta-model defines ...
  - … Concepts that can be used to create a model
  - … Attributes of concepts
  - … Rules to combine concepts
- The meta-model represents the general knowledge about the domain

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Concepts for Business Process Models

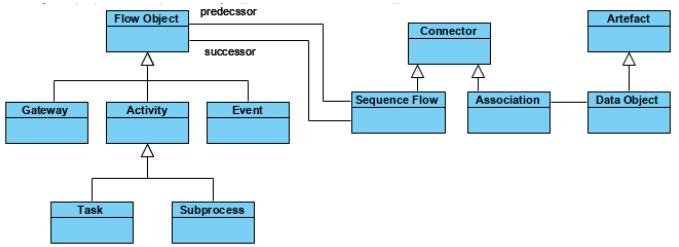
Metamodel:

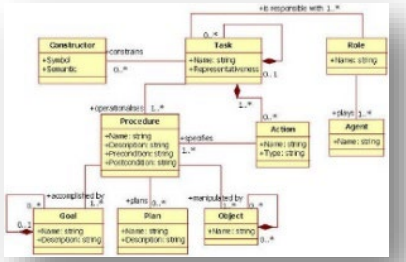
Concepts which can be used to create models.

Example: A process model consists of concepts for

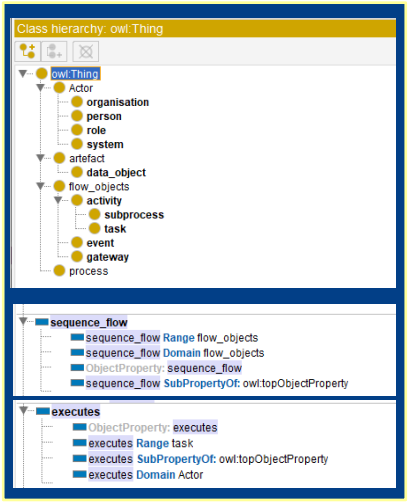
- Model elements: event, task, subprocess, gateway, data object
- Relationships: sequence flow, data association.

Metamodel represented as a class diagram or data model:





Metamodel represented as a knowledge graph:



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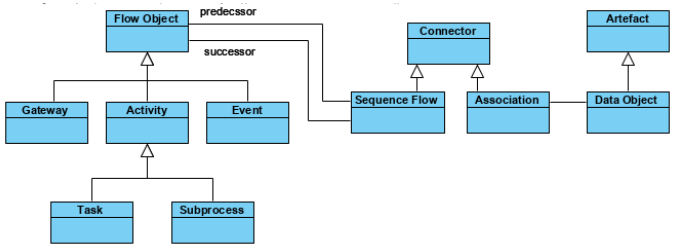
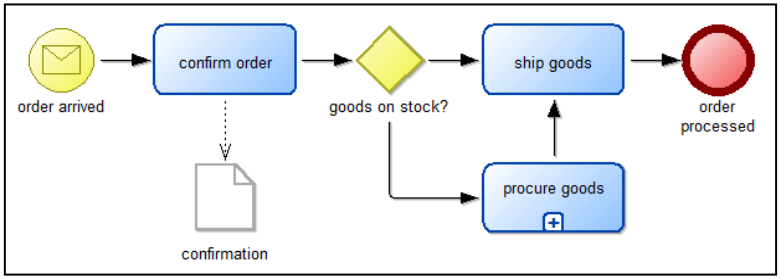
A Model is the Instantantiation of the Metamodel

Metamodel:

Concepts which can be used to create models.



Model:



A model contains instances of the concepts defined in the meta-model. The object „confirm order“ represents a real entity; it is an instance of the concept «task"

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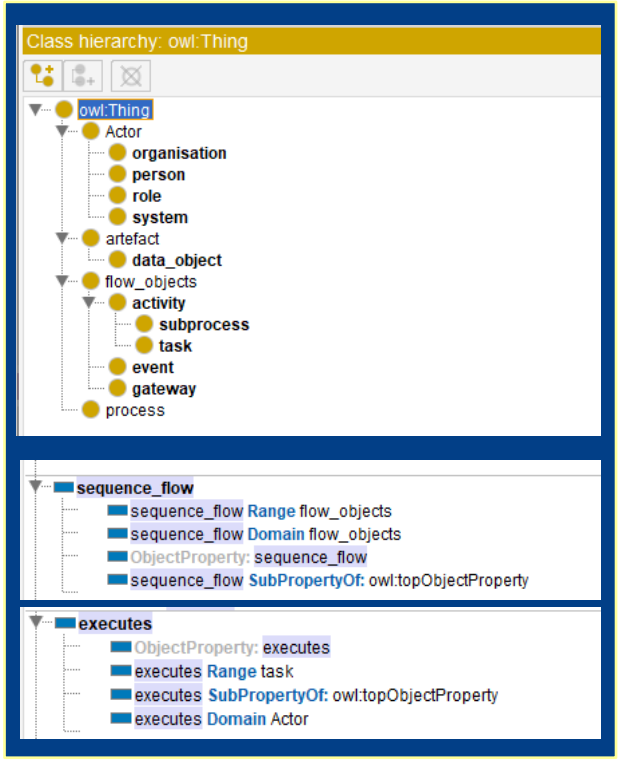

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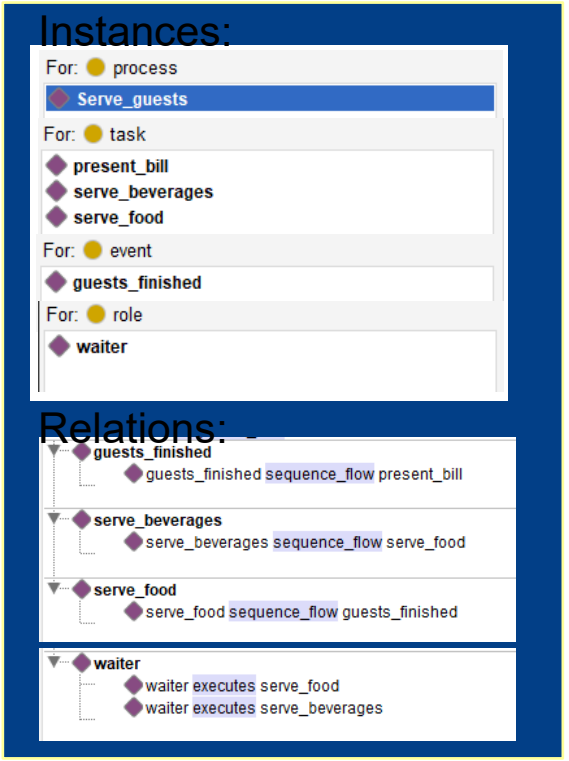

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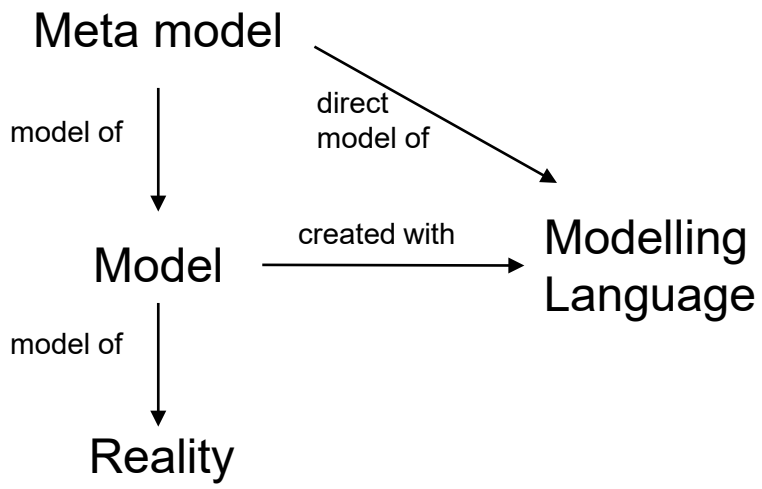
Modelling Language



- A **modelling language** specifies the notation for the concepts, from which a model can be made.
- There are different kinds of notations
  - For graphical models the notation consists of *visualization* of the concepts
  - Textual models consist of words
  - Mathematical models use symbols
  - physical model are composed of physical elements

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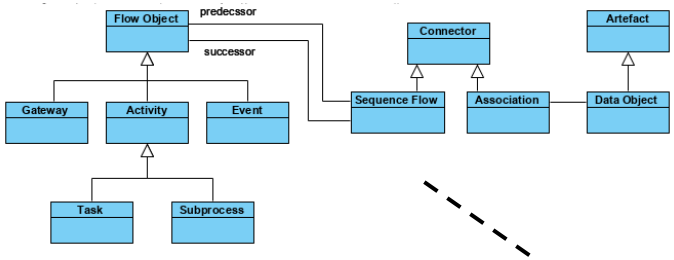
Modeling Language extends Metamodel with Notation

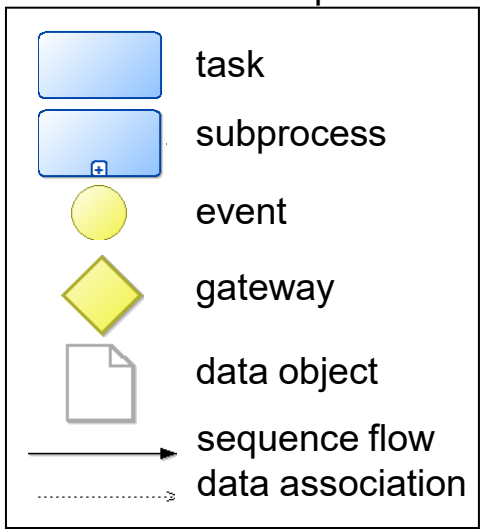
Metamodel:

Concepts which can be used to create models.

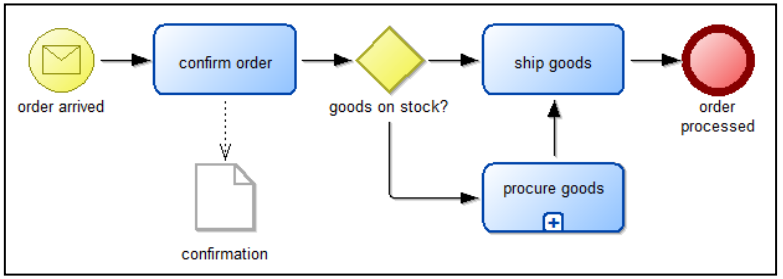


Modelling Language:

Notation/appearance of meta-model concept



Model:



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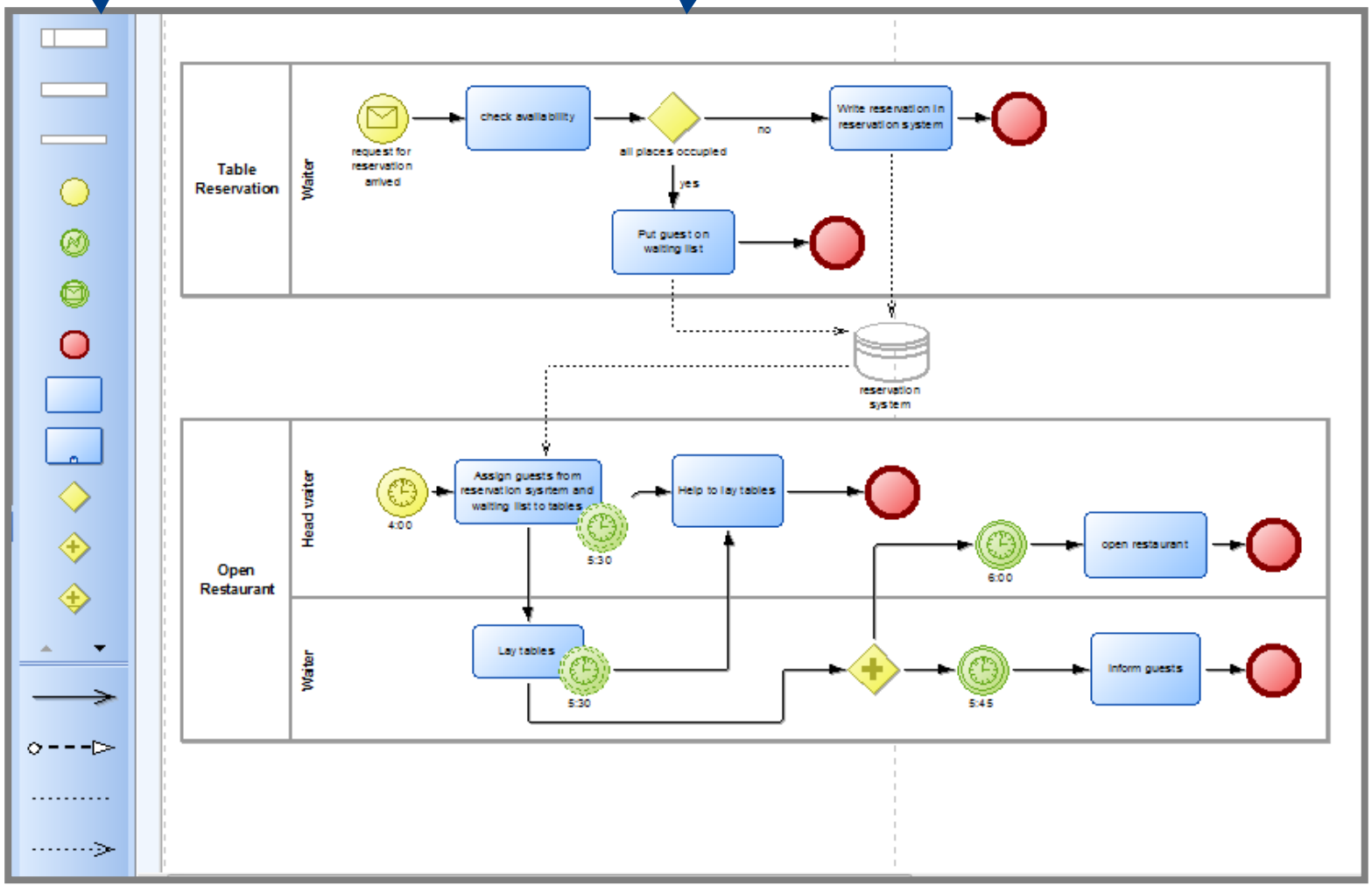
Modelling Language

Model



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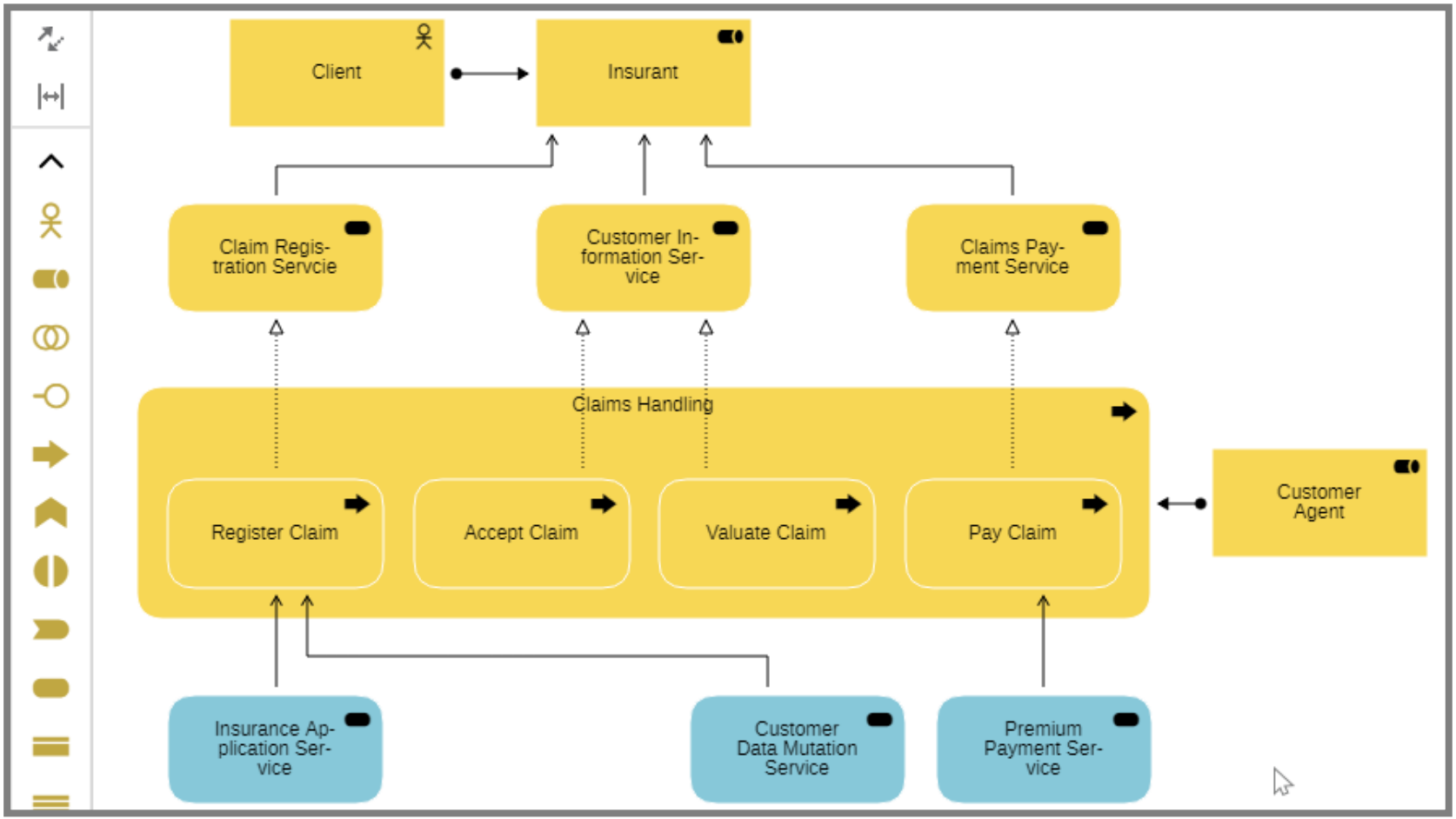
Modelling Language

Model



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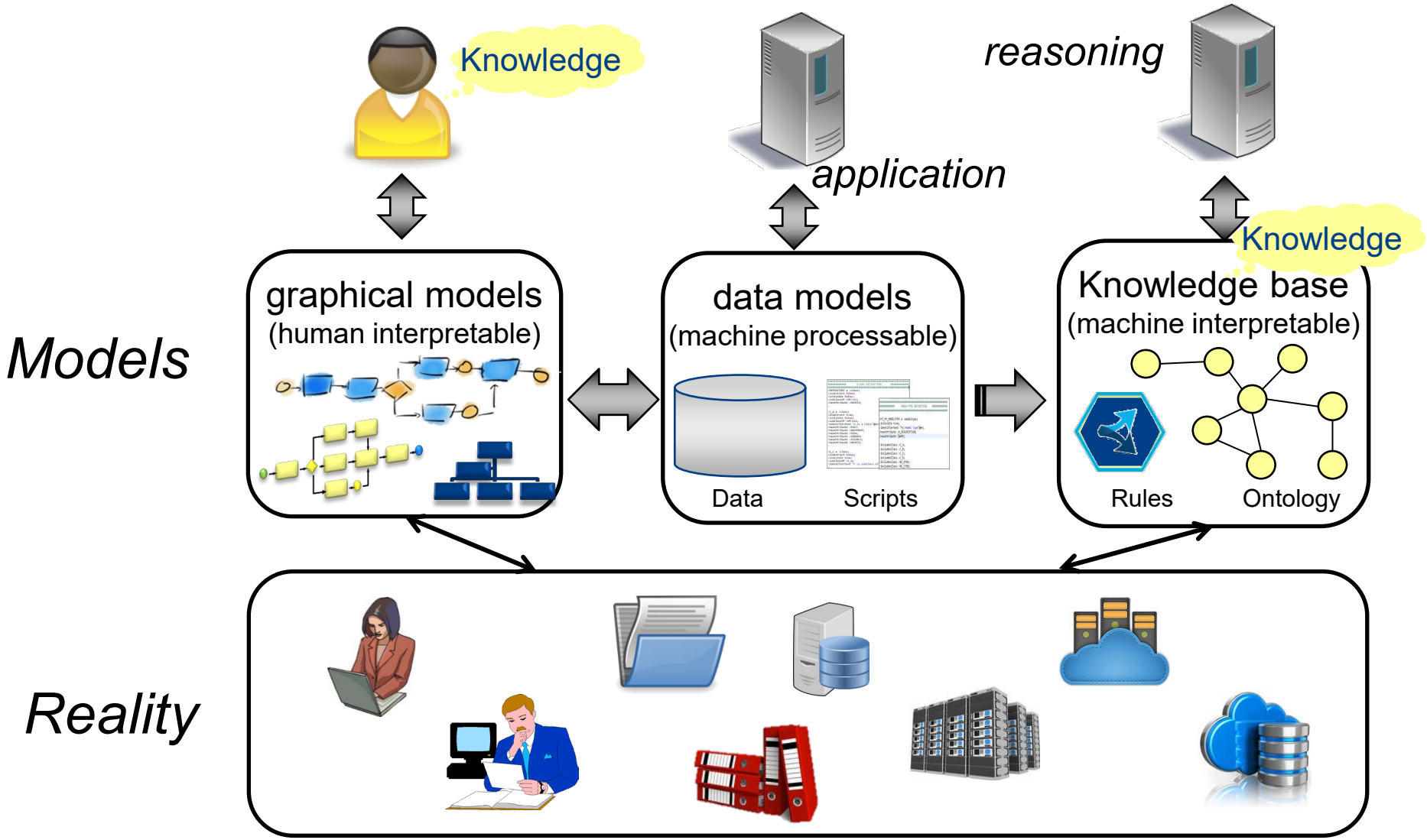
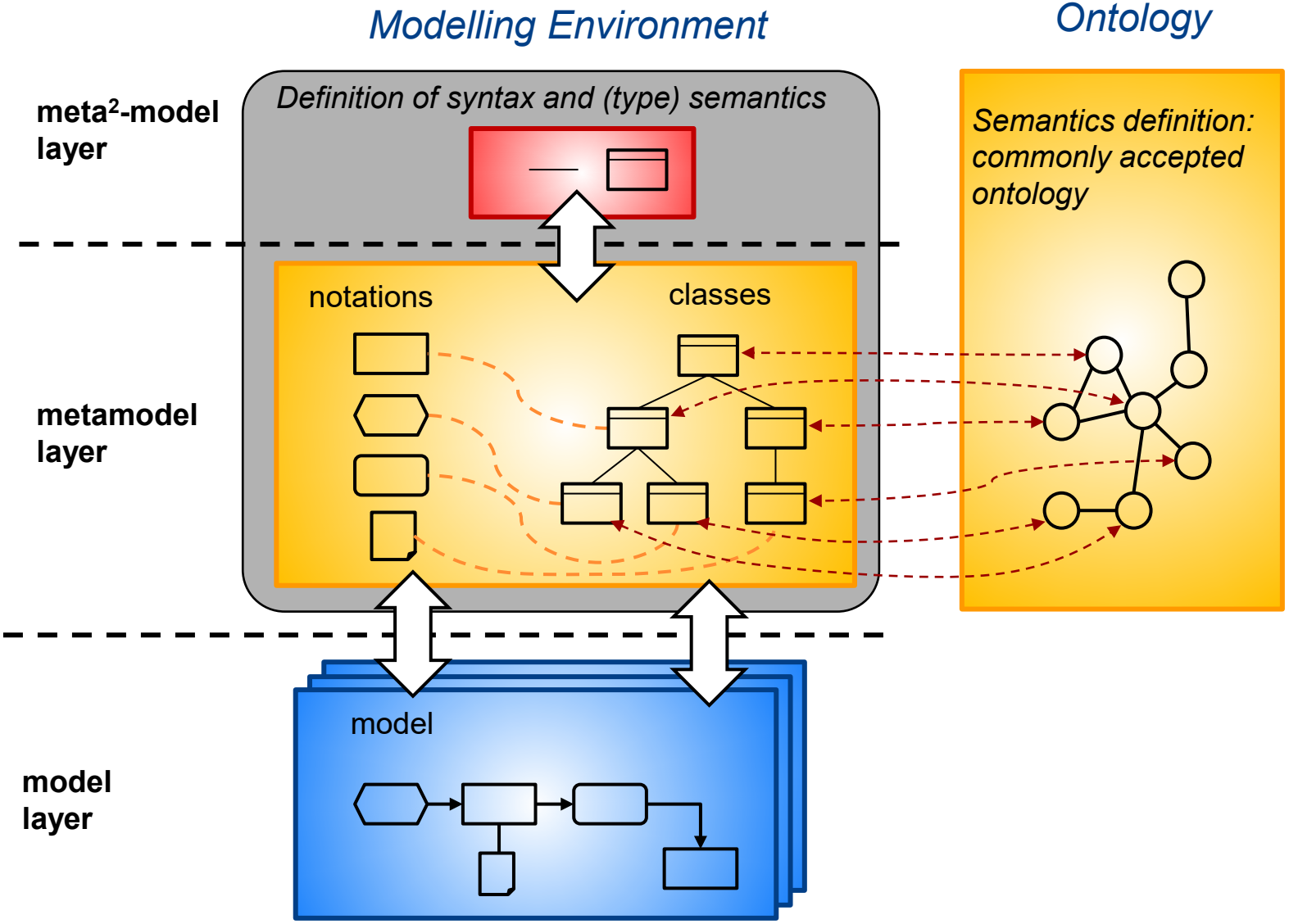
Semantic Lifting

Semantic Lifting: Map Models into an Ontology




Modelling Environment
Ontology
meta²-model layer
Definition of syntax and (type) semantics
Semantics definition: commonly accepted ontology
notations
classes
metamodel layer
model
model layer
linguistic metamodelling: syntax, structure, type semantics
ontological metamodelling (lifting): explication of type semantics

Agenda

- Conceptual Modeling with graphical models (today)
- Combining graphical modeling with knowledge graphs (next lecture)

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Metamodelling with ADOxx

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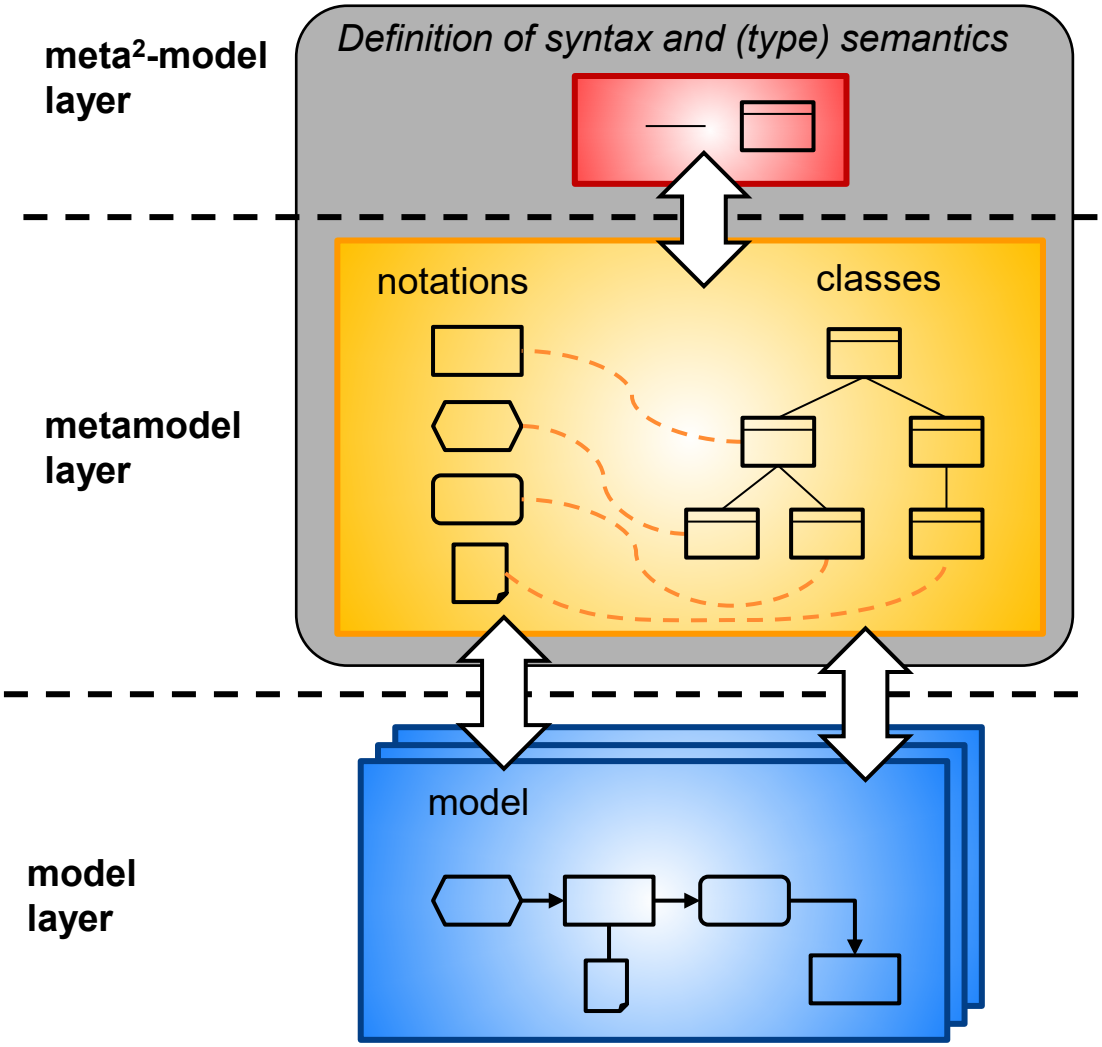
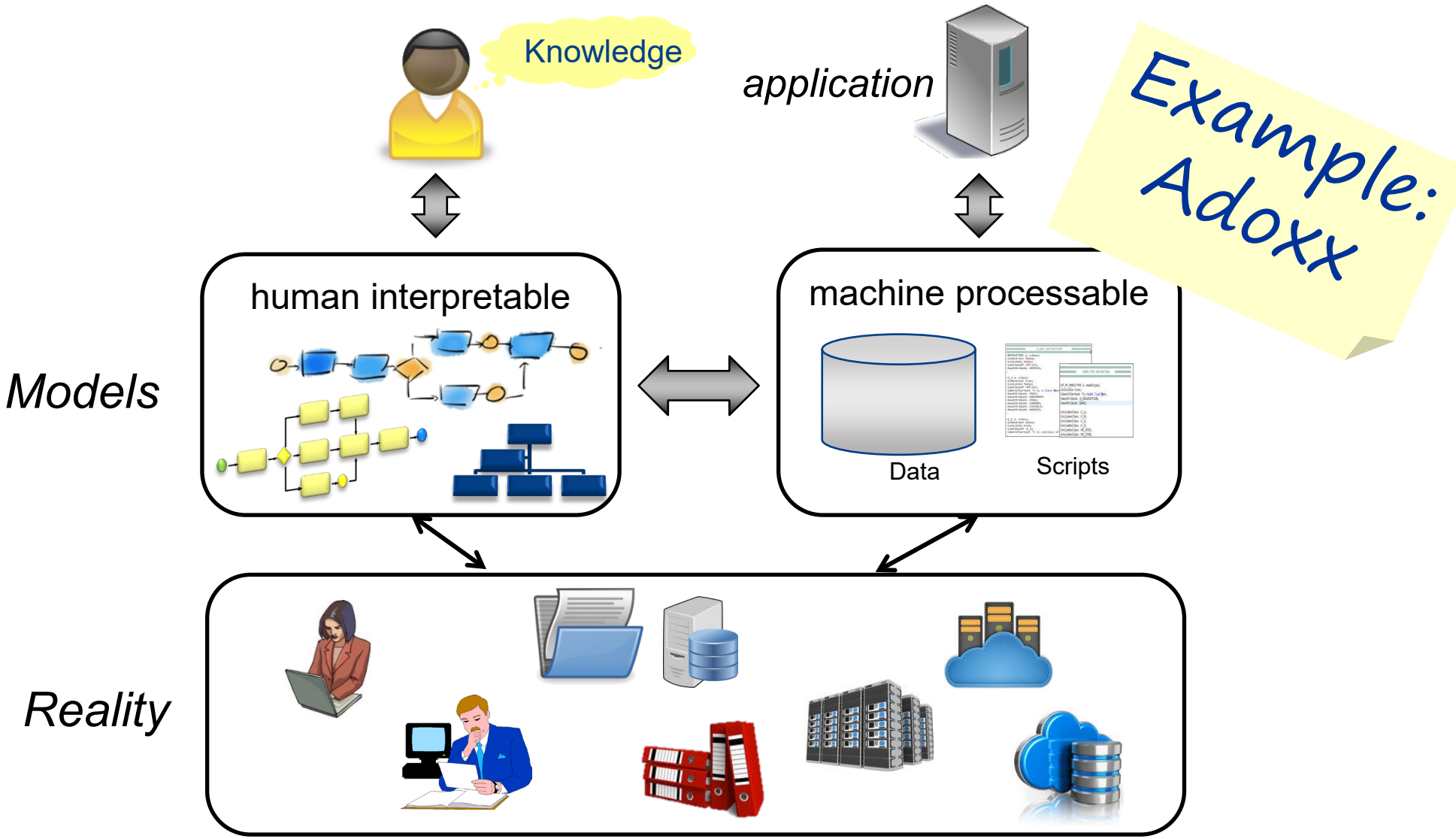
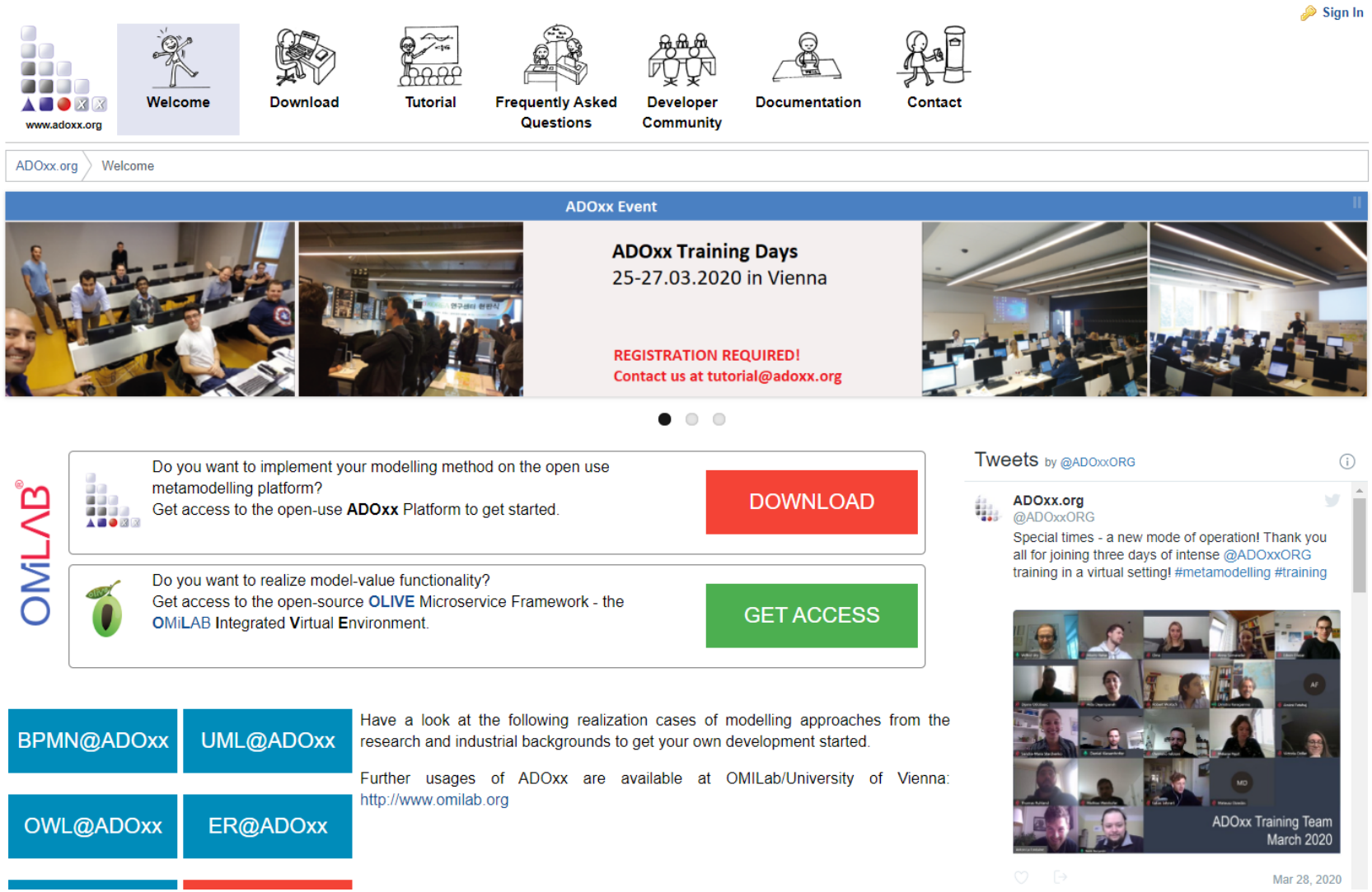
Modelling Environment



Graphical Models represented in a Database



adoxx.org – Download, Tutorials, Community



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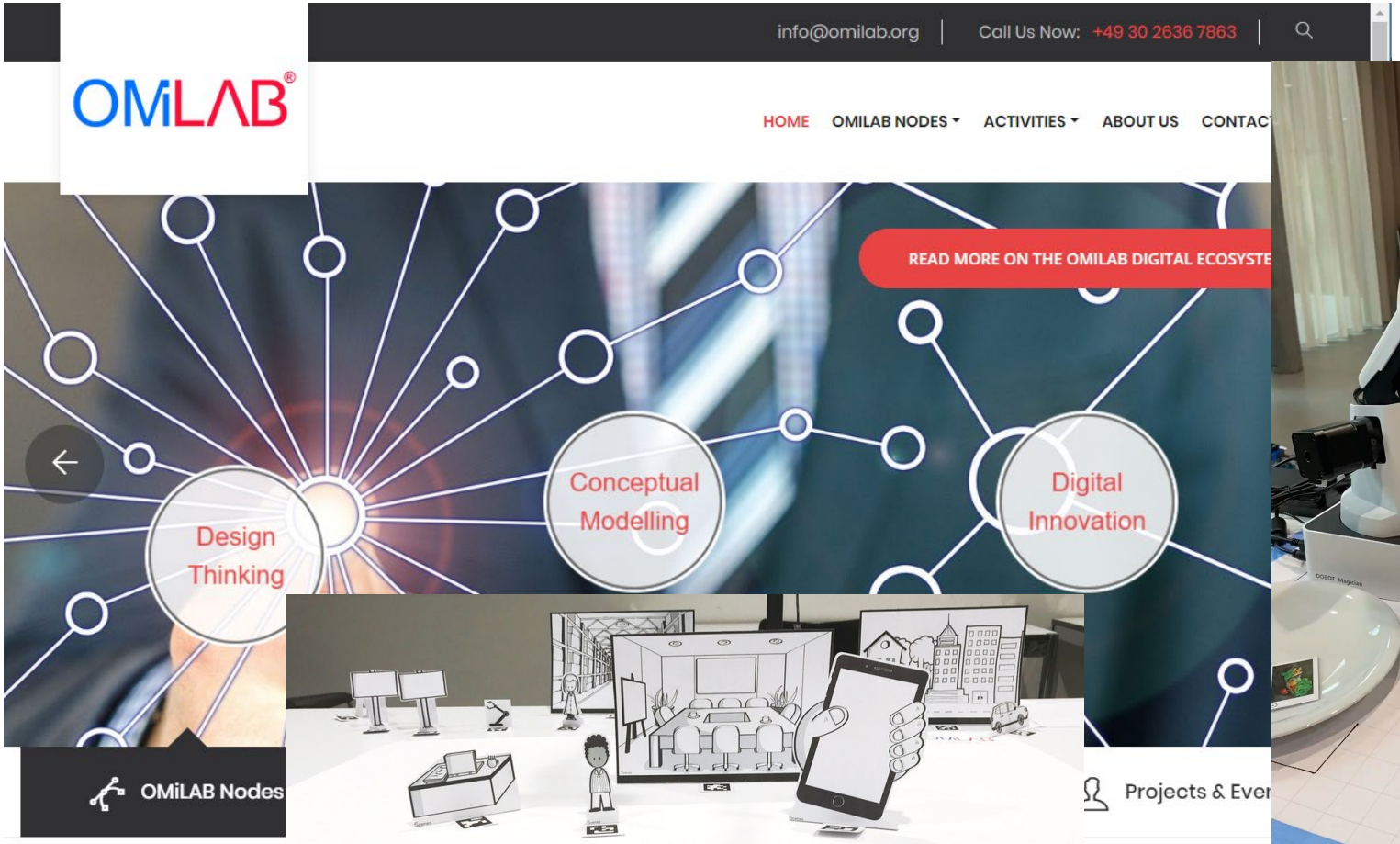
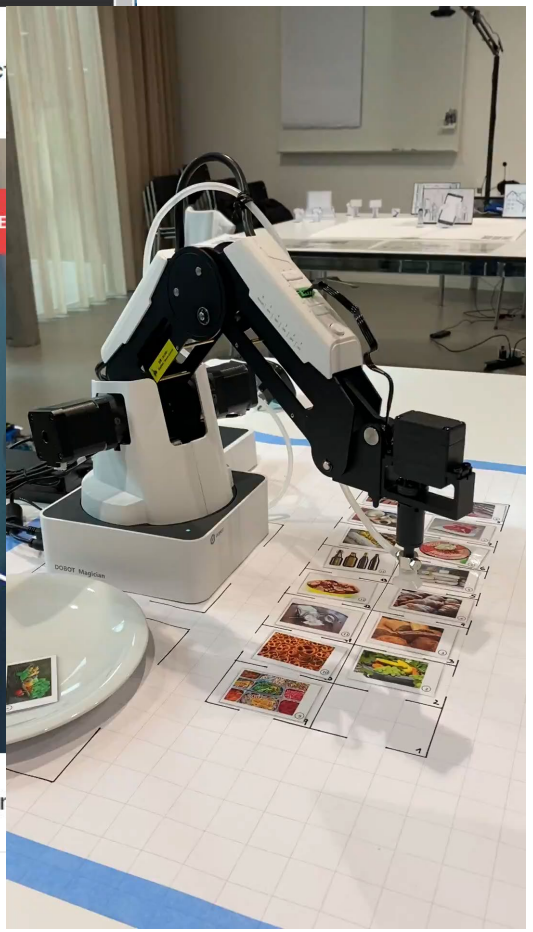
OMiLAB – A Conceptual Modelling Community

ADOxx is the basis for OMiLAB





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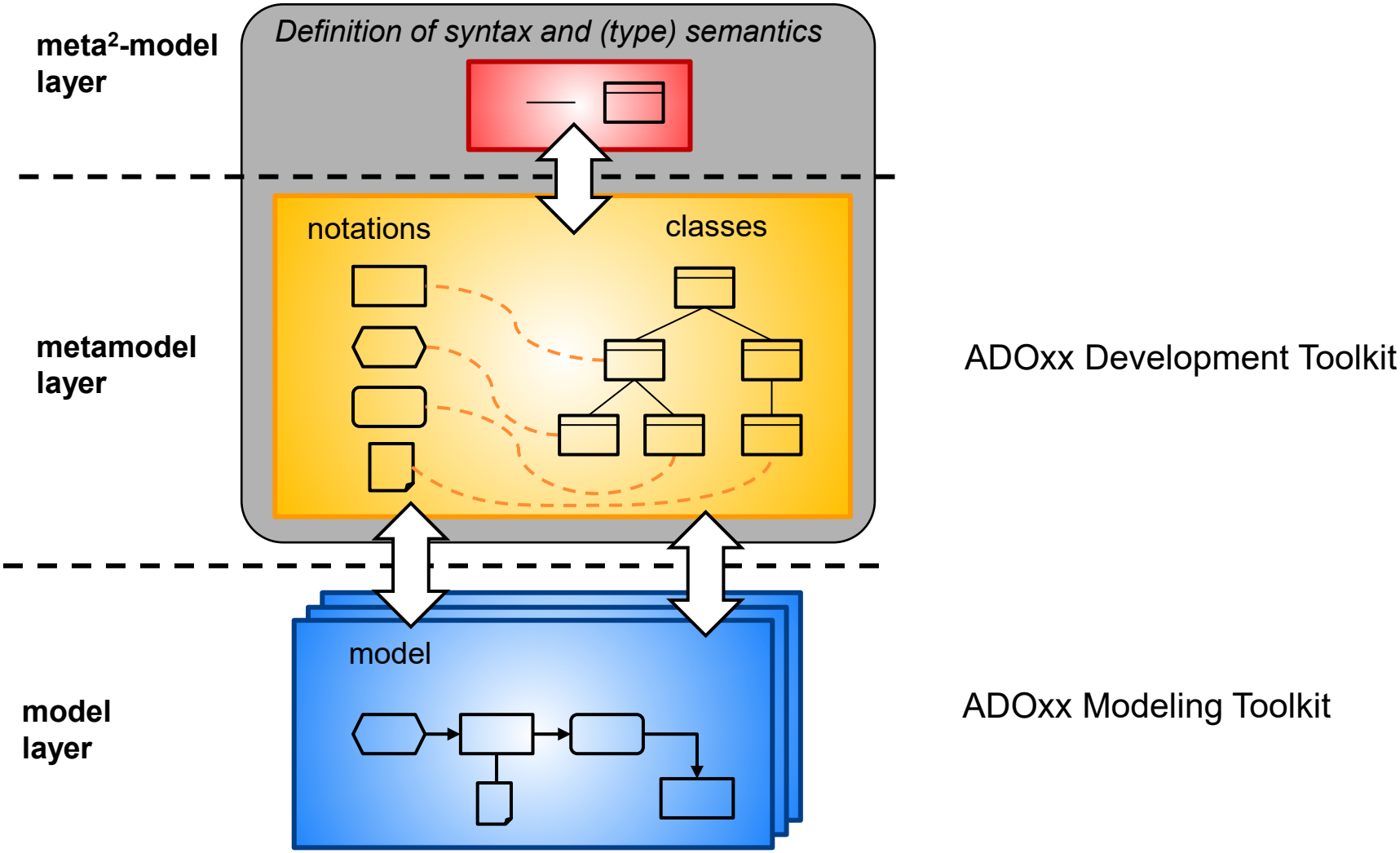
The ADOxx Environment

- ADOxx consists of …
  - ADOxx Development Toolkit
    - Defining Modelling languages – Library Management
    - Administration of users, models, components
  - ADOxx Modelling Toolkit
    - Creating models

Modeling Environment

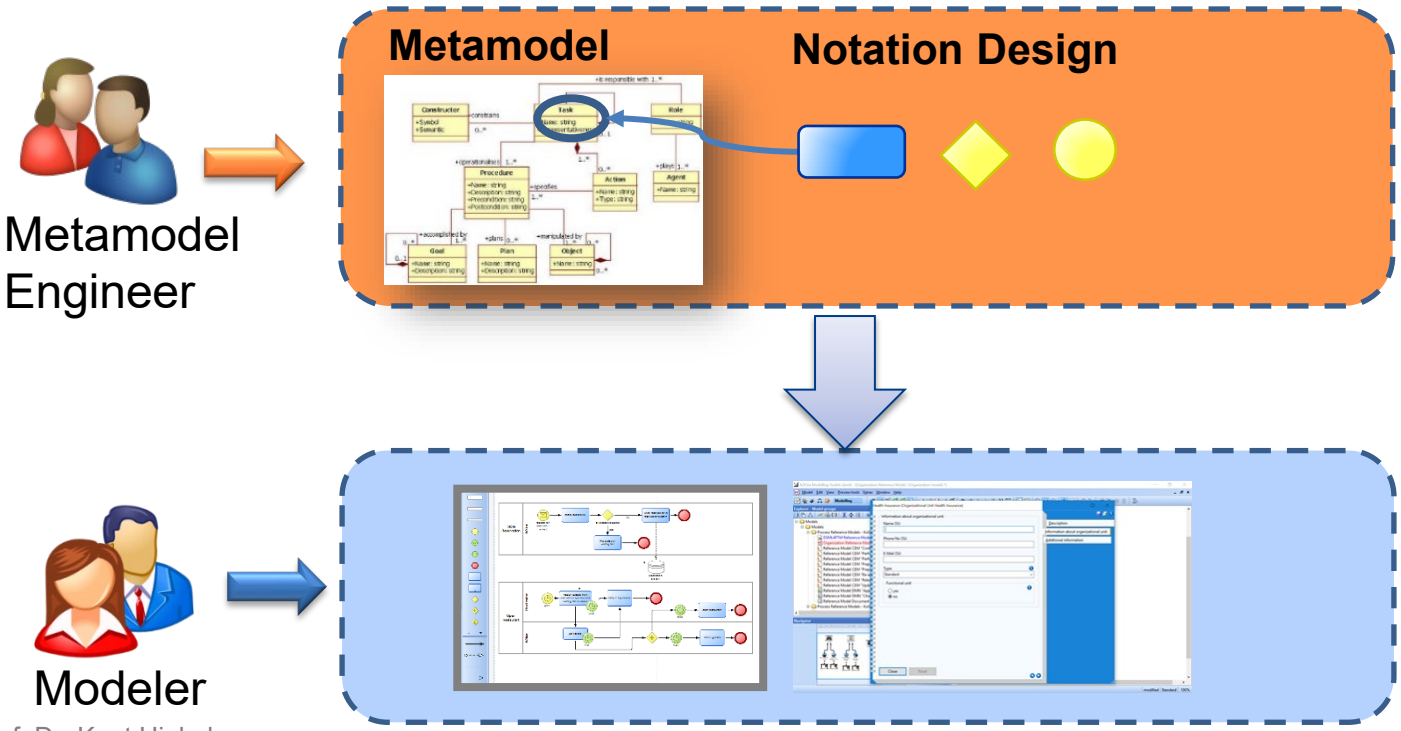


Modeling and Metamodeling

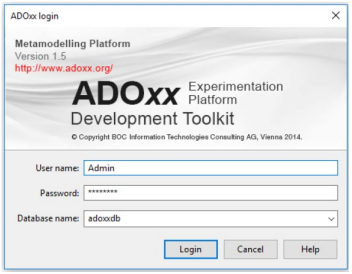
Conceptual Modeling consists of two phases

- Metamodeling: Defining (domain-specific) concepts
- Modeling: Creating models using these concepts

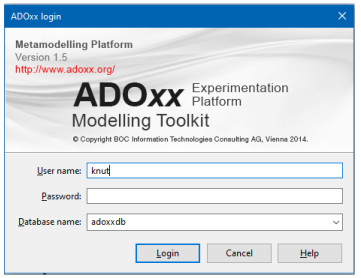
ADOxx has specific tools for each of these phases



Meta-modeling



Modeling



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Identified Roles	Major Tasks	Required Skills	Cases
 MM-tool User	Modelling Domain Knowledge	Domain Knowledge Method Knowledge	Established modelling tools Agile development of modelling tool in parallel to modelling tool usage . . . Agile development of ADOxx platform in parallel to modelling method development
 MM-Tool Developer	Developing an Meta Modelling Tool	Domain Knowledge Method Knowledge Platform Knowledge	
 ADOxx Developer	Implementation of tool specific and ADOxx functionality	Platform Knowledge ADOxx Technology Skills	

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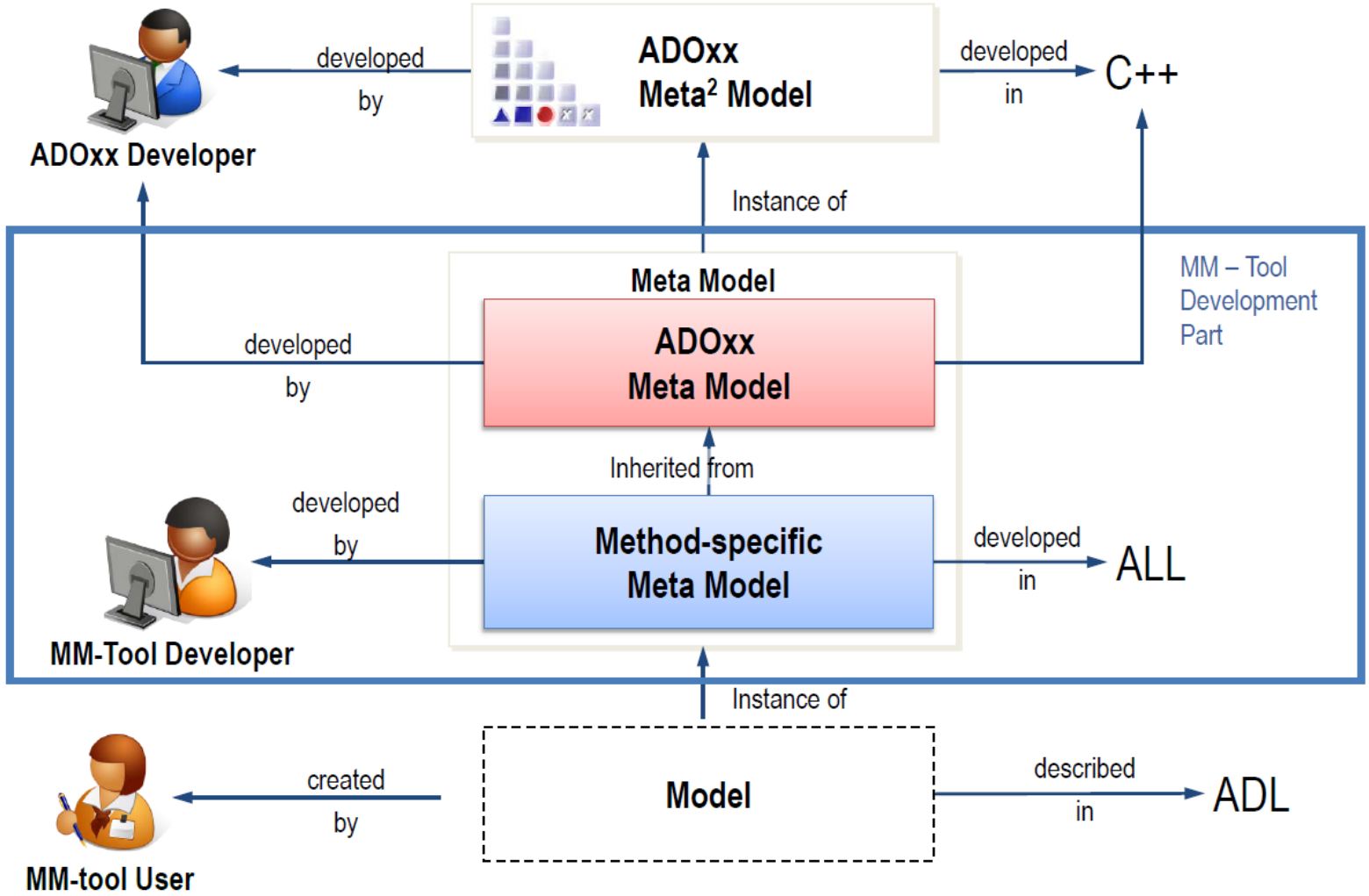
Meta Modelling Platforms Hierarchyin ADOxx



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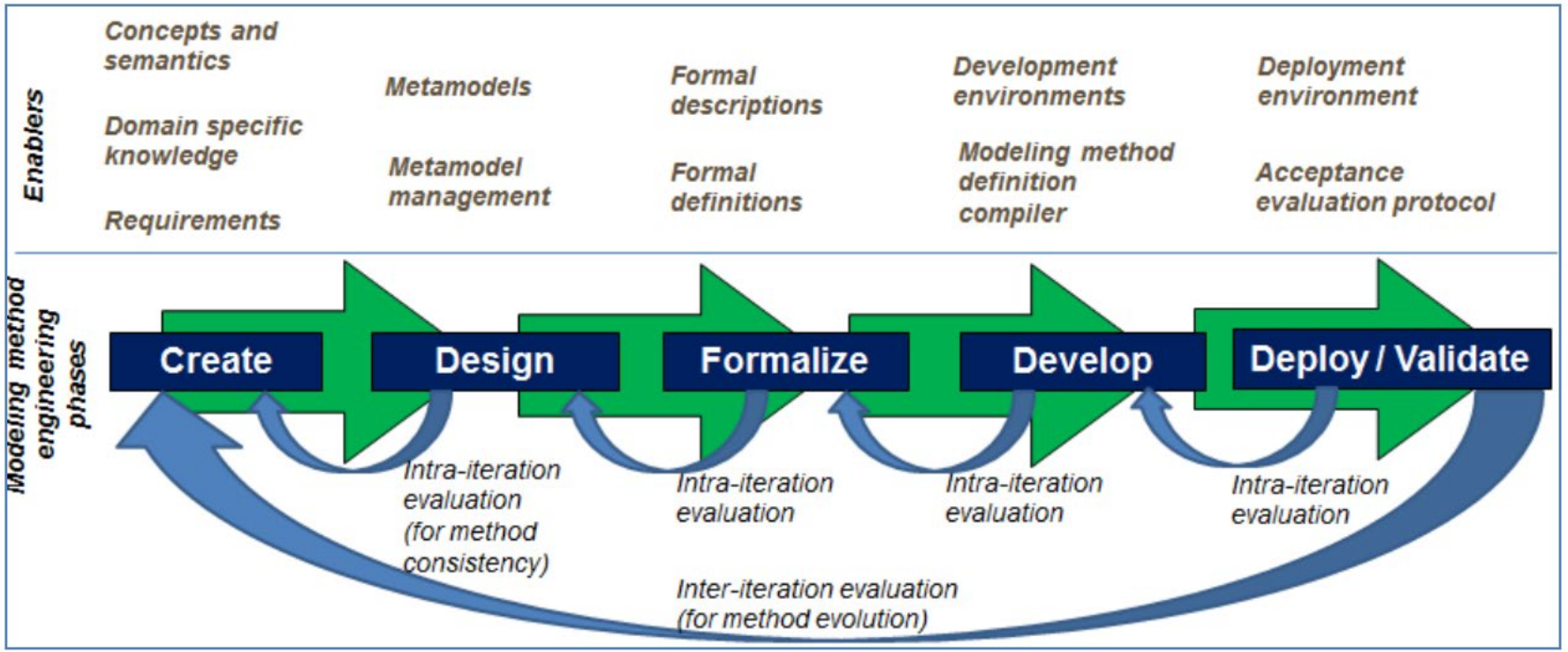
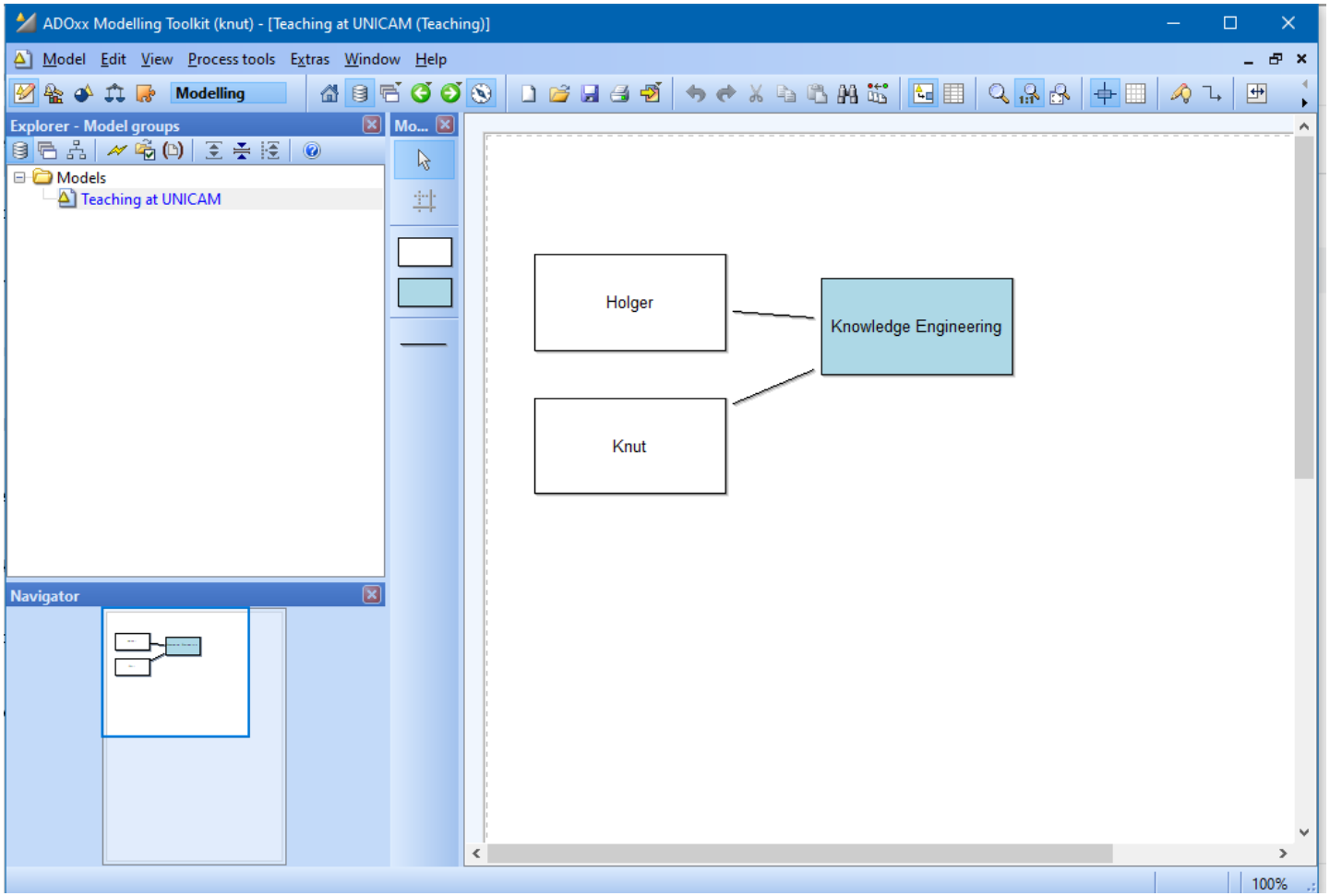
The AMME LifeCycle
Agile Modeling Method Engineering



(Karagiannis 2015)

Example: Create a Modeling Language for Teaching



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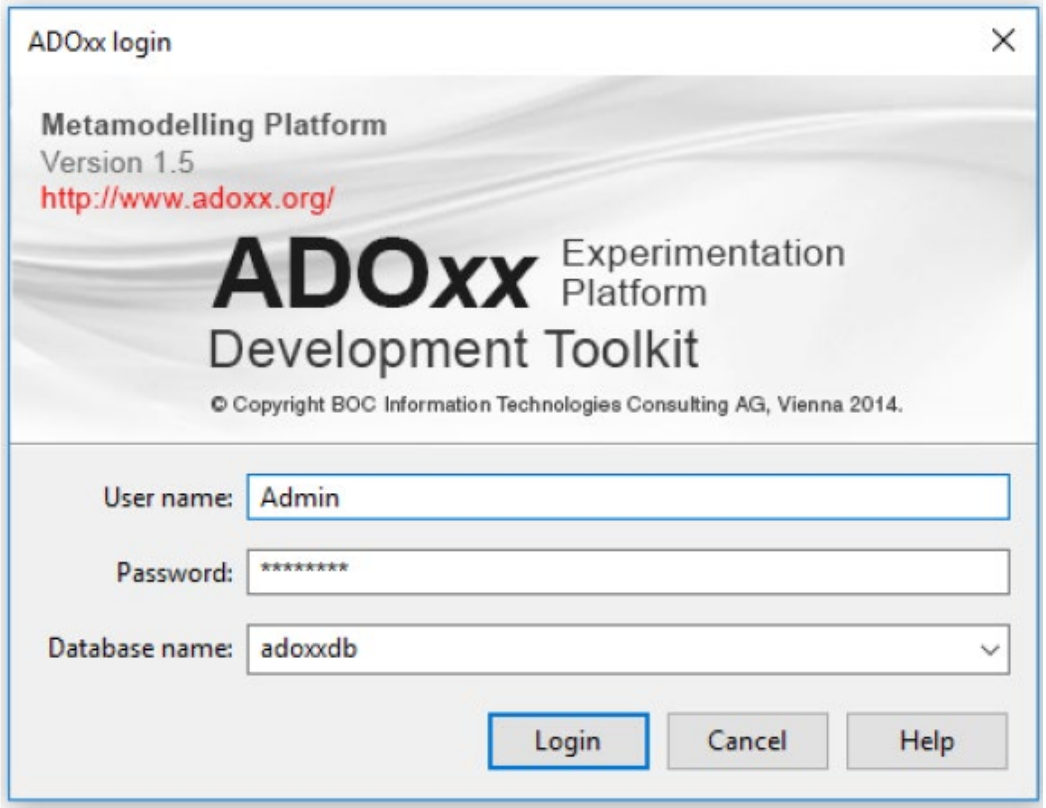
Development Toolkit

- Start Development Toolkit
- Login
  - Username: Admin
  - Password: password
  - DB: adoxxdb
    (or the one you created during installation)



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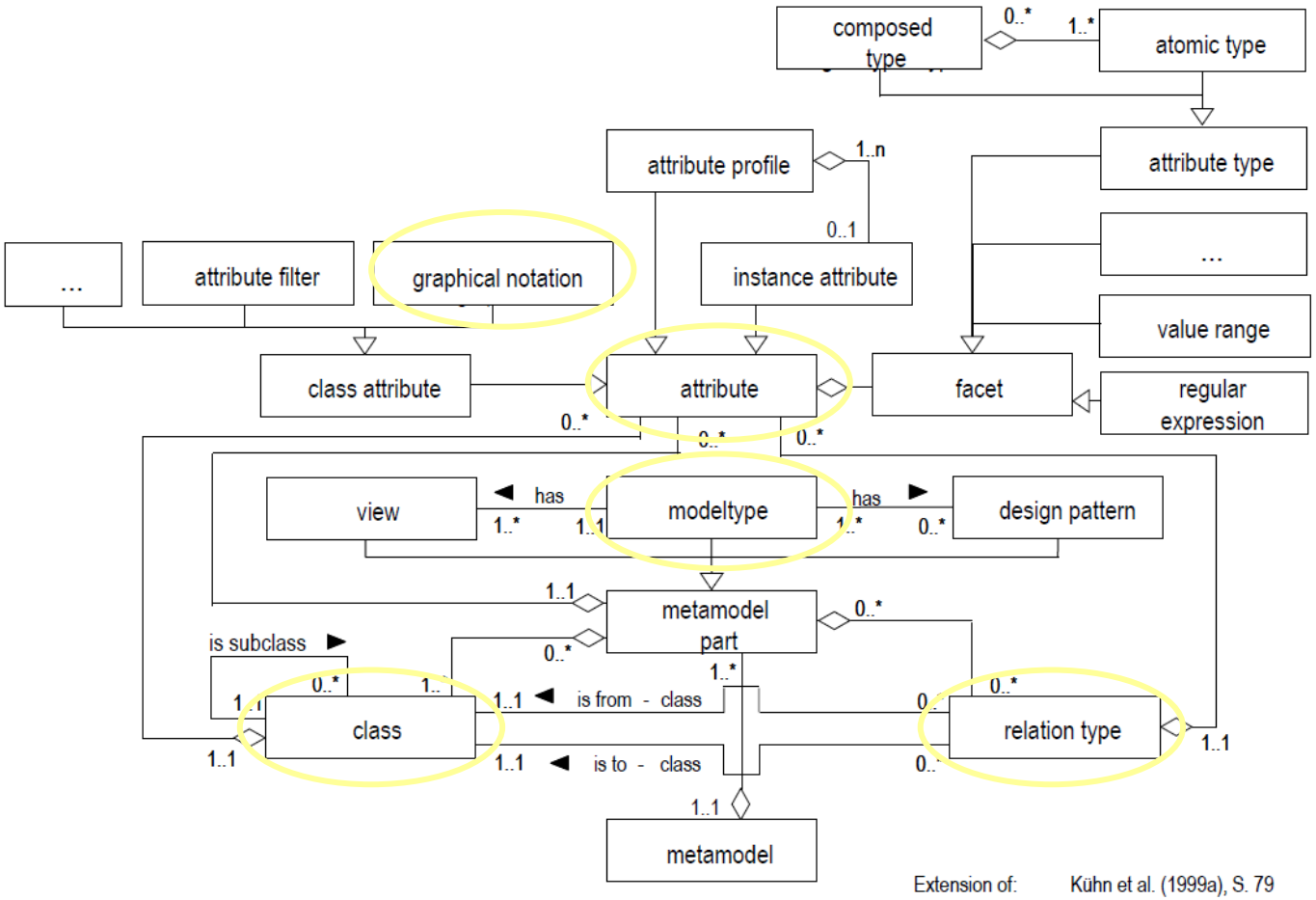
Meta² Model: Meta Model of Meta Modelling Language



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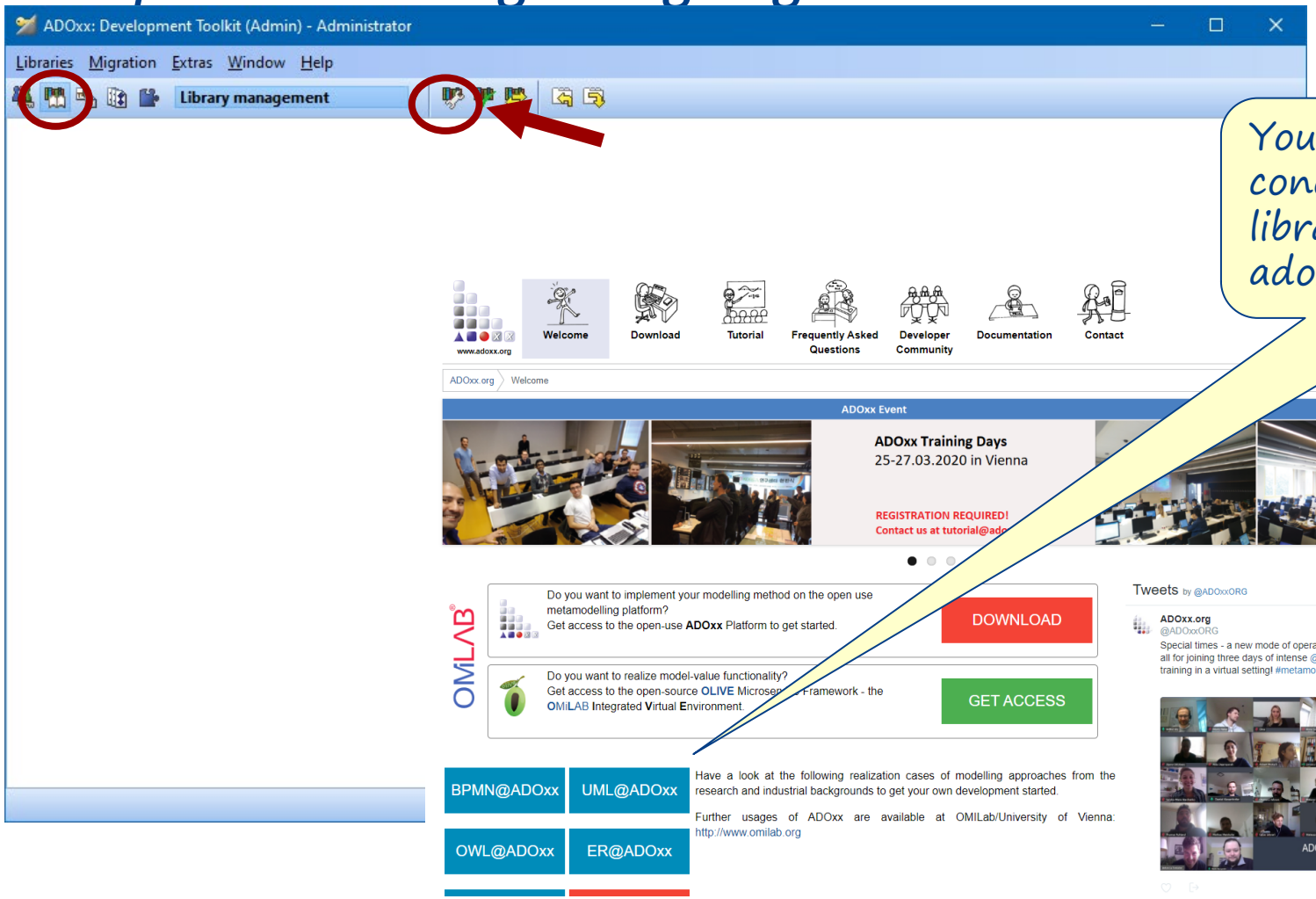
Import Modeling Language Libraries



You can download conceptual modeling libraries from adoxx.org, e.g. BPMN,

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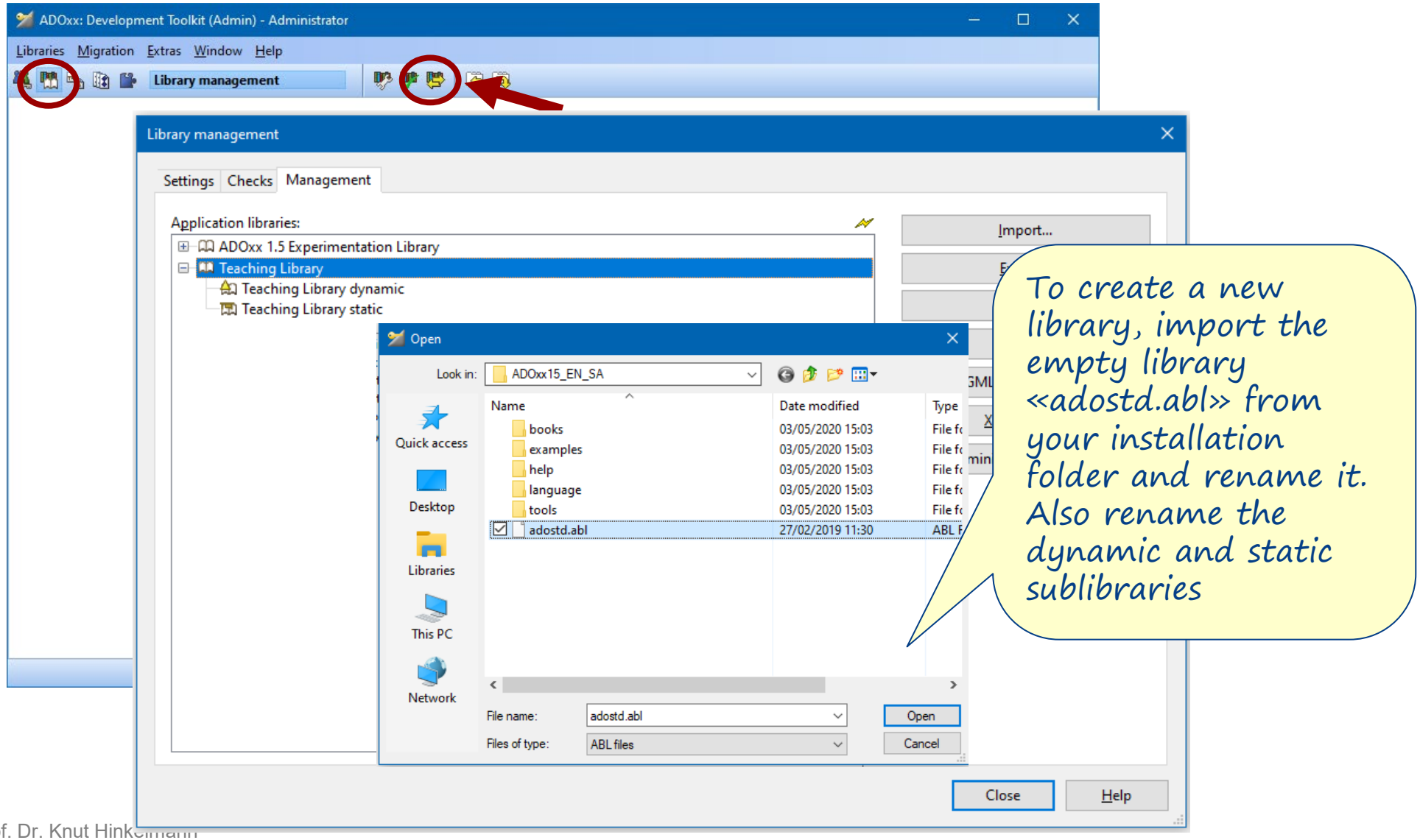
Create a new Modeling Language Library



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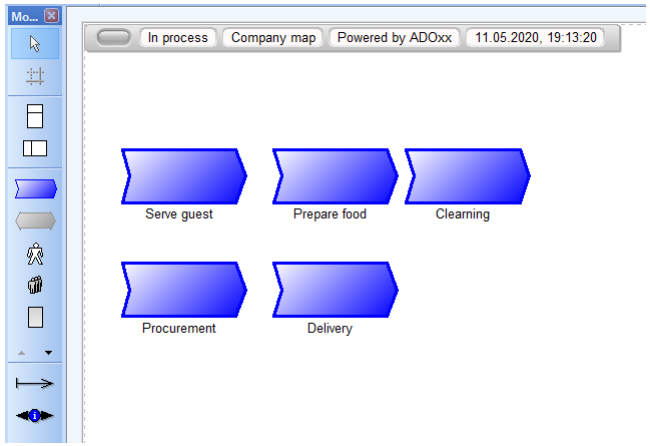
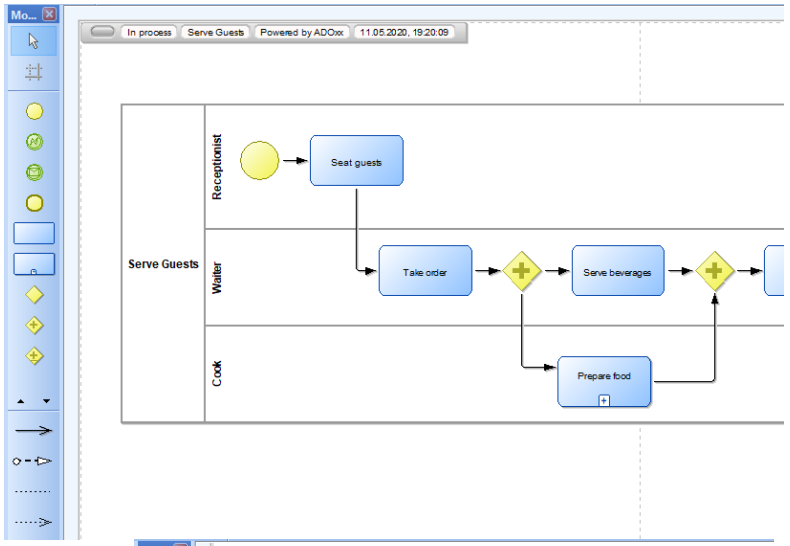
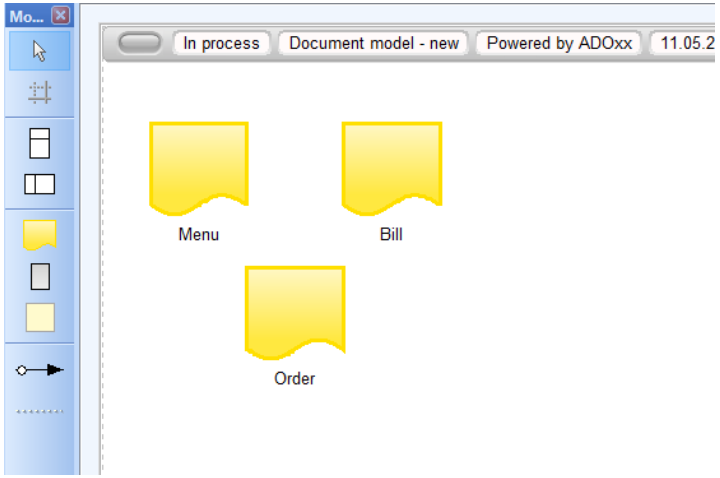
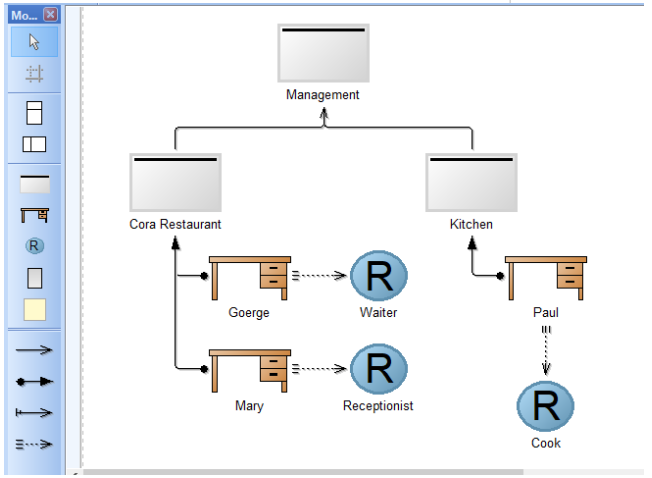
Model Types: Representing Views on the Knowledge









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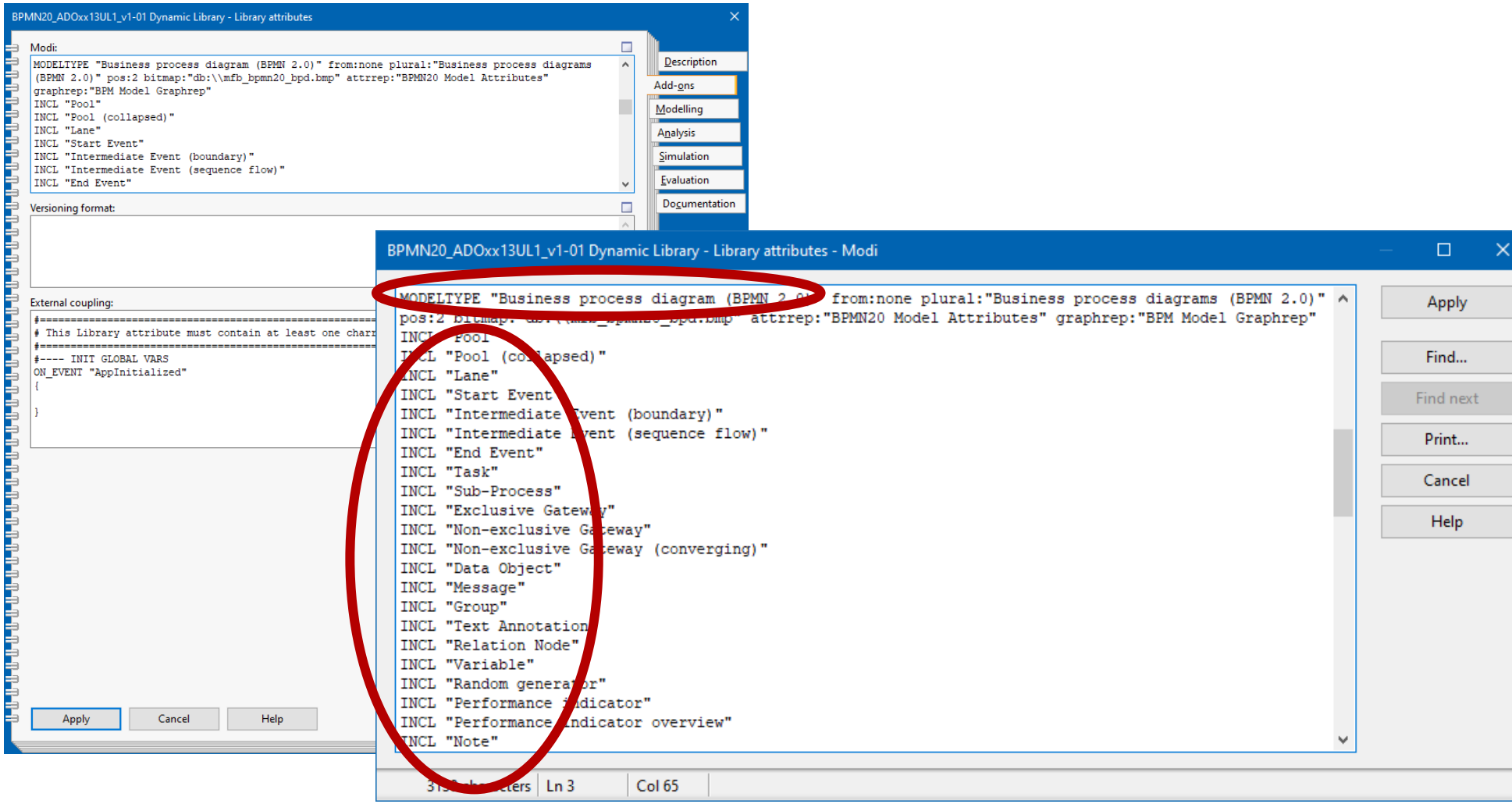
Classes are assigned to Model Types

Example: BPMN



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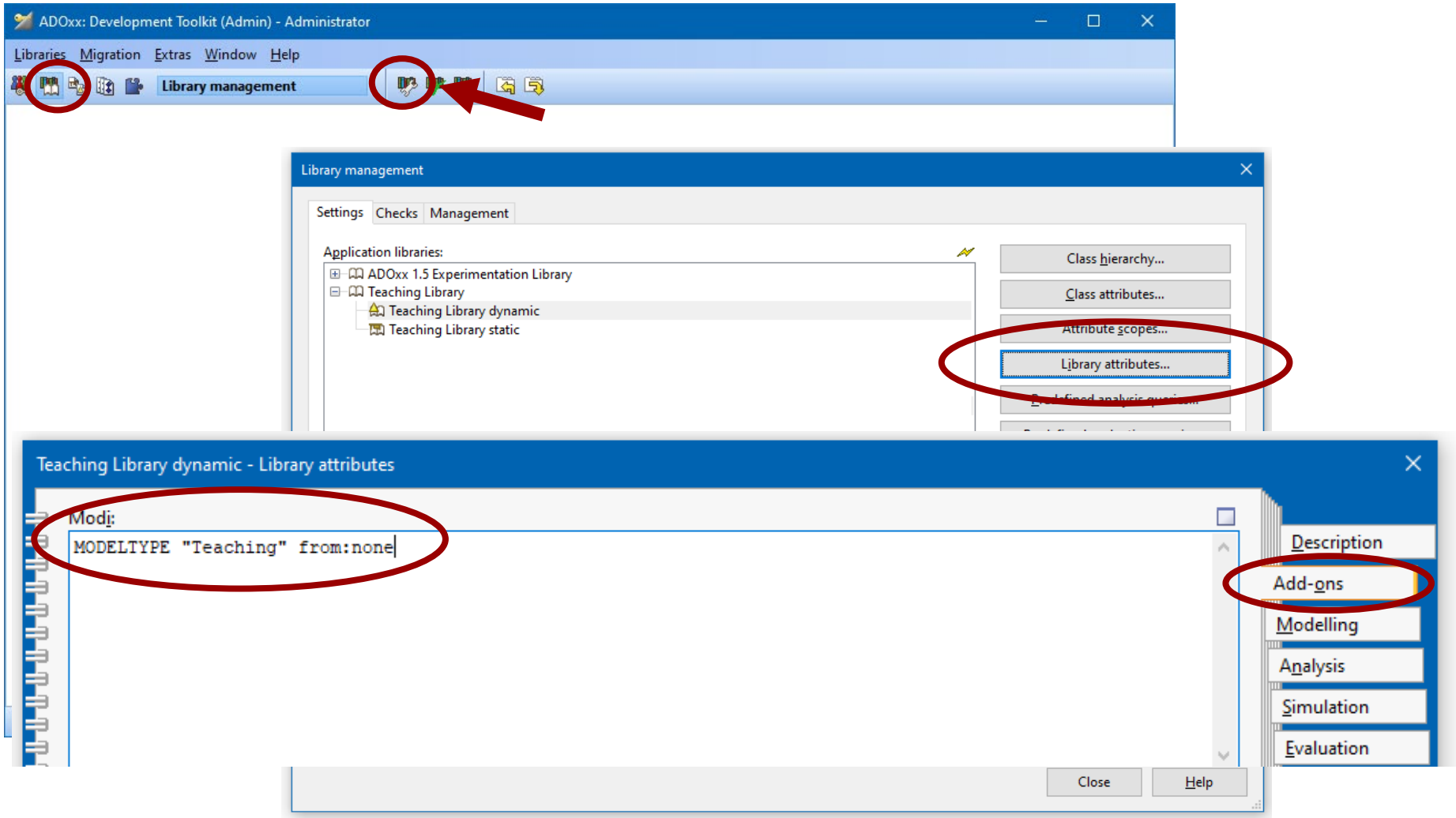

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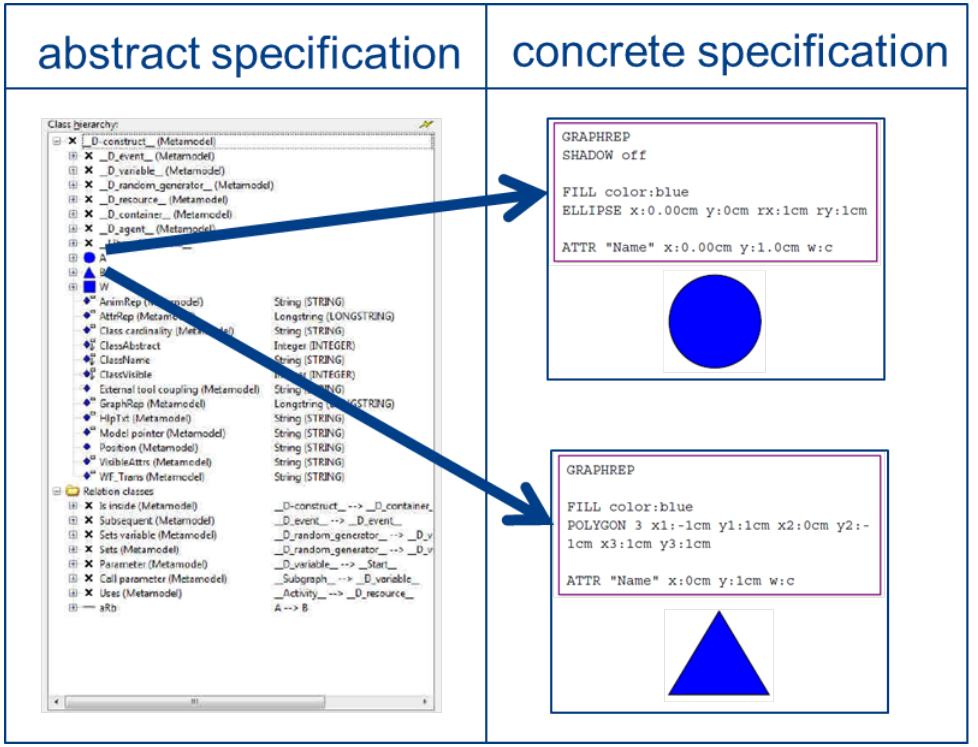
Metamodel and Modeling Language in ADOxx

- The meta model of a model language is defined by
  - Classes of elements and relations
  - Class hierarchy
  - Attributes of the elements
- The notation is defined by
  - special attribute GraphRep



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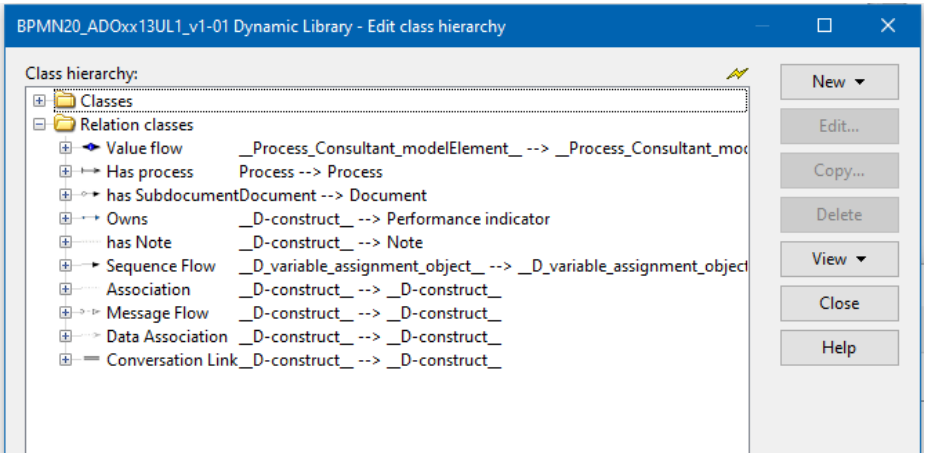
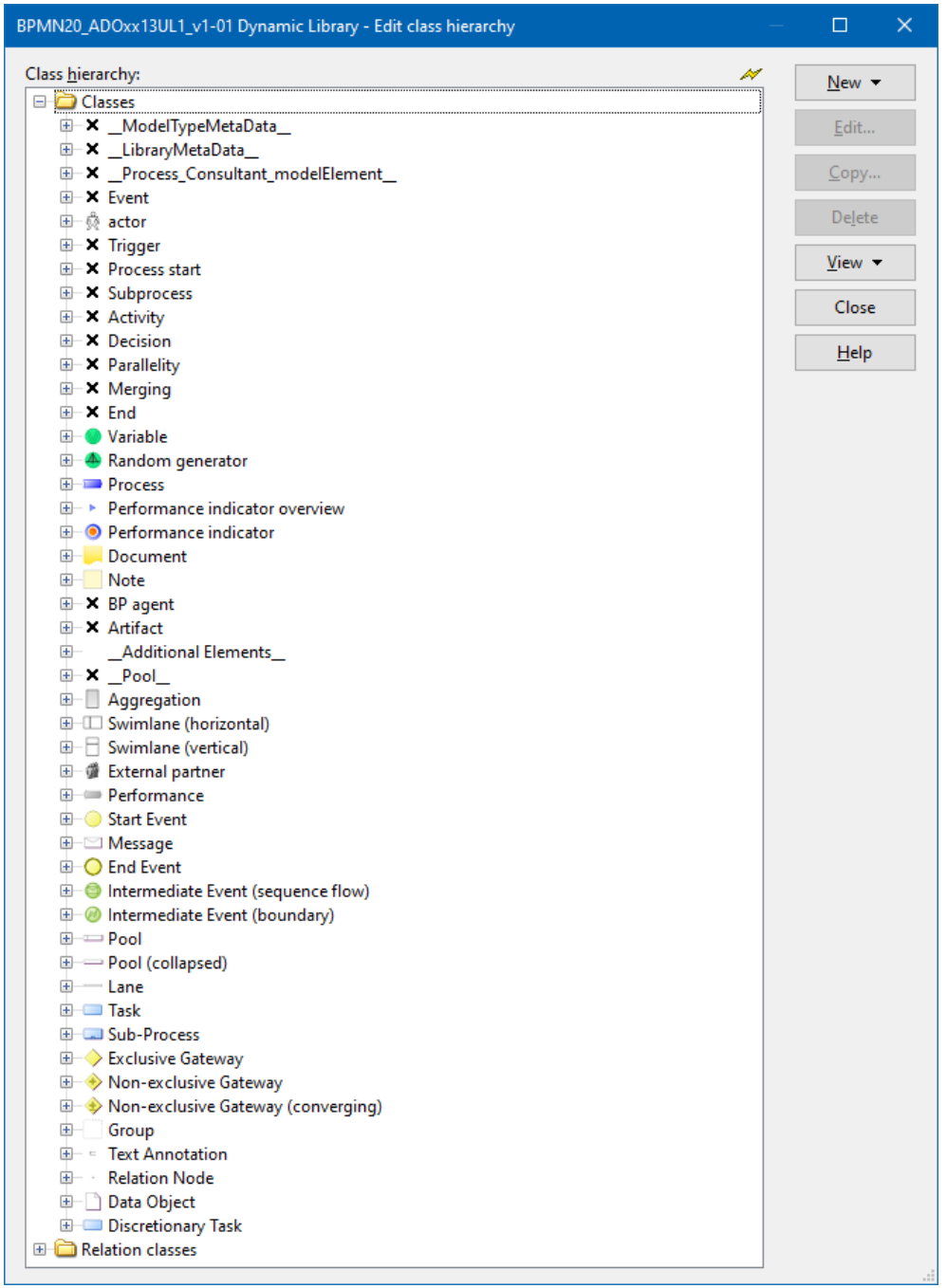
Class Hierarchies

- ADOxx distinguishes
  - Classes
  - Relation classes





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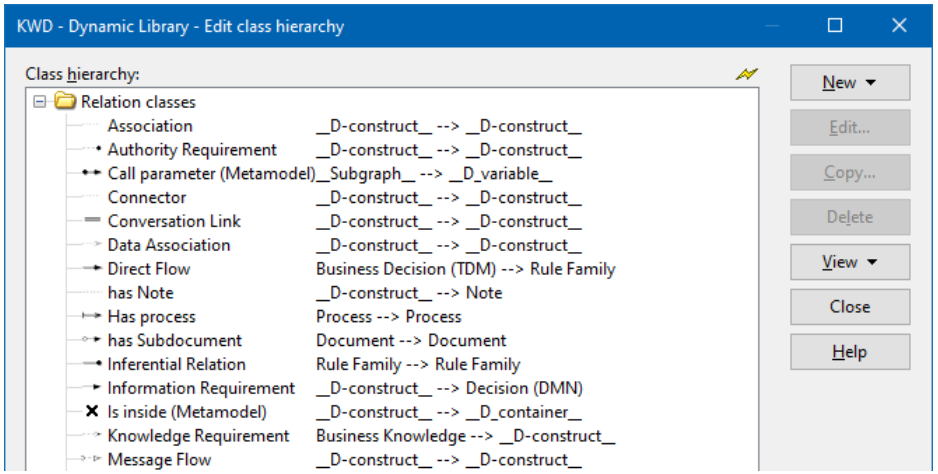
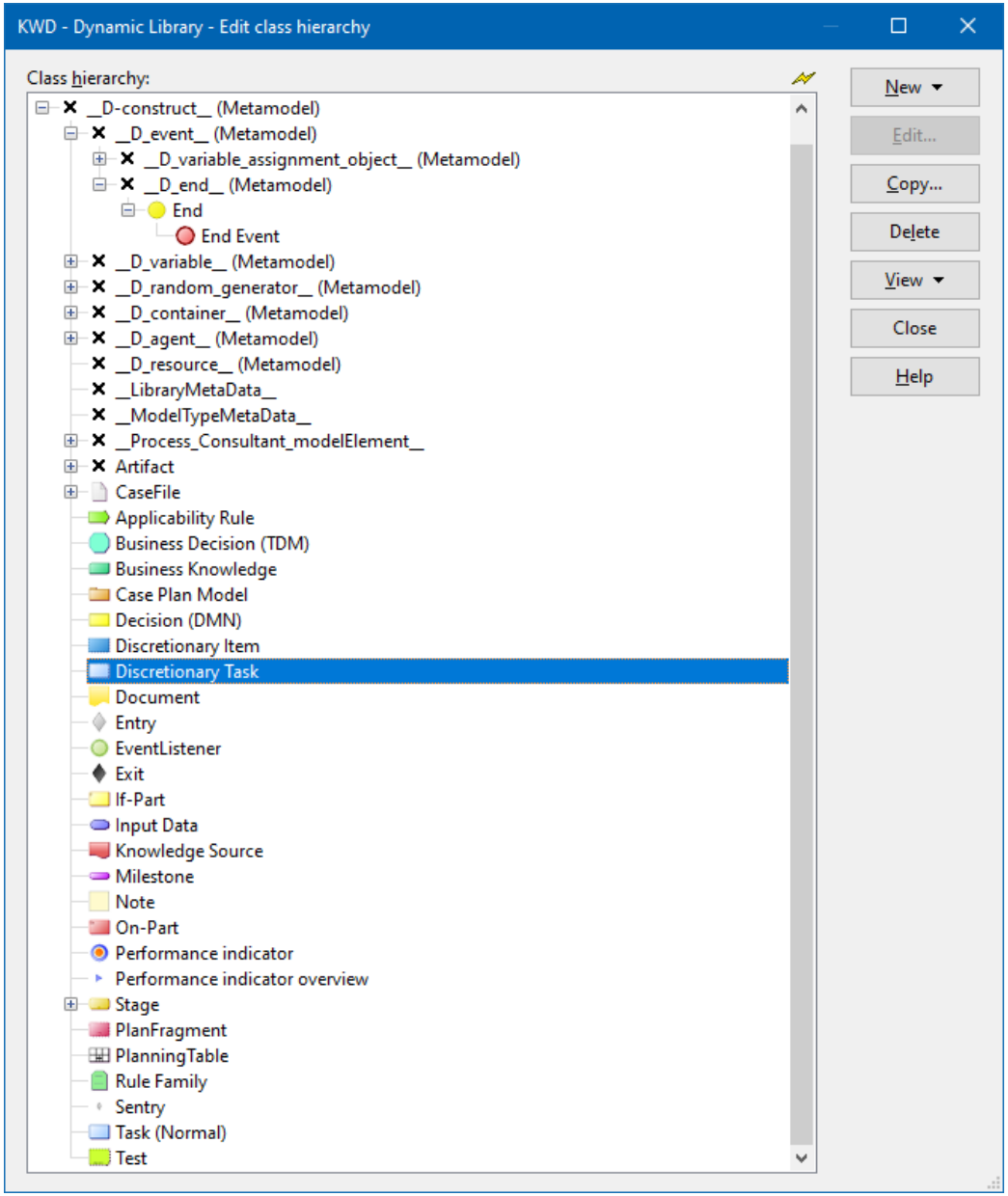
Class Hierarchies

- ADOxx distinguishes
  - Classes
  - Relation classes





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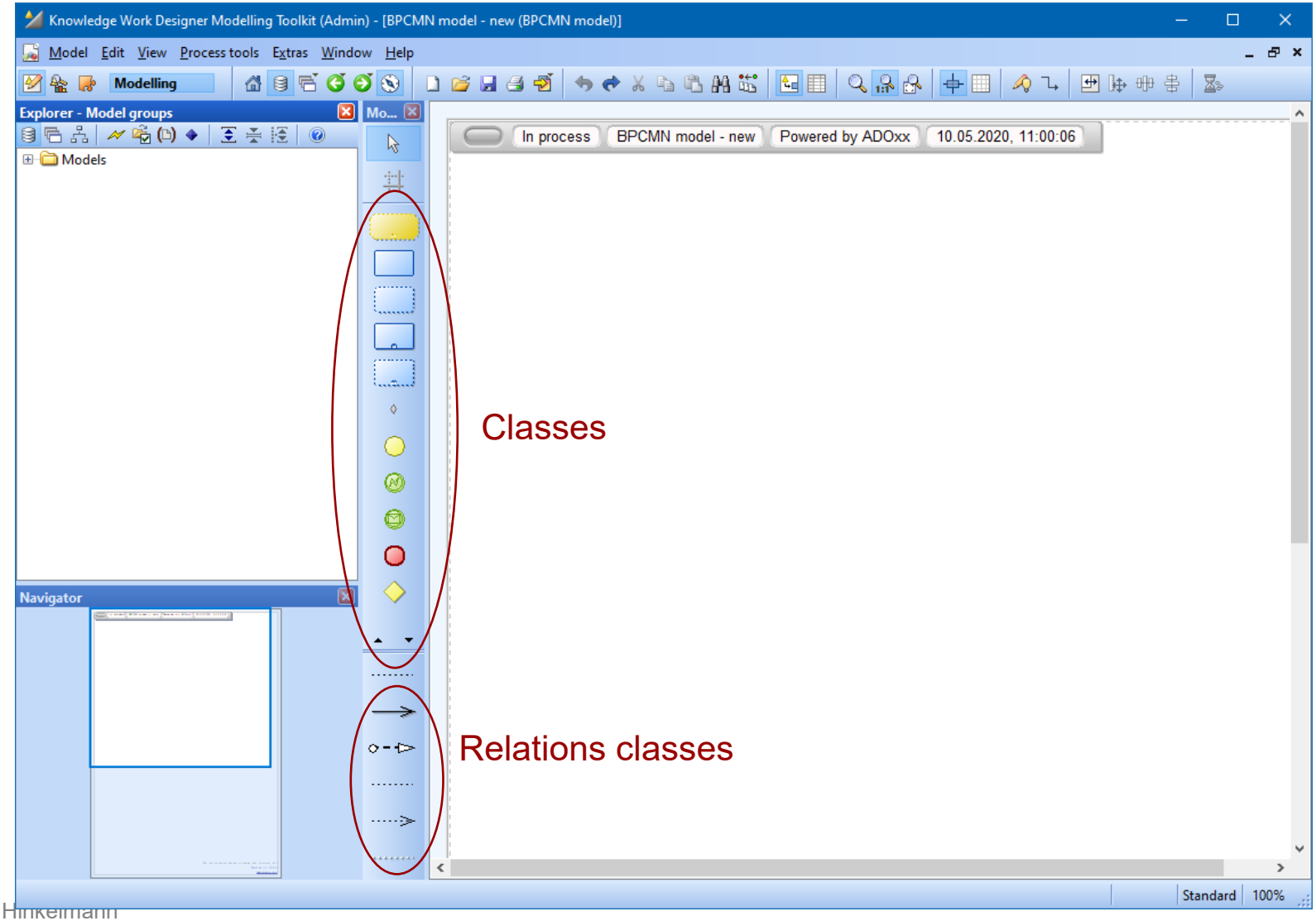
Appearance of Classes in the Modelling Toolkit



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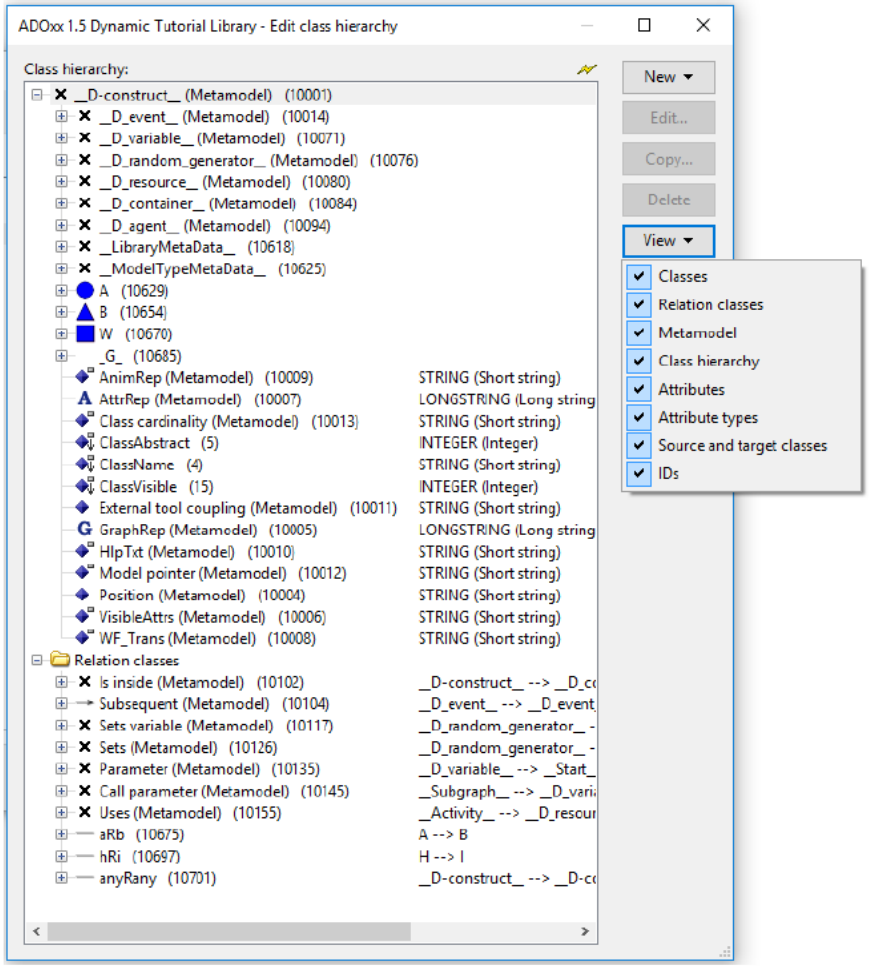
Views of the Class Hierarchy



Classes

All visible classes will be shown

Relation classes

All available relation classes will be shown

Metamodel

All classes will be shown

Class hierarchy

All classes will be shown with their inheritance in a hierarchy

Attributes

The attributes of the (relation-)classes will be shown

Attribute types

The type of each attribute will be shown

Source- and Target-classes

Shows the endpoints for each relation class, i.e. between which classes it can be used.

IDs

Shows ID numbers of classes and attributes

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Icons in Class Hierarchy

 **Class** (the icon shows the graphical definition of the object and can therefore vary)

 **Class** (without a graphical definition)

 **Attribute**

 **Attribute** (inherited from another class)

 **Class attribute**

 **Class attribute** (inherited from another class)

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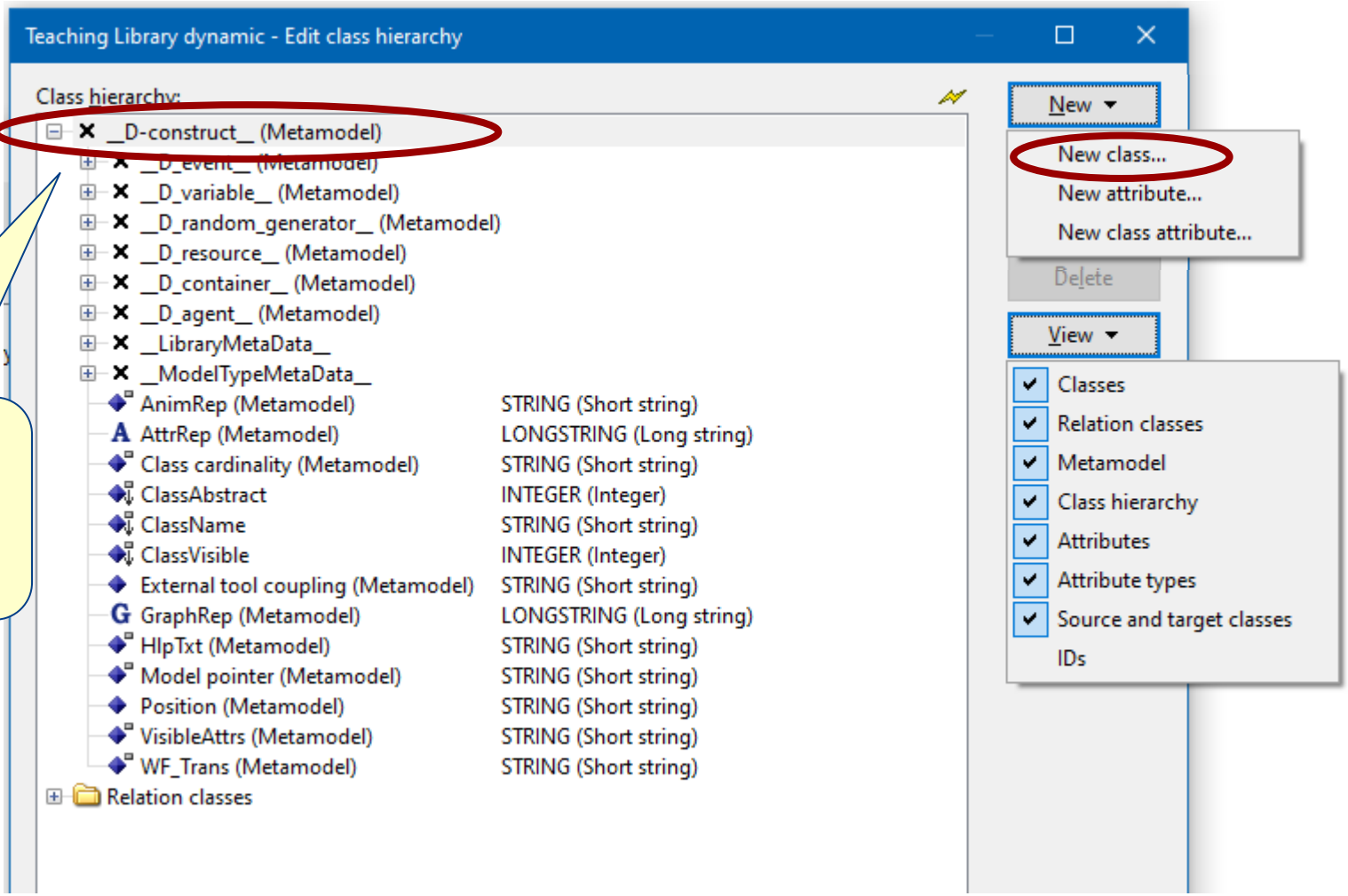
Creating new Classes



There are predefined abstract classes which have specific functionaliy

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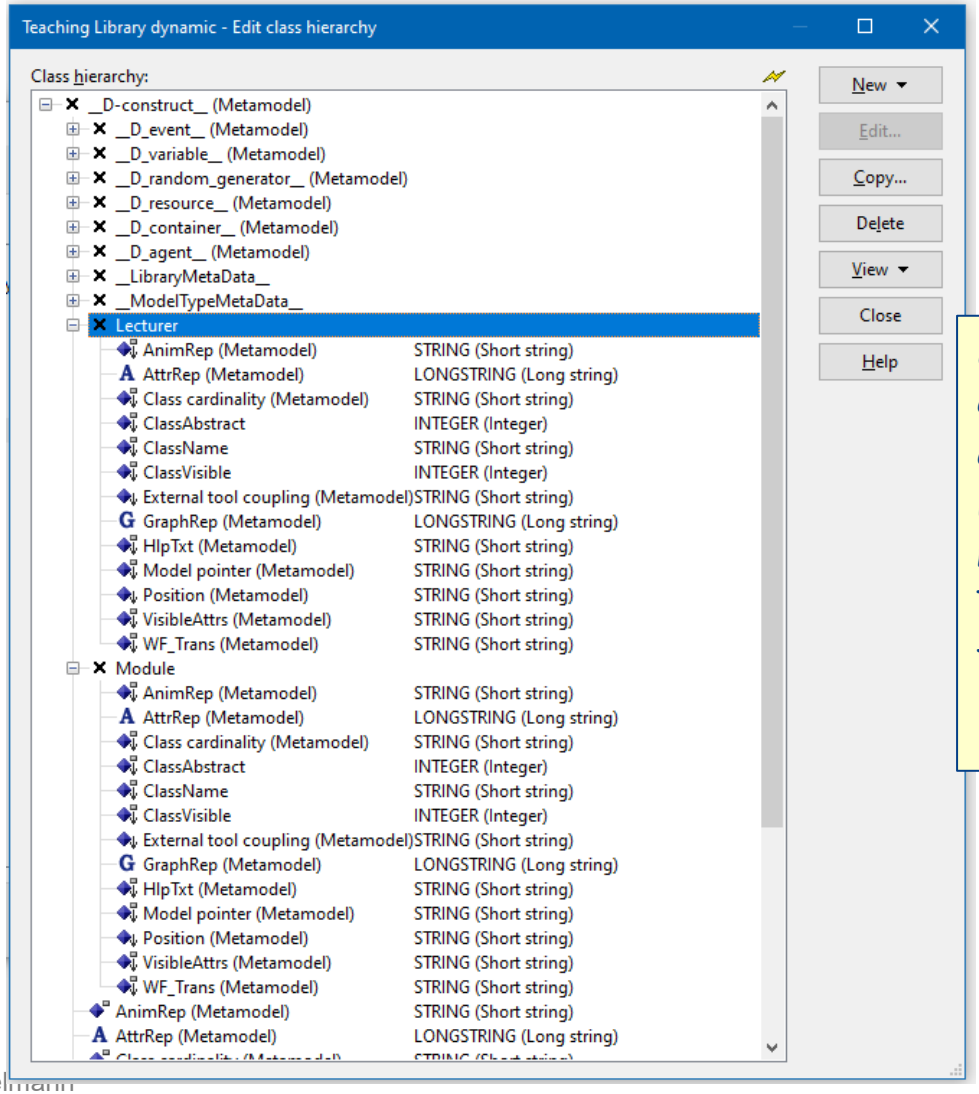
New Classes for Lecturer and Module



New classes, e.g. «Lecturer» and «Module» can be defined as subclasses of D-construct, if no specific functionality is needed.
They inherit the attributes of the superclass

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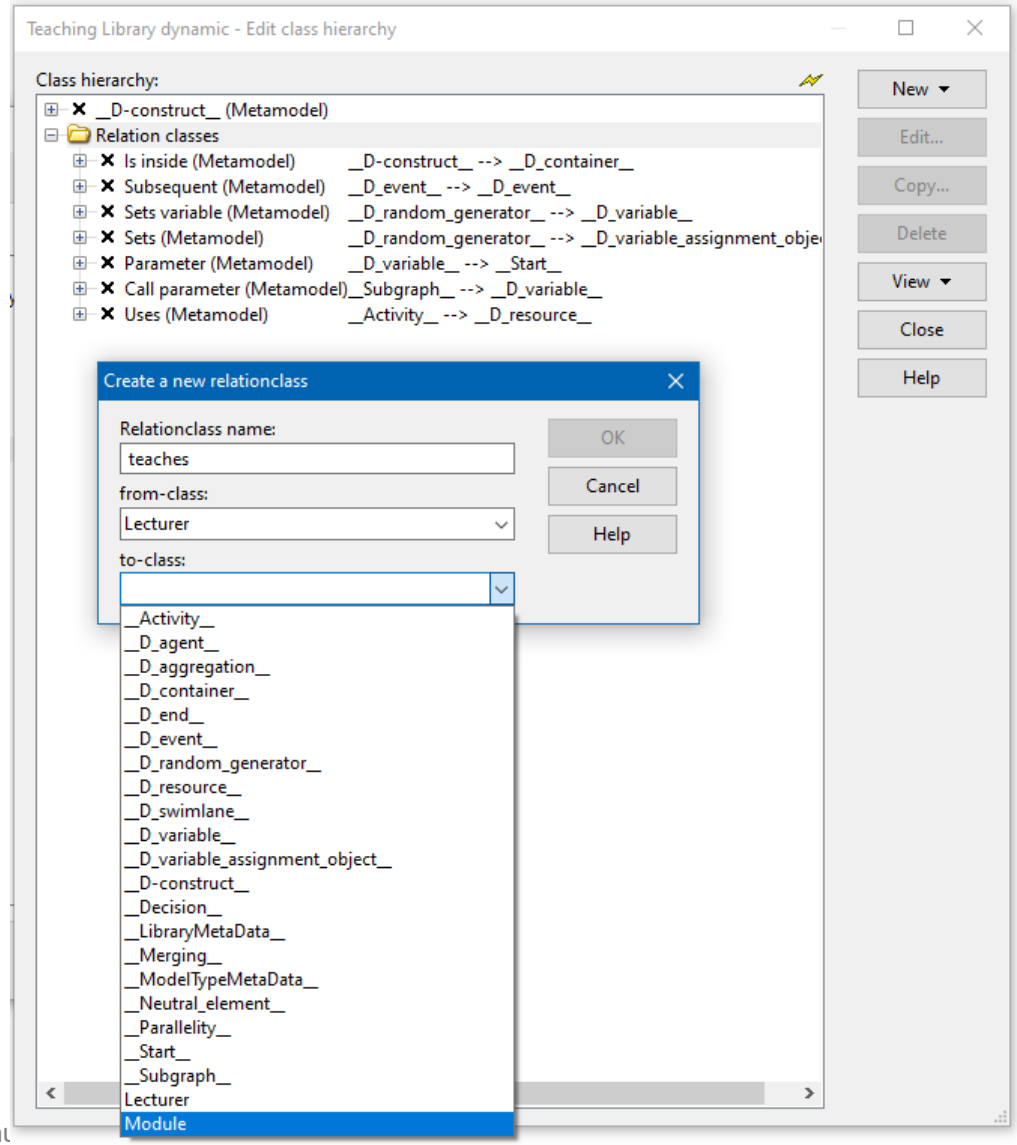
Defininig a new Relation



Example: A new relation «teaches» for elements from class «Lecturer» to class «Module»

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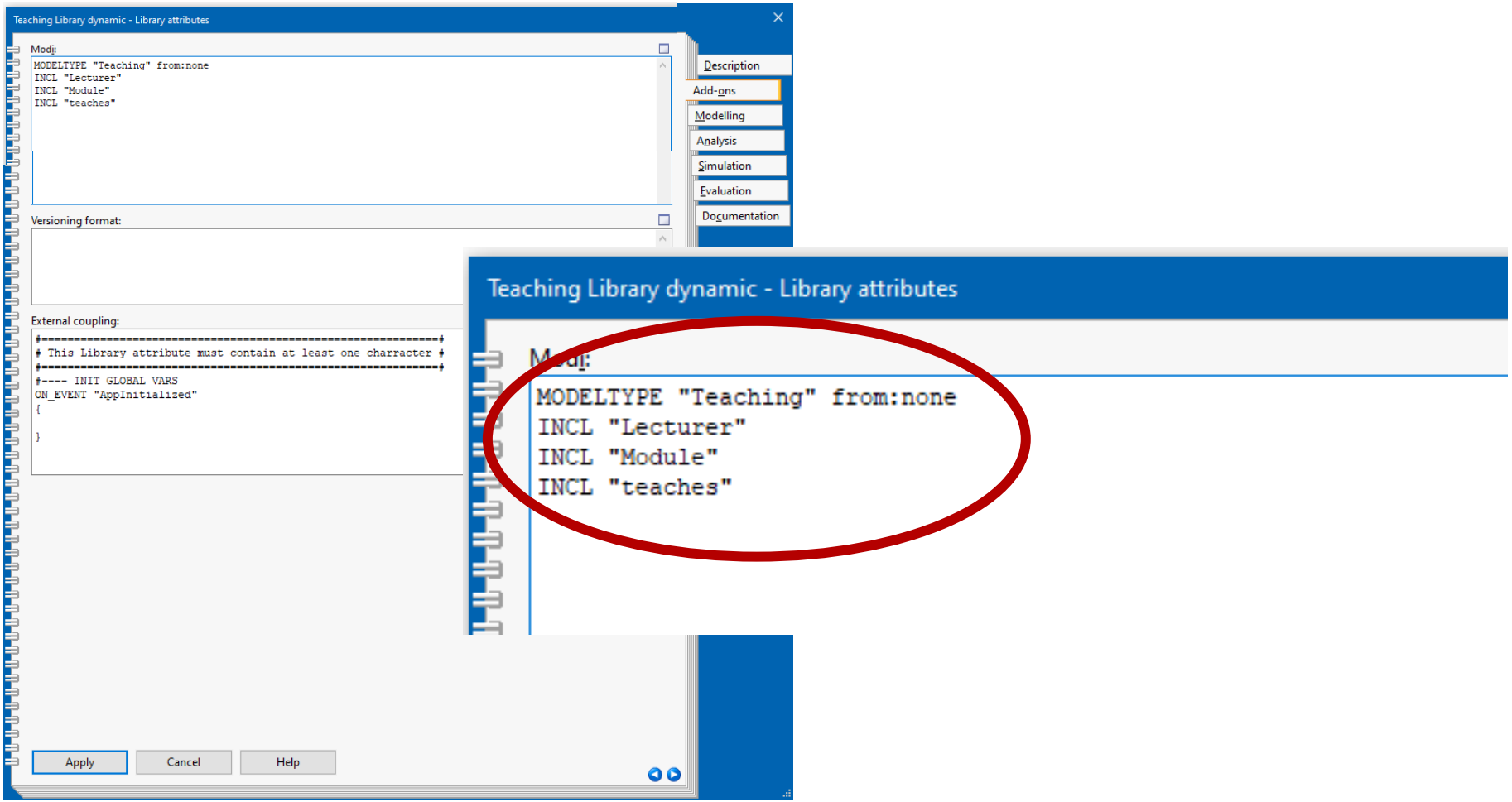
Classes and Relations are assigned to Model Types



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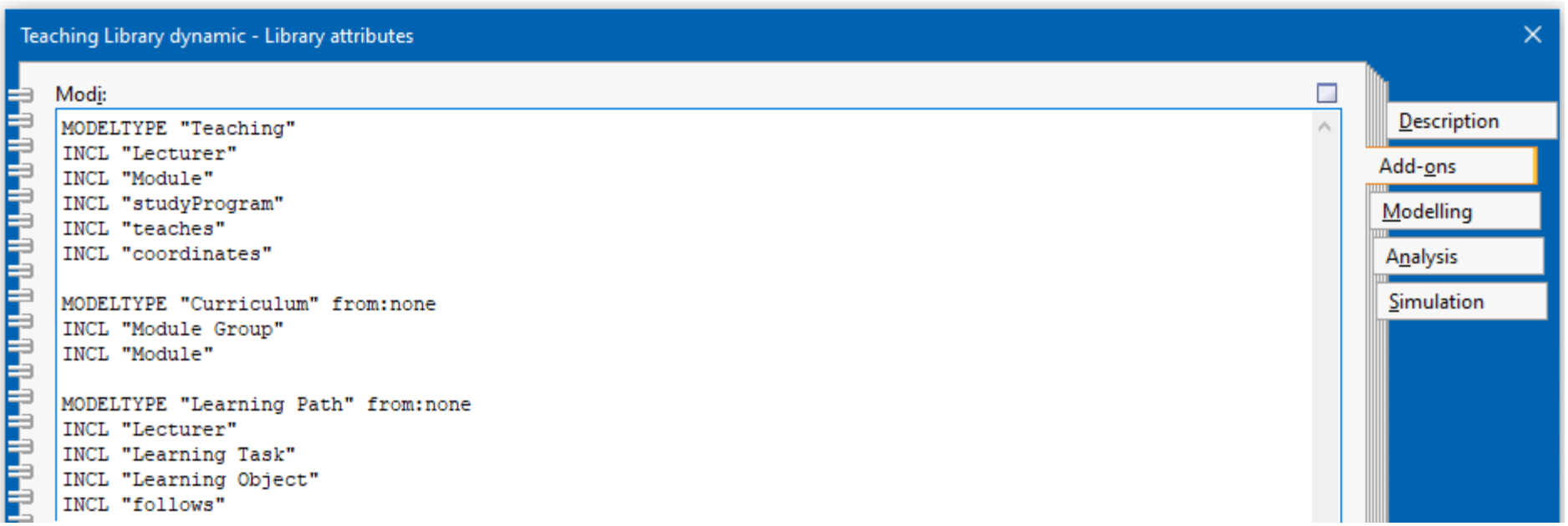
Example with several Model Types



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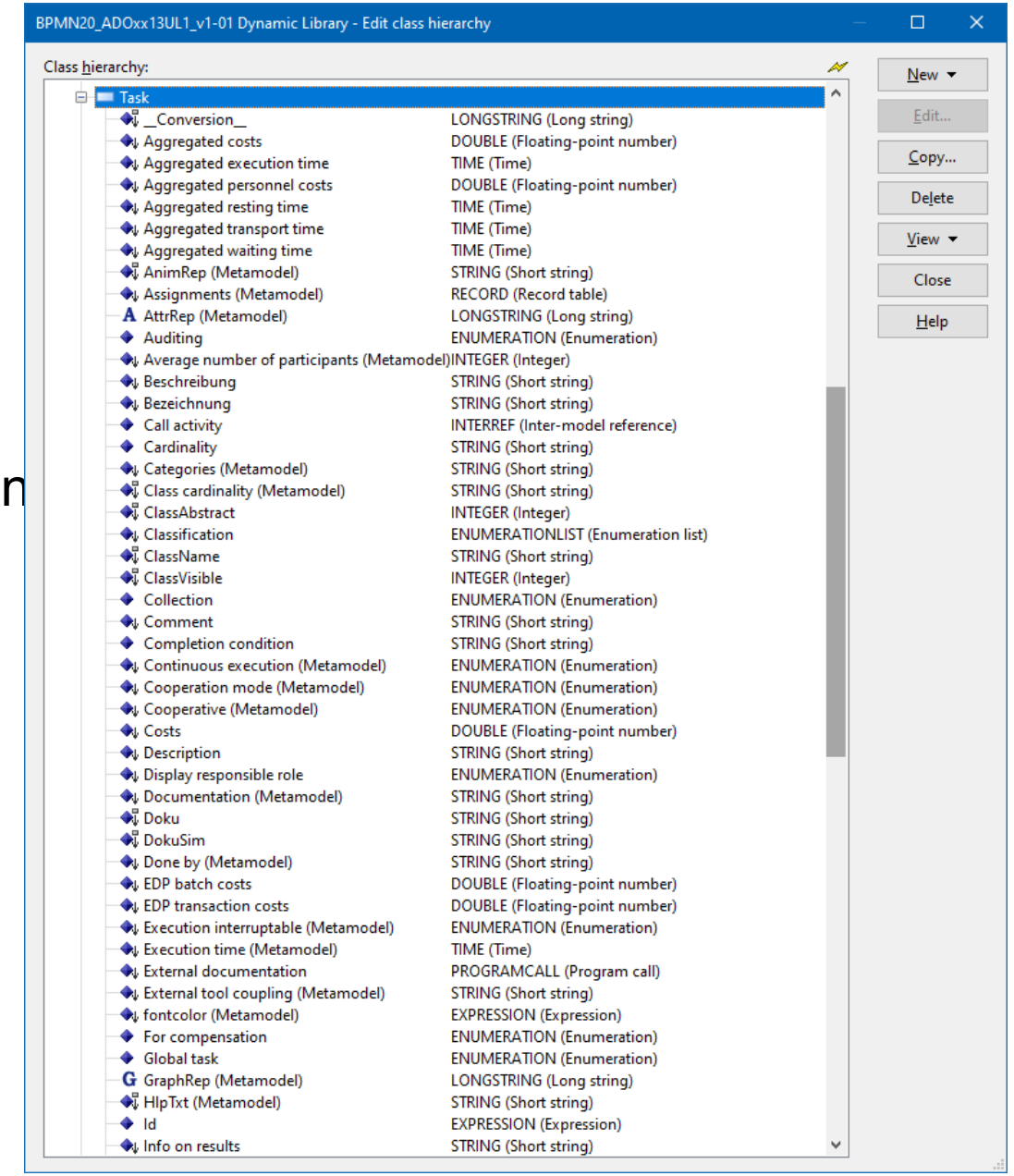
Attributes

- Kinds of Attributes
  - Properties of Models
  - Graphical Representation
  - References



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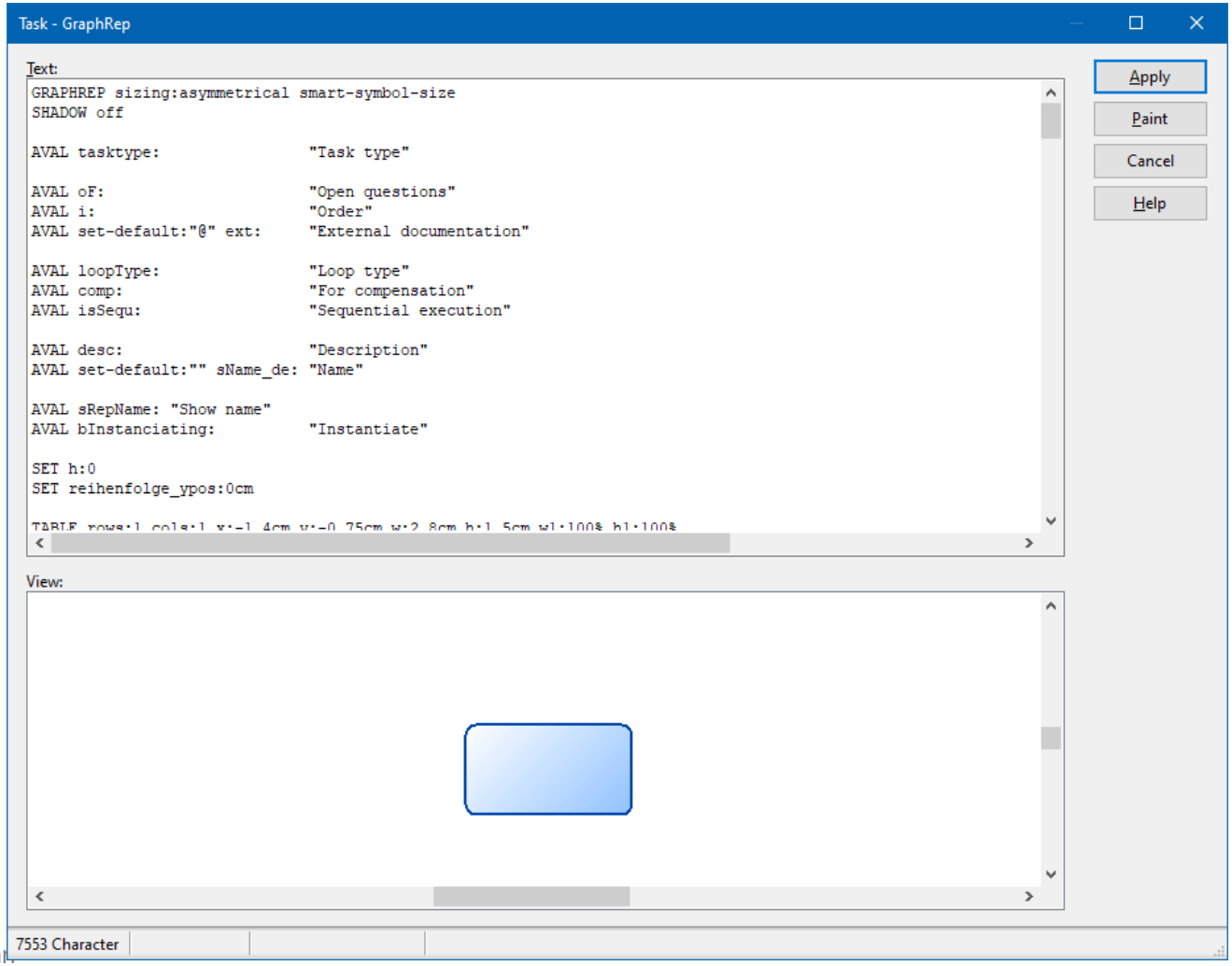
Modelling Language: Special Attribute GraphRep

GraphRep: A script language for the graphical representation



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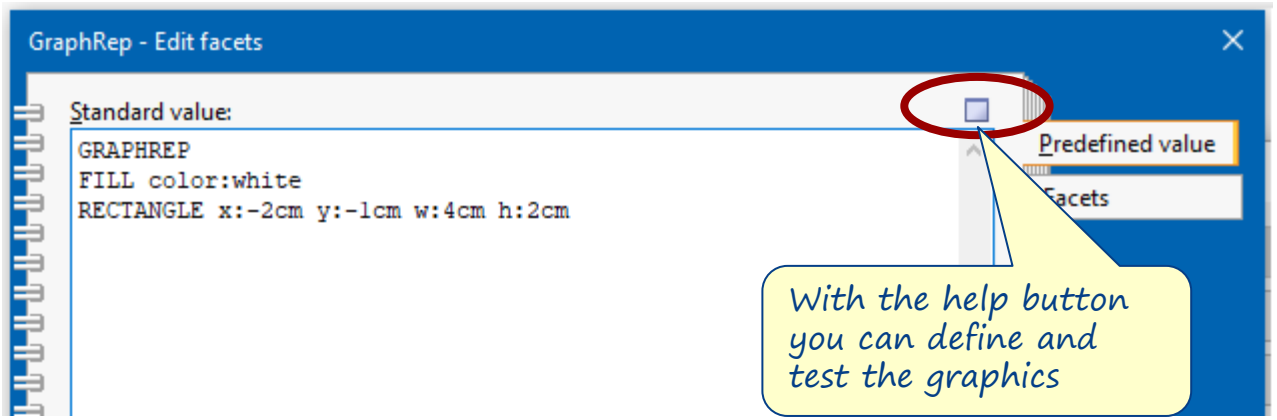
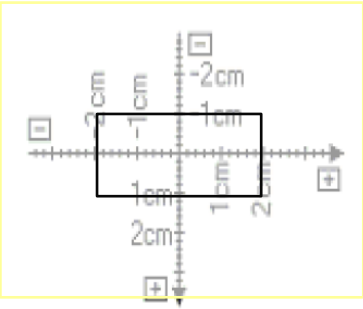
Defining a GraphRep

- GraphRep allows to draw elements and display texts
- This example draws a white rectangle
  - It starts at the top right corner, is 2cm left from the center (x:-2cm) and 1 cm above the center (y:-1cm)
  - It is 4cm wide and 2 cm high (w:4cm h:2cm)





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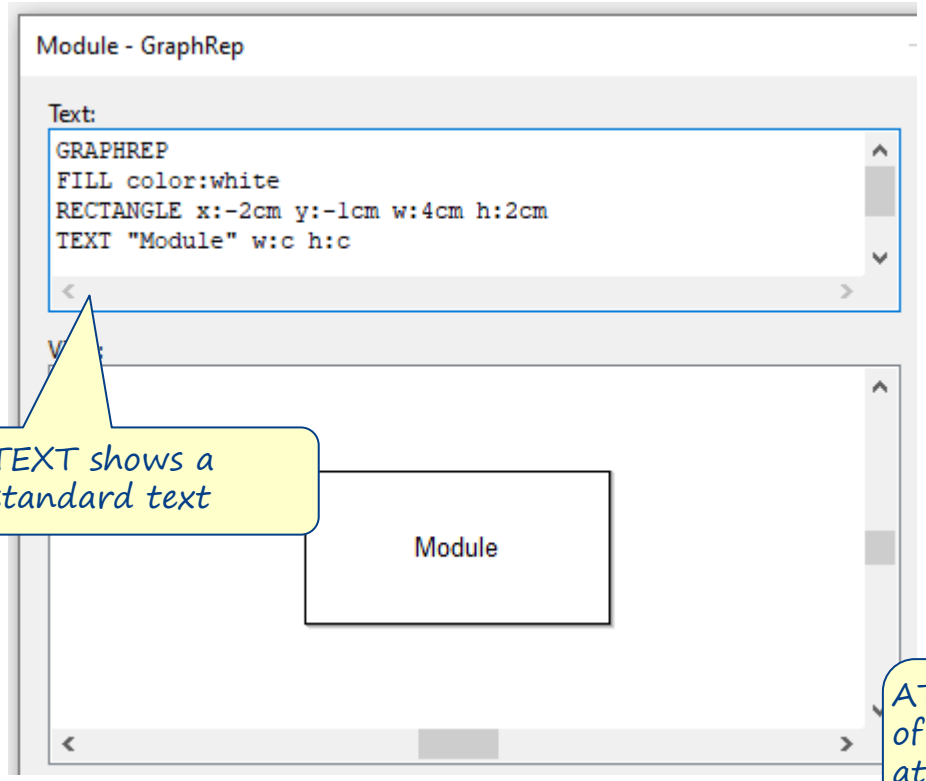
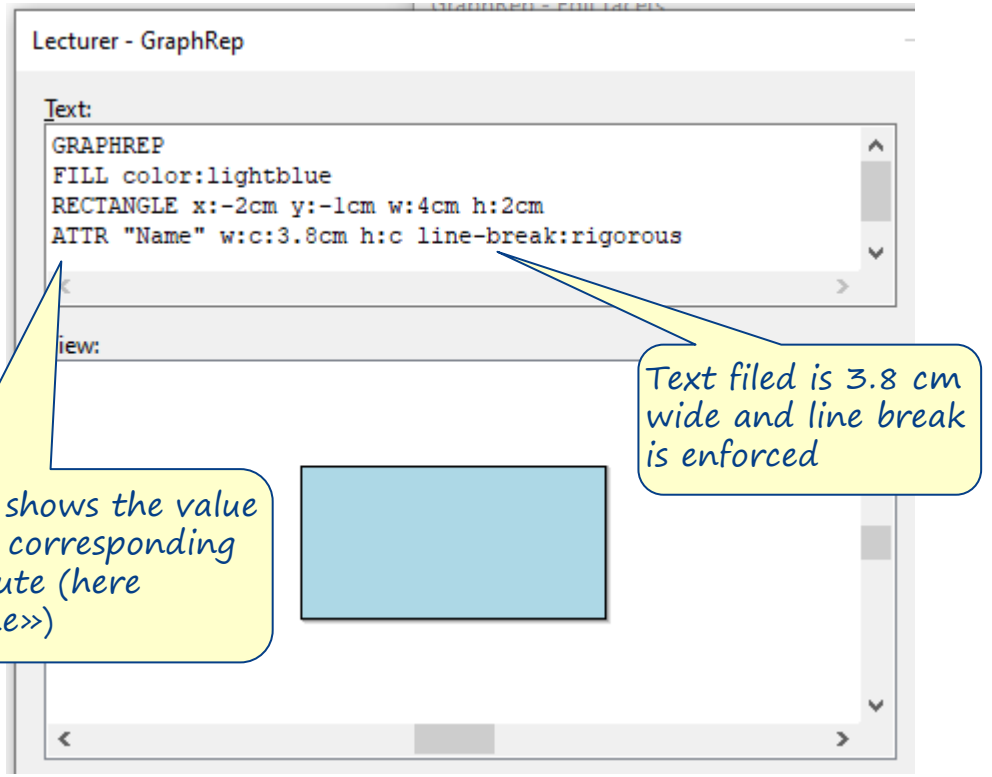
Defining a GraphRep with Text





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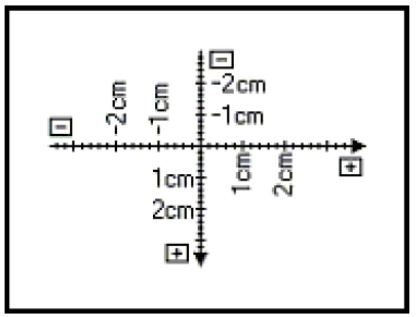
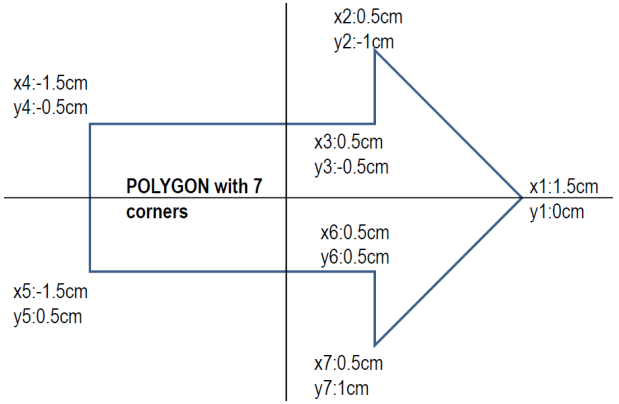
GraphRep Elements

- Types of elements
  - Style elements
  - Shape elements
  - Variable assigning elements
  - Context elements
  - Control elements

```
Edge | Start | Middle | End |
Pen | Fill | Shadow | Stretch | Map | Font |
ClipRect | ClipRoundRect | ClipPoly | ClipEllipse | ClipOff |
Point | Line | PolyLine | Arc | Bezier | Curve |
Rectangle | RoundRect | Polygon | Ellipse | Pie |
BeginPath | MoveTo | LineTo | BezierTo |
EndPath | DrawPath |
Compound | Bitmap | GradientRect | GradientTri |
Text | Attr | Hotspot |
Set | Aval | Table | TextBox | AttrBox | BitmapInfo |
IfStatement | WhileStatement |
ForNumStatement | ForTokenStatement | Execute.
```

- Elements are placed on x-y-axes





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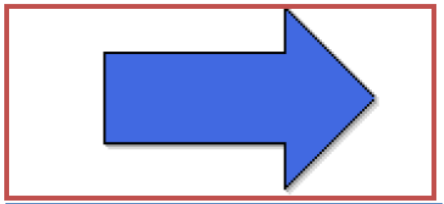
GraphRep Examples

```
GRAPHREP
SHADOW off

FILL color:blue
ELLIPSE x:0.00cm y:0cm rx:1cm ry:1cm

ATTR "Name" x:0.00cm y:1.0cm w:c
```

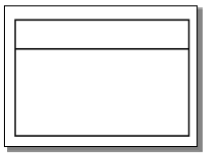
```
GRAPHREP
FILL color:royalblue
POLYGON 7 x1:1.5cm y1:0cm x2:0.5cm
y2:-1cm x3:0.5cm y3:-0.5cm x4:-1.5cm
y4:-0.5cm x5:-1.5cm y5:0.5cm
x6:0.5cm y6:0.5cm x7:0.5cm y7:1cm
ATTR "Name" y:1.4cm w:c h:c
```



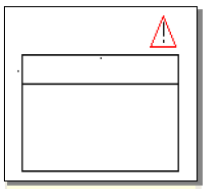
In case attribute name is available, it is shown here

Conditional Representation

```
GRAPHREP
AVAL set-default:"Modeling finished" b:"Status"
SHADOW off
FILL style:null
POLYGON 4 x1:-1.54cm y1:0.92cm x2:1.54cm y2:0.92cm
          x3:1.54cm y3:-0.98cm x4:-1.54cm y4:-0.98cm
LINE x1:-1.54cm y1:-0.50cm x2:1.54cm y2:-0.50cm
IF (b = "Modeling not finished")
  LINE x1:1.25cm y1:-1.5cm x2:1.25cm y2:-1.3cm
  LINE x1:1.25cm y1:-1.22cm x2:1.25cm y2:-1.18cm
  PEN color:red
  POLYGON 3 x1:1cm y1:-1.1cm x2:1.25cm y2:-1.6cm
            x3:1.50cm y3:-1.1cm
ENDIF
```



Condition fulfilled



Condition not fulfilled

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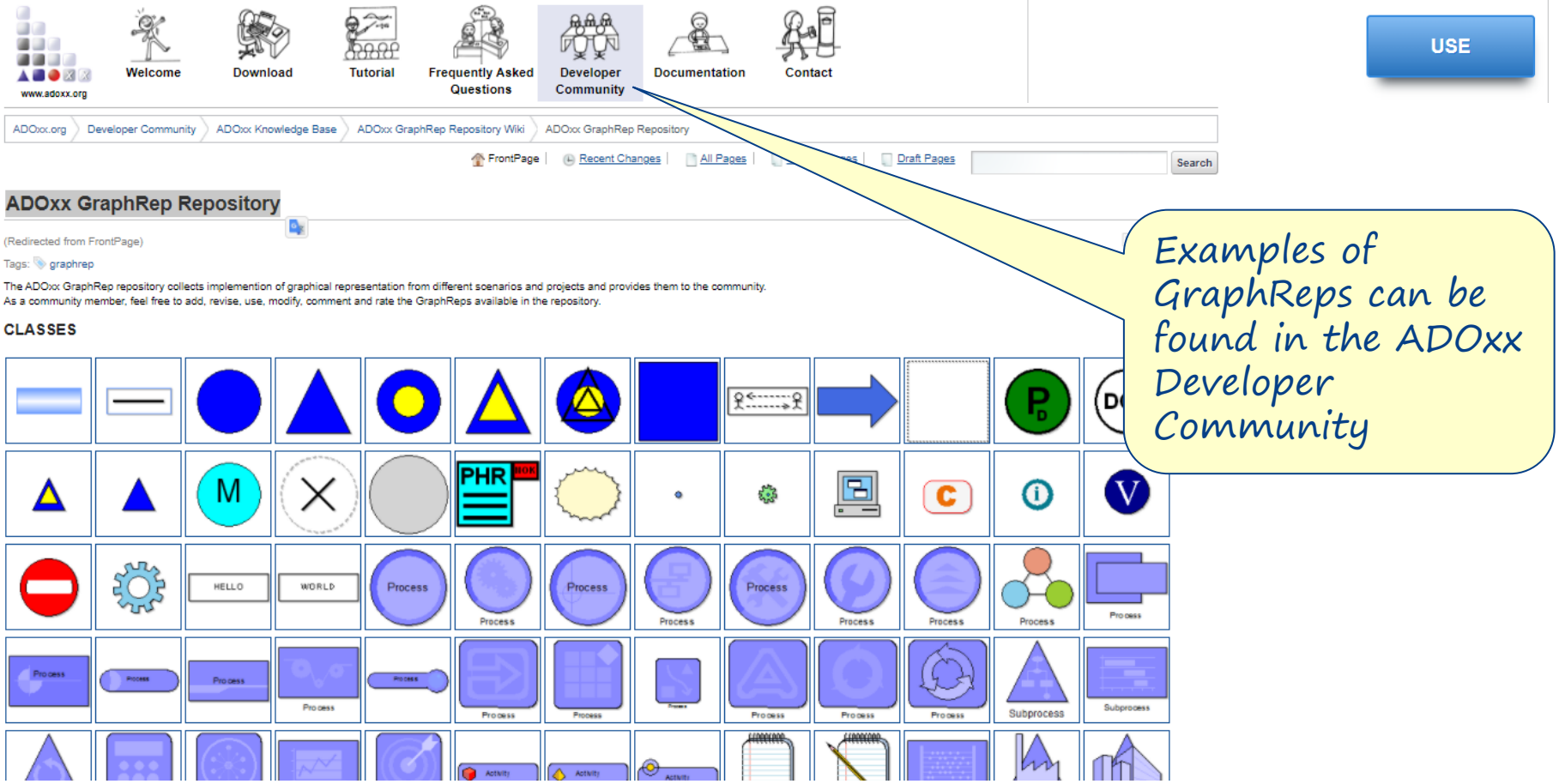
ADOxx GraphRep Repository



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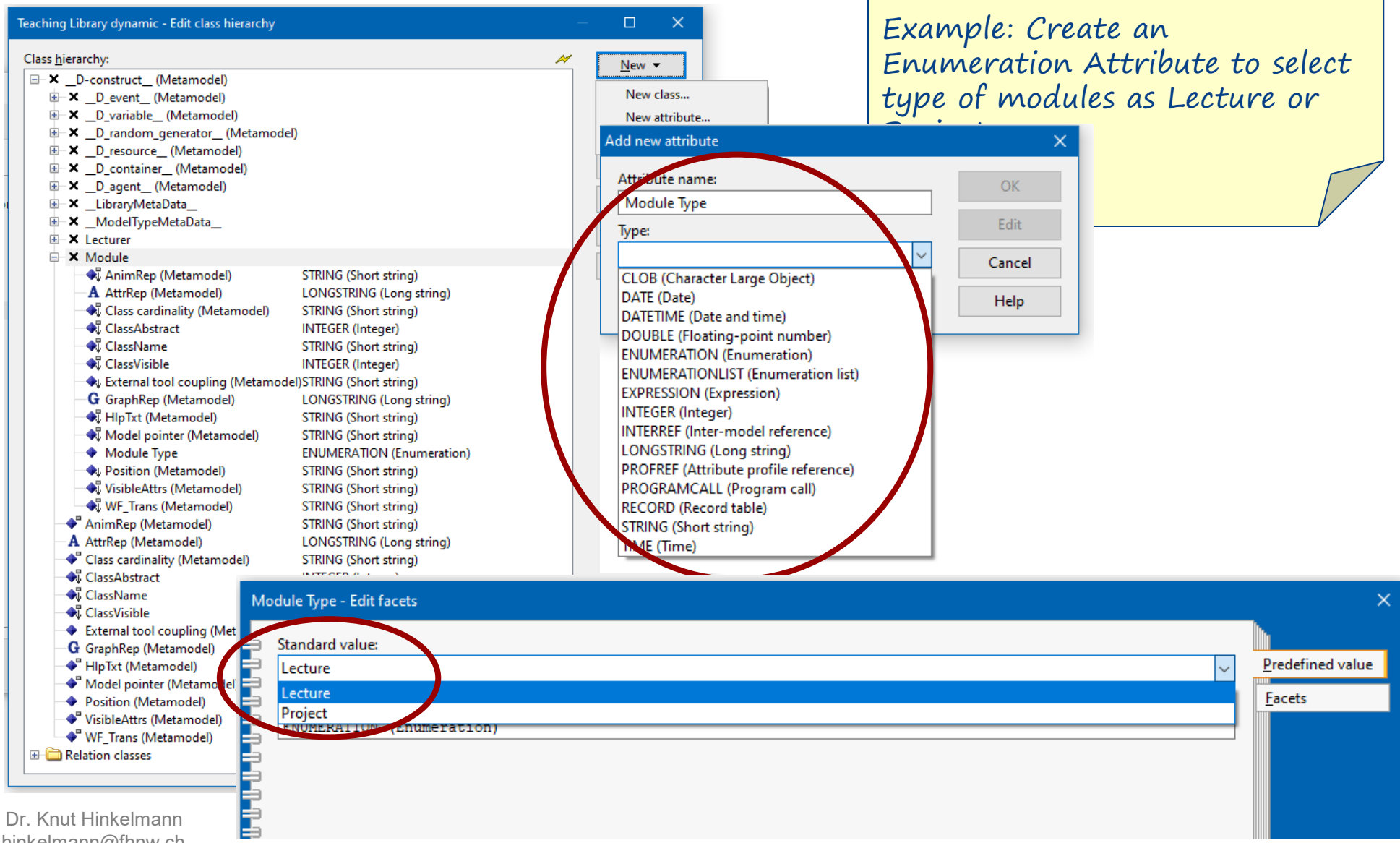
Defining a new Attribute

1. Select Class
2. Right Click or select «New Attribute ...»
3. Define Attribute

Example: Create an Enumeration Attribute to select type of modules as Lecture or



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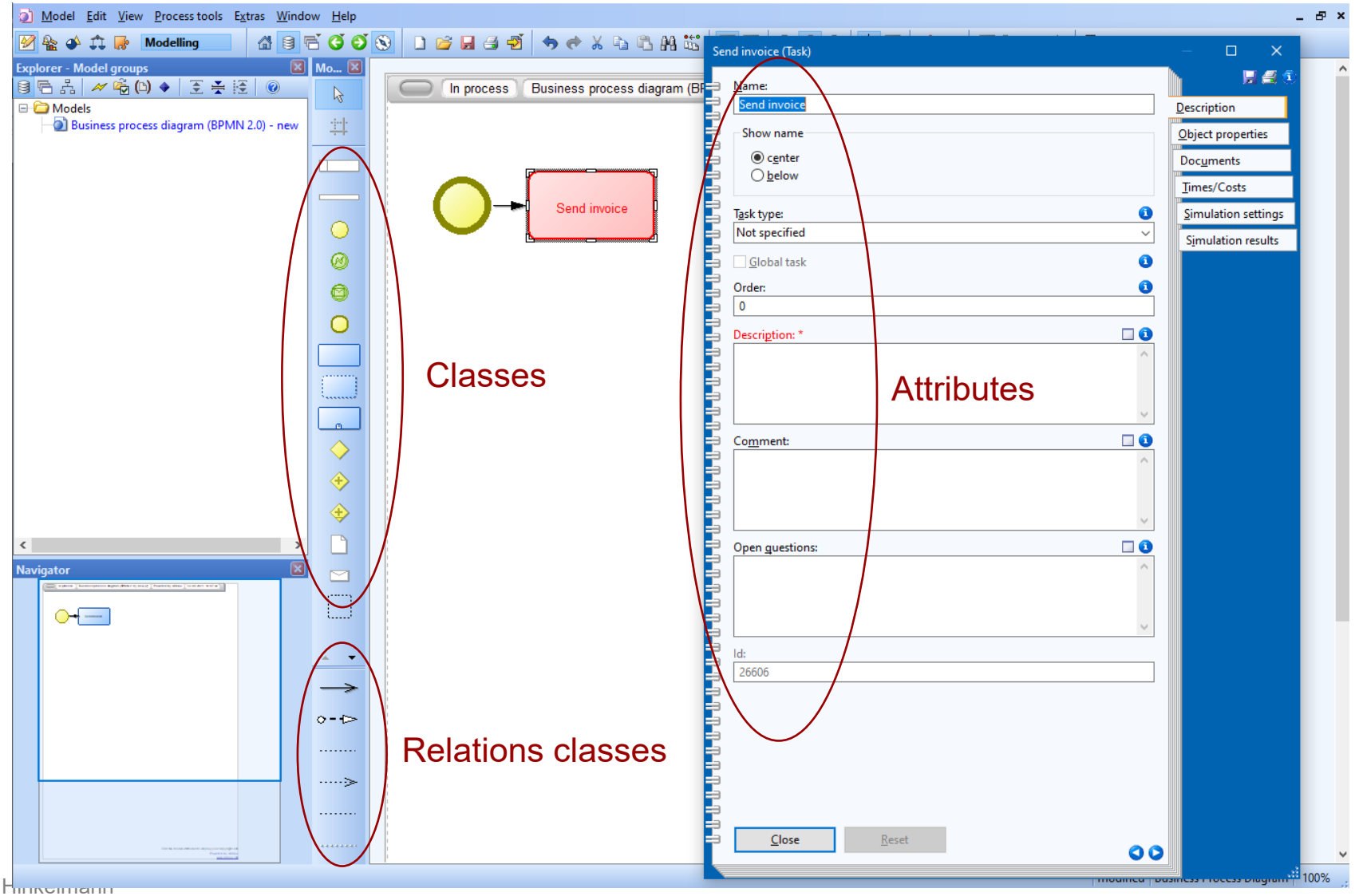
Notebook: Adding Attribute Values



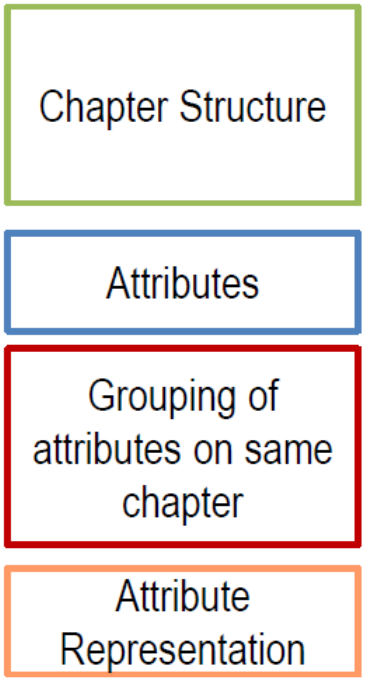
AttrRep

The class attribute „AttrRep“ controls the structure of the ADOxx-Notebook.

```
NOTEBOOK
CHAPTER "Definition"
ATTR "Name"
GROUP "Definition"
ATTR "Description"
ATTR "External content"
ENDGROUP
```

```
NOTEBOOK
CHAPTER "Definition"
ATTR "Name"
ATTR "Description"
CHAPTER "Dialectic Influence"
ATTR "Influencing dialectics" lines:10
```

```
NOTEBOOK
CHAPTER "Definition"
ATTR "External graphic"
```



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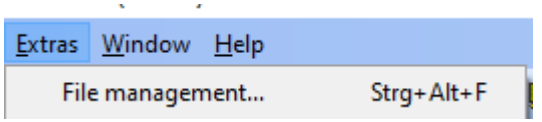
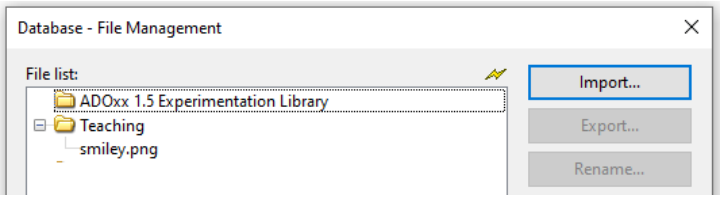
Adding Icons to GraphRep

- Icons can be imported into the System
  - Choose «File management ...» in Extras
  - Select the file and load into your library





- In GraphRep add the icon using the BITMAP

```
GRAPHREP
FILL color:white
RECTANGLE x:-2cm y:-1cm w:4cm h:2cm
ATTR "Name" w:c h:c
BITMAP "db:\\smiley.png"    x:1.4cm y:-0.9cm w:0.5cm h:0.5cm
```

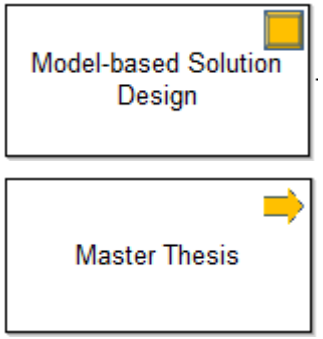

```
BITMAP "db:\\smiley.png"    x:1.4cm y:-0.9cm w:0.5cm h:0.5cm
```

Dynamic GraphRep

- Appearance of elements can be modified depending on values of attributes
- Example: Add an Icon for Module depending on the module type
  - The first line declares a variable «moduletype» using AVAL and assigns the value of the attribute «Module Type»
  - Add Icon if variable has specific value

```
AVAL moduletype: "Module Type"
IF (moduletype = "Lecture")
  BITMAP "db:\\lecture.png"   x:1.4cm y:-0.9cm w:0.5cm h:0.5cm
ENDIF
```

```
AVAL moduletype: "Module Type"
IF (moduletype = "Lecture")
  BITMAP "db:\\lecture.png"   x:1.4cm y:-0.9cm w:0.5cm h:0.5cm
ELSIF (moduletype = "Project")
  BITMAP "db:\\yellowarrow.png"   x:1.4cm y:-0.9cm w:0.5cm h:0.5cm
ENDIF
```



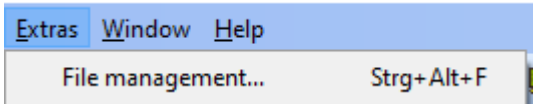
Using Images for Visualization

- Instead of drawing a visualization with GRAPHREP, it is also possible to use images.

- This example uses a file graduation_hat.png.

```
GRAPHREP
BITMAP "db:\\graduation_hat.png"   x:-2cm y:-1cm w:4cm h:1.6cm
ATTR "Name" y:1cm  w:c:4cm h:c line-break:rigorous
```

  - The keyword «BITMAP» indicates the use of a file. (The file has to be uploaded using the file management.)

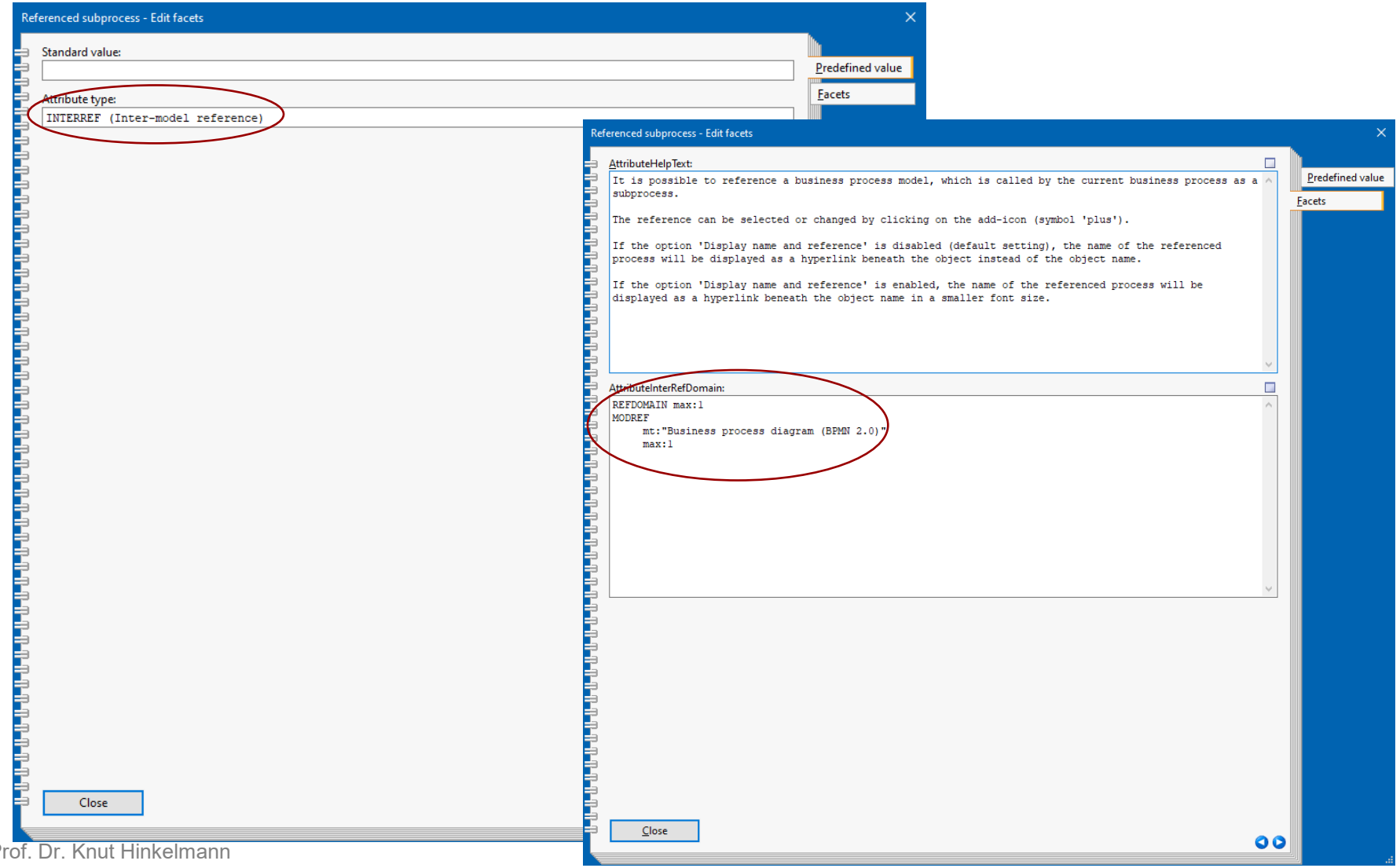


  - Behing the name of the file there is the coordinate of the upper left corner (**`x:-2cm, y:-1cm`**) and the size (**`w:4cm h:1.6cm`**)

  - The last line indicate that the name should be placed 1cm below the center, is 4cm wide and lines are broken if they are too long.

References

Referencing a Subprocess



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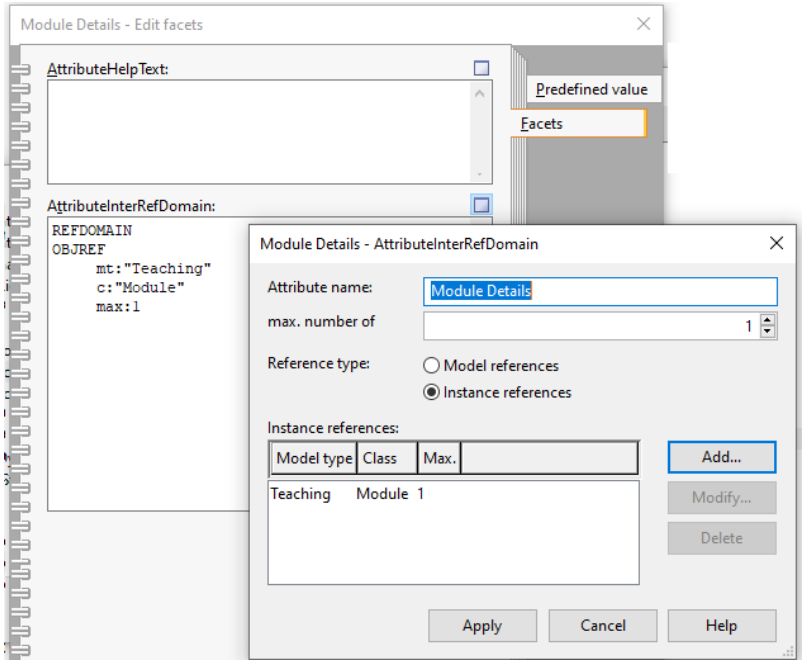
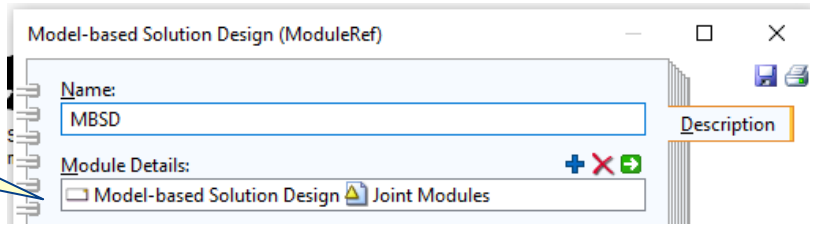
Reference

- References are used to make relations to another model or an element in another models
  - Create an attribute with data type «INTERREF»
  - In the facets specify whether it is a reference to a model or an element and determine the appropriate types



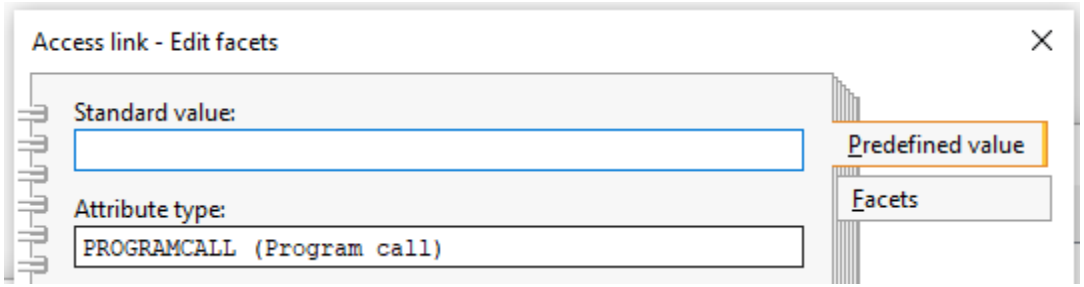
- Example:
  - In a model of a curriculum create a class which contains a reference to the module description, which is modeled in another module

Reference to the module "Model-based Solution Design" in the model "Joint Modules"



Attributes for Documents, Websites, Applications

- Attributes of type PROGRAMCALL allow to provide links to document, websites or applications



- This is how it looks like in a notebook

Clickable Links

- References from INTERREF or links to documents, website or applications can be made accessable directly from the model
- This GRAPHREP the displayed name of the element is a link to the value of the attribute Module Details

```
AVAL sname: "Name"
ATTR "Module Details" text:(sname) w:c h:c
```

  - AVAL assigns the value of the attribute **`Name`** to the variable **`sname`**
  - The second line displays the value of that variable and has as link the value of the attribute **`Module Details`**

Change of Metamodel

- Example: new task type Cloud Task